SEMINAR ON
THE PROPOSED M10 MARINE PARK

Proceedings of the seminar,
held at the Marmion Angling and Aquatic Club,
Perth, Western Australia,
June 12, 1985.

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Department of Conservation and Environment
Perth, Western Australia

Bulletin 256 March 1986

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ISBN 0 7309 0539 X

FOREWORD

On 10 December 1985, the Honourable Premier of Western Australia, Brian Burke, announced that declaration of the Marmion Marine Park would proceed. At the time of the seminar, 12 June 1985, no decision on this had been made by Government, and throughout these proceedings it is referred to as the proposed M10 marine park. M10 is the designation given it in the System 6 reports (DCE, 1981; EPA, 1983).

To avoid confusion, the terms **marine reserve** and **marine park** should be explained. In Australia, there are about 200 marine and estuarine protected areas (Ivanovici, 1984), all of which may be regarded as various forms of marine reserve. According to the intended primary purpose of these marine and estuarine protected areas, and the legislation under which they are declared, they may be referred to as Aquatic Reserve, Coastal Park, Fish Habitat Reserve, Fish Sanctuary, Historic Shipwreck Protected Zone, Marine National Park, Marine Reserve, Restricted Use Area, or any of 15 other designations. In general, the term **reserve** implies that the primary purpose of the area is to protect species or habitats, or for scientific research; the term **park** implies that an intended primary purpose is public recreation.

The intention of the System 6 study team (Department of Conservation and Environment, 1981) and subsequently the Environmental Protection Authority (EPA, 1983) was that recreational activities should be allowed, albeit controlled, in the M10 area. Therefore, in this document, the area will be referred to as the proposed M10 **marine park.**

(J.R. Ottaway and R.B. Humphries : editors.)

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INTRODUCTORY REMARKS

Barry A. Carbon
Chairman
Environmental Protection Authority

My role in representing the Environmental Protection Authority is to be educated about the proposed M10 marine reserve, and hear directly your views.

We have a very wide range of representatives here today: people representing the entire spectrum of groups who have a direct interest in the M10 area (Appendix 1). The intention is that this morning we will share information, and then this afternoon we will share points of view. Today is one step in a series of efforts to gain input for a report which will go to Government, and eventually form the basis of a management plan for this very important section of our coastline and coastal waters.

INTRODUCTION TO THE SEMINAR ON THE PROPOSED M10 MARINE PARK

Colin F. Porter
Director
Department of Conservation and Environment

Abstract

A brief history is given of the System 6 Report and the proposal for a marine reserve in the Perth metropolitan area. The purpose of this seminar is to enable professional and recreational fishing organisations, conservation groups, environmental groups, boating associations, water sports associations, State and Commonwealth agencies, local government authorities, research organisations including CSIRO, the Western Australian Museum and the Universities, and others, to contribute directly to the formulation of a draft management plan.

THE HISTORY OF THE SYSTEM 6 REPORT

In 1972, the Environmental Protection Authority (EPA) of Western Australia established a Conservation Through Reserves Committee (CTRC) to review and update national parks and nature reserves in Western Australia. Compared to the eastern States, Western Australia was underdeveloped, and much of the land was not surveyed; hence, Western Australia had the opportunity to establish a comprehensive, representative system of nature reserves denied to more populous countries. CTRC divided Western Australia into 12 systems, each representing a natural and demographic unit. There were associations within each system which made it possible to identify the systems as clearly defined entities, in terms of geology, vegetation, rainfall, or a combination of these factors and others.

System 6 covers an area of about 430 km (north to south) by about 100 km (east to west), including the Darling Range and the entire Perth metropolitan area.

It extends from the Moore River in the north, to the Blackwood River and Bunbury in the south, and from the coastal waters east to a line running north to south through Toodyay. It is one of the smallest systems considered by CTRC, but is certainly the most important. The detailed study of System 6 started in 1976, and after five years of consultation, using seven interconnected committees with separate responsibilities to identify competing demands and provide ecological information, resulted in the publication of the System 6 Study Report (Department of Conservation and Environment, 1981) Green Book.

On the basis of 1494 submissions received and considered, including some formal documents of up to 152 pages, the study report was revised and presented to Government in 1983. In March 1984, State Cabinet accepted in principle part of the report, and approved of progressive implementation, as far as possible, of the detailed recommendations contained in Part II of the System 6 Report (EPA, 1983) Red Book. This included Recommendation M10, for a proposed marine reserve adjacent the northern Perth metropolitan area (Figure 1).

THE PROPOSAL FOR A MARINE PARK BETWEEN OCEAN REEF AND TRIGG

Recommendation M10 originated from a submission by the Australian Marine Sciences Association (Western Australian Branch), in 1972, to CTRC. Parts of that submission were adopted by the System 6 Committee (DCE, 1981) and, after consideration of further public submissions, modified into the present Recommendation M10 (EPA, 1983), which is quoted here:

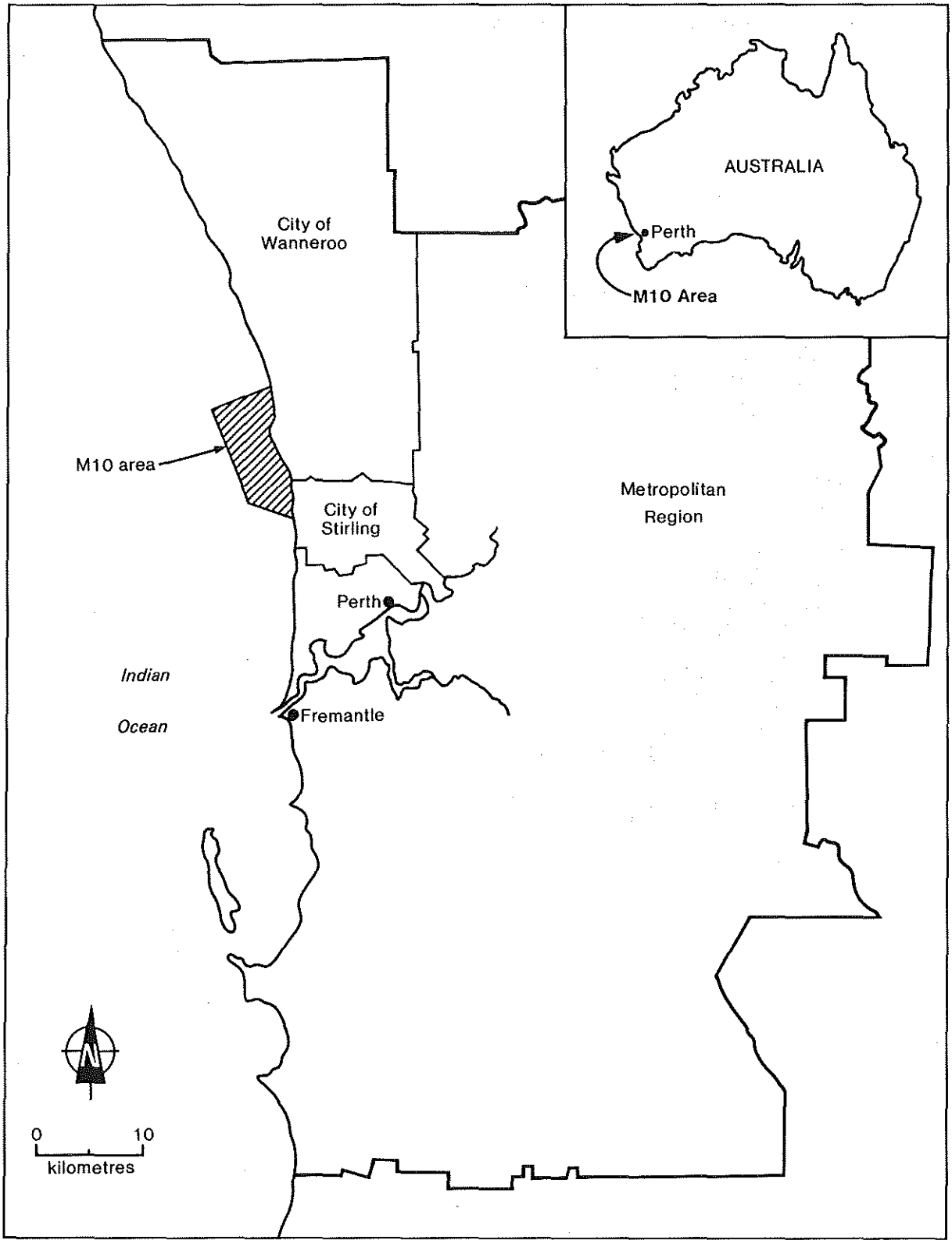

Figure 1. Location of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983).

M10 OFFSHORE REEFS - OCEAN REEF TO TRIGG

The recommended area is centred on Whitfords, about 22km north-west of Perth. Its coastal boundary is at the high water mark and it includes an offshore reef which protects a series of smaller reefs (Figure 2).

The area is affected by an MWA sewage outfall and a boat ramp at Whitfords. There is some commercial fishing of these waters for abalone, fish and crayfish.

The reefs are biologically rich and are unsurpassed locally as an underwater spectacle. Because the reefs have been heavily exploited, and as the area has education value, it is considered essential that they be reserved and protected to conserve the marine communities, including a rare species of cowrie shell which is much sought by collectors.

The area has high recreational value because the sheltered water provides safe boating, diving, swimming and fishing conditions.

Many submissions were received by the EPA on this locality and expressed the high recreational value of the area as well as the need for management to set aside areas of high educational and conservation value.

The recommended area constitutes open space of regional significance because of its high conservation, education and recreation values. Any management plan for the area should have these values as primary management objectives.

Recommendations

M10.1 That our general recommendations on planning and management of Regional Parks be applied to this area.

M10.2 That a study of the area be commissioned by the Environmental Protection Authority with the aim of establishing a Marine Reserve to the managed for the purposes of scientific research, education, conservation and recreation.

M10.3 That, subject to the implementation of M10.2, a management plan be prepared for the Reserve.

The purpose of today's seminar on the proposed M10 marine park, designated by the System 6 Report (EPA, 1983) and accepted in principle by the present Government, is to develop a draft management plan in consultation with representatives of the widest range of user-groups and organisations with interests in the M10 area.

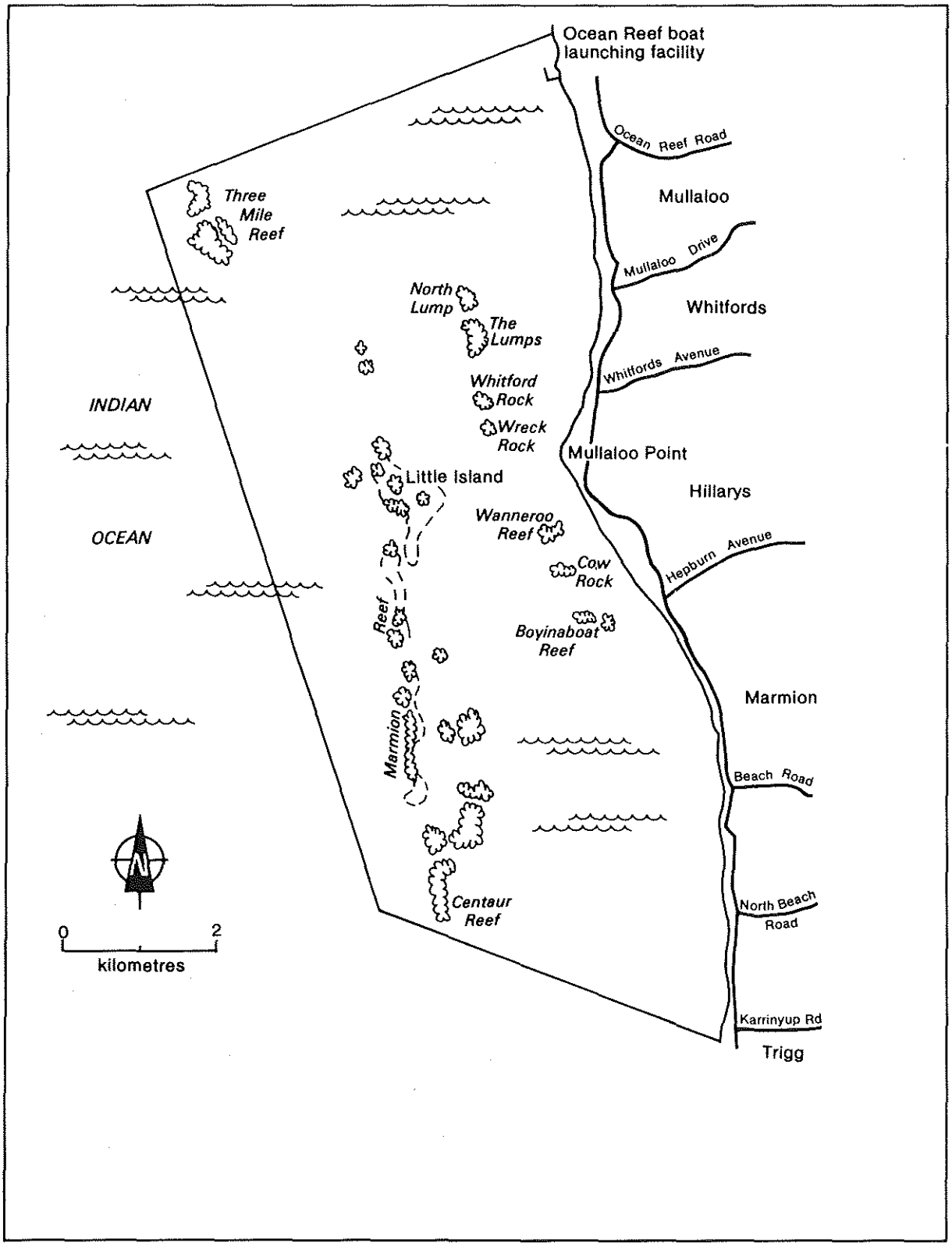

Figure 2. Boundaries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983) as Recommendation M10.

It is necessary to mention also the proposal for a boat harbour at Hillarys, which Government announced yesterday (11 June 1985) would go ahead. When this seminar was arranged, the Department of Conservation and Environment (DCE) and the EPA did not know what the Government's decision would be, or that the decision would be made yesterday. The Public Works Department (1984) had proposed that a boat harbour (then known as the Sorrento Boat Harbour) be constructed, and the EPA (1985) produced a report on the proposal under normal procedures for environmental impact assessment. The Government has agreed to release the report, so that it is available to the public. The focus of this seminar is not to discuss whether or not construction of the Hillarys Boat Harbour (as it is known now) should proceed: the Government has made that decision. While the boat harbour proposal has aroused a great deal of controversy, today's seminar is about conservation, and a management plan for this very important proposed marine park.

The boat harbour proposal, however, did have two important implications for the proposed M10 marine park. Firstly, because the Government was aware that the System 6 Report (EPA, 1983) had recommended this as an important marine reserve, Government was prepared to make available to DCE the sum of $70,000 to do a study of the area. The Hillarys Boat Harbour proposal therefore had an important, positive effect, in that because Government recognised that ecological information was needed for DCE to give advice on the proposal, it enabled DCE to do a detailed study which, otherwise, would not have been done probably for several years. The other important implication, of the Government's decision to proceed with the Hillarys Boat Harbour, is that the management proposals to be discussed and developed during the course of this seminar will assume a higher priority. The boat harbour will create greater pressure on the M10 area, and the reconciliation of those pressures, and the

conservation of the marine resources, becomes a more urgent, and perhaps a more acute task.

THE PURPOSE OF THIS SEMINAR ON THE PROPOSED M10 MARINE PARK

As stated earlier by Barry Carbon, the Chairman of the Environmental Protection Authority, delegates of this workshop represent the entire spectrum of groups with a direct interest in the M10 area : professional and recreational fishing organisations, conservation groups, environmental groups, boating associations, water sports associations, State and Commonwealth Government agencies, local government authorities, research organisations including CSIRO, the Western Australian Museum and the Universities, and other people who represent community interests rather than vested interests. The hope is that representatives will set aside protagonistic positions and co-operate to develop a satisfactory draft management plan. This will require representatives to express the views of their own organisations, but also to listen to the views of other organisations, so that agreement can be reached where possible.

The officers of the Department of Conservation and Environment are committed totally to the whole concept of conservation reserves and to the concept of community involvement in the development of management plans. The reason is that conservation reserves are for all people: not just, for example in the instance of marine reserves, for people who SCUBA dive, for fishermen, or for people who go boating. These reserves are for all sections of the community, and all sections of the community will benefit from the balance between use and conservation. It is not easy to reconcile the non-conservation aspects of recreation with the need to preserve, in the long term, areas that have high conservation values. It requires taking into account information from both scientists and non-scientific users who have knowledge of the area, and

the DCE study team is putting much effort into doing that.

The intention of this seminar then is to bring together representatives of the widest range of user-groups and organisations with interests in the proposed M10 marine park, and have you use your knowledge to help develop a management plan which the State can use for the next fifty years.

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MARINE RESERVES IN WESTERN AUSTRALIA

Dr Barry R. Wilson
Director of Nature Conservation
Department of Conservation and Land Management

Abstract

The reasons for creating marine and estuarine protected areas, such as marine reserve and marine parks, are discussed. The usual reasons for creating such protected areas are either to preserve an environment and biota in a "pristine" state to ensure the survival of species and/or communities, or, to protect an environment and its biota so that one or more of its resources can be utilised in a sustainable way. The latter situation includes extractable resources such as fish and other edible seafoods, and non-extractable resources such as recreation and tourism. Marine reserves are necessary to conserve both extractable and non-extractable resources, and ideally would contain a selection of areas representing the full range of habitat types and marine species in Western Australia waters.

It is now about 15 years since the Western Australian Branch of the Australian Marine Sciences Association first addressed the question of marine reserves in this State. I recall the special meeting, held in the Zoology Department of the University of Western Australia, which discussed this matter and undertook to prepare a report. Some of the recommendations found their way into the report of the Conservation through Reserves Committee, and now two of them have come up for actual decision: Ningaloo marine park and the proposed M10 marine park which is the subject of today's discussion.

There are many reasons why it has taken so long to get to this point. One of them is that there is a natural resistance to the concept of marine reserves, which stems from a prevalent attitude of our western society that the resources of the sea are common property to be exploited at will, competitively, by those individuals who are most able to do so. This is complemented by the mistaken notion that, unlike those of the land, the

reserves of the sea are inexhaustible. Few people are aware that increasing human usage may stress the resources of the sea, just as it does on land, and that, in the face of this pressure, it is becoming necessary to manage the marine environment in order to sustain the resources at acceptable levels.

I have just been to an international coral reef congress and can report the depressing fact that coral reefs throughout much of the western and southern Pacific and tropical Indian Ocean regions are suffering severe degradation. The causes are multiple; for example, mining of coral rock, pollution, eutrophication and gross overfishing. All of this degradation is a direct consequence of human population increase on small islands with finite resources and the inevitable increase in the demand for saleable products and for food.

Several international agencies, and many governments, are making desperate efforts to introduce management processes to arrest the environmental calamities facing Pacific island nations, but I am not optimistic about the chances of their success.

But that is not the Australian situation. Our problems are quite different. Our people do not rely on the resources of the coastal waters for subsistence. We are concerned with the maintenance of valuable income-earning fisheries, with providing opportunities for public recreation, with scientific research, and with several more esoteric values such as the conservation of species and the preservation of environment for aesthetic reasons. For many years we have practised management of commercially exploitable fish stocks. Our problems at the moment are, whether we should expand this to include management of marine resources for other purposes, and to what extent the various proclaimed purposes are in conflict.

This is new ground for our community and individual views tend to be polarized and strong; inevitably we find a wide range of viewpoints expressed. As always in public debates of this kind, much of the heat is generated because people begin their diverse arguments from different premises, and finish in semantic confusion. I want to propose that, before we argue details of the M10 proposals, we ask ourselves what we mean by such terms as marine reserve, marine park, sanctuary and recreation. If we fail to use such terms in the same ways then our debate will be always at cross purposes.

In response to this semantic problem, the neutral term marine and estuarine protected area (MEPA) has been coined. It denotes protection of some aspect of the environment or biota, at some level, without any implication of how the resource is to be used. I shall use that term also. Broadly speaking, there are two quite different motives for creating MEPA's, and going to considerable expense managing them:

i) preservation of an environment and its biota in a "pristine" state to ensure the survival of species and/or communities in perpetuity, and

ii) protection of an environment and its biota so that one or more of its resources can be utilised in a sustainable way.

Let us consider the first of these first, for it is the least complicated. It is important in my view, which I imagine is shared by most people here, that we attempt to retard the process of rapid extinction of species due to human agencies, which we observe today on land. In the sea that process seems to be not so severe (yet) so that we have the chance to avoid it if we are careful and clever. The most effective way to do this is to set aside tracts of ocean and shore as sanctuaries where human activity is minimized or excluded and

Mother Nature is permitted to look after her own, but that is not as easy as it may seem. First we would have to select representative reserves which are likely to include populations of all the species of plants and animals which inhabit the region. To do this we need to approach the matter systematically using some form of biogeographic and ecological classification of our coastline.

The Australian National Parks and Wildlife Service has taken an initiative in this respect and prepared guidelines which will help to select an appropriate system of marine conservation reserves. It has identified large biogeographic zones which will need to be represented, that is, the tropical north, temperate south, and the intermediate overlap zone of the west coast, with several subdivisions of these. Within these biogeographic zones there are distinctive habitat types which contain their own suites of peculiar species; for example, in the north there are coral reefs, mangroves, sandy flats, seagrass beds and so on.

Ideally, a conservation reserve system would contain a selection of areas which includes the full set of habitat types in the biogeographic zones and, it would follow, a full representation of our marine species. I believe that we should go through this process of classification and selection. Whether the ideal is achievable is a different question; however, selection of a set of representative reserves is only the first step.

The reserves must be biologically viable. We need elementary biological data on reproductive season, recruitment, dispersal capacity and natural mortality of key species.

In the instance of coral reefs, for example, there is great debate at present about whether reefs are closed or open systems. That is, to what extent any single reef system is reproductively self-sustaining and whether it relies on recruits received as planktonic propagules from other reefs far away. Such matters are of critical importance, not only for reserve selection but for management. Location and size of reserves will depend on this issue.

Yet we are appallingly ignorant in these areas. Mission - oriented research is needed to give us the necessary information, although which body should do the necessary research has yet to be determined.

It would seem natural that, in a pure world, reserves selected for the preservation of species would exclude destructive and extractive activities. In practise, that ideal is usually compromised.

Now I want to turn to consideration of the other category of reserve; that is reserves established to conserve a usable resource. Here I see two sub-categories relating to the nature of the resource :

i) extractable resources, such as fish and other edible seafoods, and

ii) non-extractable resources, such as recreation and tourism.

In practise, most extractive resources in the sea are conserved not by reservation but by control of fishing effort and fishing season; however, reserves are frequently set up to protect spawning or nursery areas which are given total protection in order to ensure the maintenance of the fished stock elsewhere. These are sanctuaries, like conservation reserves, although the motive for declaring the protected area is quite different.

In summary, I foresee a system of marine and estuarine protected areas in Western Australia which contains three elements:

i) Preservation reserves selected in a systematic way to contain representative samples of the Western Australian marine flora and fauna. Destructive activities would be excluded.

ii) Fish sanctuaries selected to ensure recruitment of stocks into prescribed fisheries. Destructive activities would be excluded.

iii) Recreational parks to ensure long-term viability of recreational fishing, diving and education resources, established wherever the need occurs. Some extractive activities would be accepted under control, but destructive activities would be generally excluded.

The case for conservation of fisheries is clear, but it seems to me that there is fuzzy thinking about the value of recreation and tourism to the community. These values are more difficult to measure in economic terms and tend to be discounted.

As an example, consider the case of Heron Island, on the Great Barrier Reef. There is a tourist resort there which earns, considerable revenue, and employs many people both directly and indirectly. What is the resource being used?. It is the clear water, clean sand, the coral reef, the turtles and the sea-birds; that is, the tropical island experience. Controlled recreational fishing is a part of this tropical island experience. Such a resource has a double value : straight out cash in the bank and also that indefinable asset concerning citizens' health and happiness; however, the resource may be abused and its use must be managed if it is to be sustained.

It seems to me, then, that marine reserves are necessary, in places, to conserve both extractable and non-extractable resources. Like a fishery resource, a recreational resource must be managed on the principle of sustainable yield. Too much use, or use of destructive kind, will destroy the goose that lays the golden egg. Recreational reserves need management.

Now, that seems to me to a logical account of the matter. It becomes complicated when we ask whether or not any given reserve may serve more than one of these functions. For example, a fish sanctuary may very well double as a preservation reserve, and visa versa. Recreational reserves are more problematical, for they may involve recreational activities, such as angling, which are extractive, and which some may perceive as incompatible with the objective of species preservation.

May I submit the view that, in a reserve declared for the purpose of recreation, extractive but not destructive activities are acceptable, provided that management ensures that the stock is sustained. In other words, I believe that controlled line fishing is an acceptable practise in a marine (or terrestrial) recreational reserve. Spearfishing, however, is another matter. There is one point of view which holds that spearfishing is destructive as well as extractive. That, I believe, is a serious question of debate. In fact each kind of activity proposed must be assessed to see whether or not it is destructive.

Another question which arises is, to what extent commercial fishing is acceptable in a recreational reserve? It seems to me that the same principles apply. If the fishing process is destructive then it is incompatible with the purpose of the park. Otherwise it is acceptable, in principle, as long as the fishery is managed to sustain the stock. The issue becomes complicated,

however, when the commercial fishermen and the recreational fishermen are competing for the same stock. In that case, the matter comes down to a question of relative values to the community, both financially and socially.

MARINE ENVIRONMENTS AND MARINE COMMUNITIES OF THE PROPOSED M10 MARINE PARK

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Chief Environmental Officer, Coastal Waters Branch
Department of Conservation and Environment

and

Christopher J. Simpson
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Department of Conservation and Environment

Abstract

Marine environments and marine communities, of the proposed M10 marine park between Trigg and Ocean Reef and about 5.5 km seawards, are summarised. The intertidal regions including Little Island, are mostly depauperate sand beaches or onshore limestone platforms with typical, cool temperate, invertebrate and algae communities. The subtidal areas are a complex mosaic of biotic assemblages: sand patches essentially devoid of macroepibenthos[1], dense seagrass meadows in shallow water, and a range of shallow water to deep water (> 15 m) reefal communities.

Preliminary conclusions are given from detailed technical reports currently being prepared by DCE staff. Over 400 species of macroepibenthos were recorded in the survey undertaken by the Department of Conservation and Environment M10 study team. Using cluster analysis to examine results from intensive sampling, the Waterman Marine Reserve grouped with offshore sites on the Marmion Reef, not with the other onshore reef communities sampled. It is suggested that community structure of these other onshore reefs may have been altered significantly by human pressures. Anecdotal evidence, dating back 50 years, strongly suggests that there have been marked changes in populations of molluscs, crustacea and teleosts, probably as a consequence of activities such as recreational and professional fishing, and hand-collecting.

Pressures from recreational activities are expected to increase markedly as the northern coastal suburbs develop and expand, and without proper management this will inevitably decrease the value of the area for some recreational, professional, and commercial uses.

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[1] **macroepibenthos** : any plants and animals living attached to, or in contact with, the seafloor and which are visible to the unaided eye. Seagrass on sand, sponges on reef and seaweed on dead shells are all examples of macroepibenthos.

MARINE ENVIRONMENTS

The proposed M10 marine park, as described in the System 6 Report (EPA, 1983), extends from the Ocean Reef launching facility to Trigg Island, a straight-line distance of about 13 km, and about 5 km seawards. This is an area of about 60 km^2 (Figure 1).

There are about 30 discrete, intertidal reef platforms (onshore reefs) along that section of the coast, interspersed with sand beaches ranging in length from a few tens of metres to >6 km (Figure 2; Table 1). The offshore seafloor is mostly quartz sand associated with various forms of limestone outcrops. Lal Bank is mostly carbonate sands. The outcrops range from low limestone pavement, and low broken reef, to high reef which rises about 5 m above the surrounding sand seafloor. Two chains of high reefs are found in the M10 area, 7 nearshore "patch" reefs, from North Lump to Boyinaboat Reef, and at least 20 offshore reefs, from Three Mile Reef to Centaur Reef.

Mills, Woods & Humphries (in preparation) describe the climatic and oceanographical conditions of the proposed M10 marine park. The area experiences mild wet winters and hot dry summers, with mean daily minimum air temperatures of about 9°C in winter and mean daily maximum air temperatures of about 30°C in summer. Sea temperatures range from about 17°C, between July and September, to about 22°C between January and April (Pearce et al 1984).

Astronomic tidal range is about 0.5 m (Hodgkin & Di Lollo 1958; Easton 1970), and there can be similar water level changes due to barometric pressure variations or storm and cyclone effects (Provis & Radok 1979; Mills, Woods & Humphries, in preparation).

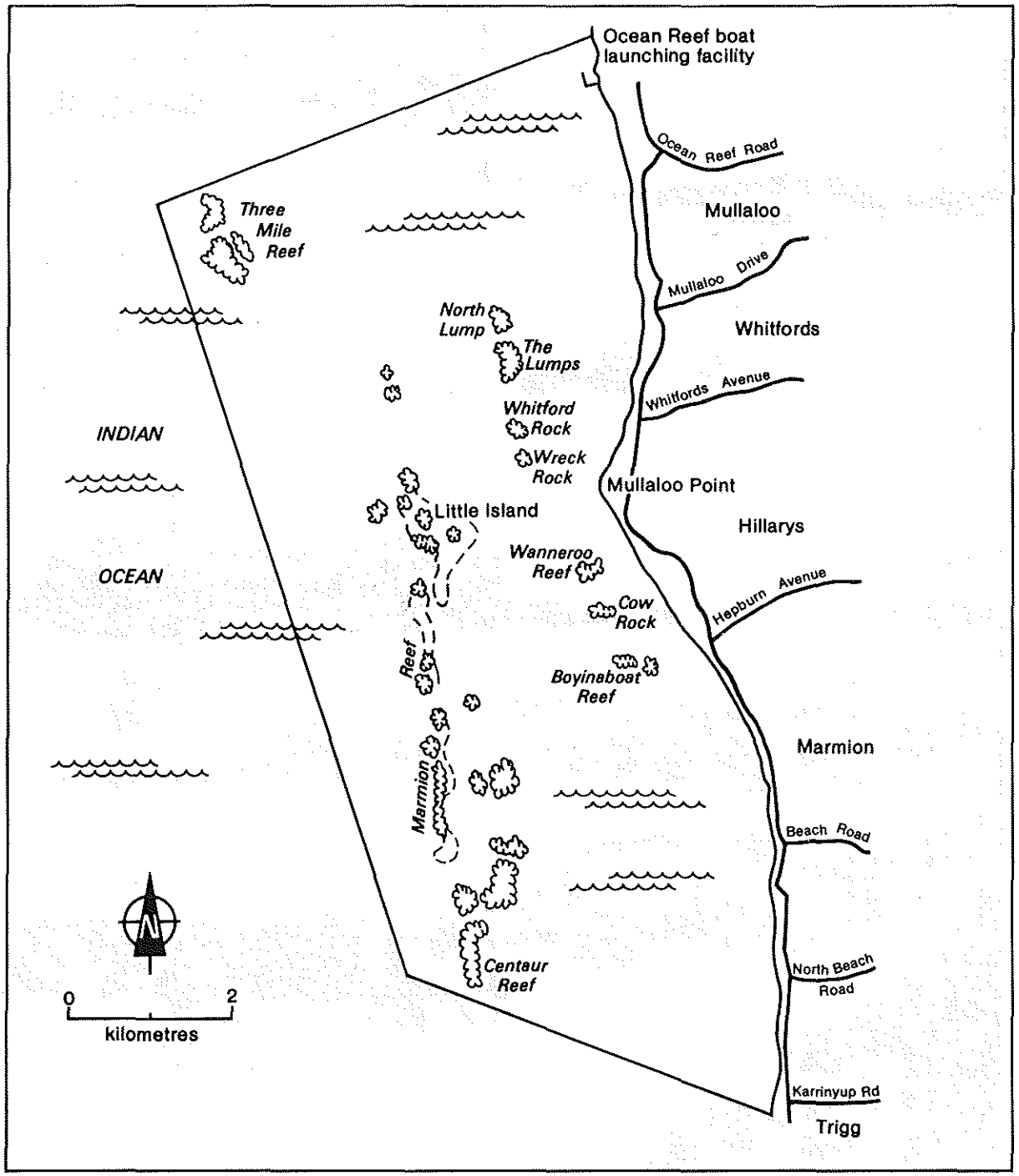


Figure 1. Boundaries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983) as Recommendation M10.

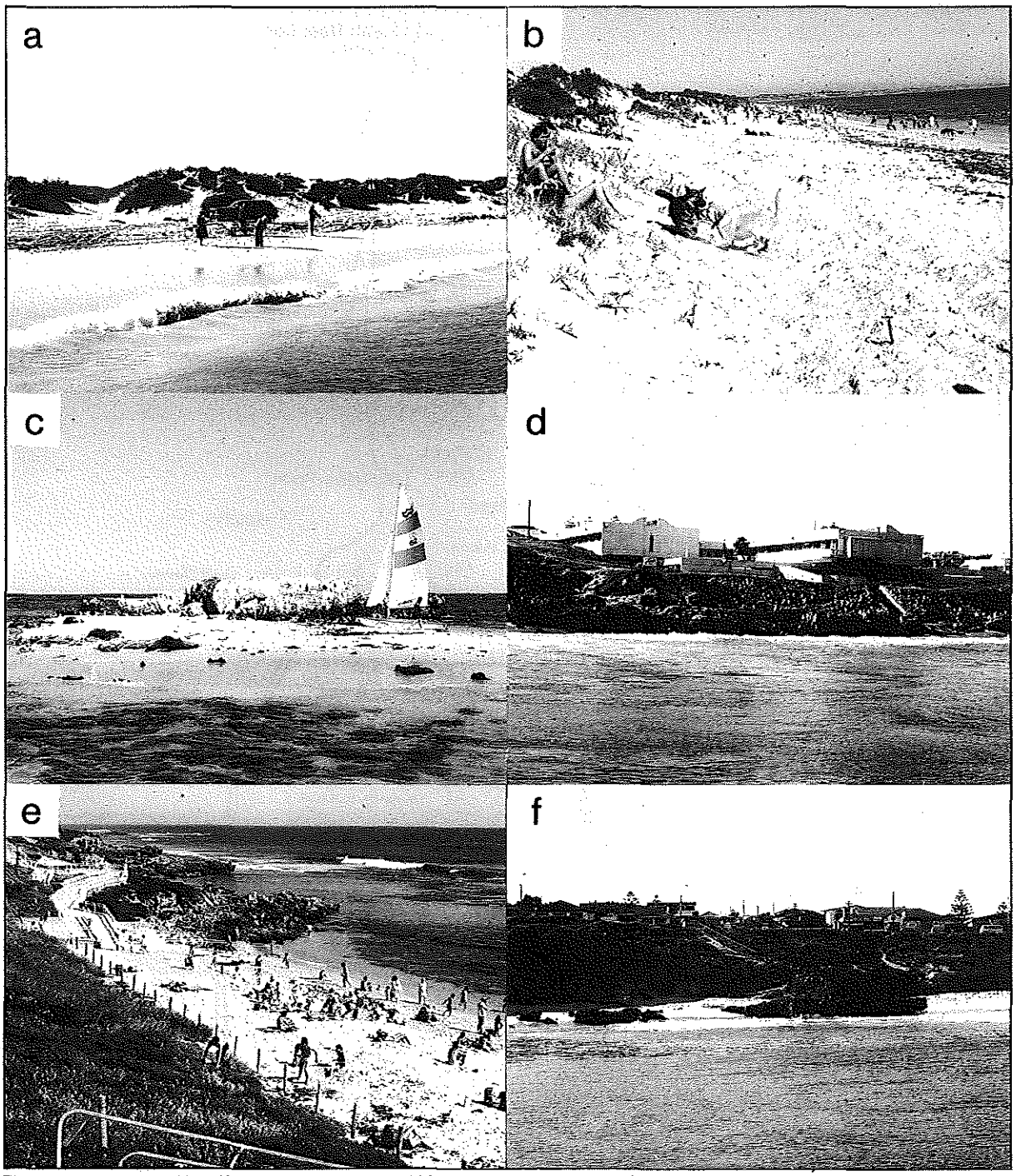


Figure 2. Intertidal landforms in the proposed M10 marine park. a: sandy beach with foredune system degraded by pedestrian and vehicular traffic (about 1 km south of Mullaloo beach, 30 July 1985). b: sandy beach with foredune system degraded by pedestrian traffic (animal exercise beach, about 0.5 km south of Mullaloo Point, 8 September 1985). c: Tamala limestone outcrop (probably a remnant of ancient terrestrial sand-dune) surrounded by recent sands (Little Island, 8 September 1985). d: wavecut platform backed by cliff of Tamala limestone (Western Australian Marine Research Laboratories, Marmion, 30 July 1985). e: Tamala limestone headlands and wavecut platform with remnant sand beach (Mettams beach, 8 September 1985). Dune has been stabilised with native vegetation planted by the City of Stirling. f: limestone cliff with narrow sand beach (Bennion Street: 0.5 km north of Trigg Island, 30 July 1985). (Photos: John Ottaway.)

TABLE 1 : **approximate areas and proportions of various geomorphic units in the proposed M10 marine park, derived from aerial photographs and field surveys.**

Geomorphic unit	Approximate area (hectares)	Proportion of total (percentage)
Terrestrial land		
between high water mark and Ocean Reef Road/West Coast Highway	529	8.7
Onshore, intertidal		
sand beaches	64	1.1
limestone platforms	23	0.4
Offshore		
exposed intertidal reefs and Little Island	4	0.1
subtidal high reefs	962	15.8
essentially bare sand	2066	33.8
seagrass meadows[1], low reef and limestone pavement	2456	40.2
TOTALS	6104	100.1

[1] : dense seagrass meadows occur in habitats quite different to low reef and limestone pavement, and therefore do not constitute a "geomorphic unit"; however, since we could not distinguish between these from interpretation of the colour (1:25 000) aerial photographs, they have been grouped (for convenience of this tabulation).

MARINE COMMUNITIES

Descriptions of the marine communities of the M10 area are given in LeProvost, Semeniuk & Chalmer (1984), and Simpson & Ottaway (in preparation). The classification by LeProvost et al (1984, pp. 39-46) was based largely on assemblages recognised in a detailed survey of the Cape Peron area (LeProvost, Semeniuk & Chalmer, 1981), about 50 km south of the M10 area, but was a modification of the earlier Cape Peron classification. LeProvost et al (1984) recognised nine biotic assemblages, which are listed and summarised below :

(i) **Intertidal rocky shore**

The 31 onshore reef platforms make up most of the area of intertidal rocky shores (Table 1). The upper intertidal levels are generally depauperate, with blue-green algae, littorinid molluscs and rock crabs present. Biota density and diversity increases towards the lower intertidal levels, with large brown algae (such as Ecklonia and Sargassum), smaller red and green algae, molluscs and echinoderms abundant.

(ii) **Sandy beach**

Thirty sand beaches occur along the coast, and one at Little Island. The sand is mobile, the beaches are dynamic, and largely as a consequence the beaches are depauperate of macroepibenthos. LeProvost et al (1984) note that infauna are in relatively low abundance; Lenanton, Robertson & Hansen (1982) and Robertson & Lenanton (1984) found that schooling fish are abundant in the shallow waters, with detached macrophytes in the surf zone being important nursery areas for juvenile fish.

(iii) **Seagrass meadow**

Seagrass meadows, predominantly of the species Posidonia australis, Posidonia sinuosa and Amphibolis antarctica, are extensive in the protected, shallow (generally 2 - 5 m depth), sand areas of the Marmion

and Mullaloo lagoons.

(iv) **Sandy seafloor**

From interpretation of recent aerial photographs, and the survey undertaken by the M10 study team of the Department of Conservation and Environment, an estimated one third of the study area (Table 1) consists of mobile sand sediments essentially bare of macroepibiota. LeProvost et al (1984) note that "the assemblage consists of burrowing infauna and the fish which occur immediately above the sand".

(v) **Kelp**

The large, distinctive brown alga, Ecklonia radiata, is common on areas of stable, hard reef, including all high reefs (onshore, nearshore and offshore) and some parts of the low reef and limestone pavement. Kelp assemblages typically contain varied biota of other algae, invertebrates and fish.

(vi) **Foliose red algae**

These algae can be found from intertidal to deep water (> 27 m) habitats. They occur as a discrete assemblage on limestone pavements in deeper water (LeProvost et al 1984), typically at depths > about 10 m. Brown algae, green algae, seagrasses and animals are also present, but in low densities.

(vii) **Coralline red algae**

As with the foliose red algae, coralline algae occur from intertidal to deep water habitats, in association with brown algae, green algae, seagrasses, invertebrates and fish. LeProvost et al (1984) note that the coralline red algae assemblage "is limited to soft, crumbling limestone reefs. This habitat is extensive on reefs in deeper water".

(viii) **Sponge - ascidian**

This assemblage is most conspicuous in caves, overhanging platforms and crevices, generally where sediment deposition rates are low and low light levels restrict the growth of algae.

(ix) **Nektonic/planktonic**

This assemblage consists of the plants and animals living freely in the water between the surface and the seafloor. Microscopic plants and animals are in relatively low densities except for periods of plankton blooms (for example, Creagh, 1985). Fish are generally abundant in the study area (Ottaway, Cary & Robinson, in preparation), bottlenosed dolphins are seen commonly, and sharks, turtles and whales are seen occasionally.

It is important to note, however, that while these assemblages (i-viii above) may be visually distinctive, assemblage area ranges from $< 1\ m^2$ to > 1 hectare. There is vertical, longitudinal and temporal zonation, but boundaries are seldom well-defined, and the offshore area presents a complex mosaic of these biotic assemblages (Figures 3 and 4).

In order to examine these assemblages quantitatively, the M10 study team undertook censuses at 63 transects throughout the study area (Figure 5), and recorded over 400 species of macroepibenthos. Full details of these DCE censuses and the results will be discussed in a technical report (Simpson & Ottaway, in preparation); however, a summary of the conclusions can be given now. Species richness was related to the amount of hard substrate, substrate diversity, seafloor "roughness" and depth. The cluster analysis grouped the transect through the Waterman Marine Reserve grouped with offshore sites on the Marmion Reef, not with the other onshore reef communities sampled. This

suggests that the community structure of onshore reefs, other than the reef contained in the Waterman Marine Reserve, may have been altered significantly by human pressures (Simpson & Ottaway, in preparation).

Anecdotal evidence gathered by the M10 study team from people who have fished or collected in the area, some since about 1935, supports this conclusion and further suggest that :

(i) collecting pressure, from both amateur and professional fishing, has caused marked reductions in the densities and mean sizes of adult populations of abalone and rock lobsters in particular areas of the onshore reefs; and

(ii) large reef fish, such as blue groper, dhufish and baldchin groper, were once abundant or common near the onshore and nearshore reefs. These species are now seen rarely in those areas, possibly as a consequence of spearfishing and angling.

The anecdotal evidence (Ottaway, Cary & Robinson, in preparation) suggests marked changes in populations of many species, due to collecting and fishing practices (collecting by hand, angling, spearfishing, netting, and lobster potting) since 1935, and particularly since about 1955. These anthropogenic influences have reportedly affected teleosts (bony fish), molluscs and crustacea. If the changes in population structures have been as marked as suggested by the anecdotal evidence, it seems likely that the structure of some marine communities, seen now in the M10 area, are markedly different from those which existed before development of the coastal suburbs north of Perth. Since most of the reported changes occurred in animal populations associated with reefs, it seems likely that the greatest changes in community structure, due to human activities, have occurred on the reefs.

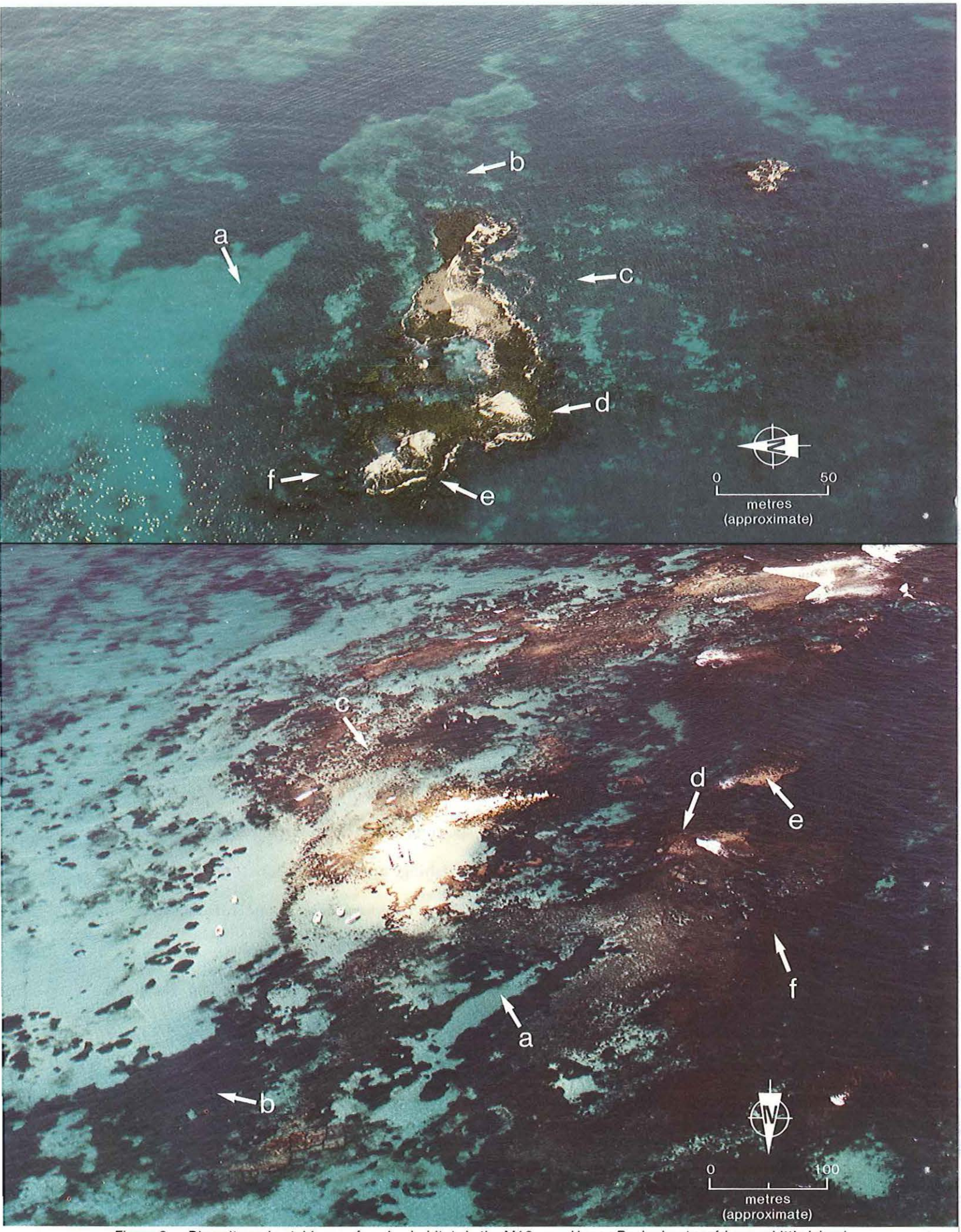


Figure 3. Diversity and patchiness of marine habitats in the M10 area. Upper: Boyinaboat reef. Lower: Little Island. a: loose sand, often forming ripples. b: seagrass meadow. c: limestone pavement with attached plants and small patches of sand. d: vertical high reef faces, with seasquirts, anemones, other attached animals, and various seaweeds (algae). e: reef platform, predominantly covered with various forms of encrusting and turf seaweeds. f: high reef, with a canopy of kelp (see Figure 4).
(Photos: Boyinaboat reef: Stuart Chape; Little Island: Aerial Survey section, Department of Lands and Surveys, Perth.)

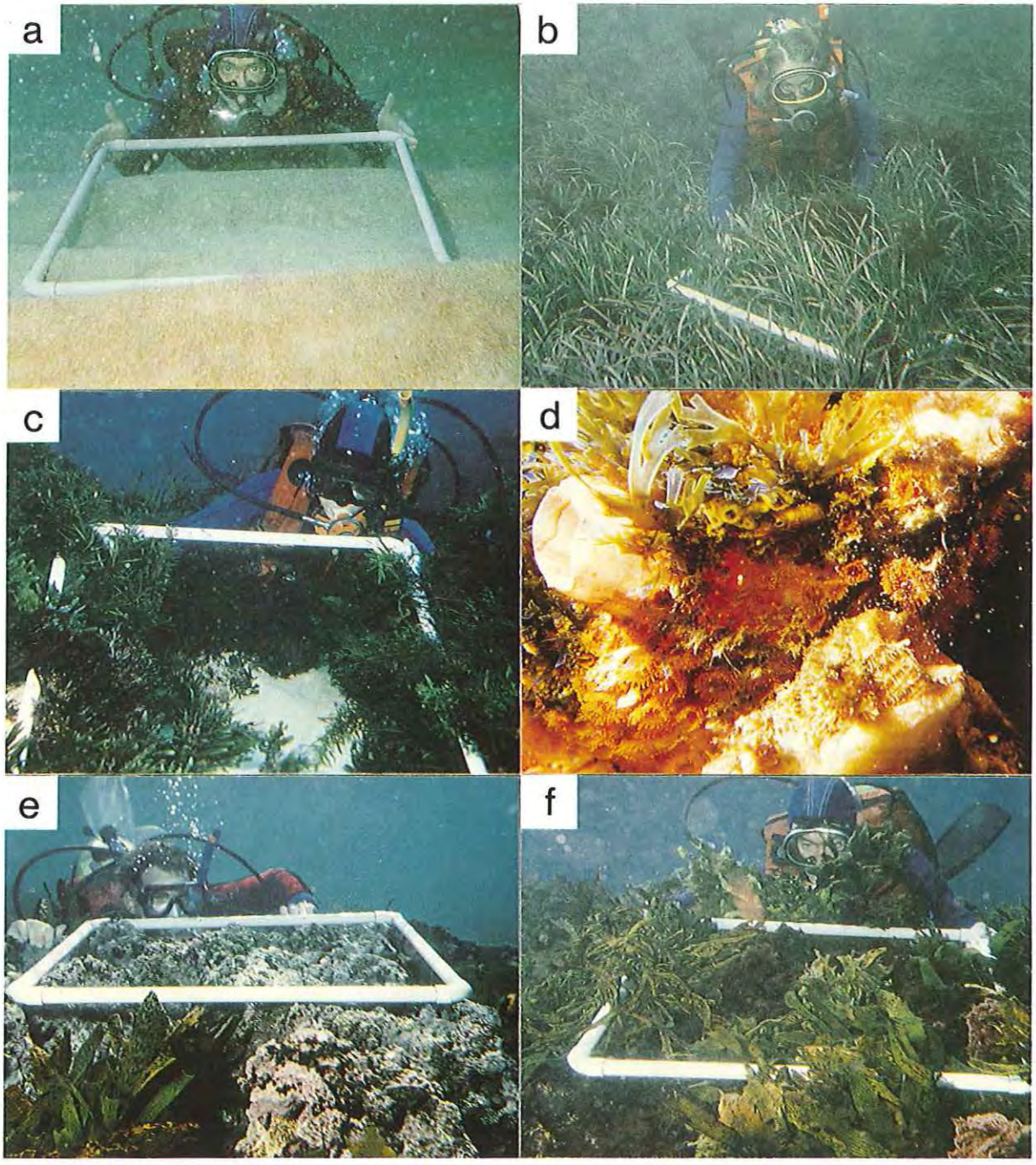


Figure 4. Marine habitats and communities in the proposed M10 marine park. a: loose sand in ripples, typically devoid of large plants and attached animals. Quadrat is 0.71 m by 0.71 m (0.5m^2). b: seagrass meadow. c: limestone pavement with attached plants and small patches of sand. d: seasquirts, anemones and algae on vertical high reef face. e: reef platform with patchy kelp (left foreground) and various forms of encrusting calcareous red seaweeds (right foreground). f: high reef with a canopy of kelp. (Photos: a: John Robinson; b: Jennie Cary; c: Kim Grey; d: John Ottaway; e: Mark Neave; f: John Robinson.)

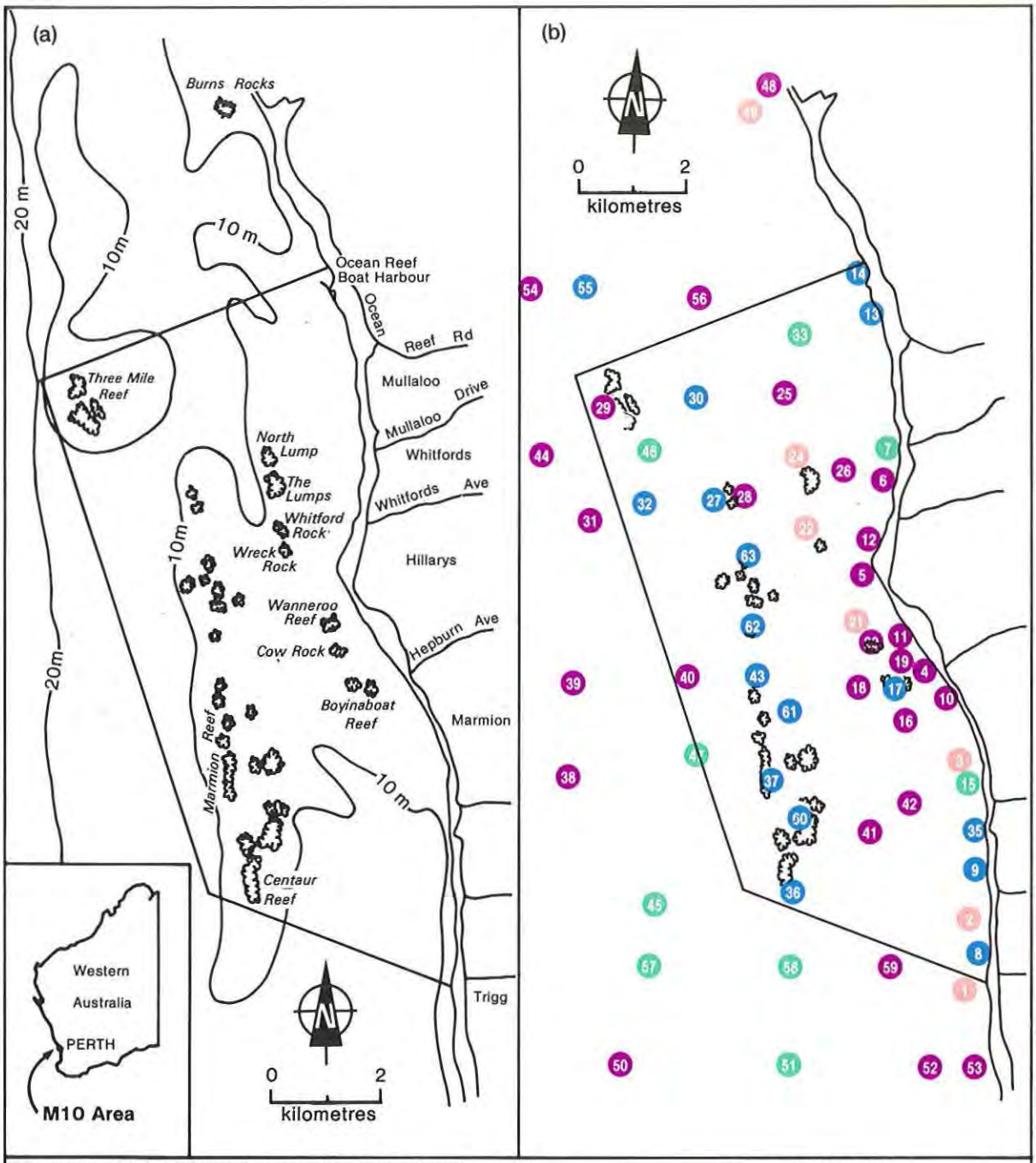
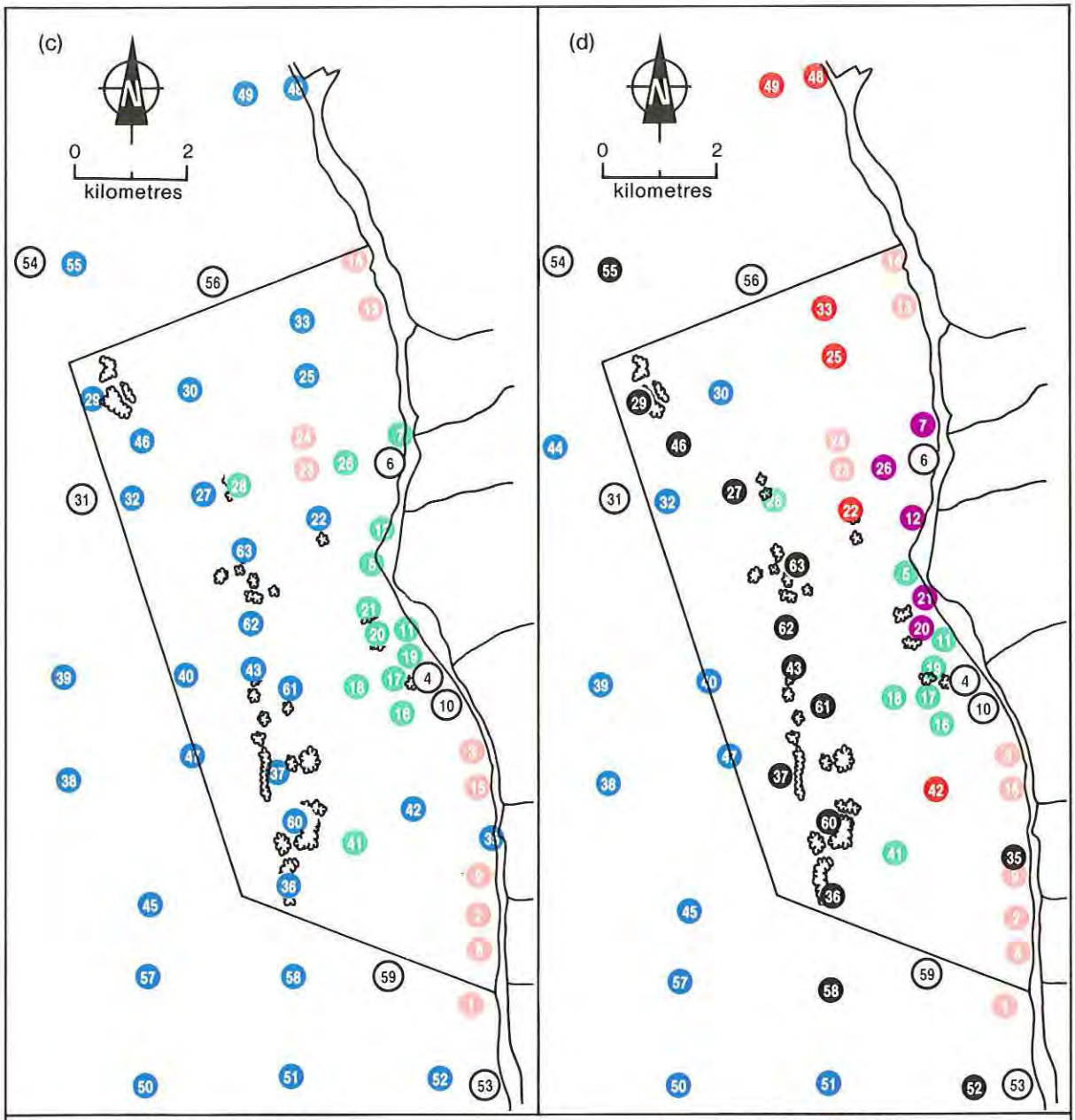


Figure 5. Substrate and community types found in the DCE 1985 survey of the proposed M10 marine park. a: the M10 area as proposed in the System 6 reports, and other general features of the area. b: predominant substrate types recorded by divers at the 63 transects (each 150 metres) sampled. c: predominant community types recorded by the divers at the 63 transects sampled. d: major community types indicated by numerical cluster analysis of large (> 10 mm) attached, bottom-living plants and animals recorded on a presence or absence basis.


(c)
(d)
N
0
2
kilometres
KEY : COMMUNITIES
No large, attached, bottom-living organisms
Seagrass
Predominantly large brown, red and green seaweeds
Predominantly large brown and red seaweeds
KEY : CLUSTER ANALYSIS
Seagrass meadows on sandy substrates, within sheltered lagoon
Large seaweeds on limestone pavement and seagrasses on sandy substrates, within sheltered lagoon
Large brown and red seaweeds attached to limestone pavement in less sheltered lagoon area
Kelp and other large seaweeds on nearshore reefs and intertidal reef platforms, with numerous molluscs and starfish.
Kelp and large red seaweeds on shallow, offshore reefs exposed to wave action.
Large red seaweeds on deeper offshore reefs, interspersed with areas of essentially bare sand.
Sand, essentially bare of any large plants or animals

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COASTAL PROCESSES IN THE M10 AREA

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Abstract

Forces acting on the coast are described. These forces generate coastal processes which have created the landforms seen today. In the M10 area, the main force is oceanic swell which drives sediment ashore and sweeps it into discrete cells. This process has, over the last 8000 years, led to formation of Lal Bank, the Whitford Plain, and the sandy beaches between Sorrento and Mullaloo.

There is a regular lonshore oscillation of sediment contained on the beaches in each sand cell, due to seasonal changes in the direction of swell and wind waves. In summer longshore transport is to the north, and in winter to the south. Net annual sand transport appears to be to the north. Superimposed on these short-term processes are medium-term processes, which have major influence on the position of the shoreline over periods in the order of decades. Major changes in shoreline position are difficult to predict; thus, management of sandy coasts should allow for slow evolution of the sandy landform, long-term fluctuations in shoreline position, and also seasonal fluctuations in beach width and rates of littoral drift. In contrast, rocky coasts are more stable and hence easier to manage. They are, however, usually more exposed to high levels of wave energy, and marine structures are therefore more prone to damage when sited on rocky coasts.

FORCES ACTING ON THE COAST

A major generator of oceanic forces is the atmospheric circulation, which induces winds at the earth's surface. When winds blow over water they generate ripples and waves. Long wavelength waves that leave the area affected by the winds are known as swell. Figure 1 shows the swell pattern generated by the strong westerlies (the Roaring Forties) that blow to the south of Australia and the wave pattern generated by the southeast Trade Winds and local storm winds. Note that the swell generated in the Southern Ocean affects the whole of Western Australia from Broome to Eucla. Superimposed on the

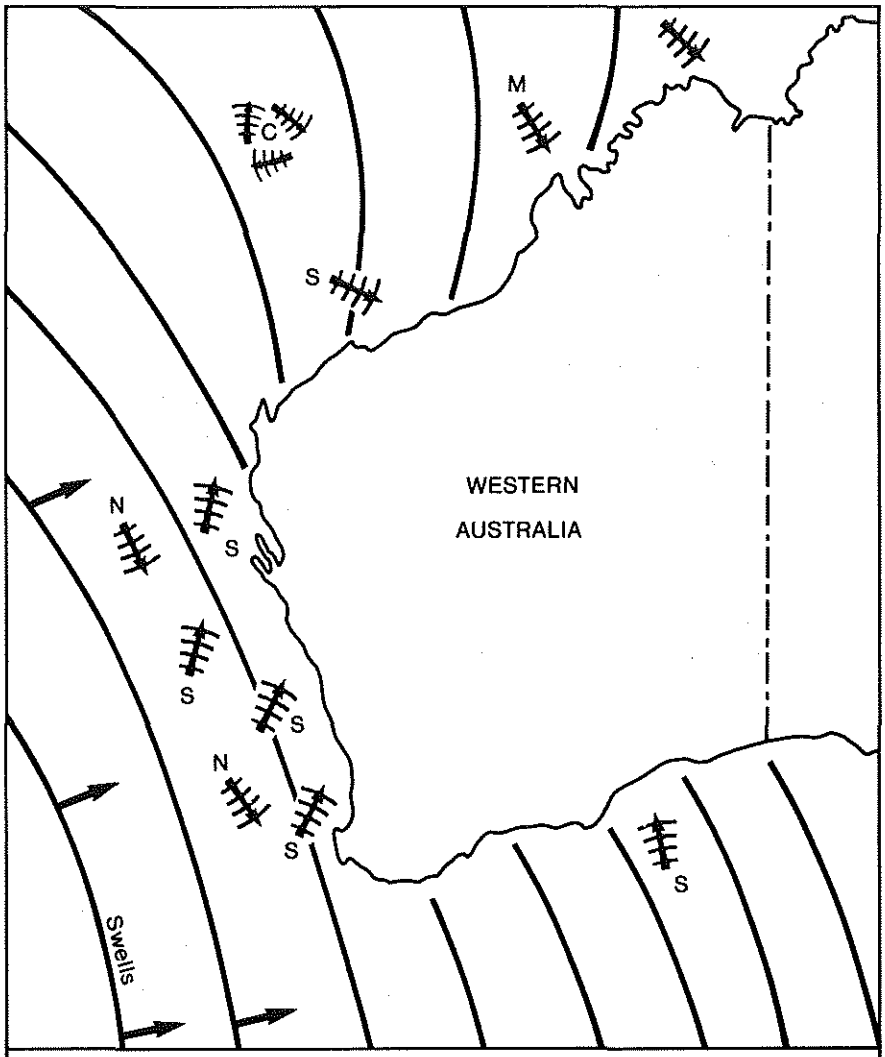

Figure 1. Swell and wave patterns around Western Australia, generated by northwest storms, monsoons, seabreezes and southeast trade winds, and cyclones.

swell are wind waves generated by local winds. On the west coast the sea breeze generates southerly waves with northerly waves generated during northwest gales. Swell and waves have a different impact on the coast, so it is important to appreciate the differences between the two.

Swell which is generated by distant winds is a long period oscillation of water, that is, it has a long wavelength. The direction of swell approach to the coast varies according to season. In winter, swell is more westerly then in summer when it arrives from the southwest. Because swell has a long wavelength it tends to "feel" the seabed and hence to be influenced by it. Thus a most important aspect of swell is that it tends to be bent (or refracted) as it comes in toward the coast.

In contrast, waves generated by local winds, have a short period, and arrive from a variety of directions according to weather and the season (Table 1). In summer the dominant waves generated by the sea breeze arrive from the southwest. In winter, waves arrive from anywhere between northwest to southwest. Because waves have a short wavelength they are not influenced by the seabed and because of this they often arrive at the coast at an angle. If a sea breeze is blowing, southwest waves will arrive at the shore at an angle because our metropolitan coast is mostly oriented north-south. Winds can also generate currents in the water mass but these are not usually important in moving sediment. Wind can also move sediment directly to form sand dunes.

TABLE 1 : **primary forces acting on the coast, and their result**

Primary force	Result/secondary force
Wind	transports sediment directly
	generates swell (long period, southwest to west changing seasonally, refracted by seabed)
	generates waves (short period, variable northwest to southerly, not refracted by seabed, generates longshore currents)
	generates currents
	increases local sea level
Tide	generates currents
	affects local sea level

Another generator of oceanic forces is planetary circulation which causes tidal rise and fall in sea level. Tides and associated currents are not important on the west coast. It must be recognised however that tides on the west coast have a range of around 0.5m but if a low pressure system crosses the coast accompanied by onshore winds, sea level may vary by up to 1 metre.

PROCESSES

The processes that are generated by these forces are summarised in Table 2. It has already been mentioned that wind can move sediment directly by transporting material inland to form sand dunes. The complex topography of the Whitford Plain and the area behind is evidence that there have been pulses of dune building in the past on this part of the coast.

Thus the first process that must be contended with is the tendency for onshore winds to blow sand inland.

TABLE 2 : forces and the resulting processes experienced on the coast

Force	Direction	Result/process
short to medium term		
wind	inland	formation of sand dunes and blowouts
swell	onshore	breakdown of offshore reefs; formation of Lal Bank
	longshore	formation of triangular Whitford Plain seasonal oscillation of sediment in beach zone
waves	longshore	transport of sediment in littoral currents seasonal oscillation of sediment in beach zone net dominance of summer (northerly) transport
	onshore/ offshore	seasonal exchange of sediment between beach and bar
long-term		
?	?	50-100 year cycles of erosion and accretion slow evolution over 1000's of years of sandy landforms, rocky cliffs and headlands

It has also been mentioned that swell and waves arrive at the coast from a variety of directions. It is important to note that when waves or swell arrive at an angle to the shore they generate a longshore current, which is often capable of transporting sediment along the coast (Figure 2a). Longshore transport of sediment from both swell and waves occurs in the study area.

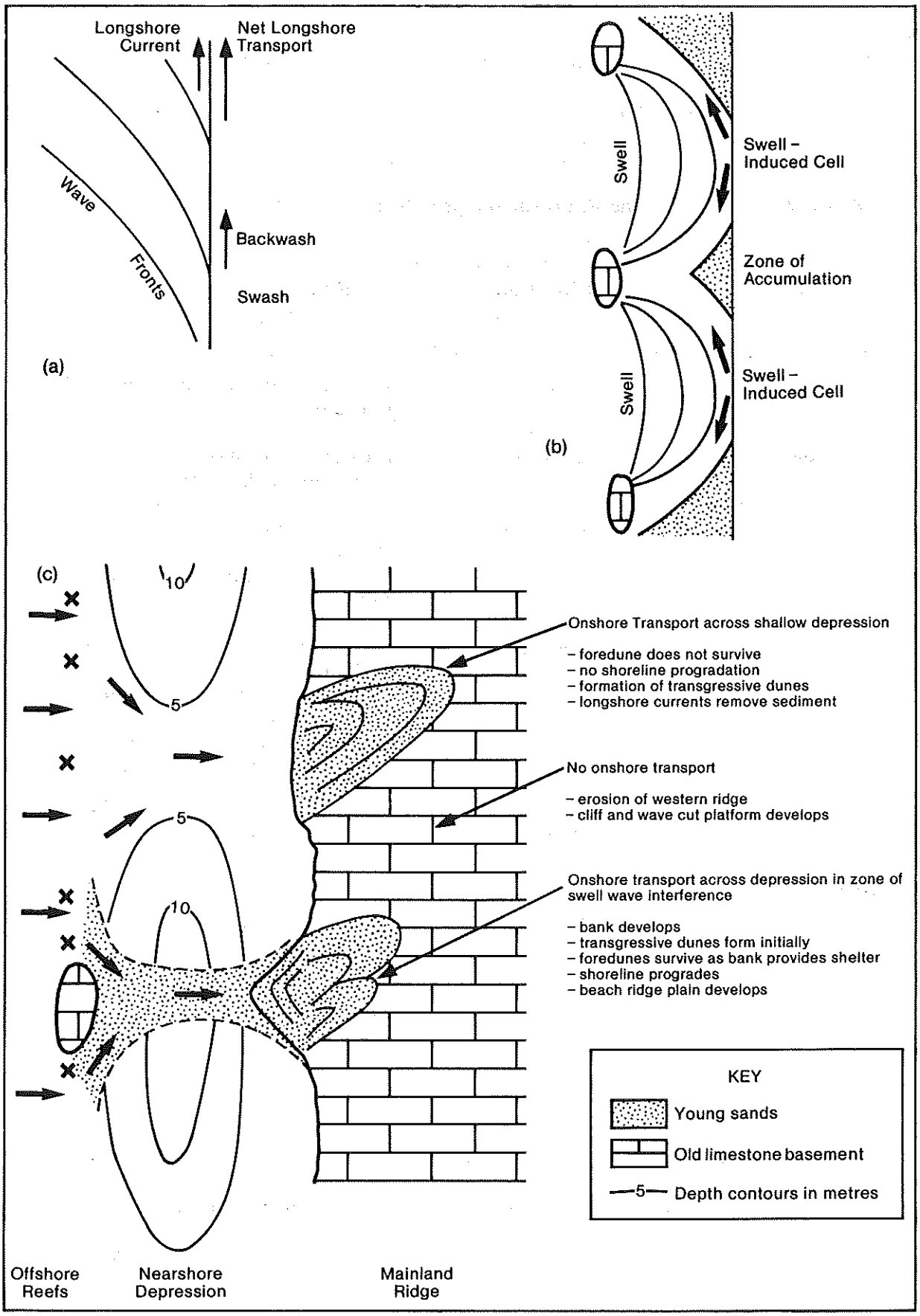

Figure 2. Schematic patterns of sediment movement on the north metropolitan coast of Perth. a: generation of a longshore current. Waves arriving at an angle to the shore will generate a longshore current, which can then move sediment, in the swash zone, along the shore. b: swell induced longshore transport. A broken chain of reef interferes with swells approaching the north metropolitan coast. The swell pattern arriving at the coast is complicated, and results in a complex pattern of longshore transport and compartmentalisation of sediment accumulation. c: swell-induced onshore transport.

The north metropolitan coast consists of a ridge of coastal limestone which is fronted by a chain of limestone reefs and islands. Between the coast and the reef chain is a shallow linear depression. Swell approaching the coast induces both onshore and longshore transport of sediment. As this swell approaches the coast it passes through the reef chains and in so doing causes erosion. The remaining swell that passes through the reefs transports the erosion products shoreward. Because there are remnants of reef lying along the coast which influence swell, the pattern of swell arriving at the shore is complicated, creating complex patterns of longshore currents which tend to sweep sand into discrete cells (Woods, 1984; Figures 2b & 2c).

Thus the major impact of swells is to bring sediment ashore and then to sweep loose material into discrete cells. The result of this over time has been to form submarine banks that are often partially covered by triangular beach ridge plains and which are separated from other similar sediment bodies by stretches of coast where little sand has accumulated and where the underlying coastal limestone has remained exposed. The coast between Trigg and Ocean Reef shows all of these features (Figure 3).

The Marmion reefs are the remnants of a more prominent ridge that has been and still is breaking down, with erosion products being swept ashore and retained in the zone behind Little Island to form Lal Bank and the overlying Whitford Plain. The coast south of Sorrento and north of Mullaloo has not been subject to arrival of sand, rather the reverse has occurred with sand being removed, so that the ridge of coastal limestone has remained exposed to the forces of the sea, which resulted in formation of the cliffs and wave-cut platforms.

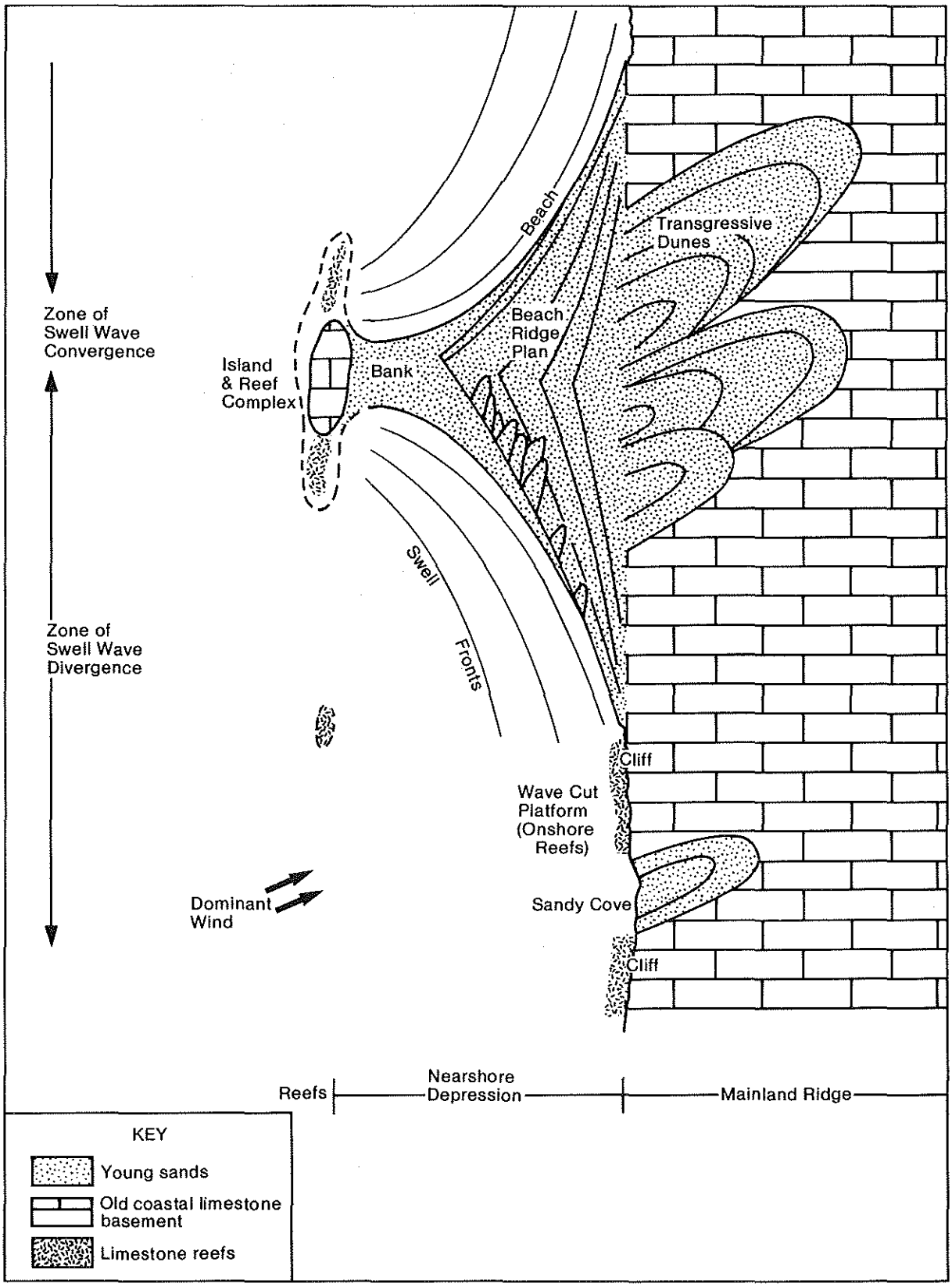

Figure 3. Schematic diagram showing the major local landforms and their relationship to the older coastal limestone.

Because there is a seasonal change in direction of swell approach, there is a regular longshore oscillation of sediment contained on the beaches of each sandy cell (Figure 4). Waves, however tend to induce mainly longshore transport because they often arrive at an angle to the coast, generating a longshore current. Because there are different wave directions in summer and in winter there is a seasonal oscillation in sediment north and south along the coast. The seasonal movement of beach sediment is evident at Sorrento where the groynes fill each winter as sand is moved south but empty each summer as sand is transported to the north. Overall the summer pattern appears to be dominant in that more sand moves north than south each year.

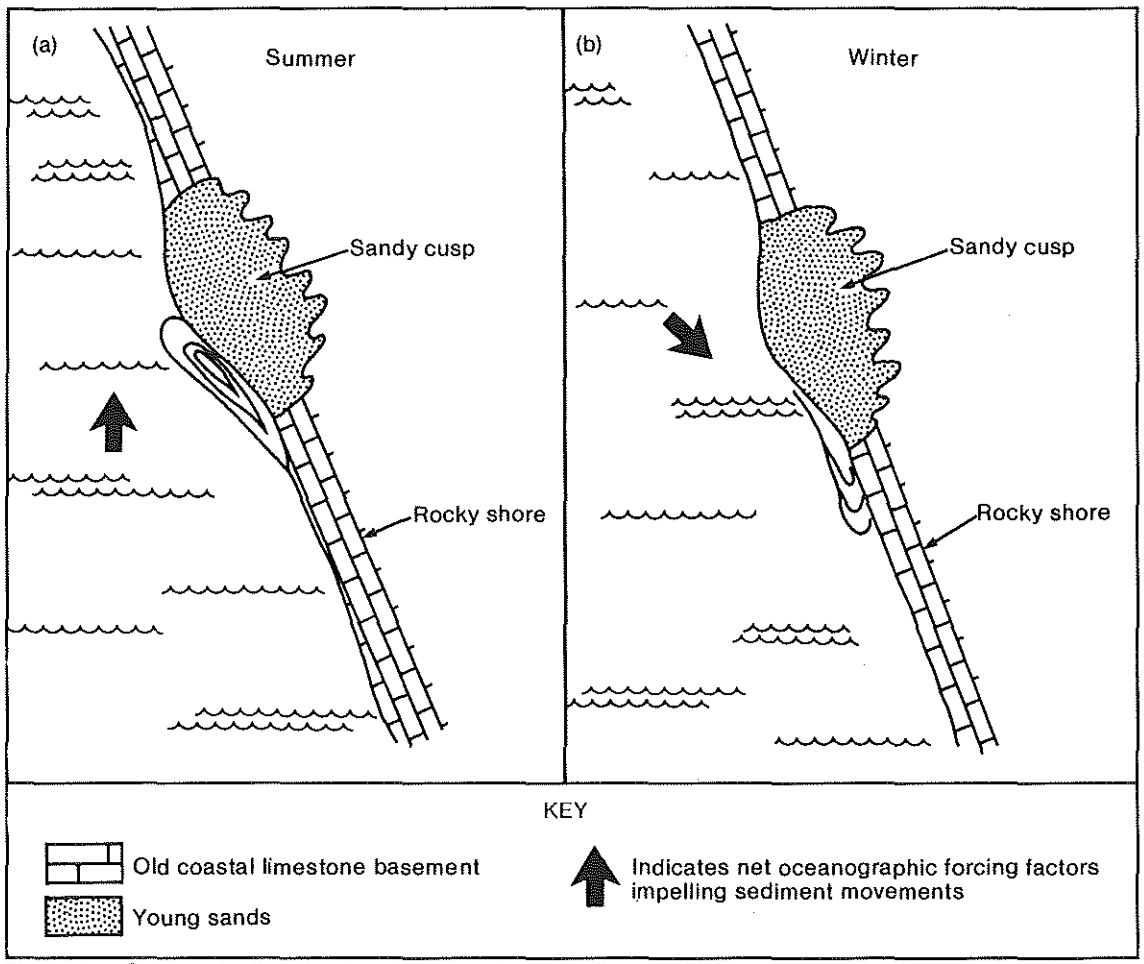

Figure 4. Schematic diagram showing the pulse of sediment which moves seasonally on the southern shore of a sandy beach ridge plain (redrawn from LeProvost, Semeniuk & Chalmer, 1985). a: summer pulse. b: winter pulse.

In summary, the second process discussed is the seasonal oscillation of sediment to the north in summer and to the south in winter because of the changing direction of longshore currents (LeProvost, Semeniuk & Chalmer, 1985; Figure 4).

Superimposed on these short-term processes are long-term processes that must also be taken into account as they influence the position of the shoreline. Evidence from elsewhere along the west coast (Woods, 1983; Woods & Searle, 1983) and from the Whitford Plain (Semeniuk & Searle, 1985) demonstrates clearly that the sandy plains are very young features, geologically speaking, and that they are still adjusting to changes in sand supply and to the forces of the ocean. Figure 5 shows cross-section and plan views of the Whitford Plain showing the ages of sediments and time lines through the sediment body. It is clear that Lal Bank and Whitford Plain did not exist 8000 years ago. Since that time, continued transport of sediment into the area has led to the creation of Lal Bank and formation of Whitford Plain. From the dates obtained, it seems that the Plain is now smaller than it once was because of erosion of its southern flank, so that the time lines intersect the present shoreline. The landforms on Whitford Plain support this interpretation. The steep dune scarp on the southern shore which is indicative of a stable or retreating coast contrasts with the low ridges behind beaches to the north of Mullaloo Point which are typical of an advancing coast (Figure 6; sections B-B and C-C). Thus geological, geomorphic and radiocarbon dating evidence suggest that the Whitford Plain is still evolving with the southern shore eroding and the northern shore advancing.

In summary, the third process to be considered is the slow evolution of the sandy shoreline over a few thousand years. Despite the fact that this process is slow, the erosion at Sorrento is probably due to this long-term trend and action

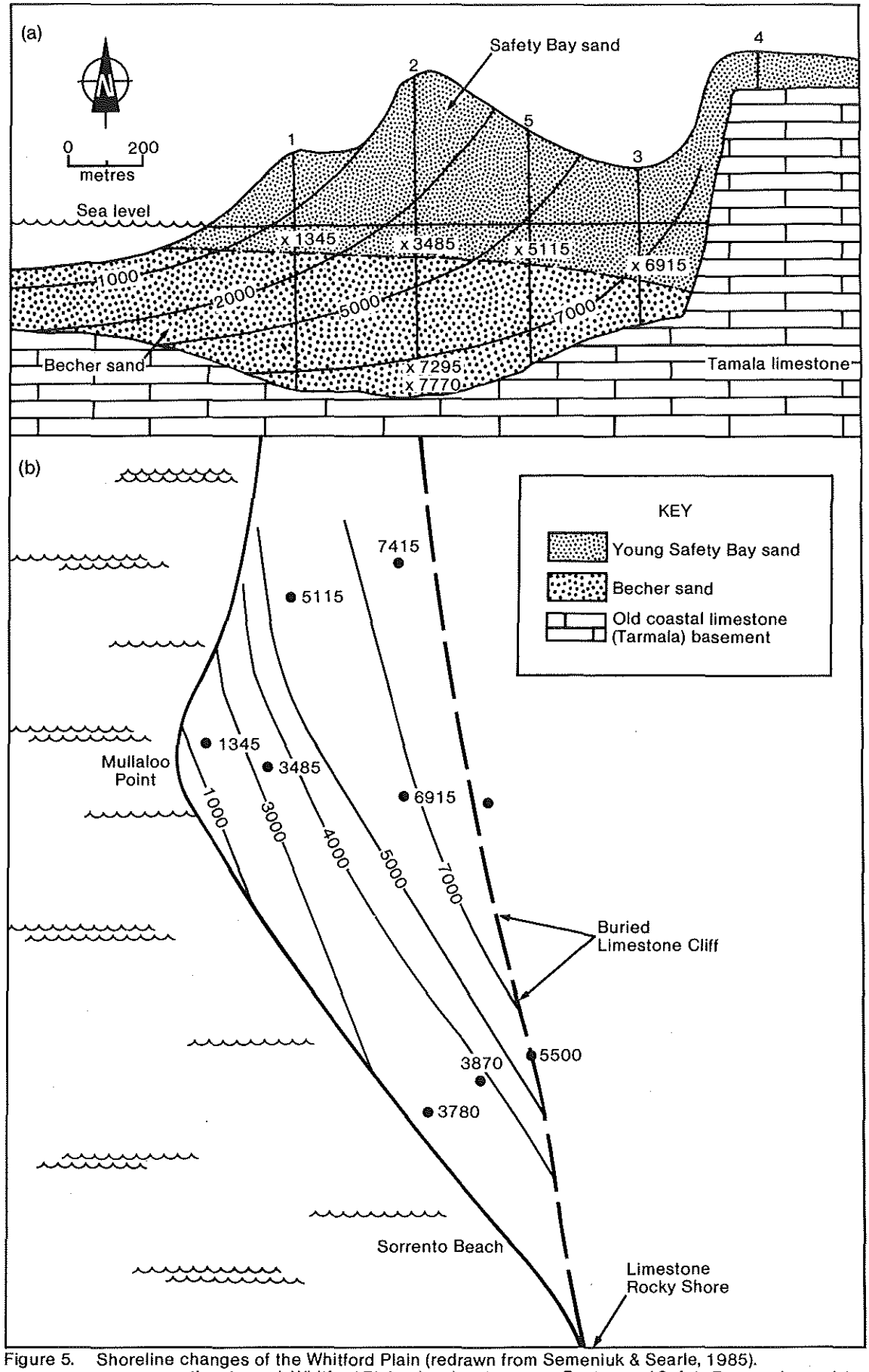

Figure 5. Shoreline changes of the Whitford Plain (redrawn from Semeniuk & Searle, 1985).
a: cross-section through Whitford Plain, showing the young Becher and Safety Bay sands overlying older Tamala limestone. Growth lines (in thousands of years) are based on radiocarbon dates (x).
b: plan view of the plain showing the position of the shoreline through time. The plain started growing about 7000 years ago, but the shoreline north of Sorrento now appears to have been eroded.

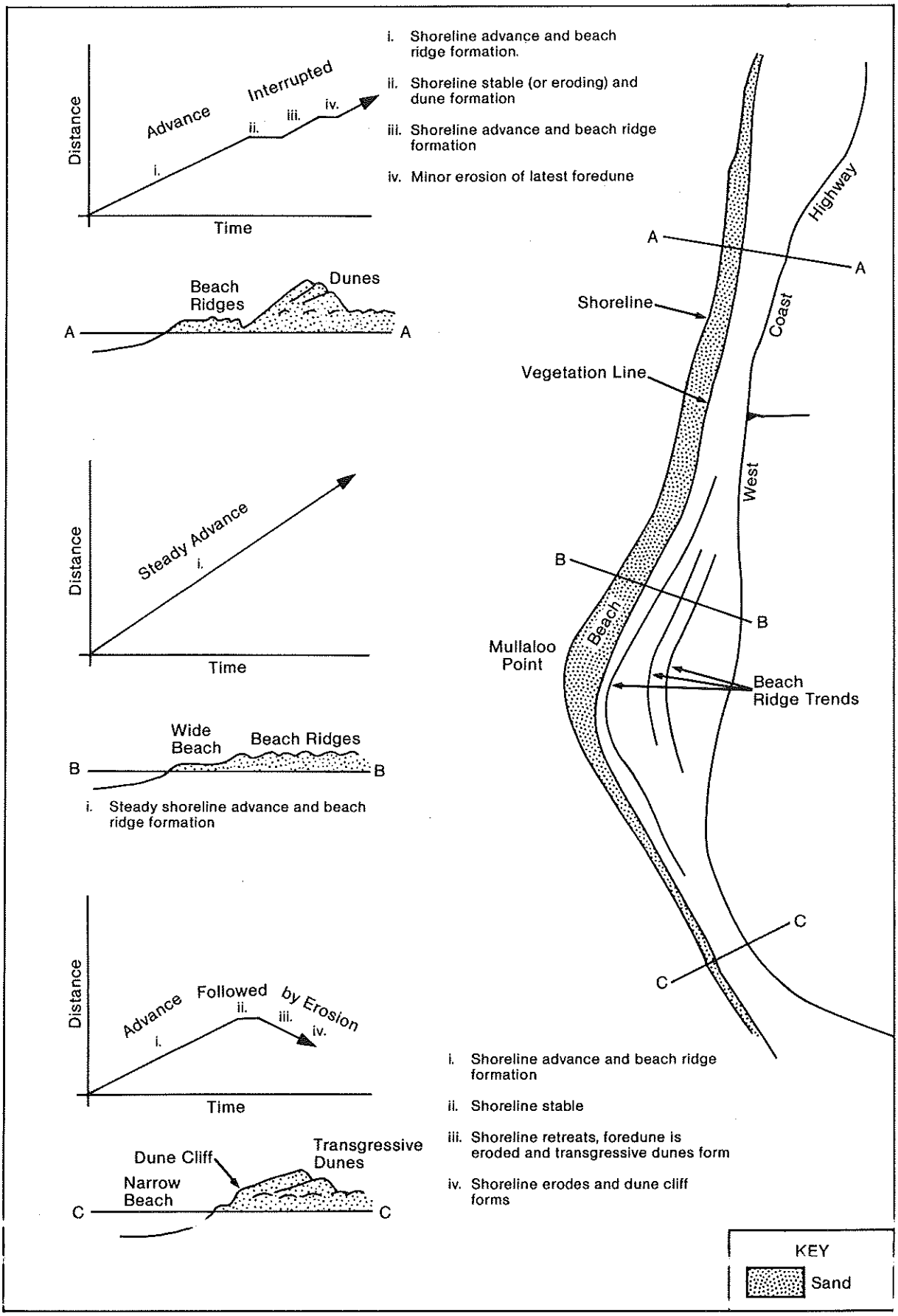

Figure 6. Whitford Plain, showing growth histories for parts of the coast, beach ridge trends, and sections through the coast.

to defend property has been taken. So even though these changes are slow they do have relevance if we are planning for time frames of 50-100 years.

On a shorter time scale, there is evidence from this and other parts of the coast which suggests that advance of the shoreline over the past few thousand years has not been steady. Rather, advance has been punctuated by periods of stability or erosion. Most of the Whitford Plain is covered by transgressive dunes which have blanketed underlying evidence of shoreline position during the Plain's period of growth. However, near Kallaroo there is still evidence that growth has not been regular. Here a large dune is fronted by a linear depression parallel to the shore which in turn is fronted by a series of low beach ridges (Figure 6; section A-A). These features are indicative of a stable shoreline along the line of the depression when the large dunes were formed. The band of low ridges in front of the depression indicates that conditions altered quite suddenly and the shoreline advanced, abandoning the depression before it had a chance to fill with sand. As the present coast is marked by a small dune cliff, it is possible that this period of rapid advance has ceased.

Thus the fourth process we must be aware of is the marked changes in shoreline position that take place over periods of about 50 to 100 years. Both the slow evolution of the coast and the long term changes in shoreline position make it very difficult to plan use of our sandy coastline because :

(a) even though it may be possible to determine the course of landform evolution, it is very difficult to reverse or influence the powerful natural forces that are responsible;

(b) the major changes in shoreline position are difficult to predict. As they are also due to powerful and not fully understood phenomena, these too are difficult to influence.

SUMMARY, AND MANAGEMENT IMPLICATIONS

The coast as we see it today is the result of landform evolution over the past 5000-6000 years. Sand has been swept ashore to form Lal Bank, the Whitford Plain and the sandy dunes that overlie the coastal limestone. Where no sand has come ashore, the underlying limestones have been exposed along the coast and eroded to form cliffs and wave-cut platforms. The rocky parts of the coast are relatively stable, whereas, the sandy parts are subject to change from a variety of coastal processes that influence them.

Table 3 shows implications for management of the coast. On sandy coasts, in the short-term, allowance must be made for fluctuation in beach width and also fluctuations in sediment movement on a seasonal basis. These are predictable to some extent and can be taken into account in planning coastal facilities. Allowances must also be made for the tendency of wind to blow sediment inland. This implies a need for maintenance of a dune system or of some artificial barrier behind the beach. In the long-term, cyclic changes in the amount of sediment arriving at the coast, which cause marked changes in shoreline position, must be considered as does the fact that the general shape of the sandy landforms that have evolved over the last few thousand years are still adjusting to the latest rise in sea levels. These last two phenomena are difficult to predict and even more difficult to take into account in planning.

In contrast, rocky coasts are far easier to manage and develop because they are made of more robust material and there is less mobile sand to deal with. However, rocky coasts are usually exposed to more wave energy than the sandy coasts so that structures in the water are more prone to damage from oceanic forces.

TABLE 3 : management implications for sandy and rocky coasts

Coast type	Management implications
sandy	**short term** seasonal fluctuations in beach width, rates of sediment transport and direction of transport inland movement of sand **long term** 50-100 year cycles of erosion and accretion landform evolution over many hundreds of years
rocky	greater exposure to swell and wave activity than normal for sandy coasts.

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IMPACTS OF ENGINEERED STRUCTURES ON COASTAL MARINE ENVIRONMENTS

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Abstract

Engineered structures in Western Australia are reviewed and impacts on coastal marine environments are discussed.

Most boat harbours can be expected to have some siltation of the harbour mouth, and hence would require maintenance dredging. The siltation rates for Western Australia harbours ranges from effectively nil (at Fremantle and Port Denison) to 100,000 - 200,000 cubic metres per year (at Peel Inlet). Within the proposed M10 marine park, the entrance to the Ocean Reef boat launching facility silts at about 5000 cubic metres annually; it is predicted that up to 10,000 cubic metres of sand will need to be bypassed annually to prevent eventual siltation of the Hillarys Boat Harbour entrance and recession of the shores to the north of the harbour.

INTRODUCTION

Breakwaters and groynes are deliberately designed to modify coastal processes, and the construction of such structures will, therefore, have an impact on the coast. This paper will discuss coastal structures in Western Australia, including one existing and another planned in the proposed M10 marine park.

GERALDTON BREAKWATER AND FISHING BOAT HARBOUR

One of the earliest breakwaters in Western Australia was constructed at Geraldton, in the early 1920's. The town jetty at Geraldton was originally used to handle shipping. Then a piled viaduct was constructed, rock was tipped from railway wagons to form the east breakwater, another piled viaduct was constructed and more rock tipped, this time to form an offshore breakwater.

Figure 1a shows the situation in 1926, which is quite different to that now (Figure 1b).

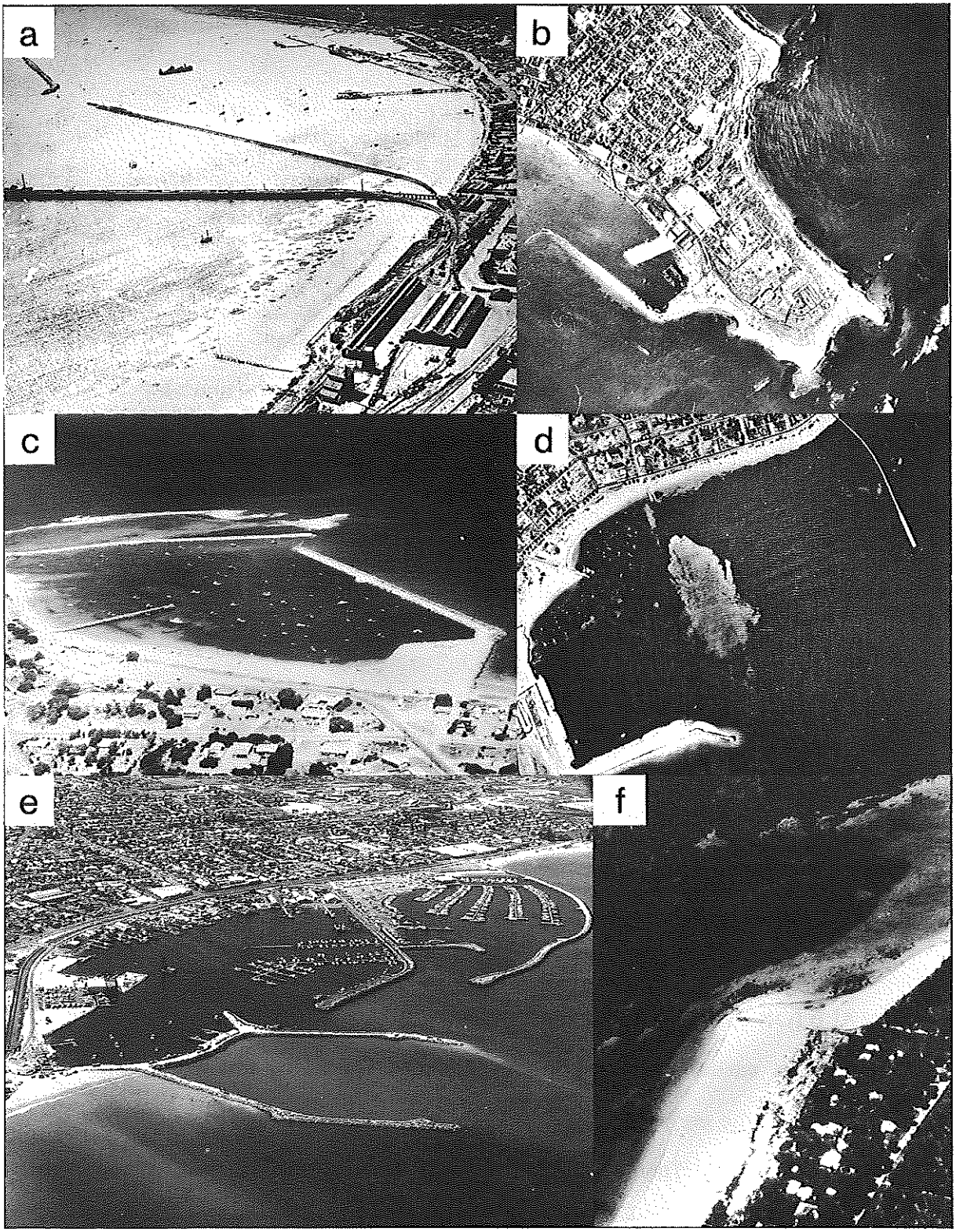

Figure 1. Coastal structures in Western Australia. a: Geraldton town jetty, 1926. b: Geraldton fishing boat harbour, 1985. c: Port Denison harbour. d: Esperance breakwater and fishing boat harbour. e: Fremantle harbours, 1985 (top right: Success harbour, top left: Fishing boat harbour; foreground: Challenger yacht harbour under construction). f: Siesta Park groyne. (Figure 1e courtesy of West Australian Newspapers Limited.)

After construction of the offshore breakwater, a tombolo formation occurred in the 1930's to 1940's. The breakwater was then closed with rockfill on the west side, to form the fishing boat harbour. A fair amount of sand comes ashore in that area, much of which is trapped on the west side of the breakwater. Much is also transported along the breakwaters, and accumulates up to about 20 metres seawards of the main breakwater.

TABLE 1 : estimated siltation figures for Western Australian harbours

Harbour	**Estimated siltation** (cubic metres/year)	**Net direction of sediment movement**
Fremantle	nil	-
Port Denison	nil	-
Jurien Bay	0 - 5000	south to north
Ocean Reef	5000	from offshore
Two Rocks	5000	south to north
Hillarys	5000 - 10,000	south to north
Esperance	25,000	southwest to northeast
Busselton	45,000	west to east
Bunbury	70,000	south to north
Peel Inlet	100,000 - 200,000	west to east

ESPERANCE BREAKWATER AND FISHING BOAT HARBOUR

The port of Esperance is protected by a 700 metre (length) breakwater (Figure 1c). Sand is transported along the breakwater from southwest to northeast. About 25,000 cubic metres of sand accumulates annually along the breakwater and around the end, and dredging is required to maintain the entrance. An extension to the breakwater could be required in the future, so that sand moving along the breakwater would be diverted into deeper water and then would not affect the port's shipping channels.

The sand accumulating along the breakwater restricts supply to the northeast part of the town beach. Experience over the past five years has shown that about 25,000 cubic metres of sand is required annually to replenish that beach, so, overall, there is a balance in the sediment budget.

PORT DENISON FISHING BOAT HARBOUR

Most boat harbours have some siltation of the harbour mouth, and hence require maintenance dredging. One exception is the fishing boat harbour at Port Denison (Figure 1d), which has been constructed in an area of virtually nil sediment transport. Some sediment may move northwards from Leander Point Reef. Also, river sediment from the Irwin River has been traced moving southwards, and, before the fishing boat harbour was constructed, accumulating in the lee of Leander Point Reef. However, eight years after construction, there is no evidence of sediment transport near the mouth, and very little change northwards.

FREMANTLE FISHING BOAT AND YACHT HARBOURS

The Fishing Boat Harbour was constructed in the early 1960's, then Success Harbour and most recently Challenger Harbour (still under construction). There is slight southwards movement of sediment, but this sediment is trapped by the north mole of the main harbour. No sediment transport problems have emerged in the 25 years since the Fishing Boat Harbour was constructed. Figure 1e shows the harbours.

SIESTA PARK GROYNE (west of Busselton)

Groynes are normally constructed where there is an erosion problem. The Siesta Park area has been eroding for a long time and this groyne (Figure 1f) was constructed to protect coastal houses and property. Accretion has occurred on the updrift side of the groyne, and erosion occurred on the downdrift side for about six times the length of the groyne as a direct result of the construction. Littoral drift is primarily one-way, from west to east, at Siesta Park : the erosion downdrift of the groyne is a once-off occurrence which has been superimposed on continuing natural erosion.

FLOREAT GROYNE (Perth)

At Floreat, sediment transport is primarily south to north, although in winter northwest storms reverse this and move sediment in a southerly direction. Consequently, the beach shifts from accretion on the north side of the groyne in winter to erosion in summer (Figure 2a).

OCEAN REEF BOAT LAUNCHING FACILITY

The first major coastal structure, in the area proposed for the M10 marine park, was the Ocean Reef boat launching facility. Built in 1978, the main breakwater was extended from the original groynes flanking the Beenyup

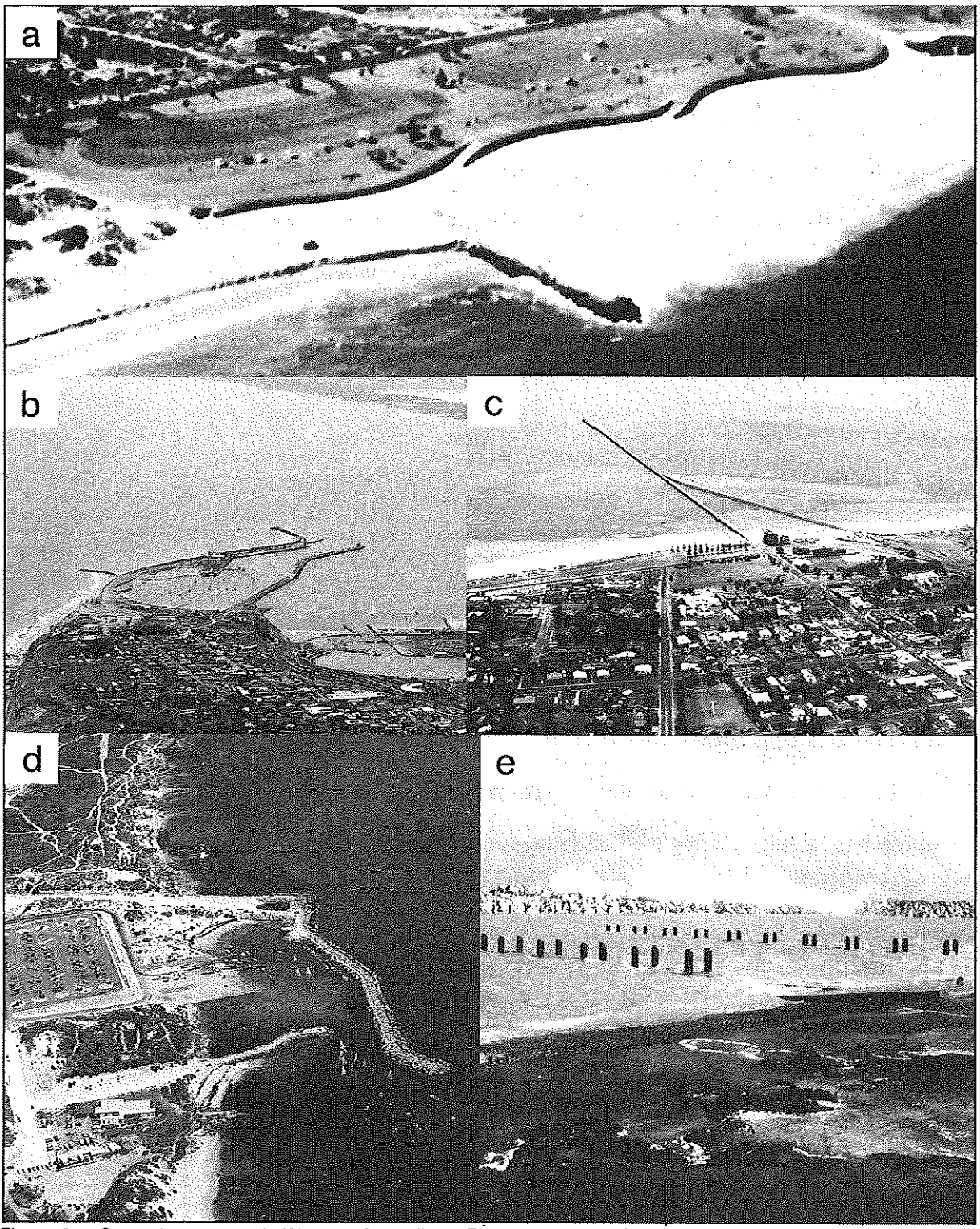

Figure 2. Coastal structures in Western Australia. a: Floreat groyne. b: Bunbury harbour. c: Busselton jetty. d: Ocean reef boat launching facility, 1985. e: Ocean reef breakwater being overtopped by waves during the storm of June 28, 1983. (Figure 2d courtesy of West Australian Newspapers Limited.)

Treatment Plant outfall pipe. Observations indicate very little longshore sediment transport on this part of the coast; in fact, there is some evidence of seabed scour, caused by wave reflection off the breakwaters, immediately seawards of the main breakwater.

In winter, however, sediment in the order of 5000 cubic metres per year is transported into the entrance of the boat launching facility under the influence of northwest and westerly storms. Means of dredging and maintaining clear passage to the harbour are being examined currently; however, as with any harbour or similar launching facility constructed on a sandy coast, maintenance of the entrance can be expected to be a continuing management requirement.

SORRENTO BEACH PROTECTION WORKS

In June 1980 and May 1981, there was severe beach erosion in front of the Sorrento Surf Lifesaving Club. Beach replenishment was carried out during those periods to protect the club facility, and if this had not been done it was possible that West Coast Highway would have been undermined during a storm in June 1981.

The situation was quite different, however, in March 1981. Erosion occurred at the south of Sorrento to the embankment of West Coast Highway, and the Shire had to place rock there as a temporary measure to dissipate wave action. Following observations and monitoring, the then Public Works Department, learned that there is significant seasonal fluctuation of sediment at Sorrento. This is abnormal for Perth metropolitan beaches and does not, for example, happen further south. Because of the alignment of the coast in a north-northwesterly direction from Sorrento to the tombolo at Mullaloo Point, there is about 100,000 cubic metres of sediment moving southwards in winter and

northwards in summer.

The first of the three Sorrento groynes was constructed in December 1982 (Figure 3a : photograph taken in April 1983), after about half the sand normally accumulated in the area had moved northwards under the influence of seasonal factors. This direction of sand transport reverses in winter, and in October 1983 (Figure 3b) the beach configuration was clearly changed. As normally experienced at Sorrento, seaweed and seagrass material accumulated in the southern area. The second groyne at Sorrento was built in October 1983, after sand had been trapped in the area from southerly transport in winter, and the middle groyne was built in December 1983. One consequence of these groynes was to shift the seasonal fluctuation of Sorrento beach to the area north of the northernmost groyne, where property was not in immediate danger (Figure 3c).

Observations in winter 1984 confirmed the sediment moving southwards (Figure 3d). At that time large seaweed and seagrass accumulations had disappeared from the southern part of the beach, but had built up in the area to the north of the groynes. In April 1985, the beach to about 100 metres north of the surf club was completely protected (Figure 3e), but further north of that there is an erosion problem in summer and sand accretion in winter. If this situation did not stabilise, another groyne would have been needed to the north of the existing three Sorrento groynes, at the location selected for the southern breakwater of the Hillarys Boat Harbour.

At Mullaloo Point, a tombolo has formed in the lee of the offshore reefs and Little Island. Since 1942, about 400,000 cubic metres of sand has accreted at the point : most of that sand would have moved from the south to give a net northerly movement of about 10,000 cubic metres of sand per year. Very little

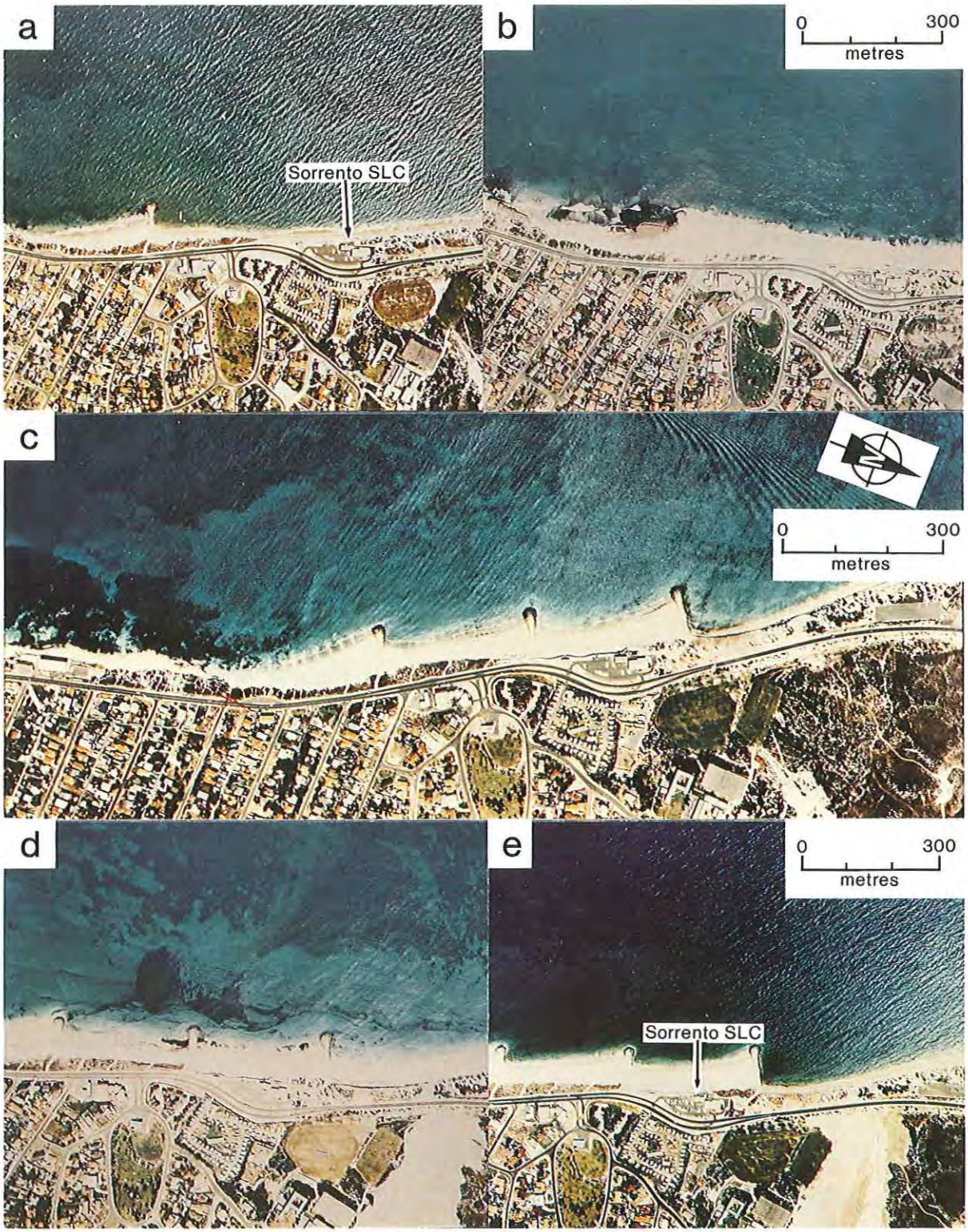

Figure 3. Sand movements on Sorrento beach. a: April 1983, with the first groyne recently completed. b: October 1983, showing large, southerly sand movement from winter. c: December 1983, after construction of third groyne. d: winter 1984, showing pattern resulting from southerly sand movements. e: April 1985, with beach to the north of groynes showing the summer erosion patterns.

change has occurred along the Sorrento shore.

HILLARYS BOAT HARBOUR

Government announced on 11 June 1985 that the Hillarys Boat Harbour project will proceed. Once the harbour has been constructed, the beach to the south will be completely stabilised. To the north of the harbour, seasonal fluctuations of sand and of the beach will continue, but will be compensated for by a large volume of sand placed on the beach during construction to nourish the area. It is predicted about 5000 - 10,000 cubic metres of sand will need to be bypassed annually to prevent the ultimate siltation of the Hillarys Boat Harbour entrance and recession of the shore to the north (Public Works Department, 1984).

One of the main reasons for siting the harbour at Hillarys rather than Ocean Reef is the difference in wave climates between the two locations. Sea conditions are often considerably rougher at Ocean Reef, and for a boat seeking refuge under deteriorating weather the approaches to Ocean Reef are far more exposed and dangerous than for Hillarys. For example, during the storm of June 28, 1983, waves at Ocean Reef were in the order of 5 - 6 metres height. The breakwater was overtopped by waves, and spray was estimated at 6 metres about the breakwater parapet. At Hillarys during the same storm, however, the largest waves were less than 2.5 metres height.

ACKNOWLEDGEMENT

I thank West Australian Newspapers Ltd. for permission to use the photographs reproduced as Figures 1e, 2b, c and d.

REFERENCE

Public Works Department (1984). Environmental Review and Management Program for Sorrento Boat Harbour. (Report to W.A. Public Works Department by Scott & Furphy Engineers Pty. Ltd. and LeProvost, Semeniuk & Chalmer). Volume I : Report, 186 pp. Volume II : Technical Appendices, 148 pp.

Thirdly, erosion of limestone intertidal platforms and headlands is hastened by recreational users who inadvertently or intentionally break pieces of limestone or excavate soft aeolianite. Fourthly, although much has been done to control unrestricted tracking through sand dunes, there are still areas where tracking is uncontrolled and blowouts may be initiated. Recreational pressures have also influenced beach cleanliness, so that both residents and retailers perceive a decline in the cleanliness of beaches in the coastal reserves.

INTRODUCTION

The Study

In February 1985, arrangements were made to enable Honours students from the Department of Geography to undertake studies of the coastal reserve bounded by Trigg Island and Sorrento Beach, Perth, Western Australia, together with the nearshore waters. The City of Stirling Coastal Report (City of Stirling, 1984) recommended, amongst other things, that a more detailed examination be undertaken of the biological status of the nearshore reefs and rock platforms, together with a more detailed examination of nearshore morphology, water circulation and sediment movements (City of Stirling, 1984). The City of Stirling and the Department of Conservation and Environment also wished to acquire more information on current beach use, to provide a basis for the assessment of future use of the coastal complex for recreational, educational, scientific and conservation purposes.

The students' research programme was designed to provide them with practical experience of current practices and problems encountered in coastal planning and management. The project began with the proposition that existing procedures for resource appraisal on the open-ocean coast are essentially inventories, static descriptions of the biophysical environment, that are set against a demand for conservation and protection. The students were asked to

consider that, perhaps, it is the unfettered, natural variability of the coastal ecosystem that we ought to conserve and the diversity of water-dependent, commercial and recreational activities that we need to protect. Hence the project has focussed on recreational activity in the coastal reserve and its environmental implications.

Definition of the Study Area

The study area includes the coastal reserves of the Stirling and Wanneroo municipalities from the northern side of Trigg Island to Sorrento Beach. Its eastern boundary is West Coast Highway, while the western boundary extends approximately 100 metres offshore to the edge of a series of rock platforms characteristic of this section of coastline. Hence, the coastal reserves include the nearshore environment of the beach system and land immediately adjacent to it, which is the shore boundary of the proposed M10 marine park (EPA, 1983). This coastal strip includes about 1.5% of the area of the proposed M10 marine park; however, that 1.5% supports about 80 - 90% of the activities of the beach going population using the park area, and is therefore especially important.

Context of the Study

Coastal management in Western Australia has been, until recently, the responsibility of local government authorities acting under advice, or working co-operatively, with the State government authorities responsible for public works and town planning. As a result of this informality, coastal management has occurred on an ad-hoc basis with adjacent local government authorities adopting, in some instances, conflicting shore protection policies (City of Stirling, 1984). Declaration of the Environmental Protection Act (1971),

formation of the Department of Conservation and Environment, and increased public interest in the coastal zone, has led to a more co-ordinated approach to coastal planning and management (Sansom and Hamilton, 1981), increased pressure for the declaration of an environmental protection policy for the coastal zone (Environmental Protection Authority, 1977), generated compilation of non-statutory coastal management plans as working plans for local government authorities (for example, Chape and Sansom, 1983; Chalmer and Davies, 1983; O'Brien et al, 1984; City of Stirling, 1984; Woods, 1984 a,b), and has led to State government declaration of its position regarding coastal planning and management (Western Australian Government, 1983).

Despite the burgeoning interest in coastal management and planning in Western Australia, there have been few systematic studies of recreational use of coastal reserves in the metropolitan area of Perth. Prior to the mid-1970's, planning proceeded in an ad-hoc manner, largely in response to government perceived pressures exerted by small interest groups with political influence. Government now plays a wider role, but coastal management continues to be organised on a piecemeal, project by project basis. Decision-making presently rests with governmental agencies which have little interest in the recreational use of marine resources (for example, see the arguments of the Main Roads Department in MRPA Technical Working Group, 1985). There does not appear to have been any general questioning of the nature and variety of recreational activities within the coastal reserves, of the space those activities demand, of the type of impact they might have on the coastal reserves, or of the economics underlying coastal recreation. This is particularly true of the M10 area, where the aims of establishing a marine reserve must necessarily be integrated with recreational and commercial usage of that reserve, if the

viability of the reserve is to be maintained.

Two surveys of beach recreation have been reported from studies of the rocky coast between Trigg and Sorrento within the M10 area. These have concentrated on the sociological attributes of the local residental population. One study was conducted by Keating (1983) for beaches between Trigg Island and Sorrento, where data were collected from local residents on a variety of attributes including their use of the beach. It is likely that there is a discrepancy between what people say they do and how they actually behave. Hence, a survey of the resident population, such as that of Keating (1983) may define the potential use of the beach, rather than the actual use of it. The second survey reported by the City of Stirling (1984) endeavoured to establish characteristics of beach users by interviewing people using the beach. A survey of this nature has some problems, not the least being determining whom to interview, and when to interview, to obtain a representative sample of the population of actual beach users.

The present study adopts a different approach to examining the actual use of beaches between Trigg Island and Sorrento. By observing the people using this stretch of coastline, it is hoped to establish what activities are being undertaken at what times and by how many people. Coupled with the data collected on the geomorphology, water circulation patterns and biota, it is hoped that some conclusions can be drawn on the factors that govern use of rocky coastlines. The specific aims of this paper are to :

(i) establish the temporal and spatial patterns of beach usage for the study area during daylight hours;

(ii) identify areas of intense recreational use and areas that are not frequently used;

(iii) report data collected by Keating (1983) to ascertain the attitudes of local residents to the development and use of the coastal reserve;

(iv) extract relevant data from an unpublished shopping centre survey conducted by Keating, in 1982, to establish the attitudes of local retailers to use and development of the coastal reserve, and

(v) report the results of an aerial-photographic survey of beach use between Trigg and Ocean Reef conducted by the Department of Conservation and Environment on 3 March, 1985.

THE SURVEYS

Beach Use between Trigg Island and Ocean Reef: 3 March, 1985

An aerial survey to examine the pattern of coastal utilisation from Trigg Island to Ocean Reef was conducted by the Department of Conservation and Environment as part of the M10 marine park study. The survey was undertaken on Sunday, 3 March, 1985 (the middle day of a long weekend), which was chosen as a day indicative of summer use. Aerial photographs were taken in three survey runs, 0800, 1200 and 1600 hours (Department of Lands and Surveys, photographic job 850018, WA2284(C), scale 1:3000, runs 1, 2 and 3, photographs 5001-5074; 5096-5168; 5009-5077) to enable estimation of both spatial and temporal beach use characteristics.

The coastline from Trigg Island to the northern side of Ocean Reef Boat Harbour was divided into sections of 250 m to facilitate interpretation from the aerial photographs. Each 250 m section included the coastal reserve, any adjacent car parks and public open space. The numbers of people, boat trailers and vehicles located in each 250 m section were counted from the aerial photographs. Data from each survey was compiled in tables. Histograms were drawn to show the spatial variations in the total number of people in each

section for 0800, 1200 and 1600 hours. These have been reported by Elliott et al (1985). A composite histogram showing the total number of people using each section over the three periods was also compiled (Figure 1).

Beach Use between Trigg Island and Sorrento Beach : 6 and 10 March, 1985

Observations were made to examine spatial and temporal variations in beach use, and to establish areas of intensive use, on two days : Wednesday, 6 March and Sunday, 10 March. The surveys were conducted on these two days to examine variation between midweek and weekend beach use patterns. The study area was divided into eleven embayments (Figure 2), defined as areas of beach enclosed between two headlands. Each embayment was surveyed from vantage points along the cycle way adjacent to West Coast Highway.

Data collected from the ground surveys were compiled in tables to show the number of people undertaking the activities in each section of coastline over the study period. To simplify further analysis, activities were grouped into five categories relating to reef, water, beach, headland and the reserve (Table 1).

Spatial variation of beach use along the coastline is illustrated by a series of pie charts for three time periods : 0800 hrs, 1200 hrs and 1600 hrs (Figures 8-13). The size of each pie chart varies depending upon the number of people at each embayment. The five categories mentioned above are used to indicate the spatial variations in the distribution of activities.

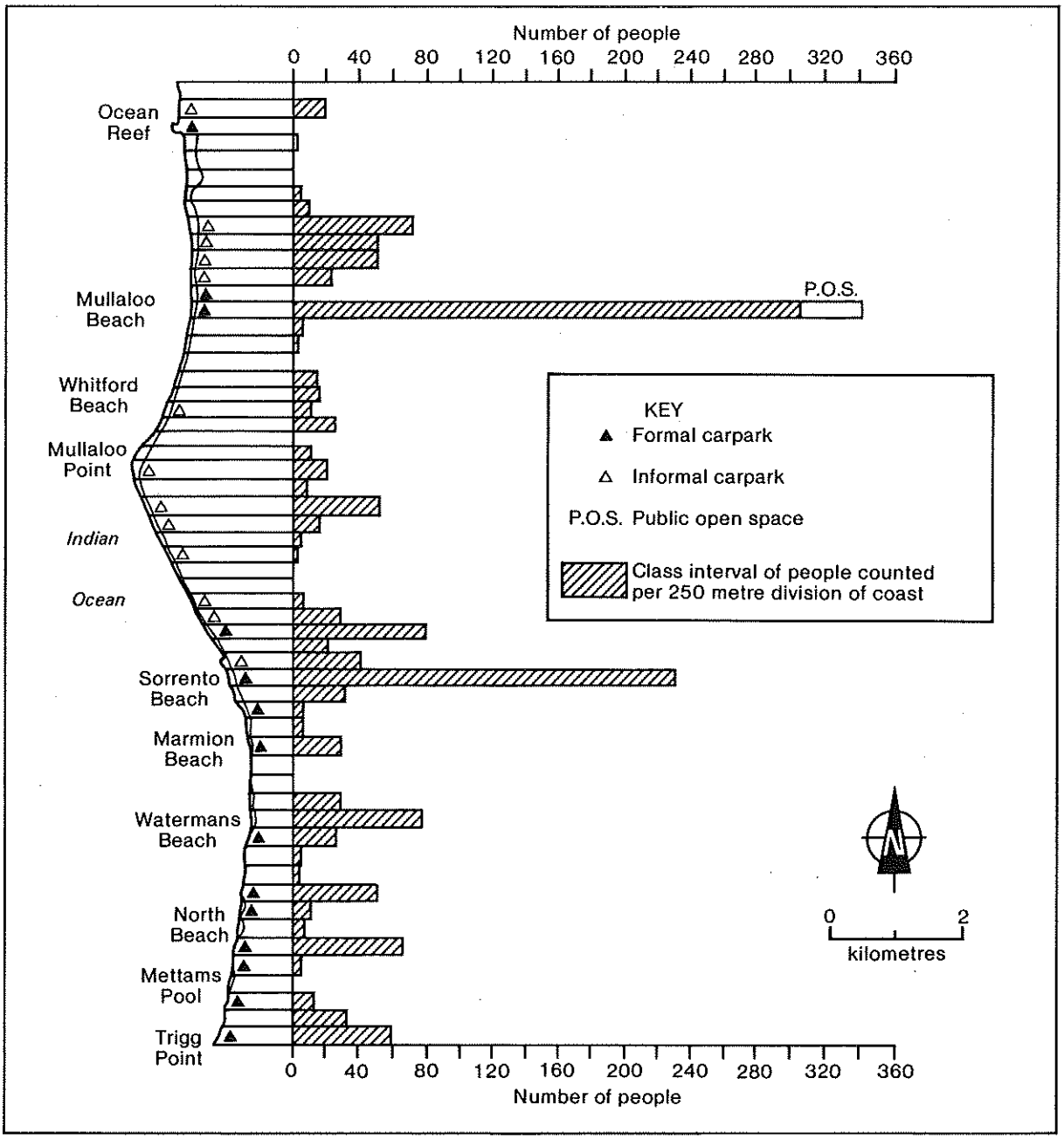

Figure 1. Distribution of people using the coastal reserve. Numbers were counted from photographic prints taken during aerial surveys flown at 0800, 1200 and 1600 hours on 3 March, 1985.

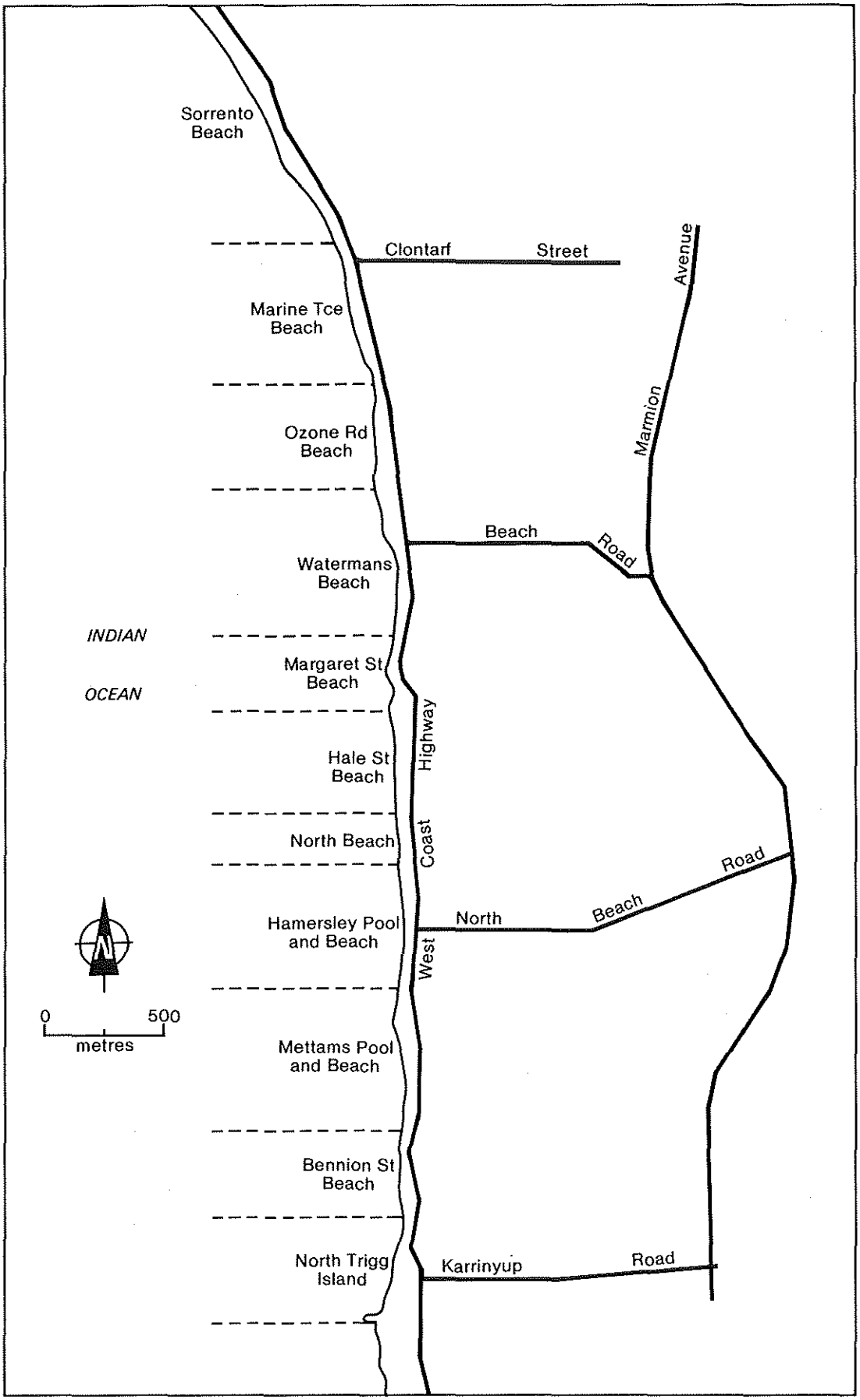

Figure 2. Division of the coast into nominated embayments, for the purpose of the recreation surveys on 6 and 10 March, 1985.

TABLE 1 : types of recreational activities observed between Trigg Island and Sorrento during surveys on 6 and 10 March, 1985

Water related activities	Reef related activities	Beach related activities	Headland related activities	Reserve related activities
launching boats	snorkelling	line fishing	line fishing	picnicking
yachting	reef harvesting	walking	walking on rocks	using playground
surf skiing	education	jogging	education	walking
windsurfing	scuba diving	exercising dogs		jogging
wading		sunbathing		cycling
swimming		beachcombing		viewing scenery
board surfing		sporting activities		

Attitudes of Local Residents and Retailers to the Study Area

Data collected by Keating in 1982 and 1983 were used to establish attitudes to the coastal reserve of local residents (Keating, 1983) and retailers (unpublished data) adjacent to the study area. Responses to selected questions have been used as indicators of the attitudes of both groups and to establish patterns of beach use by local residents.

SURVEY RESULTS

Results from the aerial survey conducted on 3 March, 1985 indicate the population dimensions of the discrete clusters of people using beaches between Trigg Island and Ocean Reef. Several important recreational focus points can be identified from this survey. Primary focus points are located at Mettams Pool, Mettams Beach, Sorrento Beach and Mullaloo Beach (Figure 1). Secondary focus points are located at Watermans Beach and Mullaloo Point. These findings are supported by the ground survey data collected on 6 and 10 March, 1985. On these two days, four recreational focus points were identified

between Trigg Island and Sorrento Beach. These were immediately north of Trigg Island, Mettams Pool and Mettams Beach, Watermans Beach and Sorrento Beach. The range of activities found at these four beaches is wide. Areas that show consistently low levels of recreational use were also identified. They include the beaches opposite Hale Street, Margaret Street and Ozone Road.

The observed variations in numbers of people and range of activities occurring in the study area can be explained partly by the availability of facilities (including access and parking) and partly by the physical characteristics of each embayment (including water quality and beach cleanliness, as well as safety factors). The availability of amenities was determined by historical precedent, through development of the coastal communities as small, holiday settlements (Newell and Weller, 1980). Environmental factors and supporting facilities which influence the decision of people to select a particular area for recreation are listed (Table 2).

All three surveys indicate that, although zoning is not formalised, there is potential for the encouragement of informal zoning through the provision of appropriate facilities, which should enhance as well as support existing recreational use of the major recreational focus points.

TABLE 2 : requirements for various types of water-based utilisation of the coastal reserve

(P) : primary requirements and industries considered necessary for the particular recreational practice.
(S) : secondary requirements support the recreational activity, and are needed in the general area.

Activity	Sea requirements	Onshore support requirements/industries
Swimming	Clean water, sufficient water circulation and flushing; no dogs or sewage	Car and cycle parking reasonably close by (P)
		Access (P)
	Calm protected water of reasonable depths. (Open water can be experienced at South Trigg or Sorrento)	Changerooms, toilets, showers (P)
		Areas of sandy beaches (P)
		Surf life-saving clubs (S)
	Presence of sandy-bottom and absence of sharp, dangerous rocks	Suitable retail support in nearby shopping centres (S)
	Absence of strong or permanent rips	
	Infrequent accumulation of seaweed	
	Freedom from boats, boards, windsurfers, surf-skis and line fishing	
Wading	Water cleanliness for swimming (above)	
	Calm shallow water	
Board surfing/ surf skiing	Waves of suitable height, type and frequency	Parking facilities for cars or for bicycles with board trailers (P)
	Moderately deep water	
	Rips useful for 'lift' past breaker line	Suitable retail support in nearby shopping centres (S)
	Water for surfing should be free from rocks, although shoreline doesn't necessarily need to be rock-free	

TABLE 2 : requirements for various types of water-based utilisation of coastal reserve (continued)

Activity	Sea requirements	Onshore support requirements/industries	
Windsurfing	Freedom from shallow water over rock platforms	Carpark facilities in immediate vicinity	(P)
	Uninterrupted wind, viz., not in immediate lee of headland	Suitable retail support in nearby shopping centres	(S)
Snorkelling (recreational)	Scenic underwater areas, such as those provided by rock platforms and even submerged reef	Car and cycle parking reasonably close by	(P)
		Suitable retail support in nearby shopping centres	(S)
	Freedom from power boats, and skis		
	Clear water for visibility		
	Absence of strong wave activity		
Spearfishing (beginners)	Supply of diverse fish (sustained)	Carpark facilities	(P)
		Fish cleaning facilities	(S)
	Absence of strong wave activity and underwater currents	Spearfishing equipment shop	(S)
	Freedom from power boats	Medical back-up	(S)
	Absence of other recreation users		
Scuba diving	All of above snorkelling requirements	Carpark requirements	(P)
	Deeper water	Scuba equipment and tank filling shops	(S)
		Medical back-up	(S)

TABLE 2 : requirements for various types of water-based utilisation of coastal reserve (continued)

Activity	Sea requirements	Onshore support requirements/industries	
Reef harvesting	Intertidal rock platforms		
	No rips or strong shedding		
	Adequate and sustained supply of biota		
Line fishing	Supply of fish (sustained)	Car and cycle parking	(P)
	Freedom from swimmers and boats	Bait and tackle shop	(S)
	No floating or submerged litter	Fish cleaning facilities	(S)
	Place from which to cast-off		
Boat launching	Access not too steep, either onshore or in water	Parking facilities for cars and trailers	(P)
	Freedom from shallow submerged reefs	Waiting facilities near the boat ramp	(P)
	Away from areas of turbulence and/or strong rips	Boat fuel supply	(S)
	Preferably in lee of headland		
	Preferably away from areas of frequent seaweed accumulation and sand drift	Suitable retail support in nearby shopping centres	(S)
	Away from other recreational activities		

The Range of Recreational Activities Occurring Between Trigg Island and Sorrento Beach

There is great diversity in activities undertaken in the study area (Table 1). On Wednesday 6, the largest range of activities occurred at Watermans Beach, where twelve different activities were recorded. Eleven different activities were recorded at Sorrento Beach. Hale Street Beach showed the least diverse range of activities with only four different activities. On Sunday 10, the greatest range of activities was again recorded at Watermans Beach. The embayment north of Trigg Island, Mettams Pool and Beach, and Marine Terrace all recorded thirteen different activities, while the beach at Margaret Street had the least varied beach use pattern, with only seven different activities recorded. Overall, the embayment north of Trigg Island, Mettams Pool and Beach, and Watermans Beach showed the greatest range of activities over the study period. The beach at Margaret Street showed the lowest diversity of beach use (Table 3).

TABLE 3 : the number of different activities recorded at each beach over two study periods, Wednesday, 6 March and Sunday, 10 March

Beach	Number of different activities recorded		Total number of different activities
	Wednesday	Sunday	
Trigg Island	10	13	15
Bennion Street	10	11	14
Mettams	10	13	15
Hamersley	7	8	10
North Beach	7	9	11
Hale Street	4	10	10
Margaret Street	5	7	8
Watermans	12	14	15
Ozone Road	6	9	10
Sorrento	11	12	13

Temporal Variation in Beach Use Between Trigg Island and Sorrento Beach

The variation in the total number of beach users over the two study days between 0600 hours and 1800 hours is illustrated (Figure 3). There were four discernable peaks in beach use Wednesday, 6 March 1985, at 0630, 1000, 1230 hours and 1630 hours. The peak at 0630 hours was due primarily to early morning exercisers and fishermen. Peaks at 1000 hours and 1230 hours were due to school children using the beach and nearshore areas for educational purposes. At 1630 hours, numbers along the coast were increased by people board surfing, wind surfing, and by school children using the coastal area for recreation after school had finished. The maximum number of people recorded in the study area was 337, at 1000 hours.

The data for Sunday, 10 March, 1985 are substantially different from those recorded during the midweek survey. The weekend observations indicated only two peaks, at 1030 hours and 1530 hours. On both occasions family type activities, and water based activities such as swimming and surfing, made up significant portions of the total number of people using the rocky coastline. At 1030 hours, surf club activities at Sorrento also contributed to the large number of people using the study area.

Broad-scale variations in total number of people using the coastline do not reflect the temporal patterns of beach use in individual embayments. To illustrate the variations between embayments, the total numbers of people at Trigg Island north, Mettams Pool, Watermans Beach and Sorrento are now considered in more detail.

There were three peaks in beach-user numbers at Trigg Island on Wednesday, 6 March (Figure 4), at 0830, 1130 and 1430 hours. The maximum number of

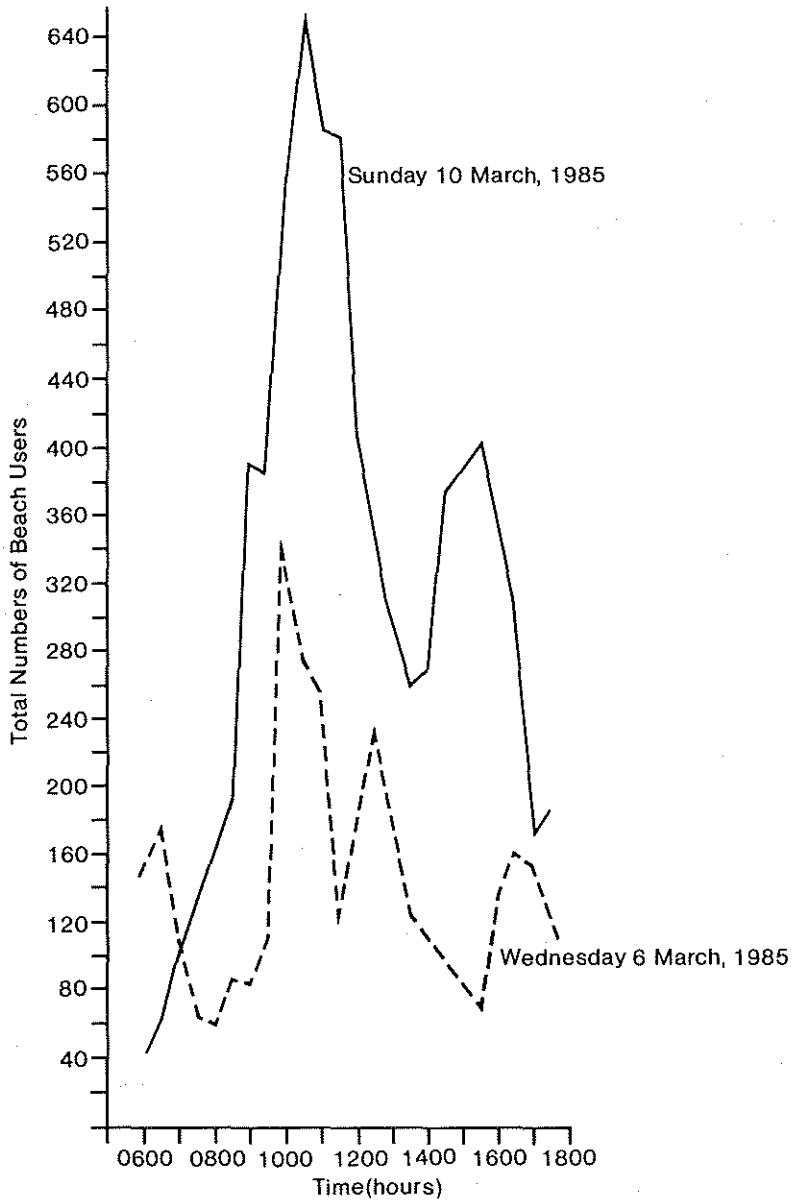

Figure 3. Variations in the total number of people using beaches in the study area on 6 and 10 March, 1985.

people at Trigg Island on the day was 19, at 1130 hours. On Sunday, 10 March, peaks occurred at 0930, 1030 and 1430 hours. The maximum number of people at Trigg Island was 73. The dominant activities occurring at this embayment over the study period were line fishing, passive beach activities such as walking and sunbathing. Families also used the Clarko Reserve, located between the parking area and the West Coast Highway

Data collected at Mettams Beach are shown (Figure 5). On Wednesday there were three peaks in total numbers of beach users, one at 0700 hours, one at 1300 hours and a small peak at 1630 hours. The maximum number of people recorded at this beach was 117, at 1350 hours. On Sunday, however, there were only two peaks in total numbers. These occured at 1130 hours and 1500 hours. The maximum number of people was 90 at 1130 hours.

Mettams Pool was a popular swimming area on both days. This area also proved attractive for school groups on Wednesday, 6 March 1985. Passive beach activities such as sunbathing and walking along the beach dominated beach use over the study period.

Watermans Beach had a more complex pattern of temporal variation (Figure 6). On Wednesday there were four peaks in beach-users, at 0630, 0930, 1430 hours and 1730 hours. The maximum number of people using Watermans Beach (57) was at 1730 hours. Data collected on Sunday showed only two peaks, one at 1230 hours and one at 1630 hours. The maximum number of people using Watermans Beach on Sunday was 84 at 1230 hours. Watermans Beach proved to be popular for surfing and swimming on both days. The beach area was used by families with young children on Sunday, and, to a lesser extent, on Wednesday. The grassed reserve area and playground also was popular for families. School

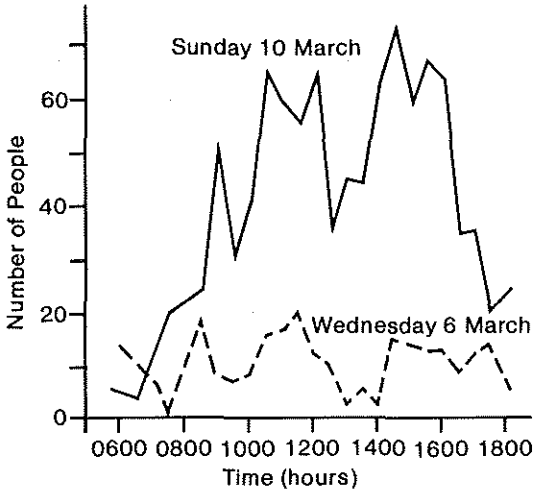

Figure 4. Variation in the number of people using Trigg Island north beach on 6 and 10 March, 1985.

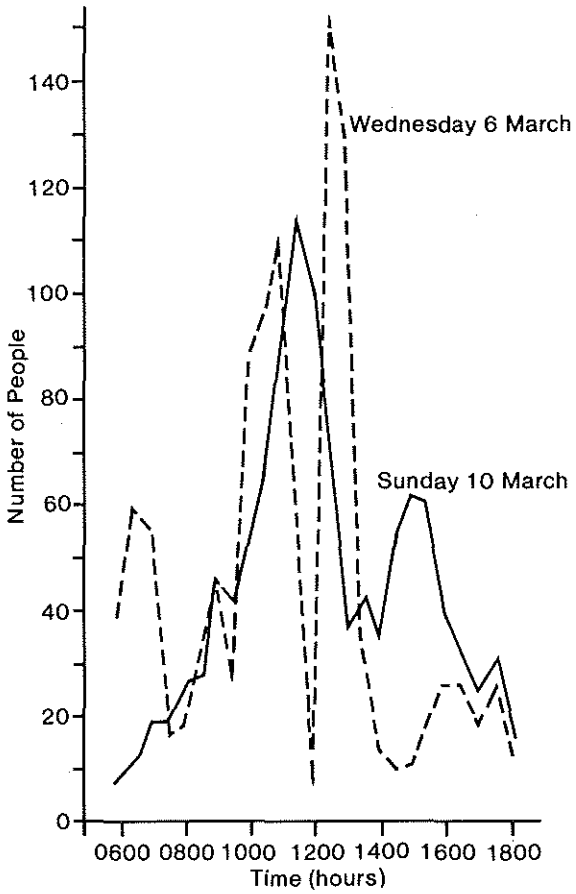

Figure 5. Variation in the number of people using Mettams beach on 6 and 10 March, 1985.

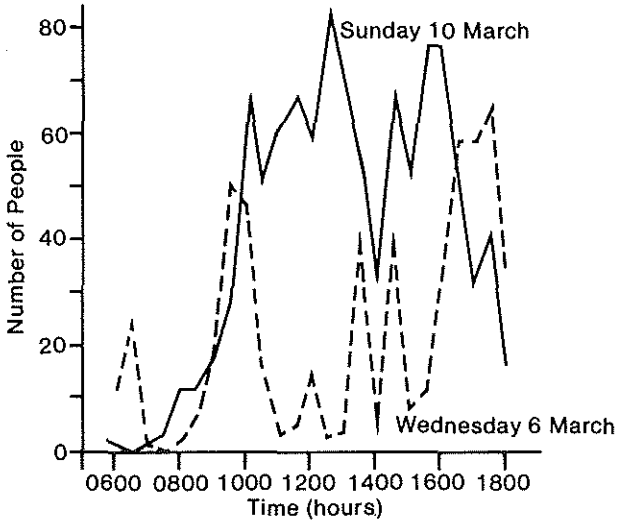

Figure 6. Variation in the number of people using Waterman beach on 6 and 10 March, 1985.

groups used the area for sports, including cricket and volleyball.

Sorrento Beach showed a different pattern of temporal variation in use (Figure 7). There were four peaks on Wednesday at 0630, 1030, 1400 and 1630 hours, with a maximum of 76 at 1400 hours. On Sunday there was only one peak. This occurred at 1030 hours when 243 people were recorded on Sorrento Beach. Sorrento Beach was popular for water activities such as swimming and wading. The three Sorrento groynes were popular for line fishing. Passive recreation such as sunbathing and exercising also dominated beach use. School sporting activities were observed on Wednesday, 6 March, and surf life saving club activities attracted many people to the area on Sunday, 10 March 1985.

Spatial Variation in Beach Use between Trigg Island and Sorrento Beach

The proportion of people undertaking activities on the beach, in the water, on headlands, on reefs and in the reserve have been determined for 0800, 1200 and 1600 hours on both days (Figures 8 - 13).

Patterns of beach use are spatially complex. Generally however, numbers of people were fairly evenly distributed along the coastline at 0800 hours on both days (Figures 8 and 9). By 1200 hours on both days the range of activities increased and the distribution of people became more concentrated at several beaches. On Wednesday the largest crowd was at Bennion Street. This concentration was due to school children using the rock platform for biological studies. On Sunday, people were concentrated at Trigg Island north, Mettams Beach, Watermans Beach and Sorrento Beach. The concentration of people at Sorrento Beach, at this time, was due primarily to surf club activities. Surfing and windsurfing were the dominant activities at Watermans Beach at 1200 hours on Sunday, whereas Mettams Pool was dominated by swimmers and Trigg

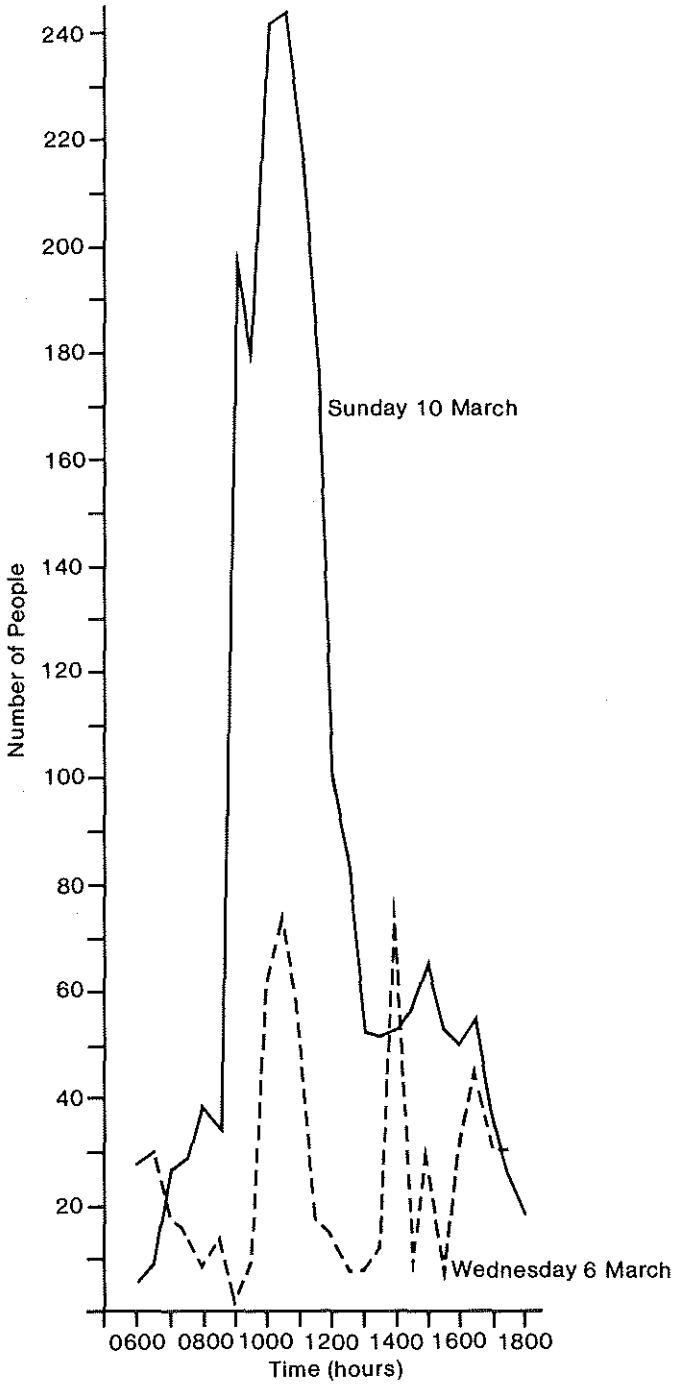

Figure 7. Variation in the number of people using Sorrento beach on 6 and 10 March, 1985.

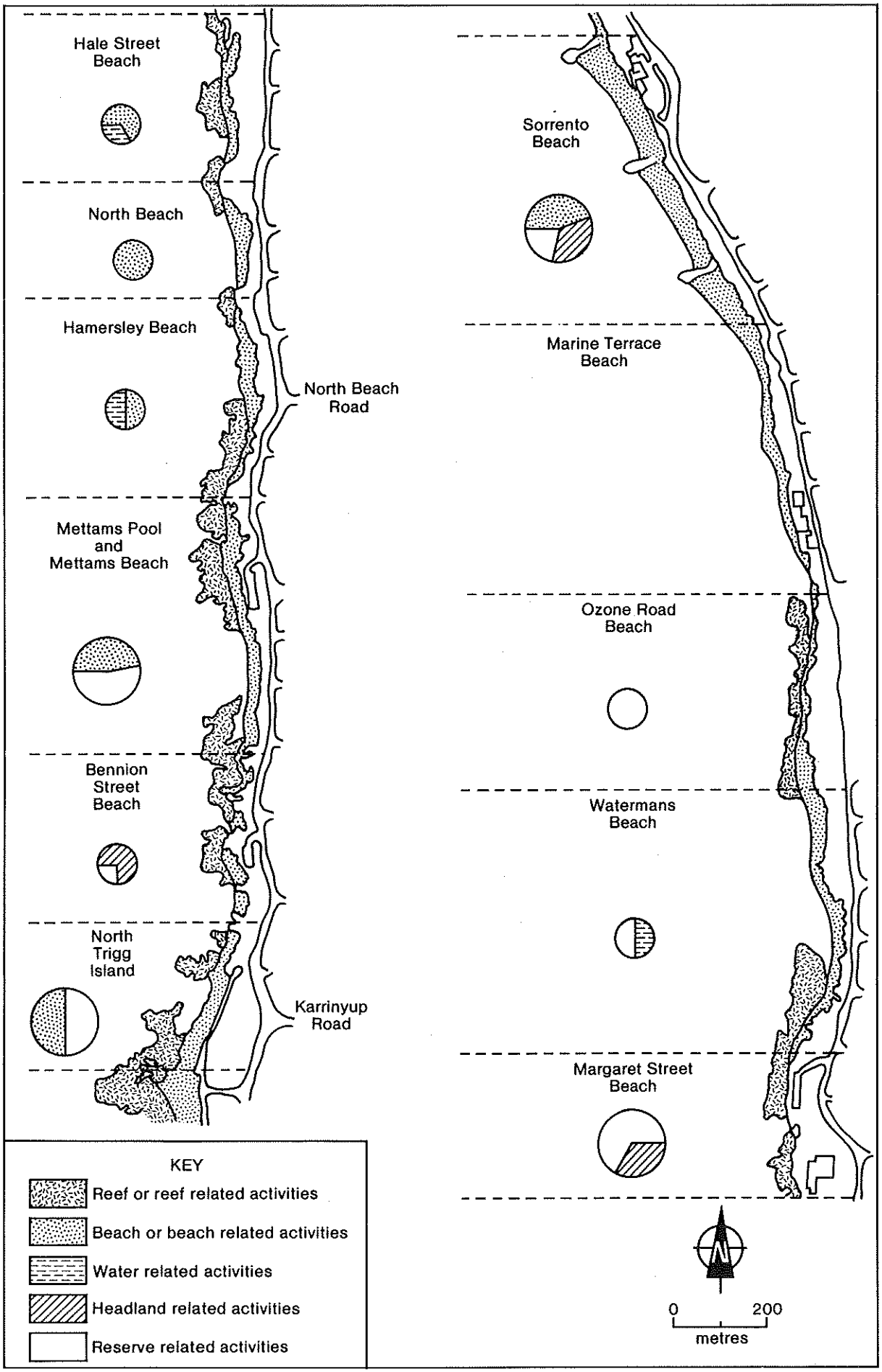

Figure 8. Variations in beach user activities at 0800 hours on Wednesday, 6 March, 1985.

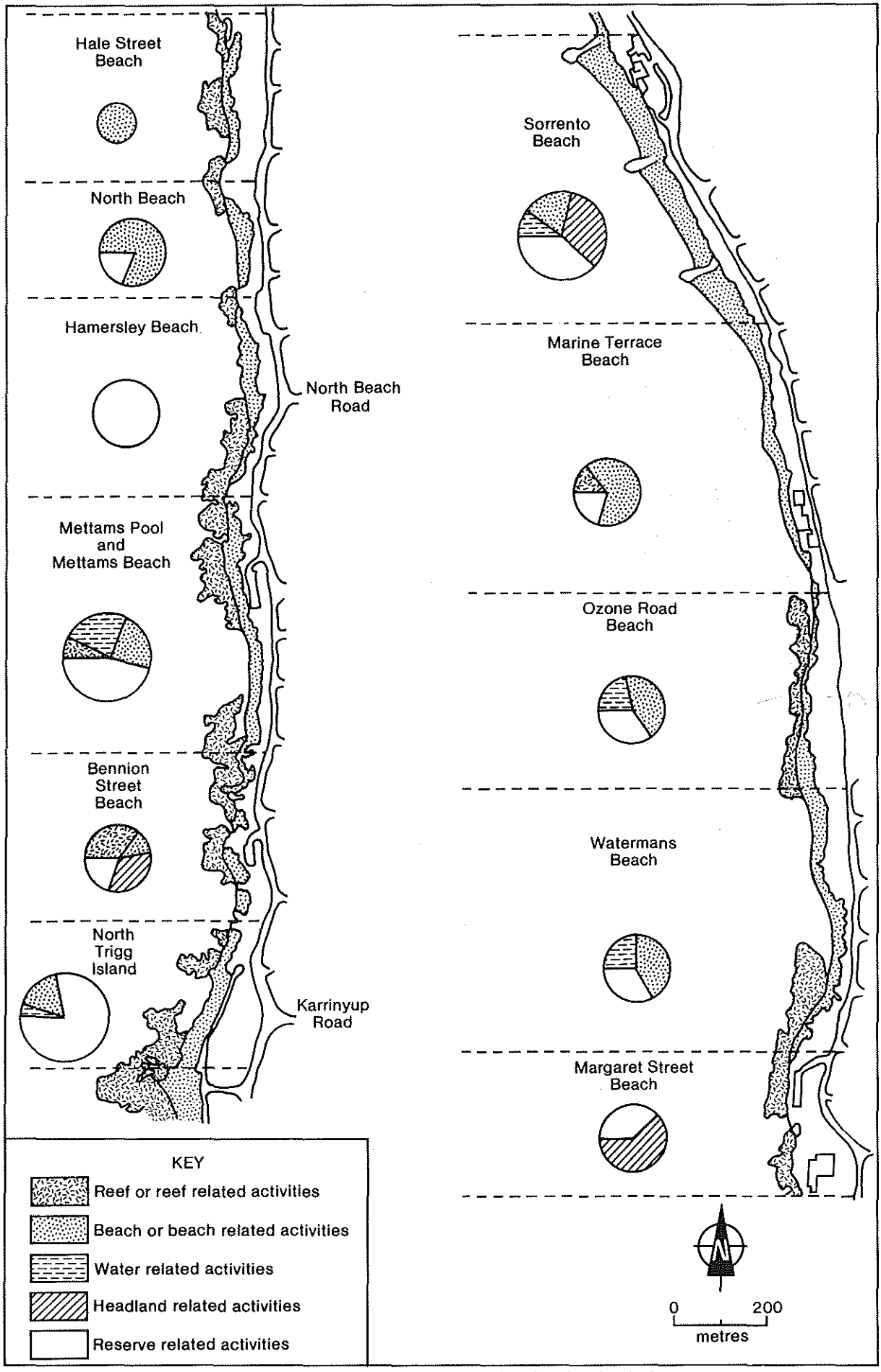

Figure 9. Variations in beach user activities at 0800 hours on Sunday, 10 March, 1985.

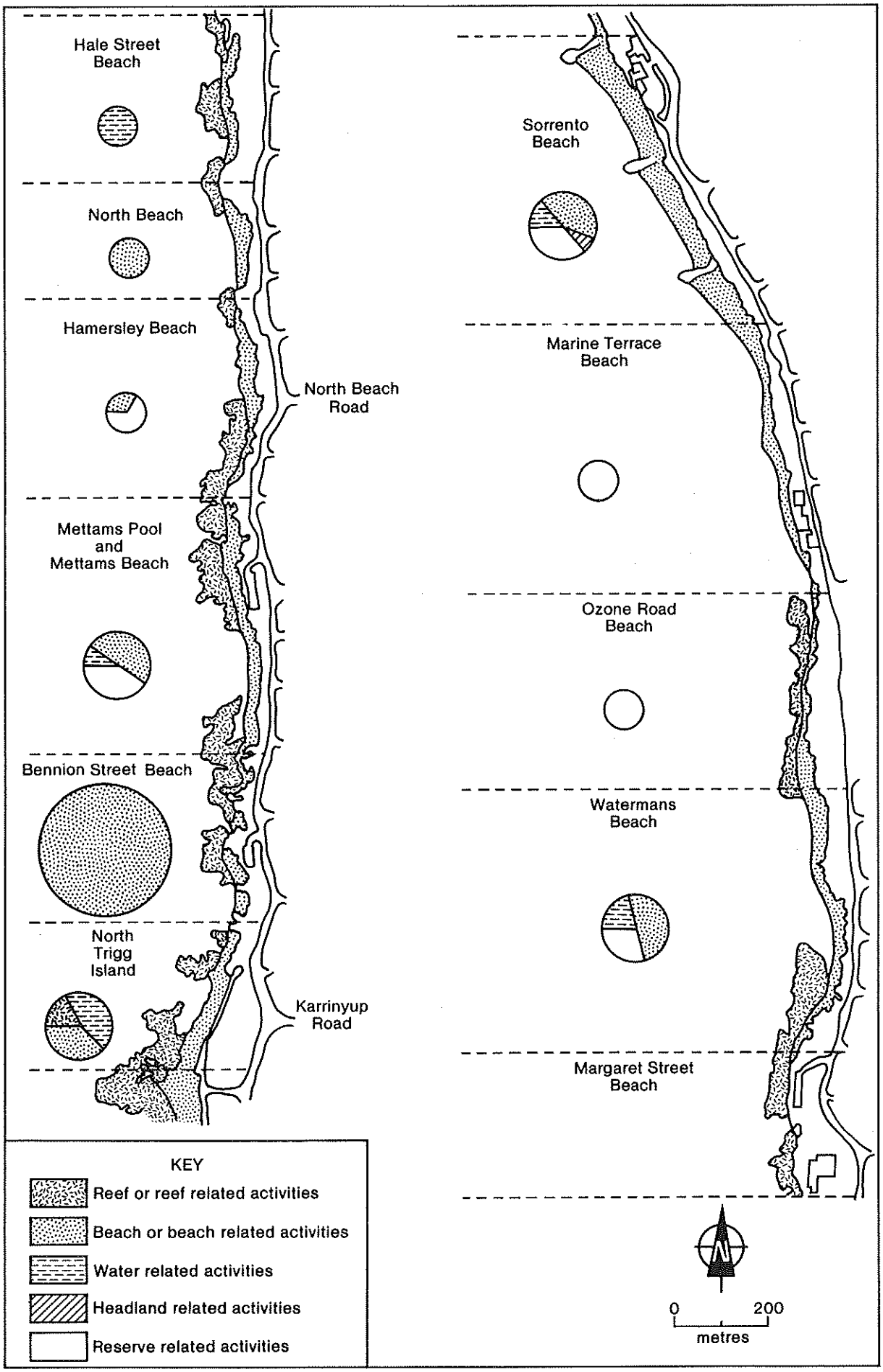

Figure 10. Variations in beach user activities at 1200 hours on Wednesday, 6 March, 1985.

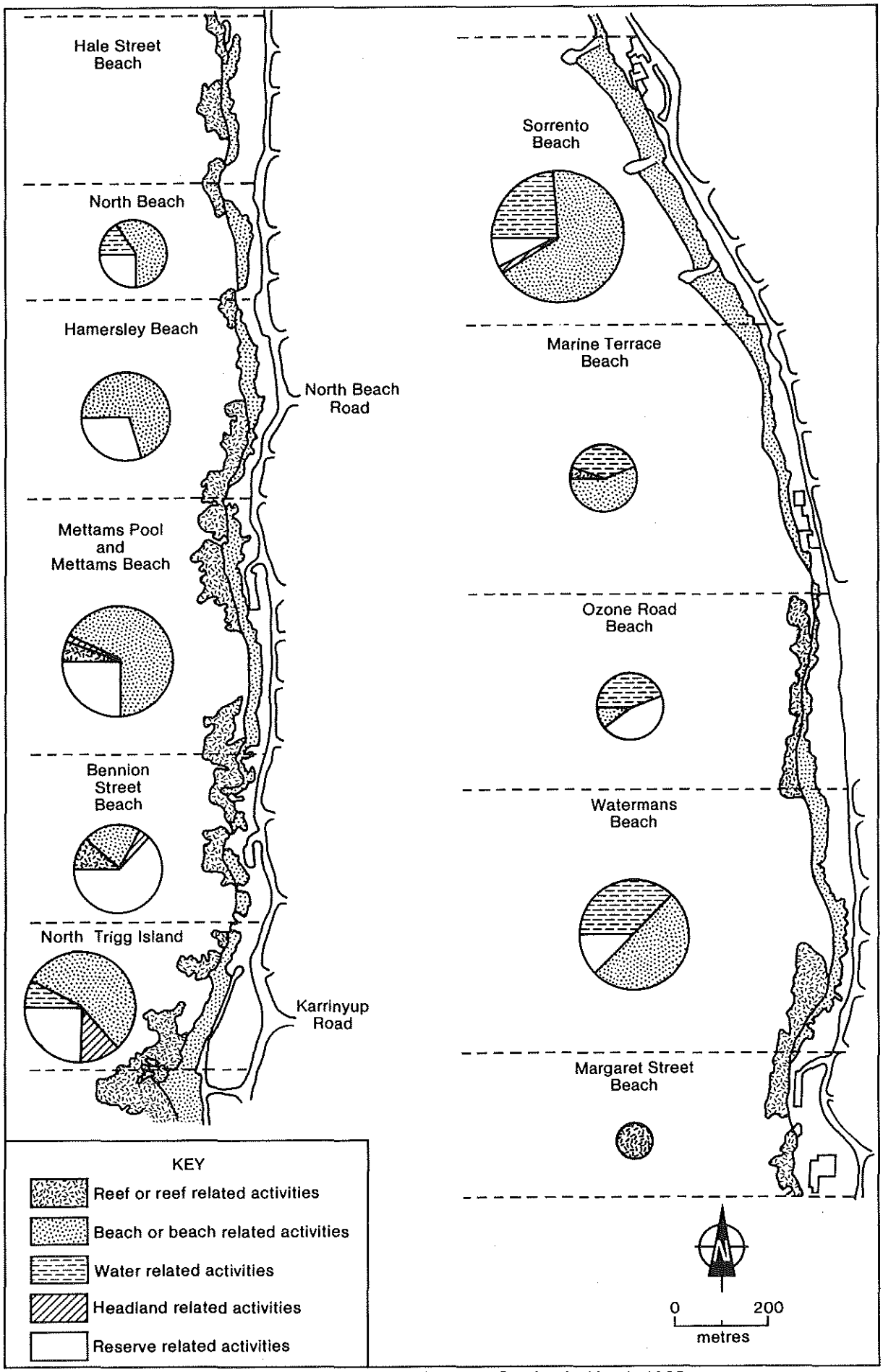

Figure 11. Variations in beach user activities at 1200 hours on Sunday 10 March, 1985.

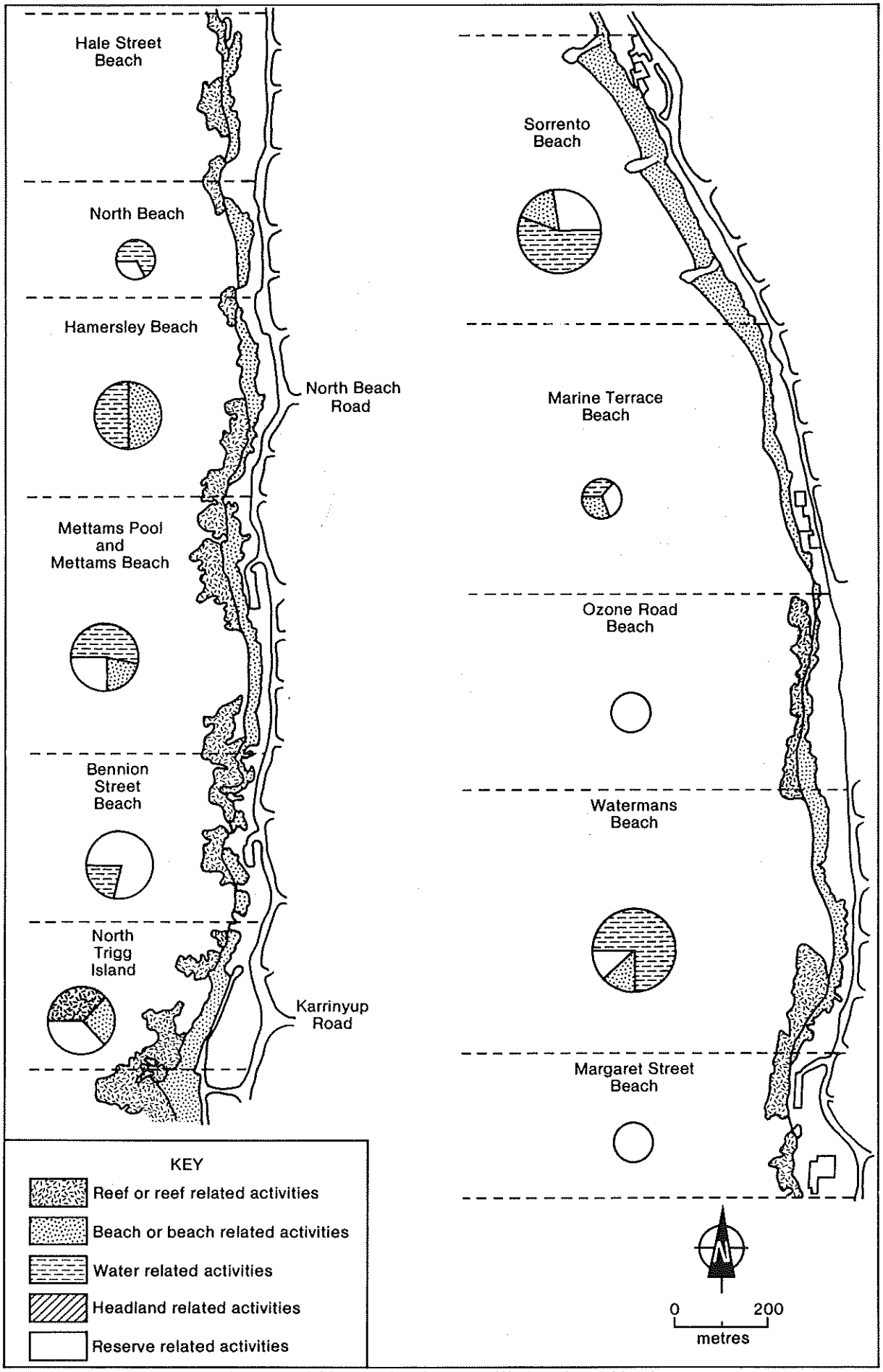

Figure 12. Variations in beach user activities at 1600 hours on Wednesday, 6 March, 1985.

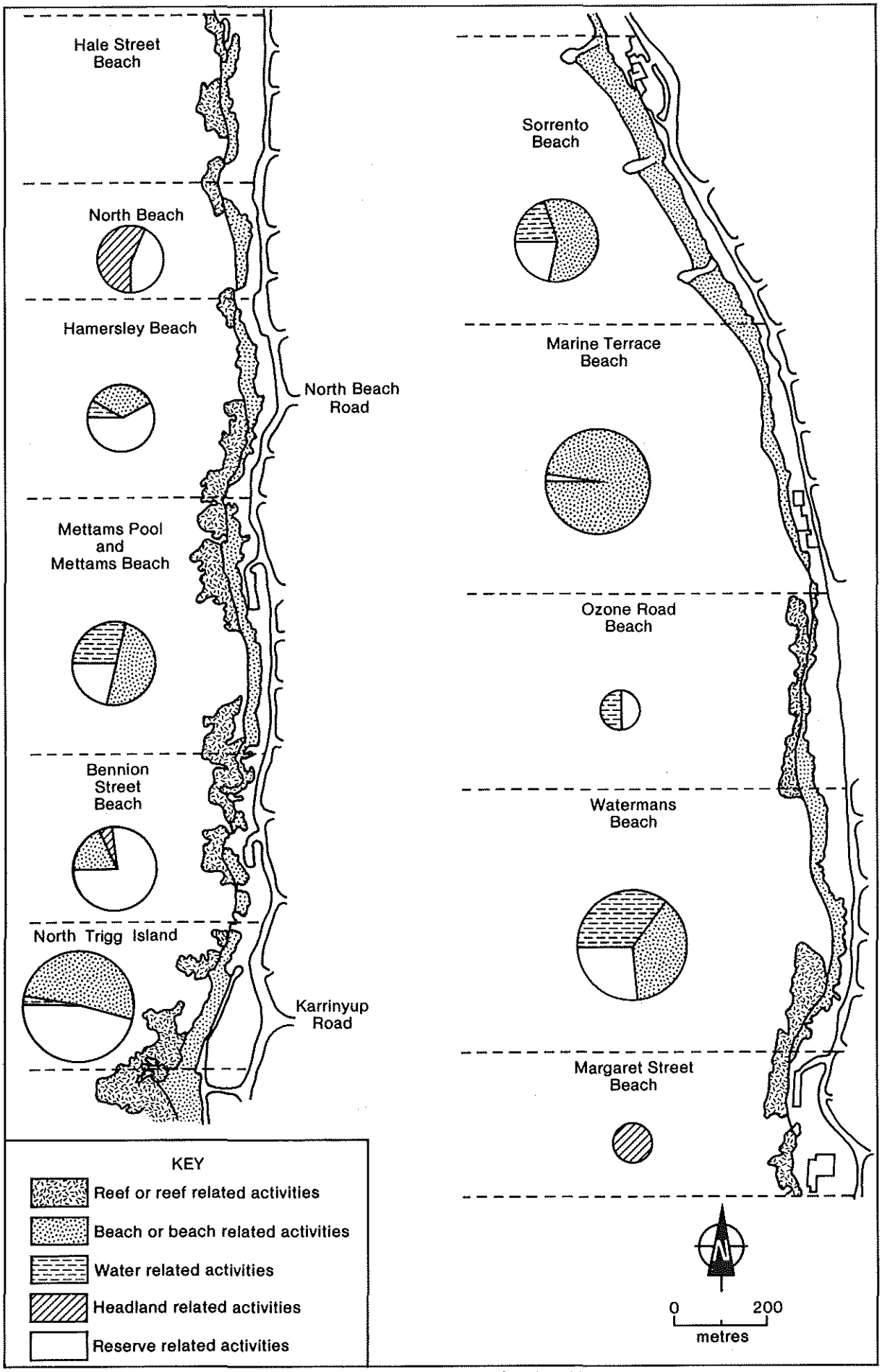

Figure 13. Variations in beach user activities at 1600 hours on Sunday, 10 March, 1985.

Island north by family groups with young children (Figures 10 and 11). By 1600 hours people were again distributed evenly along the coastline (Figures 12 and 13).

Attitudes of Local Residents and Retailers to the Study Area

Keating (1983) found that local residents used local beaches in preference to non-local beaches. The accessibility of a beach appeared to be the most significant factor in beach selection, but safety factors in reaching and using the beach were also considered important. Distance from the beach was important in determining, firstly whether a resident would use a beach and, secondly, what mode of transport would be used to travel there. Keating (1983) found that most of local residents chose to walk. The critical distance for walking versus driving was 0.75km along this part of the metropolitan coast (Figure 14). Many residents perceived traffic safety as a problem and through traffic on West Coast Highway as being an impediment to beach use.

Generally, local residents considered facilities adequate on the coast between Trigg Island and Sorrento (Keating, 1983). They believed, however, that more changerooms would be beneficial and that access to the beach should be improved. They also considered that beach activities should be controlled by zoning, to reduce conflict; for example, specific beaches were needed for exercising dogs and for surfing. Cleanliness of beaches was also seen as requiring improvement, to enhance the amenity value of this part of the coast.

Most retailers interviewed by Keating (1983) believed that there were traffic problems on West Coast Highway which included parking, poor visibility and large volumes of through traffic. Suggestions made for solving these problems included reducing the speed limit on the highway, diverting all through traffic

to a freeway, and making West Coast Highway a dual carriage-way with better access to the highway. Most respondents, however, did not believe that diverting traffic to other streets or slowing traffic would alleviate perceived problems in this area. Some 70% of the interviewed retailers believed that facilities along the rocky coastline were adequate and 30% believed that they were inadequate. Overall, 65% of retailers believed that improvements could be made to the facilities provided, including improvements to the cleanliness of facilities and the beach, safety controls on West Coast Highway, more parking, and better access to the beach.

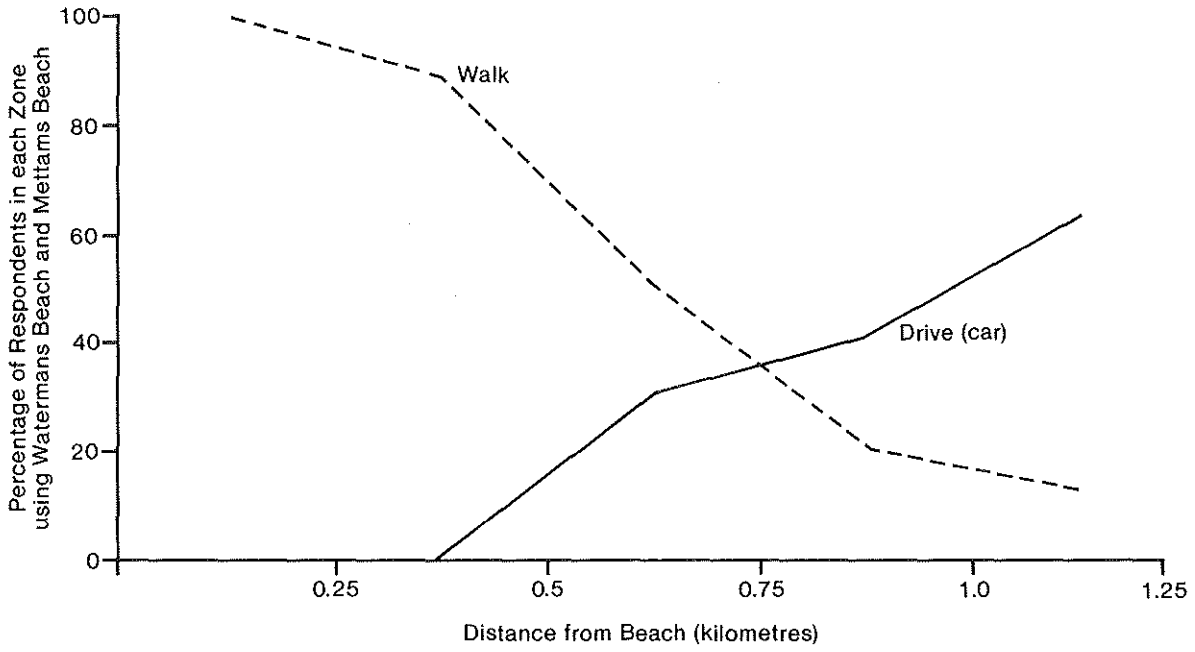

Figure 14. Mode of transport for residents of Trigg and Sorrento, when using Watermans beach and Mettams beach, related to distance of home from the beach (redrawn from Keating 1983).

ENVIRONMENTAL IMPACTS

Recreational use of the coast has contributed to degradation of the physical and biological environment, by exacerbating the effects of natural processes such as erosion (City of Stirling, 1984) and changes in species composition and abundance (Elliott et al 1986). Degradation of beach environments is indicated by the purported decrease of the abundance and species diversity of biota, in the decline of water quality and beach cleanliness, in the erosion of limestone features (including headlands and platforms), and in the increase in dune tracking and the erosion of sand (Elliott et al, 1986). Such degradation needs to be more closely researched, monitored and minimised if the high recreational amenity of the coastal reserve is to be maintained. The various problems and environmental conflicts identified in this study are now described.

The abundance and diversity of biota varied considerably between and within rock platforms; however, all the species identified are known to exist on other rock platforms along the Perth coastline and on nearby islands (Hodgkin, 1960; Marsh & Hodgkin, 1962). The zones developed for a habitat classification of the area (Elliott et al, 1986) are similar to those formed for Mudurup Reef, Cottesloe (Smith, 1952; Marsh, 1955). It should be noted, however, that the zones only represent the types of biological associations that are expected to be found, and do not describe the diversity and abundance of species at any one site. Whether the biological associations observed have been affected by anthropogenic factors is not known, as environmental factors, such as water quality, were not measured.

Molluscs are removed from the intertidal platform by indiscriminate, uncontrolled harvesting, as well as by professional fishing of abalone,

Haliotis roei. Professional abalone fishing is controlled by regulations, which allow removal of the species only at certain times and only from the seaward subsurface notch of the platform. Monitoring and control of the professional fishing will prevent depletion of the abalone stock. On the other hand, indiscriminate harvesting of molluscs by amateur collectors will affect the mollusc stocks (including the abalone stock for professional fishing), and may result in changes in community structure. There is evidence of this at the pool south of Mettams where species diversity is low and the recreational index use of the platform is intense (Elliott et al, 1986). An indirect effect of faunal community degradation may be the reduction of grazing pressure on the macroalgae, thus enabling a greater extent of growth; however, this is complicated by other factors such as water quality.

Water quality, measured at the end of the summer season, may help determine the amount of recreational pressure within an embayment, and conversely, different concentrations of recreational pressure result in varying levels of water cleanliness. Water circulation flushes pollutants, such as body excretions (especially urine), groundwater and stormwater discharge, from an area. Johannes and Hearn (1985) studied water circulation in the inner shelf of the Marmion area, of which our study area is a part. They found that 'flushing time is ... very variable on a day to day basis because of the importance of wind stress to the circulation of the lagoon' (Johannes and Hearn, 1985). Offshore reefs act as a barrier to flushing, but the average turnover time in the wider waters of the inner shelf lagoon is 1.3 days. This should be more than adequate to keep water in the small, nearshore rock pools sufficiently clean for recreational purposes. (Clark, 1977, specifies a maximum turnover time or flushing rate of 2 to 4 days for water in marinas). However, during late summer when periods of extended calm and low currents often prevail, turnover

of water within the lagoon may take up to 4-5 days (Public Works Department, 1984). Water exchange between the onshore rockpools and swimming areas, and the offshore waters, are further impeded by the intertidal rock platform, so flushing times for nearshore areas under intensive recreational use may be greater than 4-5 days. Since intensity of beach use and the associated pollution of onshore rock pools are apparently high during late summer, there are serious ramifications concerning cleanliness of the waters and the number of people able to safely use the water. At Mettams Pool, the distribution of macroalgae (including Ulva lactuca) differed from other sites. The percentage cover of macroalgae decreased from the rock pool edge to seaward margin of the platform (Elliott et al, 1985). Various species of macroalgae grow more prolifically when there is an increased nutrient supply. Therefore, the increase in macroalgae at the rock pool edge of the platform, as mentioned above, also may be due to recreational pressure.

Limestone erodes due to natural chemical, physical and biological processes. The first involves chemical weathering of limestone by contact with the salt water, facilitated by alternating wetting and drying. The second involves mechanical erosion by physical breakages in areas of weakness, mostly by various wave action effects. Biota can also erode limestone by biochemical and biomechanical processes (Hodgkin, 1964; McLean, 1974). Removal of invertebrates may cause physical breakages of the limestone substratum, but on the other hand, bioerosion may be diminished when gastropods are removed. It has been suggested that physical damage to intertidal platforms is also caused by the erection of fishing tripods at the platform edge, although this would be minimal. Natural caves in the limestone headlands have been further excavated by people, many of whom leave rubbish and light fires inside the caves. Blowouts occur in sand dunes. In many places, for example at

Watermans Beach between Troy Avenue and Lennard Street (City of Stirling, 1984), these have been initiated by tracking through dune sand. Tracking is difficult to control, but ringlock fencing seems to have been effective in controlling accesses in this area. Provision of formalised access paths, such as those at Sorrento, has also helped control tracking and dune degradation. Discharge from storm water drains may increase dune erosion. The City of Stirling has carried out maintenance work to minimise these effects.

Consideration of recreational resources between North Trigg Island and Sorrento Beach, together with the recreational pressures exerted upon the area, has led to an identification of problems as well as an assessment of potential uses of this section of rocky coastline. The most significant problem is the proximity of West Coast Highway to the beach. As was pointed out by the City of Stirling Coastal Report (1984), this reduces the area of coastal reserve available for recreation. It also results in a demand for engineered protection of amenities, including West Coast Highway itself (at Hamersley and Sorrento), causes segregation of the recreational area from the local residential community, and severely constrains planning for recreation. In an environment where recreational use is concentrated in distinct clusters, West Coast Highway would not be necessary in a recreational planning context, or resource exploitation context : this point appears to have been overlooked in the MRPA Technical Working Group (1985) study.

SUMMARY

This paper defines recreational resources of the coastal reserve between North Trigg Island and Sorrento Beach, and discusses areas where future research is required. The primary resource of the study area is the space for various recreational, educational, scientific and conservation activities, and the physical and biological attributes of that space. The physical attributes of a coastal area include the geology, geomorphology, water circulation patterns, and biological components. As the dynamic components of the coastal zone alter, so the pattern of recreational activity may change. Changes in the primary resource generally occur slowly; however, they may be exacerbated by inappropriately placed facilities or by the development of new recreational activities, such as windsurfing.

The coastal reserves between Trigg and Sorrento are used by people for a wide range of activities. These activities constitute a secondary resource because people are gregarious and this leads to the establishment of a tertiary resource base that includes the provision of facilities to enhance recreational activities. The tertiary resources are not essential to maintain the recreational activities and, hence, may be viewed as expedient in the context of a marine park.

Data from an aerial survey on Sunday, 3 March 1985, indicate that there is a marked temporal variation in total numbers of people using the coastal reserve and nearshore environment. Data collected on Wednesday, 6 March and Sunday, 10 March, confirm this, and indicate that there are temporal variations in beach use numbers during the day, and also between midweek and weekend days. Furthermore, patterns of temporal variation differ from embayment to embayment.

The range of recreational activities undertaken on the coastal reserve differs markedly from embayment to embayment. Variations in both the range of activities and the numbers of people at embayments during 6 and 10 March show that there are recreational focus points for beach activities along the rocky coastline. There is an informal zoning of activities along the coastal reserve with recreational focus points identified at Trigg Island north, Mettams Pool and Mettams Beach, Watermans Beach and Sorrento Beach. Embayments which show consistently low levels of recreational activity are located at Hale Street, Margaret Street and Ozone Road. These embayments are therefore suitable for purposes such as conservation, or for activities such as fishing which should be kept apart from other recreational activities.

Once people are attracted to an area, they exert pressure upon the environment and exacerbate natural processes already operating. It is noted that pressures from recreational activities have had impacts upon the study area already.

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SCIENTIFIC RESEARCH IN THE M10 AREA

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Marmion Laboratory
CSIRO Division of Fisheries

Abstract

A review is presented of scientific research in the coastal waters of the Perth metropolitan area, and specifically in the area of the proposed M10 marine park.

EARLY SCIENTIFIC WORK IN THE M10 AREA

Being close to Perth, the Museum and Fisheries research laboratories, and the Universities, the M10 area is an obvious location to conduct marine research pertinent to southwestern Western Australia; however, little work has been carried out in this area, except for some collecting by museums and the herbarium up to 1978. In the 1950's, Loisette Marsh compared fauna along three sites of which one, Trigg, was inside the proposed M10 area. The 1978 Cockburn Sound study and earlier work were centred further south, while the control study area for Cockburn Sound was Warnboro Sound.

MORE RECENT WORK

In 1979, the CSIRO Division of Fisheries and Oceanography, as it then was, began a reef ecology programme. The charter was "to investigate the physical, chemical and biological factors that influence the distribution, abundance and metabolism of marine organisms and communities in coastal waters with emphasis on Western Australia". The studies for this programme were centred in the M10 area. The fringing reef made an ideal substratum for many hundreds of species of marine macrophytes and animals. The reef also acted as a barrier to the often heavy swell generated by winter storms. The protection

offered by the reef allowed large areas of sand between shore and reef to be occupied by seagrasses and their associated communities.

The programme, initiated by Dr Bill Wiebe in 1979, involved a core of about 11 CSIRO scientists. It was the laboratory's policy to collaborate with as many outside bodies as possible, working under the broadest definitions of "reef ecology". The programme involved collaborative work with Murdoch University, University of Western Australia, Western Australian Institute of Technology, the Museum, Fisheries Department, and other divisions of CSIRO. During the period 1979 - 1982, many visitors from overseas visited the Marmion laboratory and the study site in the Marmion Lagoon.

To set the scene for a research site, we had an area representative of others along the southwestern Western Australian coast, close to research laboratories, and with some reliable physical data available such as wind speed, rainfall and tide heights. One of the disadvantages of having a research site so close to a major metropolis is that human wastes may pollute the area. This aspect of the Marmion and Whitfords lagoons was investigated at the beginning of the project. The Beenyup outfall at Ocean Reef releases about 35 million litres per day, of secondary treated effluent, over a flat platform of limestone about 1.6 km west of the Ocean Reef launching facility. The effect, in terms of nutrient concentrations, was found to be detectable in a local area of about 100 m radius of the outfall. The pipe and diffuser supported prolific macroalgal growth at the outfall end.

Another likely input of allochthonous nutrients, which may perturb the marine ecosystem, was groundwater. Outlets of groundwater were found along the shoreline by Dr Bob Johannes who recorded higher than ambient nutrient

concentrations in seawater up to 10 m from the source of groundwater. The groundwater released along suburban beaches was higher in nitrate than that from areas away from the suburbs. Circulation in the Marmion and Whitford lagoon was investigated by Dr Cliff Hearn. He found that effluent from Cockburn Sound and the Swan River did not often enter the study area and its effect was negligible. A circulation model was developed by Dr Hearn and others from the physical oceanography group at the University of Western Australia.

The scientists in this new study had to choose, within their fields, the most important features, using subjective observations and previous knowledge. To me, Ecklonia radiata and seagrasses appeared the most important plants in terms of biomass and, from the literature, the most important primary producers. Dr Alistar Robertson looked at the seaweed drift and found the tiny amphipod Allorchestes compressa to be important in breaking down detritus. Judi Hansen investigated microbial breakdown in these drifts. She also measured the seasonal size changes of beach drift. Judi Hansen and Alistar Robertson showed that beach drift was important as a source of plant nutrients. Their work emphasised the importance of detritus and decomposed organic matter to the ecosystem. Rod Lenanton from Fisheries Department collaborated with these two to look at juvenile fish in the drift zone. They found that the drift zone had associations of juvenile fish of commercial species, much as an estuary would.

At the same time that these aspects of nutrient cycling and drift breakdown were being investigated, David Rimmer was examining the carbon : nitrogen ratio of many large algae, while I was looking at the nitrogen dynamics of Ecklonia. At the beginning of 1983, a review of the reef ecology programme

revealed various omissions to the programme. To be complete, the study needed more work on drift, detritus and nutrients. It was also shown that little was known about the secondary producers, particularly the filter feeders and fish.

Due to budgetary and other considerations, however, the direction of the reef ecology programme was changed to emphasize the ecology of the western rock lobster. Most of the CSIRO scientific team moved north to Seven Mile Beach at Dongara leaving Dr Dave Smith and myself to continue work in the Marmion area. Dr Smith is currently looking at the effects of long term nutrient addition to a reef area using Amphibolis epiphytes as an indicator. I am investigating the effects of storms on nutrient supply to the plants. Oceanic water is low in nutrients which fertilise the reef plants and seagrasses yet they are highly productive. Water over the reef during winter has occasional peaks of nutrients. The nutrients appear to be generated from the decomposition of organic matter released by the high energy of storms. Dr Chris Crossland and myself are now investigating the importance of organic matter in nutrient cycling.

From the early work in the reef ecology programme the collaboration from the University of Western Australia has continued with a number of projects.
Bill Wood is continuing his work on relationships between kelp plants and light and has looked at the geological role of kelp holdfasts on limestone reefs.
Annamarie Hatcher is investigating the encrusting organisms on hard substrata and has conducted a number of quantitative surveys of communities on the reefs. She has concentrated on the inshore isolated reefs. She is also working on an important filter feeder, the ascidian Herdmania momus.

Staff from the Western Australian Museum, headed by Dr Fred Wells, is looking at the edible molluscs of reef top platforms at four sites near Perth, two of which, Trigg and the Waterman Marine Reserve, are in the M10 area. The biology of Roe's abalone is being studied with emphasis on the effects of four different levels of pressure on the animal.

SUMMARY

It is obvious from this summary of research in the proposed M10 marine park that little work has been done on many of those animals and plants which may be adversely affected by recreation or other uses of the area. The six isolated inshore reefs, each about 500 m from shore, have fragile organisms more diverse and different from the fringing reefs further west. The protection offered by the fringing reefs allows more delicate organisms to live on the inshore reefs. Some of these organisms are fragile and attractive to collectors: if hardened exoskeletons can be taken home they are even more vulnerable to predation by people. Little is known of the biology of the vulnerable gorgonian corals, small corals, crinoids, echinoderms, and molluscs such as cowries and Syrinx aruanus (the largest conch in the world). Perhaps more research on these organisms, such as the Museum's research on abalone, should be carried out in the proposed M10 marine park. With research, inventories and quantitative surveys, the decisions made now can be reassessed in five years' time. Without more baseline data we cannot hope to prepare a suitable management scheme for the future.

RECREATIONAL USE OF THE PROPOSED M10 MARINE PARK

Major Brian S. Hicks
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Whitfords Sea Sports Club

Abstract

The M10 area is rich in marine resources and would form an ideal marine park. Over 500 - 600 boats may be launched from the Ocean Reef launching facility alone, on a fine summer's day. The general M10 area is popular for power boating, yachting, beach and boat fishing, surfing, snorkel and SCUBA diving, swimming, bathing, waterskiing, windsurfing, and exercising of animals on designated beaches. Whitfords Volunteer Sea Rescue Group is based adjacent the Ocean Reef launching facility, in the Whitfords Sea Sports Club, and has effected rescues as far distant as City Beach, Rottnest Island and Two Rocks. The group is always on standby to rescue vessels and people in distress. Surf lifesaving clubs are based at Sorrento and Mullaloo beaches.

INTRODUCTION

Over the past 12 years, Whitfords Sea Sports Club has promoted continuously all forms of sea sports and recreation in an organised, responsible manner. The club is firmly committed to the future of the general M10 area (Figure 1).

Whitfords Sea Sports Club recognises this area is rich in marine resources and would form an ideal marine park. We also recognise that the adjacent hinterland has a growing population, and that the Ocean Reef boat launching facility has eight ramps for launching all types of boats. The Beenyup treatment plant discharges secondary treated effluent 1.6 km west of the Ocean Reef launching facility, and, because of land development in the northern suburbs, will discharge increasing amounts to the sea. We are not certain of the effects of this on the marine environment. The land area north of Sorrento is being developed extremely rapidly, due possibly, in part, to the America's Cup frenzy.

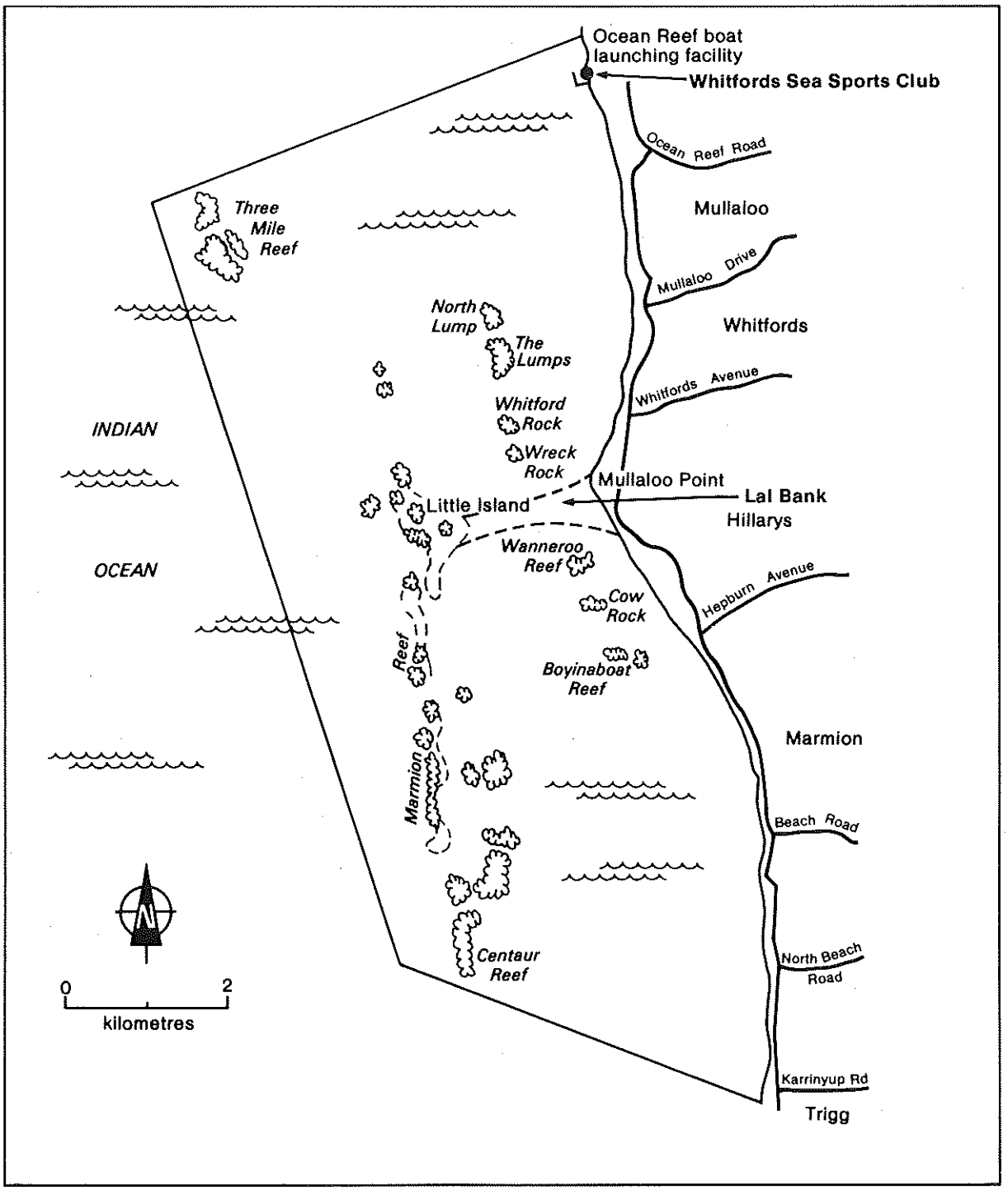

Figure 1. Boundaries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983) Recommendation M10. General features of the area, and the location of the Whitfords Sea Sports Club, are shown.

This paper will discuss the recreation aspects of the proposed M10 marine park. Considering the size of the area, I have classified it into various localities and will discuss the recreational uses of each locality separately.

RECREATIONAL USES OF SPECIFIC LOCALITIES

Ocean Reef boat launching facility

Over 500 - 600 boats have been launched from this facility on a fine summer's day. The area is excellent with little impediment to safety with a course to either Direction Bank, Rottnest Island or offshore. The lead lights are clear and most people putting to sea are aware of the locations of reefs in the area, although there are foolhardy or inexperienced boaters who take risks under any conditions.

For people who develop problems, the Whitfords Volunteer Sea Rescue Group is always on standby. These dedicated people can be called out 24 hours per day and have been called upon to effect rescues as far distant as City Beach, Rottnest Island and Two Rocks. Whitfords Volunteer Sea Rescue Group is located near the Ocean Reef launching facility, in the Whitfords Sea Sports Club, although the group hopes to eventually establish its own headquarters in an adjacent area.

Many children and young people surf all year around at Ocean Reef at the spot known locally as Mosquitoes. They often ride breakers nearly in the mouth of the boat launching facility, which sometimes puts them in peril from boats.

Our club also operates a large contingent of trailer-sailers and catamarans as well as motor-powered craft. These participate in offshore racing, regattas and championships, and of course, add to the congestion of the waterways of

the area concerned. Races may involve the complete M10 area, with river clubs participating, and may include Fremantle to Ocean Reef races. We also have a large boat-fishing fraternity which uses all areas available to them. They have stated that they consider the proposed M10 marine park is "fished out", and that they intend to go further afield. Club members generally fish together or have developed enough sense not to be foolhardy, but there are exceptions. Generally, club members have radios on board which monitor our base station VJ6LQ. Club non-members also use this base station.

Three Mile Reef

This reef is notorious for unpredictable waves. It is an ideal spot for some types of fish, but unwary boathandlers have been caught in its shallow water on a few occasions and there was a fatal accident on this reef recently. Our divers do not consider it a worthwhile area to visit because of the unpredictable waves.

The Lumps, and Whitford Rock

Small boats use these reefs a good deal for good catches of small fish. Divers prefer this area because of its caverns and ledges. The water in the area is dangerous.

Little Island

This outcrop of rock and sand is host to sea lions which require some protection (Figure 2). The island is visited throughout summer by people who sailboard out to it, SCUBA divers who make use of the many caves and crevices in nearby reefs, and surfers, who hitch rides out on their boards to the reefs to surf the swells. The area is considered dangerous to the south and the north of the island as waves rise without warning out of otherwise calm water. Little Island

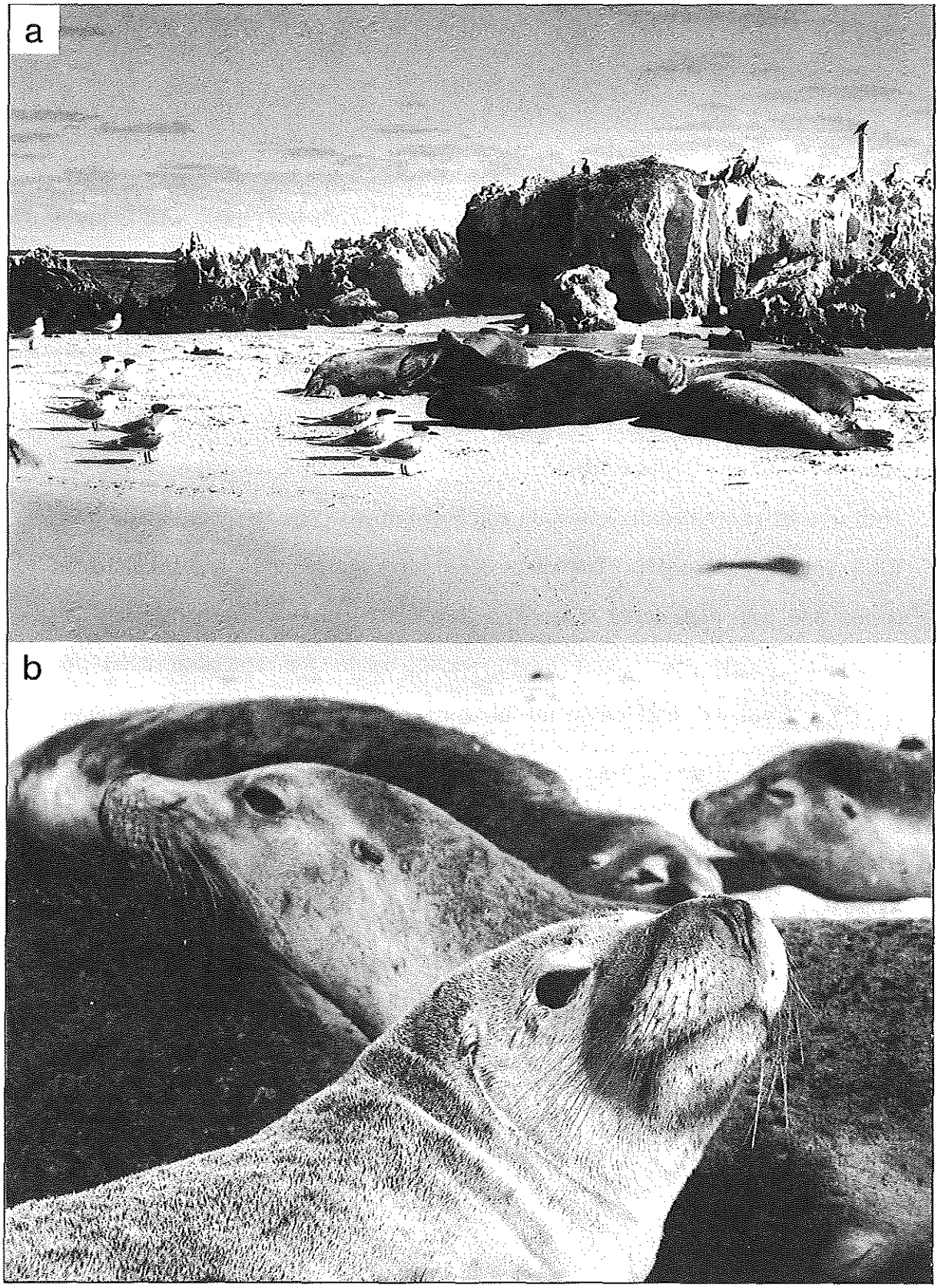

Figure 2. Wildlife on Little Island, July 1985.
a: the limestone outcrop and small beach are resting sites for terns, gulls, cormorants, other sea birds, and sea lions. Only roseate terns breed on the island.
b: sea lions are common visitors to Little Island. Usually about 1-10 are present in the area at any one time.
(Photos: John Ottaway.)

is connected to Mullaloo Point (sometimes known as Pinnaroo Point) by a shallow sand bar, Lal Bank.

Wanneroo Reef, Cow Rock and Boyinaboat Reef

These outcrops of rock are much frequented by small boat users who enjoy a day's fishing by line or trolling. Again, divers snorkelling or on SCUBA use these reefs, though waves are usually breaking in the area. At high tide the reefs are often indiscernable until a boat is on top of them.

Marmion Reef and Centaur Reef

This area of reef protects Marmion and Sorrento beaches to some extent from the Indian Ocean swells. The reefs often have waves and swell breaking on them, and are considered dangerous for inexperienced boathandlers. On extremely rough days small boats travel inside the Marmion Reef for protection, but can only enter the lagoon south of Centaur Reef then travel north along the coast to Ocean Reef for safe harbour.

Mullaloo, Whitfords, Sorrento, Marmion and Trigg Island beaches

These beaches have a reputation for being mostly clean and free of pollution. This is particularly true of Mullaloo, Whitfords and Sorrento. Marmion is protected by a small reef which offers shelter to the elderly and the very young who use this beach, offering them safe water to bathe or swim in.

Mullaloo is a surfers beach with the Mullaloo Surf Life Saving Club situated there. State and Commonwealth championships are conducted at this venue and at Sorrento. The major difference between these two beaches is the groynes constructed for retention of sand on the beach and a rock wall to protect the land at Sorrento. South of Mullaloo Point is an animal exercise

beach where trainers bring their horses for fitness training, including swimming. Some of these trainers come to the beach from many kilometres away. Their parking often causes a traffic hazard on West Coast Highway.

North of Mullaloo Point is a gazetted water skiing area. This area is frequently used by power boats towing skiers. Its relatively calm waters are ideal for this activity and it is the only such area north of Fremantle. The power boats used to tow skiers are very powerful but are not sea boats in the true sense, and require experienced drivers at the wheel.

DISCUSSION

The M10 area is practically always occupied by the younger members of our society. They surf and wind-surf all year round. The water appears to hold no danger for them. They are a fraternity to themselves, and can be found on the reefs at Little Island, Marmion or Sorrento. They should be encouraged to participate in these sports. It should be noted that wind-surfing has developed into a lucrative business, and the Australian Championships were held in Perth recently. These young people possibly will graduate to be the yachtsmen of tomorrow.

The area is used by people in power and sail boats of all descriptions. Our power boatmen conduct time trials off Ocean Reef and take in nearly all of the proposed M10 marine park. Reefs are commonly used as markers during these trials. We have recently conducted our first Fremantle to Ocean Reef time trial inside Marmion Reef, and it is planned to make this a yearly event.

Our members conduct races for trailer-sailers and catamarans every Saturday during the summer and winter. The rougher the water, the better members

appear to like it. There have been days when boats had to be towed in to shore because of completely flat seas and becalmed conditions, but that is rare.

I have not mentioned the proposed boat harbour at Sorrento. We are opposed to the establishment of a boat harbour on a beach. One could say, with tongue in cheek, we would relish it being constructed at Sorrento as it would take the congestion from Ocean Reef, but for reasons of safety, ecology and the destruction of the sand beach we believe it is not warranted. Now we have a proposal for the construction of the Mindarie Keys marina, north of the M10 area. Although a private concern, it will encourage the boating population to use its facilities. I will not elaborate on the advantages and disadvantages of the construction of the boat harbour at Sorrento.

Now that the Sorrento boat harbour (named as the Hillarys Boat Harbour yesterday, in the Government announcement) is to be constructed, we will see an end to Boyinaboat Reef and possibly Cow Rock. The congestion of the Hillarys Boat Harbour, if it is to cater for yachts and other large boats including crayfishing vessels, can only be imagined. We predict that the traffic of new boat owners using the reef waters around this locality will pose considerable safety problems which I hope will be considered before the Hillarys Boat Harbour and associated small boat launching ramps become operational.

The Whitfords Sea Sports Club conducts courses aimed at developing a sense of responsibility. In conjunction with the Yachting Association of Western Australia we conduct boating courses (called TL3 courses) to enable new boat owners to learn what they did not know or re-learn everything they had forgotten. Their families are included in this activity. We also have courses

which train those who have never handled a radio previously giving them the opportunity to learn the mysteries of voice procedure and the practical application of correct radio communication techniques.

We have noted that the Assessment Report from the Environmental Protection Authority on the Hillarys Boat Harbour ERMP has stated that, and I quote, "the marine reserve falls into the concept of a marine park, rather than a marine nature reserve" (EPA, 1985 : p. 8). Consequently, if the boat harbour can enhance public recreation and has acceptable or manageable environmental impacts then the [Environmental Protection] Authority cannot recommend against it proceeding", unquote. If this is the case, then action is required NOW by the potential managers of this boat harbour and the potential managers of the M10 marine park if it proceeds.

SUMMARY

The Whitfords Sea Sports Club was founded in 1973 from within a small but growing population of the northern suburbs. It provides sea sports recreation and in so doing satisfies the needs of the community. The commitment to sea sports and community recreation has grown with the community and is providing today, recreation and sport and social enjoyment to many.

ACKNOWLEDGEMENTS

Members of the Whitfords Sea Sports Club are thanked for contributing information used in this paper. The photographs were supplied by the W.A. Department of Conservation and Environment.

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FISHING AND FISHERIES MANAGEMENT IN THE M10 AREA

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Abstract

Fisheries resources of importance to professional and amateur fishermen in the proposed M10 marine park, are the western rock lobster, Roe's abalone and various fin fish species. These resources are sustained by the presence of seagrass, seaweed (macroalgae) and limestone reefs. Additionally, the area supports a number of shell species, particularly cowrie shells, which are sought by collectors and have scientific interest.

WESTERN ROCK LOBSTER (Panulirus cygnus)

Sources of Information

(i) Discussions with professional rock lobster fishermen who fish the area,

(ii) rock lobster research log books for 10' (10 nautical miles) transects 315 and 316 from 0 to 10 fathoms depth, 1982-83 and 1983-84 seasons, and

(iii) Australian Bureau of Statistics (ABS) commercial catch data for block 3115 (31°S to 32°S, 115°E to 116°E), 1982-83 and 1983-84 seasons.

Available Information

An indication of the significance of the proposed M10 marine park to professional rock lobster fishermen can be obtained by recent logbook records for transects 315 and 316, which contain the M10 area (Figure 1).

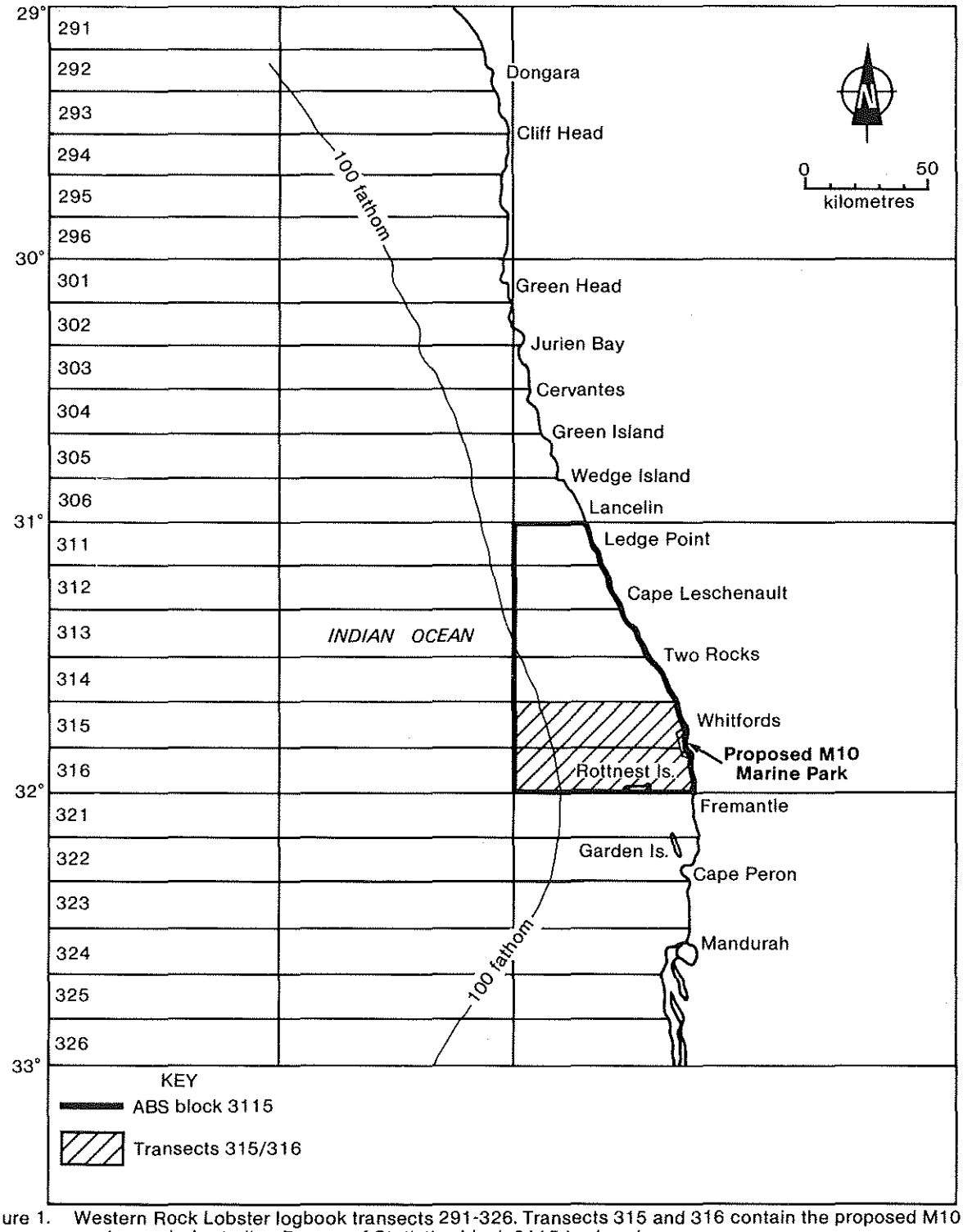

Figure 1. Western Rock Lobster logbook transects 291-326. Transects 315 and 316 contain the proposed M10 marine park. Australian Bureau of Statistics block 3115 is also shown.

TABLE 1 : catch (kg) per pot lift per month in 0-10 fathoms depth

Years (and transects)	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1982-83								
315	1.55	1.41	0.46	0.79	0.73	0.33	0.54	N/A
316	1.42	1.86	0.50	0.89	N/A	N/A	N/A	N/A
294-322 (coastal average)	1.35	1.51	0.57	0.84	0.88	0.67	0.64	0.65
1983-84								
315	0.97	1.4	0.56	0.65	0.62	0.28	0.35	N/A
316	1.01	2.15	0.65	0.46	N/A	N/A	N/A	0.17
294-322 (coastal average)	0.96	1.68	0.59	0.61	0.69	0.59	0.49	0.47

The outer seaward boundary of the proposed M10 marine park, as shown in the System 6 Report (EPA, 1983), is close to the 10 fathoms depth contour. Figures from the log book data (Table 1) show that the rock lobster catches in the 0 to 10 fathoms area within transects 315 and 316 are comparable with the coastal average from 29°30'S to 32°20'S. Based on 1982-83 ABS catch figures for block 3315, the annual professional catch from all depths in the 10' transects 315 and 316 is estimated to be in excess of 700 000 kg, worth over 7 million dollars. Of this, the 0 to 10 fathoms component is considered to represent about 250 000 kg or 2.5 million dollars.

The proposed M10 marine park will cover close to 30% of the 0 to 10 fathoms depth area in transects 315 and 316 and therefore currently supplies about

80 000 kg rock lobsters, worth about 800,000 dollars on recent prices. The total annual catch in Western Australia has recently been 11 - 12 million kg, worth about 100 million dollars. The proposed reserve area thus supports about 0.7% of the total Western Australian catch.

From information supplied by rock lobster fishermen, at least 20 boats fish the M10 area for part or all of the season, which is also an indication of its importance for professional fishing. Further, the good 'whites' catch that occurs in November and December shows that the area is a source of recruits to the breeding stock in deeper waters.

Based on a Fisheries Department study of amateur rock lobster fishing, it is likely that the amateur catch in the area, both by potting and diving, would be about 4 to 5% of the professional catch; that is, about 3200 - 4000 kg annually.

ROE'S ABALONE (Haliotis roei)

Sources of Information

(i) Fisheries Department catch records, and

(ii) Fisheries Department inspectors' observations.

Available Information

The location of abalone stocks in the M10 area is shown (Figure 2). The stocks in the Marmion-Trigg zone are capable of supporting an annual professional catch of 15 000 - 20 000 kg, and also an amateur fishing catch at current levels of activity. This zone and Penguin Island are the two major amateur fishing locations for Roe's abalone.

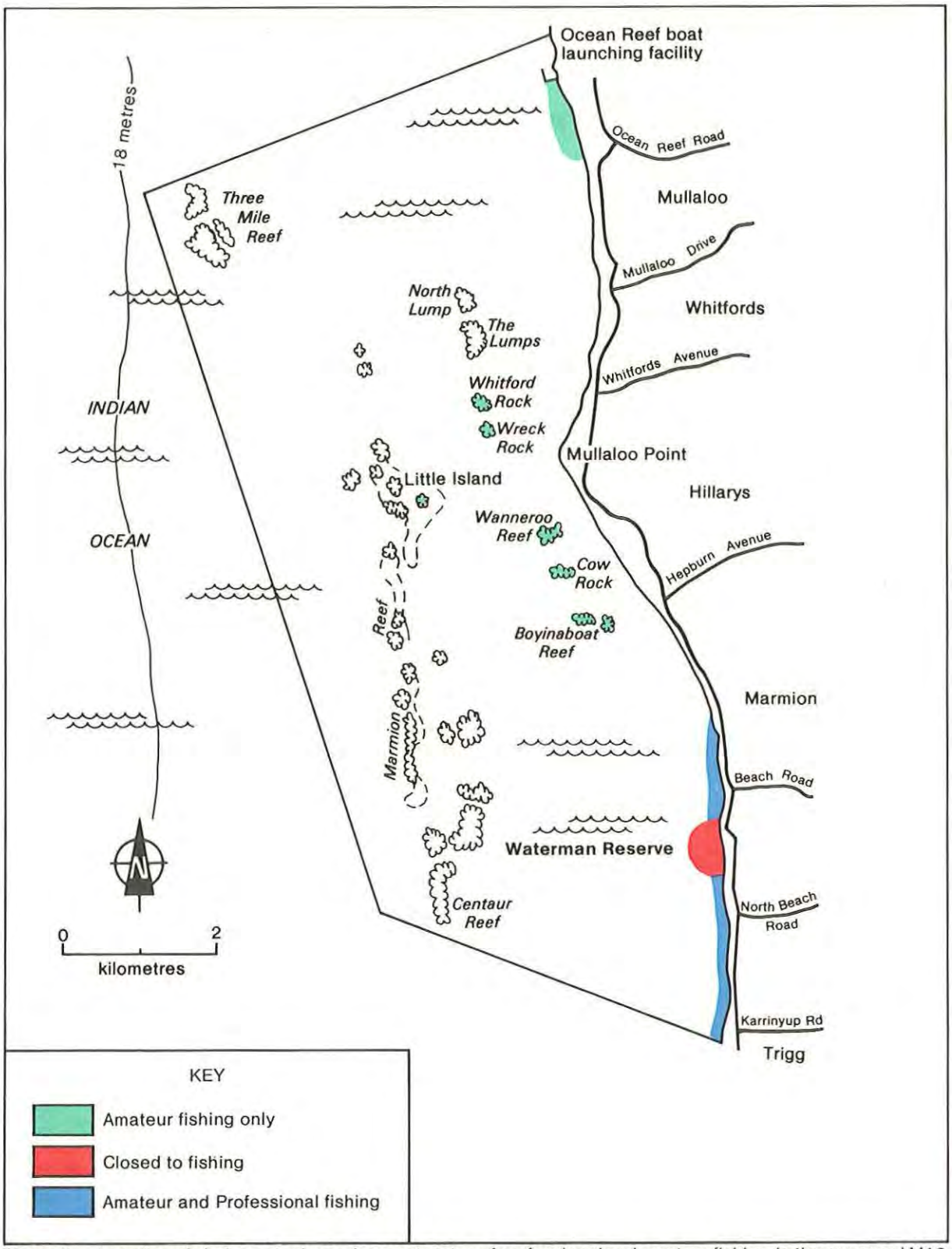

Figure 2. Location of abalone stocks, and current status of professional and amateur fishing, in the proposed M10 marine park. The M10 boundary is that as shown in the System 6 reports (DCE 1981; EPA 1983).

At about 4 dollars per kg live weight, the professional catch is worth 60 000 to 80 000 dollars and constitutes approximately 20% of the total annual Western Australian catch of Roe's abalone.

Of the other areas indicated (Figure 2), only the Mullaloo coastal reef platform and Little Island have any significant stocks. These are fished exclusively by amateurs. The remaining offshore reefs contain limited stocks of abalone, apparently due to a lack of detached algae in suspension as a result of the local water circulation characteristics. Drift algae are the main food source of Roe's abalone.

As a result of excessive amateur activity, the metropolitan reefs (Moore River to Cape Bouvard) were closed during 1982 and 1983 to allow stock recovery. The metropolitan fishery for both professionals and amateurs is now open from 1 October to 1 March and there are different size and catch limits for each type of fishing. During peak fishing conditions on one day in December last year, 400 amateurs were counted taking abalone, in a spot check in the area. Normally, at weekends, about 50 people can be seen at any one time.

It should be noted that the three groynes on the Sorrento beach may well provide an additional habitat suitable for settlement of abalone. The Cottesloe groyne has successfully provided such a habitat.

The Western Australian Museum is conducting a research project on platform reef molluscs, with an emphasis on abalone, which is sponsored by the Fisheries Department. Two of the research localities, Waterman Marine Reserve and Trigg reef, are within the proposed M10 marine park.

FIN FISH

Sources of Information

(i) ABS commercial catch data for block 3115, 1983-84,

(ii) Australian Amateur Angling Association club competition results,

(iii) Fisheries Department and CSIRO research results,

(iv) isolated discussions with amateur fishermen and Fisheries Department officers, and

(v) 'Coastwatch', a fishing column which appears in the Friday edition of 'The West Australian'.

Available Information

No figures can be given for professional or amateur fin fish catches in the proposed M10 marine park. A rough estimate might be obtained from people who fish the area regularly. Most of this fishing, by far, is by amateurs. About six professionals fish the area by inshore netting, for migrating sea mullet from January to March, and by limited netting for blue sardines at Trigg about March and April. Trawling is forbidden in the area from the coast to 800 m seaward.

Commercial Fishing

Thirty-four species are listed in the 1983-84 ABS commercial catch data for the larger area, block 3115, which encloses the proposed M10 marine park.
Apart from the large pilchard catch, which is taken off Fremantle over a sand/seagrass floor, these adult commercial species will be representative of those found and caught in the M10 area.

Yellow-eye mullet, sea mullet, sandy sprat and western sand whiting occur in the surf zone. The remainder of the adult species are found mainly in association with reef areas, except for school whiting, sole, skates, rays and

some sharks which occur over sand area seagrass meadows.

Seine netting by the Fisheries Department and CSIRO, between Mullaloo and Sorrento, showed that juveniles of many of these species (Table 2) predominate in the surf zone. A total of 29 species were recorded, of which seven made up more than 95% of the total number of fish caught. These seven species, in order of numbers caught, were sea trumpeter, yellow-eye mullet, school whiting, cobbler, sand fish, weedy whiting and blowfish. Five of the seven species were present almost entirely as juveniles, while the other two species present were a mixture of adults and juvenile fish. The study also showed that there was a marked positive correlation between number of fish caught and quantity of detached macrophytes (macroalgae and seagrass). From gut contents of the fish, day and night netting, and observations on cormorants, it was concluded that the detached macrophytes in the surf zone were important as a food habitat for the fish, mainly because of associated amphipods, and as a habitat providing shelter for the fish from potential predators such as diving birds and large fish.

Results on surf-zone decomposition of macrophytes, produced by CSIRO, also show that detached macrophytes are an important component of the food chain in inshore systems off the southwest coast of Western Australia.

TABLE 2 : twenty most abundant species (by kg catch) for block 3115, 1983-84

Species	Weight (kg)	Species	Weight (kg)
Pilchard	248 868	Samson fish	2 887
Bronze whaler shark	50 706	Gummy shark	2 180
Whiskery shark	21 963	Queen snapper	1 738
Westralian dhufish	21 597	Skates and rays	1 449
Yellow-eye mullet	10 298	Yellowtail kingfish	1 429
Pink snapper	7 679	Red mullet	1 225
School whiting	6 933	Sole	978
Wobbegong shark	5 113	Western sand whiting	959
Sea mullet	5 574	Skipjack trevally	645
Sandy sprat	3 090	Mulloway	583

Amateur Fishing

The proposed M10 marine park appears to be the most popular fishing area north of Perth, and includes two angling clubs situated on the coast. According to Fisheries Department officers who know the region well, the amateur anglers catch up to about 40 species. Fin fish species commonly caught, and their preferred habitats are shown (Table 3).

Records from Whitfords Sea Sports Club angling competitions and from 'Coastwatch' also show that garfish, western school whiting, tailor and Australian herring form a large part of the amateur angling catch. A limited amount of netting is done by amateurs in the area. Due to many reefs, much

TABLE 3 : Fin fish species commonly caught in the study area and their preferred habitats

Fish	Habitat
Garfish	Coastal waters over seagrass
Western school whiting	Sandy bottoms in surf zone and offshore
Tailor	Juveniles school in surf zones. Larger fish around offshore reefs
Australian herring	Around coastal reefs - over seagrass
Skipjack trevally	Coastal reef areas
Yellowtail scad	Surf zone to offshore reefs. Active at night
Wrasses (several species)	Mostly in association with coastal reefs
Common species are :	
Cobbler	Coastal reef and weed areas. Juveniles associated with nearshore drift macrophytes. Adults feed in the surf zone mainly during winter evenings
Blue-spotted flathead	Inshore sandy bottoms
Sea trumpeter	Adults in seagrass beds. Juveniles associated with shoreline drift macrophytes
Western sand whiting	Surf zone sand, particularly around reefs
Red mullet	Sand/seagrass areas
Buffalo bream	Around coastal reefs
Yelloweye mullet	Surf zone
Leatherjacket (several species)	Common over seagrass beds
Blowfish	Inshore sandy bottoms, but also seagrass and reef areas
Snook	Offshore weed beds
Shark species	Offshore species roving throughout the water column
Westralian dhufish	Around reef areas
Sea mullet - migratory	Just off surf zone
Australian salmon - migratory	School around offshore reefs and in the surf zone.

spearfishing occurs in the M10 area. Besides individuals, three clubs concentrate their activities there: the Undersea Fishermen's Association, the Pirates, and the West Coast Divers. Major species sought are blue groper, westralian dhufish, sea kingfish, pink snapper and queen snapper. According to Fisheries Department officers these species are present in reasonable numbers at the moment.

SHELL SPECIES

Sources of Information

(i) Fisheries Department officers, and

(ii) locally-written books on shells.

Available Information

Both the inner and outer (1.5 km and 5 km) reef bands of the M10 area have prolific cover of a khaki sponge, which is the principal diet of the cowrie species Cypraea venusta. This cowrie is more common in this region than in the rest of its geographic distribution. Specimens farther south are larger and the local variety has therefore been distinguished by the sub-species name sorrentensis (from the locality-name of Sorrento). Cypraea friendii friendii is also found in this region, though in lesser numbers than Cyprea venusta sorrentensis, and is generally larger than those found in other inshore regions of its distribution.

Other large molluscs in the area are the orange conch shell (Syrinx aruanus) and the southern baler shell (Melo miltonis), which live in the sandy weed habitats between and shorewards of the reefs. In addition to Roe's abalone, two other Haliotis species, Haliotis scalaris (moderately common) and Haliotis

semiplicata (uncommon) are found in the area. Smaller and less well-known gastropods are also prevalent throughout the area: information on these can be obtained from the Western Australian Museum.

The rarity of sea-urchins, turbo shells (Turbo torquatus) and attractive gastropods on easily accessible reefs from Marmion to Trigg probably indicates the effect fishing pressure can have on edible or collectors' species.

RESTRICTIONS AND MANAGEMENT

The proposed M10 marine park approaches 60 km^2 and is considerably used for recreational purposes. It also forms a part of important commercial fisheries. Any proposed restrictions in the area should take into account the problems of policing such a large offshore expanse, its historical, current and future recreational popularity and its professional fishing value.

In agreement with part of the original Australian Marine Sciences Association recommendation for the Sorrento-Mullaloo reefs, the M10 marine park should contain reef areas protected to maintain them in at least their present condition for the benefit of underwater observation of associated flora and fauna. Such areas would foster the reserve purposes outlined in the System 6 recommendation M10 : that is, scientific research, education, conservation and recreation. While it is not expected that a boat harbour in the M10 area would be used to any degree by professional fishing boats, such a development and launching ramps would provide an enlarged focus for amateur boats with, consequently, greater increased pressure on all resources in the vicinity.

On the basis of the above considerations and current Fisheries Department knowledge of the region, the following proposals are put forward on restriction

and management within the M10 area.

1. The current Fisheries Department 400 m radius marine reserve at Waterman (Figure 3) prohibits the taking of aquatic animal or plant life by any means, with the exception that fish may be taken only by rod or line fishing from the shore. Extension of this reserve to 500 m radius is recommended. This would extend the area available for scientific research, education, conservation and recreational purposes and would allow the coastline boundary to terminate in sand rather than reef, thereby avoiding the possibility of people inadvertently taking organisms from the wrong side of the boundary when on the reef.

2. Shire regulations prohibit spearfishing in several spots on the coastal strip either side of the Waterman reserve. For the protection of reef fish and swimmers it would be preferable to have a total ban on spearfishing along this strip (200 m width) as shown in Figure 3.

3. In addition to the Waterman reserve, which is land-backed, it is suggested that a 500 m radius reserve be created around Little Island. This will have the same restrictions as the Waterman reserve plus a restriction on fishing from the shore, and will thus be a small offshore reef reserve suitable for underwater observation where sessile organisms will not be touched and reef fish will be protected from all forms of fishing.

4. Apart from within the boundaries of such an enlarged Waterman reserve and the additional reef reserve offshore at Little Island, professional and amateur fishing should continue as at present. These activities are a

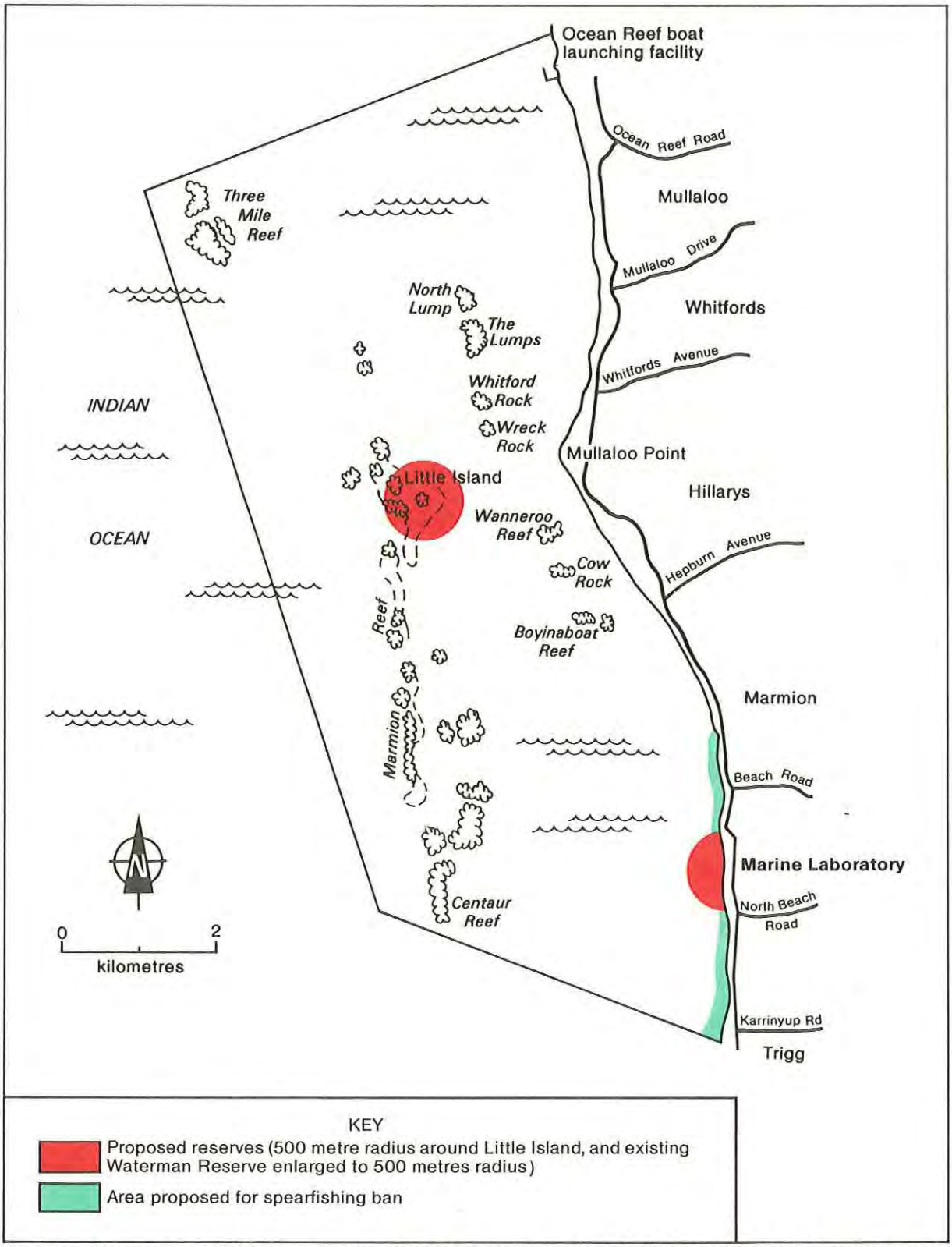

Figure 3. Reserve areas (Waterman Reserve and Little Island) proposed by Fisheries Department, superimposed on the M10 reserve area as proposed in the System 6 study reports (DCE 1981; EPA 1983). A spearfishing ban is also proposed for the additional area shown.

significant part of current use of the M10 area and, in this restricted form, would not be incompatible with the purposes of the reserve listed in the System 6 Report.

5. Seagrasses, seaweeds and limestone reefs, which support the fishing activities, should be protected from any damage by physical or chemical agents which could cause measurable harm to their function in the area.

6. In the event of greater pressure on the M10 marine environment, particularly the reefs, due to increased boating activity, it may be necessary to enlarge the boundaries of the reserves or increase their number.

7. Rather than any proposed reserves existing purely as paper reserves with prohibitory signs in their vicinities, the public should be encouraged to visit them for observation purposes. This will require the presence of an officer who will have not only a policing function but also an educational role. The officer should be backed up by brochures illustrating the ecological significance and life-histories of the flora and fauna, and signs which indicate what is available for observation. Such an educational programme will encourage participation by the public and make the policing function a lot easier and more effective.

8. A certain amount of coarse monitoring of reserve and control areas will be necessary to determine their condition and to show whether changes in management or an increase in reserves is required to maintain the availability of relatively unspolit observation areas. As knowledge of the area increases, unique features may arise which will require

protection in the form of reserve status.

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PROFESSIONAL FISHING IN THE M10 AREA

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Australian Fishing Industry Council (W.A.)

Abstract

Philosophy of the professional fishing industry is discussed, particularly with reference to use of the proposed M10 marine park. Fisheries harvest renewable resources, and the only legislation required is that which ensures conservation of the fishery resources. Rock lobsters worth about $1,200,000 are taken from the M10 area annually, and Roe's abalone to the value of about $120,000. Professional net fishermen also take sea mullet and yelloweye mullet from the area.

The Australian Fishing Industry Council (W.A.) considers that the proposed M10 marine park should be available to both recreational and professional fishermen. If regulation and monitoring are sufficient to prevent overfishing, and permitted fishing methods are restricted, no conflict should occur between professional and recreational fishermen, or between professional fishing and conservation.

INTRODUCTION : PHILOSOPHICAL POSITION TO CONTROL OF FISHERIES

The Australian Fishing Industry Council accepts management measures or restrictions which are introduced for sound biological reasons. This position has been accepted at both State and Federal levels, and has found some level of acceptance in international forums when the expolitation of highly migratory species are discussed.

The fishing industry consults closely with the Fisheries Department on the management of fisheries resources, to maintain sustainable yield. Fisheries resources are renewable resources, and the view of the Australian Fishing Industry Council is that no additional legislation is required other than what is adequate to ensure conservation of the fisheries resources of an area. The industry assists with the monitoring of fisheries by log books kept by all

professional fishermen. These log books provide much data used by the Fisheries Department in assessment of each commercial fishery.

PROFESSIONAL FISHERIES OF THE M10 AREA

Fin Fish

No trawling is allowed within 800m of shore in the M10 area, and most of the area is unsuitable for trawling because of the widespread distribution of reef.

The least important fishery is that for fin fish. There is a small amount of fishing for sea mullet and yelloweye mullet in the area. These are both migratory species and fishing has had little effect on the biomass of fish present at any time.

Roe's Abalone

The second most important fishery is that for Roe's abalone, and, notwithstanding Dr Jones' statement, the value of the abalone fishery is probably closer to $120,000 than $60,000 per year because of recent changes in the value of the Australian dollar. There is worldwide depletion of abalone stocks because they are susceptible to overharvesting. Currently, in Western Australia, the demand for abalone is such that the number of exporters almost exceeds the number of professional divers.

Roe's abalone is part of a managed fishery which extends from Cape Naturaliste to the Northern Territory border. The number of professional abalone divers, for Roe's abalone, is limited to twelve. Of the twelve licensed divers, four operate outside the metropolitan area, one based in Augusta and operates in the southern area, and three in the Kalbarri area. The open season for abalone in the M10 area also applies to the wider metropolitan fishery,

which extends from Moore River in the north to Cape Bouvard, south of Mandurah. A management plan has been adopted by the professional abalone fishermen, involving fishing different areas on a rotational basis and only taking the largest animals, so that the adverse effects of taking abalone are minimised.

There is ongoing consultation between these abalone divers and the Fisheries Department, and only areas believed capable of sustaining commercial exploitation are opened to the professional divers. After opening, the area is monitored, and as soon as the stock reaches a level at which commercial fishing should stop, it does; for example, the popular area from Sorrento to Trigg was fished by professional abalone divers for 35 days last year, because after that the divers believed that commercial fishing should cease, and voluntarily withdrew.

There are a number of regulations applying to commercial abalone divers. These are, firstly, a daily bag limit of 100 kg, and, secondly a legal minimum size of 70 mm. Eight years ago, the professional divers requested the Fisheries Department to raise the legal minimum size from 60 mm to 70 mm, as they felt the 60 mm minimum size was too small. This was done, although the minimum size limit for amateurs has remained at 60 mm.

Fisheries Department research officers have assisted the industry greatly in the determination of minimum size limits, and there also are some commercial considerations. For example, at 70 mm or above there is a large meat recovery from the abalone, but below that size meat recovery, as a percentage of total weight, is low, which we feel is a waste of the resource.

As well as these management measures, professional abalone divers attempt to avoid conflict with amateurs by not working on weekends, public holidays or between the Christmas to New Year break. Professional abalone divers do not work reef tops, but work in areas of surge which would be uncomfortable for amateurs. The industry wishes to maximise the degree of separation from amateur fishermen. The main management problem is that Roe's abalone is sessile and lives in the white water, which makes it very accessible. It is common to see elderly people at Mettams Pool and other places with a bucket of abalone.

The fishing industry is concerned that abalone stocks can be fished to very low levels. The industry observes that the Roe's abalone fishery is well-controlled at the professional level, but that the amateur fishery is not. This might affect the professional fishery through a decline in the sustainable yield of abalone. Obviously, the fishing industry wants to ensure maximum sustainable yield of abalone. There is great financial incentive to ensure this, and that is precisely why the industry wants the whole abalone fishery properly managed.

Western Rock Lobster

The rock lobster fishery which operates in the proposed M10 marine park is a subset of a much larger fishery which is extremely closely monitored, managed and regulated by consultation between the fishing industry and the Fisheries Department. The Western Australian rock lobster fishery is admired internationally as one of the most successfully managed fisheries in the world. It is managed on a biologically-sound basis to maintain the lobster population as a renewable resource.

There is a complex legislative and consultative mechanism between the

Fisheries Department and the fishing industry to monitor the western rock lobster fishery. This is now at the stage that fairly reliable estimates of catch can be made four years in advance. All other fisheries in the world are envious of this because reliable forecasting of the lobster fishery enables us to take action to avoid overfishing. We are currently considering what to do with a predicted bad season in 1985/86.

The proposed M10 marine park supports five vessels virtually all year, and some of the skippers work on the tops of the reefs. Their catch supports processing factories, which rely on them for lobsters. There are about twenty vessels working the area during the "whites" period in December and January, when lobsters are most active, and most likely to be caught.

My estimate of the value of the catch from the M10 area is slightly higher than that of the Fisheries Department. The industry estimates that $1.2 million worth of rock lobsters will be taken from the area, assuming a price of $15 per kilogram, although final prices will depend on the exchange rate between the Australian dollar and the United States dollar. (The final price for the 1984/85 season was A$17.20 per kilogram).

The rock lobster fishery has been operating in the M10 area since the 1930's. Many people will remember that Sorrento, Marmion and Mullaloo were fishermen's settlements, which were originally opened up by professional fishermen who have since moved north, or gone elsewhere, because of the pressures of urbanisation. Those professional fishermen operated in this area for years, and have a good understanding of the fishery, both in terms of its response to environmental pressures and to pressures from the fishing industry.

SUMMARY

The Australian Fishing Industry Council (W.A.) and the fishing industry consider that the proposed M10 marine park should be available to both recreational and professional fishermen. The professional fishermen attempt to minimise conflict among themselves and to minimise any perceived conflict between professional and recreational fishermen. The fishing industry welcomes recreational fishermen into an area, and feels that they have a right to maximise their enjoyment by participating in the fishery.

The industry maintains that if regulation and monitoring are sufficient to prevent overfishing, no conflict will exist between the professional users and the recreational users. Nor will conflict exist between the needs of professional fishing and those of conservation, provided that permitted fishing methods are restricted. For example, trawling is incompatible with conservation, but line fishing, diving, and fishing using rock lobster pots or fish traps should present no conflict between professional fishing and conservation in the M10 area.

AMATEUR FISHING IN THE M10 AREA

John M. Farrell
President
Marmion Angling and Aquatic Club

Abstract

Organised fishing clubs such as Marmion Angling and Aquatic Club and the Whitfords Sea Sports Club undertake limited fishing in the proposed M10 marine park. That which occurs is mostly line fishing for whiting and herring, although a few club members spearfish, set rock lobster pots and occasionally net for fin fish.

Most people who fish the M10 area are not club members. These people may be categorised into (i) **reef-walkers** who collect enough abalone or other particular seafood for a meal; (ii) **reef-raiders**, who appear to take virtually anything that is edible, without concern for ecological implications, and (iii) **anglers** who fish from shore or boats. This last group mostly takes migratory fish, probably because there are very few reef inhabitants left in the area of the proposed M10 marine park.

Boat access and the taking of migratory fish are not seen as problems. Critical points in the establishment and success of a marine park, however, will be the enforcement of park legislation policy and regulation, and the development of a public education program.

INTRODUCTION

The Marmion Angling and Aquatic Club is particularly pleased to see that such a broad base of consultation has been established at this seminar, from which the decision makers on the matter of this marine park may gain information. As can be seen, scientific, commercial and community interests are represented.

My paper gives the community or amateur fishing perspective, although it is noted that while about 2000 members of the Whitfords Sea Sports Club and the Marmion Angling and Aquatic Club are represented here, there are many more people that fish in the proposed marine park area and who are not formally represented today.

HISTORICAL PERSPECTIVE

Fishing has been practised for many decades in the proposed M10 marine park (Figure 1). In the late 1800's Mr P Marmion had a base here for his whaling operations. In the early 1900's, through the Great Depression and pre-war years, fishermen's shacks were built on this site (Figures 2a & 2c), but pressures of development later forced the removal of those shacks. Afterwards, the Marmion Angling and Aquatic Club was built on the site, and officially established in 1953 (Figure 2d). Many of the original members are still in the club today.

ACTIVITIES OF RECREATIONAL FISHING CLUBS

The two main clubs in the area are Marmion Angling and Aquatic Club and Whitfords Sea Sports Club. The members fish almost exclusively by line (Figure 3). Few members fish within the proposed M10 marine park area, but those that do take primarily whiting and herring. A few club members spearfish, set rock lobster pots, and occasionally net for fin fish. Mostly, club members travel through the proposed park area to fishing grounds elsewhere, particularly seeking larger fish associated with deep-water outer reefs.

Since the development of the Ocean Reef boat launching facilities, less pressure is placed on the Marmion Angling and Aquatic Club launching area by larger craft, although significant numbers of small craft are launched at the club ramp and travel through and around the proposed park area.

In effect then, people belonging to the organised fishing clubs occasionally take migratory fish from the proposed M10 marine park, but take few of the fish species permanently resident in the reef areas.

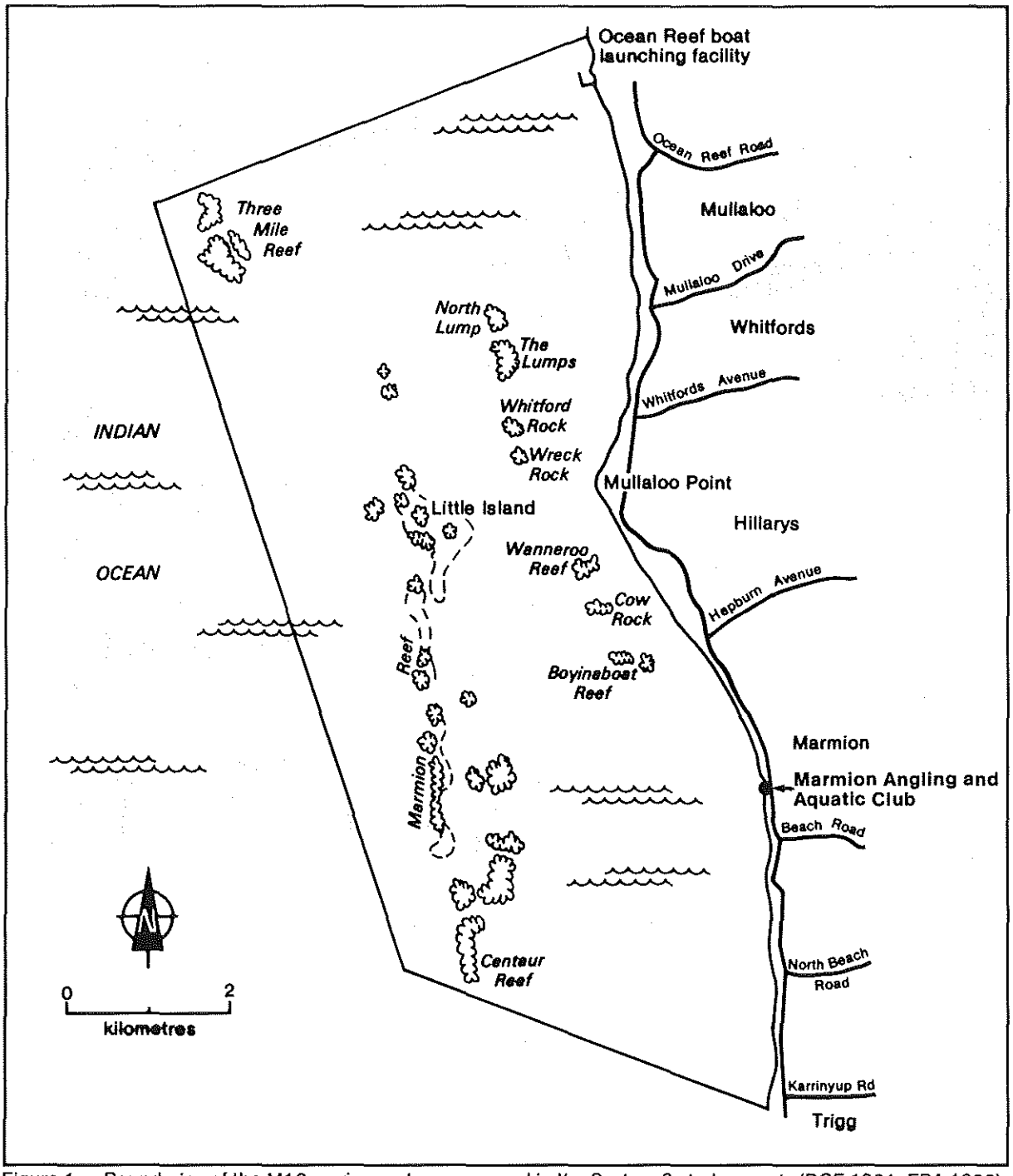

Figure 1. Boundaries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983). General features of the area, and the location of the Marmion Angling and Aquatic Club, are shown.

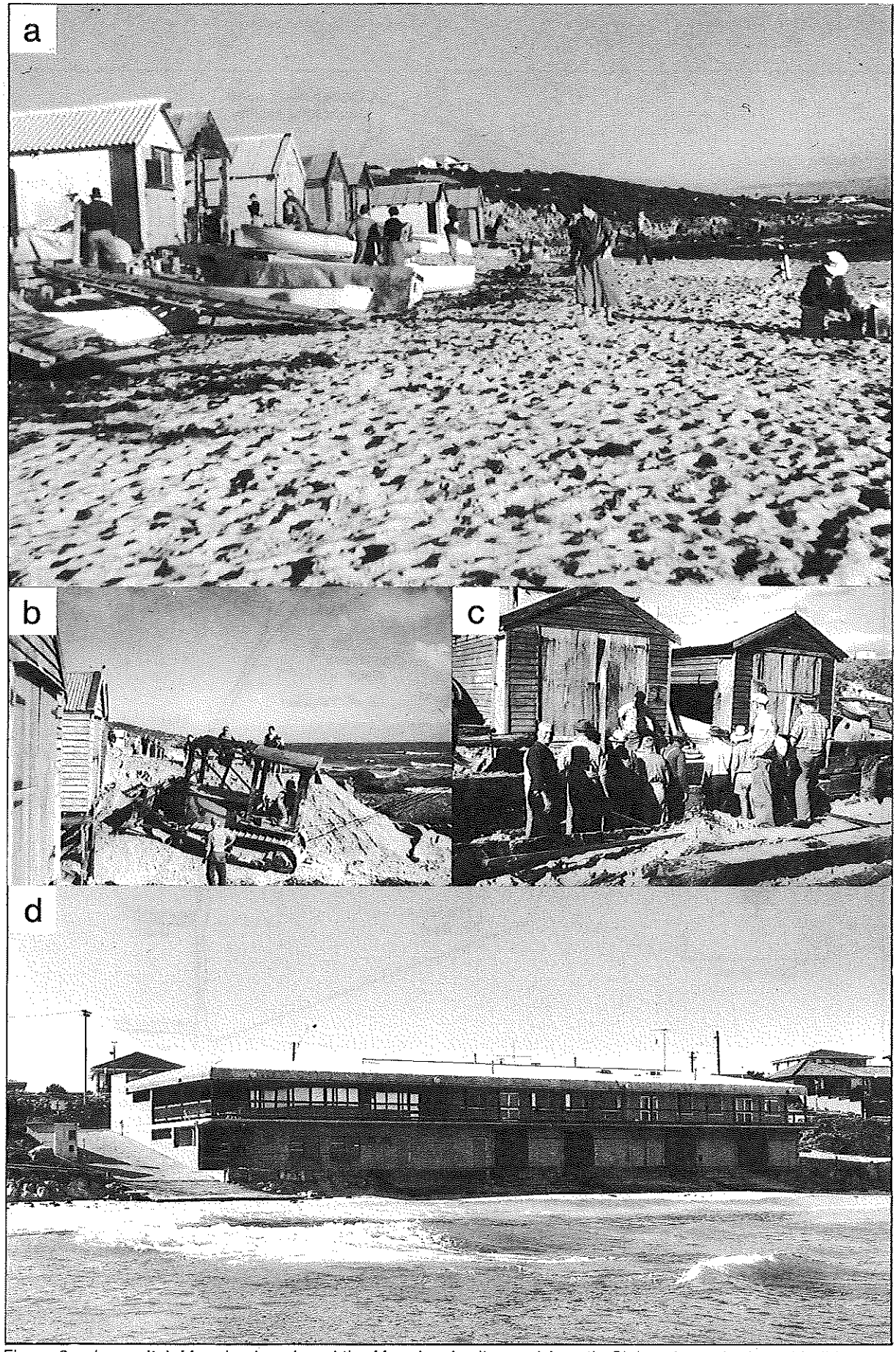

Figure 2. (opposite). Marmion beach and the Marmion Angling and Aquatic Club. a: boat sheds and holiday cottages on the beach, about 1953. b and c: preparations for the construction of the new Club premises (1953). d: Marmion Angling and Aquatic Club (1985). (Photos a-c: Marmion Angling and Aquatic Club archives; d: Department of Conservation and Environment.)

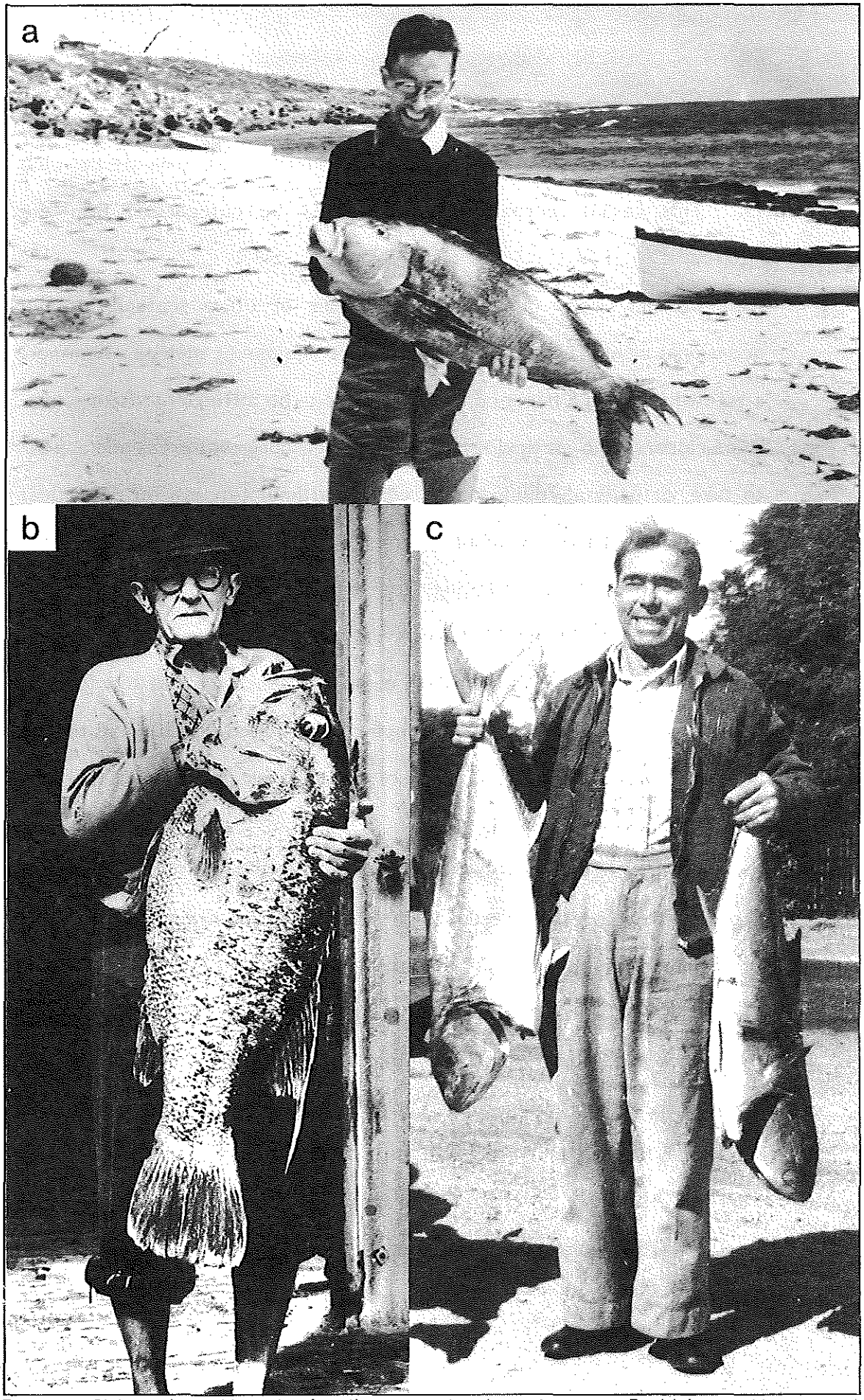

Figure 3. Club members with catches from the proposed marine park area. a: Fred Johnson with queen snapper (about 1954). b: George Kirk with dhufish (about 1955). c: Albert Hull with sampson fish (about 1950). (Photos from Marmion Angling and Aquatic Club archives.)

EFFECTS OF CASUAL RECREATIONAL FISHING

Most of the people who fish in the proposed M10 marine park area are not club members. This casual recreational fishing may be categorised into the following groups.

(i) **Reef-walkers,** who collect enough abalone or other seafood for the occasional meal. These people usually have equipment such as a hammer, a screwdriver and a bag, and mainly appear to be infrequent visitors.

(ii) **Reef-raiders,** who meticulously search the onshore reef areas and appear to take virtually anything that is edible, without concern for ecological implications. This is a minority group of those that fish the area, but they have been observed taking large bags of shellfish, and sometimes including apparently undersize Roe's abalone.

Marmion Angling and Aquatic Club expresses concern about this form of fishing : it indicates excessive cropping of the area which could reduce numbers of reef-dwelling fish, other animals and the general onshore reef community.

No obvious effort has been noticed to curtail this type of activity, and it appears that the staff resources of the inspection branch of Fisheries Department are obviously inadequate. In one instance, a group of reef-raiders was active in front of the Marmion Angling and Aquatic Club : the relevant authority was contacted but the group had taken its haul and left before any action was taken to apprehend these people.

(iii) **Anglers,** who fish from shore or boats. This last group takes mostly migratory fish such as whiting and herring, probably because there are very few reef fish inhabitants left in the proposed M10 marine park. Overall, because most casual anglers take the migratory fish, line fishing

is not considered to be a cause for concern. Barriers in the form of physical restrictions and netting activities, however, are significant problems for line fishermen and are affecting the numbers of migratory fish available to the anglers.

There is no doubt that many fish species have been reduced in numbers in the area of the proposed M10 marine park, and others are now totally absent, as a result of past fishing activities.

CONTROLS

From the preceding discussion, it can be seen that, from the amateur fishing viewpoint, reef-raiding and netting have led to much of the decline in biological resources in the area. It is evident that even existing regulations are not adequately enforced, and one needs to ask what will change if the area becomes a marine park as proposed.

One could also query whether it would be necessary to gazette a marine park if existing regulations were properly enforced, particularly with respect to closed seasons, size and bag limits, methods of capture, netting limitations and boats in open water without the required safety equipment.

Enforcement, of course, is a matter of money for staff and equipment. It will be of no value to create a marine park without adequate regulations, or without the necessary resources to enforce the regulations. As a corollary to this, should the M10 marine park be declared and the management of the area be effective, increased fishing pressures on adjacent areas may hasten the decline of the biological resources of those adjacent areas, unless they too are monitored and effectively policed. This matter of a shift in user pressures

must be thoroughly considered and resolved prior to declaration of a marine park.

MANAGEMENT OF THE PROPOSED M10 MARINE PARK

The proposed park should not be considered out of context of the ecological implications of surrounding areas, and should be considered in context of being a regional community resource. It is considered reasonable therefore that people who use the M10 area should be involved with the management of the proposed marine park. Accordingly, it is suggested that a management board should be established reflecting technical and community interests, and which could make use of the resources of the various State government departments to ensure the best control of the park. Such a board would require a balance of technical and community involvement in the same way as the management boards of Kings Park, the Botanic Gardens, the Zoological Gardens, and Rottnest Island. Rangers would be required, probably to operate specifically in the marine park, and these too could be employed specifically by the management board.

Once the marine park is established, the development of controls and regulations will be a continuous, ongoing process; however, it should not be overlooked that the main purpose of the park should be to allow the general community to use, appreciate, and benefit from its natural resources.

SUMMARY

(i) Some of the casual, unorganised activities currently being practised in the general area of the proposed M10 marine park require control to stop the damage being done, and to arrest the decline of the living marine resources.

(ii) Boat access to the M10 area is not seen as a particular problem at this time, as the availability of small boat launching ramps at present restricts numbers of users; however, assessment of future use pressures, taking into account the proposed Hillarys Boat Harbour and the extra ramps there, will be required.

(iii) Angling for migratory fish is not considered a problem in the M10 area; however, any artificial barrier to migratory fish movements is considered undesirable. Accordingly, we would support a total ban on netting in the M10 area.

(iv) A critical point in the establishment and success of the proposed M10 marine park will be the effective enforcement of park legislation, policy and regulation.

(v) It is suggested that a management board should be established representing community and technical interests, to control development of park facilities and to co-ordinate education of park users. The management board should facilitate community use of the park, while ensuring conservation, protection, and where appropriate rehabilitation of the park's natural resources.

ACKNOWLEDGEMENTS

I thank members of the Marmion Angling and Aquatic Club for supplying information and photographs for use in this paper. The W.A. Department of Conservation and Environment supplied the photograph of the Club building.

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INTRODUCTION TO DISCUSSIONS ON A DRAFT MANAGEMENT PLAN FOR THE PROPOSED M10 MARINE PARK

Dr John R. Ottaway
Chief Environmental Officer, Coastal Waters Branch
Department of Conservation and Environment

DEMOGRAPHIC CHANGES OF PERTH'S NORTHERN METROPOLITAN POPULATIONS

The population of Perth has changed markedly this century (Table 1; Figure 1). The northern metropolitan area has shown particularly rapid growth since about 1970, and predictions indicate that by about 2021 the northwestern corridor will contain about the same number of people as currently live north of the Swan River in the Perth metropolitan area.

TABLE 1 : actual (recorded) and predicted population growth of Perth 1901 - 2021. (Figures from Carr, 1983 : "Perth Towards 2001".)

Year	Population	Year	Population
1901	73,000	1961	475,000
1921	170,000	1981	918,000
1941	260,000	2001	1,500,000
1951	363,000	2021	2,300,000

Furthermore, the relative proportion of recreational, small boat owners has significantly increased (Table 2), and access to the northern metropolitan coastal waters has become easier with development of concrete boat launching ramps at Trigg and Marmion, and the Ocean Reef launching facility in 1979. The construction of the Hillarys Boat Harbour will continue this trend, with another four ramps operational in 1987. Consequently, over the past 30 years, there has been a rapid increase in human pressures on the coastal and offshore

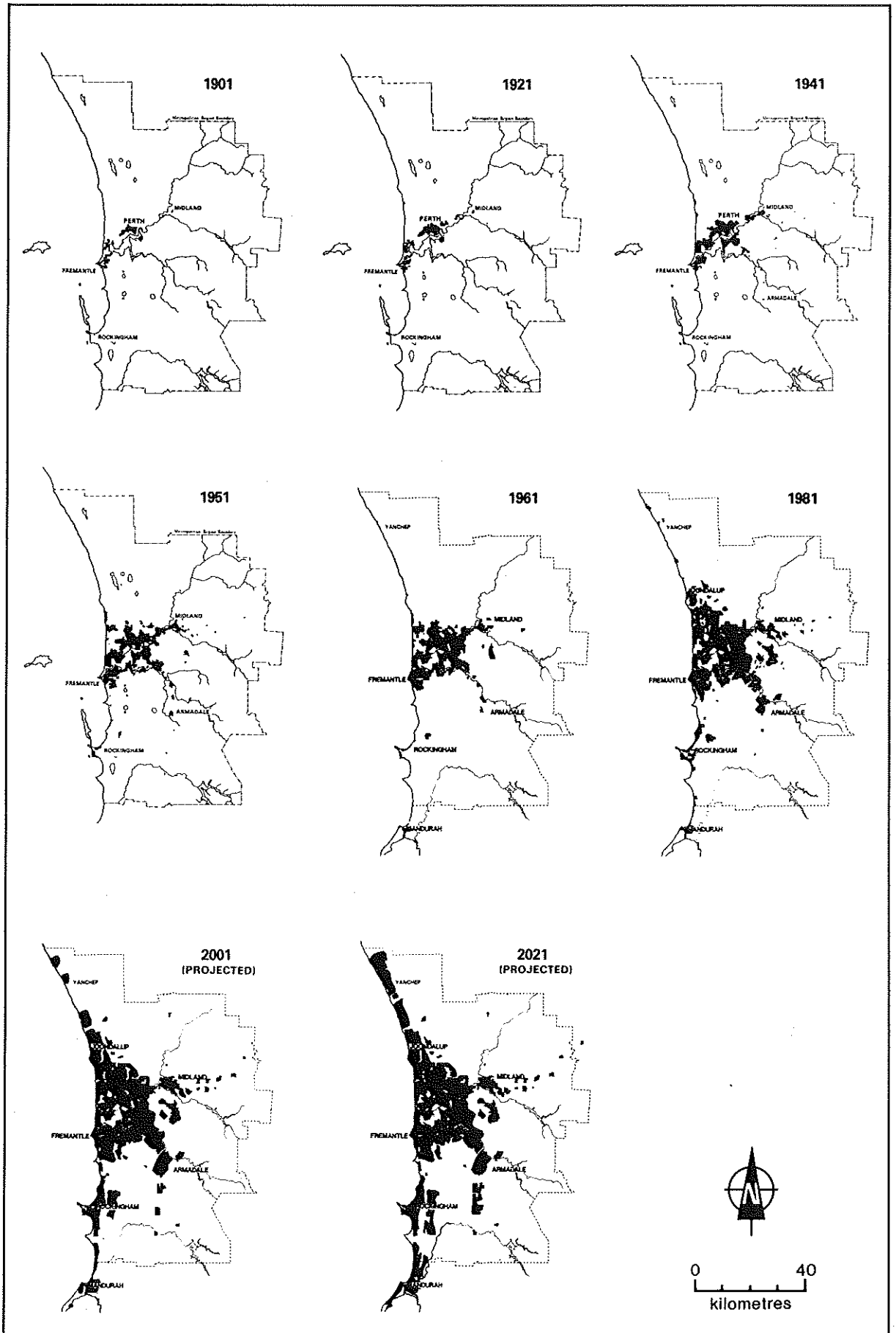

Figure 1. Urban growth of the Perth metropolitan region, 1901-2021. (Reproduced from Carr 1983, with permission of the Western Australian State Planning Commission).

areas of the proposed M10 marine park, particularly from increased recreational use; these pressures, potentially, could continue to increase markedly for another 20 years.

Table 2 : actual and predicted growth of population, and number of boats owned, in the North-West Corridor of the Perth metropolitan area, 1971 - 2021. (Figures from MRPA, 1977 and P.A. Australia, 1981).

Population of North-West Corridor	**Boat owners** (as percentage of total population)	**Estimated number of boats**
1971	2.2	50
1985	4.8	3,300
1993	5.5	7,000
2021 (?)	5.5	18,000

IMPLICATIONS FOR USE OF RESOURCES IN THE M10 AREA

With such marked increases in population of the northern suburbs and in levels of recreational pressures on the M10 area, it is unrealistic to expect that all uses that occurred in the past, and in some instances are occurring now, will continue to be sustainable or acceptable. The physical resources of the area are finite and acceptable use must take into account current community expectations. For example, while in 1960 it was acceptable to speed off-road vehicles along isolated Mullaloo beach, the area is now rapidly developing and will be highly urbanised in 2001 (see Figure 1) : user pressure of the future will undoubtedly dictate that stringent restrictions are placed on the use of off-road vehicles on Mullaloo beach.

The biological resources, while renewable, also have finite limitations on the level of use which can be indefinitely sustained. When the level of use exceeds the reproductive capacity of the biological resource, populations can be reduced to extremely low levels in local areas. An object of fisheries management is to regulate use of populations such that the fished resource is maintained at maximum sustainable yield. If users of the park are to be permitted to take biological resources, all of the affected species need to be similarly managed.

There is no scientific evidence that user pressure has adversely affected any of the biological resources in the area of the proposed M10 marine park; however, there is abundant anecdotal evidence that several species have been markedly affected. This anecdotal evidence will be presented in detail and discussed in a Department of Conservation and Environment technical report (Ottaway, Cary & Robinson, in preparation).

RECOMMENDATION M10 OF THE SYSTEM 6 REPORT

The System 6 Report (EPA, 1983) listed four purposes for the M10 area : scientific, research, education, conservation and recreation. These were not listed, necessarily, in intended order of importance. Part of the purpose of this seminar is to discuss the nature of the M10 area and to record opinions on the order of importance of these four purposes. We also wish to hear the opinions of representatives on whether commercial activities, such as professional fishing, are considered compatible with the philosophy and intent behind the proposal to make this M10 area a marine park.

FORMULATION OF A MANAGEMENT PLAN FOR THE PROPOSED M10 MARINE PARK

The speakers of this morning have indicated already a diversity of views regarding what should be permitted uses of the M10 area. This diversity of views is further apparent from submissions received (Appendix 2) on acceptable zoning of the area : two submissions called for the entire M10 area to be declared high protection, and in effect a marine nature reserve with no extractive or destructive activities permitted (this would effectively exclude such activities as all forms of professional and amateur fishing, and hand collecting of molluscs, corals and any other marine life). There were many combinations of suggested high, medium and low protection areas, and two submissions proposed that the area should be largely low protection (with all activities allowed except trawling, dredging and blasting).

Since most of the organisations which sent in submissions, and many more, have representatives at this seminar, there can be no agreement on the necessary level of management or on acceptable zoning of the area if all representatives hold rigidly to predetermined views.

ORGANISATION OF THE AFTERNOON DISCUSSIONS

Representatives have been assigned to one of eight syndicates. Each syndicate contains a diverse range of interests : members represent conservation groups, recreational fishing groups, professional fishing organisations, local authorities or State government departments, community environmental groups, educational and scientific institutions, and sea sports clubs. Each syndicate is chaired by a representative of the Department of Conservation and Environment, whose function is to ensure that all topics are discussed, that each syndicate member has the opportunity to speak, that a record is made of

points agreed upon or decisions made, and finally to ensure a correct summary of syndicate discussions is available for incorporation into the proceedings of this seminar. Please note that the proceedings of this seminar, and the syndicate reports, will be published and will be made available to the general public.

On the basis of input from all representatives at this seminar, a list has been compiled of the topics of greatest concern for discussion; however, if there is general agreement within a syndicate, any other topic may also be discussed and put into the syndicate's record.

TOPICS LISTED FOR DISCUSSION

1. **Priority of Purpose for the M10 Area**

   What priority is given to the four uses (scientific research, education, conservation and recreation) mentioned in the System 6 Report (EPA, 1983) ?

   Should commercial activities, for example professional fishing, be allowed within the M10 area ?

   What other activities should or should not be allowed in the M10 area ?

2. **Implications of Increasing Recreational Use of the M10 Area**

   Which are the important implications, which need to be addressed in the draft management plan ?

3. **Zoning of Activities**

   Is it necessary to zone activities within the M10 area ? If so, which activities should be zoned, where should the zones be, how large should the various zones be, and should they be fixed or flexible ?

4. **Management**

What is the appropriate management mechanism and authority for the M10 area ? What should be the composition of any management authority ? What powers of regulation and enforcement should the authority have ? Who should pay the cost of management ?

5. **Monitoring, Public Education, and Access of the Public to Information**

Are these functions necessary, and if so at what level ?

6. **Other Issues or Matters for Consideration**

ACKNOWLEDGEMENTS

I thank staff of the W.A. Department of Conservation and Environment, J.L. Cary, M.G. Kerr and J.E. Robinson, for researching the data used in this paper.

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SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 1

Chairman : C Simpson

Members : M Butcher
R Lethbridge
A O'Connor
V Panizza
K Pearce
P Pruden
B Richard
G Saueraker
W (Bill) Spencer

1.1 PRIORITY OF PURPOSE

The syndicate grouped priority of purpose in the following manner.

(i) All agreed that conservation was the priority, but only in respect to its application to the other uses (for example, recreation and education).

(ii) Recreation.

(iii) Education.

(iv) Scientific research.

(v) Professional fishing.

Most members felt that the professional fishermen should not be excluded from the reserve unless there is clear evidence that negative aspects to the community, of professional fishing, outweigh the beneficial aspects.

1.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

General agreement was reached that the general M10 area would be under ever-increasing pressure due to urban development in the next twenty years, and that management was necessary to regulate the use of the resources on a rational basis. Members outlined areas of concern.

(i) Increased pollution from sewage, litter and fuel spills (especially from the vessels using the Hillarys Boat Harbour) to the general M10 area.

(ii) Depletion of marine life by both professional and amateur interests (for instance, by fishing and collecting).

(iii) Loss of sandy beaches caused by the presence of the Hillarys Boat Harbour and by possible erosion of existing beaches (as a consequence of the boat harbour, or by users trampling stabilising dune vegetation).

(iv) Increased erosion of rocky headlands and intertidal reefs by human pressure.

(v) Increased pressure from developers on the landward portion of the proposed M10 marine park.

1.3 ZONING OF ACTIVITIES

Most agreed the concept of zoning was good, but that the number of zones should be low to avoid confusion and the difficulty of policing any offshore zones. Most agreed that high protection areas, containing representative habitat types, were necessary: however, these areas should be a small proportion of the M10 marine park. The size of the area suggested by the Fisheries Department was considered, by some members, to be suitable. Other members considered the Fisheries Department suggestion inadequate. Concern was expressed by one

member over the suggested exclusion of people from Little Island.

Most agreed that a monitoring programme was essential, and that zoning should be flexible and reviewed periodically, in order to make use of any new information gained. Some members considered that a review of the marine park zoning should take place every five years.

1.4 MANAGEMENT MECHANISMS

Composition of the Management Authority.

Most thought that the management of the marine park should come under existing State legislation, and that a management committee consisting of representatives from these State government departments, and other organisations with interests in the M10 marine park, should be set up as an advisory body. Most members agreed that a management presence (that is, marine park rangers) should be established.

Who Pays?

Most agreed that the State government should fund the management of the marine park, with additional funding coming from private interests using, or associated with, the Hillarys Boat Harbour.

Powers of the Management Authority

This was little discussed, but syndicate members thought that education of users and the public generally, rather than regulation, should be a primary management objective.

Staff Requirements

At least ranger(s) and a public education officer were required.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 2

Chairman : E Paling

Members : J Davis
B Evans
D Hay
R Leman
D Mills
M Neave
M Venning

2.1 PRIORITY OF PURPOSE

The syndicate grouped priority of purpose in the following manner.

(i) Conservation, education, scientific research (first priority, all equal).

(ii) Recreation (second priority, consistent with above).

Professional fishing was not considered to have priority, and, in fact, the syndicate concluded that professional fishing should be banned from within the boundary of the proposed M10 marine park.

It was considered that the increasing population pressure (particularly competition from amateur fishermen) would eventually force the professional fishermen out of the area. All members of the syndicate agreed it was simply a matter of time before professional fishermen would have to move further north or south; hence, banning professional fishermen from the M10 marine park would simply accelerate an

inevitable process.

In the instance of the rock lobster fishery, it was concluded that most of the catch was probably outside the M10 area, in deeper water westwards of the Three Mile Reef and Marmion Reefs area, and that rock lobster fishermen banned from the M10 marine park area would probably catch most of those lobsters anyway, but in deeper water.

It was noted there were discrepancies in the various figures given by different authoritative sources for the numbers of professional lobster fishermen and abalone fishermen operating within the proposed M10 marine park and the metropolitan area generally. It was concluded that the professional abalone divers should also move out of the M10 area.

2.2 IMPLICATION OF INCREASING RECREATIONAL USE

This was little discussed. It was considered that the more obvious recreational uses should be controlled, to fit the objectives of a marine recreational park. The increasing use of boats and beaches, and the increasing pressure of recreational fishing, could be "softened" by appropriately zoning the M10 area (see 2.3 below).

As the population of, particularly, the northern suburbs increases there will be increased boat traffic in the M10 area, and less "room to move". This was inevitable. It was important that zoning allow at least some of the local fish populations to recover.

2.3 ZONING OF ACTIVITIES

This topic was of greatest concern to members. Rigid (non-flexible)

zoning was considered to be the better alternative. Nevertheless, it was concluded that zones should be monitored, and reviewed perhaps five years after they were declared.

Two categories of zones were suggested for the proposed marine park,

(i) **high protection**

This should include all reef areas, including exposed and submerged reefs.

(ii) **low protection**

To include areas used by "boats in transit"; for example, areas to the north and south of the proposed Hillarys Boat Harbour, between the Marmion Reef chain and the coast.

The syndicate members agreed that entry/exit channels from the Hillarys Boat Harbour and from the M10 area should be clearly marked (perhaps using buoys) for vessel safety. Also, the marking of high protection areas around the reefs could be undertaken in the same way, with the limit of high protection areas some 250 metres to 500 metres away from the reefs, either with or without marked mooring facilities.

It was considered the following activities should be banned from the entire area of the proposed M10 marine park :

- netting for fish
- spearfishing
- taking of crayfish on compressed air
- taking of abalone by amateurs (some syndicate members dissented)
- all professional fishing.

Members were equally divided on whether all line fishing from boats should be banned from the park, except from the beach.

Also, it was concluded that any zoning scheme should include the beaches, to protect the beaches and dune areas, to minimise impacts of structures such as kiosks, car parks, the Hillarys Boat Harbour, and so on. It was felt strongly that the coastal zone for the proposed M10 marine park should be protected.

2.4 MANAGEMENT MECHANISMS

Composition of Management Authority

It was felt that a single management authority should be set up, for the M10 marine park, similar in function to the Kings Park Board, the Rottnest Island Board, or the Swan River Management Authority, but that the M10 area should be vested in the Department of Conservation and Land Management (CALM). Syndicate members also felt that jurisdiction of the M10 coastal land, presently in Wanneroo Shire and the City of Stirling, should be taken over by this M10 management authority.

Who Pays?

This was discussed only briefly, but it was concluded that since users would be from all areas of metropolitan Perth, the State government should make adequate funds available to CALM to manage the M10 marine park. Users should make some contribution, however, through boat launching fees and mooring fees.

Powers of the Management Authority

Again, little discussed. Generally felt that enforcement of regulations

should be carried out by the management authority, in co-operation with Department of Fisheries inspectors. Should have designated marine park rangers, and facility for checking returning boats.

Staff Requirements

Not discussed.

Education

Public education was considered of primary importance, particularly to inform and educate users about the reasons for zoning.

2.5 OTHER CONSIDERATIONS

(i) It was agreed that there should be further marine reserves and marine parks on other parts of the coast; and

(ii) the boundaries of the M10 marine park as proposed should be redefined, particularly to be extended northwards to include the onshore, intertidal reefs north of the Ocean Reef boat launching facility.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 3

Chairman : R Chittleborough

Members : G Andrich
J Cary
S De La Hunty
J Fitzpatrick
R Lenanton
R Prince
J Robinson
G Smallacombe

3.1 PRIORITY OF PURPOSE

The syndicate grouped priorities in the following order.

(i) Conservation, with highest priority on education and scientific research.

(ii) Recreation and professional fishing should be facilitated to the extent that they do not conflict with conservation aims.

One syndicate member dissented, and considered that recreation should be the major purpose of the proposed M10 marine park.

3.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

It was agreed that recreational pressures (and other use pressures) will have to be regulated. Syndicate members suggested this could be done through three approaches.

(i) Control of access through the coastal strip of land (western side of highway). This should be incorporated into the marine

park, or an integrated management plan worked out with the local authorities.

(ii) Exclusion, from the entire marine park, of activities not compatible with the conservation objectives. For example :

- collecting of shells, corals and algae
- spearfishing with SCUBA or hookah
- waste discharge
- trawling
- dredging
- mining and blasting
- any major works not compatible with conservation.

(iii) Zoning of other activities permitted within the park (see item 3.3, below).

3.3 ZONING OF ACTIVITIES

No spearfishing at all along coastal reefs or beaches. Exclusion zones (look, but don't take) kept to a small number : would accept the two 500 metre radius zones proposed by Fisheries Department, plus all the coastal reefs.

Separate areas should be specified for windsurfing, water skiing and similar activities (for safety, rather than conservation).

3.4 MANAGEMENT MECHANISMS

Composition of the Management Authority

Most agreed that under existing legislation, CALM, should manage, with guidance from the National Parks and Nature Conservation Authority. Syndicate members suggested there also be an advisory body with

representatives of user groups and local authorities. The view was expressed that Fisheries Department could share management responsibility for the marine park (but most syndicate members disagreed because Fisheries Department clearly has a vested interest in one user group : commercial fishing). Management body must have marine park rangers/inspectors with adequate powers.

Education

Group stressed education of users most essential, to ensure their support in self-regulation. This would be much more effective than coercion. (One example of a user group which could be the focus of an education program is the Youth, Sport and Recreation camp on east side of highway).

3.5 OTHER CONSIDERATIONS

(i) The syndicate unanimously endorsed Recommendation M10 of the Environmental Protection Authority (1983), that there should be a marine reserve in the area.

(ii) Research by CSIRO, the Department of Fisheries, the universities and DCE, should be used as a basis for the management plan.

(iii) Fishing industry representative said the abalone fishery is now even more valuable, as price is escalating due to depletion of stock. Amateur fishing representative expressed concern that reef walkers (the reef-raiders described by John Farrell) take everything in sight (especially abalone). There seemed to be a lack of confidence in management by Fisheries Department.

Was suggested that perhaps onshore reefs should be totally protected.

(iv) Fisheries Department representative claimed that Fisheries Act prevails over the CALM Act (1984) with respect to marine reserves. That statement should be verified.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 4

Chairman : R B Humphries

Members : J Farrell
J Hunter
F Jacobi
R Shepherd
A Smith
Wayne Spencer
G Stewart
B Wilson

4.1 PRIORITY OF PURPOSE

The syndicate grouped priorities in the following order.

(i) Recreation and education (top priorities), and

(ii) conservation (secondary priority).

Conservation should be achieved without exclusion of users. Preservation reserve should be more remotely located, so that difficulty of human access may be used as a management tool.

Compatible uses, of the reserve area, were discussed.

(i) Limited blasting, for the purpose of setting up navigation aids, and then only if no other method is available.

(ii) Professional fishing is considered to be compatible with the intended uses of the reserve area, providing it is properly managed. There should be no netting, either professional or

amateur in the marine reserve.

(iii) While the fish resources are renewable, it needs to be understood they are also finite. There should be regular stock assessments to ensure that no long-term reduction of stocks occurs (this applies to fish stocks taken by recreational fishing, as well as professional fishing).

(iv) Spearfishing is considered an incompatible activity, for the whole area.

4.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

(i) Increasing pressure from recreational users is inevitable. This will probably lead to decrease in the level of professional fishing, because of increased numbers of amateurs competing for the fish resources.

(ii) Development of education activities will lead to increasing (non-exploitative) use of the M10 area.

(iii) Can expect (and will need measures to control) anchoring and anchor damage, marine disposal of garbage, trampling of onshore platform reefs and loss of species from M10 area, damage to beaches and dunes, and boat noise (from fast-moving speedboats) frightening fish.

(iv) Need clear separation of activities; for example divers and diving areas must be separated from boat traffic corridors.

4.3 ZONING OF ACTIVITIES

(i) Fisheries Department proposals generally acceptable.

(ii) 500 metre wide high protection area required around Little Island. There should be no landing on the island.

(iii) No angling or landing on the nearshore reefs (Wanneroo Reef, Cow Rocks, Boyinaboat Reef, Whitford rock, and Wreck Rock). Fixed moorings should be established for small boats, so that people can look at and touch marine life on the reefs, but not collect or damage. Need to take account of boats using Hillarys Boat Harbour (HBH), and impact of HBH on Boyinaboat Reef and Cow Rocks.

(iv) Members are concerned about proliferation of moorings outside HBH; this should be controlled.

(v) There should be no spearfishing or netting anywhere in the proposed M10 marine park.

4.4 MANAGEMENT MECHANISMS

Composition of the Management Authority

Various Acts already exist :

Fisheries Act 1905-1979 (as amended)

Conservation and Land Management Act 1984

Marine and Harbours Act 1981

Local Government Act 1960-1981 (as amended)

Western Australian Marine Act 1982

Fremantle Port Authority Act 1902-1969

plus various international treaties.

CALM should be the management authority, and form an advisory committee including professional expertise from the following groups :

Department of Marine and Harbours

Department of Conservation and Environment

sea sports clubs from the Trigg to Ocean Reef area

professional fishing organisations

boating representatives

local government authorities

Who Pays?

Funding should be from government, through CALM. Should not adopt "user pays" principle.

Powers of the Management Authority

These are specified already by existing Acts (listed above).

Staffing Requirements

A ranger should be assigned to the M10 marine park, and should be based at Hillarys Boat Harbour. Other staff requirements not discussed.

Education

CALM budget should make provision for this. One or two education centres could be developed along the coast of the M10 marine park, and perhaps one education centre associated with the Hillarys Boat Harbour.

Monitoring

The Department of Fisheries is already monitoring some stocks. Could use amateur fishermen to catch, measure and return fish; Department of Fisheries and CALM should analyse data and make joint report. An annual report is necessary.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 5

Chairman : P Woods

Members : B Churchward
J Clarko
F Csiczac
D Edwards
J James
R Muller
H Nankivell
W West

5.1 PRIORITY OF PURPOSE

The differences between a marine nature reserve and a marine park, as defined in the CALM Act (1984), were clarified and discussed.

Considering various aspects, it was concluded that the normal (present) range of recreational activities were acceptable, and should be permitted to continue; hence the area should be classified as a marine park.

After lengthy discussion, the syndicate grouped priority of purpose in the following manner.

(i) Balanced conservation with compatible recreational activities were the most important uses of the proposed marine park. There was strong support for recreation being the primary purpose of the park, but it was recognised that conservation of resources was important to maintain the recreational value of the area.

(ii) Education and scientific research were seen as side benefits of the proposed marine park.

(iii) Professional fishing. Strong arguments were made and generally accepted that professional fishing should be a permitted use of the marine park, although there was some dissension on conservation grounds. Overall, however, agreement was reached that the present level of rock lobster fishing can be accommodated for the present.

5.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

Discussion concentrated on the principle that forward planning on a wide scale was needed, as the M10 area has only limited capacity. Unless other marine areas were also set aside, the capacity of M10 would be quickly exceeded by increasing pressure from recreational users, thus defeating the primary purpose for which the M10 area should be managed. It was suggested other areas further northwards should also be "reserved" for future generations.

It was then agreed that there is a need for forward planning in recognition of the limited capacity of the proposed M10 marine park, and that other marine areas should be set aside for future marine parks.

5.3 ZONING OF ACTIVITIES

Zoning, of both land and water areas, was discussed in detail. The concept of zoning was accepted with the condition that declaration of high protection areas should follow only from valid, demonstrated reasons for doing so. It was agreed that :

(i) zoning is acceptable;

(ii) high protection areas are acceptable, where appropriate;

(iii) user-group zoning, for the coastal land, is acceptable in order to separate potentially conflicting activities (for example, to separate horse and dog exercise beaches from family recreation beaches); and

(iv) all netting activities (recreational and professional) should be phased out of the proposed park area.

5.4 MANAGEMENT MECHANISMS

Composition of the Management Authority

It was accepted that the overall management authority would be some governmental agency, such as CALM; however, local government authorities and user groups should also be involved in the management.

It was suggested that the eastern boundary of the park should be the West Coast Highway. This raised the question of land vesting, local government authority involvement, and who would have the powers of management and enforcement of regulations. One syndicate member pointed out that a change in present land vesting arrangements would require an Act of Parliament.

Who Pays?

There was strong support for a user-pays philosophy, where direct charges can be made for use of facilities.

Power of the Management Authority

The overall management body (for example, CALM) should have the powers to co-ordinate management, monitoring and enforcement.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 6

Chairman : K Grey

Members : C Hearn
A Kinnear
H Kirkman
G Major
D Rose
M Rose
P Sharp
J Penn
W Wood

6.1 PRIORITY OF PURPOSE

The syndicate considered the following purposes were acceptable, but did not assign any particular order of priority.

(i) Scientific research. Should be conducted in the M10 area, but by permit only to avoid or control destructive sampling.

(ii) Education. Was considered very important. Need areas, such as Waterman Reserve, managed at a level for education purposes. Important to preserve coastal reefs for education, as they are a valuable accessible resource.

(iii) Conservation. Was agreed this was important for the proposed M10 marine park area.

(iv) Recreation. No collecting should be allowed of vulnerable species such as shells and coral. Spearfishing could be allowed in some areas, with the stipulation that a regular review be

undertaken of the effects of spearfishing.

(v) Professional fishing. No changes were wanted to existing arrangments. No member of the syndicate had any strong argument to oppose professional fishing in the area.

6.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

The main issues raised by members are listed below.

(i) Whether there will be a conflict between amateur and professional fishing in the area.

(ii) Whether enough reef areas are to be set aside for education purposes, considering the increasing recreational use.

(iii) Reserving certain areas for particular activities could cause management problems.

(iv) Monitoring programmes should be reviewed on a regular basis to determine whether they are effective.

(v) It is essential to have some continuing assessment of resources and species diversity within the reserve.

6.3 ZONING OF ACTIVITIES

The principle of zoning of activities, and selecting areas for high, medium and low protections, was accepted.

(i) High, medium and low protection areas need to be defined carefully.

(ii) Nearshore reefs, such as the Lumps and Boyinaboat Reef, need high protection. These reefs are the most useful for recreation, but need protection.

(iii) Onshore, intertidal reefs should be medium protection areas.

(iv) Rock lobster fishing should be allowed.

6.4 MANAGEMENT MECHANISMS

Composition of Management Authority

Should be composed of representatives from fishing, scientific, education, conservation and recreational organisations. Advice from these representatives should be taken into account by the reserve managers. One member made the point, very strongly, that the Surf Live Saving Association should be included in the advisory body, to have input into matters relating to coastal recreation and water safety.

Who Pays?

Declaration of the marine park is pointless without State government commitment to adequate level of funding. Perhaps public funding could also be encouraged by allowing donations to be tax-deductible.

Powers of the Management Authority

Not discussed.

Staffing Requirements

It is essential that CALM be allocated extra staff and resources by the State government; for example, extra funds are essential for marine park rangers to enforce management regulations, and also to educate the public generally and users specifically.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 7

Chairman : R Wallis

Members : P Berry
I Eliot
B Hicks
J Penrose
D Strickland
P Thompson

7.1 PRIORITY OF PURPOSE

The syndicate grouped priorities in the following order.

(i) Recreation and professional fishing (equal highest priority).

(ii) Conservation : this is necessary to maintain the quality of recreational activities, and to maintain the professional fisheries.

(iii) Education and scientific research : low priorities.

7.2 IMPLICATIONS OF INCREASING RECREATIONAL USE

Syndicate members saw the following needs.

(i) Conservation measures to protect the reserve resources for recreational activities; for example, regulation of reef-walking activities to maintain diverse reef communities.

(ii) Public education, to have members of the general public assist, by their behaviour, to preserve the area. Public education should include also programmes for schools and sporting clubs,

and should make use of media advertisements to "get the message across".

(iii) Monitoring should be designed to determine whether use-impacts are affecting the area; conversely, whether management policities to minimise user impacts are effective.

(iv) Boat and vessel traffic across the M10 marine park area should be minimised; for example, use of Hillarys Boat Harbour by Rottnest Island ferries should be opposed.

7.3 ZONING OF ACTIVITIES

In general, the conclusion was that the simplest form of zoning should be applied. This would facilitate management and enforcement of zones. The following zones are recommended (listed below).

(i) Water-skiing area off Whitfords beach.

(ii) Horse exercise area, south of Mullaloo Point.

(iii) The existing Waterman's Reserve should be extended to 500 metres radius.

(iv) The professional abalone fishery, from Marmion to Trigg, should be permitted to continue.

(v) No spearfishing at all in the proposed M10 marine park area.

(vi) Little Island should be made a high protection area, to a radius of 500 metres. Some of the nearshore reefs should be similarly protected. No destructive uses should be permitted in these high protection areas.

(vii) Beach areas should be designated for specific purposes (for example, "general recreation" as against "nude beach" or "animal exercise beach").

(viii) Access to beaches must be controlled. This could be done

through provision of access paths, and provision of facilities, at suitable sites.

In a general zoning context, the question of status of the West Coast Highway was considered important for control of beach usage. It was suggested that the West Coast Highway, from Trigg to Sorrento, could become a local-use road. This could be achieved by discontinuing the road at some point between Trigg and Scarborough, and not connecting the road to Hepburn Avenue.

All zones put into effect by the management authority should be flexible. Their status should be evaluated by environmental monitoring, and status of zones changed as and when required, in the same manner that the professional abalone fishery is managed.

7.4 MANAGEMENT MECHANISMS

Composition of Management Authority

The syndicate was uncertain which agency had jurisdiction over the area. Suggestions included various combinations of :

Department of Conservation and Land Management

Environmental Protection Authority

Department of Marine and Harbours

Department of Fisheries

Another suggestion was a management board, possibly similar to the Rottnest Island Management Board, or the Kings Park Management Board. This board could manage all marine reserves in Western Australia, but should have a local secretariat for each reserve; for

example, this M10 marine park would have a local secretariat dealing only with M10 matters. The secretariat could consist of representatives from CALM, Fisheries, Wanneroo Shire council, Stirling City Council, recreational user groups, and so on, but the secretariat would have an advisory function only. The secretariat would require a full-time secretary and full-time field personnel.

There needs to be resolution of the respective roles of Public Works Department and the Metropolitan Region Planning Authority. Syndicate members felt these bodies should be excluded from ongoing roles in the marine park management.

Who Pays?

Since the main use of the area will be recreation, recreational users should pay, perhaps through the Department of Sport and Recreation.

Powers of the Management Authority

The functions of the secretariat are suggested below.

(i) Control of monitoring programs. Assessment and corrective measures.

(ii) Control of continuous educational activities, making use of school programs and media releases.

(iii) Control of field officers.

Staffing Requirements

At the very least, a full-time secretary and field personnel.

Education

Public education is seen as a major issue. Will need sustained effort. Information should be given in appropriate languages, including languages of ethnic minority groups using the resources of the area.

SUMMARY OF DISCUSSIONS ON THE PROPOSED M10 MARINE PARK

SYNDICATE 8

Chairman : M Kerr

Members : W Alpers
K Elliott
F Douglas
D Grinceri
H Jones
R MacFarlane
B Mongan
I Spaulding
J Watkins

8.1 PRIORITY OF PURPOSE

The syndicate grouped priority of purpose in the following manner.

(i) Recreation and professional fishing. These were considered the main purposes of the proposed marine park.

(ii) Scientific research and education. These were considered important, secondary purposes.

(iii) Conservation. An essential purpose in this particular marine park, to maintain suitable resources for the other uses.

(iv) Emphasising (i) above, all forms of professional fishing should be allowed unless monitoring or scientific research indicates some aspects of professional fishing are deleterious or having undue impact on reserve. Excessive impact on reef-dwelling fish was discussed.

8.2 IMPLICATIONS OF INCREASING RECREATOINAL USE

(i) Leads to conflict between all user groups.

(ii) Access to the area is a major issue. Need to look carefully at various options.

(iii) Value of the proposed M10 marine park area might be destroyed by overuse.

(iv) Professional fishing in the area may diminish, due to increasing pressure on stocks by increasing numbers of recreational users.

(v) Congestion of West Coast Highway could develop into a major problem. Need to estimate maximum use of locations, and possibly re-route West Coast Highway if necessary.

8.3 ZONING OF ACTIVITIES

(i) All present activities should be allowed.

(ii) General agreement with the Fisheries Department proposals; that is, make Little Island a high protection area (sanctuary) and increase size of Watermans reserve.

(iii) The onshore, intertidal rock platform opposite Bennion Street should be given high protection and used for education and research.

(iv) May be necessary to increase the number of zones and levels of protection because of presence of the Hillarys Boat Harbour.

(v) No scientific evidence has been presented to support banning of spearfishing.

(vi) Areas for scientific research are not catered for in the Fisheries Department proposals.

(vii) Much more monitoring and research is needed before marine zones are allocated.

(viii) Flexibility in zoning is implicit in the planning and management process.

8.4 MANAGEMENT MECHANISMS

Composition of Management Authority

A separate authority should be set up to manage coastal areas, since there is a combination of land and sea involved. That authority could be either independent of government, or could be a separate section in a government department.

There may be problems of conflicting interests between management authority and other authorities. Necessary to co-ordinate different agencies for effective management.

Who Pays?

Users should pay costs of managing the proposed marine reserve.

(i) Professional fishing : users pay.

(ii) Boat launchers pay ramp fees.

(iii) Management authority could fund necessary research and monitoring, undertaken by other departments and organisations.

(iv) The management authority should have a separate budget to manage the marine park.

Powers of the Management Authority

(i) Fisheries Department representative states Fisheries Act overrides CALM Act in proposed M10 marine park. This situation should be clarified.

(ii) Stricter regulations, than those existing at present, may be necessary.

Staffing Requirements

(i) Minimum is one professionally qualified, full-time park ranger.

(ii) Greater effort in enforcing regulations may be necessary, and could require two rangers.

Public Education

Various possibilities were suggested. Some are listed below.

(i) Local papers.

(ii) Workshops and seminars.

(iii) Ranger(s) should educate users, in addition to enforcing regulations.

(iv) Brochures should be prepared explaining the various aspects of the park. These should be available to the general public free of charge.

(v) Nature trails, underwater and above water, could be set up to encourage non-destructive recreation, and general nature appreciation.

(vi) Extensive, comprehensive, public education program is required.

(vii) Adequate public education will make enforcement easier.

Monitoring

(i) More research is needed on reef-dwelling fish, including the impacts of fishing on reef fish populations.

(ii) More research is needed on natural processes in the marine environments.

(iii) A beach use survey is required.

(iv) Research and monitoring are seen as major tools for effective management.

APPENDIX 1 : participants in the seminar on the proposed M10 marine park, held on 12 June 1985 at the Marmion Angling and Aquatic Club, West Coast Highway, Marmion, Western Australia.

Amateur Fishermen's Interest Group
B. Mongan, Secretary

Australian Democrats
G. Major, delegate, WA Division

Australian Fishing Industry Council
G. Stewart, Executive Officer (1979 - June 1985), WA Branch

Australian Labor Party
P. Beggs, MLA (Member for Whitford)
G. Edwards, MLC (North Metropolitan Province)
R.F. Edwards, MHR (Federal Member for Stirling)
J. James, electorate assistant (of Federal Member for Stirling)
J.P. Watkins, MLA (Member for Joondalup)

Australian Liberal Party
J.G. Clarko, MLA (Member for Karrinyup)

Australian Underwater Federation (WA Branch)
G. Saueracker

Boating Industry Association of Australia
J. Fitzpatrick, Chairman

City of Stirling
B. Evans, Town Clerk

Commonwealth Scientific and Industrial Research Organisation Marine Laboratories, Marmion
H. Kirkman, Research Officer

Conservation Council of WA
W. Alpers, member
B. Churchward, assistant

Conservation and Environment, WA Department of

M. Butcher,	Information Officer
J.L. Cary,	M10 marine park study team
R.G. Chittleborough,	Chief Research Scientist
K.A. Grey,	M10 marine park study team
D. Grinceri,	M10 marine park study team
M.G. Kerr,	M10 marine park study team
C. McDavitt,	Technical Officer, Division of Applied Ecology
D.A. Mills,	Research Scientist, Coastal Waters Branch
M. Neave,	M10 marine park study team
J.R. Ottaway,	Chief Environmental Officer, Coastal Waters Brar
E.I. Paling,	M10 marine park study team
C.F. Porter,	Director
J.E. Robinson,	M10 marine park study team
C.J. Simpson,	Environmental Officer, Coastal Waters Branch
R. Wallace,	Environmental Officer, Evaluation Branch

Conservation and Land Management, WA Department of

R. Prince,	Senior Research Officer (Wildlife Research Centr
B.R. Wilson,	Director of Nature Conservation

Environmental Protection Authority

B.A. Carbon,	Chairman

Federation of Australian Underwater Instructors

D. Hay, member

Fisheries Department, WA

H. E. Jones,	Research Officer
R. Lenanton,	Research Officer
J. Penn,	Research Officer

Foreshores and Waterways Protection Council

S. de la Hunty, President

Fremantle Professional Fishermen's Association

G. Andrich, member

Marine and Harbours, WA Department of

A. Smith, Acting Principal Engineer, Engineering Division
W. Spencer, Manager Shipping & Transport, Marine Division

Marmion Angling and Aquatic Club

J. Farrell, President

Murdoch University
M. Borowitzka, Lecturer
J. Davis, Tutor

Quinns Rock Recreation Association
M. Venning, member

Scuba Divers Federation (WA)
R. Muller, President

Seabird and Ledge Point Professional Fishermen's Association
F.W. Douglas, President

Shire of Wanneroo
P. Thompson, Shire Planning Officer

Sorrento Marina Watchdog Committee
R. Leman, member
P. Pruden, member

Sorrento Surf Lifesaving Club
D. Rose, President

South West Professional Lobster and Net Fishermen's Association
I. Spalding, President

Sport and Recreation, WA Department of
P. Sharp, Research Officer

Trigg, North Beach & Waterman Community Association
D.M. Edwards, President

Two Rocks Professional Fisherman's Association
K. Pearce, President
W. West, Secretary

University of Western Australia
I. Eliot, Senior Lecturer, Geography Department
K. Elliott, Geography Department
C. Hearn, Research Fellow, Civil Engineering Department
A. O'Connor, Geography Department
V. Panizza, Geography Department
R. Shepherd, Geography Department
W. Wood, spokesperson, University marine laboratories

WA College of Advanced Education, Churchlands
A. Kinnear, Senior Lecturer

WA Institute of Technology
J.R. Hunter, Senior Research Fellow, School of Physics and Geosciences
J. Penrose, Director, Centre of Marine Sciences and Technology

WA Museum
P. Berry, Curator of Natural Science

WA Recreational Fishing Council
F. Csiczak, Secretary

Wanneroo Beaches Action Group
Y. Lee, member
R. McFarlane, President
M. Rose, Vice President

West Coast Roei Abalone Diver's Association
F. Jacobi, member
D.J. Strickland, member

Whitfords Bay Sailing Club
H. Nankivell, President

Women Against Marina Organisation
B. Richard, member

Other participants

R.B. Humphries,	environmental consultant
W. Spencer,	professional abalone diver
P.J. Woods,	coastal management consultant

APPENDIX 2 : zoning submissions for the proposed M10 marine park, received by the Department of Conservation and Environment.

APPENDIX 2a : list of groups (in alphabetical order) from whom zoning submissions were received.

APPENDIX 2b : boundries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983). General features of the area are shown.

APPENDIX 2c : zoning submissions for the proposed M10 marine park, received by the Department of Conservation and Environment. Submissions have been arranged in approximate order from those indicating highest overall protection, to those indicating lowest overall protection.

APPENDIX 2a : list of groups (in alphabetical order) from whom submissions were received.

Amateur Fishermen's Interest Group

Australian Fishing Industry Council

Australian Marine Sciences Association (W.A. Branch)

Australian Underwater Federation (W.A. Branch)

City of Stirling

Conservation and Land Management, W.A. Department of

Education Department (W.A.)

Fisheries Department (W.A.)

Marmion Angling and Aquatic Club

Northern Districts SCUBA Club

Recreational Fishermans Interest Group

SCUBA Divers Federation of W.A.

Shire of Wanneroo

Sport and Recreation, W.A. Department of

Trigg, North Beach, Watermans Community Association

University of Western Australia

W.A. College of Advanced Education (Churchlands)

W.A. Institute of Technology

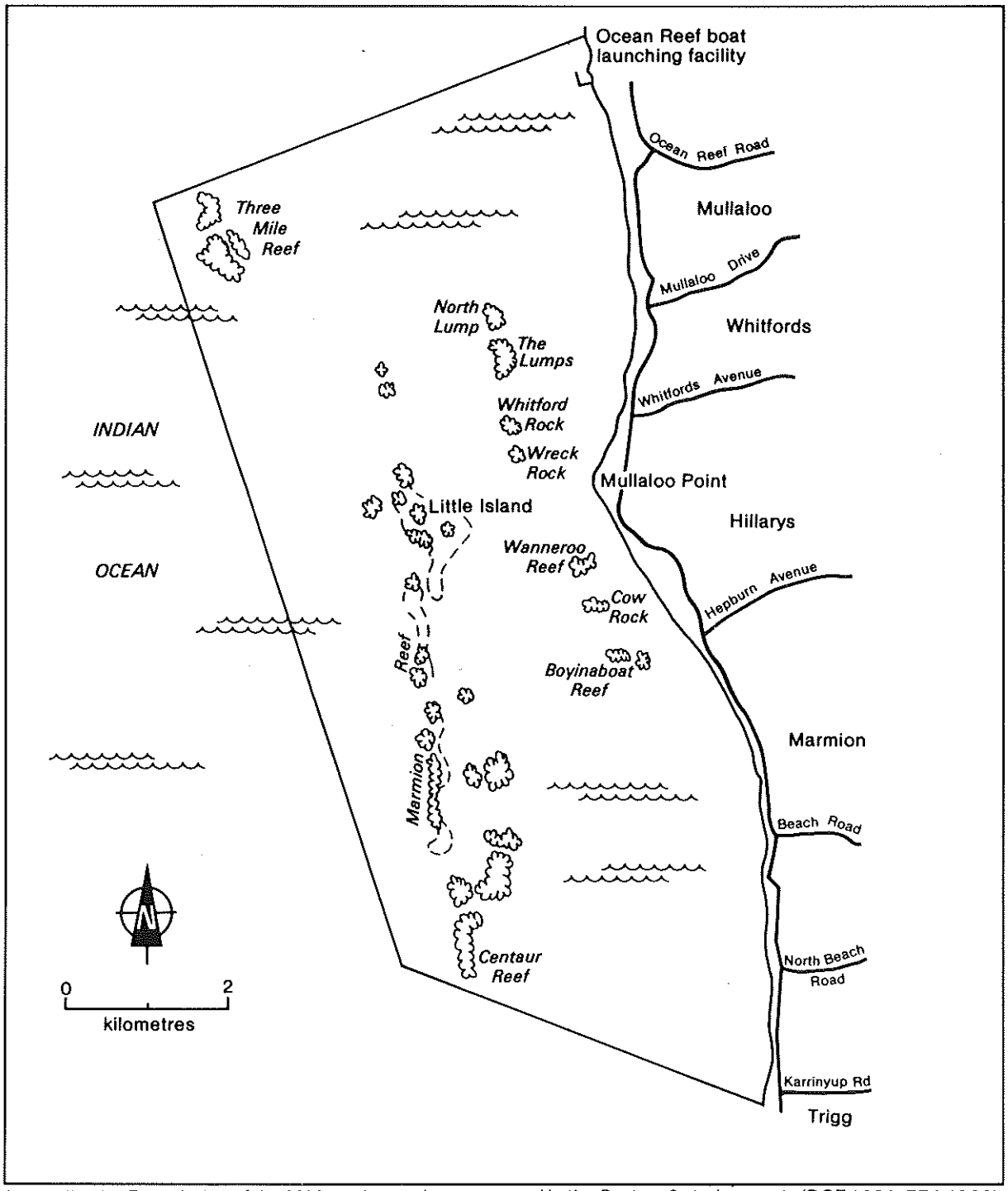
W.A. Museum

W.A. Recreational Fishing Council

W.A. Wave Ski Association

Wanneroo Beaches Action Group

Whitfords Sea Sports Club

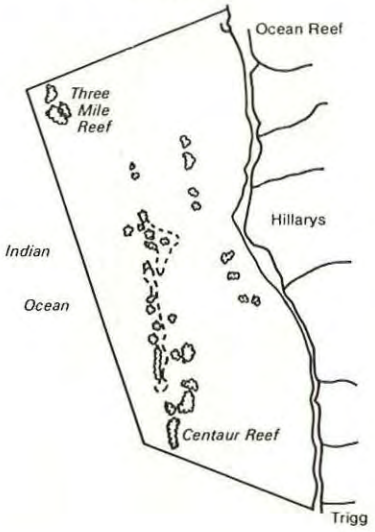


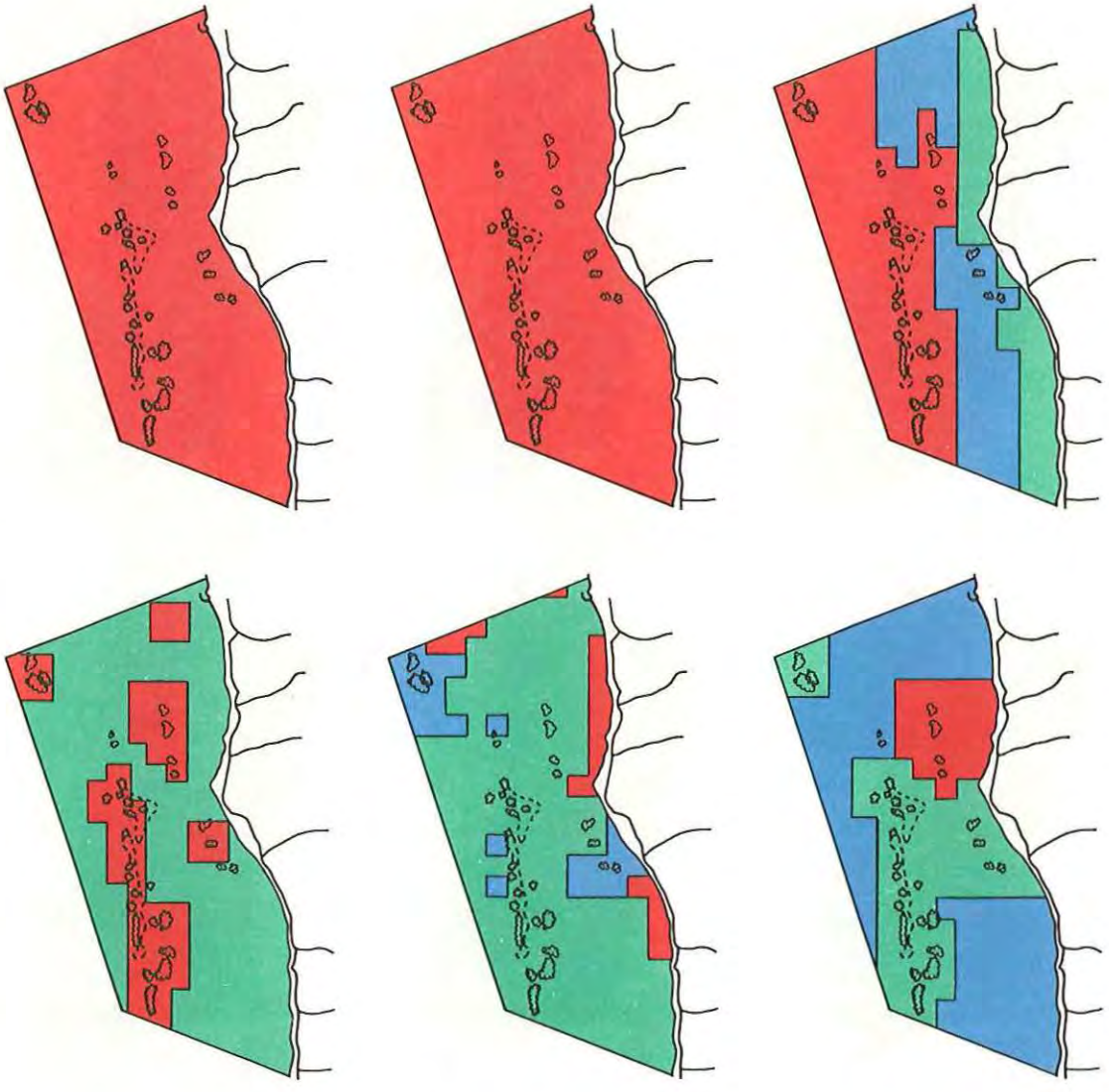
Appendix 2b. Boundaries of the M10 marine park as proposed in the System 6 study reports (DCE 1981; EPA 1983). General features of the area are shown.

Appendix 2c. Zoning submissions for the proposed M10 marine park, received by the Department of Conservation and Environment.

Submissions have been arranged in approximate order from those indicating highest overall protection, to those indicating lowest overall protection.

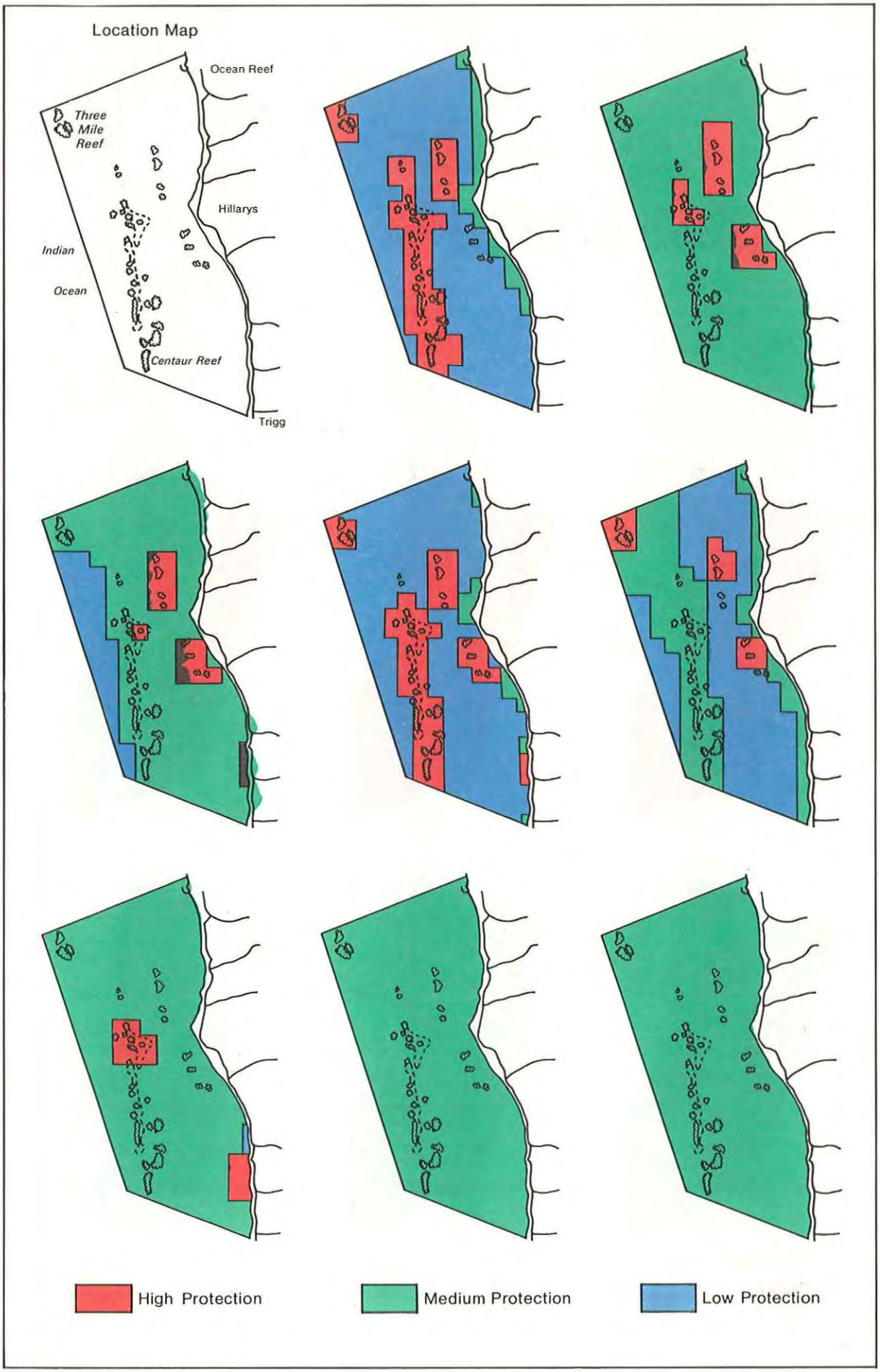
Location Map



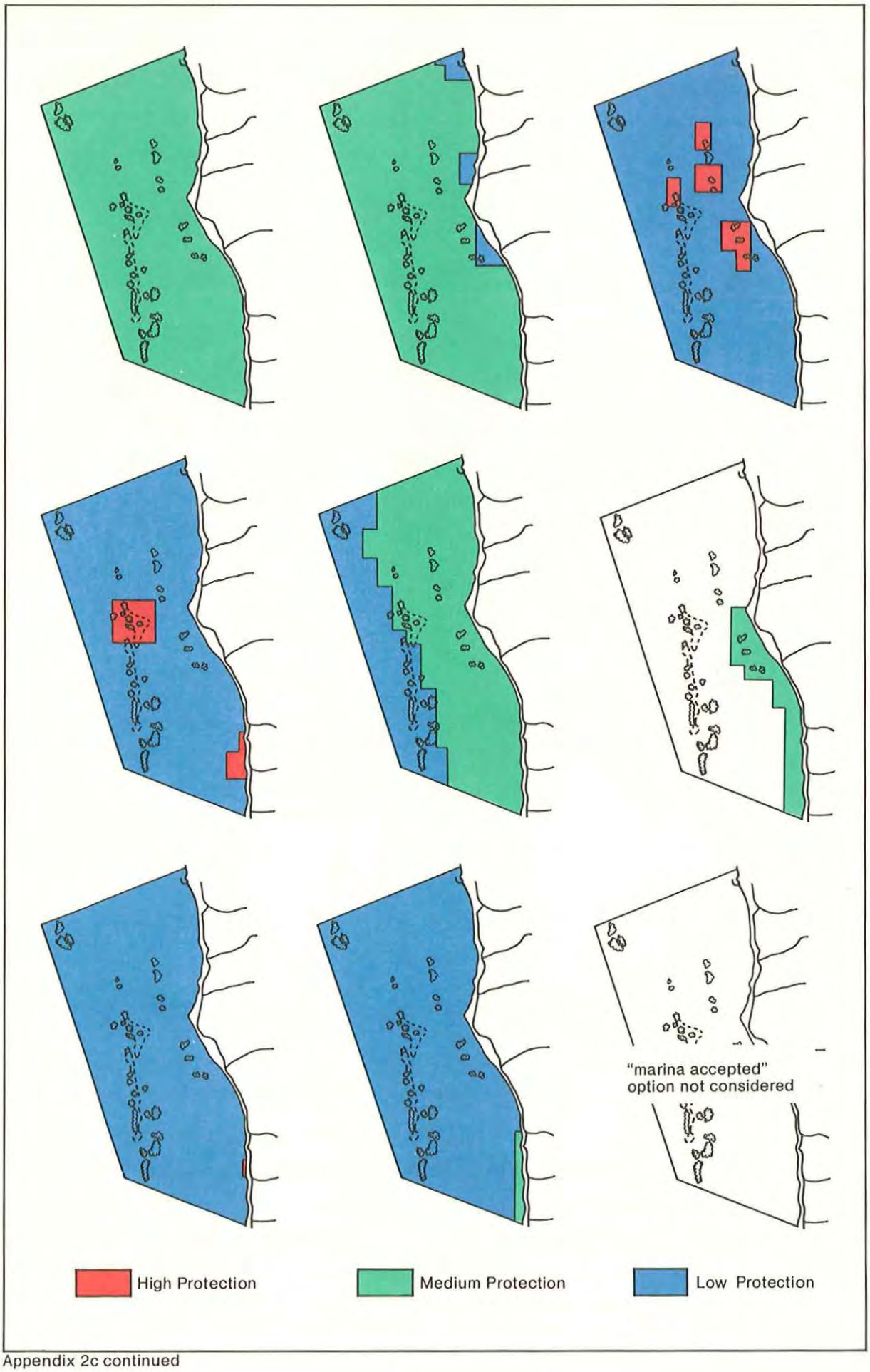


High Protection Medium Protection Low Protection

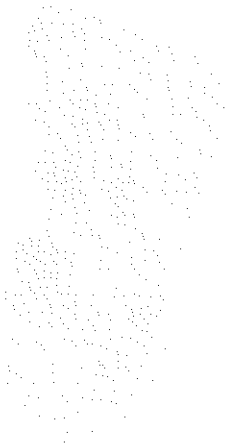
Appendix 2c.



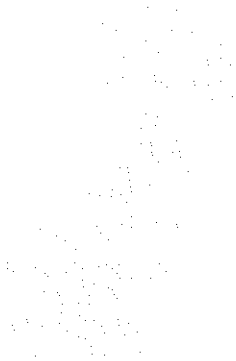
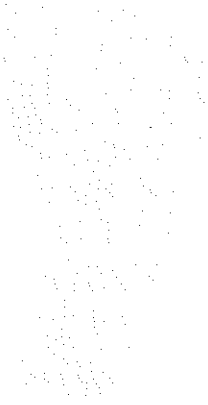
Appendix 2c continued



Appendix 2c continued





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