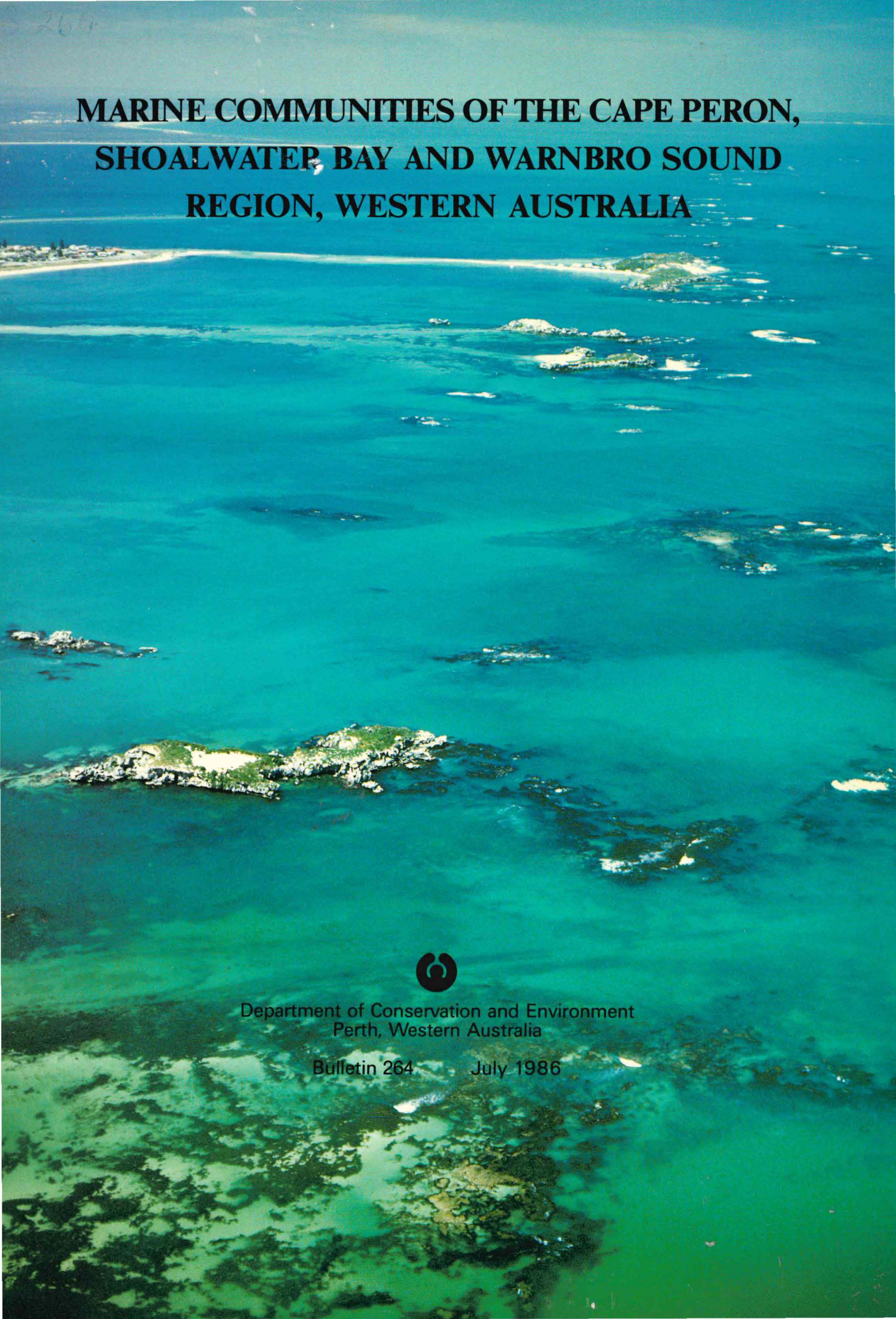
MARINE COMMUNITIES OF THE CAPE PERON, SHOALWATER BAY AND WARNBRO SOUND REGION, WESTERN AUSTRALIA



Department of Conservation and Environment
Perth, Western Australia

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Front cover photograph: Aerial view of the M101 region looking south from Cape Peron, November 1985. The sand-bar connecting Penguin Island to the mainland is clearly visible.
(Photograph : S. Chape.)

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David M Gordon

Department of Conservation and Environment
Marine Impacts Branch
Perth, Western Australia

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INTRODUCTION

This report discusses a survey of marine communities of the Cape Peron (Point Peron[1]), Shoalwater Bay and Warnbro Sound region conducted in November 1985. Part of the work was prepared earlier as a preliminary report to the State Planning Commission (Gordon 1986). These waters include a proposed marine reserve as recommended in the System 6 Report (Environmental Protection Authority 1983).

System 6 Recommendation M101 states that the Cape Peron, Shoalwater Bay and Warnbro Sound area "constitutes open space of regional significance... because of its high conservation, education and recreation values and its proximity to the Perth residential areas" (page 294). The reserve area encloses the visible features of islands, rocks and reefs from Cape Peron in the north to Becher Point in the south (Figure 1). The System 6 Report recommends that a detailed survey of the area be undertaken (M101.4) with the aim of establishing a marine reserve, or, more appropriately in terms of current legislation, a marine park (Conservation and Land Management Act 1984).

Interest in this section of the coast has arisen because of urban expansion in Rockingham and Warnbro, a need for access to coastal waters by an increasing population, and intense recreational use of the marine environment, especially in summer.

Existing and proposed recreation and tourist activities in the Rockingham area focus on foreshore and marine environments which provide opportunities for a wide range of uses, for example the Port Kennedy regional park (Metropolitan Region Planning Authority 1978). There are also a number of development projects which have either been completed or are planned within the study area and these relate to the local marine environment. They include a boat-launching facility now in operation immediately west of the Garden Island causeway, a proposed marina in Mangles Bay adjacent to the M101 (Rockingham Marina; John Holland Group 1985), a waterways project (Westport) in Warnbro, and an effluent wastewater disposal treatment plant now operating at Cape Peron.

OBJECTIVES

In July 1985, the Cape Peron-Mangles Bay Recreation/Tourism Plan Technical Committee resolved that there was a need for integration of the EPA's recommendations for M101 with the planning of the Cape Peron-Mangles Bay area. In November that year, the Metropolitan Region Planning Authority (now the State Planning Commission) proposed that the Marine Impacts Branch of the Department of Conservation and Environment (DCE) undertake a survey of the marine communities of M101 as an initial step towards implementing M101.4. The objectives of this survey were to document the marine communities of M101 and their extent, to provide baseline information for planning and development of this section of the coast. The M101 boundary is an arbitrary one, and marine habitats within this region are continuous with those outside it. The survey area was therefore extended beyond the existing M101 boundary to include the marine communities inshore from the eastern boundary of M101 south of Mersey Point and in the western section of Mangles Bay (Figure 1).

MATERIALS AND METHODS

From 4-22 November 1985, surveys were made of marine plants and animals and their habitats at 28 locations in and around the M101 region, using a manta board to tow SCUBA divers along fixed bearings. A qualitative assessment of the dominant plants and animals was made along each transect, with the information recorded *in situ*. This was supplemented by diving at specific locations to record the dominant biota and describe the nature of the sea bed. Samples of the common and conspicuous species were collected for identification. The extent of major habitats was assessed by interpretation of aerial photographs (1:5000, 9-10-1983; 1:10 000, 28-6-84; WA Lands and Surveys Department), charts of these waters (WA Public Works Department), and from previous research and survey work. Areas of the major habitats available for plants and animals were calculated using the above sources and a digitized planimeter (Summagraphics, Connecticut, USA).

RESULTS

Description of the Study Area

Location

The general location of the coastal area surveyed for this report is shown in Figure 1. It is situated about 25 km south of the city of Fremantle and extends from Mangles Bay, immediately east of the Garden Island causeway, south to Becher Point, and west from the mainland to approximately the 15 m isobath. This area includes nearly 60 km^2 of coastal waters. Much of the surveyed waters, and nearly all of the M101 region, is less than 10 m deep (Figure 1), with the exception of Warnbro Sound which, for most of its area, is deeper than 15 m.

Physical Environment

The climate of this region is Mediterranean, with cool, wet winters and hot, dry summers. Rainfall is approximately 800 mm annually, and is minimal

[1] Cape Peron here should not be confused with Cape Peron in Shark Bay, WA.

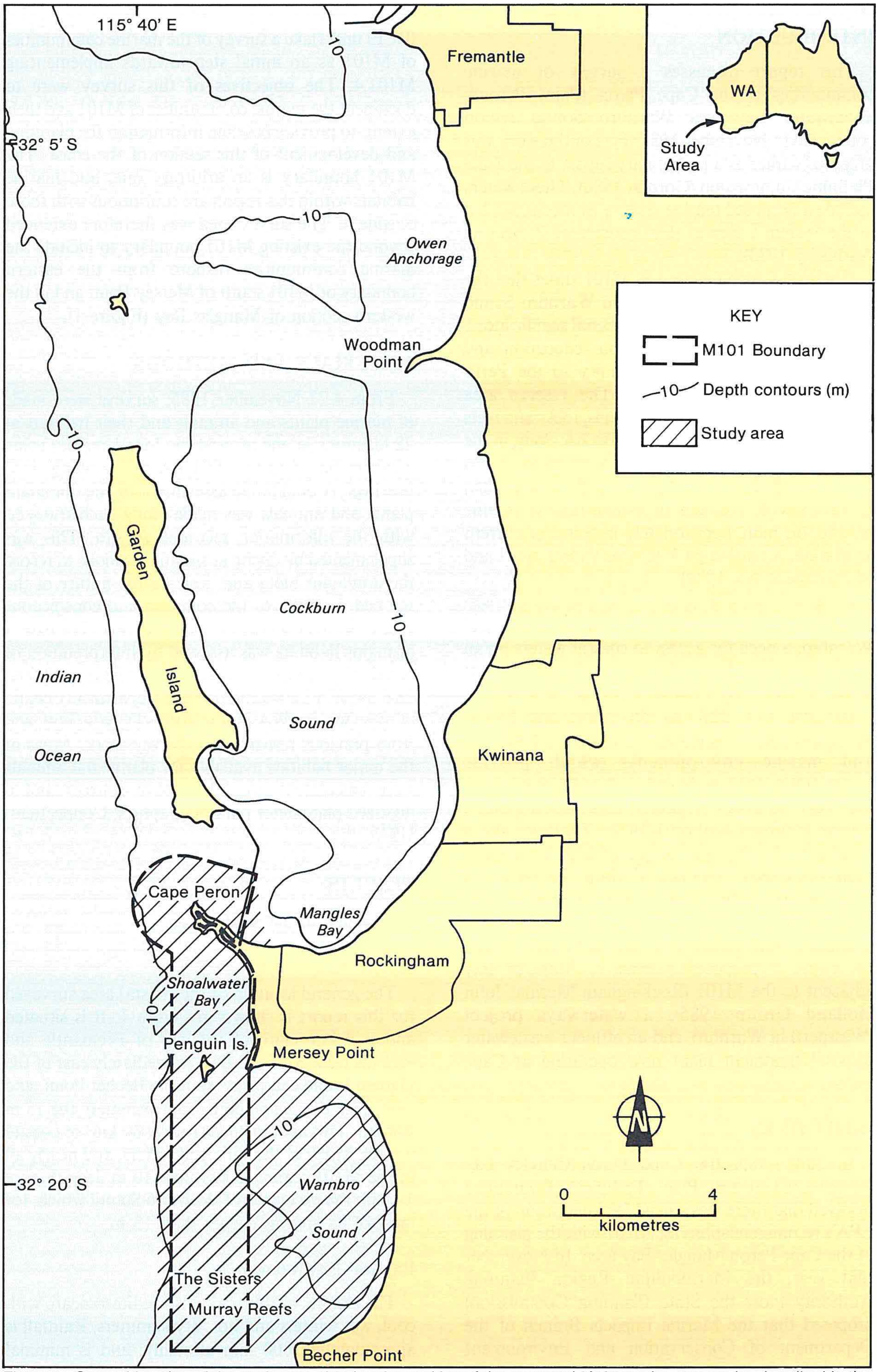

Figure 1: General location of the study area showing the position of the proposed M101 marine reserve (as described in the EPA 1983 System 6 Report). Insert: Location of the study area on the western coast of Australia.

from November through into April. The synoptic wind pattern of south- western Australia is controlled largely by movement of the anticyclone belt between about 30°S and 40°S latitude. Typical winds for this region can be gauged from data for nearby Fremantle, summarized by Steedman and Craig (1983). Differential heating of land and sea produces sea breezes — typically easterly to offshore in the night and morning, and to onshore in the afternoon. High pressure systems in summer produce predominantly easterly winds. In winter, storm winds are generated from low pressure systems, being predominantly from the north-west and backing to the west and south-west. Occasional short-duration cyclonic activity in late summer produces winds from all directions. Winds are important for generating waves, inducing water circulation and transporting sand into the study area.

Surface water temperatures have an approximate annual range of 8°C, from about 23°C in summer to 15°C in winter, based on long-term monthly means of daily maxima and minima for adjacent Cockburn Sound (Hodgkin and Phillips 1969). Corresponding seasonal extremes are 12.8°C to 24.7°C.

The tidal range for this part of the coast is narrow (Hodgkin and DiLollo 1958), from about 0.7 m to 0.9 m. There is generally a single astronomic tide per day, but superimposed on this are the effects of barometric pressure changes and wind fetch which can extend the high water range to over 1 m.

Information on water circulation in the study area is limited. Steedman and Associates (1981) have discussed the important mechanisms for circulation of waters offshore from Cape Peron. These include wind stress as an overwhelming influence in shallow water, exposure of the coast to the open ocean, absence of any significant tidal-forcing and the role of the coastline as a barrier influencing shoreward flow. Data from adjacent Cockburn Sound basin show that circulation is largely wind-driven, with gyres driven by either seabreezes or by low pressure systems. Similar activity has been suggested for Warnbro Sound (see Chape 1984), with northwardly-directed, anti-clockwise circulation in summer. The shallower and smaller Shoalwater Bay, with its ready exposure to north-westerly winds in winter, would be expected to show a different circulation pattern to that in Warnbro Sound.

Geomorphology and Coastal Setting

The main sedimentary unit of the area is the coastal or "Tamala" limestone laid down during the Pleistocene. This is part of the Spearwood Dune System of McArthur and Bettenay (1960) and forms a major component of the present features of the metropolitan coastline. The Tamala limestone is aeolian in origin and consists largely of carbonate, skeletal material and quartz. Where it is exposed as offshore reefs and islands, or on the mainland, it is often capped with a travertine hardcap from the repeated dissolution and re-deposition of calcium carbonate.

The existing coastline, with its onshore rocky outcrops, sandy embayments and inlets, is a product of a series of sand deposits over the Tamala limestone during the Holocene, subsequent weathering of both the sand dunes and limestone, and eustatic changes in sea-level. It was formed following the last inundation by the sea, some 7 000 - 8 000 years BP. The present marine habitats are thus a drowned relic of the former Swan coastal plain, which has since been considerably modified by contemporary marine weathering and biological activity (calcification, erosion, encrustation).

Onshore remnants of the old Pleistocene dune system in the survey area can be seen in the limestone outcrops at Cape Peron; offshore remnants of the old dune system are present today as a series of submarine parallel limestone ridges aligned north to south. These are the Garden Island Ridge, which extends parallel with the coast from Mandurah through Penguin Island, Cape Peron and Garden Island, to the west end of Rottnest Island, and the Five Fathom Bank, further west. These reef ridges are composed of a mixture of high and low fragmented limestone (Tamala limestone) and low limestone pavement overlain in places by pockets of sand. Where exposed, they form islands and rock stacks. The submarine reefs display a variety of features, some quite spectacular, including pinnacles, ledges and caves.

Inside and between the reef chains, the sea bed is covered by sands generated from erosion of the Pleistocene sediments. The resulting series of submarine reef ridges and sandy depression are shown in Figure 2, along with the approximate boundary of the area surveyed for this report.

Adjacent to the Garden Island Ridge is a smaller parallel reef ridge displaying similar variable features. The deep (24 m) trough of the Sepia Depression and the embayments inside the Garden Island reef chain (Figure 2) consist of sands deposited during the Holocene and generated from erosion of the Tamala limestone.

Sandy embayments of the study area (Figure 2) inside the Garden Island reef chain are of varying depth, typically less than 5 m, but in places up to 20 m deep (Warnbro Sound basin). These sandy embayments form part of the Warnbro-Cockburn depression which separates the north-south trending limestone ridges of the Garden Island reef chain with those on the mainland. Though still present in places as a deep trough (for example, Cockburn Sound), the original deep depression has been reduced in the study area to a single basin (Warnbro Sound) through

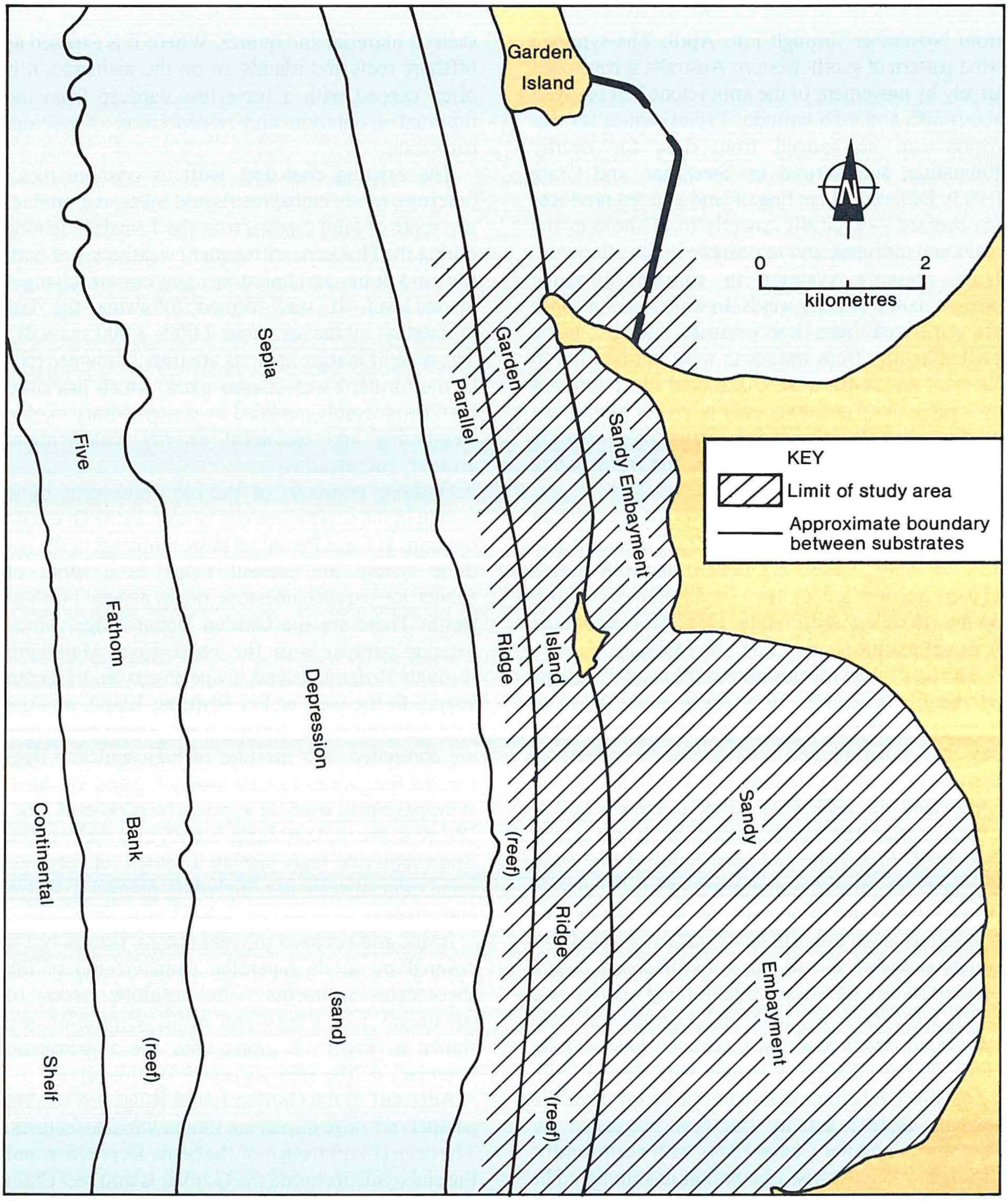

Figure 2: Distribution of predominantly – sand or predominantly – reef substrates inside and adjacent to the study area (adapted from Le Provost, Semeniuk and Chalmer 1981).

the subsequent deposition of Holocene sands. Thus the existing mainland adjoining and east of the study area is a vast (about 10 km wide) Holocene sand plain overlying much of the original Warnbro -Cockburn depression (see Gozzard 1983).

Sand movement influences the marine communities (see Discussion). Sands carried in the water are deposited by wave action along the interference lines of the prevailing swell waves, which are diffracted around the reefs and islands. This action has produced the tombolo separating Penguin Island from the mainland (see frontcover illustration) and similar sand banks connecting Seal and Bird Islands with the shore, to produce the lagoons of Shoalwater Bay. Shallow sand banks are also evident in Safety Bay, and these become exposed at low water.

Aquatic Habitats and Communities

Locations of the 28 subtidal manta-board surveys are shown in Figure 3. The length of each transect shown is to scale. These were supplemented with bounce-dives at specific locations (positions shown

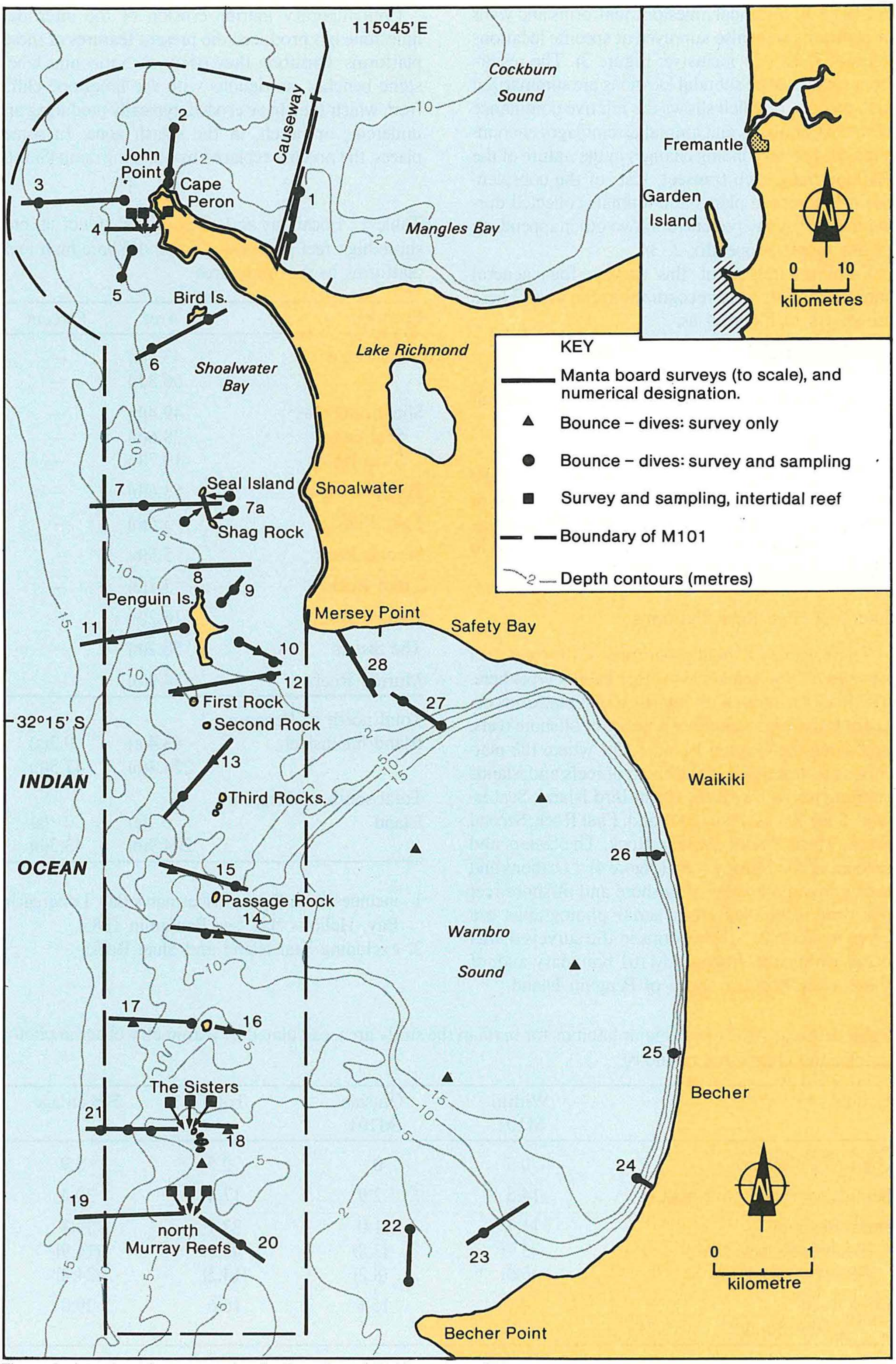

Figure 3: Location of survey and collection sites, 4-22 November 1985.
The boundary of the proposed M101 marine reserve (as recommended by the EPA, 1983) is shown.
Transect lines are to scale. Inset: Location of the surveyed area with reference to Fremantle.

in Figure 3). Intertidal limestone platforms and walls of platforms were also surveyed at specific locations (Sites 4, 7, 18 - 21 inclusive: Figure 3). The results from surveys of all subtidal locations are summarized in Appendix 1, which shows the relative dominance of the major plants and animal assemblages encountered, and corresponding changes in the nature of the seafloor along each transect. Lists of the conspicuous and common plants and animals collected during this survey are presented in two other appendices to this report (Appendix 2, 3).

From the results of this survey, four general aquatic habitats were recognized in the area. These are shown in Figure 4 as:

A. Intertidal high reef platforms
B. Subtidal reefs and limestone pavement
C. Sandy seafloor and embayments (including seagrass meadows)
D. Warnbro Sound basin.

The area occupied by each of the major habitats is given in Table 1. This includes the proportion of each present within the M101 region. Typical marine communities in these habitats are illustrated in Figures 5 and 6 (Pages 18 and 19).

Intertidal High Reef Platforms

These occupy a small proportion of the total area surveyed (Table 1) relative to other habitat types here. The main locations with intertidal reef platforms occur at Cape Peron, as either onshore or offshore reefs, and along the Garden Island Ridge where the platforms are developed in the chain of reefs and islands running parallel with the coast: Bird Island, Seal Island, Shag Rocks, Penguin Island, First Rock, Second Rock, Third Rocks, Passage Rock, The Sisters and sections of the Murray reefs (Figure 4). Locations and the approximate areas of onshore and offshore reef platforms estimated from aerial photographs are given in Table 2. All platforms in the surveyed area occur within the proposed M101 boundary and, of these, over 40% are south of Penguin Island.

Contemporary marine erosion of the intertidal limestone has produced the present features of these platforms. Onshore, they occur as horizontal limestone benches contiguous with the limestone cliffs from which they have eroded, typically producing an undercut, or notch, in the splash zone. In some places, the notch is replaced by a sloping ramp (Smith

Table 2 : Locations and areas ($m^2 \times 10^3$) of (a) onshore high reef platforms and (b) offshore high reef platforms in the study area

Location	Area	Percent
Cape Peron[1]	43.4(a)	—
	66.8(b)	—
Shoalwater Bay[2]	49.4(b)	—
Seal Island	28.6(b)	—
Shag Rocks	19.7(b)	—
Penguin Island	53.6(b)	—
First Rock	3.6(b)	—
Second Rock	5.5(b)	—
Third Rocks	7.7(b)	—
Passage Rock	18.2(b)	—
The Sisters	38.2(b)	—
Murray Reefs	54.9(b)	—
Total north of Penguin Island (inclusive)	43.4(a)	9.2(a)
	224.4(b)	47.5(b)
Total south of Penguin Island	0 (a)	0 (a)
	204.9(b)	43.3(b)

1. includes John Point, Fisherman's Bay, Longreach Bay, Haliotis Bay (see Benjamin 1985)
2. excluding Seal Island and Shag Rocks

Table 1: Areas (km^2) of the major habitats for biota in the study area, calculated by planimetry of aerial photographs and charts (see methods).

Habitat	Within M101	Outside M101	Total	Percentage
High reef platforms	0.5	0	0.5	0.9
Subtidal reef and pavement	14.5	2.9	17.4	30.4
Sandy seafloor	11.7	11.0	22.7	39.7
(Essentially bare sand)	(5.7)	(2.8)	(8.5)	(14.9)
(Seagrass meadows)	(6.0)	(8.2)	(14.2)	(24.8)
Deep basin (Warnbro Sound)	1.0	15.6	16.6	29.0
Total	27.7	29.5	57.2	100.0

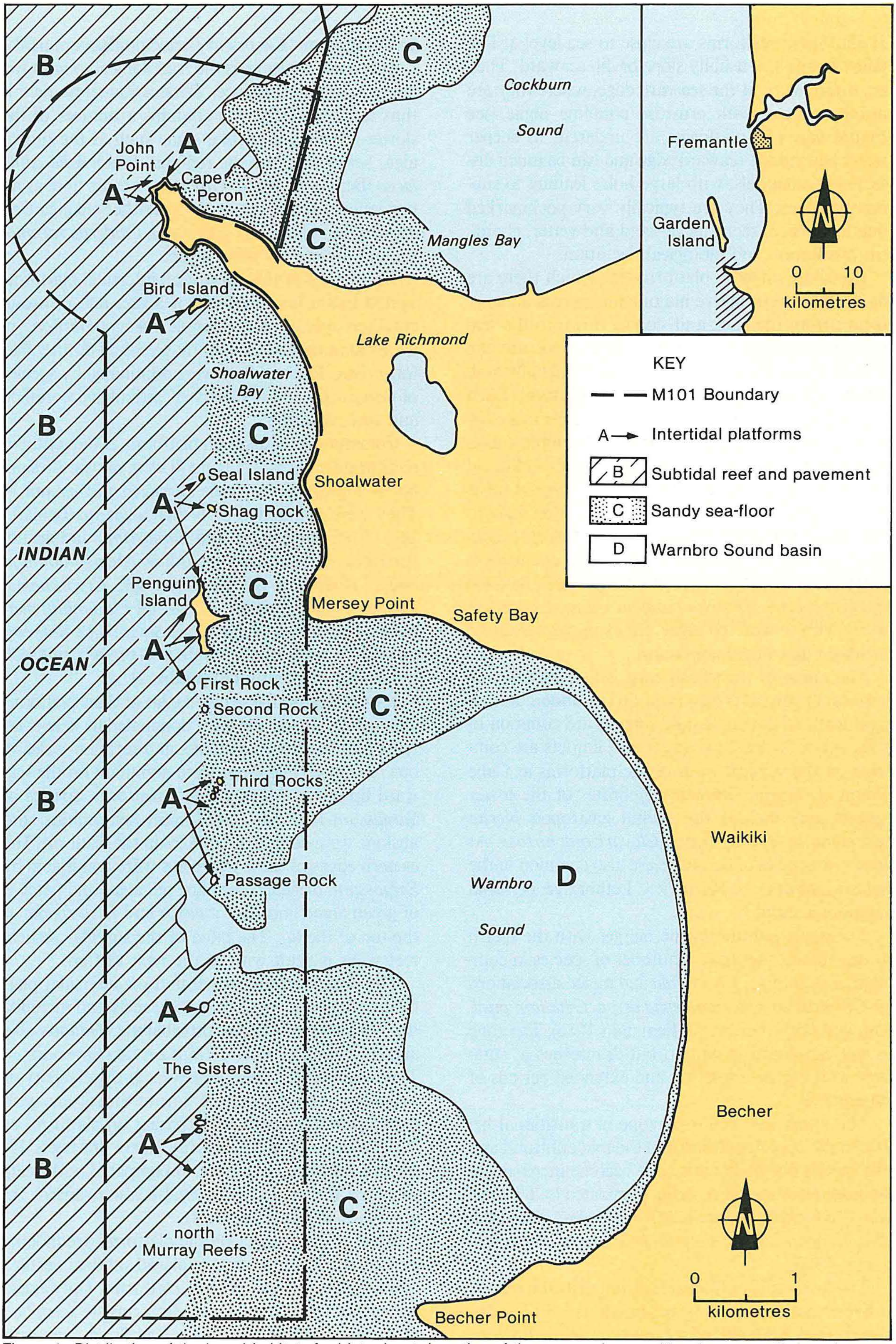

Figure 4: Distribution of the broad habitats for biota. Inset: Location of the surveyed area with reference to Fremantle.

1952). These platforms are close to sea-level at low tide (datum), but usually slope or dip seaward. They are often raised at the seaward edge, where they are usually topped with crustose coralline algae (see Figure 6a). The platforms are undercut in deeper water beyond the seaward edge and can be much dissected by channels, with large holes leading to submarine caves. They are typically very pockmarked due to physical scouring by sand and water, chemical dissolution and biological accretion.

For those onshore platforms for which there are data, algae occur in five major zones across the platforms, from the back and sloping down to the seaward edge (Benjamin 1985). These zones are the splash zone, upper eulittoral, upper mid-eulittoral, lower mid-eulittoral and the lower eulittoral. Each zone displays a number of dominant species in a community which changes seasonally. Benjamin's data indicate that the splash zone and upper eulittoral zones are characterized by seasonal opportunists whose appearance is partially dependent on daily tidal submergence. The blue-green algae *Calothrix confervicola* and *Scytonema hofmannii* are common in summer, while, in winter, green algae such as *Ulva rigida* and *Enteromorpha prolifera* are more common along with several red algae, for example, *Gelidium pusillum* and *Porphyra lucasii.*

The fauna of the splash zone is limited to a few species. Littorinid snails occur on the undercut, vertical walls of the notch, and limpets are common in rock pools. At least two species of limpets are common on the vertical walls of the platforms at Cape Peron at datum. Other invertebrates of the lower splash zone include the neritid gastropod *Nerita atramentosa* and the chiton *Clavarizona hirtosa.* At least two species of barnacles are also common in the splash zone at Cape Peron (R C Lethbridge, personal communication).

The upper eulittoral zone merges with the splash zone. These zones have a number of species in common, for example, *Ulva rigida* and mixed associations of *Giffordia* sp, *Chaetomorpha aerea, Gelidium pusillum* and *Porphyra lucasii* (Benjamin 1985). The zone is well-developed in winter, but diminishes in summer with higher insolation and extended periods of emergence.

The upper mid-eulittoral zone is transitional between the upper eulittoral and the mid-eulittoral and the species occupying this zone become increasingly homogeneous in winter, being dominated by *Ulva rigida, Cladophora lehmanniana, Colpomenia sinuosa, Porphyra lucasii* and *Polysiphonia scopulorum* (Benjamin 1985).

The lower mid-eulittoral is distinguished from the adjacent zones by having an abundance of *Gracilaria* sp. Other examples of species occupying this zone during the year, but subordinate to *Gracilaria,* are *Jania fastigiata, Polysiphonia decipiens, Laurencia heteroclada,* and *Ceramium flaccidium* (Benjamin 1985).

The lower eulittoral is the zone subject to most frequent tidal submergence. Desiccation-stress here is thus reduced. This zone contains a number of the slower-growing, perennial algae such as the brown alga, *Sargassum* and the red alga *Pterocladia capillacea* (Benjamin 1985). *Gracilaria* occurs here as an understorey species along with another red alga *Ceramium flaccidium,* the green alga *Caulerpa racemosa,* and diverse coralline algae.

At the time of this survey, all intertidal platforms visited had a low diversity of algae; red, crustose, coralline species, for example *Neogoniolithon* sp, were common and frequently bleached on the platform rims. The reef flats were dominated by species of *Sargassum* and a variety of articulated coralline and turf red algae.

Communities of algae on platforms of the southern reefs (transects 18-21; Figure 4) were outwardly similar in appearance to those surveyed further north. They were dominated by brown algae, particularly kelp, *Ecklonia radiata,* and *Sargassum,* and an understorey of red algae including *Metagoniolithon chara, Haliptilon* sp, *Amphiroa* spp, *Cryptonemia kallymenioides, Callophycus* sp and *Plocamium mertensii.* The brown fucoid algae *Scytothalia dorycarpa* and *Carpoglossum* sp were also present, but seen much less frequently (Appendix 2).

Raised rims on the seaward edge of these platforms are well developed and were dominated by kelp overlying both crustose, coralline, and soft non- calcareous red algae. The latter were dominant on the seaward lip of the Murray Reefs platform. Species of *Sargassum* here harboured many sea urchins, and abalone were noticed in potholes in the platform. The eastern edges of these platforms were dominated by *Sargassum,* bleached coralline red algae and patches of green algae (mostly *Caulerpa* and *Ulva rigida*) at the top of the lip. The biota of the subtidal vertical reef walls is dealt with in the next section.

The dominant animals found on intertidal platforms are common to most local reefs and included the commercially-important abalone, *Haliotis roei* and the common whelk, *Thais orbita* (Appendix 3). There were differences, however, in the diversity of animals encountered at the time of the survey, with a greater range of species apparent on platforms at The Sisters and north Murray Reefs (transects 18, 21 and transect 19, Figure 3) compared with reefs surveyed further north, at Seal Island (transect 7a) and Cape Peron (transect 4).

Some of the animals on the platforms are mobile, and inhabit both the intertidal and subtidal vertical reef walls as well as the reef platforms. Only those animals collected on the reef platforms are described here; those collected from the reef walls are dealt with in the section dealing with subtidal reefs. Mobile herbivorous species, such as the sea urchin *Holopneustes* *porossimus,* were collected at Cape Peron and on the Murray Reefs but not at The Sisters. Starfish were not common on the reef platforms, but these animals are more common in adjacent, subtidal habitats. A number of gastropod molluscs (marine snails) were common on the Murray Reefs platforms, including the large turban shell, *Turbo torquata.* Another gastropod, *Pyrene bidentata,* was common on the reef platforms of Seal Island. Other molluscs collected were the chiton *Rhyssoplax torriana* and the edible mussel *Mytilus edulis planulatus* (Appendix 3).

Hydroids resembling *Solanderia* were collected on The Sisters reef top (and subtidally at Seal Island). The Sisters reef flats contained the most diverse animals of the platforms surveyed, including an unidentified zoanthid, the common gorgonian soft coral *Mopsella* sp, the featherstar *Comanthus* sp, and two scleractinian corals: the solitary *Scolymia australis* and colonies of *Plesiastrea versipora* (the latter was also collected in this survey from subtidal reefs along transect 19 west of the Murray Reefs).

Subtidal Reefs and Limestone Pavement

Subtidal reefs extend along the entire western boundary of the study area as part of the Garden Island Ridge (Figures 2 and 4). These make up about 30% of the study area, and over 50% of the M101 region (Table 1), and were represented in transects 2-7, 11-15, 17, 19 and 21 (Figure 3). At the time of the survey, the sites displayed similar assemblages of plants (Appendix 1), dominated by large brown algae such as kelp and *Sargassum* and a variety of red algae (non-calcareous, fleshy, foliose and filamentous species, as well as crustose and articulated coralline species).

The inventory of flora collected from the subtidal reefs for this survey is very conservative. The list in Appendix 2 is not complete due to major taxonomic difficulties with some species. Those plants identified so far included green algae such as *Ulva* spp, *Codium duthiae, Derbesia marina, Bryopsis* spp and several species of *Caulerpa.* Brown algae, though dominated by kelp and species of *Sargassum,* were also represented by *Scytothalia dorycarpa, Colpomenia sinuosa* and several representatives of the Dictyotales, including *Lobophora variegata, Lobospira bicuspidata, Padina* sp, *Zonaria* spp, *Dictyota* sp and *Taonia* sp. Red algae on subtidal reefs were represented by species from at least 20 families (Appendix 2). These include the coralline algae *Mesophyllum* sp, *Haliptilon* spp, several species of *Amphiroa* including *A anceps, Metagoniolithon chara, M stelligera* and *Metamostophora flabellata.* Crustose coralline algae, such as *Neogoniolithon,* were collected throughout the subtidal reefs, where they are seen commonly encrusting the reef surfaces as an understorey to kelp. They are not easily identified. Non-calcareous species are present in a variety of forms — filamentous, foliose and fleshy, as well as simple, mucilaginous thalloid forms such as the large *Grateloupia* sp collected along transect 7 (Appendix 2).

Examples of non-calcareous red algae included *Curdiea obesa, Predaea* sp, several species of the fleshy red *Callophycus, Eucheuma speciosum, Plocamium mertensii,* several *Hypnea* species, including *H episcopalis, Rhodopeltis australis, Rhodymenia australis, Champia zostericola, Bornetia binderiana, Euptilotia articulata, Myriogramme erosa, Heterosiphonia muelleri, Amansia* sp, *Dictymenia sonderi, Dasyclonium incisum, Echinothamnion hystrix, Jeanerettia lobata, Lenormandia smithii* and several species of *Laurencia* including *L. filiformis.* Though no attempt was made during this survey to sample the numerous species growing epiphytically on other algae on the reefs, those encountered in the samples have been included in the species list shown in Appendix 2. They include the green alga *Caulerpa* sp, the brown alga *Asperococcus bullosus* and red algae such as *Pterocladia lucida,* the coralline reds *Mesophyllum (on Haliptilon), Jania* spp, *Metagoniolithon chara* and *M stelligera.* The latter was also found commonly growing epiphytically on the seagrass *Amphibolis.* Other epiphytic reds included *Griffithsia teges, Hypnea* spp and *Laurencia* sp (Appendix 2).

Many of the algae listed above are common to similar habitats of other local reefs, for example, west of Garden Island and along Five Fathom Bank (LeProvost, Semeniuk and Chalmer 1981). The algae of the reefs are strongly seasonal and many other species could be expected if sampling was undertaken at other times of the year. Relative proportions of the dominant flora varied from site to site (Appendix 1). Some reefs displayed areas with barren pavement, or pavement topped with crustose coralline red algae. Others had a predominance of non-calcareous, red algae and few coralline species. These differences were apparent sometimes along small sections of single transects (transect 17, Figure 3). Kelp, along with *Sargassum* spp, occurs in photic areas of the reefs and becomes so conspicuous in spring and summer that it hides the often extensive cover of red algae and the resident fauna of the reefs. Biomass of these algae is strongly seasonal, and is reduced in winter when parts of the canopy become detached during storms (Kirkman 1981). Kirkman's data for the reefs at Whitford, north of Perth, indicate that the canopy is not completely removed in winter. No similar seasonal records are available for the study area.

The seagrass *Thalassodendron pachyrhizum* is found, less commonly, inhabiting the subtidal reefs. It extends into deep water throughout the metropolitan coast (Cambridge 1980) and was observed along transects 3 (at 10 m depth), 14 (at 13 m depth) and 19 (at 15 m depth) growing with kelp and *Sargassum* species (Appendix 1).

Subtidal reef habitats include caves, crevices, ledges with their overhangs, and high pinnacles, some many metres high (for example, along transects 15, 19 and 21; Figure 3). Animals here include sessile invertebrates such as a colonial and solitary sea-squirts (ascidians), a wide range of sponges (not identified) and the colourful and common soft coral, *Mopsella;* these communities prefer shaded habitats such as cavern walls and under ledges, where they form extensive communities in some areas (Figure 6d). Other attached animals included featherstars, hydroids and corals. The latter were not frequently encountered. The scleractinian coral, *Plesiastrea versipora* was recorded along transects 7, 17, 19 and 21 (Figure 3) while the solitary coral, *Scolymia australis* occurred at transects 7a and 21 (Figure 3). Mobile invertebrates on the reefs included the herbivorous sea urchins, *Heliocidaris erythrogramma,* and *Holopneustes porossimus* which are reasonably common under the kelp canopy, suspension-feeding holothurians (sea cucumbers) such as *Stichopus mollis* and a variety of the carnivorous seastars such as *Pentagonaster duebeni, Coscinasterias calamaria, Petricia* sp and *Plectaster decanus* (Appendix 3).

Vertical Walls of the Reef Platforms

Walls of the high reef platforms provide diverse habitats, with undercuts and crevices similar to those encountered on subtidal reefs along the seafloor. At Cape Peron (transect 4), the reef faces commonly displayed a mixture of kelp and *Sargassum* spp with an understorey of crustose and articulated, coralline red algae such as *Amphiroa ?ephedra, Mesophyllum* sp and *Metagoniolithon chara,* and non-calcareous red algae, including *Gelidium pusillum, Curdiea obesa, Callophycus ?dorsiferus, Plocamium dilatatum* and *P mertensii, Hypnea* spp, *Rhodymenia australis, Haloplegma preissii* and *Jeanerettia lobata.* The largely tropical to sub-tropical siphonous green alga *Anadyomene stellata* was also found on the seafloor here. Dominant invertebrates of the reef walls and adjacent seafloor included the sea urchin *Heliocidaris erythrogramma,* the turban shell, *Turbo torquata,* the predatory seastars, *Pentagonaster duebeni, Petricia* sp and *Coscinasterias calamaria,* and the sea cucumber, *Stichopus ?mollis.* Sessile animals included a variety of sponges (unidentified), the gorgonian *Mopsella* sp in shaded underhangs, and lace corals (bryozoans).

The western (seaward) vertical walls of The Sisters reef platform (transect 21) were dominated, at the platform edge, by kelp and an understorey of red algae, including *Pterocladia lucida, Halymenia rosea, Peyssonnelia sp Curdiea obesa, Callophycus* sp, *Mychodea* sp, *Hypnea episcopalis, Botryocladia obovata, Haloplegma preissii, Laurencia spp and the coralline Metamostophora flabellata.* Less commonly seen was the green alga *Caulerpa cactoides* and the brown alga *Lobospira bicuspidata,* mixed with kelp and crustose coralline red algae on the limestone boulders at the base of the slope. The underhangs and rock crevices were densely-covered with a variety of sponges (unidentified) and gorgonians, with occasional solitary and colonial sea squirts such as *Pyura pachydermatina* and *?Alopozoa* sp, as well as featherstars such as *Comanthus.* The coral *Coscinaraea ?mcneilli* was also collected from the reef face here. *C mcneilli* is common at Rottnest Island but has not yet been seen during surveys at Penguin Island (R C Lethbridge, personal communication). These specimens may, in fact, be another species: *C marshae.* Molluscs were not conspicuous on the vertical reef walls here; however, the gastropods *Thais orbita* and *?Septa tabulata* were collected.

The biota of the leeward (eastern) reef walls of The Sisters platform (transect 18; Figure 3) was variable from site-to-site. Less-exposed walls were dominated, at the platform edge, by a dense cover of *Sargassum,* or by bleached crustose coralline red algae and *Ulva ?rigida.* Below the lip of the platform, in the sub-littoral, was a mixutre of non-calcareous and coralline red algae, such as *Pterocladia lucida, Callophycus* sp, *Plocamium dilatatum, Hypnea episcopalis* and *Amphiroa* sp. From here to the base of the reef wall, at about 2 m depth, the flora was predominantly kelp or a mixture of kelp and species of *Sargassum.* Invertebrates were not conspicuous compared with the western reef face, being confined to occasional sponges, sea squirts, marine snails, and starfish. More-exposed walls were dominated by kelp, growing from the platform lip to the seafloor. Non-calcareous and crustose coralline red algae continued as an understorey over most of the reef face. This section of the reef consisted of many large tunnels, caves and caverns containing diverse assemblages of invertebrates similar to those of the western reef faces. Fish were prolific, with large schools of buff bream and wrasse.

The western (seaward) edge of the Murray Reefs platform (transect 19; Figure 3) displayed similar algae to those seen at The Sisters reef, with kelp, *Sargassum* and an understorey of red algae, for example, *Pterocladia lucida, Curdiea obesa, Callophycus ?dorsiferus, Hypnea* spp, *Botryocladia obovata, Rhodymenia australis, Rhodopeltis australis, Amphiroa* sp and *Metamastophora flabellata.* Other algae included the brown algae *Eudesme* sp, *Lobophora variegata, Lobospira bicuspidata* and a variety of green algae, including *Caulerpa racemosa, C scalpelliformis* and *Halimeda cuneata* (Appendix 2). Animals were sparse, but those seen included calcareous bryozoans, sea squirts, for example, *?Herdmania* sp, and numerous unidentified sponges. At the base of the walls, the sea bed was composed of broken reef covered with crustose coralline red algae and sturdy, healthy non-calcareous foliose red algae. Many large caves and crevices were found.

Flora of the more-sheltered vertical reef walls was similar to that of The Sisters, being again dominated by bleached, crustose coralline red algae and *Sargassum* on the sub-littoral fringe of the platform. Below the platform lip, this graded into a zone with non-calcareous and articulated, coralline red algae. Deeper, on the face, kelp and an understorey of crustose coralline red algae dominated and extended to the seafloor (3 m depth). Common algae on the walls included *Amphiroa* spp, *Haliptilon cuvierii* and *Curdiea obesa.* Invertebrates were again sparse, though seastars and crinoids were conspicuous in places along with occasional solitary sea-squirts, for example, *Pyura pachydermatina,* and molluscs such as *Turbo torquata.*

Sandy Seafloor (including Seagrass Meadows)

Sandy seafloor habitats occur as sandy embayments inside the Garden Island Ridge reef chain (Figure 2), with water depths typically less than 5 m except in the deep basin of Warnbro Sound (maximum depth 20 m). The latter is dealt with separately below.

Major sand habitats include beaches, bare sandy seafloor and seagrass meadows. The approximate extent of sandy seafloor is shown in Table 1. These habitats occupy approximately 40% of the area surveyed, of which about 14 km^2, or 25%, is associated with seagrasses. The extent of seafloor with seagrasses is shown in Table 3. The distribution of seagrass communities has been recently mapped for the study area, including part of Shoalwater Bay, and south to Becher Point. It is reproduced in Figure 7.

There are approximately 6 km^2 of seagrass meadows in the M101 reserve, of which nearly 3 km^2 occurs south of Mersey Point (Figure 1). A further 8 km^2 of the sandy seafloor of the study area covered by seagrass is outside the proposed M101 reserve. Much of this area occurs east of M101 in Safety Bay, the periphery of Warnbro Sound basin and around Becher Point (Table 3).

Seagrass meadows and bare sand areas occupy similar proportions of the seafloor in the M101 reserve. Seagrass meadows, however, are more extensive than bare sand within the study area but outside M101.

The biota of beaches and bare sandy seafloor has not been investigated for this report but the assemblages found in these habitats have been described by LeProvost, Semeniuk and Chalmer (1981) for locations in Shoalwater Bay, Safety Bay and at Becher Point. The biota of sandy beaches is restricted to fish and invertebrates, largely because strong wave-action produces an unfavourable environment for plant growth. The biota of the bare sandy seafloor is dominated by burrowing animals, including molluscs, polychaetes, and the demersal fishes sole, flounder and ray, as well as pelagic fish species such as skipjack trevally.

Table 3 : Seagrass cover[a] (km^2) in the study area

Habitat	Within M101	Outside M101	Total
Mangles Bay[b]	0	1.8	1.8
Cape Peron[c]	1.5	0	1.5
Shoalwater Bay[d]	1.7	0	1.7
Safety Bay, Warnbro[e]	2.8	6.4	9.2
Total	6.0	8.2	14.2

[a] includes patchy seagrass and fibre-mat.

[b] calculated from maps in Hillman (1986); extends from east of the Garden Island causeway to Rockingham Jetty.

[c] west of Garden Island causeway to John Point.

[d] north of Mersey Point to John Point.

[e] south of Mersey Point to Becher Point.

Marine flowering plants, the seagrasses, are the dominant and most visible living component of the sandy seafloor, and were recorded during this survey along sections of transects 1, 2, 6, 7, 9, 10, 12, 13, 15, 16, 18, 20, 22, 23, 24, 25, 26, 27 and 28, (Figure 3). Some of these locations include subtidal reefs, where seagrasses occur in sand pockets or colonize the seafloor in the lee of the reef chain. Eight species were recorded in the study area during this survey. None is endemic to M101, or to the study area. The dominant species are *Posidonia sinuosa, Posidonia australis, Amphibolis antarctica* and *Amphibolis griffithii.* The last two species were not differentiated in this report. Less abundant species which occur are *Halophila ovalis, Heterozostera tasmanica, Thalassodendron pachyrhizum,* and the largely tropical *Syringodium isoetifolium.* From Figure 7 and Appendix 1, it can be seen that the seagrass meadows occur usually either as a mixture of *Posidonia sinuosa* and *Amphibolis* spp (for example in Shoalwater Bay), as monospecific stands of *P sinuosa* (for example, leeward of Penguin Island; along section of transects 9, 10 and in Safety Bay; transects 27, 28 in Figure 3), as a mixture of *Amphibolis* and patchy *Posidonia*, or as patchy *Posidonia* and mixed species (for example around Becher Point; parts of transects 22 and 23; Figure 3).

All seagrass meadows surveyed appeared healthy, with the exception of a section of the narrow, fringing meadows in south-east Warnbro Sound (transects 24 and 25; Figure 3). These were a patchy mixture of *Posidonia* and *Amphibolis,* reduced in places to fibre-mat with many red algae attached to the rem-

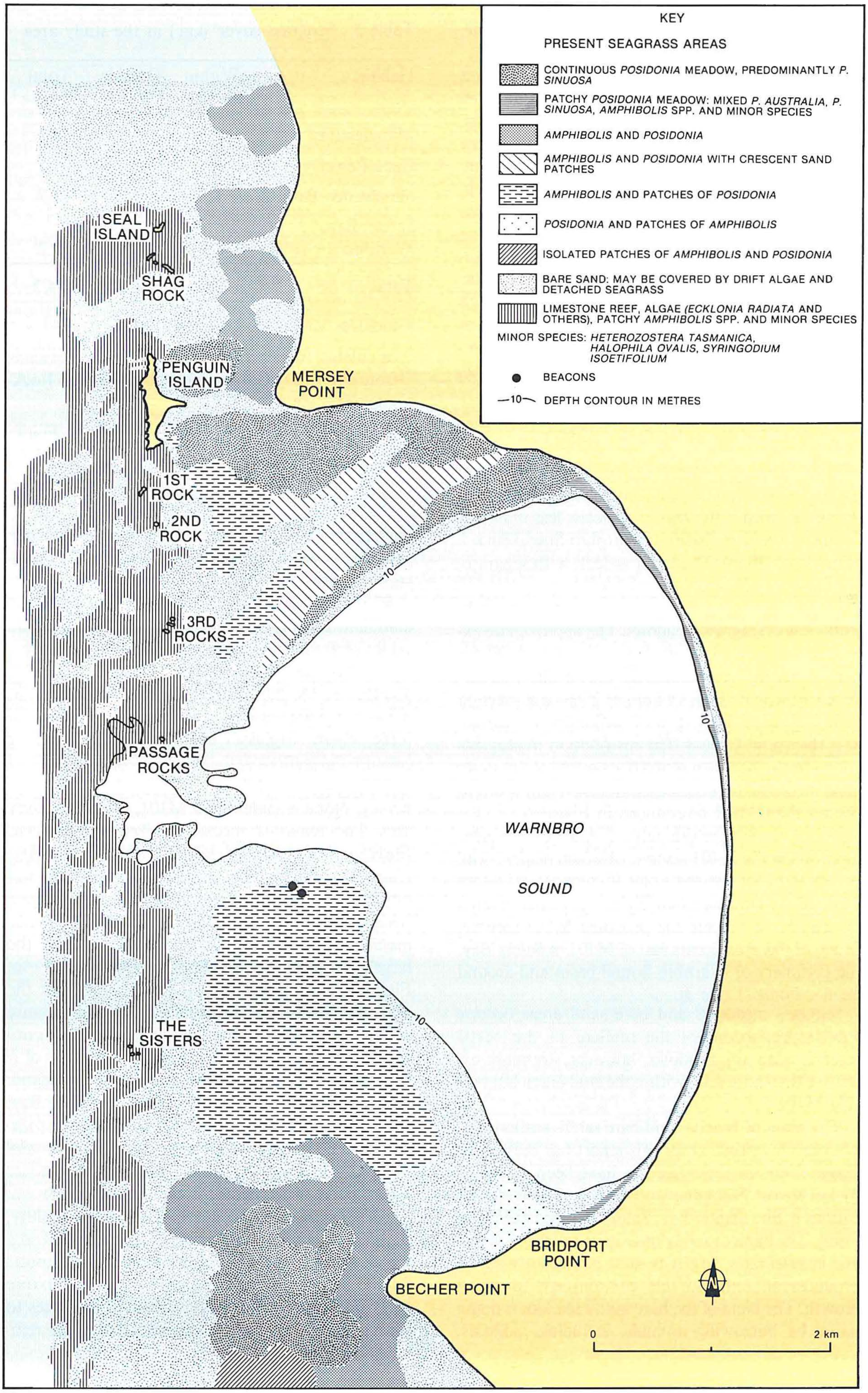

Figure 7: Seagrass distribution from Shoalwater Bay to Becher Point (map reproduced courtesy of Delta Holdings Pty. Ltd.).

nants of the leaf-stalks. At the base of the slope, in deep water at transect 24, the seafloor was littered with tins, plastic bags and other rubbish. Animals seen here were confined to a few starfish and blue-manna crabs (*Portunus pelagicus*). A large sea-pen, *Sarcoptilus* sp, was present in deep water (15 m) at densities of one individual per 10- 15 m^2. Animals encountered along transect 25 consisted of occasional invertebrates, mostly sponges (unidentified) and colonies of large mussels covered with crinoids. These occurred at the base of the slope, from depths of 15 m up to 11 m. Seagrasses were patchy where the slope levelled off towards the beach.

Physical damage to seagrass meadows was evident at inshore locations in Mangles Bay (transect 1; Figure 3) and in Safety Bay (transect 28; Figure 3), through the scouring action of anchors and anchor chains of boats on swing-moorings. Aerial photographs of these locations clearly show the otherwise healthy contiguous seagrass beds "pockmarked" by many patches of bare sand, where the plants have been removed (Figure 5a, b).

These seagrass meadows provide shelter and food for the resident marine life, including fish and invertebrates such as snails and sea urchins. Epiphytic algae, which attach to the host seagrasses and use them as a substrate, were prominent along some transects (13, 15, 20, 24 and 25; Figure 3). The range of epiphytic plants and animals associated with seagrasses in this area is wide, and only recently has their diversity been investigated in detail. For example, about 140 species of algae and about 23 species of epiphytic invertebrate animals associated with *Amphibolis* alone, have been collected around Penguin Island (unpublished data; Appendix 4). This list is not complete and excludes mobile species.

The sandy seafloor under the seagrasses also harbours diverse animals. LeProvost, Semeniuk and Chalmer (1981) recorded 35 separate species of encrusting biota (mostly sponges), associated with seagrass assemblages around Shoalwater Bay and Warnbro Sound. Besides several unidentified sponges collected within seagrass meadows during the present survey, other animals typical of this habitat include colonial and solitary sea-squirts such as *Herdmania* sp and the stalked *Pyura pachydermatina*, sea-anemones such as the common *Heteractis malu*, lace corals, marine worms, and featherstars such as *Comanthus* sp, hydroids, for example *Thyroscyphus marginatus*, a variety of sea-stars, including the large *Luidia australie* and *Astropecten* sp (both of these were not encounted during this survey), *Retaster insignis*, *Archaester laevis*, *Nectria* sp and *Nepanthia ?crassa*, as well as a variety of marine snails such as *Pyrene bidentata*, ?*Calliostoma* sp, *Thalotia* sp, *Astrea squamifera* and *Amblychilepas nigrata* (Appendix 3). The last is apparently not seen frequently in the area (R C Lethbridge, personal communication); it was collected during this survey from seagrass meadows east of Penguin Island (transect 10; Figure 3). Large baler shells (*Melo miltonis*) and turban shells (*Turbo torquata*) were common inshore, in the meadows at transect 2 (Figure 3). Sea-hares (*?Aplysia* sp) were recorded infrequently, in some sandy areas near seagrass meadows (for example, along transects 6 and 7; Figure 3). One species, *Aplysia gigantea* appears to be very common in the shallows at Penguin Island during February and March (M A Borowitzka, personal communication). Sponges dominated the conspicuous invertebrates of the meadows in the lee of Penguin Island (transects 9 and 10; Figure 3). At the time of this survey, the meadows along transect 23 at Becher (Figure 3) harboured many invertebrates, particularly solitary orange, and pink-lipped sea-squirts, featherstars, lace corals (around the leaf-stalks of *Amphibolis*) and sea-cucumbers, such as *Stichopus ?mollis*. Nudibranch sea-slugs and starfish were common amongst the seagrasses in Safety Bay (transect 28; Figure 3).

Warnbro Sound Basin

Surrounded by steeply-shelving banks (see depth contours in Figure 3) which support seagrasses to a depth of 10 m, the silty Warnbro Sound basin has a conspicuous, abundant fauna, especially echinoderms. A major proportion of the Warnbro Sound seafloor is over 15 m deep; about 16 km^2, or 94%, lies outside the proposed M101 reserve (Table 1 and Figure 4).

The detritus-feeding sea-star *Stellaster inspinosus* is very common (Figure 6f), in some areas approaching densities of one individual per square metre. A filter-feeding holothurian (?*Pentacta* sp) and the sand-dollar, *Peronella leseuri*, are very common in the northern sector of the basin. The sand-dollar was also encountered in the seagrass meadows around Safety Bay (transect 27; Figure 3). Large anemones and cerianthids are conspicuous components of the benthic fauna, along with a variety of sponges (unidentified), tunicates and crinoids, locally associated with the silty bottom of the basin. The flora is impoverished and restricted to occasional clumps of green algae, mostly species of the genus *Caulerpa* and a few foliose red algae.

Marine Life of the Islands

Youngson and Henry (1981) listed the vertebrate fauna of the islands, including those inhabiting Carnac and Garden Islands, adjacent to the survey area. The fauna of White Rock, Bird Island, Seal Island, Shag Rocks, Third Rocks and The Sisters within the proposed M101 reserve, is protected. These islands are C-class reserves under the Land Act, and are vested in the Department of Conservation and Land Management. First Rock, Second Rock and Passage

Rock (Figure 3) are vacant Crown land. Penguin Island is an A-class reserve under the Land Act.

The islands and rock stacks are important as resting, breeding and nursery areas for birds and mammals, especially in Shoalwater Bay. Third Rocks and The Sisters are breeding sites for the pied cormorant, *Phalacrocorax varius.* A total of 72 species of birds has been recorded from this area (Youngson and Henry 1981); 18 of these use the islands for breeding. None of the fauna is endemic to the islands. These are an important refuge for the little penguin (*Eudyptula minor*; see backcover illustration) whose northernmost breeding site is Carnac Island, 4 km north of Garden Island. Good water quality, in the shallow waters around the islands, is considered essential to maintain an adequate, uncontaminated food supply for the little penguin, especially during the breeding season (Youngson and Henry 1981). Other seabirds include the Australian pelican (*Pelecanus conspicillatus*), the storm petrel (*Pelagodroma marina*), the reef heron (*Egretta sacra*), the pied oystercatcher (*Haematopus ostralegus*), the silver gull (*Larus novaehollandiae*), the bridled tern (*Sterna anaetheta*) and the fairy tern (*Sterna nereis*; see backcover illustration). Fairy terns have declined in number in recent years, as have sightings of sea-lions (*Neophoca cinerea*), which were once quite abundant on the islands (Youngson and Henry 1981).

DISCUSSION

Intertidal High Reef Platforms

Data from Benjamin's recent research at Cape Peron indicate that the structure of the communities of algae on the platforms is largely determined by a small tidal range, high insolation and summer desiccation. Diversity is greatest in winter, when high tides and strong wave action favour opportunistic species.

Algae of the splash zone, upper eulittoral and upper mid-eulittoral zones, which are areas of instability on the platforms, grow quickly and are strongly seasonal, dying when killed by stressful environmental conditions (Benjamin 1985). The perennial species are able to colonize stable sections of the platforms and are either strongly competitive or stress-tolerant, as exemplified by the red alga *Gracilaria* at Cape Peron. Slower-growing species, such as *Sargassum*, occupy stable areas where desiccation, during low tides, is less extreme, and where they can develop a dense canopy (Benjamin 1985).

The Cape Peron region is a harsh environment for intertidal algae, with high insolation in summer, a small tidal range and irregular periods of sand- scouring. This harshness is reflected in the proliferation of turf algae rather than the large macrophytes typical of similar habitats on cool, temperate coastlines (Dakin et al 1948; Womersley 1981; Benjamin 1985; Jernakoff 1985). Though the biomass attained by the algae on local intertidal reef platforms appears to be quite large relative to those elsewhere in Australia (M A Borowitzka, personal communication), these communities fail to attain a climax apparently because of the factors described above (Benjamin 1985). Her experiments indicate that algae on the Cape Peron platforms can recolonize denuded areas rapidly. Reefs of this type, which may appear to have an impoverished flora, may not necessarily be completely devoid of marine life year-round, and the strong seasonal changes such communities undergo should be recognized.

The intertidal fauna is typical of reefs along this part of the coast; the invertebrate animals were less conspicuous, and less abundant, at the time of the survey, on the tops of the platforms compared with the sub-littoral reef walls. Reef platforms support large populations of certain animals (for example the sea-star *Patiriella gunnii* at Penguin Island; R C Lethbridge, personal communication). The ecology of animals on the platforms, however, is not fully understood. For example, *P gunnii* is common at Penguin Island but is not seen often on adjacent onshore reef platforms at Cape Peron (R C Lethbridge; personal communication). Marine life of the platforms south of Third Rocks (Figure 3) has been little-studied, and the present survey did not record the full range of the biota which occupies these habitats.

The high diversity of the biota found in these intertidal habitats, which occupy only a small area within M101, makes them valuable for conservation. Furthermore, these reefs, including those south of Penguin Island (Figure 4), represent a large proportion of this type of habitat along the metropolitan coast.

Subtidal Reefs and Limestone Pavement

These are valuable for a number of reasons, notably the wide range of marine plants and animals which they attract and the underwater limestone features of the area, such as caves and pinnacles which harbour a variety of fish and colourful assemblages of sponges, gorgonians and other invertebrates (Figure 6d).

Large macrophytes such as kelp, which dominates the flora of reefs throughout summer, are recognized as being substantial contributors to primary production of inshore coastal waters (Mann 1972). Kelp contributes to the food chain through the breakdown of tissue into particulate matter. This is consumed by various animals, enters the food chain and is passed through various trophic levels. Studies on kelp on reefs off Whitford, north of Perth, indicate that maximum growth rates of the alga are achieved in spring between October and November, and decline towards mid-summer (Kirkman 1981). The *Sargassum* which is conspicuous along with kelp on local reefs also contributes to production. At Whitford, growth of this alga complements the summer decline of kelp, growing between September and mid- February, then breaking down in March (Kirkman 1981). Though there have been no measurements made on growth of these algae in the study area, similar seasonal changes might be expected to those observed at Whitford.

A number of secondary producers, including fish and herbivorous invertebrates such as sea urchins, depend on the reef communities for food and shelter. Like seagrasses, algae are also host to a range of plant and animal epiphytes. Reefs in M101 and adjacent areas, particularly west of Garden Island, are part of the State rock lobster fishery (Brown and Barker 1985), providing settlement sites and nursery grounds for larvae and juveniles of the western rock lobster, *Panulirus cygnus.* Another commercially-important species, Roe's abalone, *Haliotis roei,* is fished on reefs west of Garden Island and Penguin Island, and was conspicuous on the reef platforms and upper reef platform walls at Cape Peron and on offshore reefs south of Penguin Island during this survey. The reefs west of Garden Island and Penguin Island are important sites for the abalone fishery in this State. These abalone feed on drift algae in the water, especially along reefs situated off land-backed beaches (J Penn, personal communication). The duration and location of this fishery is controlled by the WA Fisheries Department.

The dominant flora occupying the reefs at the time of this survey was superficially similar throughout the locations visited, though there were variations from site-to-site in the relative proportions of kelp and understorey species (Appendix 1). Algae inhabiting these reefs are strongly seasonal; many of the perennial species, such as *Cryptonemia kallymenioides and Codiophyllum decipiens,* are only conspicuous at certain times of the year. The flora collected also includes some rare and undescribed algae, such as *Pradaea.* This means that a complete view of the range of biota, and the seasonal changes in the biota, is only possible through detailed observations taken over, at the very least, an entire year.

Distribution of the fauna sighted on the reefs in M101 was patchy. For example, the solitary coral *Scolymia australis* appears to have a markedly discontinuous distribution, being recorded in this survey from The Sisters reefs, reefs along transect 17, and from around Seal Island. Previously, it has been found on reefs at the northern extremity of Penguin Island and around First Rock (R C Lethbridge, personal communication). There is an apparent absence of corals, such as *Montipora* sp and *Pocillopora damicornis,* and sea urchins such as *Echinometra mathaei,* which are common at Rottnest Island (R C Lethbridge, personal communication). Both coral genera, however, have been recorded in reefs west of the study area (LeProvost, Semeniuk and Chalmer 1981). Colonies of hydroids, such as ?*Solanderia* and *Stylaster* are common at Rottnest Island, but appear to occur patchily in the M101 area, and have never been encountered at Penguin Island (R C Lethbridge, personal communication). Similarly, the large lace coral, *Adeona* sp was collected in deep water west of The Sisters reef during this survey, but has apparently not been seen previously south of Rottnest Island (R C Lethbridge, personal communication).

The presence and density of sponges was found to be highly variable, even on adjacent reefs, for example on walls of adjacent platforms at The Sisters and north Murray Reefs (transects 19, 21; Figure 3). These animals are very diverse as suggested by data of LeProvost, Semeniuk and Chalmers (1981), who recorded over 70 genera from around reefs of the Garden Island Ridge and Five Fathom Bank. Collections of sponges in the Roche Research Institute of Marine Pharmacology suggest that this region has one of the most diverse sponge communities in Australia (M A Borowitzka, personal communication).

Why there is such patchy distribution and absence of particular animal species in the survey area is unclear. Part of it will be apparent rather than real, due to limited and selective sampling methods. A further factor likely to be important is a difference in sea-temperature between near-shore coastal habitats such as this and sites further offshore, brought about by the influence of the Leeuwin current (Cresswell and Golding 1980) providing warmer conditions in locations close to the continental shelf.

Sandy Seafloor (including Seagrass Meadows)

Seagrasses are found growing extensively along the Western Australian coast, and seagrass speciation appears to be highly developed. For example, the genus *Posidonia* is represented by at least four species locally but only by a single species outside Australia (Cambridge 1980; Cambridge and Kuo 1979; Womersley 1984). Recent recognition of new species of *Posidonia* along this coast including some collected the M101 region (Cambridge and Kuo 1984), suggests that there may be more species in the study area than indicated from this brief survey.

Seagrasses, like algae, are important primary producers and attract a variety of animals and plants to sandy habitats, by providing a substrate for growth as well as a source of food and shelter. Epiphytic algae, on stems and leaves of the seagrasses, contribute to primary production and also to the formation of sediments from production of calcium carbonate (S M Horner, Australian Marine Sciences Association Conference, Hobart, Tasmania, February 1986, abstracts, p 77). The animal component of seagrass communities is complex and covers many trophic levels, represented by carnivores, herbivores and detritivores. Loss or degradation of the meadows is thus likely to make an impact on the structure and proportions of the resident fauna.

The quite variable proportions of seagrass species making up the meadows depend on biological factors such as succession, competition and grazing by animals, and on physical factors such as water turbulence and sediment movement. Sands are transported by water currents and wave action throughout the study area and influence the ability of the seagrasses to colonize bare areas. The local sedimentation regime is, itself, modified once seagrass meadows become established, as these efficiently trap, bind and stabilize the sediments (Cambridge 1980; Cambridge and McComb 1984).

Posidonia meadows in Shoalwater Bay display a characteristic accretion of sands at their edge, and a "depression' in the centre of the meadows where sands have eroded out of the bed (Cambridge 1980). Other examples have been given of this type of meadow around Becher Point and in the southern flats area of Cockburn Sound (Cambridge 1980). Like *Posidonia sinuosa, P australis* grows in sheltered conditions (Kuo and Cambridge 1984), apparently in accreting sandy areas; for example where the seagrass meadows are already established and erosion is subsequently reduced (Cambridge 1980). *Posidonia australis* and *Amphibolis* spp occur together, along with *P sinuosa,* in the more-exposed parts of Shoalwater Bay, northeast of Penguin Island (Figure 7).

Posidonia is generally less tolerant of turbulent water conditions than the wiry-stemmed *Amphibolis* spp. Cambridge (1980) considered *Amphibolis* to be a secondary colonizer because of the less-robust rhizome system and the morphology of the seedlings, which are not suited to settling on bare substrates. *Amphibolis* thus appears frequently in areas where the substrate has been modified or colonized. Species of *Amphibolis* were conspicuous in meadows south of Penguin Island, east of Third Rocks (for example, the eastern sections of transects 12 and 13; Figure 3), on sandy seafloor east of the southern reef chain (east of transects 16, 18 and 20; Figure 3), and around Becher Point (transect 22; Figure 3).

Minor species in the study area, such as *Halophila ovalis* and *Heterozostera tasmanica,* generally cannot tolerate high energy conditions and are frequently damaged, or uprooted during storms. They were commonly found on sandy seafloor in the lee of the reef chain: for example, inside The Sisters (transect 18), Murray Reefs (transect 20), and the inner end of transect 15 mixed with *Posidonia* (Figure 3; see Appendix 1).

Damage to the meadows at Safety Bay and Mangles Bay from scouring by boat anchors and chains should be rectified by finding alternative methods for securing boats. Further damage to these meadows is undesirable because their loss is likely to lead to increased erosion locally. There have been, up to now, no large-scale losses of seagrass in the survey area. About 15 ha of seagrass meadows adjacent to the Garden Island causeway, but outside M101, (transect 1; Figure 3) may be removed during the construction of a boat marina (John Holland Group 1985).

A considerable proportion of healthy seagrass meadows in the study area is not included in the proposed M101 reserve, notably east of Mersey Point in Safety Bay, at Becher Point, immediately west of the Warnbro Sound basin, and the narrow, fringing meadows along the eastern shore line of Warnbro Sound (Table 2 and Figures 4 and 7). These meadows are extensive and grow close to the beach. They are thus susceptible to degradation from development on the shoreline. The narrow and somewhat patchy meadows on the eastern shore of Warnbro Sound are degraded in some places where they have been reduced to fibre-mat. These meadows, as well as those in Safety Bay, are probably important for stabilizing the shoreline, though there are no data here to confirm this. France (1978) investigated the sedimentology of seagrass meadows of the barrier and fringing banks of adjacent Cockburn Sound and considered these to exert a strong influence on sedimentation and beach stability. Cambridge (1980) has discussed the likely effects of removal of the leaf canopy of the seagrasses fringing Cockburn Sound. These include loss of detritus (leading to a change in the resident fauna), increased erosion around the roots (rhizomes), increased wave energy to the beaches because of reduced damping of wave-energy across the meadow resulting from a loss of the leaf canopy, and changes in beach-form resulting from increased removal of beach sands seasonally. The likely effects of removal or loss of seagrasses from the upper vegetated slopes which surround the Warnbro Sound basin are not known.

The appearance of locally-degraded seagrass meadows in this survey, reduced to fibre-mat with epiphytes on leaf stalks and colonies of mussels, resembles previous descriptions of these communities in adjacent Cockburn Sound following dieback (Cambridge 1980; Cambridge and McComb 1984), and suggests that they are under some stress at present. Evidence from Cockburn Sound indicates that seagrass habitats are severely degraded through nutrient enrichment (Cockburn Sound Environmental Study 1976 -1979; Cambridge and McComb 1984; Silberstein 1985) and that this process is not reversed rapidly (Hillman 1986). Decline of seagrasses in Cockburn Sound has been attributed to a reduction in light reaching the seagrass leaves due to shading by attached epiphytes. Growth of epiphytes was stimulated by elevated nutrient concentrations derived largely from discharges of industrial effluent to Cockburn

Sound. Recent improvement in the condition of some meadows has coincided with reductions in nutrient loads, particularly of inorganic nitrogen (Hillman 1986). Thinning of the leaf canopy and reduction in the density of leaf shoots in seagrass meadows in the study area may provide an early indication of their decline (Silberstein 1985). In view of the implications of nutrient enrichment for seagrass survival, there are strong arguments for maintaining high water quality throughout the survey area, particularly since this includes tracts of healthy seagrasses almost continuously from Shoalwater Bay to Becher Point (Figure 7).

At present, there is no direct discharge of industrial or treated domestic effluents into the study area. The Cape Peron ocean outlet has been discharging primary treated effluent through a disperser into the Sepia Depression, 4 km offshore from Cape Peron, since July 1984, but the impact of this on the marine communities in the study area is unknown.

Warnbro Sound Basin

This area contains a low diversity of animals but at high densities in some localities. The flora is impoverished, largely due to the depth and turbidity of the Sound which limits the light available for photosynthesis. The animal communities here include species which are typical of those inhabiting soft, silty substrates, and many of these are not present on nearby offshore reefs and in sandy embayments. Only 1 km^2 of the Warnbro Sound basin lies within M101 (Table 1). After Cockburn Sound, it is the only large, deep-water basin in the southern metropolitan region and, unlike Cockburn Sound, has the advantage of being largely free of pollution. It is presently the location for several scientific research projects on marine organisms. These include investigations on populations of the sea- star *Stellaster inspinosus* (Figure 6f), and on the colonization of an artificial reef placed in Warnbro Sound in June 1984. This reef was constructed by the Combined Services League, Rockingham, and consists of 130 "pyramids" of linked automobile tyres, 21 per pyramid, in a circle of 50 m radius, at 15 m depth. These habitats have been monitored opportunistically for biota since June 1984 by scientists from the School of Environmental and Life Sciences, Murdoch University (R C Lethbridge and M A Borowitzka, unpublished data). Recruitment of plants and animals to the reef has been sporadic, and the new populations have not stabilized. The reef provides habitats for a number of fish, for example, wrasses, leatherjackets, sweep and cowfish, and it is also attracting numerous pelagic fish such as skipjack trevally. The tyres are now covered with a fine layer of turf algae and support diverse sedentary and mobile invertebrates (see back cover illustration).

General

The littoral and sub-littoral marine plants and animals of the survey area are generally typical of those described for sandy bays and reefs elsewhere along the metropolitan coast (Marsh and Devaney 1978; Kirkman 1981; Woods, Kerr, Ottaway and Mills 1985; Ottaway and Simpson 1986), with exceptions. These include the apparent absence of some of the tropical corals and sea urchins which are found at Rottnest Island, in Cockburn Sound and in the Marmion Marine Park.

Easy access to some of the marine habitats makes them attractive and suitable sites for scientific investigation and for general study, but also opens them to exploitation, particularly the onshore reefs around Cape Peron. The survey area included contrasting habitats such as the deep Warnbro Sound basin and the prolific healthy, peripheral seagrass meadows such as those in Safety Bay (Figures 4 and 7). The basin, unlike similar adjacent deepwater habitats close to Perth, has not yet become subject to the detrimental effects of pollution, and its marine life is a good example of the few communities of this nature found locally.

Contemporary studies on the marine life of the M101 region have been both limited and selective in subject and choice of locations. Most attention has been given to the biota, particularly the algae, of onshore reef platforms at Cape Peron (Smith 1952; Benjamin 1985) and around Penguin Island (Borowitzka and Lethbridge; unpublished data). These studies indicate that the area is rich floristically. The biota of the rest of the study area, particularly of the offshore limestone reefs south of Penguin Island, is poorly studied, including knowledge of the invertebrates; however, some have been dealt with in detail in adjacent Cockburn Sound (Marsh and Devaney 1978; Wells 1978; Wilson et al 1978).

The present surveys were general and of too short duration to detect subtle differences amongst communities in each of the broad habitats. The fauna, for example, may be at least as rich as the flora appears to be, but this is often masked by the behaviour and inconspicuous nature of some of the animals, which exist, for example, as a thin veneer on cryptic surfaces of the reefs beneath the more conspicuous and larger species, or remain hidden during daylight hours. Furthermore, there is a diverse and complex interaction of marine life associated with the seagrass meadows and on the sandy seafloor, which was not considered in this report.

The diversity and extent of marine communities in the area, research projects currently underway on some of these, and the ready accessibility for a wide range of activities including recreation, are compatible with the priorities laid down for the establishment of marine parks (Ivanovici 1984). Though the organisms and communities described herein are not,

Figure 5. Aerial photographs of the study area. a: damage to seagrass meadows in Mangles Bay from scouring by anchors and anchor chains of moored craft; b: intense scouring of seagrass meadows by barges in Mangles Bay; c: view of the M101 region looking south from Cape Peron. The reefs and islands are clearly visible on the right of the picture. (Photographs : S. Chape.)

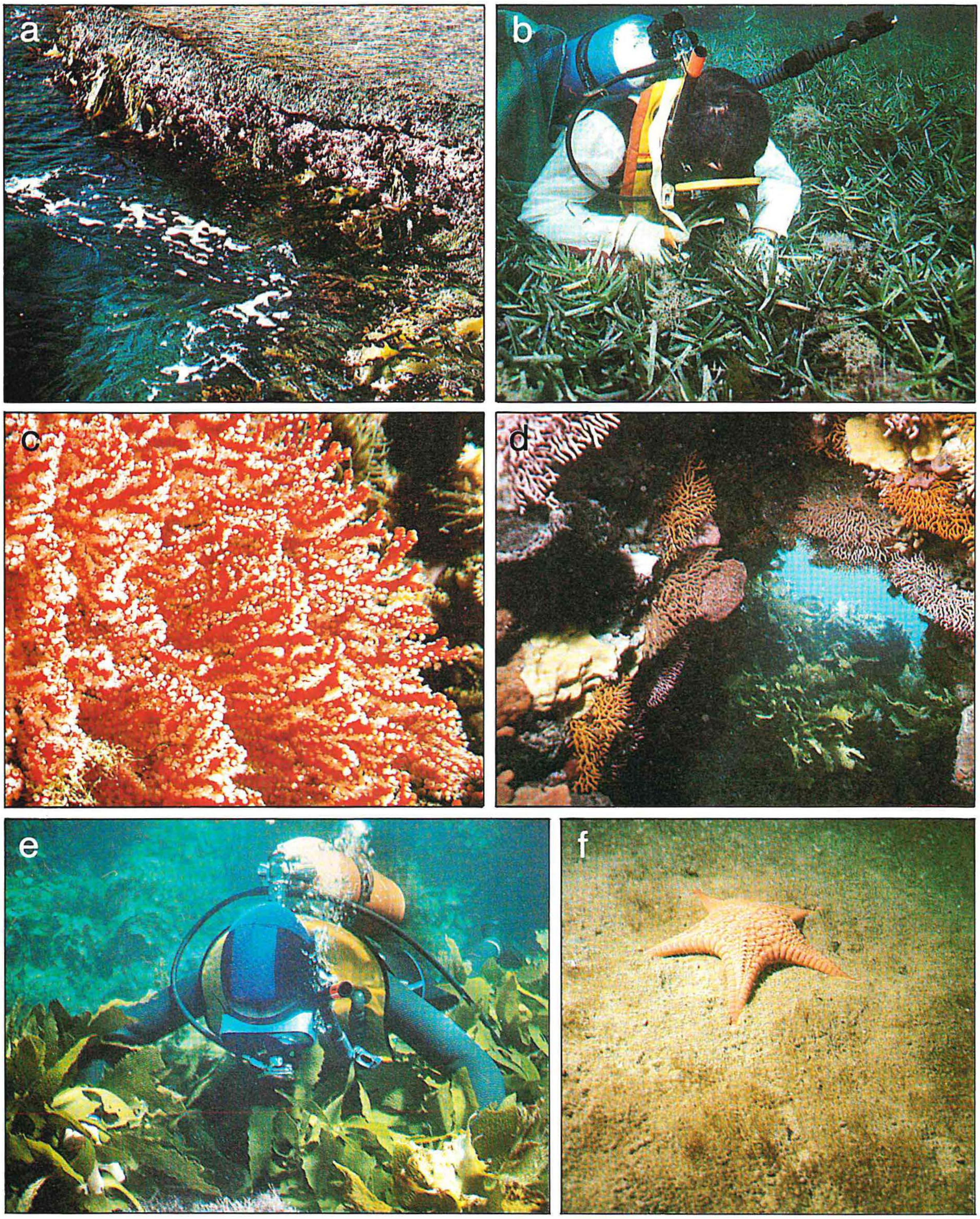

Figure 6: Marine communities typical of the M101 region. a: seaward edge of an intertidal reef platform with algae exposed at low tide; b: seagrass meadows such as this *Amphibolis* meadow are extensive, and help to stabilize the sandy seafloor; c: the colourful soft coral, *Mopsella* is common on subtidal reefs; d: underwater caves and ledges attract many animals including sponges; e: kelp *Ecklonia radiata*, is common on reefs and is a source of food and shelter to fish; f: the deep and silty seafloor of Warnbro Sound harbours many animals, including this starfish, *Stellaster inspinosus*. (Photographs : a: G.G. Smith; b-d and f: R.C. Lethbridge; e: J.R. Ottaway.)

generally, unusual for this part of Western Australia, they are valuable because of the need to protect the poorly studied but representative marine life, to preserve habitats of the economically important species such as edible shellfish and lobster, and to maintain the genetic diversity within these communities so that natural stocks in the area can, if necessary, be replenished. This last point is particularly important in view of the severe and widespread degradation and loss of seagrass communities in adjacent Cockburn Sound.

CONCLUSIONS

1. Over 65 different animal species in eight phyla were collected from four major habitats. This number is very conservative and represents only conspicuous and common species at one time of year. It does not include the numerous (thousands?) sponges and hidden, cryptic species present. At least eight species of seagrasses in four families, and an unknown number (possibly hundreds?) of species of algae occur in the study area. Research is now uncovering previously undescribed and new records of marine life on a coastline which is presently little studied, either taxonomically or ecologically. Most information available on the marine life of M101 comes from data collected at Cape Peron and around Penguin Island; offshore habitats south of Penguin Island are poorly collected and barely studied.

2. The islands and rock stacks of Shoalwater Bay and Warnbro Sound are of high conservation value as resting, breeding and nursery sites for a variety of mammals and birds. These are all included within the proposed M101 region. Most are reserves under the Land Act, and vested in the Department of Conservation and Land Management. The fauna is protected.

3. Four broad aquatic habitats are recognized for marine plants and animals: intertidal limestone platforms, subtidal limestone reefs and pavement, sandy seafloor (which includes seagrass meadows) and the silty Warnbro Sound basin.

4. Intertidal platforms provide habitats for a wide range of algae, which are strongly seasonal. Zonation of the plants across the platforms is limited by a small tidal range, high insolation and consequent dessiccation stress during summer. High reef platforms occupy about 0.5 km^2, or less than 2%, of the proposed M101 reserve. Over 40% of these are situated south of Penguin Island. Because of the strong seasonal changes in marine communities occupying high reef platforms, bare areas here may not necessarily be devoid of life throughout the year.

5. There is easy access to onshore reef platforms at Cape Peron and this is a potential source of disturbance, through trampling and removal of plants and animals.

6. Subtidal reefs and pavements are extensive in the study area; they occupy over 50% of the proposed M101 reserve. These have conservation value for the following reasons:

   - presence of large algae such as kelp and *Sargassum* which dominate the reefs in summer; these are highly productive and make a major contribution to primary production of the marine communites in the area;

   - kelp is an important food source and shelter for many marine animals including fish;

   - kelp and other algae contribute to the food-chain following breakdown;

   - the M101 reserve includes part of the Garden Island Ridge whose reefs are habitats for commercially important species, including the western rock lobster and abalone;

   - the reefs contain both new records of previously described species and new species of plants and animals.

7. It is noted that the algae of limestone reefs and pavement have a strong seasonal component. A complete view of the abundance and diversity of marine plants and animals is only possible through observations taken over at least a year.

8. There was a patchy distribution of the dominant algae on subtidal reefs. The distribution of invertebrate animals on reefs between Penguin Island and the southern offshore reefs also appears to be patchy. There is a paucity of detailed information on plants and animals of the reefs south of Penguin Island.

9. None of the seagrasses recorded in this survey is endemic to the study area.

10. All seagrass meadows surveyed appeared healthy except locally in some meadows south-east of Warnbro Sound.

11. Obvious physical damage to seagrass meadows has occurred in Mangles Bay and in Safety Bay. Parts of the meadows have been removed

through the scouring action of anchors and anchor-chains of boats on swing-moorings.

12. The seagrass meadows in the study area are not uniform but contain different proportions of the eight seagrass species recorded.

13. Vertical distribution of seagrasses is limited to water depths less than 10 m.

14. Of the 14 km^2 of seafloor associated with seagrasses, 6 km^2 occurs within the proposed M101 reserve; 3 km^2 of seagrasses in M101 occur south of Penguin Island.

15. About 6 km^2 of extensive healthy seagrass meadows occur in Safety Bay, surrounding the Warnbro Sound basin, and at Becher Point.

16. Water and sand movement are important physical factors influencing the establishment and survival of seagrasses.

17. Seagrass meadows throughout the survey area have conservation value for the following reasons:

    - they stabilize sands and influence physical coastal processes;
    - they contribute to primary productivity;
    - they are healthy and extensive examples of a community type which has been severely depleted in adjacent Cockburn Sound;
    - they are an important source of food and shelter to a variety of marine animals and fish;
    - they increase the diversity of the marine life of the sandy seafloor;
    - they contribute to the detrital food pathway following break-down;
    - they include plants with a high degree of speciation, which is of considerable scientific interest.

18. Warnbro Sound basin contains populations of animals at high densities and low diversity. The marine life includes communities which are different to those found on adjacent reefs or on the shallower sandy seafloor.

19. The flora of Warnbro Sound basin is impoverished due, largely, to high turbidity reducing light at the seafloor.

20. About 1 km^2, or 6%, of the deep Warnbro Sound basin occurs within the proposed M101 reserve. This represents less than 4% of the total area of the proposed M101 reserve.

21. Because of its unusual bathymetry and generally abundant animals, Warnbro Sound is of high conservation value. Notably, the Sound is the only large, deep-water basin free of pollution close to the metropolitan area. Moreover, a number of scientific research studies are being undertaken on marine life.

22. The study area is largely free of pollution, with no direct discharges of effluents.

23. Water quality during this study was high and appears better, generally, than in the adjacent Cockburn Sound.

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APPENDIX 1

Results of manta board surveys, November 1985, showing the relative dominance of the common marine plants and animals, and the seafloor types.

KEY

A Dominant plants and animals

Algae:

- *Ecklonia radiata*
- *Sargassum* spp.
- Non-calcareous red algae
- Coralline red algae
- Green algae: mixed species, dominated by *Caulerpa* spp., *Codium* spp., *Ulva* spp.
- Brown algae: mixed species excluding *Sargassum* spp.

Seagrasses:

- *Posidonia sinuosa*
- *Posidonia australis*
- *Amphibolis* spp. (not differentiated)
- *Halophila ovalis*
- *Thalassodendron pachyrhizum*
- *Heterozostera tasmanica*
- *Syringodium isoetifolium*
- Ascidians and sponges
- Drift material (algae and seagrasses)
- Seagrasses dead or reduced to fibre-mat.

B. Substrate types (subtidal)

- Sand, no ripples
- Sand, ripples < 1 m
- Sand, ripples ⩾ 1 m
- Fine silt
- Limestone pavement
- Low fragmented limestone reef
- High fragmented limestone reef

Relative dominance of biota and substrates is shown as a gradation in lines above and below the transect line, respectively.

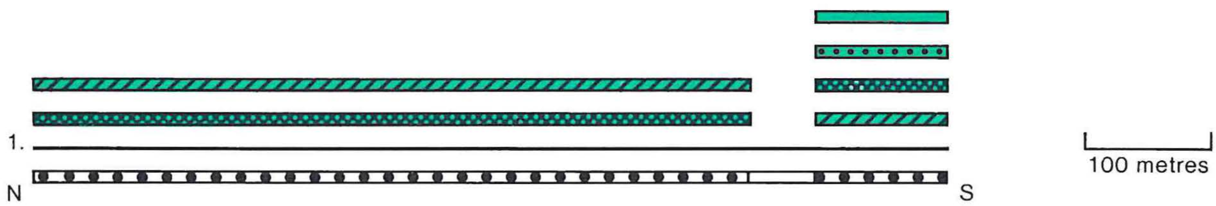
Note: lines shown give no indication of patchiness along the transects.

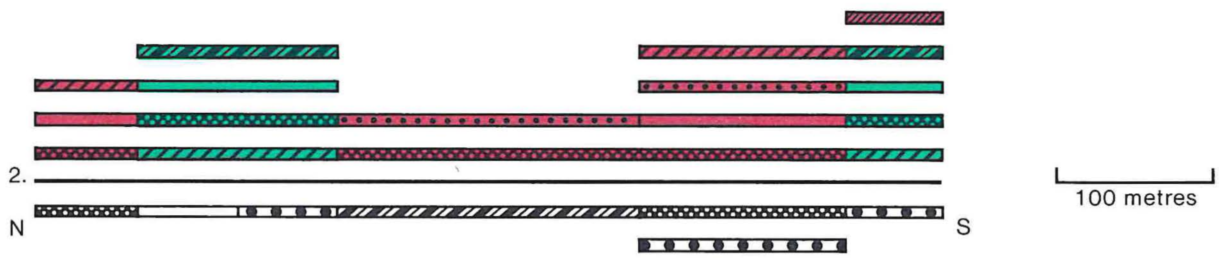
N = North

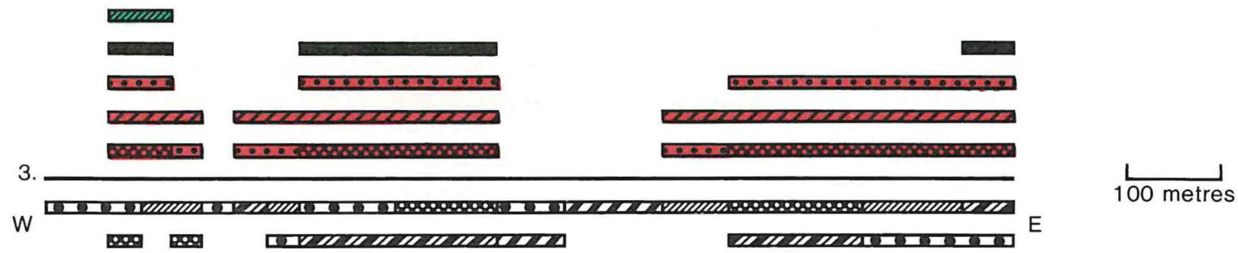
S = South

E = East

W = West



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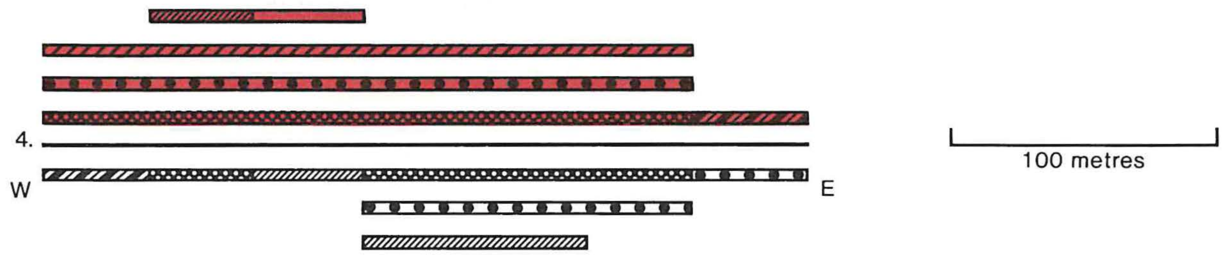
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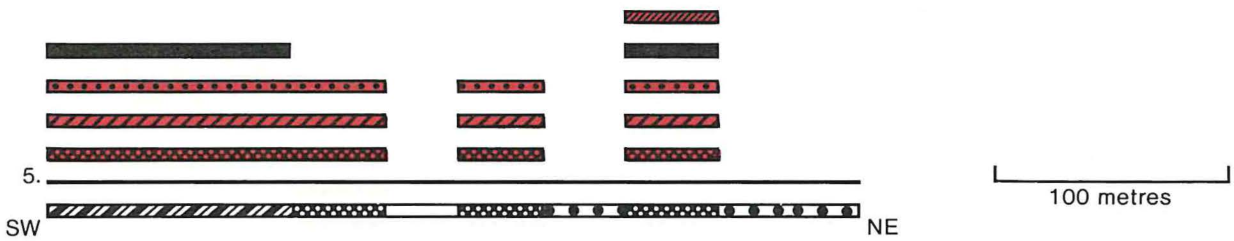
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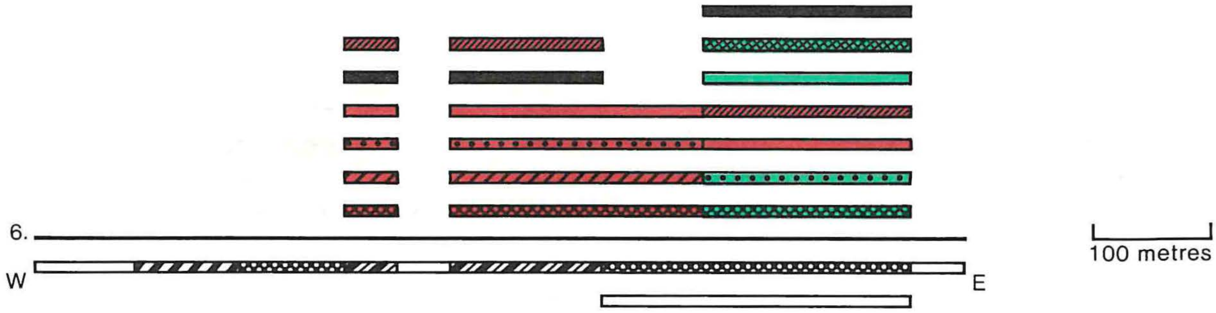
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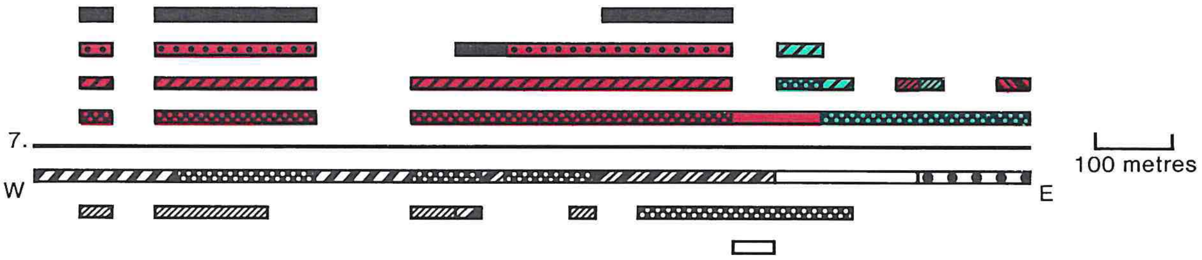
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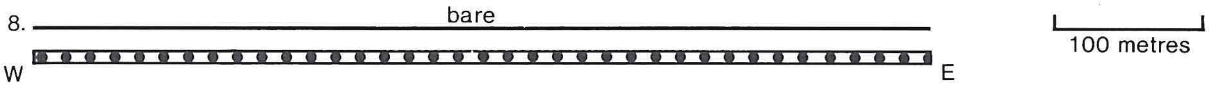
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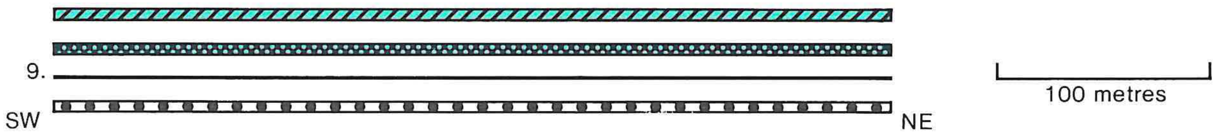
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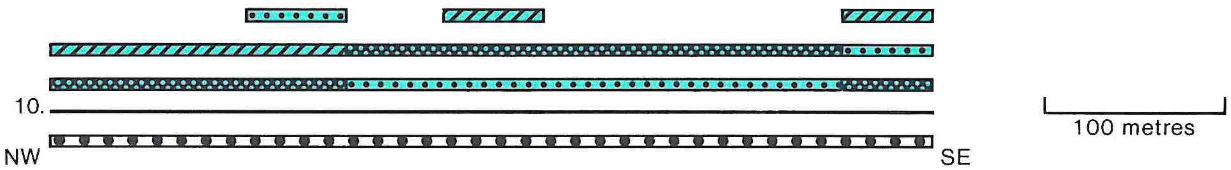
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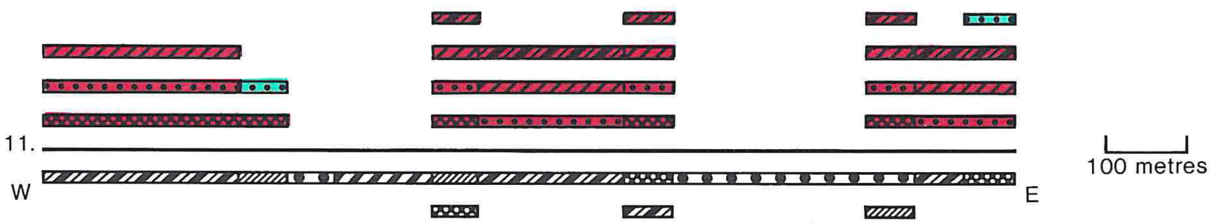
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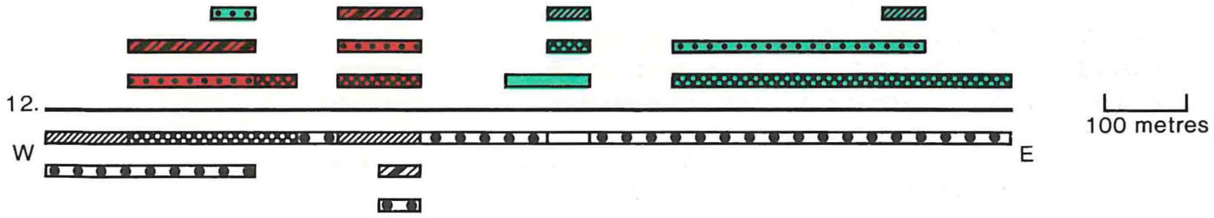
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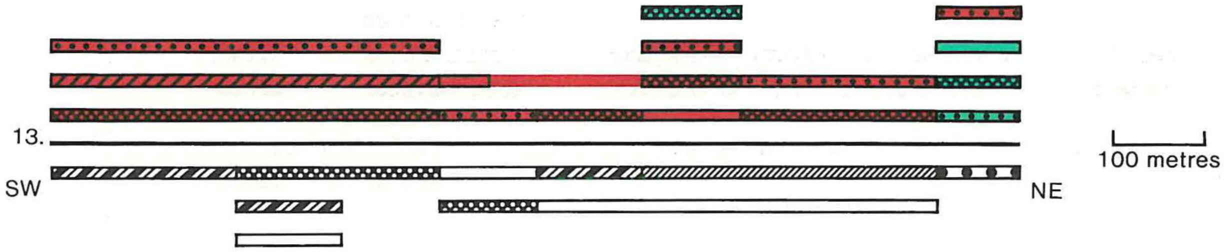
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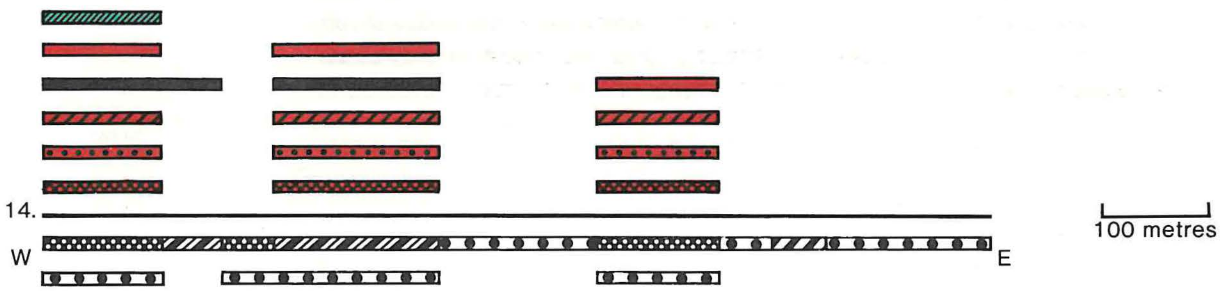
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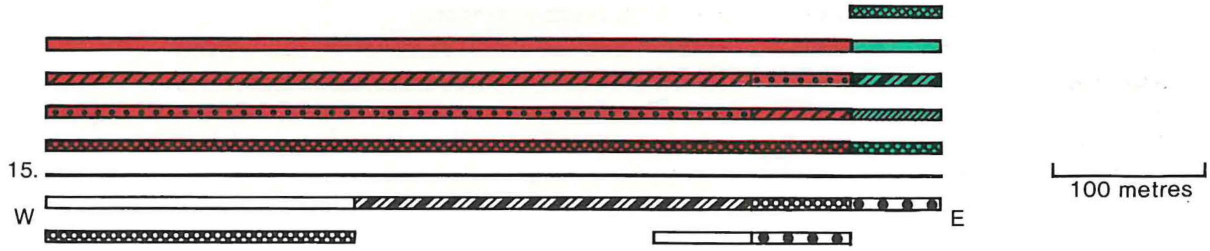
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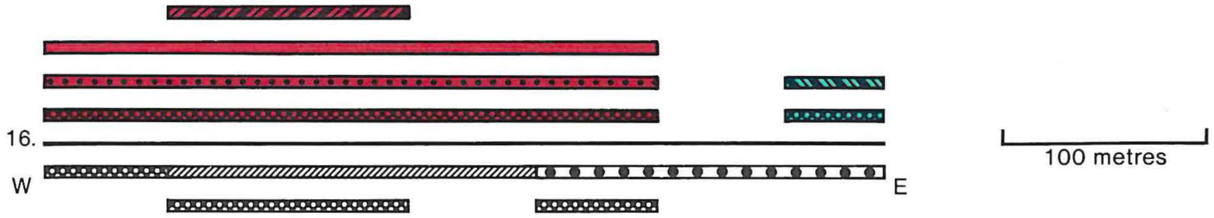
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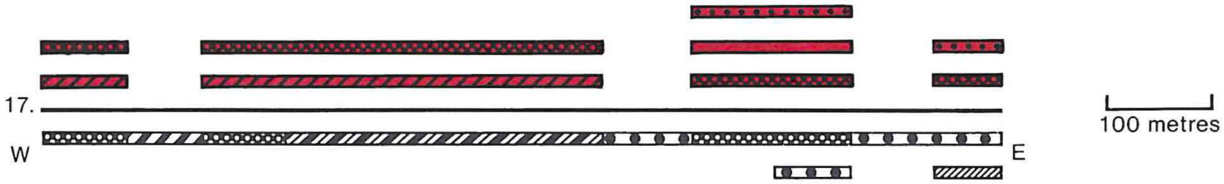
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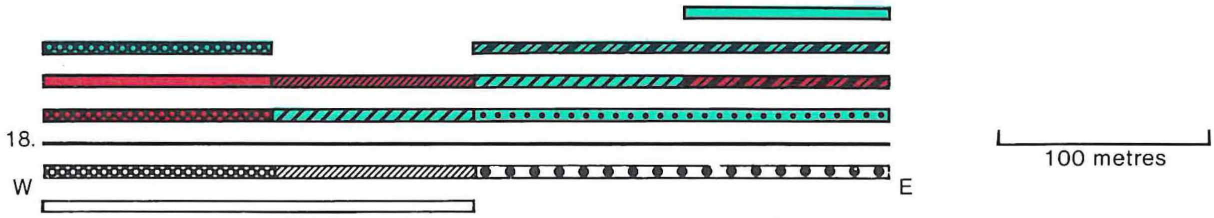
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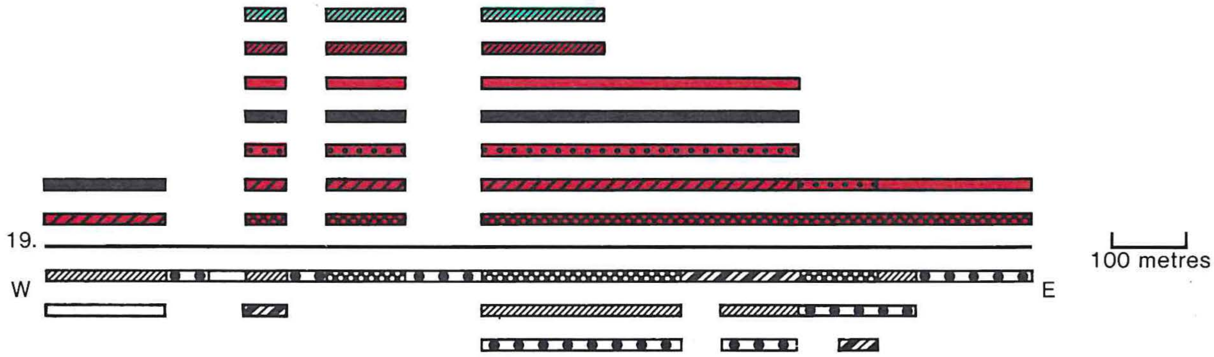
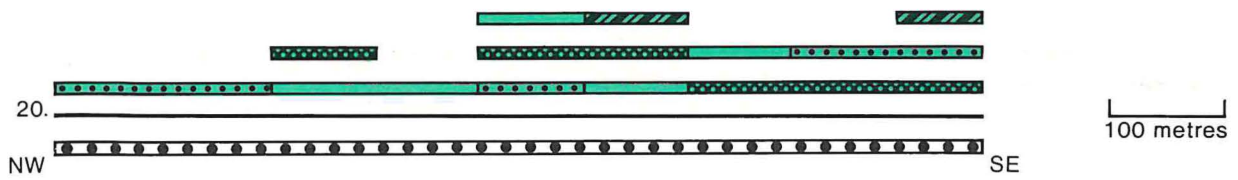
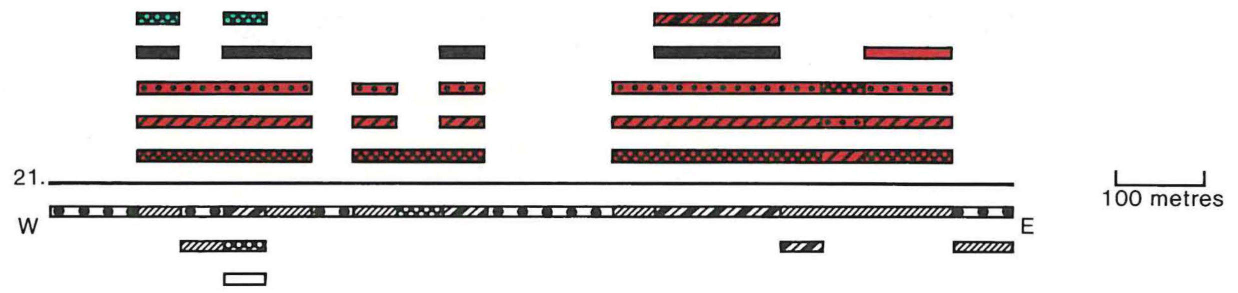
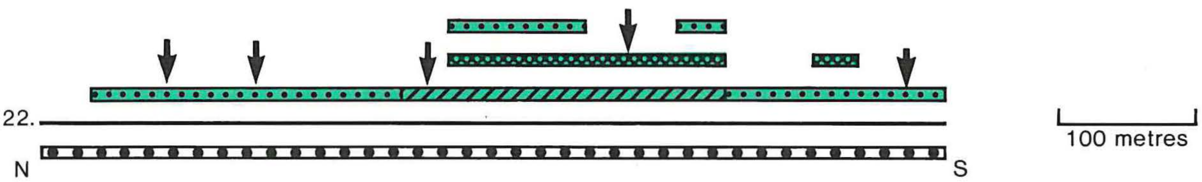
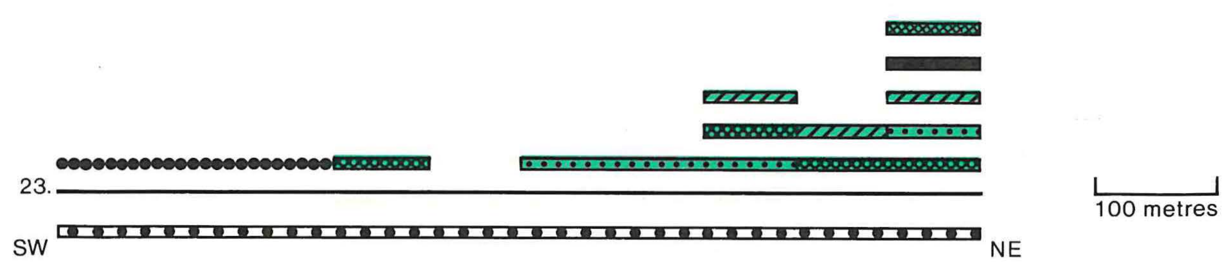
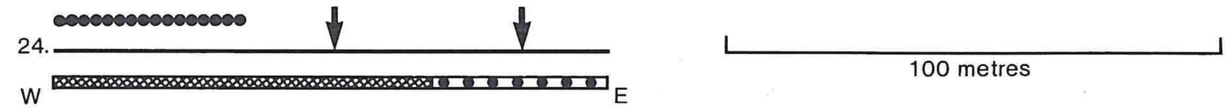

19.
W
E
100 metres

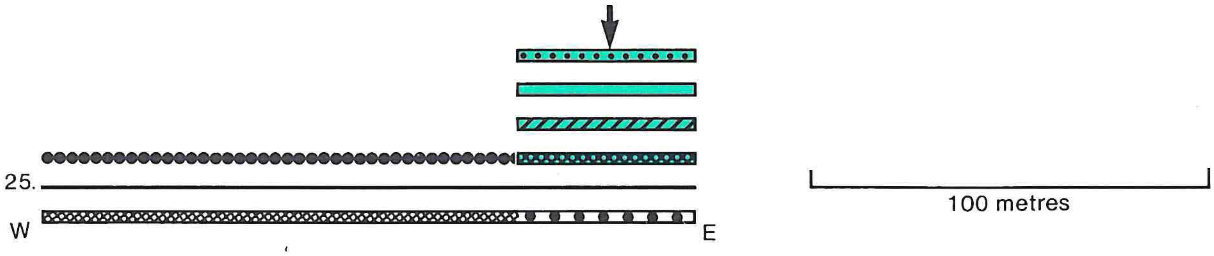

20.
NW
SE
100 metres

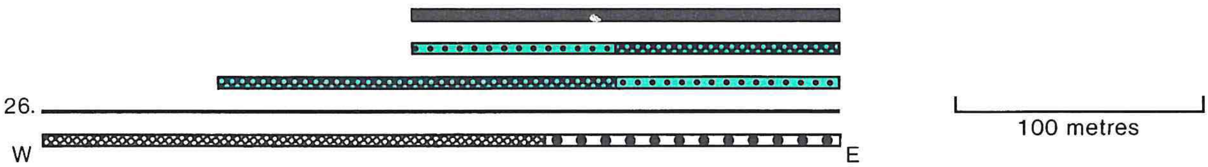

21.
W
E
100 metres

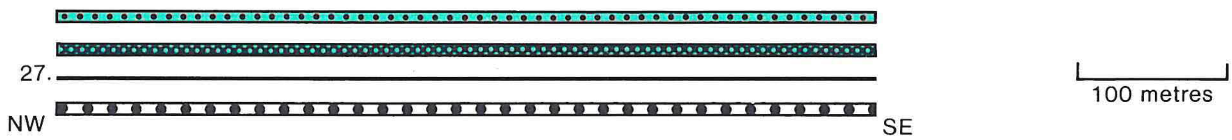

22.
N
S
100 metres

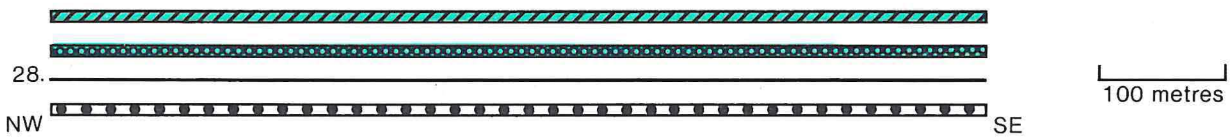

23.
SW
NE
100 metres


24.
W
E
100 metres


25.
W
E
100 metres


26.
W
E
100 metres


27.
NW
SE
100 metres


28.
NW
SE
100 metres

APPENDIX 2

List of algae collected during the survey of the M101 region, November 1985.

Note: This list is conservative and represents only the conspicuous and common species; most of the smaller species were either not collected or not identified for this report. This includes most representatives of the Ceramiales, especially the genera *Ceramium* and *Dasya*, many of the Rhodymeniales such as *Polysiphonia* and *Lobosiphonia*, Ectocarpales (*Giffordia* and *Ectocarpus*), Sphacilarales (*Sphacilaria*) and Cladophorales (*Cladophora*, *Chaetomorpha*). A permanent collection of all species collected, including those not reported here, is housed in the herbarium, School of Environmental and Life Sciences, Murdoch University, Western Australia. The list may be subject to alteration as names become validated or changed.

KEY
x intertidal reef platforms
● subtidal vertical reef walls
▲ subtidal seafloor
e epiphytic

TRANSECT NUMBER

ALGA	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	28	29
CHLOROPHYTA																						
ULVALES																						
U ?australis	▲					▲																
Ulva ?rigida			x▲			x▲											●x▲e	x●	▲●	x▲		
CLADOPHORALES																						
Anadyomene stellata			▲																			
CODIALES																						
Codium duthieae						▲			▲													
DERBESIALES																						
Bryopsis sp										▲												
Derbesia marina																				▲		
CAULERPALES																						
Caulerpa browniia																				▲		
Caulerpa cactoides																				▲		
Caulerpa cylindracea	▲																					
Caulerpa ?longifolia	▲					▲																
Caulerpa racemosa						x											▲	●		▲		
Caulerpa scalpelliformis					▲													●		▲		
Caulerpa flexilis	▲		●		▲	▲																
Caulerpa sp	▲																▲e	●		▲		
Halimeda cuneata																		●				
PHAEOPHYTA																						
ECTOCARPALES																						
Bellotia eriophorum													▲									
Eudesme sp																		●				
CHORDARIALES																						
Ralfsia sp			*x*																			
LAMINARIALES																						
Ecklonia radiata	▲	▲	x●▲	▲	▲	●▲				▲	▲	▲	▲	▲	▲	▲	x●▲	x●▲	▲	x●▲		
SPHACELARIALES																						
Asperococcus bullosus						▲e																
Colpomenia sinuosa/			x																		▲	
Colpomenia peregrina			●							▲							x▲					
DICTYOTALES																						
Taonia sp																▲				▲		
Labophora variegata						▲												●				
Lobophora sp	▲		●														●			x		
Lobospira bicuspidata	▲				▲	▲			▲									●				
Padina ?fraseri																			▲			
Zonaria sp						*x*											▲					
FUCALES																						
Scytothalia dorycarpa																			●	x▲		
Carpoglossum sp																			x			
Sargassum sp		▲	x●▲	▲	▲	x●▲				▲	▲	▲	▲	▲	▲	▲	x●▲	x●▲	x●▲	x●▲		
Cystophyllum onostum																						▲
RHODOPHYTA																						
NEMALIONALES																						
Bonnemaisoniaceae																						
Asparagopsis sp						▲																

TRANSECT NUMBER

ALGA	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	28	29
Gelidiaceae																						
Gelidium pusillum			●▲																			
Pterocladia capillacea			x																			
Pterocladia lucida			x	▲e													x●	x		x		
Pterocladia sp 1																		●▲		●		
Pterocladia sp 2																	x					
CRYPTONEMIALES																						
Corallinaceae																						
Amphiroa anceps						▲●											x					
Amphiroa ?anceps																	x●▲	x		x		
Amphiroa ?ephedra			●▲	▲		▲											x	●	●	●▲		
Amphiroa sp 1						▲											x					
Amphiroa sp 2																			x	x		
Mesophyllum sp			●		▲e	▲												●		▲		
Haliptilon cuvieri																			●			
Haliptilon graniferum																	▲					
Haliptilon sp					▲e													x				
Jania sp 1						▲e																
Jania sp 2																						▲e
Metagoniolithon chara		▲			▲e															x		
Metagoniolithon stelligera											▲e											
Metamastophora flabellata			●														x	●		●▲		
Halymeniaceae																						
Cryptonemia kallymenioides																				x●		
Grateloupia sp						▲																
Halymenia rosea																				●		
Peyssonneliaceae																						
Peyssonnelia sp																		●		●		
GIGARTINALES																						
Gigartinaceae																						
Curdiea obesa		▲	●			▲				▲		▲					x	x●	●	●▲		
Gracilaria sp 1	▲					x																
Gracilaria sp 2																	▲					
Gymnophloeaceae																						
Predaea sp																				▲		
Solieriaceae																						
Callophycus ?dorsiferus			●	▲		x▲										▲	●	x●	x●	x		
Callophycus harveyanus		▲																				
Callophycus oppositifolius																				▲		
Callophycus sp		▲																		▲		
Eucheuma speciosum																				▲		
Caulacanthaceae																						
Erythroclonium muelleri		▲																				
Phacelocarpaceae																						
Phacelocarpus labillardieri				▲																▲		
Cystocloniaceae																						
Craspedocarpus sp																				▲		

TRANSECT NUMBER

ALGA	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	28	29
Mychodeaceae																						
Mychodea sp			x																	●		
Plocamiaceae																						
Plocamium dilatatum			●																			
Plocamium mertensii			●	▲														●	x	●		
Hypneaceae																						
Hypnea episcopalis			▲		▲e	▲											●▲			●▲		
Hypnea musciformis						▲											▲					
Hypnea sp 1	▲	▲	●▲		▲e	x											x▲	●	▲			
Hypnea sp 2	▲	▲	●▲		▲e	x											x▲	●	▲			
Polyideaceae																						
Rhodopeltis australis						x														▲		
Rhodopeltis sp						x												●				
Rhodymeniaceae																						
Botryocladia obovata																		●		●		
Rhyodymenia australis			●			▲										▲		x●		●▲		
Champiaceae																						
Champia zostericola																	▲					
CERAMIALES																						
Ceramiaceae																						
Bornetia binderiana	●																					
Euptilota articulata			▲			▲													x●	●		
?Euptilota sp																				▲		
Griffithsia teges					▲e																	
Haloplegma preissi			●▲																	▲		
Delesseriaceae																						
Myriogramme erosa				▲																		
Dasyaceae																						
Heterosiphonia muelleri												▲					▲					
Rhodomelaceae																						
Amansia ?pinnatifida		▲					▲			▲												
Dictymenia sonderi	▲																					
Dasyclonium incisum	▲																			●▲		
Echinothamnion hystrix	▲																					
Jeanerettia lobata			●																			
Jeanerettia sp	▲																					
Laurencia ?brogniartii						x																
Laurencia filiformis																	▲					
Laurencia sp 1	▲																					
Laurencia sp 2											▲											
Laurencia sp 3						x																
Laurencia sp 4					▲e																	
Laurencia sp 5				▲																		
Lenormandia spectabilis																				▲		
Lenormandia smithii		▲											▲									

APPENDIX 3

List of invertebrate animals collected during the survey of the M101 region, November 1985.

Note: This list is conservative and represents only common and conspicuous invertebrate animals. The sampling procedure was highly selective; reef platforms were surveyed at 3 locations (see text) and not all seagrass meadows were sampled equally intensively. The list may be subject to alteration as names become validated or changed.

KEY:
- x intertidal reef platforms
- ● subtidal vertical reef walls
- ▲ subtidal seafloor

TRANSECT NUMBER

ANIMAL	2	4	7	10	17	18	19	20	21	24	25	26	27	28
CNIDARIA														
Hydrozoa (hydroids)														
Thecata														
Thyroscyphs marginatus				▲										
Hydroid sp 1				▲										
Hydroid sp 2				▲										
Athecata														
?Solanderia sp			▲						● x					
Hydrocorallina														
Stylaster sp									x					
Anthozoa (anemones and corals)														
Hexacorallia														
Actinaria														
Heteractis malu			▲											
Anemone sp 1						▲								
Zoanthidea														
Zoanthus ?praelongus			▲											
Zoanthid sp 1						x								
Scleractinia														
Plesiastrea versipora			▲		▲		●		x					
Coscinaraea ?mcneilli									●					
Scolymia australis			▲						●					
Octocorallia														
Sarcoptilus sp (sea pen)										▲				
Mopsella sp (gorgonian)		●				●	●	●	●					
BRYOZOA (lace corals)														
Adeona sp									▲					
Calcareous bryozoan sp 1							●		●					
Calcareous bryozoan sp 2		●							▲					
Calcareous bryozoan sp 3				▲										
ECHINODERMATA														
Crinoidea (feather stars)														
Comanthus sp				▲				▲	x ●		▲	▲		
Crinoid sp 1				▲										
Asteroidea (sea stars)														
Pentagonaster duebeni		●							▲					
Coscinasterias calamaria		●						●						
Petricia vernicina		●												
Retaster insignis				▲										
Archaster laevis												▲		
Nectria sp													▲	
Nepanthia ?crassa				▲									▲	
Echinoidea (sea urchins, sand dollars)														
Heliocidaris erythrogramma		●	▲											
Holopneustes prosssimus		●					x ▲	▲						
Peronella leseuri													▲	
Holothuroidea (sea cucumbers)														
Stichopus ?mollis		●	●								▲			
Holothuroid sp 1											▲			
Holothuroid sp 2											▲			
CHORDATA														
Ascidiacea (sea squirts)														
Pyura pachydermatina							x ●	●	●					
?Pyura sp		x ●												
Herdmania sp							●							
Alopozoa sp									●					
solitary ascidian sp 1														▲
solitary ascidian sp 2													▲	
solitary ascidian sp 3											▲			

TRANSECT NUMBER

ANIMAL	2	4	7	10	17	18	19	20	21	24	25	26	27	28
colonial ascidian sp 1							●							
colonial ascidian sp 2				▲										
colonial ascidian sp 3									●					
colonial ascidian sp 4				▲										
colonial ascidian sp 5				▲										
colonial ascidian sp 6				▲										
MOLLUSCA														
Polyplacophora (chitons)														
Clavarizona hirtosa		x				x								
Rhyssoplax torriana							x							
Chiton sp 1							x							
Gastropoda														
Halliotis roei		x					x		x●					
Amblychilepas nigrata				▲										
Turbo torquata		x●					x	●	x					
Thalotia sp				▲										
?Calliostoma sp				▲										
Astrea squamifera				▲										
Septa ?tabulata									●					
Pyrene bidentata			x	▲										
Patella sp		x												
?Aplysia sp			▲											
Thais orbita	▲	x	x			●▲	x	●	x●					
Bivalvia														
Mytilus edulis planulatus							x				▲			
Barbatia pistachia					▲									
CRUSTACEA														
Balanus sp							x							
?Lepas sp										▲				
?Porcelain crab										▲				
ANNELIDA														
calcareous tube worms sp 1				▲			●		x	▲				
PORIFERA (sponges)														
Numerous unidentified sponges collected. Some were common at most sites surveyed.	▲	●▲	▲	▲	▲	●	●▲	●▲	●▲					

APPENDIX 4

List of epiphytic plants and animals associated with seagrass communities.

Note: This is a preliminary list of epiphytic marine plants and animals from the research work of M A Borowitzka and R C Lethbridge, Murdoch University, Western Australia. The species listed were all associated with the seagrass *Amphibolis* at locations in Warnbro Sound and around Penguin Island. Where there are two or more unidentified species for a specific genus, their numbers are shown in parentheses. The organisms are grouped alphabetically. The animals listed here exclude mobile species.

ALGAE

CHLOROPHYTA (green algae)

Bryopsis sp
Bryopsis plumosa
Caulerpa sp
Chaetomorpha (2 species)
Cladophora (4 species)
Cladophora lehmanniana
Codium sp
Enteromorpha spp
Ulva rigida

CYANOPHYTA (blue-green algae)

Phormidium sp
Calothrix sp

PHAEOPHYTA (brown algae)

Cladosiphon sp
Colpomenia sinuosa
Dictyota (2 species)
Dictyota radicans
Dictyopteris sp
Giffordia irregularis
Lobophora varigata
Lobospira bicuspidata
Petalonia sp
Pachydictyon sp
Sphacilaria novae - hollandiae

RHODOPHYTA (red algae)

Acrothamnion armatum
Amansia pinnatifida
Amoenothamnion planktonicum
Anotrichium lichmophorum
Anotrichium tenue
Antithamnion verticale
Asparogopsis sp
Bornetia binderiana
Brongniartella australis
Callithamnion (2 species)
Centroceras calvulatum
Ceramialeans (3 species)
Ceramium isogonium
Ceramium puberbulum
Ceramium pusillum
Ceramium rubrum
Ceramium shepherdii
Champia zostericola
Champia muelleri
Champia parvulavaramphibolus
Coeloclonium verticillatum
Craspedocarpus tenuifolius
Craspedocarpus venosus
Cryptonemia sp
Dasya (4 species)
Dasyclonium incisum
Delesseria revoluta
Dicranema revolutum
Dictymenia sonderi
Dictymenia tridens
Erythroclonium muelleri
Euptilocladia spongiosa
Euptilota articulatum
Gelidium sp
Gelinaria ulvoidea
Gloiosaccion brownii
Gracilaria sp cf *flichenoides*
Grateloupia filiciana
Griffithsia monilis
Griffithsia teges
Haliptilon (3 species)
Haloplegma preissi
Herposiphonia sp
Heterosiphonia callithamnion
Heterosiphonia wrangelioides
Hypnea sp
Hypnea cervicornis
Hypnea episcopalis
Hypoglossum sp
Jania sp
Jeanerettia sp
Kuetzingia canaliculata
Lasiothalia (2 species)
Laurencia clavata
Laurencia cruciata
Laurencia (14 species)
Lenkormandia marginata
Lenormandia spectabilis
Lenormandia sp
Lophosiphonia sp
Mesothamnion sp
Metagoniolithon chara
Metagoniolithon stelliferum
Mirocladia sp
Mychodea gracilaria
Mychodea marginifera
Mychodea pusilla
Myriogramme erosa
Nemalion sp
Nemastoma sp
Neurymenia fraxinifolia
Platysiphonia sp
Platythamnion nodiferum
Plocamium (4 species)
Polysiphonia (6 species)
Polysiphonia forfex
Rhodophyllis sp
Rhodophyllis multipartita
Rhodophyllis volans
Rhodymenia australis
Rhodymenia (5 species)
Spyridia sp

INVERTEBRATE ANIMALS

HYDROZOA

Aglaophena plumose
Amathia ?biseriato
Amathia sp
Amphisbetia minima
Camplanularia australis
Lineolaria spinulosa
Plumularia compressa
Plumularia nodosa
Pycnotheca producta
Stereotheca elongata
Thyroscyphus marginatus

BRYOZOA

Adeonellopsis portmarina
Celleporina nov sp
Celleporina costata
Electra flagellum
Elzerina blainvilli
Lichenopora sp
Phripora polita
Thairophora mamillaris

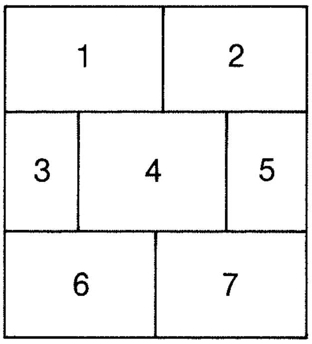
ECHINODERMATA

Aporometra occidentalis

PORIFERA

Several species (unidentified)

Back cover photographs



1. Sea lions use the beaches of offshore islands as nursery and rest areas. (Photograph : R. Beilby.)

2. The bridled tern is one of many seabirds using the islands for breeding and nesting. Eggs are laid usually from November through January following the arrival of breeding pairs in September. (Photograph : S. Chape.)

3. Lace coral with its calcified skeleton is a colourful animal sighted on reefs. (Photograph : R.C. Lethbridge.)

4. Seal Island — one of the islands in the M101 region designated a wildlife sanctuary (note the seals on the beach). (Photograph: S. Chape).

5. The little penguin during the moulting phase (November-December), on Penguin Island. This island has one of the largest colonies in Western Australia. (Photograph: S. Chape).

6. A common starfish in subtidal habitats in the M101 region. (Photograph : R.C. Lethbridge.)

7. Fish swimming through an automobile tyre reef, constructed on the seafloor of Warnbro Sound. The reef is heavily encrusted with various animals and turf algae. (Photograph: R.C. Lethbridge).