Frontier Mozambique Environmental Research

REPORT 2

Northern Islands Group - Macaloe, Mogundula, Rolas and Matemo Islands.

Marine Biological and Resource Use Surveys of the Quirimba Archipelago.

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Stanwell-Smith, D., António, C.M., Heasman, M., Myers, M. and Whittington, M.W. (eds)

Ministry for the co-ordination of Environmental Affairs, Mozambique

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Frontier-Mozambique was initiated in January 1996 when a Memorandum of Understanding was signed between The Society for Environmental Exploration and the Ministry for the Co-ordination of Environmental Affairs (Ministério para a Coordenação de Acção Ambiental), Mozambique. The aim of Frontier-Mozambique was to undertake field research within the Quirimba Archipelago, an area of recognised biological interest and conservation value.

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CONTENTS

EXECUTIVE SUMMARY

The following report details the findings of the Darwin/Frontier-Moçambique Quirimba Archipelago Marine Research Programme's surveys of the Northern Islands Group (N.I.G.) - namely the islands of Macaloe; Mogundula; Rolas and Matemo. The surveys were completed between April 1996 and December 1997 by the Programme's staff, research assistants, visiting scientists from the UK and Mozambican participants. This report is one of a series produced which describe the status and distribution of habitats, floral and faunal biodiversity and the scale and nature of resource use activity within the marine environment of the archipelago. A detailed introduction and background to the work of the Programme, together with a full explanation of the methods employed during the field-based survey work, are presented in "Technical Report 1: Introductions and Methods".

The N.I.G. covers an area of approximately 435 km^2 close to the coastline of Cabo Delgado Province, northern Mozambique. It includes a variety of habitat types: large stands of mangrove (Matemo island); seagrass beds (in extensive meadows between the islands and the adjacent mainland), and; fringing and patch reefs around most of the more exposed sections of shoreline. In addition, the islands are situated close to the edge of the continental shelf and the deep, oceanic waters of the Mozambique Channel.

This high concentration of differing habitat types was found to support a correspondingly rich and abundant flora and fauna. In turn, many of the fish, invertebrate and mangrove tree species were observed to be exploited by the local population who were heavily dependent on the natural resources of the islands. The abundance of natural resources also attracts increasing numbers of migrant fishermen from mainland Cabo Delgado Province, Nampula Province to the south and Tanzania to the north. The resulting increase in resource extraction poses a threat to the sustainability of many of the N.I.G. resources.

The results of the biological and resource use surveys are discussed in terms of the flora and fauna of the islands, potential threats to the habitats and considerations for management.

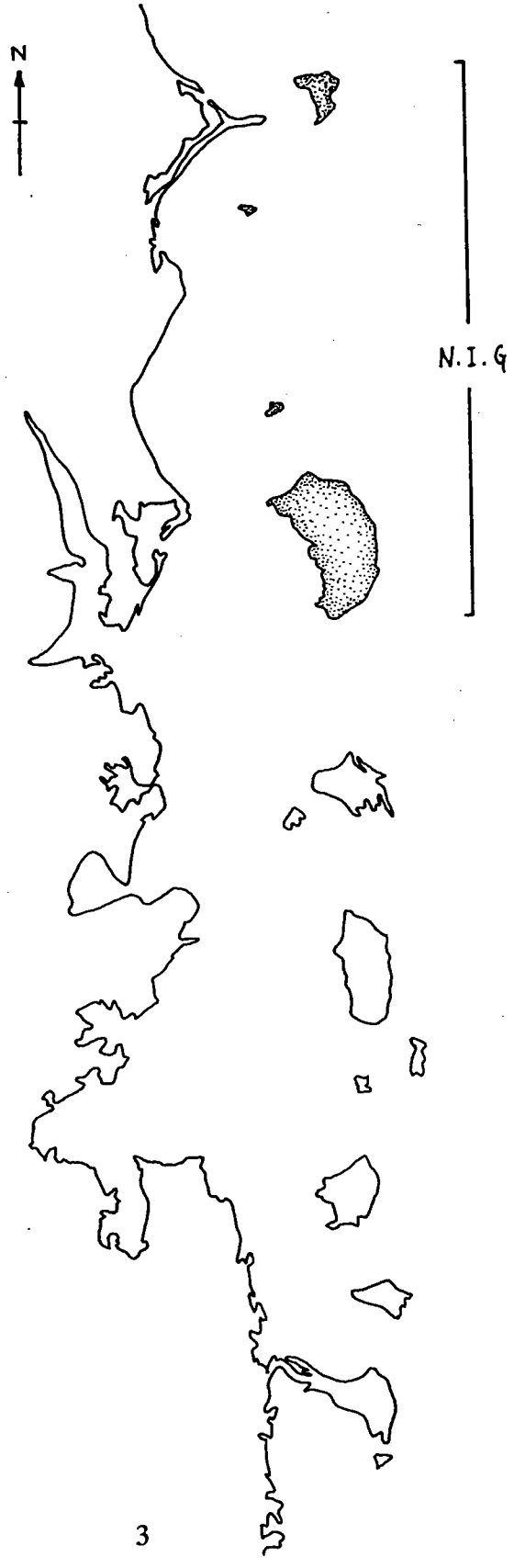
1.0 INTRODUCTION

This Report presents the findings of the Darwin/Frontier-Moçambique Marine Research Programme's survey work on four islands within the Quirimba Archipelago off the coast of Cabo Delgado Province in northern Mozambique. These four islands of Macaloe, Mogundula, Rolas and Matemo, have been collectively grouped and named as the 'Northern Islands Group' and will be abbreviated to N.I.G. throughout this report (Fig. 1.1). These surveys represent a part of a larger study which aims to include a number of other islands within the southern part of the archipelago. The surveys were completed between April 1996 and December 1997.

The purpose of these surveys was to provide sufficient information to enable a framework for a coastal zone management plan to be developed which will ensure sustainable development and resource use within the Quirimba Archipelago. Prior to this study, little information on the distribution and composition of the marine habitats, or the pattern and scale of resource exploitation within the Archipelago was known.

The rationale and methodology for all surveys are summarised in Section 2.0.

Figure 1.1 A map illustrating the position of the Northern Islands Group study area within the Quirimba Archipelago, northern Mozambique.



2.0 METHODS

2.1 Introduction

The methods employed are explained here in brief as full details can be obtained from an earlier report entitled: *Technical Report No. 1: Introduction and Methods*. Any more recent modifications to methods or newly adopted techniques are noted below.

All geographic data relevant to the islands was taken from the nautical charts *Direcção Principal de Navegação e Oceanografia do Ministério da Defésa de URSS. No. 46605-M and No. 46604-M. 1:50 000.* A full listing of island dimensions and co-ordinates is presented in Appendix A1.

2.2 Intertidal Surveys

The Quirimba Archipelago is subject to a tidal range in excess of 4m which, combined with the shallow topography on the western side (continental side) of many of the islands, has led to the formation of extensive intertidal areas. These areas are commonly colonised by a high abundance and diversity of flora and fauna. The intertidal serves an important role in both stabilising and protecting the shoreline and in the provision of a food source for a number of fish species which graze the area on the high tides. Seagrasses and macroalgae play important roles in both substratum stabilisation and as a food source for feeding fish and crustaceans. The intertidal surveys conducted concentrated primarily on these flora.

The lack of coastal development within the N.I.G. has left the seagrasses and macroalgae relatively undisturbed. However, with the potential for coastal developments increasing it is important to identify the current distribution and diversity of algae and seagrass to allow development planning to minimise any subsequent impacts. Likely impacts from coastal development include siltation, dredging and pollution. Natural threats include physical disruption from hurricanes/storms (occurring mainly during the 'wet season', November-April), and salinity changes due to increased fresh water input or long dry spells.

The Programme's intertidal surveys therefore aimed to assess the diversity of seagrasses and macroalgae, their distribution, community types, associated fauna and status in terms of impacts by human activity.

2.2.1 Intertidal Flats

The first level of survey produced an overview of the distributions of flora and fauna for the intertidal area of the island as a whole. The intertidal area was then split into 'Areas' based on major differences in habitat structure and composition. Quadrats were then surveyed along transects within each area to identify species composition and any zonation of species assemblages. The tabulated data presented below in the results represents the median count per survey quadrat completed and the range of counts made.

2.2.2 Mangroves

Mangroves traditionally play an important role in the lives of people inhabiting the coastal areas of Mozambique and extensive use of mangroves of all species was observed during the course of the Programme's surveys. However, mangroves also play an important role in the stabilisation of the shoreline and in the provision of a food source and nursery area for many fish and invertebrates. The Programme's mangrove surveys aimed to identify the distribution, diversity and structure of stands and to also assess the scale and impact of mangrove cutting.

The surveys were conducted along transects and within 5m x 5m quadrats with the aim of producing a relatively detailed picture of the structure and composition of mangrove stands within the survey area. Data gathered from the individual transects was combined and extrapolated to give estimates for the whole stand.

For each tree, the basic structural attributes of 'diameter at breast height' (dbh) and height were recorded. The dbh value was then converted into a value for the basal area, which is the cross-sectional area of the tree stem at the point where dbh was measured.

The basal area (g) was calculated using the formula:
$g = \pi.r^2$

However, as $r = dbh/2$ then the equation, $g = \pi/4\ (dbh^2)$, was used. As it was most useful to express the basal area in terms of m^2/hectare(ha) then for dbh values measured in centimetres:
$g(m^2) = \pi.(dbh^2)/4(10,000) = 0.00007854.(dbh^2)$

Due to the relatively small number of trees normally found within a 5m x 5m quadrat, the basal area was calculated for all the trees of a particular species and was not split into dbh size categories for each species.

The individual basal areas were added together for each species and a basal area for the stand as a whole was estimated. Basal area is a good indication of the development of the stand and can be related to wood volume and biomass, however, as no sample felling was conducted it was therefore not possible to make estimates of stand biomass.

The relative density and dominance (contribution to the stand's basal area) of each species was estimated in the following way for each zone within a stand:

Relative Density = (number of individuals of a species / total number of individuals of all species) x 100

Relative Dominance = (total basal area of a species / basal area of all species) x 100

Finally, mean diameter of the stand for each species was estimated using the following formula:

$$dbh = \sqrt{((BA)(12732.39)/n)}$$

where; 'dbh' is the diameter of the tree of mean basal area, 'BA' is the total stand basal area for the species and '*n*' is the stand density for the species.

2.3 Subtidal Surveys

Coral reefs, seagrass beds, bare sand and rubble platforms, and mud channels, are all features of the area for which there is very little information with regard to species diversity, community composition and distribution. Subtidal habitats are often overlooked when assessing potential impacts as they are difficult to survey. However, even if not visible from the surface, these habitats provide some of the most productive and diverse communities on earth and, as such, their importance to man as a resource is enormous.

Surveys aimed to determine the distribution and extent of habitats and the diversity of flora and fauna within them. In addition to surveying the dominant structural biota, such as corals and seagrass, the following three groups of animals were examined: 'Invertebrates', which were included both for their importance in shaping reefs and as a resource to the local islanders; 'Reef Fish', which are a conspicuous and important component of the reef system fauna and are known to be good indicators of the general health of the reef; and 'Commercial Fish', (those species normally targeted by fishermen) which are an obviously important resource for the islanders.

2.3.1 Subtidal Habitat Surveys

Habitat surveys involved the census of species and an estimation of habitat compositions along swum transects running horizontally along the reef at a series of depths. For each of the islands within the N.I.G., an overview is presented summarising the main features of the subtidal habitat based on the sites surveyed. 'Site reports' detail the results of the surveys, which may be split into Upper and Lower Reef zones, based on a description of 'Reef Structure', 'Substratum Composition' and 'Biotic Cover'. The results for each site are also tabulated for each depth level surveyed, with a mode and range given for each data element.

Data elements are presented in the form of the "P6" abundance scale, listed below:

Scale	%
0	0
P	<1
1	2-5
2	6-25
3	26-50
4	51-75
5	76-90
6	91-100

2.3.2 Invertebrates and Impacts Surveys

The results of the surveys of the invertebrates and the natural/human impacts at each site are presented together, despite their obvious differences, for two reasons. Firstly, the levels of impact at all sites within the N.I.G. were very low and do not warrant a separate results section; and secondly, there are links between the two groups of data elements with the Crown of Thorns starfish (*Acanthaster plancii*) and the scar groups it produces during feeding activity.

An overview is presented summarising the main features of sites surveyed. Site reports detail the results of the surveys. The data show the mean count per 5 minutes (accurate to 1 d.p.) surveying completed and the range of counts made. A description outlining the main features of the data elements is also presented.

2.3.3 Reef Fish Census

An overview is presented summarising the main features of sites surveyed and includes a table of relative species richness indices (RSRi), (Note: these values are equivalent to the misnamed relative diversity indices of Technical Report 3), Shannon-Weaver diversity indices (SWi) and total species number for each site.

The Relative Species Richness indices (RSRi) were calculated for each site using the following formula:

$$RSRi = \frac{\text{No. of Reef Fish Species Observed}}{\text{Total No. of Reef Fish Species on Census List}}$$

A site report is given for each site surveyed, describing the major features of the reef fish population together with graphs summarising the diversity and abundance of reef fish at the family level. Due to the similarity between the family Acanthuridae (Surgeonfish) and Zanclidae, the Moorish Idol (*Zanclus cornutus*) was included in the former group. All the species included in the species survey list are given in Appendix A3 (adapted from Technical Report 1, Introduction and Methods). All species were used in the analysis except the Napoleon Wrasse (*Cheilinus undulatus*). This was the only fish of the family Labridae surveyed and its inclusion in the surveys was due to its popularity in many dive

resorts in the Tropics. Therefore, where it was observed, a note is made in the appropriate results section.

2.3.4 Commercial Fish Census

The commercial fish surveys were aimed at indirectly estimating levels of fishing pressure and fishing potential throughout the N.I.G. through an assessment of the commercial fish populations.

Although species-level identifications were made the results presented in this report concentrate on analysis at the family level e.g. Lethrinids; Lutjanids; Scarids; Siganids; Serranids; Haemulids and Carangids to avoid problems of mis-identification. A description is given of the commercial fish observed at each site and reference may be made to the presence and abundance of dominant species within a catch.

A few sites were dominated by a variety of seagrass species. Commercial fish (and the reef fish species normally censused during the reef fish survey) were found to be relatively scarce at these sites, the fish assemblages being dominated by species not normally surveyed by the Programme. Individual reports are made for these sites.

Abundance
Graphical presentations are given for the 'frequency of encounter' (numbers of sample intervals during which the species was seen: a measure of the species ubiquitousness over the site) and the composition of commercial fish families observed. These are presented for each site and where applicable for different depth ranges at a single site.

Size distributions
Due to the relatively small number of fish recorded for a particular species at any site, it was necessary to pool the data to attain a worthwhile sample size. Length distributions were combined for all species within each commercial fish family and for all the sites from each of the islands. Median estimated lengths and length ranges are presented for each commercial fish family for each island.

2.4 Resource Use Surveys

The islanders of the N.I.G., and the Quirimba Archipelago as a whole, are heavily dependent on the exploitation of natural resources for food, building materials and goods for trade. Additionally, the resources of the islands are exploited extensively by fishermen from both Nampula Province to the south and from Tanzania to the north during the 'dry season' (April-November). This exploitation can have a significant impact on the marine habitats and the Programme's surveys were targeted at assessing the type, scale and impact on the environment of these activities within the N.I.G.

The surveys were split into two broad areas, studying; first, the exploitation of finfish, and second, the exploitation of non finfish (primarily Mollusca and Holothuria). Assessment of mangrove cutting was carried out during the surveys of intertidal habitats.

2.4.1 Finfish Fisheries

The Programme's Finfish Resource Surveys aimed to determine the scales and patterns of the fishing methods for each of the islands of the N.I.G. With the exception of the Quirimba island (see Technical Report 5: The Seagrass Fishery of Quirimba Island), all the island summaries presented in this report were based on a short observation visit or a number of such visits and therefore only serve as a relatively limited 'snapshot' of the fishing activity and are not necessarily representative of the long-term patterns in fishing activity. To gain more information about the long-term situation informal interviews were conducted with local residents and local fishermen on all the islands studied. Results are presented as a simple description and a summary table where applicable.

2.4.2 Other Resource Collection

The results of surveys are split into three sections, based on: overall patterns of resource exploitation; resource exploitation within different intertidal zones; and resource exploitation in the subtidal areas. Within the first two sections, the results are analysed in terms of; gender, group activity and origin of collectors, collection methods and the catch composition. Appendix A5 gives an indication of the monetary value of each resource at the time of this study and Appendix A6 lists the common names of each of the resources exploited.

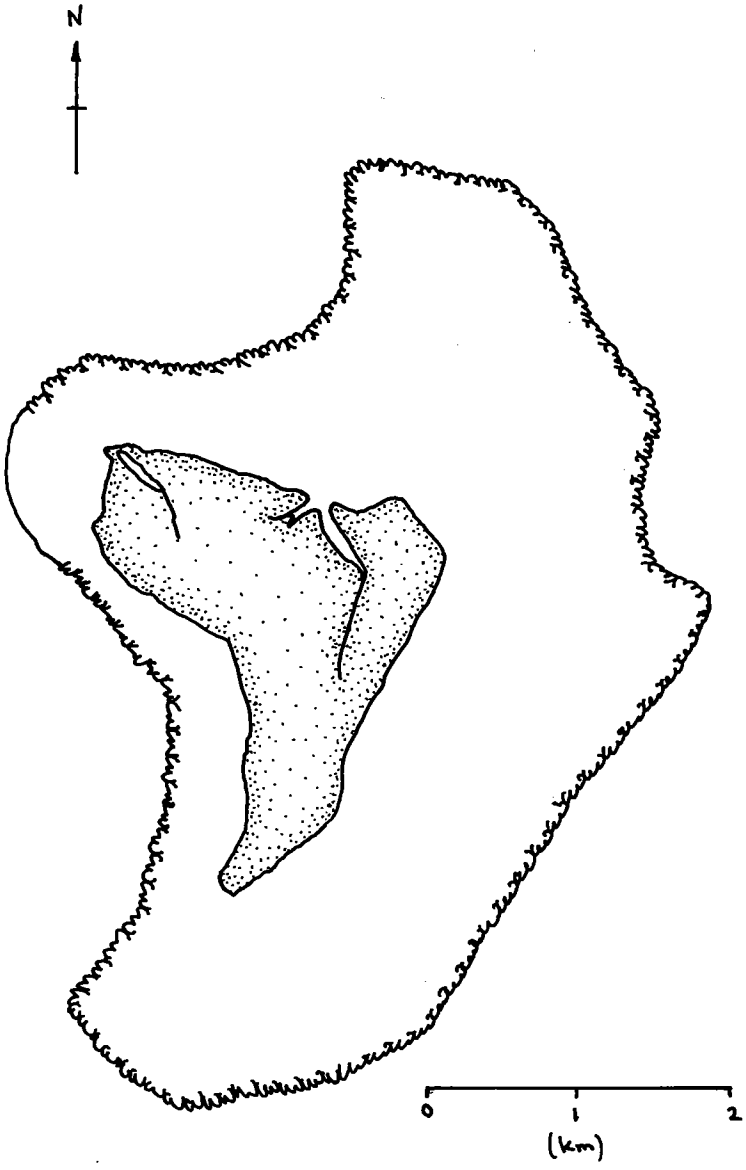
3.0 MACALOE ISLAND

3.1 Introduction

Macaloe is the most northerly island of the Programme's study area (11°59'00"S 40°35'00"E) and lies close to Ponto Pangane, the site of an important village for coastal trade and fishing (Fig. 3.1). There is no permanent settlement on the island and no source of freshwater. On the western side of the island there is the remains of an old Portuguese fort and a few abandoned buildings that remain from a ceased commercial fishing operation. To the north of these buildings is a little-used runway. Along the beaches on the southern side of the island migrant fishermen regularly build temporary encampments.

The island is constructed from coral rag and consequently much of the island is covered in dry scrub vegetation. In the north, close to the shoreline, a series of depressions are filled with small stands of mangrove.

Figure 3.1 Macaloe Island



3.2 Intertidal Surveys

3.2.1 Overview

Macaloe has a large intertidal area of approximately 15.5km^2, most extensive on the eastern side of the island. In contrast to the other three islands of the N.I.G., which supported relatively well developed macroalgal habitats, the intertidal zone on Macaloe contained far less developed macroalgal assemblages. Much of the intertidal was devoid of vegetation and the seagrass beds were poorly developed. The western side was predominantly sand with some patches of macroalgae. The dominant species in these patches were *Hypnea cornuta* and *Chondria dasyphila* which commonly colonised coral rubble.

One seagrass species, 66 species of macroalgae and 53 species of invertebrates were recorded. A checklist of recorded taxa is presented in Appendix A2. The macroalgal flora included 1 Cyanophyta, 31 Chlorophyta, 11 Phaeophyta and 23 Rhodophyta. Unlike the majority of islands of the N.I.G., the macroalgal flora on Macaloe was dominated by members of Chlorophyta which represented 46% of the species recorded for this island. Of 53 invertebrate species recorded, 49 were molluscs, 3 were echinoderms and 1 was crustacean.

Area Reports
Three transects were surveyed in the locations shown in Figure 3.2: 'North Area' (Transect 1), 'South Area' (Transect 2) and 'East Area' (Transect 3). Cross sectional profiles are presented in Figures 3.3, 3.4 and 3.5, respectively.

'North Area'
The width of this intertidal was approximately 2.3km and is exposed to northerly monsoon winds. Four zones were identified within which a total of 15 macroalgae species and 5 species of invertebrates were recorded. The substratum types within each zone are presented in Table 3.1. The distribution of taxa across zones is presented in Tables 3.2 and 3.3.

Table 3.1 Percentage cover of substratum along a typical transect within the 'North East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 4
Sand	8 (0-80)	6.5 (0-55)
Broken Shell	1.6 (0-12)	0
Rubble	0	13 (0-100)
Rock	100 (20-100)	100 (0-100)

Zone 1 consisted of sand beach with no vegetation or invertebrates. Zone 2 comprised an undulating rocky terrace covered by sand in some areas, especially close to the reef-lagoon. This zone was dominated by gastropods with very few macroalgae. Zone

3 consisted of lagoon which was approximately 1.0 m deep. Due to the nature of the tide the lagoon was not sampled. However, a qualitative assessment revealed that the lagoon was relatively devoid of macroalgae, with an extensive area being covered by soft and hard corals including 'massive', 'branching' and 'table' forms. The reef crest (Zone 4) was very exposed and as a consequence supported a low macroalgal diversity and cover. Few invertebrates were found along the transect, the most common being (in Zone 2) *Rhinoclavis* sp., *Cypraea annulus* and *Cypraea* sp.

Table 3.2 Percentage cover of macroalgae along a typical transect within the 'North Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 4
Macroalgae		
Boergesenia forbesii	0	(0-P)
Cladophora sp.	0 (0-10)	0
Dictyosphaeria cavernosa	0	0 (0-1)
Dictyota divaricata	0	0 (0-1)
Enteromorpha kylinii	(0-P)	0
Gelidiella acerosa	0	(0-P)
Halimeda opuntia	0	4.5 (0-30)
H. renschii	0	(0-P)
Hypnea cornuta	0	(0-P)
H. nidifica	0	(0-P)
Jania adhaerens	0	2 (0-20)
Lyngbya majuscula	0	1 (0-10)
Padina boryana	0	0 (0-2)
Udotea indica	0	(0-P)
Ulva pertusa	0	(0-P)

Table 3.3 Abundance (individuals/m^2, n=10) of invertebrates along a typical transect within the 'North Area'.

Taxonomic Group	Zone 2	Zone 4
Gastropods		
Cypraea annulus	0 (0-3)	0
Cypraea sp..	0 (0-3)	0
Rhinoclavis sinensis	0	0 (0-1)
Rhinoclavis sp.	0 (0-18)	0
Echinoderms		
Actynopyga mauritiana	0	0 (0-1)

'South Area'

Five distinct zones were identified (Fig. 3.4). The lowest two zones were not sampled due to the state of the tide. A total of 7 macroalgal species and 14 species of invertebrates were recorded within the three zones. The proportion of substratum types is summarised in Table 3.4. The distribution of taxa across zones is presented in Tables 3.5 and 3.6.

Table 3.4 Percentage cover of substratum along a typical transect within the 'South Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3
Sand	7 (0-70)	0
Rubble	4 (0-40)	0
Rock	80..(60-100)	100 (100)

Zone 1, closest to the cliff, was a rocky beach supporting high abundances of gastropods *Nerita plicata* and *N. albicilla*. Zone 2 consisted of a shallow lagoon which supported low macroalgal diversity and cover. The most abundant invertebrates were *Cypraea moneta, Cypraea annulus* and *Cypraea* sp. Zone 3 comprised exposed rocks with numerous depressions colonised by macroalgae. The zone was dominated by *Thais* sp. The lowest two zones were a reef-lagoon and a narrow coral rubble, reef crest.

Table 3.5 Percentage cover of macroalgae along a typical transect within the 'South Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3
Macroalgae		
Coralline algae	0	0 (0-10)
Dictyosphaeria verluysii	4 (0-15)	3 (0-10)
Gelidiella acerosa	0 (0-7)	1 (0-10)
Halimeda opuntia	2 (0-25)	0 (0-3)
Lyngbya majuscula	1 (0-15)	0 (0-1)
Turbinaria conoides	0-P	0
Valonia fastigiata	0	0-P

Table 3.6 Abundance (individuals/m^2, n=10) of invertebrates along a typical transect within the 'South Area'.

Taxonomic Group	Zone 2	Zone 3
Gastropods		
Cypraea annulus	2 (0-8)	1 (0-4)
C. moneta	4 (0-11)	0 (0-1)
Cypraea sp.	2 (0-6)	0
Morula granulata	0	1 (0-4)
Morula sp.	0 (0-1)	0
Rhinoclavis sinensis	0	0 (0-1)
Strombus mutabilis	0	0 (0-1)
Tectus sp.	0 (0-1)	0
Thais savignyii	0	1 (0-4)
Thais sp.	1 (0-3)	16 (0-40)
Bivalves		
Perna cf. perna	0 (0-1)	0
Trachycardium rubidicum	0 (0-1)	0
Echinoderms		
Echinometra mathaei	0 (0-1)	0
Hermit crabs		
Clibanarius virescens	0 (0-1)	0 (0-1)

'East Area'

The eastern intertidal flat (width approximately 1.0km) had a lagoon considerably wider than those of the northern and southern sides of the island. Four zones were identified and the typical zonation is illustrated in Figure. 3.5. One seagrass species, 6 species of macroalgae and 2 species of invertebrates were recorded. The substratum composition is summarised in Table 3.7. The distribution of taxa across zones is presented in Tables 3.8 and 3.9.

Table 3.7 Percentage cover of substratum along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 3	Zone 4
Sand	10 (0-50)	0
Rubble	10 (0-50)	50 (0-100)
Rock	90(0-100)	50 (0-100)

Zone 1 was a sand beach devoid of biota. Zone 2 comprised exposed undulating rock on which *Thais* spp. dominated. A Green turtle, *Chelonia mydas* was observed in the lagoon of Zone 3 The reef crest had two distinct areas; the lower part was flat rock and the upper consisted of coral rubble. A feature of the coral rubble area was the occurrence of saplings of the mangrove *Rhizophora mucronata.*

Table 3.8 Percentage cover of seagrass and macroalgae along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 3	Zone 4
Seagrasses		
Thalassia hemprichii	0	2 (0-25)
Macroalgae		
Chlorodesmis sp.	0	(0-P)
Dictyosphaeria cavernosa	(0-P)	0
Gelidiella acerosa	0 (0-4)	0
Halimeda opuntia	0 (0-2)	0
Lyngbya majuscula	0 (0-4)	20 (0-70)
Valonia fastigiata	(0-P)	0

Table 3.9 Abundance (individuals/m^2, n=10) of invertebrates along a typical transect within the 'East Area'.

Taxonomic Group	Zone 3	Zone 4
Gastropods		
Turbo coronatus	0	0 (0-1)
Echinoderms		
Diadema sp.	1 (0-4)	0

Figure 3.2 Location of intertidal transects on Macaloe.

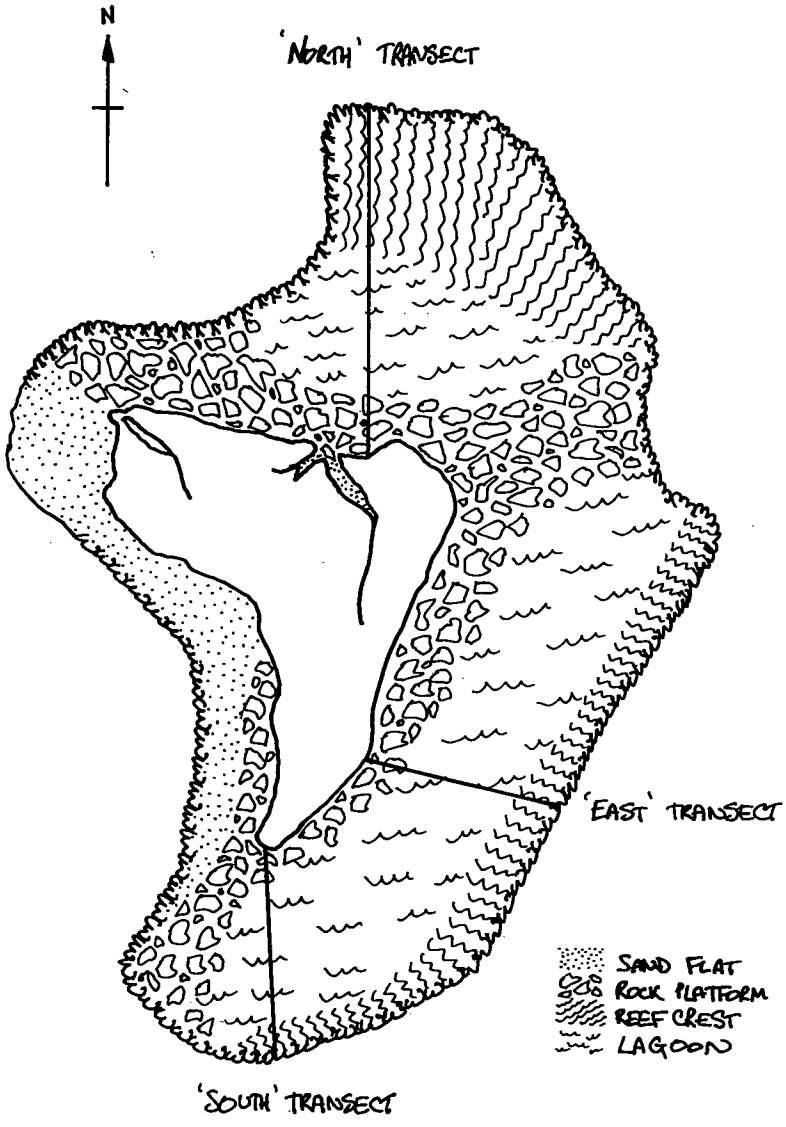


Figure 3.3 Cross section of 'North' intertidal transect, Macaloe.

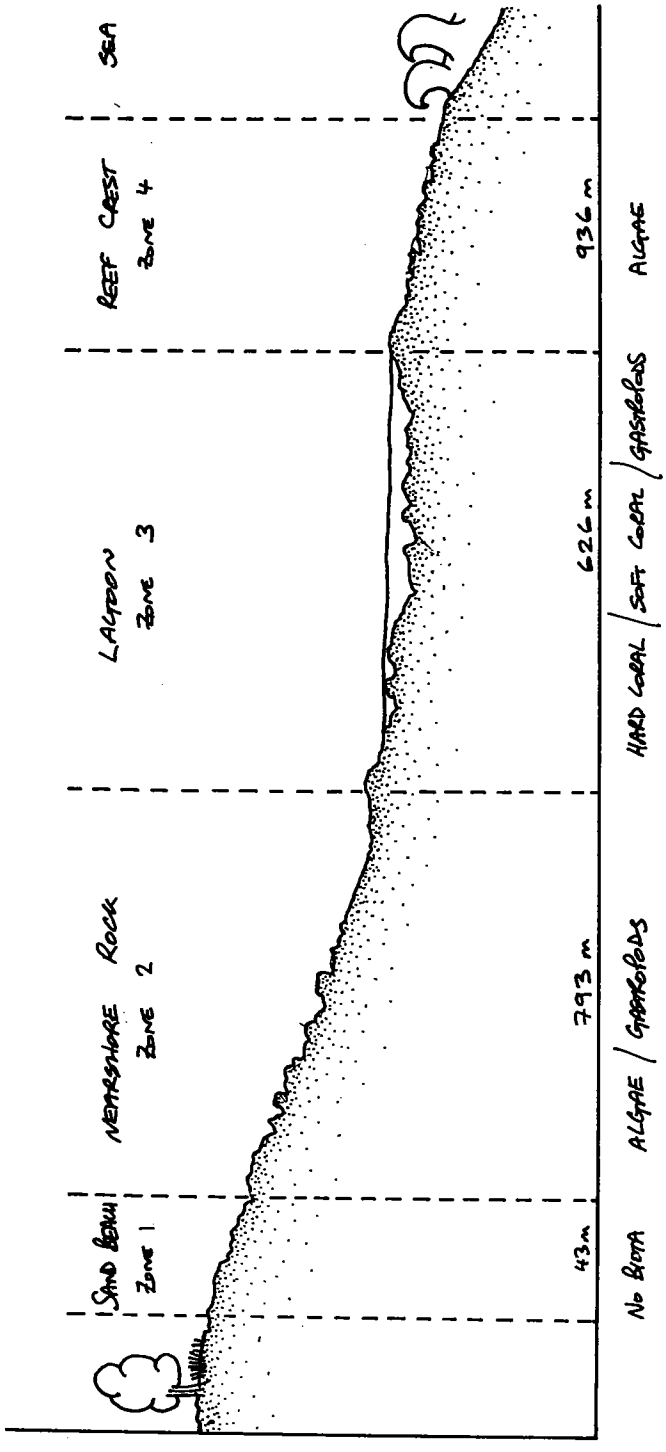


Figure 3.4 Cross section of 'South' intertidal transect, Macaloe.

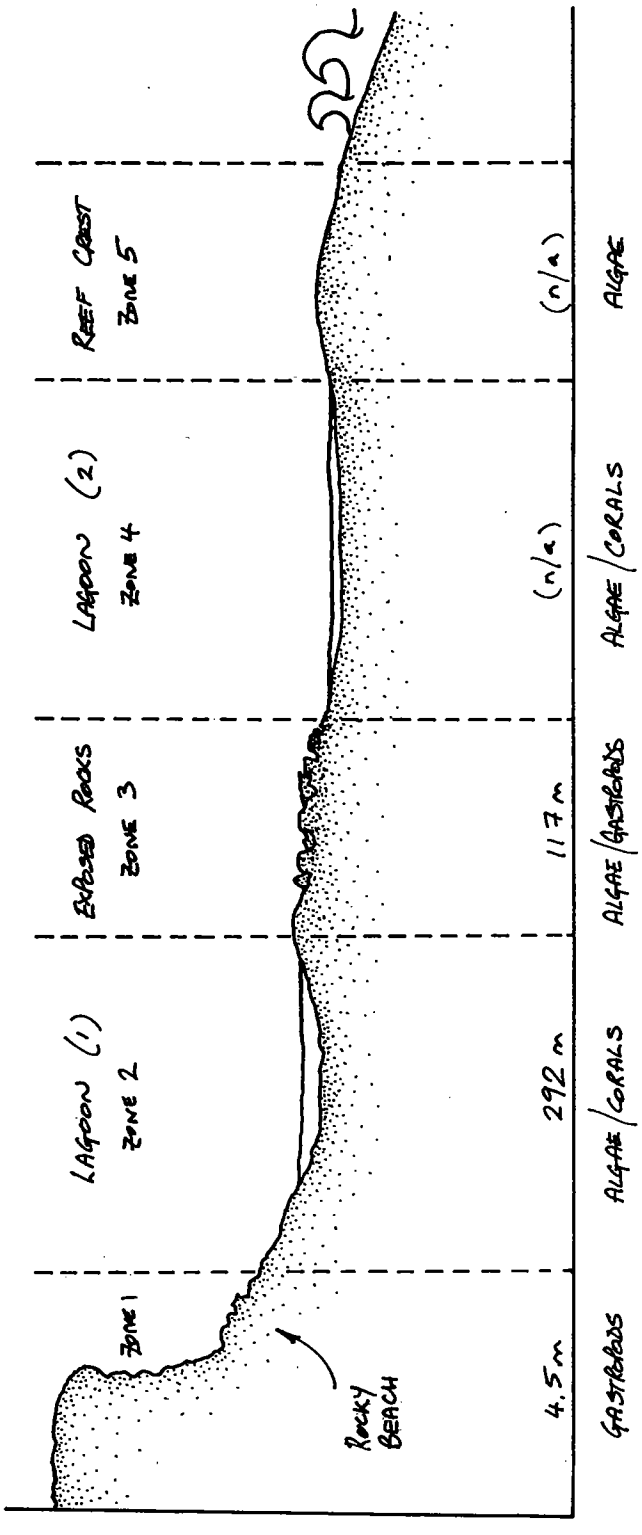
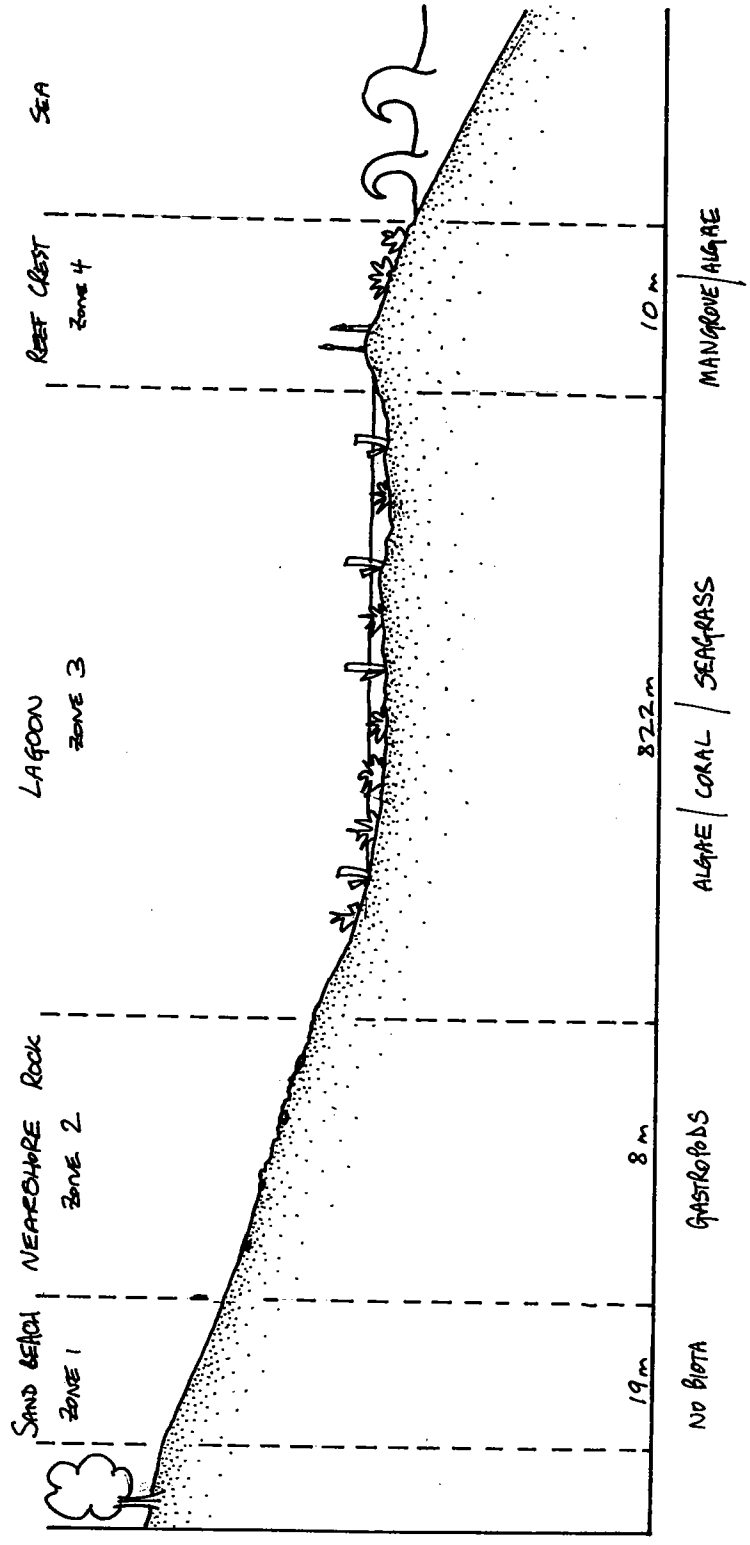


Figure 3.5 Cross section of 'East' intertidal transect, Macaloe.



3.3 Mangrove Surveys

3.3.1 Overview

The unusual topography of Macaloe island has meant that mangrove distribution is limited to scattered pockets close to the northern edge of the island, rather than forming the more commonly observed fringing stands (Figure 3.6). Small clumps of trees occur within sunken grottoes in the coral rag. There is apparently limited water exchange between these areas and the open sea; the tidal water movement occurring by seepage through the rock. Consequently, the bottom of most of the grottoes is constantly submerged and the build-up of leaf litter has formed a deep anoxic layer of organic material. Within the grottoes many of the larger trees appeared to be dying or were rotten. In other areas of mangrove, the water has receded completely and the mangrove trees are situated on dry sand-based substrata surrounded by terrestrial vegetation. As a result, the island can be considered as not supporting a 'healthy' mangrove stand and appears to be undergoing a natural transition whereby the mangrove will gradually diminish.

3.3.2 Area Reports

The Programme's standard transect survey technique was not possible given the nature of the island's mangrove. Instead, a series of spot assessments were made at each of the isolated pockets of mangrove.

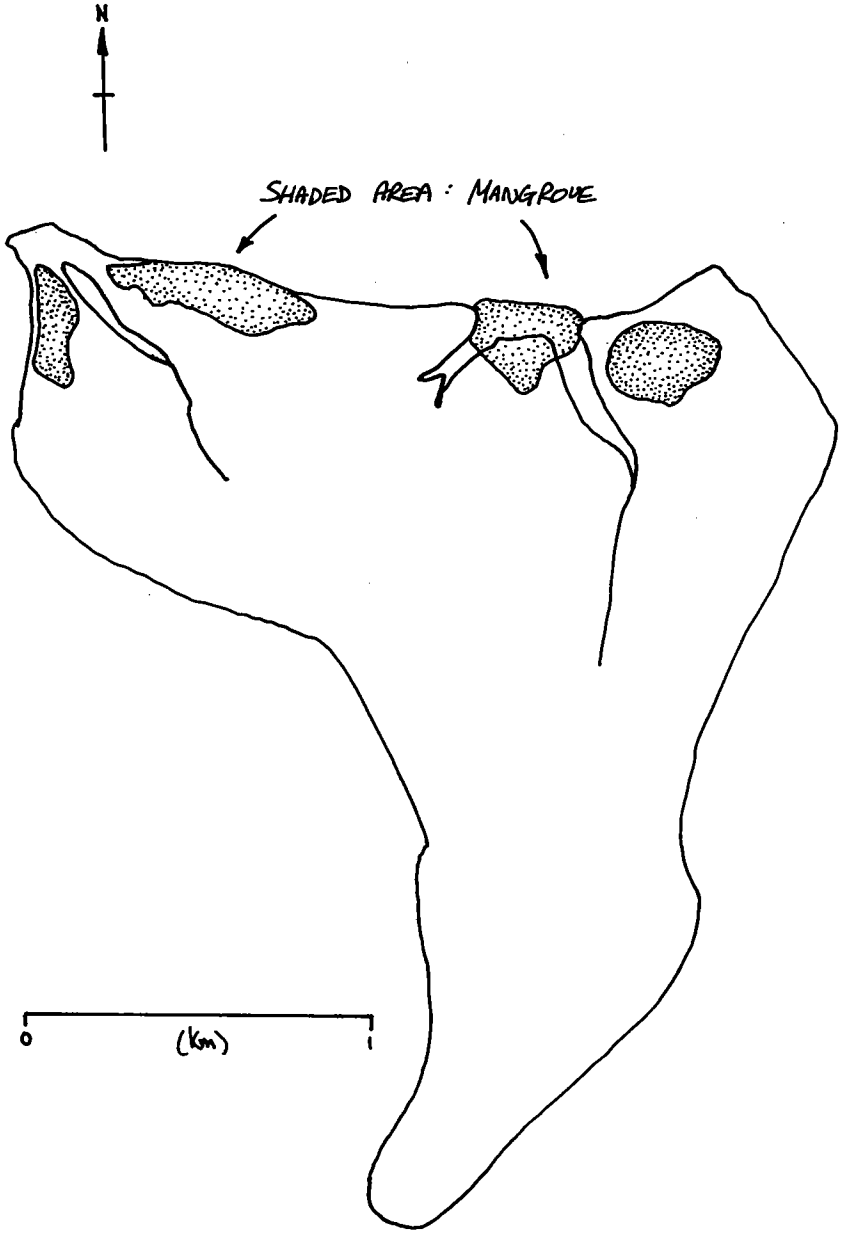
Area 1 (11°58'27.9''S 40°34'04.2''E) close to the north-east corner of the island. The grotto was approximately 100m x 50m and surrounded by a short coral rag wall. Most of the enclosed area contained mangrove trees, predominantly *Brugiera gymnorrhiza* (Estimated Basal Area m^2/ha=131.0; trees/m^2=0.24) and *Rhizophora mucronata* (Estimated Basal Area m^2/ha=14.0; trees/m^2=0.16). Few saplings (*B. gymnorrhiza* <0.1/m^2) were noted. Fauna was also scarce with the density of active crab burrows less than 0.5/m^2.

Area 2 (11°58'25.5''S 040°34'08.9''E) supported a few tall *B. gymnorrhiza* (<20m high) on a dry sand substratum. Could not be considered a mangrove stand area.

Area 3 (11°58'25.9''S 40°34'09.7''E) was a deep bowl behind the ridge at the top of the shore. Water appeared to enter the depression through seepage. A single large *B. gymnorrhiza* (20m high; dbh=65cm) stood in the centre of the pool.

Area 4 (11°58'25.7''S 40 34'13.1''E) was an irregular lagoon, approximately 5m below the coral rag level and flooded to a depth of 60cm. No mangrove was present in the lagoon but through narrow splits in the coral rag wall small pockets of mangrove (mainly *R. mucronata* and *B. gymnorrhiza*) were observed. The lagoon contained a single Convict surgeonfish (*Acanthurus triostegus*).

Figure 3.6 Location of mangrove transects, Macaloe.



3.4 Subtidal Habitat Surveys

Subtidal surveys were undertaken at five sites around the island, MC1 to MC5. Due to the shallow waters at sites MC4 and MC5, surveys were undertaken by snorkelling (Fig. 3.7).

3.4.1 Overview

Reef Structure and Composition
The seabed sloped gently away from the reef crest in the eastern and southern area of Macaloe. Low lying reef formations were found in shallow areas, typical of exposed shores, while generally beyond 10 - 15m depth the reef disappeared. In the north (MC1) a few bommies in the shallows gave way to a sandy slope descending into deep water where the continental shelf curves close to the mainland. All western and north-western areas were shallow and characterised by extensive bommie fields.

The substratum composition of western and northern sites was predominantly of sand. MC2 and MC3 on the east and south respectively were of rock with patches of rubble in shallow water, but beyond this a sandy substratum was typical in deep waters. Most sites were of low rugosity although areas of high rugosity were occasionally recorded on MC2 Inner and MC1 Outer.

Hard and soft corals were the dominant biota on sites MC2 and MC3, as well as in the bommie fields in the west. Seagrasses were absent from these bommie fields while in the north, site MC1, seagrass cover was extensive to a depth of approximately 20m. Seagrass cover was also seen to be high in the shallow area between the mainland and island. Macroalgae was only present only in low densities on site MC2. *Halimeda* spp. was not recorded around the island. Reef areas had a mixed diversity of low lying coral forms. Bommies at site MC1 were predominantly of 'big massive' form while site MC2 contained 'staghorn', 'fire' and 'foliose' forms. Many 'table' corals were also noted at this second site.

3.4.2 Site Reports

Site MC1:
The reef structure and community composition are described below and summarised in Table 3.10.

Reef Structure
Small bommie areas in shallow waters disappeared quickly as the depth increased. The slope was gentle (<10°) but increased slightly beyond 21m depth.

Substratum Composition
All areas were predominantly of sand with a few patches of rubble and rock/bommies, especially in shallower waters.

Biotic Cover

The sandy substratum was colonised extensively with dense meadows of seagrass. Expanses of clear sand often separated these meadows. Hard and soft corals were present in equally low densities, being especially low in the deeper areas of the site. Macroalgae and *Halimeda* spp. were both present in small quantities.

Table 3.10 A summary of the structure, composition and biotic cover at MC1 (P<1 % cover).

Reef Features		Upper Reef (n=18) Mode (0-6)	Upper Reef (n=18) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	0	0	)0	0-10
	Rugosity	2	1-4	2	0-3
Substratum	Rock	3	1-4	1	0-5
	Rubble	P	0-3	0	0-1
	Sand/Shell	4	1-5	6	2-6
	Mud	0	0	0	0
Biota	Hard Coral	2	1-4	P	1-4
	Soft Coral	2	P-2	P	0-2
	Seagrass	4	P-4	5	P-6
	Macroalgae	P	0-1	P	0-P
	Halimeda spp.	P	0-P	0	0-P
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching/Big Massive		Branching /Small Massive	

Site MC2:

The reef structure and community composition are described below and summarised in Table 3.11.

Reef Structure

A shallow slope (<10^0) continued away from the island and beyond a depth of 17m at the outer survey area. Rugosities were generally higher in shallow areas.

Substratum Composition

Rubble and rock was dominant in shallow areas while sand was more evident further from the shore.

Biotic Cover

Hard corals were found on rocky outcrops between rubble areas as well as forming a number of small bommies in shallower water (approximately 6m depth). Soft coral colonies formed a low cover throughout the site, although occasionally formed small dense patches in deeper areas. Seagrass, while present everywhere, only dominated biotic cover below 6m depth. Both macroalgae and *Halimeda* spp. were present in most survey replicates, but never in abundance.

Table 3.11 A summary of the structure, composition and biotic cover at MC2 (P<1 % cover).

Reef Features		Upper Reef (n=18) Mode (0-6)	Upper Reef (n=18) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	10	0-10	)0	0
	Rugosity	3	2-4	1	0-2
Substratum	Rock	3	2-4	1	1-4
	Rubble	4	2-5	1	0-2
	Sand/Shell	2	P-3	5	3-6
	Mud	0	0	0	0-P
Biota	Hard Coral	3	P-4	2	P-4
	Soft Coral	P	P-2	1	0-3
	Seagrass	P	0-1	4	1-6
	Macroalgae	P	0-P	P	0-1
	Halimeda spp.	0	0-P	P	0-P
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching /Small Massive		Branching	

Site MC3:
The reef structure and community composition are described below and summarised in Table 3.12 and Figure 3.8.

Reef Structure
A gentle slope (<10°) extended from the edge of the reef crest. A cover of degraded coral and bommies was recorded to a 6m depth contour. Beyond this the reef became more patchy, falling more rapidly towards a depth of 14m where it levelled out. A profile of this site has been presented graphically with a breakdown of the various coral forms (Fig. 3.9). Rugosities were generally low, although occasionally high values were obtained within some survey replicates, confirming the patchy nature of the reef at depth.

Substratum Composition
The substratum composition in the upper reaches of the reef was generally of rock with varying proportions of rubble and sand. Towards the bottom of the reef areas of rubble and rock were separated by sand, while beyond the reef sand became dominant.

Biotic Cover
Hard and soft corals were equal in proportion in shallower waters, although cover was always less than 50%. Soft corals tended to be present only in low abundance on the deeper parts of the site while hard corals formed occasional dense patches. Seagrass was recorded in some areas towards the bottom of the reef. Macroalgae was present in most survey replicates, while *Halimeda* spp. was uncommon.

Table 3.12 A summary of the structure, composition and biotic cover at MC3 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	0	0-10	0	0
	Rugosity	3	2-3	2	1-4
Substratum	Rock	3	2-3	4	3-4
	Rubble	1	1-4	3	2-5
	Sand/Shell	3	1-4	2	1-3
	Mud	0	0	0	0
Biota	Hard Coral	3	2-3	2	1-4
	Soft Coral	3	2-3	P	P-2
	Seagrass	0	0	1	0-2
	Macroalgae	P	0-1	1	0-1
	Halimeda spp.	0	0	0	0-P
Coral State	Heterogeneity	0	0	0	0
	Dominance	Small and Big Massive/ Branching		Branching/Big Massive	

Site MC4:
The reef structure and community composition are described below and summarised in Table 3.13.

Reef Structure
There was no reef at this site.

Substratum Composition
Sand was the dominant substratum with some small patches of rubble.

Biotic Cover
Seagrass cover was extensive. Apart from occasional colonies of soft coral no other biotic cover was recorded.

Table 3.13 A summary of the reef structure, composition and biotic cover at MC4 (P<1 % cover).

Reef Features		Upper Reef (n=6) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	0	0-1
Substratum	Rock	0	0-P
	Rubble	1	1-2
	Sand/Shell	6	5-6
	Mud	0	0
Biota	Hard Coral	0	0
	Soft Coral	0	0-P
	Seagrass	5	3-5
	Macroalgae	0	0
	Halimeda spp.	0	0
Coral State	Heterogeneity	0	0
	Dominance	None	

Site MC5:
The reef structure and community composition are described below and summarised in Table 3.14.

Reef Structure
Large bommies, 3 - 10m in diameter, were seen sporadically on flat sand.

Substratum Composition
Sand was the dominant substratum throughout this site with typically one or two large rock/coral bommies seen within each 5 minute survey replicate.

Biotic Cover
Hard and soft corals were similar in cover (<25%) on rock bommies. Macroalgae was also present in small quantities, both on the sandy substratum and bommies.

Table 314 A summary of the structure, composition and biotic cover at MC5 (P<1 % cover).

Reef Features		Upper Reef (n=6) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	0	0-4
Substratum	Rock	2	1-3
	Rubble	1	0-2
	Sand/Shell	6	4-6
	Mud	0	0
Biota	Hard Coral	2	P-2
	Soft Coral	2	P-2
	Seagrass	0	0
	Macroalgae	P	0-P
	Halimeda spp.	0	0
Coral State	Heterogeneity	0	0
	Dominance	Big Massive/Branching	

Subtidal Flora

The eastern side of the islands comprised fringing reef with a substratum consisting of a mixture of rock, sand and rubble. The western side was predominantly sand with scattered bommies. These habitats supported a variety of seagrass and macroalgae. A total of 5 seagrass species and 33 species of macroalgae were recorded. A checklist of seagrass and macroalgae for the N.I.G. is presented in Appendix A2. The macroalgae included Cyanophyta (1 species), Chlorophyta (15 species), Phaeophyta (6 species) and Rhodophyta (11 species).

Area Report

A total of 4 sites: MC1, MC2, MC3 and western Macaloe (MC4 and MC5) were surveyed including coral reefs, seagrass beds and sand/bommies.

Site MC1:

Between 16-18m this site consisted of sand/rubble on which the seagrass *Thalassodendron ciliatum*, was common. The most common macroalgae were *Halimeda* spp. and *Poritiera* spp.. Between 18-21m depth *Padina* sp. was the most abundant macroalgae with *Halophila stipulacea* also abundant where sandy substratum occurred. A total of 2 seagrass and 15 macroalgae species were recorded.

Site MC2:

The substratum mainly consisted of rock which was colonised by hard corals with some patches of *Thalassodendron ciliatum*. One seagrass and 13 macroalgae species were identified.

Site MC3:
This site was noteworthy for the predominance of *Lyngbya majuscula* in the shallower area with an abundance of dead *Turbinaria/Sargassum*. The outer part of this site supported the Chlorophyte *Halimeda cilindracea*. No seagrass were recorded and the macroalgal diversity was high (20 species).

Western Side of Macaloe:
The western sheltered subtidal zone had a predominantly sand substratum suitable for colonisation by a variety of seagrass species. A total of 3 species of seagrasses and 2 macroalgae species were recorded.

Figure 3.7 Subtidal habitat survey sites, Macaloe.

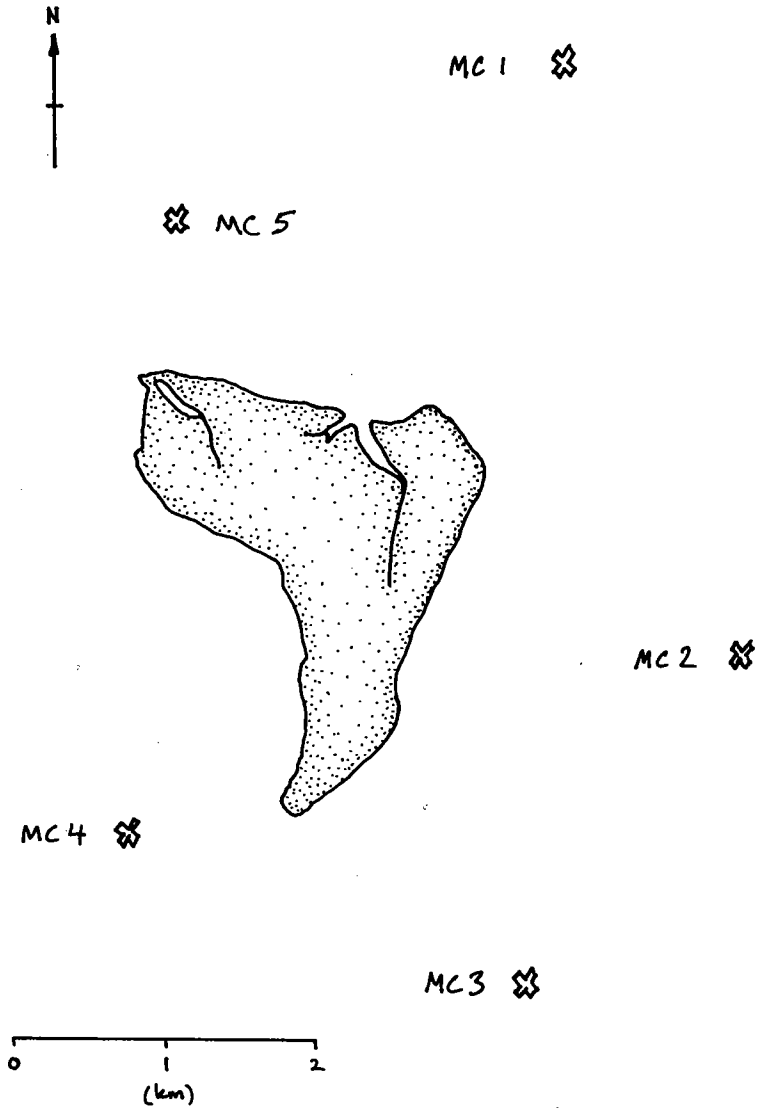


Figure 3.8 Habitat profile of site MC3 (Macaloe).

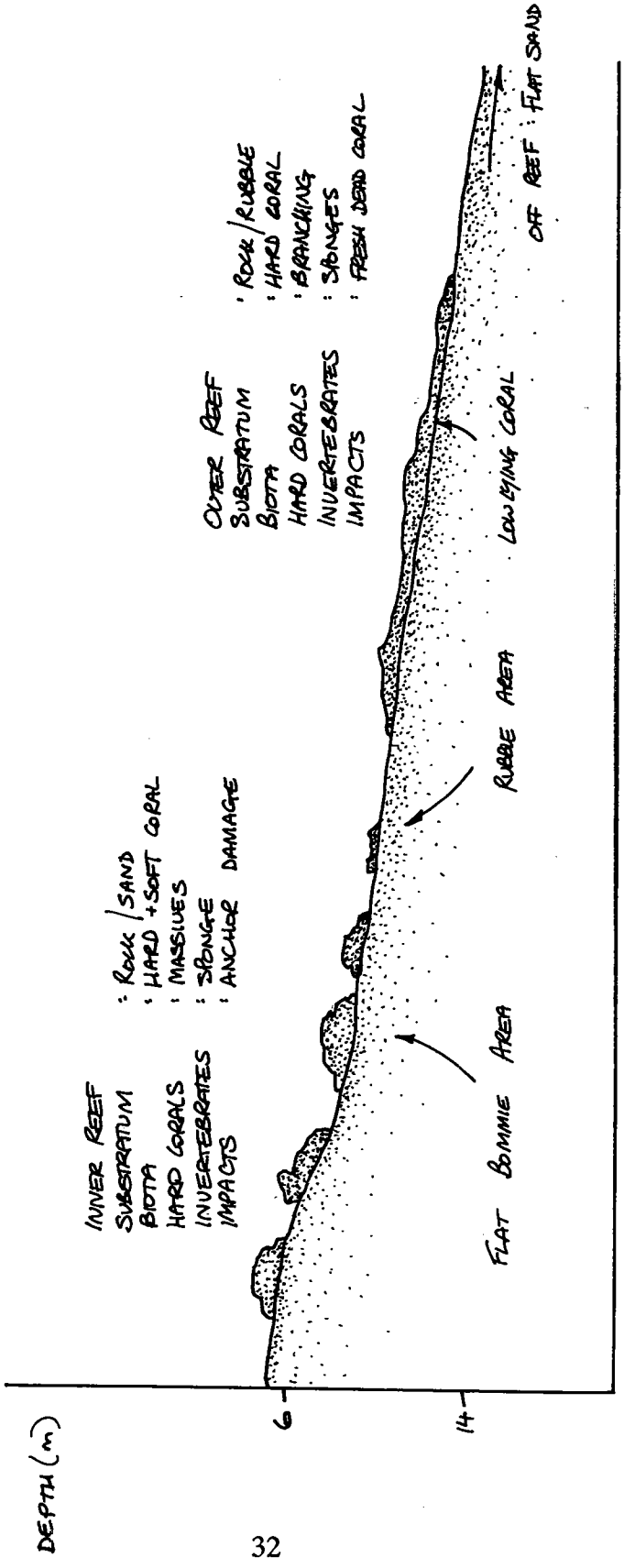
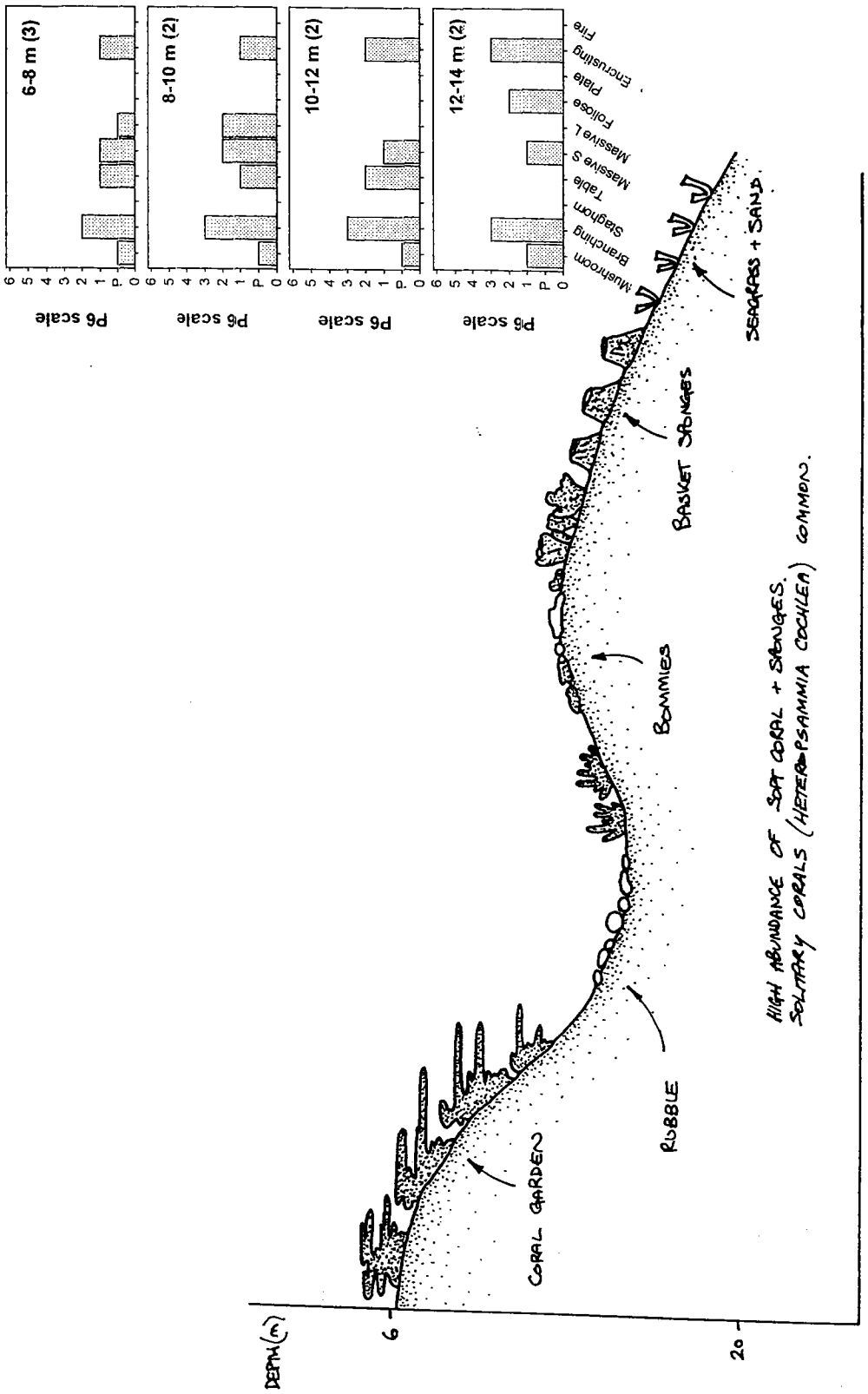


Figure 3.9 Coral profile of site MC3 (Macaloe).



3.5 Subtidal Invertebrate and Impact Surveys

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 3.7).

3.5.1 Overview

Macrosponges and sea urchins were the most numerous invertebrates around the island. Urchins often formed dense aggregations in shallower water. Sea cucumbers were present in low numbers at all sites, apart from site MC2 where the frequency of occurrence increased in deeper water. Triton, Murex and Tulip shells were rarely seen and although clams and lobsters were recorded, numbers were low. Freshly dead coral was seen at most sites and two Crown of Thorns starfish *Acanthaster plancii* were found on site MC3. Evidence of human impact was found on all but one site in the form of anchor damage.

3.5.2 Site Reports

Site MC1:
The distribution and density of invertebrates and incidences of reef damage are discussed below, and summarised in Table 3.15.

Numerous macrosponges (up to 50 individuals / 5 minutes) and urchins (also up to 50 / 5 minutes) were recorded at this site. Higher abundances for each were recorded in shallower waters. Clams, Triton shells and Tulip shells were found in small numbers while Holothuria occasionally occurred in high numbers in the deeper waters of the site. A few examples of fresh dead coral were seen during the inner reef survey, while human impact, in the form of anchor damage, was recorded only once.

Table 3.15 Invertebrates and Natural/Human Impacts at Site MC1 (values are for 5 minutes of survey).

Invert./Impact	Type/Cause	Inner Reef (n=12)		Outer Reef (n=11)	
		Median	Range	Median	Range
Macrosponges		7	3-A+	0	0-A
Bivalves	Giant Clams	0	0-2	-	-
Gastropods	Triton Shells	0	0-2	-	-
	Tulip Shells	0	0-1	-	-
Urchins		16	0-A+	0	0-2
Sea Cucumbers	Holothuria	0	0-3	0	0-A
	Others	1	0-2	-	-
Dead Corals	Unknown	0.5	0-4	-	-
	Sed. Massives	0	0-1	-	-
Human Effects	Anchor damage	0	0-1	-	-

Site MC2:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 3.16.

Macrosponges were abundant on both the inner and outer reef, while urchins were observed to be more abundant on the inner reef. Clams and sea cucumbers were less common (typically <2 individuals/5 minutes) and a single lobster was seen in shallow water. Freshly dead coral (cause unknown) and sedimented massives were recorded on a number of occasions. Human impacts on the site were restricted to a single area of anchor damage.

Table 3.16 Invertebrates and Natural/Human Impacts at Site MC2 (values are for 5 minutes of survey).

		Inner Reef (n=12)		Outer Reef (n=12)	
Inverts/Impacts	**Type/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		9.5	3-25	17.5	9-A+
Bivalves	Giant Clams	-	-	0.7	0-5
Lobsters		0	0-1	-	-
Urchins		12	0-A+	1	0-8
Sea Cucumbers	Holothuria	0	0-1	0	0-2
	Synapta spp.	0	0-1	2	0-1
	Others	0	0-3	0	0-7
Dead Corals	Unknown	0	0-2	-	-
	Sed. Massives	0	0-3	-	-
Human Effects	Anchor damage	0	0-1	-	-

Site MC3:
The distribution and density of invertebrates and incidences of reef damage are discussed below, and summarised in Table 3.17.

Macrosponges and urchins were the most abundant invertebrates recorded and, although found over the full reef profile, urchins were seen to occur in greater numbers towards the top of the reef. Sea whips occurred in dense aggregations (<100 individuals/5 minutes) in deeper water (14m). Other invertebrates were found in low numbers, as well as two Crown of Thorns starfish at the bottom of the reef. Occasional patches of freshly dead coral (cause unknown) and sedimented massives were noted. A single area of anchor damage was also found.

Table 3.17 Invertebrates and Natural/Human Impacts at Site MC3 (values are for 5 minutes of survey).

		Inner Reef (n=18)		Outer Reef (n=12)	
Invert/Impact	**Type/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		9.5	0-A	11.5	0-A
Gorgonians	Sea Whips	-	-	0.5	0-A+
Bivalves	Giant Clams	0	0-1	0	0-1
Gastropods	Triton Shells	0	0-1	-	-
	Murex Shells	0	0-2	-	-
Lobsters		0	0-1	0	0-4
Urchins		A	0-A+	0	0-A
Sea Cucumbers	Holothuria	0	0-1	0.5	0-3
	Synapta spp.	0	0-3	-	-
	Others	0	0-4	0.5	0-2
C-O-T		-	-	0	0-2
Dead Corals	Unknown	0	0-1	0	0-5
	Sed. Massives	-	-	0	0-1
Human Effects	Anchor damage	0	0-1	-	-

Site MC4:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 3.18.

There were few invertebrates to be found on this predominantly sandy site.

Table 3.18 Invertebrates and Natural/Human Impacts at Site MC4 (values are for 5 minutes of survey).

		Inner Reef (n=6)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		0	0-1
Urchins		1	0-1
Sea Cucumbers	Others	0	0-2

Site MC5:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 3.19.

Macrosponges, clams and sea cucumbers were the only invertebrates to be recorded. None of these were high in numbers. Freshly dead coral was the only form of reef degradation seen.

Table 3.19 Invertebrates and Natural/Human Impacts at Site MC5 (values are for 5 minutes of survey).

		Inner Reef (n=6)	
Invert/Impact	**Type/Cause**	**Median**	**Range**
Macrosponges		0	0-2
Bivalves	Giant Clams	0	0-2
Sea Cucumbers	Others	0	0-2
Dead Corals	Unknown	0.5	0-3
Human Effects	New fish traps	0	0-4

3.6 Reef fish census

3.6.1 Overview

Macaloe was characterised by a sloping outer reef to the south and east of the island, with a sand and bommie channel to the west, between the island and the mainland peninsular of Pangane. The reef fish census was conducted at five main sites, of which three were subdivided into inner and outer reef sites, as described in the subtidal habitat survey (section 3.4). Maximum fish diversity and abundance was seen at sites MC2 and MC3, reef areas to the south east of Macaloe. A summary of species richness and diversity of reef fish has been presented in Table 3.20. A list of all species recorded at Macaloe is in Appendix A3.

Table 3.20 The number of five minute replicates, number of species recorded, relative species richness indices (RSRi) and Shannon Weaver diversity indices (SWi) at Macaloe Island.

Site	Reps	Spp	RSRi	SWi
MC1 inner	18	19	0.26	1.96
MC1 outer	18	12	0.16	2.01
MC2 inner	24	30	1.41	2.60
MC2 outer	25	31	0.42	2.59
MC3 inner	25	32	0.44	2.68
MC3 outer	18	27	0.37	2.41
MC4	12	4	0.05	1.16
MC5	6	17	0.23	2.57

3.6.2 Site reports

Site MC1:
This site was on a shallow reef slope and was subdivided into inner and outer reef areas. Many more fish were observed on the inner reef than the outer reef (527 and 87 respectively) from a few more species (19 to 12 respectively). Of these , the majority were surgeonfish, dominated by the Dusky surgeonfish *Acanthurus nigrofuscus* and the Twospot bristletooth *Ctenochaetus binotatus*. The outer reef, in contrast, was numerically dominated by the Halfmoon triggerfish *Sufflamen chrysopterus*. The abundance and species richness of reef fish at the two areas of site MC1 are presented graphically in Figs. 3.10, 3.11.

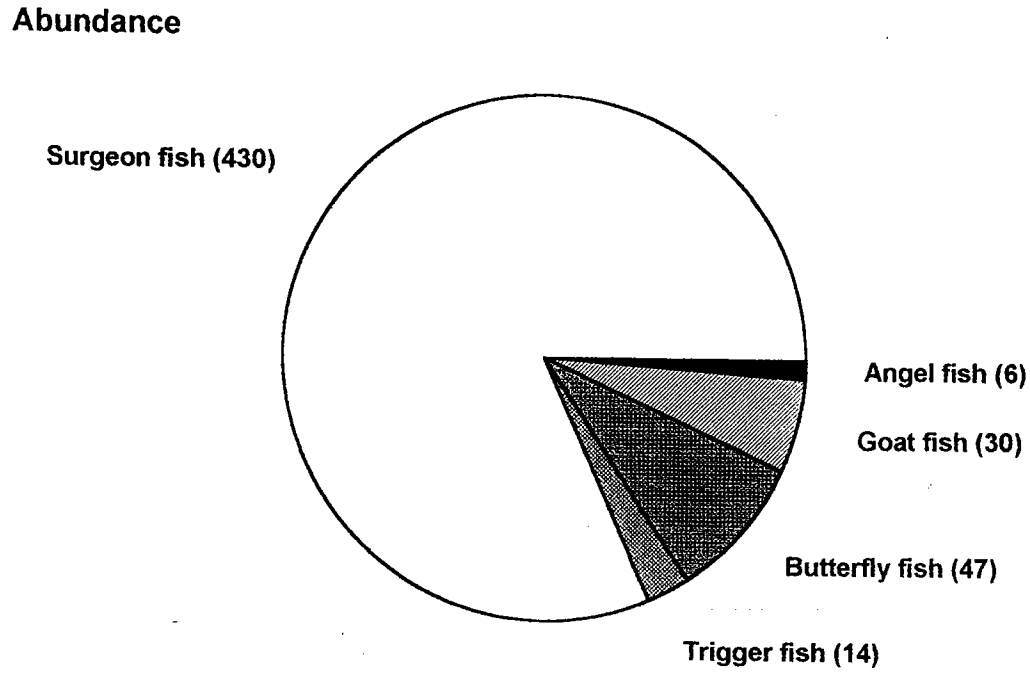
Site MC2:
This was another site on a shallow reef slope, subdivided into inner and outer reef areas. High numbers of fish were recorded on both the inner (619) and outer reef (536). As with site MC1, surgeonfish were the major fish family recorded on the inner reef, of which the Dusky surgeonfish *Acanthurus nigrofuscus* and the Striped bristletooth *Ctenochaetus striatus* were dominant. The most numerous fish on the outer reef area were the Twospot bristletooth *Ctenochaetus binotatus* and the Dot-dash butterflyfish *Chaetodon kleinii*. The abundance and species richness of reef fish at the two areas of site MC2 are presented graphically in Figs. 3.12, 3.13.

Site MC3:
This site was a reef slope, and for reef fish census purposes, was subdivided into inner and outer reef areas. The highest fish species richness and diversity was observed on the inner area of this site, with 12 surgeonfish species and 11 butterflyfish species recorded. However the most numerically abundant fish on the inner area was the Halfmoon triggerfish *Sufflamen chrysopterus*. Of the 392 fish observed on the outer reef, almost half (160) were the Twospot bristletooth *Ctenochaetus binotatus*. The abundance and species richness of reef fish at the two areas of site MC3 are presented graphically in Figs. 3.14, 3.15.

Site MC4:
This site was a sandy area, with scattered bommies. Only 18 fish from 4 species were recorded on this site, of which 9 were the Dash-dot goatfish *Parupeneus barberinus*. The abundance and species richness of reef fish at site MC4 are presented graphically in Fig. 3.16.

Site MC5:
This was a site also a sandy area, like MC4, with scattered bommies. However, more fish were observed than MC4, with 67 fish recorded, from 17 species. No one species was dominant, hence the quite high Shannon Weaver diversity index (2.57) for the relatively low number of species seen. The abundance and species richness of reef fish at site MC5 are presented graphically in Fig. 3.17.

Figure 3.10 The abundance and species richness of reef fish at site MC1 (inner).



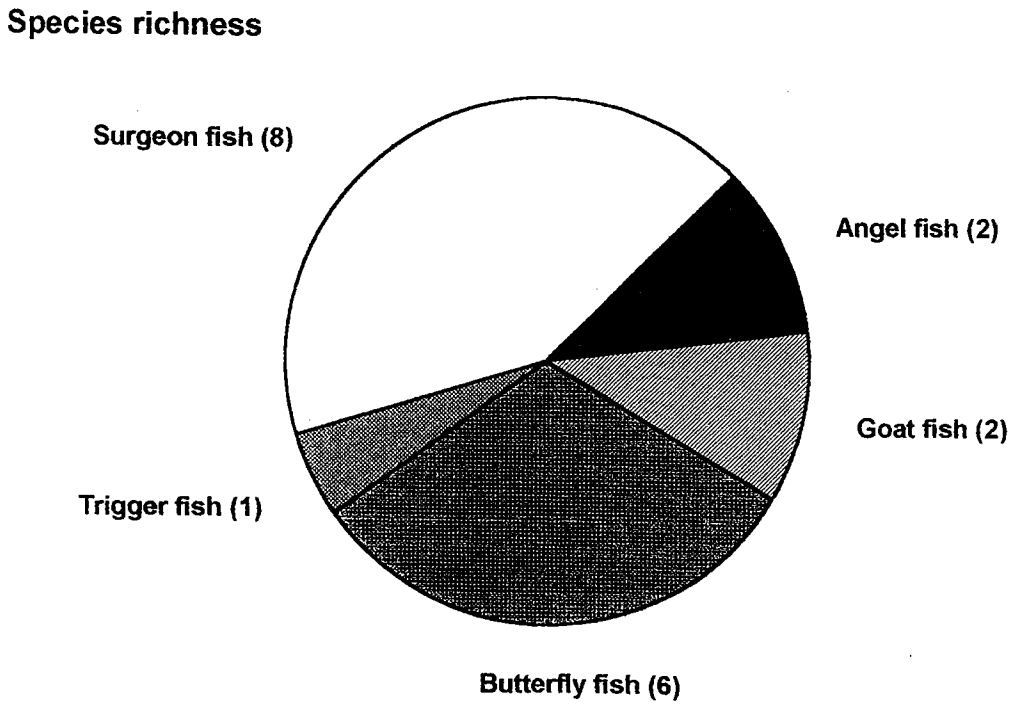


Figure 3.11 The abundance and species richness of reef fish at site MC1 (outer).

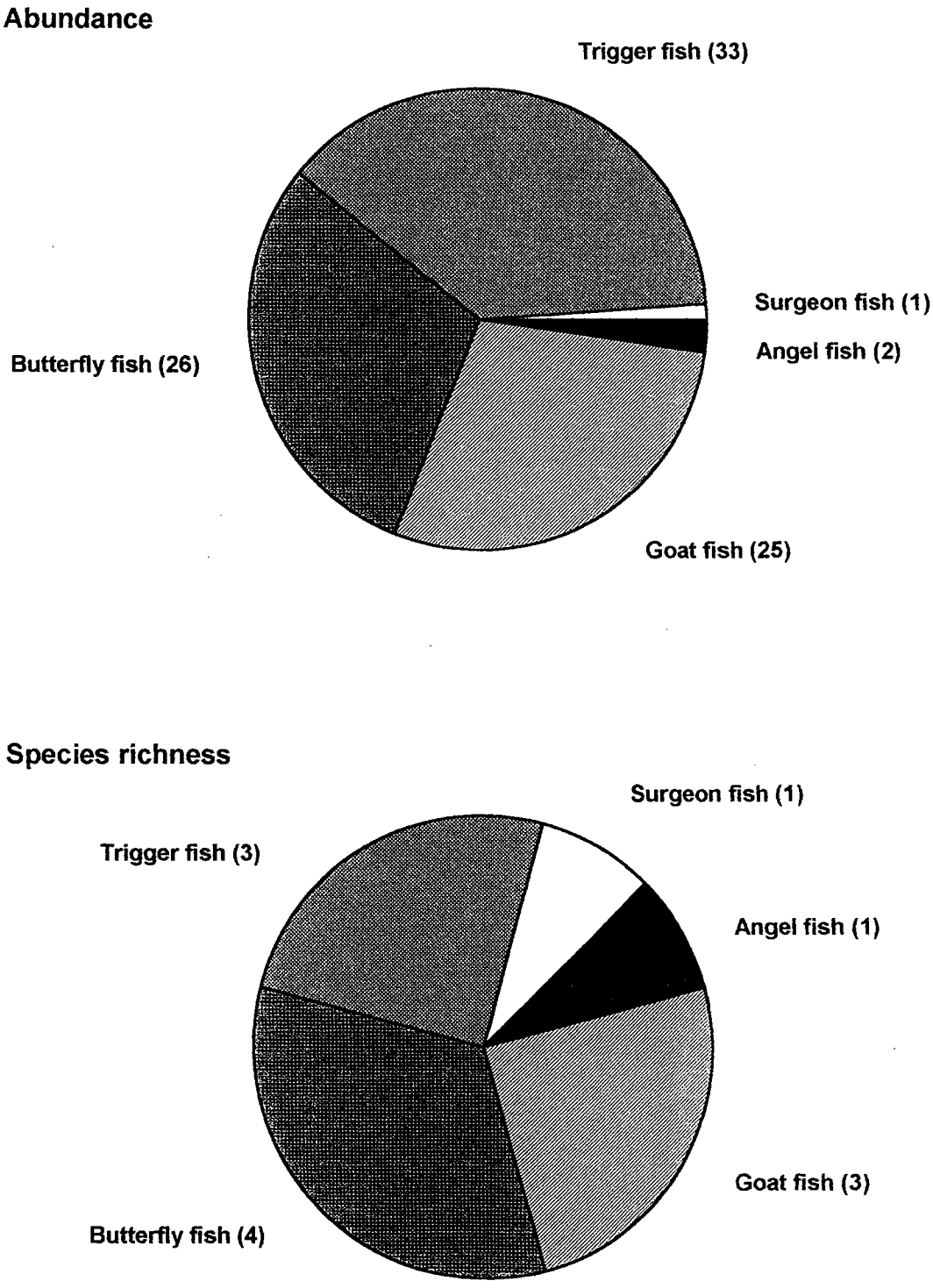
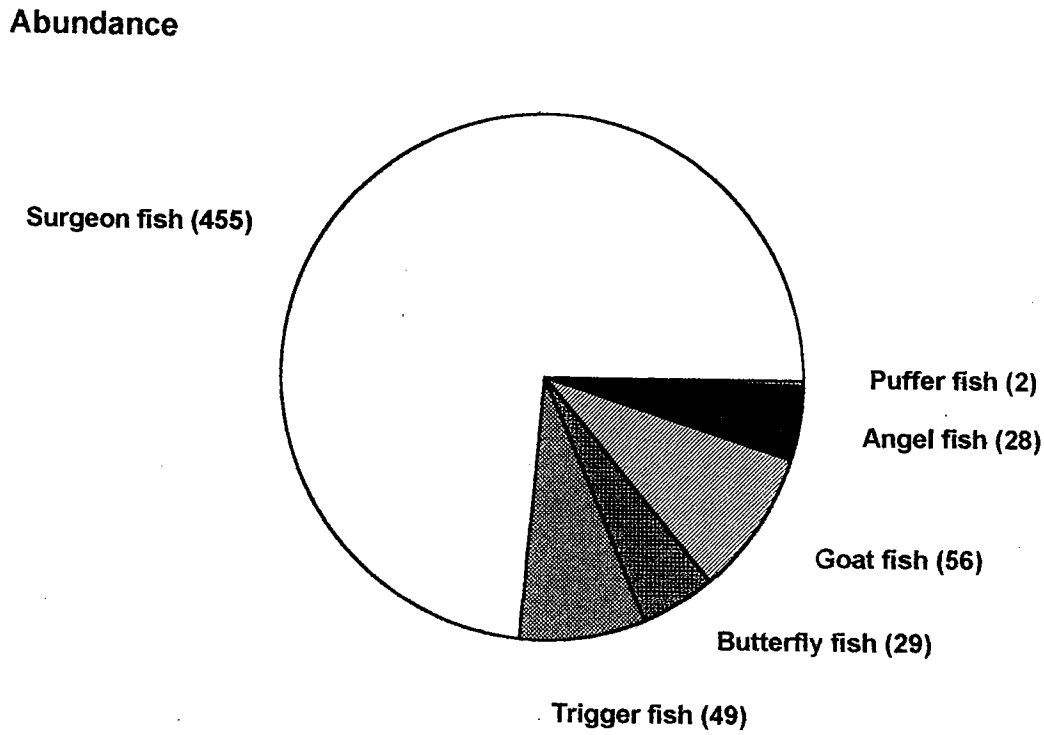


Figure 3.12 The abundance and species richness of reef fish at site MC2 (inner).



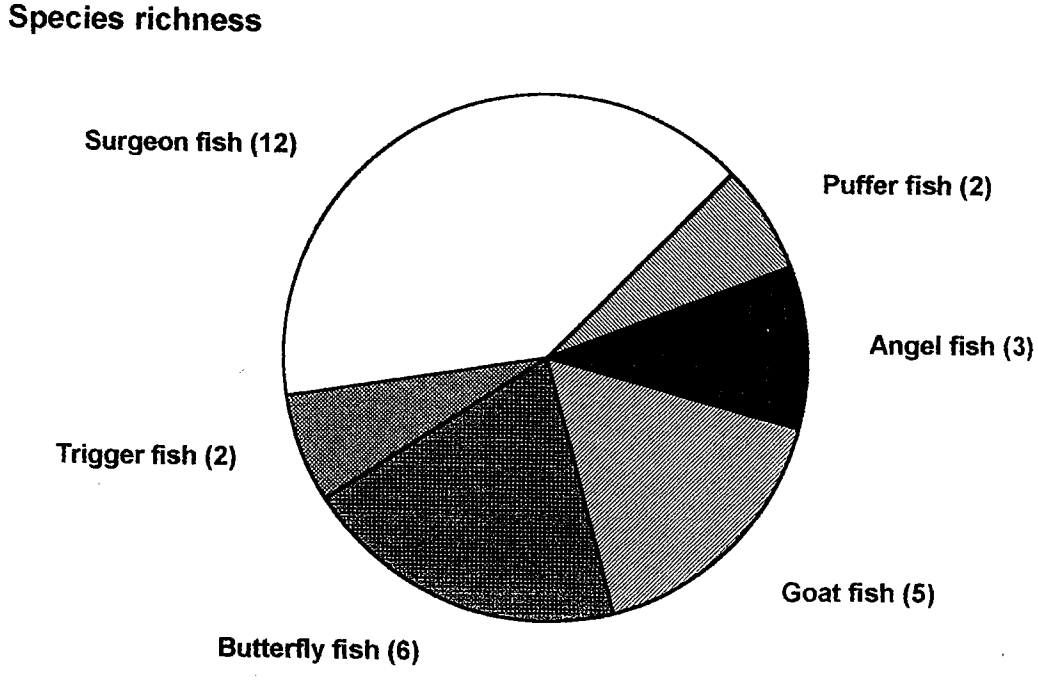
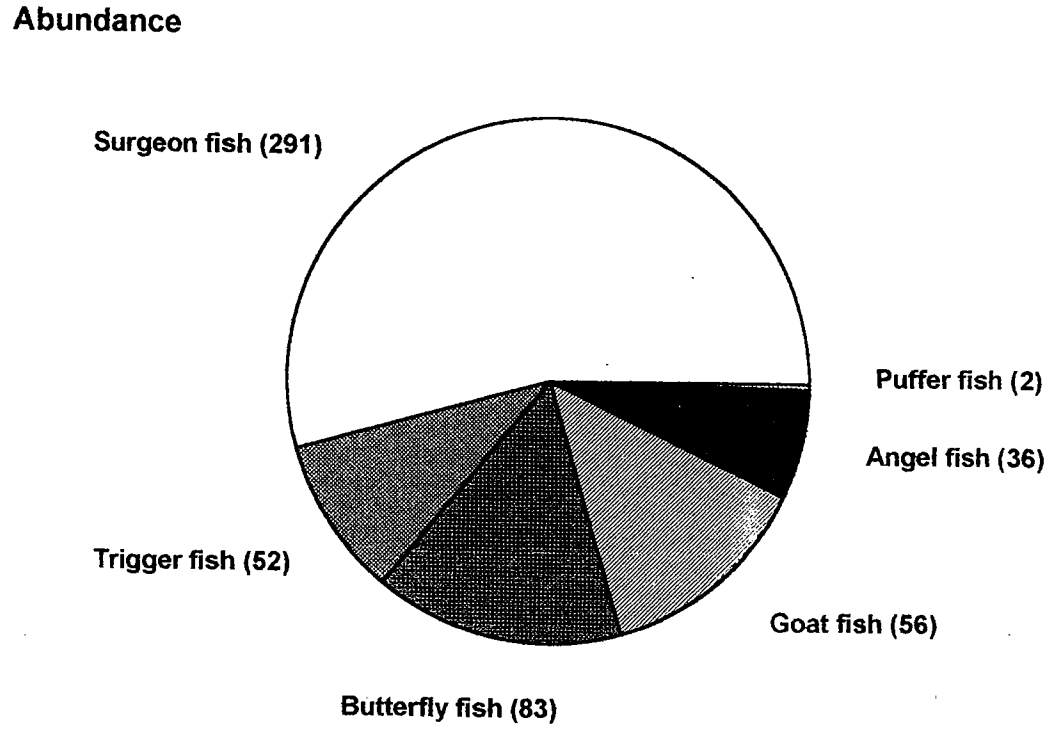


Figure 3.13 The abundance and species richness of reef fish at site MC2 (outer).



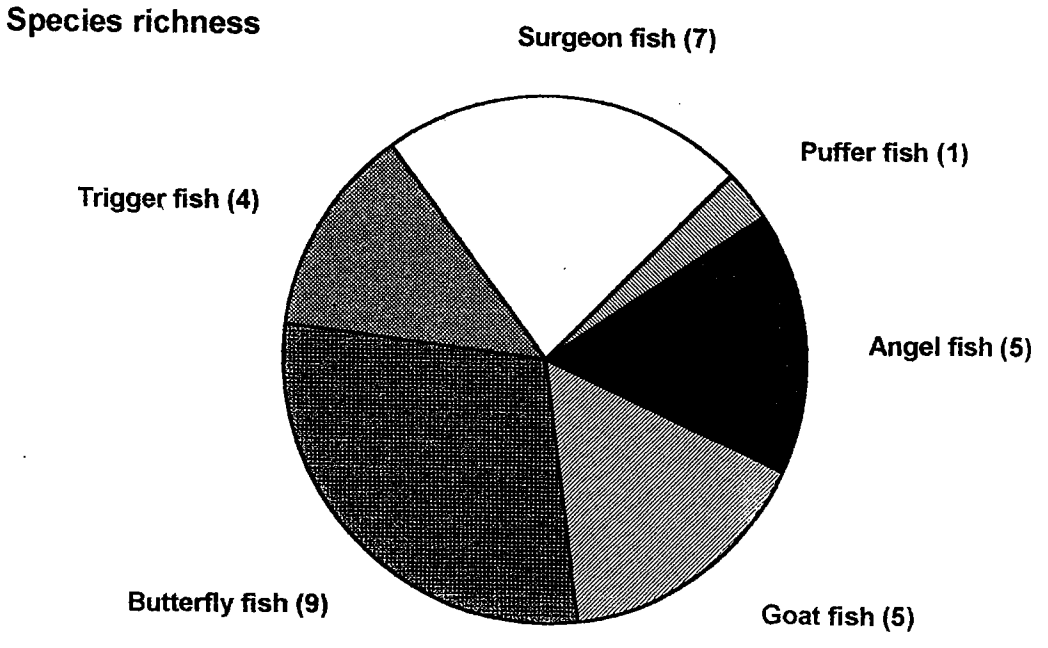


Figure 3.14 The abundance and species richness of reef fish at site MC3 (inner).

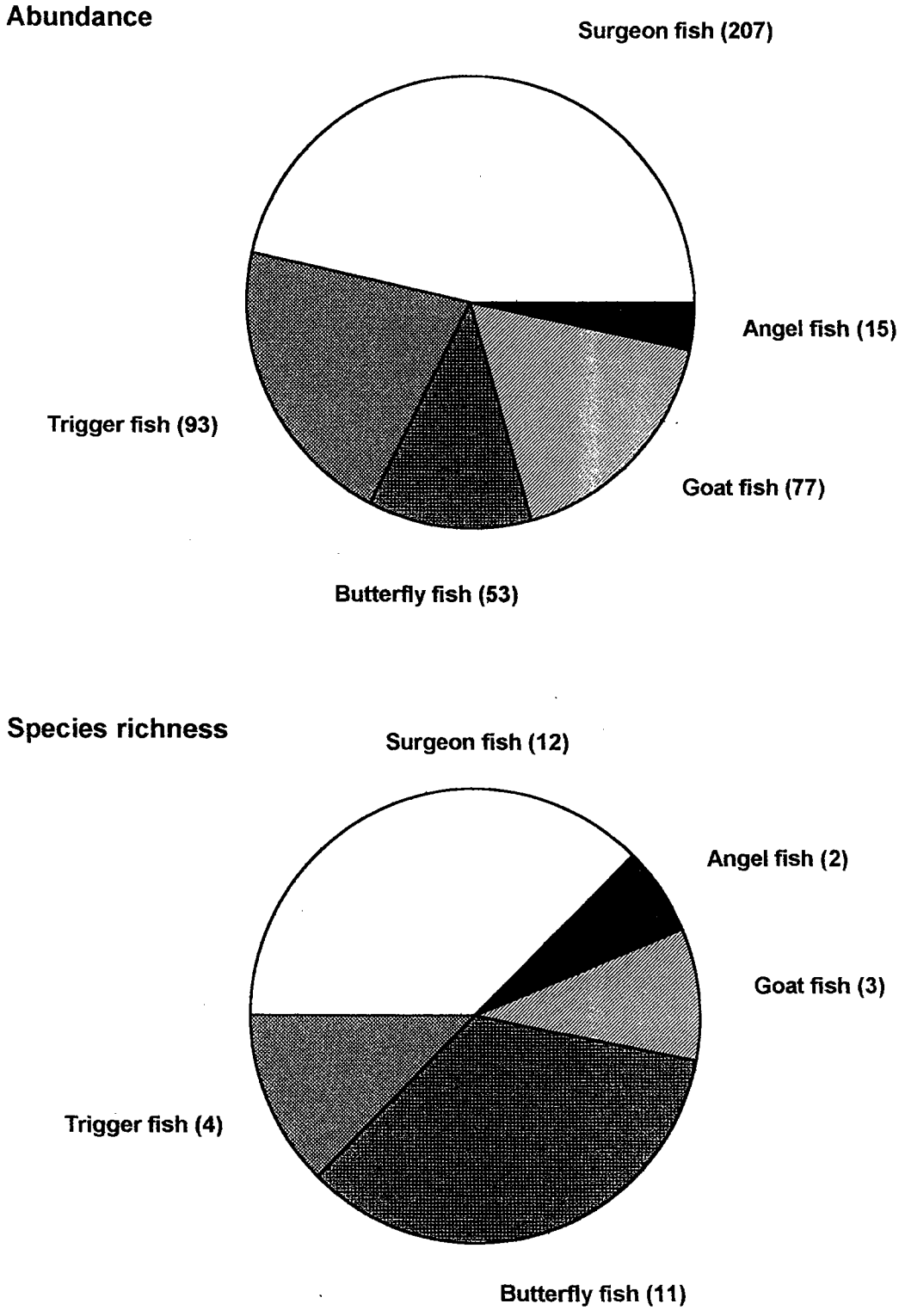
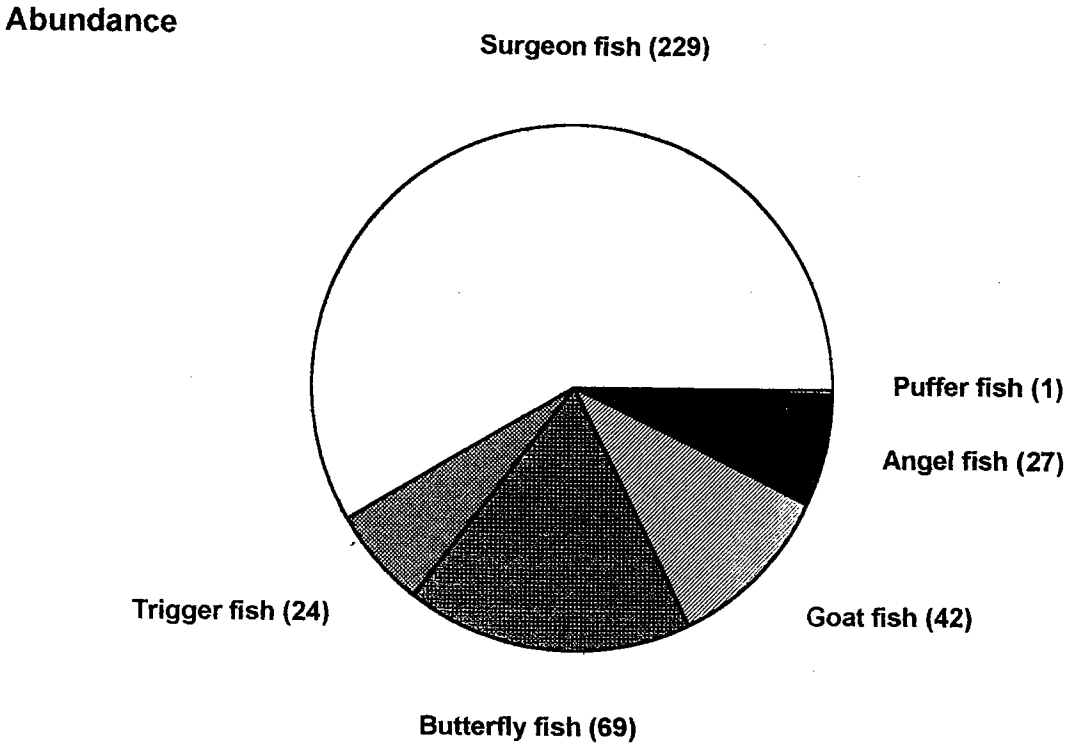


Figure 3.15 The abundance and species richness of reef fish at site MC3 (outer).



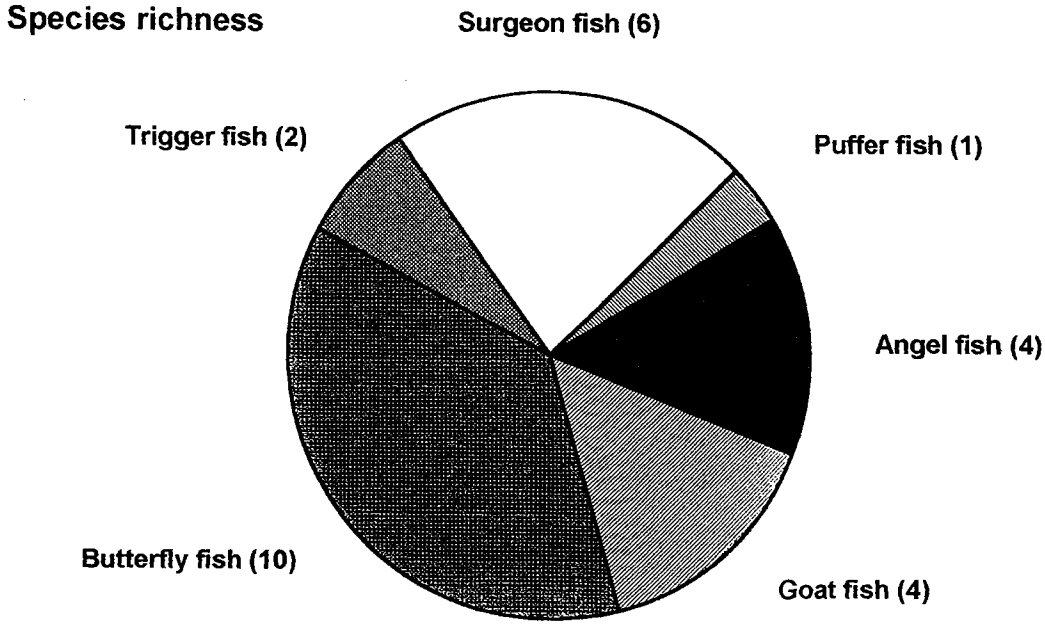


Figure 3.16 The abundance and species richness of reef fish at site MC4.

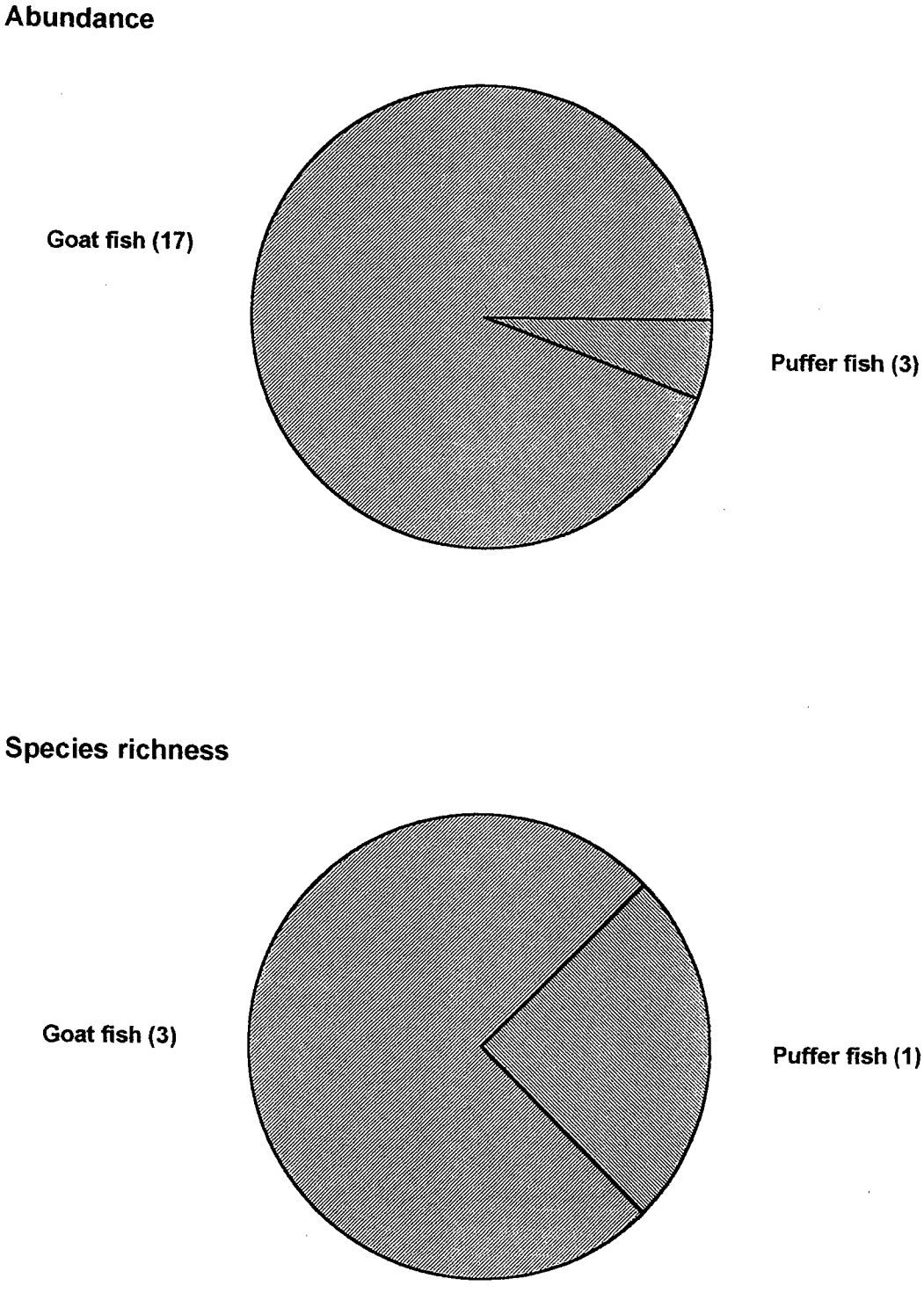
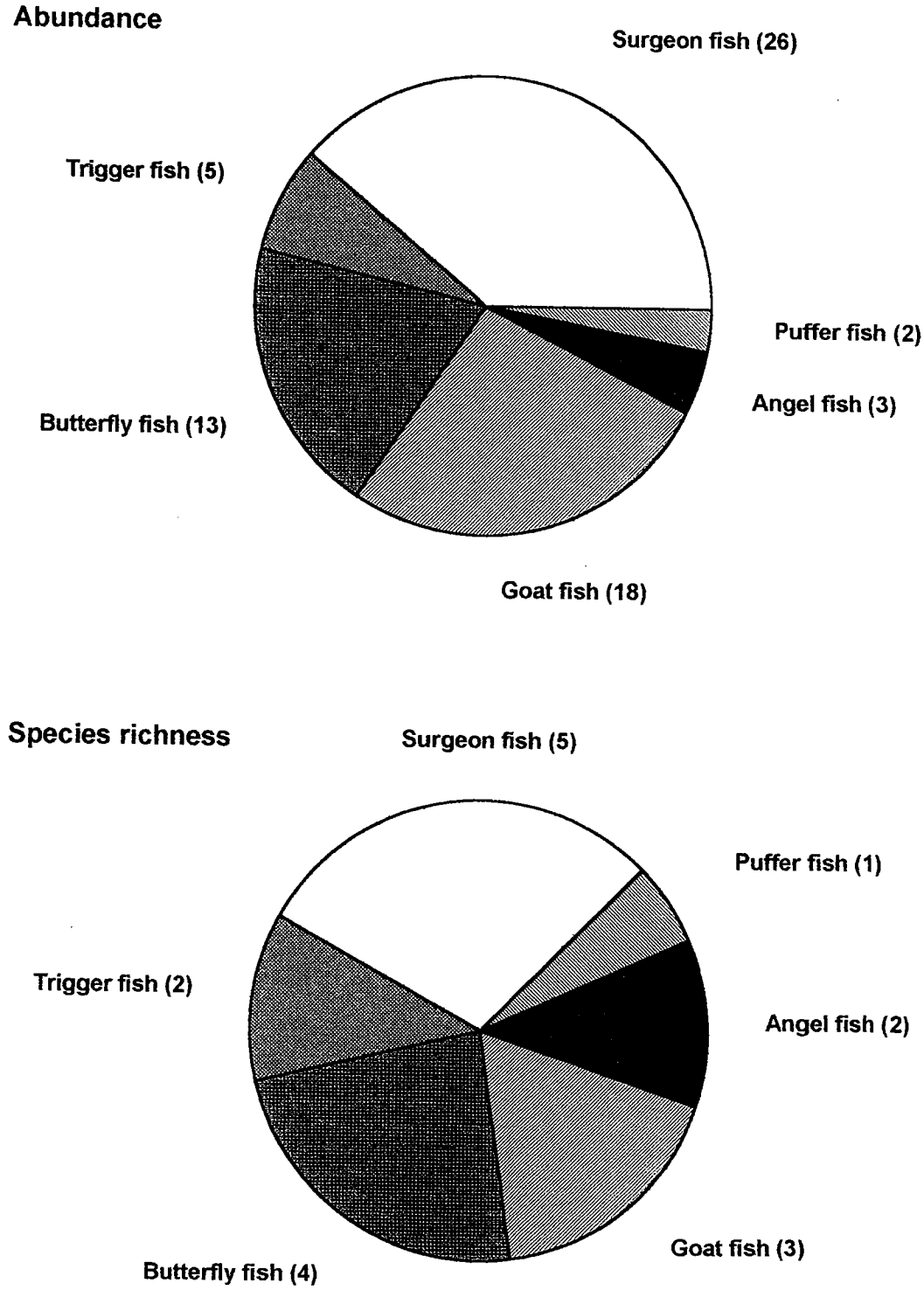


Figure 3.17 The abundance and species richness of reef fish at site MC5.



3.7 Commercial fish census

3.7.1 Overview

A comprehensive commercial fish survey was possible at Macaloe island, hence 3 of the 5 sites chosen were subdivided into inner and outer reef areas. Although high numbers of commercial fish were recorded, a variety of different species made up the assemblages at the five sites. Snappers (Lutjanidae) and parrotfish (Scaridae) made up the majority of the observed fish. The snappers were usually associated with the deeper reef slopes to the south and east of Macaloe island. Shoaling barracuda were also observed here.

3.7.2 Site reports

Site MC1:
Sufficient surveys were conducted to allow this site to be subdivided into inner and outer reef areas. Of these higher species richness (17 species) was recorded on the inner reef, compared to the outer (11 species). At both areas, diverse grouper (Serranidae) populations were observed. Parrotfish (Scaridae), however, were numerically the most abundant, in particular the Bullethead *Scarus sordidus* and Tailbarred *Scarus caudofasciatus*. The abundance and distribution of commercial fish at both areas of this site have been presented in Figs. 3.18, 3.19.

Site MC2:
This site was subdivided into inner and outer reef areas, with more species richness observed on the outer reef than inner reef (15 and 7 species respectively). By far the most numerically dominant fish at both areas was the Bullethead parrotfish *Scarus sordidus*. The abundance and distribution of commercial fish at both areas of this site have been presented in Figs. 3.20, 3.21.

Site MC3:
This site was also subdivided into outer and inner reef areas. Both areas were diverse, with 19 species recorded. Of these, the several fish were numerous, including the African whitespotted rabbitfish *Siganus sutor*, the Bluelined snapper *Lutjanus kasmiri*, the Blackspotted sweetlips *Plectorhinchus gaterinus* and the Bullethead parrotfish *Scarus sordidus*. The abundance and distribution of commercial fish at both areas of this site have been presented in Figs. 3.22, 3.23.

Site MC4:
This site was a sandy area with scattered coral bommies. Of the 313 fish recorded, all but 13 were in a single shoal of barracuda (Sphyraenidae). The remainder comprised mainly of the African whitespotted rabbitfish *Siganus sutor*. The abundance and distribution of commercial fish at this site have been presented in Fig. 3.24.

Site MC5:

This was another site of sand and bommies, although had a higher species richness than site MC4 (10 species recorded here). Most of the fish seen were snappers, in particular the Bluelined *Lutjanus kasmiri* and Onespot *Lutjanus monostigma*. The abundance and distribution of commercial fish at this site have been presented in Fig. 3.25.

Figure 3.18 The abundance and distribution of commercial fish at site MC1 (inner).

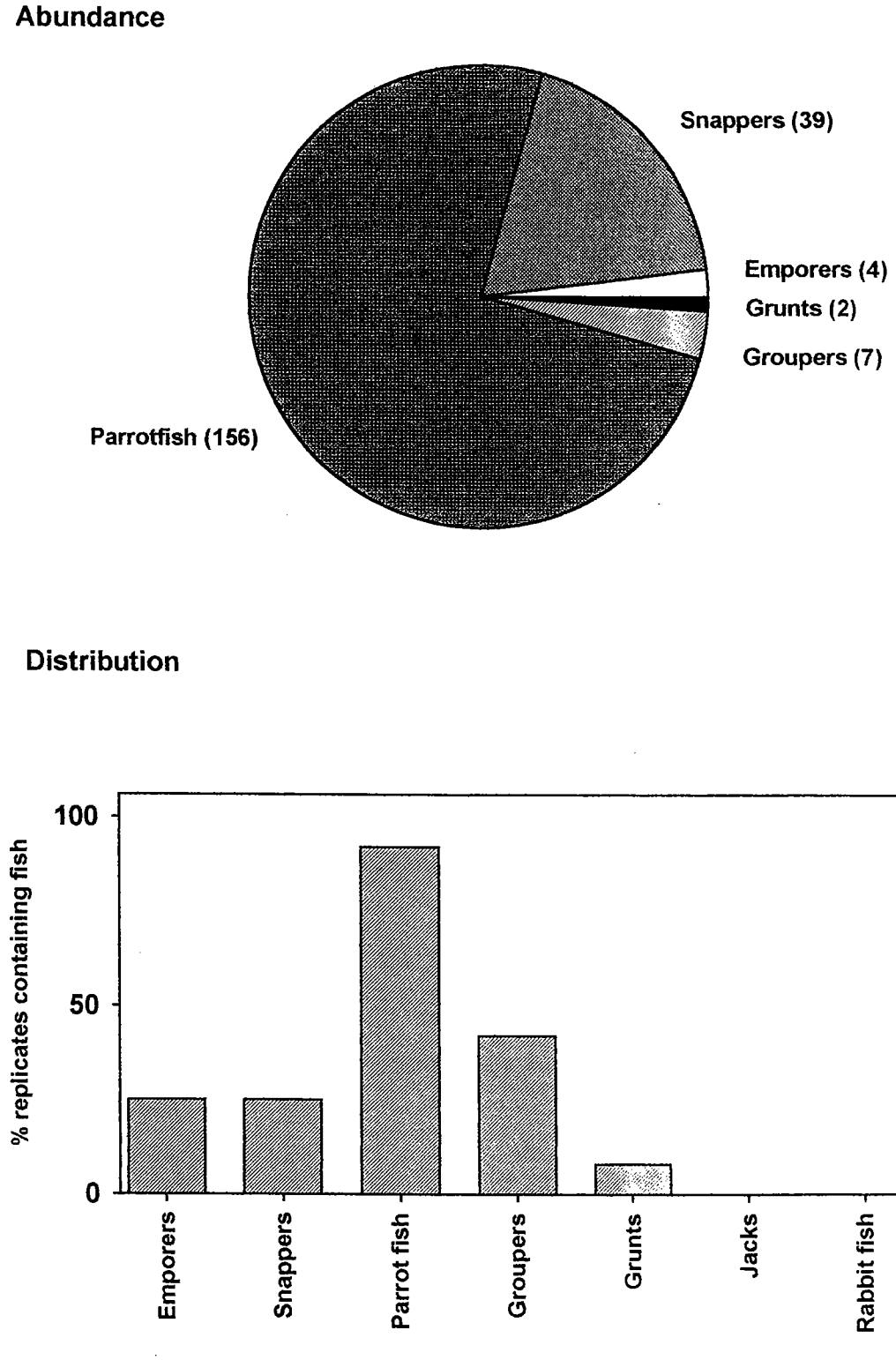
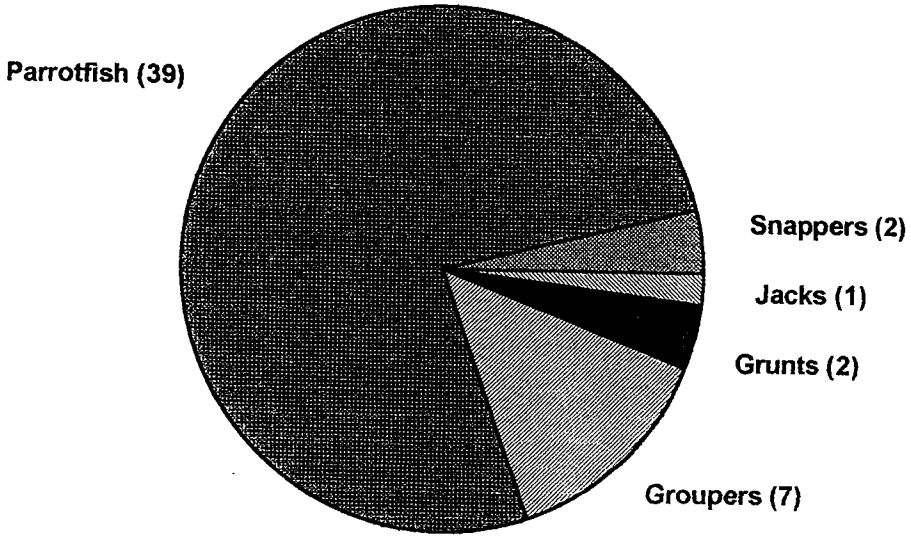


Figure 3.19 The abundance and distribution of commercial fish at site MC1 (outer).

Fig. 3.19 MC1 (outer) commercial fish

Abundance



Distribution

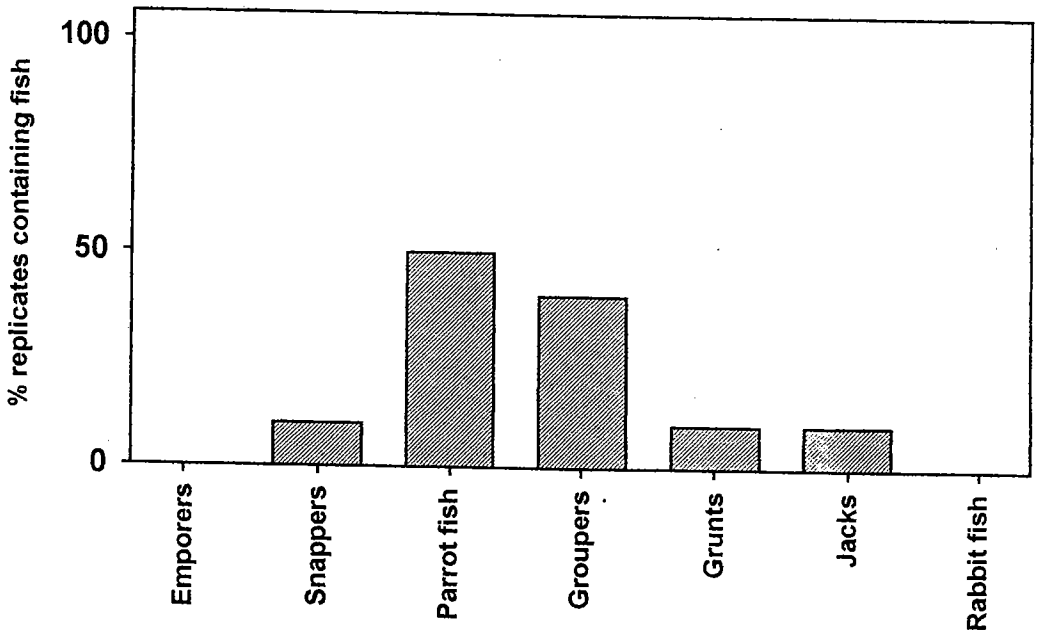


Figure 3.20 The abundance and distribution of commercial fish at site MC2 (inner).

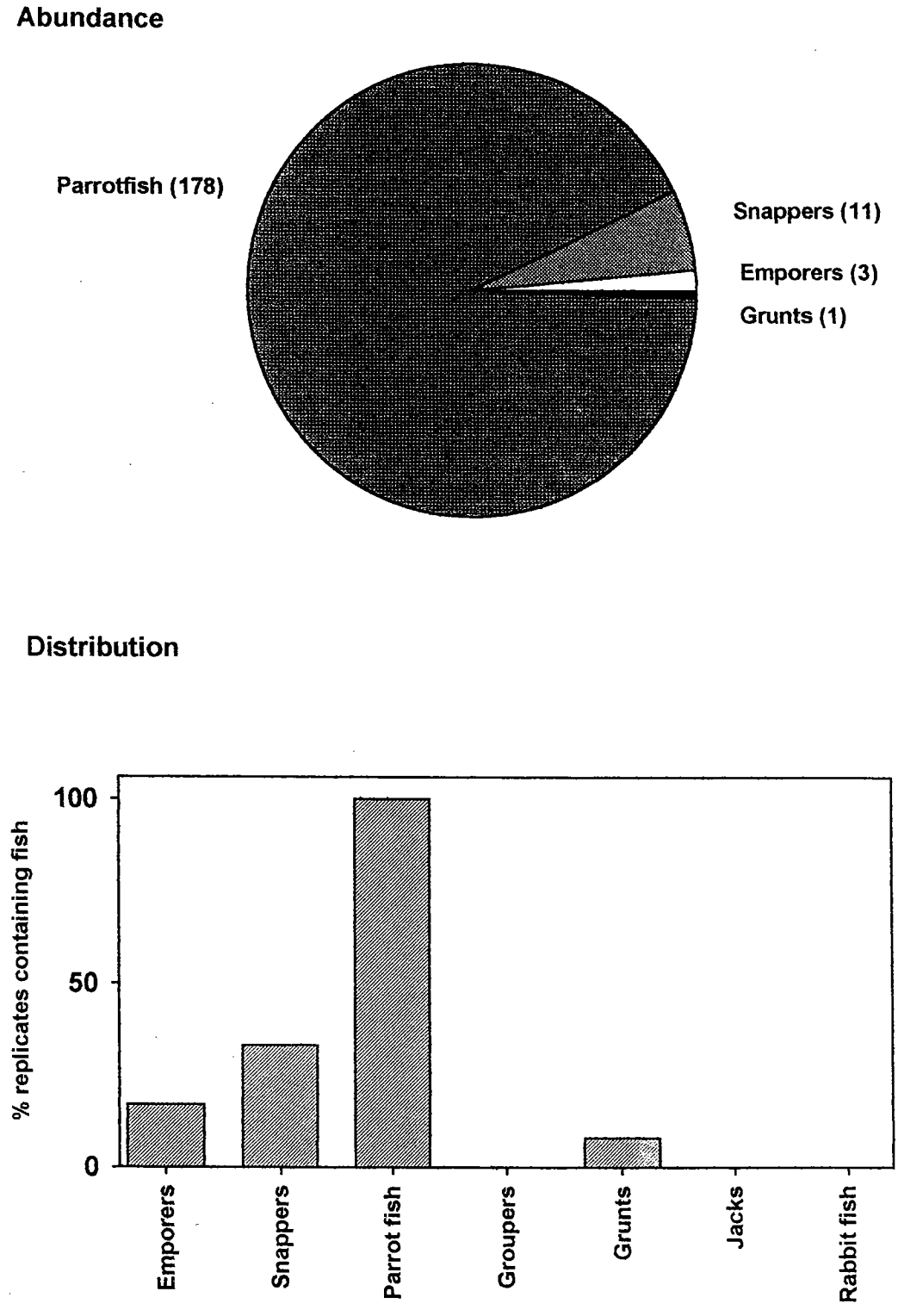


Figure 3.21 The abundance and distribution of commercial fish at site MC2 (outer).

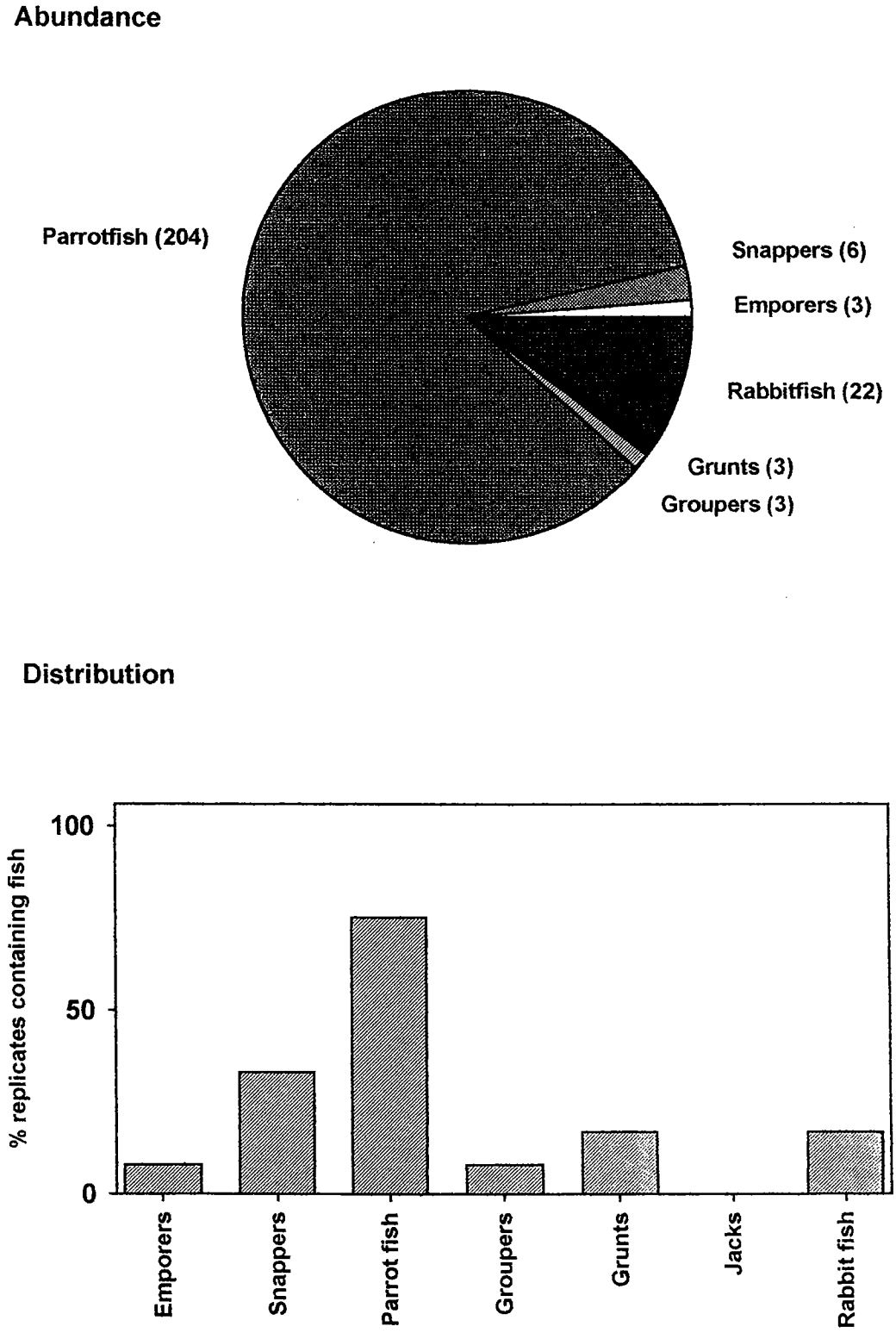
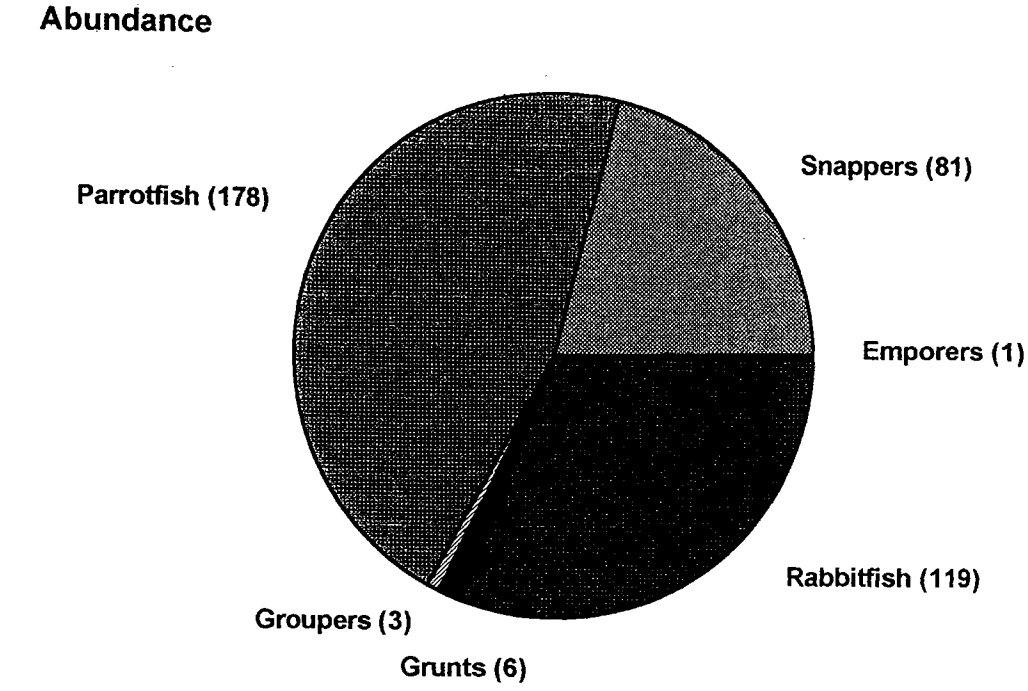


Figure 3.22 The abundance and distribution of commercial fish at site MC3 (inner).



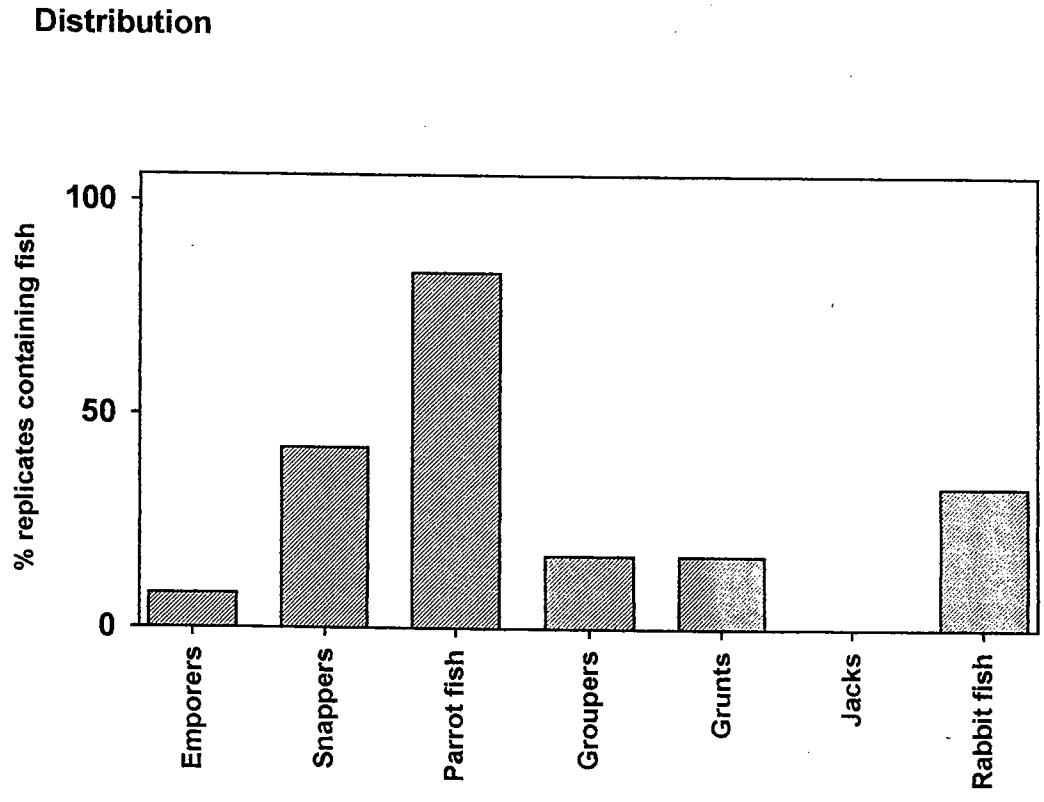


Figure 3.23 The abundance and distribution of commercial fish at site MC3 (outer).

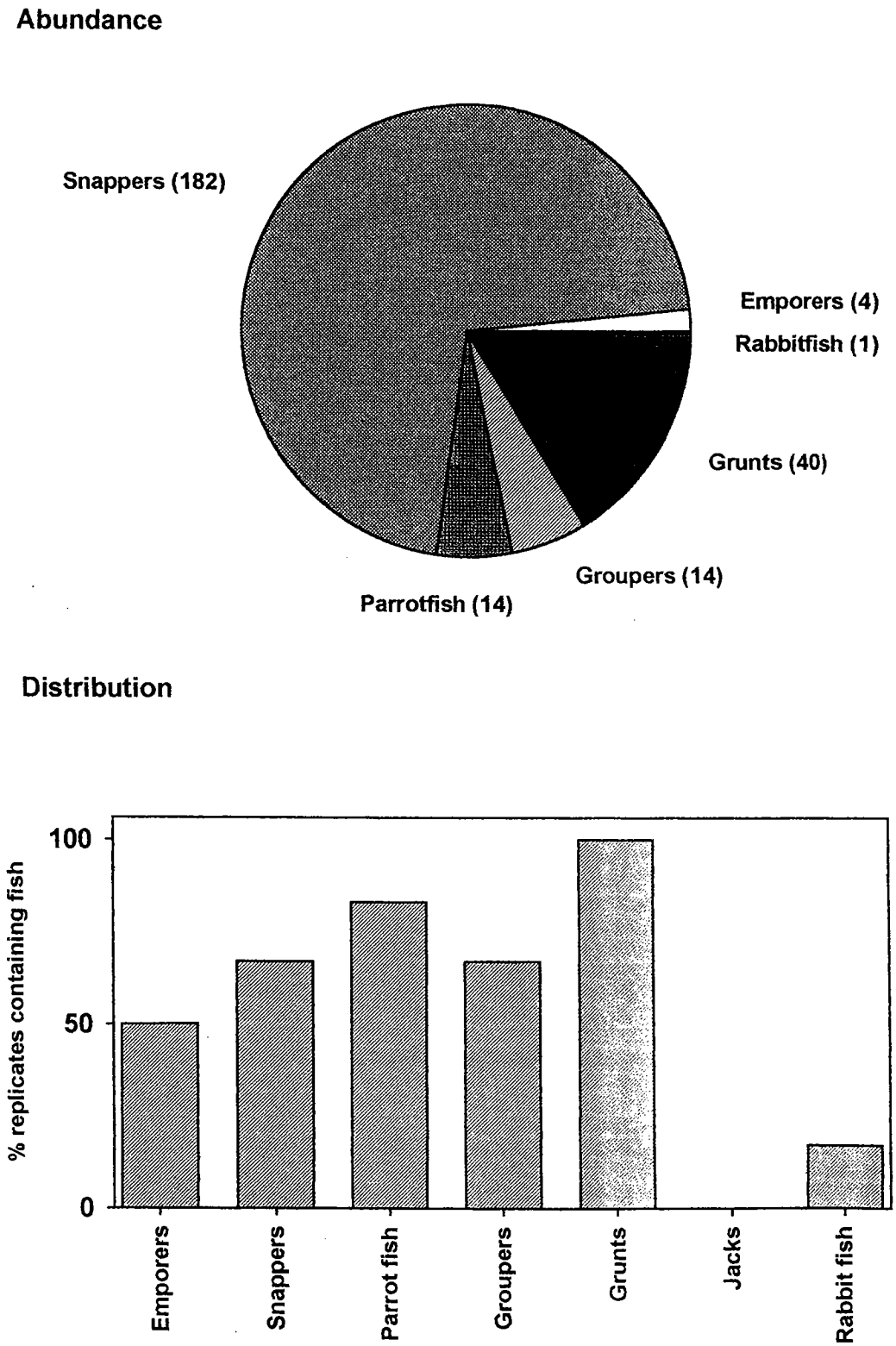


Figure 3.24 The abundance and distribution of commercial fish at site MC4.

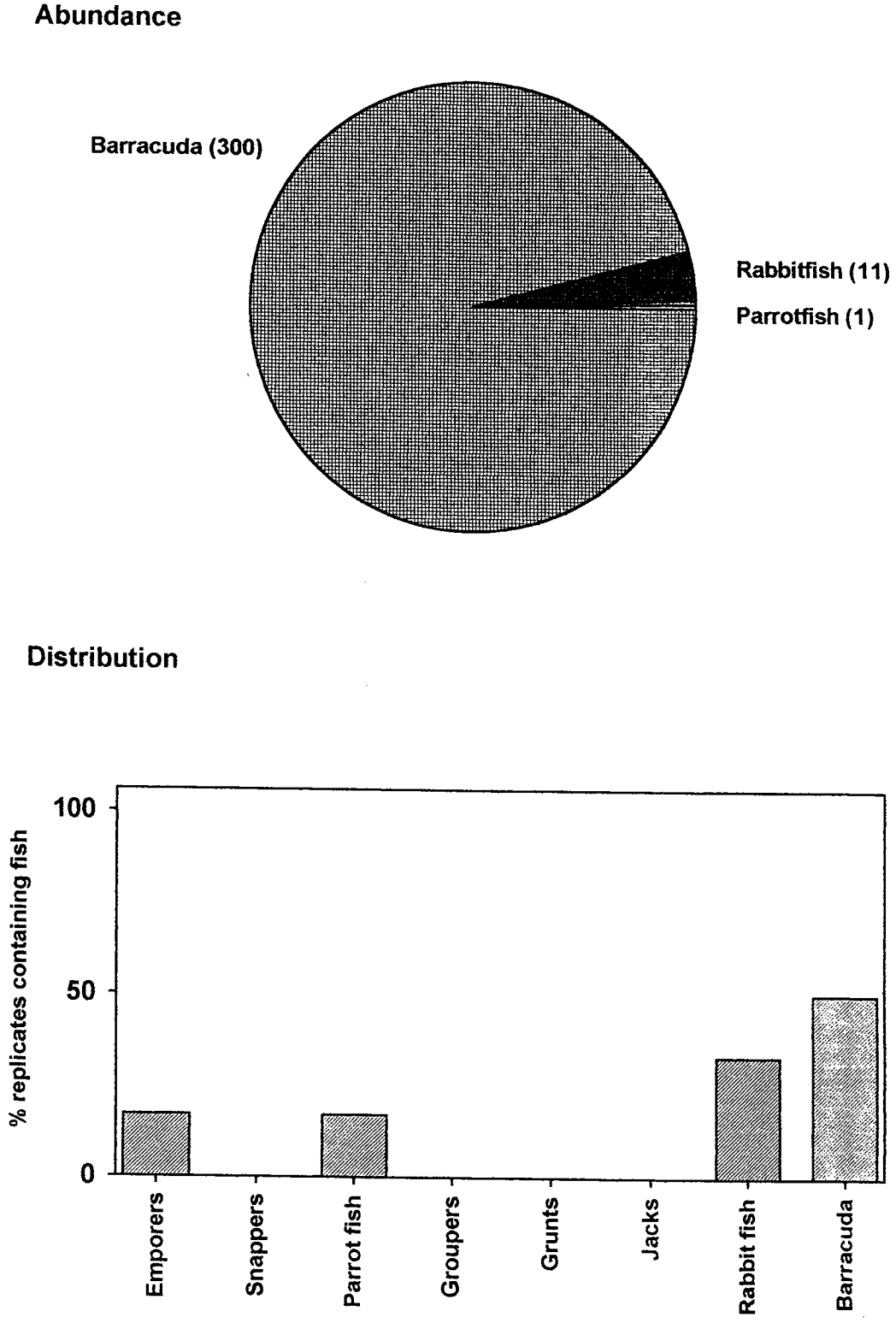
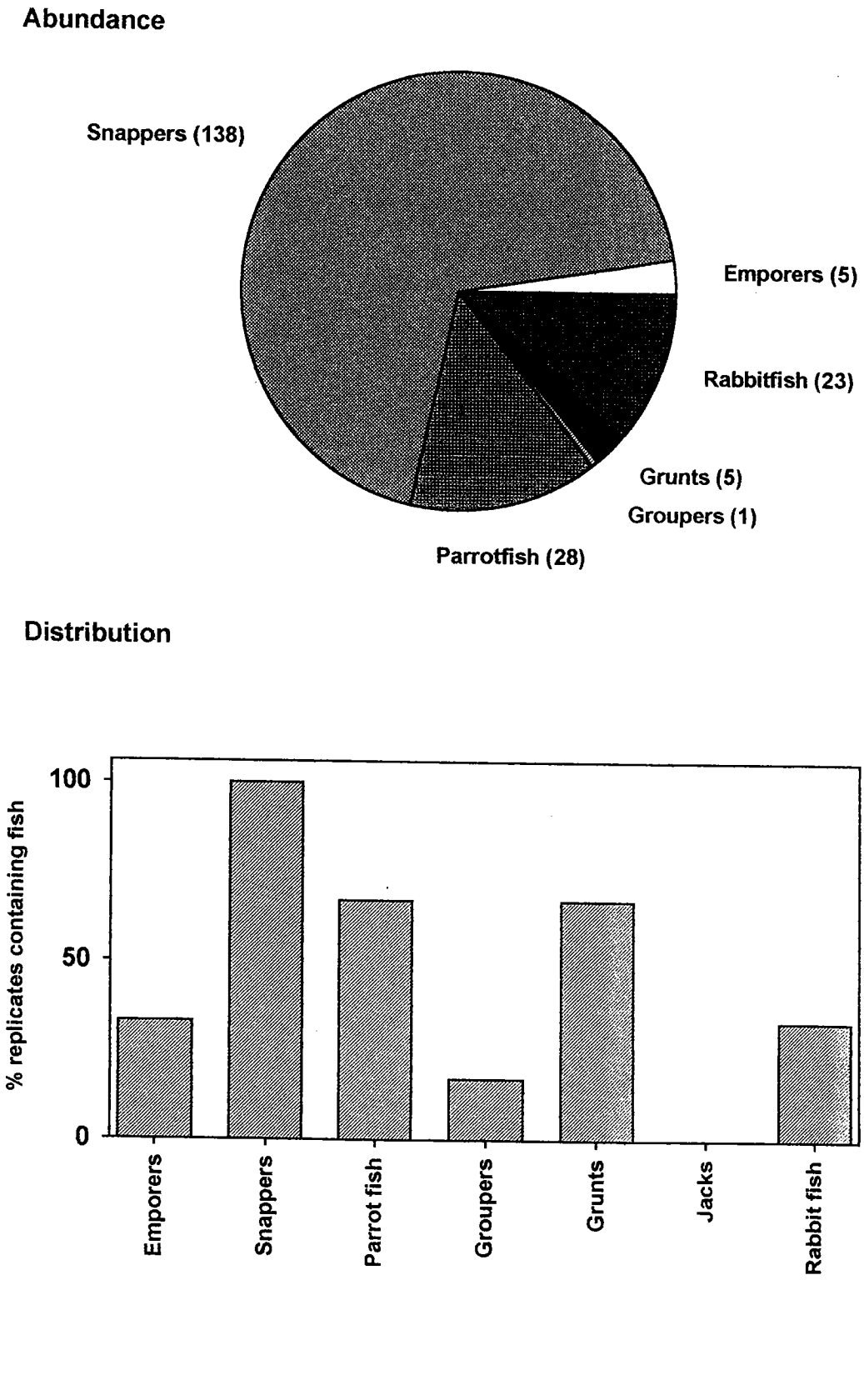


Figure 3.25 The abundance and distribution of commercial fish at site MC5.



3.7.3 Size distribution

Within the constraints of surveying a commercial fish population of mainly pelagic and fast moving fish, Macaloe island had a wide range of fish recorded, with a size range typical of the species observed. The south eastern sites at Macaloe, in particular, were characterised by an abundance of large commercial fish. Table 3.21 summarises the size distributions of fish seen at Macaloe island, pooled from the 5 sites of the survey.

Table 3.21 Size distribution summary for the commercial fish of Macaloe island.

'Commercial' Fish Family	Number	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae	20	25	20-60
Lutjanidae	464	25	20-90
Scaridae	799	20	10-70
Serranidae	51	30	15-70
Haemulidae	61	30	20-70
Carangidae	1	50	-
Siganidae	111	20	10-40

3.8 Finfish Fisheries

The island of Macaloe lies less than 3km from the village of Pangane on the mainland and has few permanent residents. A combination of a lack of drinking water, poor soil for cultivating crops and a high number of mosquitoes, has perhaps discouraged population growth. A single, permanently occupied house was situated on the southern tip of the island at the time of this study (November, 1997) and housed six people.

A number of concrete buildings are also located on the north-west of the island, close to an old Portuguese fort, but these have been disused for a number of years and once belonged to a commercial fishing operation. Freezers and generators in various states of repair are housed in some of these buildings and a guard is employed by the latest owner from Pemba to keep watch.

The number of fishermen visiting the island fluctuates greatly in the months leading up to the rainy season, which starts in December, and many temporary shelters were visible on the north, north-west and south-west of the island. The number of these shelters was greatest in the north-west (approximately 20), forming a small village on a site where the beach provided easy boat access and protection from high winds. The population of the island and fishing techniques used is summarised in Table 3.22.

Table 3.22 A summary of the estimated population and different fishing techniques used on Macaloe.

Macaloe Island	**Number**
Permanent population	6
Fishermen: resident	2
itinerant	80*
Fishing Method	
Line	30
Seine net	3
Trap: Large Marema	0
Trap: Marema	8
Trap: Suri	0
Luwando	0
Spear	35
Boats	
Sailing boats	4
Canoes	>40

* number present in November 1997 during survey.

The visiting groups of fishermen encountered appeared to come from as far as Nampula Province and Tanzania and included approximately 40 canoes and 4 sailing boats. Three of the sailing boats used surround nets and employed up to 10 people per boat, while a further boat involved 8 people for sea cucumber fishing. No SCUBA diving equipment was seen on this latter boat and it was presumed all collection was done by snorkelling. Most fishermen in canoes appeared to utilise a mixture of fishing techniques, including line, small gillnets, marema traps and spears. The least popular method of the four was marema trap fishing and the most popular was with spears.

Catches of sea cucumber were sold in Tanzania and market prices at that time ranged between 15,000 Mt. and 75,000Mt. /kg (dried). Most fish caught were dried and sold in Pangane, Arimba or Pemba, although some of the larger specimens were taken to the mainland (Pangane) for immediate sale. Larger specimens seen included unicornfishes (Acanthuridae) of at least two species (*Naso brachycentron and N. brevirostris)* and barracudas (Sphyraenidae). The majority of dried fish included the following species; Onespot snapper *Lutjanus monostigma,* Blackspotted sweetlips *Plectorhinchus gaterinus,* Oriental sweetlips *P. orientalis,* Goldspotted sweetlips *P. flavomaculatus,* Bigeye emperor *Monotaxis grandoculis,* Blackspot emperor *Lethrinus harak,* Pinkear emperor *L. lentjan,* Sidespot goatfish *Parupeneus pleurostigma,* and Dash-dot goatfish *P. barberinus,* plus many Serranidae (Groupers) and Acanthuridae (Surgeonfishes).

3.9 Resource Collection

3.9.1 Overview

The scale and patterns of intertidal collection on Macaloe were surveyed on 2 spring tides and 1 neap tides in November 1997. During the survey, a total of 55 people were observed collecting in the intertidal habitats. Along the sheltered western shore the intertidal area was relatively steep, with a substratum commonly consisting of sand and occasional coral rubble in some areas.

The eastern outer reef intertidal zone consisted of undulating nearshore rock, lagoon and reef crest. The lagoon was commonly up to 1.0m deep, with colonies of corals and micro-atolls. The substratum was a mixture of rock, sand and rubble. In some areas, the reef crest was composed of coral rubble on the upper part and flat rock below, with occasional pools averaging 1.0m in depth. These varied habitats supported a variety of resources which have been mainly exploited by itinerant collectors, since the island has fewer than 10 permanent residents.

3.9.2 Distribution of effort across intertidal zones

The distribution of intertidal habitats is illustrated in Figure 3.1 and the scale and patterns of collection are described below. The area where resources were targeted within the intertidal zone are illustrated in Fig. 3.26.

Scale and Intensity of Collection
A total of 55 people were observed collecting a variety of resources, giving an exploitation density of 3.5 people/km^2 for the entire intertidal flat.

Group Structure
A high proportion of people collected in groups, reflecting the high proportion of women collectors who traditionally prefer to work with their relatives or friends.

Origin of Collectors
The majority (80%) of intertidal collectors were women who had come by boat from the adjacent mainland village of Pangane. Each day on spring tides, boat loads of 20-40 people come across from the mainland specifically to collect on the intertidal. Three women were based on the island with their husbands who were fishermen.

Collection Methods
The intertidal resources were collected either by hand or by wood or iron rods. Collection by hand was undertaken for 'FO' (food) gastropods and sea cucumbers. Both wood and iron rods were used to catch octopi and to kill fish in the lagoon and at the edge of the subtidal zone.

Catch Composition

The main catch from the intertidal zone were octopi, notably *Octopus vulgaris* (60 specimens from 17 collectors in one spring tide). Fewer people collected 'FO' gastropods (18 specimens of *Fasciolaria trapezium* and 3 specimens of *Chicoreus ramosus*), holothuria (10 specimens), chitons (0.5 kg of *Acanthopleura* sp.) and a variety of reef fish. Although a huge amount of shells of *Strombus mutabilis* were observed on the beach of the northern fishing camp, this resource was not recorded in the catches during this survey. A single young female collected 6 small individuals of the Swimming crab *Portunus pelagicus*.

Distribution of Effort across Intertidal Zones

Most people (92%) collected in the lagoon/reef crest zone of both eastern and western shores. There was no collection noted on the nearshore rocks. On neap tides, two women concentrated their efforts on the western side of the island where they collected *Octopus vulgaris* and a single young female collected a couple of crab specimens.

3.9.3 Subtidal Collection

The 50 itinerant fishermen mainly collected fish and sea cucumbers using a range of techniques such as spearing, marema trapping, netting and snorkelling. Octopi and lobsters were also occasionally caught. During the survey period a boy brought 2 individuals of the lobster *Panulirus ornatus* to sell for 15,000 Mt.

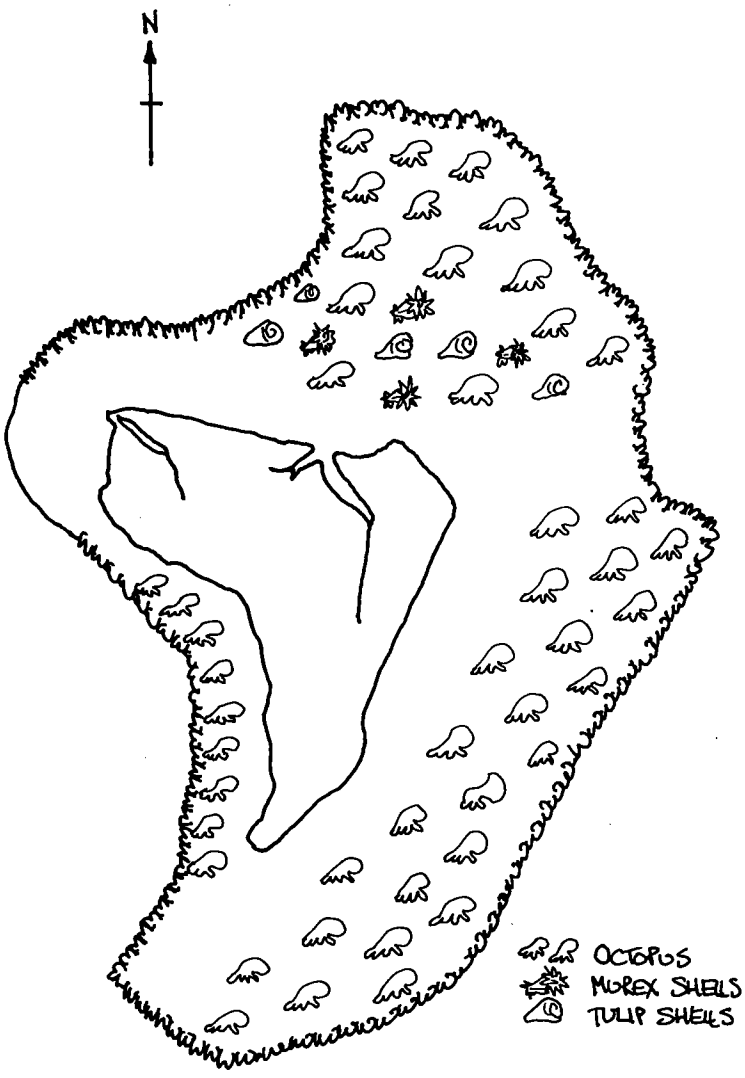
3.9.4 Discussion

The catch diversity on Macaloe was low, with only 2 species of 'FO' gastropods and no 'CT' (curio trade) gastropods were recorded within the catches.

Like Matemo, the island's resources have been open to people from the 2 major coastal towns of Pemba and Nacala. Additionally more collectors had come from other coastal areas such as Pangane and Mecúfi. At the time of surveying the number of visiting fishermen was 50 with an additional three women and 6 children. Most of the fishermen were on the island for several months but made frequent trips to the mainland for water.

The main target resource from the intertidal zone was octopus with opportunistic collection of 'FO' gastropods which appeared to be less abundant. The most collected resources of the subtidal zone were fish and sea cucumbers.

Figure 3.26 Location of intertidal target species, Macaloe.



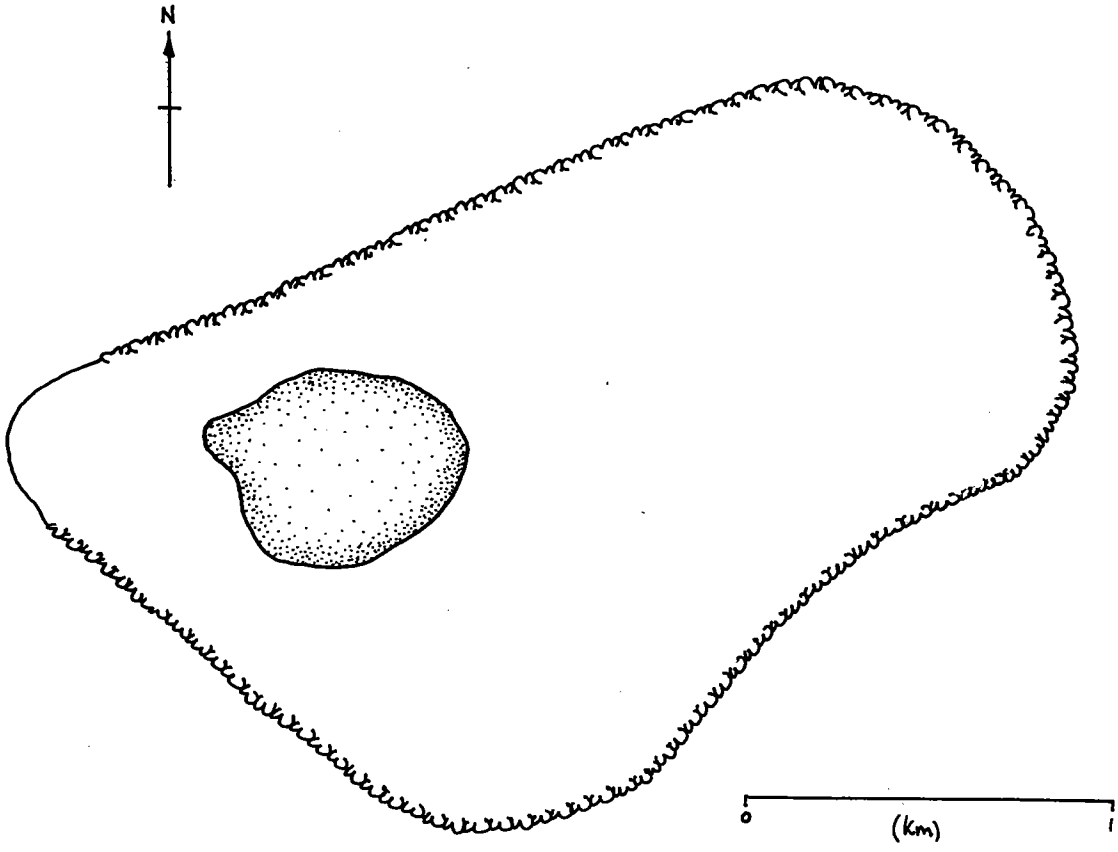
4.0 MOGUNDULA ISLAND

4.1 Introduction

Mogundula island (12°02'36"S 40°32'36"E) is a relatively small (0.5km by 0.7km), oval island approximately 1km south of Ponto Pangane and accessible by foot on low spring tides (Fig. 4.1). On the west side of the island is a small temporary settlement of around 15 people (November 1997) who are all involved with fishing based activities. There is no freshwater on the island. The island was historically a leper colony.

Towards the centre of the island is a shallow lagoon approximately 150m in diameter and fringed with mangrove. Behind the mangrove is a short area of scrub vegetation. To the east of the island stretches a long intertidal area which is notable for its well-developed lagoon and pronounced reef crest.

Figure 4.1 Mogundula Island



4.2 Intertidal Survey of Mogundula

4.2.1 Overview

Mogundula is a small island with an estimated intertidal flat of 1.1km^2, most of which occurred on the eastern side of the island. In contrast to the neighbouring island of Macaloe, which had less developed macroalgae assemblages, on Mogundula the narrow intertidal contained relatively well developed macroalgae beds. As with all the islands of the N.I.G., seagrass beds were not conspicuous and the island generally lacked the soft substratum which is required for seagrass beds to establish.

One seagrass species, 66 species of macroalgae and 28 of invertebrates were recorded. The macroalgal flora included Cyanophyta (1 species), Chlorophyta (21 species), Phaeophyta (14 species) and Rhodophyta (30 species). The diversity of 66 species matched that recorded for Macaloe. A checklist of seagrasses and macroalgae is presented in Appendix A2.

4.2.2 Area Reports

'East Area'

A single intertidal transect was surveyed, on the north east of the island (Fig. 4.2). The proportions of substratum types are summarised in Table 4.1. Along this transect 7 zones were identified within which a total of 12 species of macroalgae (Table 4.2) and 12 invertebrate species (Table 4.3) were recorded. A cross-section profile of the transect is presented in Figure 4.3.

Table 4.1 Percentage cover of substratum along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3	Zone 7
Sand	5 (0-50)	100 (0-100)	0
Broken Shell	0	0	0 (0-8)
Rubble	5 (0-50)	0	55 (0-100)
Rock	90 (0-100)	2(0-24)	40 (0-100)

The intertidal area of Mogundula is typically narrow, however, the 'east area' intertidal zone extended approximately 900m from the cliff. Seven zones were identified on the basis of community structure and topography. Zone 1 was a bare sand beach backed by cliff. Zone 2 was a macroalgae dominated lagoon with *Cladophora mauritiana*, *Gelidiella* spp. and *Laurencia papillosa* the most abundant species. The most common invertebrate was *Cypraea annulus*. Although *Holothuria* spp. were noted as being abundant in the lagoon they were not recorded within the survey quadrats. Zone 3 was predominantly sand flat without conspicuous vegetation. Two species of invertebrates - *Turbo coronatus* and *Nerita albicilla* were recorded

within this zone. Active burrows containing small crabs were also noted. Zone 4 consisted of elevated bare flat rock.

Zone 5 was a small island made of coral rubble in the centre of which was a lagoon containing mud substratum with small mangrove trees. Zone 6 consisted of exposed, undulating rock on which no biota were seen. Zone 7 comprised a reef crest of coral rubble that was generally devoid of macroalgae. A variety of invertebrates were also observed in this zone. The flatter areas of the reef crest were characterised by very low macroalgal and invertebrate diversity and abundance.

Table 4.2 Percentage cover of macroalgae along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3	Zone 7
Macroalgae			
Acrocistis nana	0	0	0(0-8)
Cladophora mauritiana	8 (0-20)	0	0
Coralline algae	0 (0-2)	0	0
Dictyosphaeria cavernosa	1 (0-10)	0	0
Gelidiella acerosa	(0-P)	0	0
Gelidiella sp.	6 (0-30)	0	0
Laurencia columellaris	0 (0-4)	0	0
L. papillosa	5 (0-40)	0	0
Lyngbya majuscula	3 (0-10)	0	5 (0-60)
Ulva pertusa	3 (0-10)	0	(0-P)
U. pulchra	1 (0-10)	0	0
Valonia fastigiata	0 (0-8)	0	0

Table 4.3 Abundance (individuals/m^2, n=10) of invertebrate taxa along a typical transect within the 'East Area'.

Taxonomic Group	Zone 2	Zone 3	Zone 7
Gastropods			
Conus ebraeus	0	0	0 (0-1)
Cypraea annulus	1 (0-3)	0	1 (0-3)
Cypraea sp.	0 (0-1)	0	0
Marginella sp.	0	0	0 (0-1)
Morula granulata	0	0	0 (0-2)
Nerita albicilla	0	4 (0-11)	5 (0-17)
Patella sp.	0	0	1 (0-4)
Rhinoclavis sinensis	0	0	0 (0-2)
Strombus mutabilis	0 (0-1)	0	0
Thais sp.	0 (0-2)	0	5 (0-13)
Turbo coronatus	0	0 (0-1)	0
Echinoderms			
Holothuria spp.	0	(0-2)	10 (0-19)

Figure 4.2 Location of intertidal transect, Mogundula.

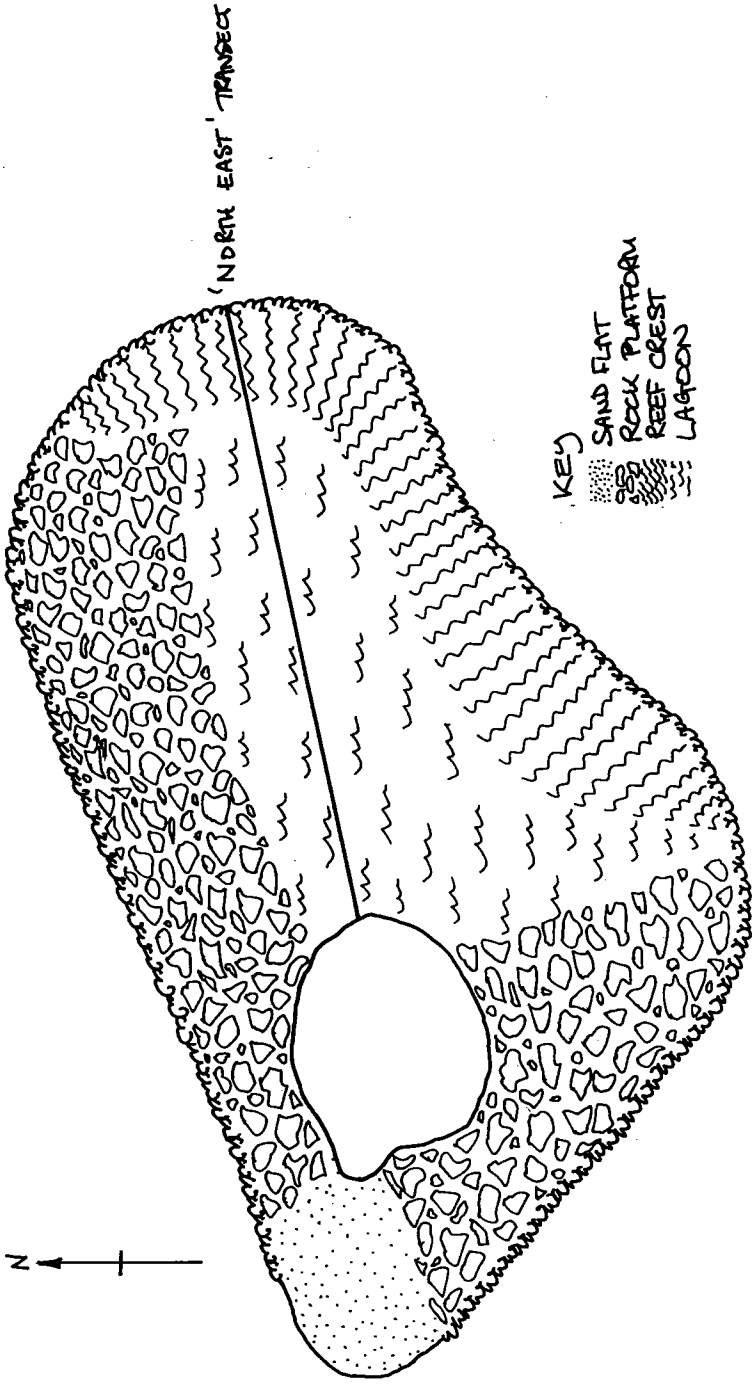
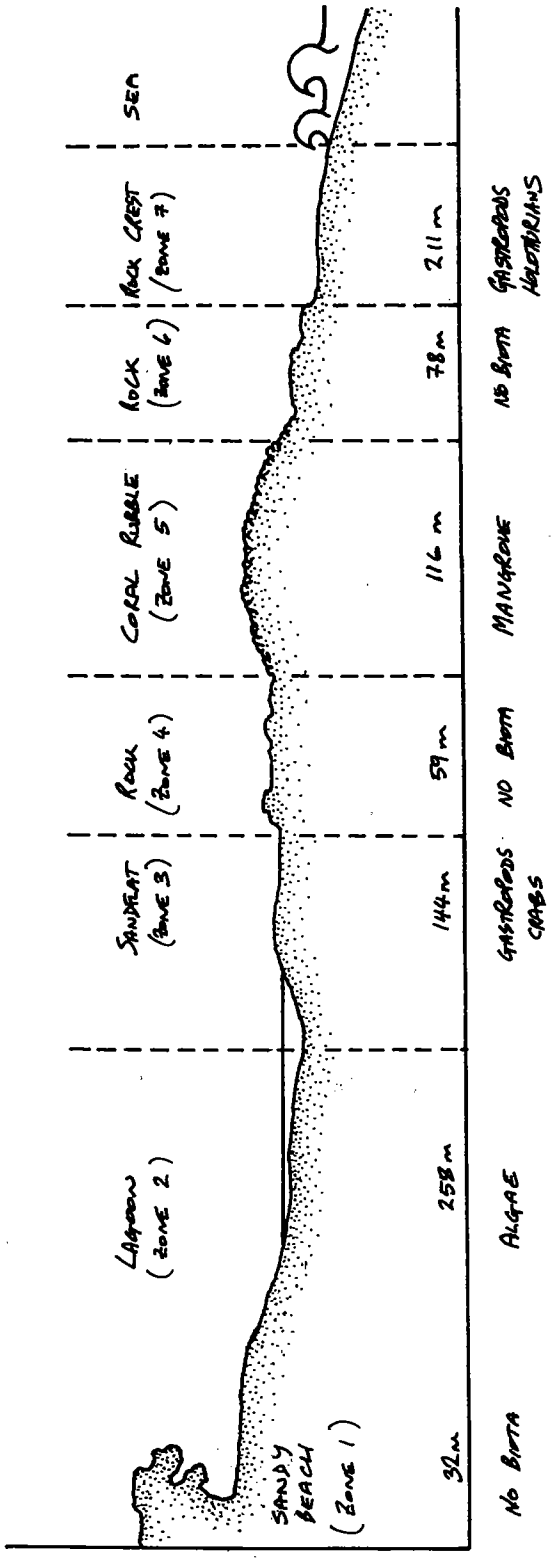


Figure 4.3 Cross section of 'North East' intertidal transect, Mogundula.



4.3 Mangrove Survey of Mogundula

4.3.1 Overview

The mangrove on Mogundula is situated around the edge of the island's lagoon where it forms a relatively narrow border (7-20m wide). Water exchange between the open sea and the lagoon is limited, with no discernible drainage channel. Consequently, a large amount of leaf litter has accumulated in the lagoon forming a thick layer of anoxic mud. Widespread cutting of the larger *Ceriops tagal* trees was evident.

4.3.2 Transect Reports

There was no observed zonation of mangrove tree species within the stand and consequently, the stand can be regarded as a single unit. The stand formed a continuous ring around the edge of the lagoon; being widest (approximately 20m wide) towards the south-western section and narrowest (approximately 7m wide) close to the temporary settlement on the west of the island.

The mangrove was dominated by *Ceriops tagal* and *Rhizophora mucronata*, both species commonly forming dense areas of saplings. *Avicennia marina* was observed along the outer edge of the stand but was not widespread and no specimens fell within the survey quadrats. In the centre of the stand, the canopy height of mature trees was between 12m and 16m. Cutting of *C. tagal* was widespread and was probably an important resource for the islanders.

Quantitative Description

The species composition and structure for the stand is presented in Table 4.4. Both *R. mucronata* and *C. tagal* occurred in similar numbers. The marked differences in basal area values between the two species reflects the greater abundance of mature *R. mucronata* and the large numbers of young *C. tagal* trees. This may well be the result of cutting activity which favours the removal of the larger *C. tagal*.

Table 4.4 Mangrove species composition and structure of the Mogundula stand. Mean values and 95% confidence limits are given (n=3).

Zone	Species	No. of trees/m^2	Relative density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2*
Stand	*R. mucronata*	0.32±0.04	54	69.9±77.6	97	5-10
	C. tagal	0.27±0.33	46	1.9±3.7	3	2-10

* The very high density of saplings found in the quadrats meant that an estimation of numbers rather than an exact count was made.

The stand of mangrove found on Mogundula island is small enough that it cannot be considered a major resource for future harvesting. Whilst the numbers of *R. mucronata* and *C. tagal* remaining are similar, the estimates of mean stand diameter

and total basal area (Table 4.5) indicate that the few of the larger *C. tagal*, the species favoured for building material and firewood, remain.

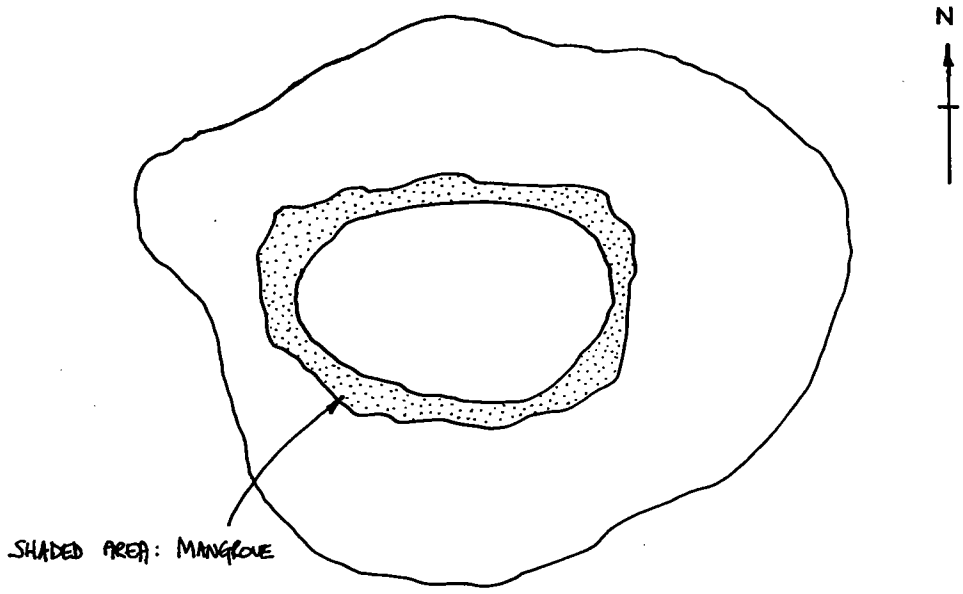
Table 4.5 Estimates for the size and composition of the complete stand. All original figures have been estimated to the nearest 100 and all basal area values have been estimated to the nearest $10m^2$. 'n/a' denotes present in stand but not recorded within survey quadrats. Mean values and 95% confidence limits are given (n=3).

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	4200±600	16.6	90±100
C. tagal	3500±4500	3.1	3±6
A. marina	n/a	n/a	n/a

4.3.3 Fauna of the Mogundula mangrove

Little fauna was observed associated with the mangrove. A few crabs (unidentified spp.) were noted along the northern outer edge of the stand. The anoxic leaf litter and limited water exchange is probably a limiting factor in the faunal colonisation of the stand. A large colony of Weaver birds (*Ploceus* sp.) were resident on the outside of the stand south of the village.

Figure 4.4 Location of Mogundula mangroves.



4.4 Subtidal Habitat Surveys

Subtidal surveys were undertaken at two sites around the island, MD1 and MD2, located to the south-west and south-east of the island respectively (Fig. 4.4). Further observations were made of northern, eastern and western areas, although no specific sites were chosen. Due to the shallow waters around the island all subtidal habitat surveys were undertaken by snorkelling.

4.4.1 Overview

Reef Structure and Composition
The more exposed eastern and southern sides of the island exhibited gently sloping shallow 'spur and groove' zones, descending into rubble and sand. North and south-western areas were predominantly of sand with small bommie fields close to the edge of the intertidal, while undulating expanses of sand were indicative of all areas beyond these bommies, as well as in all areas west of the island towards the mainland.

Substratum compositions varied between sites MD1 and MD2. Site MD1 consisted predominantly of sand and rubble with low rugosity and a scattering of large coral bommies. MD2 was a combination of rock and rubble with rugosity between 3 and 4.

Hard corals were the dominant biota on site MD2 while hard and soft corals were seen in equal proportions on site MD1. Seagrasses were absent from MD1, although observations of the shallow area between the mainland and island indicated numerous dense patches. Macroalgae was present in only low densities on site MD2. *Halimeda* spp. was not observed around the island. Reef areas had a mix of low lying coral forms. Bommies on site MD1 were predominantly of 'big massive' form while site MD2 contained 'staghorn', 'fire' and 'foliose' forms. Many 'table' corals were also noted at this second site.

4.4.2 Site Reports

Site MD1:
The reef structure and community composition are described below and summarised in Table 4.6.

Reef structure
Reef structures in this area were predominantly small and large bommies (often up to 5m in diameter). Finger-like projections of reef also extended into the sandy substratum away from the island and reef crest. These projections could be described as the remnants of a 'spur and groove' zone.

Substratum Composition
The substratum was mainly of sand (up to 100%) with rubble patches. Rock/bommie outcrops and reef structures, as described above, interrupted this cover, although never more than 25% within each survey replicate.

Biotic cover

The abundance of hard and soft coral was similar but generally low in all areas, covering 0-50% of the reef surface along the survey transect (at a depth of 5m). Away from the island and greater than 5m depth the substratum was of sand with little biotic cover. 'Big massive' and 'branching' forms of coral achieved dominance on the rocky areas. Macroalgae and *Halimeda* spp. were not found.

Table 4.6 A summary of the structure, composition and biotic cover at MD1 (P<1 % cover).

Reef Features		Upper Reef (n=6) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	10	0-20
	Rugosity	2	0-3
Substratum	Rock	3	0-2
	Rubble	2	0-3
	Sand/Shell	1	2-6
	Mud	0	0
Biota	Hard Coral	2	0-2
	Soft Coral	1	0-2
	Seagrass	0	0
	Macroalgae	P	0
	Halimeda spp.	0	0
Coral State	Heterogeneity	0	0
	Dominance	Branching/Big massive	

Site MD2:

The reef structure and community composition are described below and summarised in Table 4.7.

Reef Structure

A low lying reef extended along a shallow slope down to a depth of 10m. A shallow 'spur and groove' zone was evident perpendicular to the shore with 'grooves' approximately 5m apart.

Substratum Composition

All areas were predominantly of rock and rubble with sand filling the 'grooves'. Beyond a depth of 10m the substratum was dominated by sand.

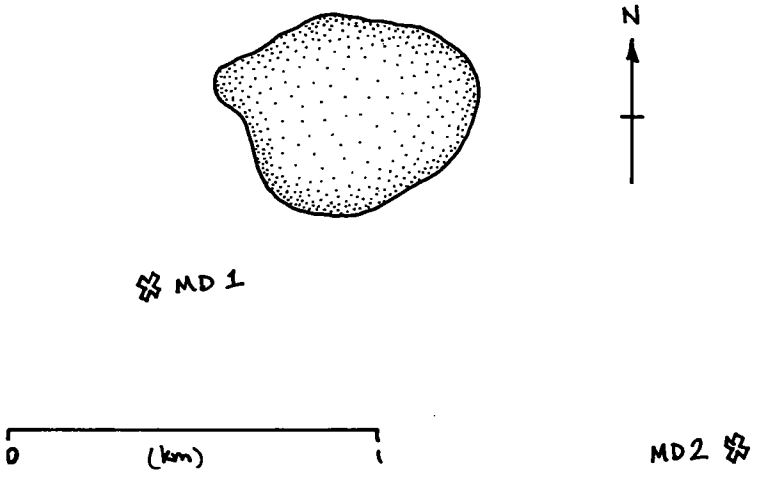
Biotic Cover

Hard corals were dominant in all survey replicates, although soft corals were always present in low abundance. Macroalgae and *Halimeda* spp. were both present in small quantities.

Table 4.7 A summary of the structure, composition and biotic cover at MD1 (P<1 % cover).

Reef Features		Upper Reef (n=6) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	3	3-4
Substratum	Rock	3	3-4
	Rubble	2	2-3
	Sand/Shell	2	1-2
	Mud	0	0-P
Biota	Hard Coral	3	3-4
	Soft Coral	1	P-1
	Seagrass	0	0-P
	Macroalgae	1	P-1
	Halimeda spp.	0	0
Coral State	Heterogeneity	0	0
	Dominance	Branching	

Figure 4.5 Subtidal habitat sites, Mogundula.



4.5 Subtidal Invertebrate and Impact Surveys

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 4.5).

4.5.1 Overview

Few invertebrates were found on the survey sites. Triton, Murex and Tulip shells were rare and although clams were recorded, many piles of empty shells were seen, indicating heavy fishing pressure. The only other evidence of human impact was a single fish trap (Marema). Incidences of freshly dead coral and sedimented 'massive' coral were seen occasionally.

4.5.2 Site Reports

Site MD1:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 4.8.

Macrosponges and sea cucumbers were the only invertebrates to be recorded, and neither of these were abundant. Fresh dead coral and sedimented 'massive' forms of coral were the only types of degradation seen, while evidence of human impact was a single new fish trap. The absence of Triton, Murex and Tulip shells, as well as clams, should be noted.

Table 4.8 Invertebrates and Natural/Human Impacts at Site MD1 (values are for 5 minutes of survey).

		Inner Reef (n=6)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		2	0-7
Sea Cucumbers	Others	0	0-1
Dead Corals	Unknown	1.5	0-4
Sed. Massive		0	0-2
Human Effects	New fish traps	0	0-1

Site MD2:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 4.9.

There were few invertebrates at this site. Empty clam shells were frequently found in large piles (10-20 whole shells), indicating intense fishing pressure.

Table 4.9 Invertebrates and Natural/Human Impacts at Site MD2 (values are for 5 minutes of survey).

		Inner Reef (n=6)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		2	1-6
Bivalves	Giant Clams	0	0-2
Urchins		1	0-5
Sea Cucumbers	Others	0	0-1

4.6 Reef fish census

4.6.1 Overview

Mogundula island was small, and close to the mainland peninsular of Pangane. A reconnaissance of the island showed that coral rubble surrounded the north and east of the island, with coral bommies to the west and a coral garden slope to the south. Both sites surveyed were rich in reef fish, in particular on the southern coral garden. A summary of the species richness and diversity at Mogundula is presented in Table 4.10.

Table 4.10 The number of 5 minute replicates, total species count, relative species richness indices (RSRi) and Shannon Weaver diversity indices (SWi) calculated from the Mogundula reef fish assemblage.

Site	Reps	Spp	RSRi	SWi
MD1	18	18	0.25	2.57
MD2	18	25	0.34	2.71

4.6.2 Site reports

Site MD1:
This site was a bommie field to the west of the island, just south of the sandy spit that extends from the Mogundula settlement. The scattered bommies were extensive and some quite large, with most reef fish associated with them. Eighteen species of fish were recorded. Most of these were butterflyfish, of which 7 species were seen; notably the Theadfin butterflyfish *Chaetodon auriga* and the Racoon butterflyfish *Chaetodon lunula*. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 4.5.

Site MD2:
This site was a sloping coral garden with an abundant and species-rich reef fish assemblage. A total of 563 fish were seen, from 25 species, including 10 species of surgeonfish. Surgeons were also numerically dominant, in contrast to the butterflyfish dominance of site MD1. In particular, the Twospot bristletooth *Ctenochaetus binotatus* and the Brown tang *Zebrosoma scopas* were numerous. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 4.6.

Figure 4.6 The abundance and species richness of reef fish at site MD1.

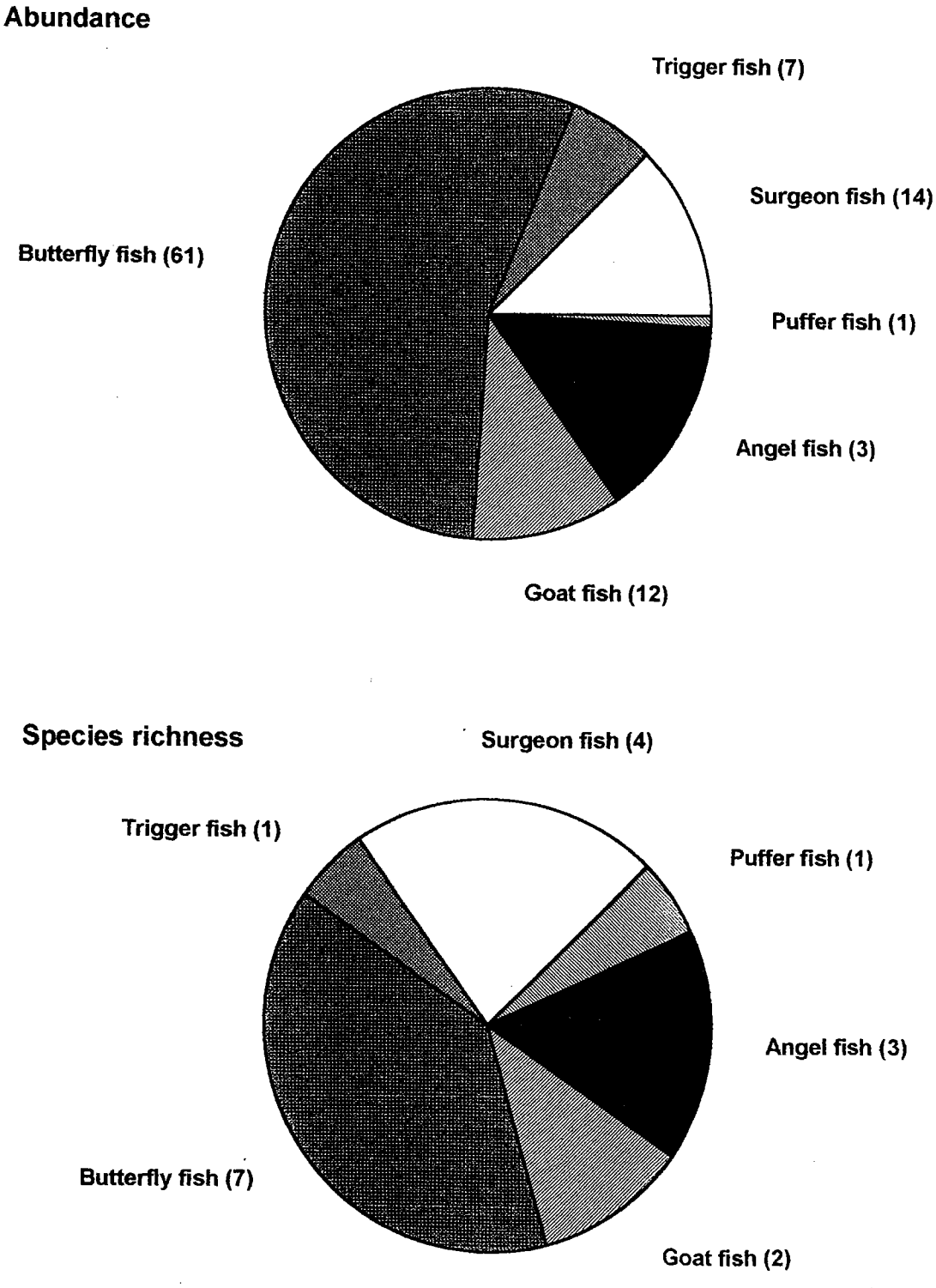
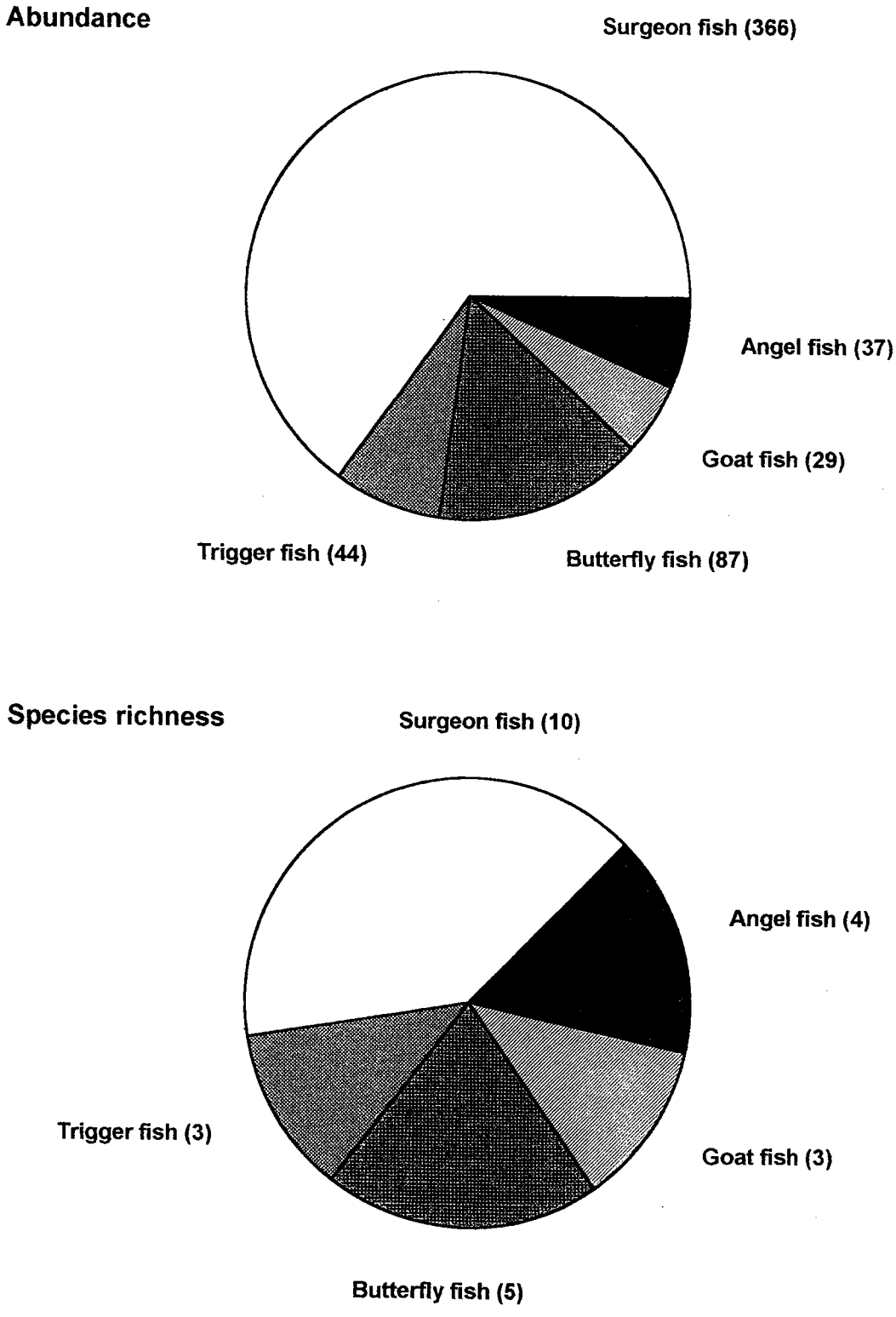


Figure 4.7 The abundance and species richness of reef fish at site MD2.



4.7 Commercial fish census

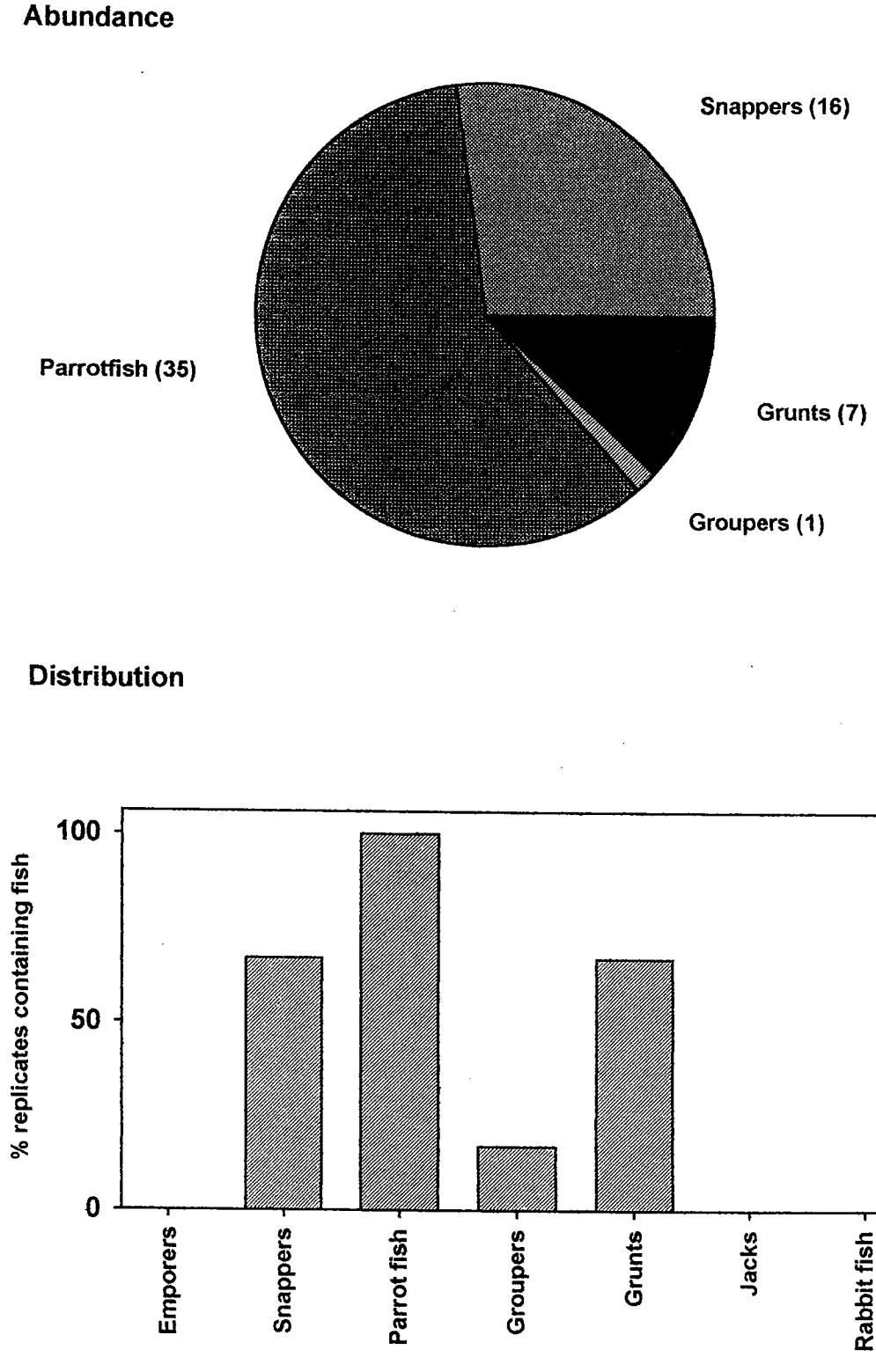
4.7.1 Overview

Mogundula is a small island, and only one site was surveyed for commercial fish. The assemblage recorded was typical of the islands in the N.I.G.

4.7.2 Site reports

Site MD2:
This was a coral garden, on which 59 fish were seen, from 5 species. Most were the Bluebarred parrotfish *Scarus ghobban* and the Onespot snapper *Lutjanus monostigma.* The abundance and distribution of commercial fish at this site have been presented graphically in Fig. 4.7.

Figure. 4.8 The abundance and distribution of commercial fish at site MD2.



4.7.3 Size distribution

A summary of the size distribution of the fish observed at Mogundula island is presented in Table 4.11. As only one site was surveyed, little inference can be made, except the sizes seem typical of the N.I.G., if a little small.

Table 4.11 Size distribution summary for the commercial fish of Mogundula island.

'Commercial' Fish Family	Number	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae	0	-	-
Lutjanidae	16	30	25-30
Scaridae	35	30	25-30
Serranidae	1	25	-
Haemulidae	7	25	20-30
Carangidae	0	-	-
Siganidae	0	-	-

4.8 Finfish Fisheries

Mogundula had no permanent population and was solely a base for a few itinerant fishermen from the mainland. No fresh water was available, although the island was situated close to the mainland and the village of Pangane (<2km). One small fishing camp of five shelters was observed on the west of the island, where a sand spit provided an excellent landing site for boats. The number of fishermen using different techniques is summarised in Table 4.12.

Table 4.12 A summary of the estimated population and different fishing techniques used on Mogundula.

Mogundula Island	Number
Permanent population	0
Fishermen: resident	0
itinerant	10*
Fishing Method	
Line	8
Seine net	0
Trap: Large Marema	0
Trap: Marema	6
Trap: Suri	0
Luwando	0
Spear	8
Boats	
Sailing boats	0
Canoes	8

* number present in November 1997 during survey.

Spear and line fishing were the most popular fishing methods at the camp, although some marema traps were seen. Emperors (Lutjanidae), grunts and sweetlips (Haemulidae), groupers (Serranidae), surgeonfish (Acanthuridae) and barracudas (Sphyraenidae) were commonly caught. Catches were relatively small of perhaps 6 kg of fish per canoe per day. Most fish was dried and sold on the mainland. Sea cucumbers were also taken when found and sold on to local processors in Pangane.

4.9 Resource Collection

4.9.1 Overview

The main intertidal habitats are shown in Fig. 4.2. The scale and patterns of resource collection described below are based on surveys undertaken on 2 mid-neap tides in November 1997.

Scale and Intensity of collection

A total of 14 people were observed collecting on the intertidal, giving an exploitation density of 12.7 people/km^2 for the entire intertidal area. The most heavily exploited area was the north-eastern side of the island where the intertidal area sloped gently and included habitats such as nearshore rock, lagoon and reef crest.

Gender of collectors
All collectors were adult males and neither women nor children were observed on the island.

Group Structure
The collectors worked alone, which is typical of adult males throughout the N.I.G..

Origin of Collectors
The island had no permanent residents and all collectors had come from the adjacent mainland, notably Mucojo. During the survey there were 2 temporary fishing camps established with a total of 15 fishermen.

Collection Methods
The intertidal resources were mostly collected by hand, reflecting the targeting of effort towards the collection of holothuria. Some people had wood and iron rods for the opportunistic capture of octopus and fish.

Catch Composition
The catch in the intertidal was predominantly composed of small individuals of *Holothuria* spp. (estimated 130 specimens from 2 collectors in single neap tide); one collector took a single *Octopus vulgaris* while searching for sea cucumbers. The majority of itinerant fishermen based in the island were interested in the finfish fishery.

4.9.2 Distribution of Effort across Intertidal Zones

The most intensively exploited area of intertidal zone on Mogundula was the north-eastern area, especially in the lagoon and adjacent reef crest. Since the intertidal flat is narrow the collectors move constantly between lagoon and reef crest. The areas where resources were targeted within the intertidal zone are illustrated in Fig. 4.8.

4.9.3 Subtidal Collection

The itinerant fishermen declared that they were interested in the finfish fishery and the collection of sea cucumbers. No subtidal collection of molluscs or crustaceans was observed.

4.9.4 Discussion

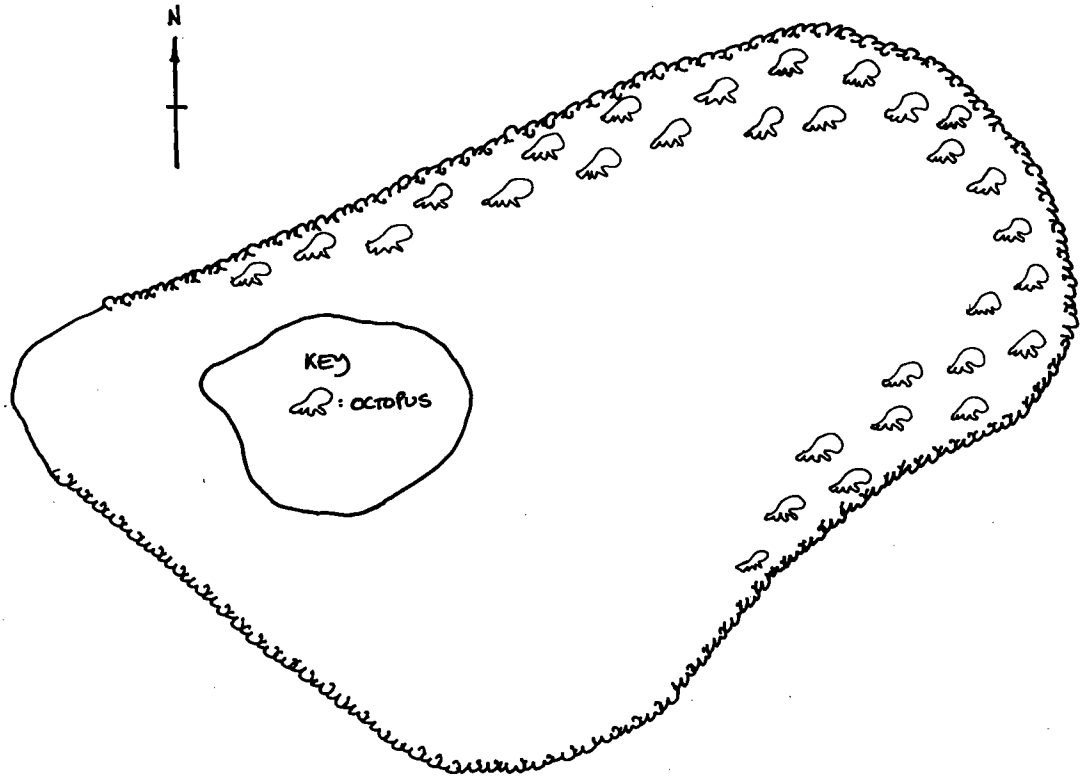
The diversity of the catch in Mogundula was very low, with only 3 species - 1 of octopus and 2 of holothuria. Neither 'FO' (food) gastropods nor 'CT' (curio trade) gastropods were recorded. This low catch diversity could be a reflection of limited availability of other species due to a scarcity of suitable habitats for their occurrence, such as well developed lagoon and reef crest zones.

The sea cucumbers appeared to be intensively exploited and prone to depletion, as the catches were predominantly composed of small individuals.

As at Rolas, Mogundula's resources have been exploited by people from Mucojo, who set up camp for several weeks in the dry season (May to November) or arrive on the island on a daily basis during spring tides. Mogundula, together with Rolas Island, was an important site for the finfish fishery for the adjacent mainland village of Mucojo. Clearly the resources of these islands play an important role providing livelihood and income for people living in Mucojo.

As the intertidal zone is narrow the collection pressure was localised in the north-eastern area, where the intertidal flat sloped gently and supported habitats such as lagoon and reef crest which tend to be rich in resources.

Figure 4.9 Target areas for intertidal resources, Mogundula.

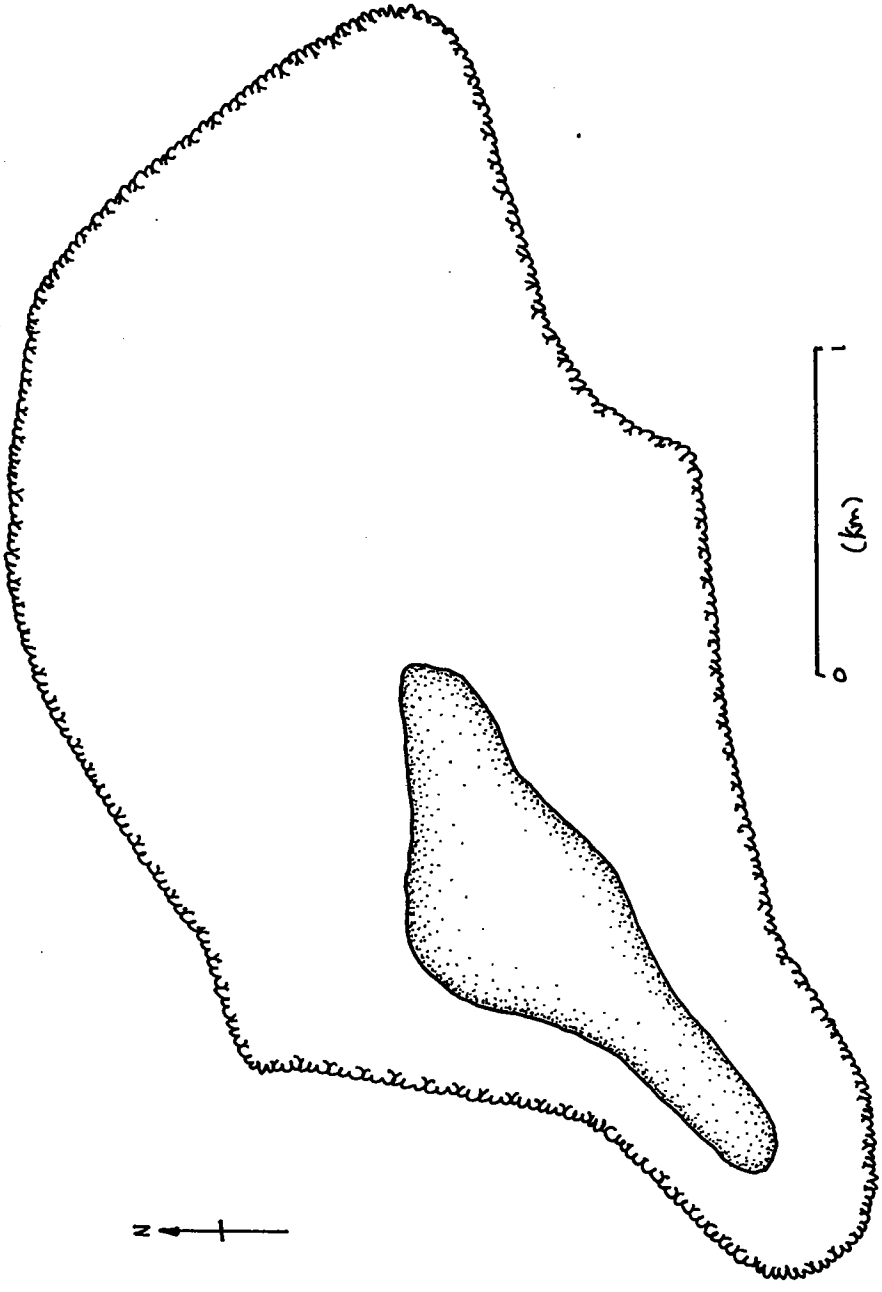


5.0 ROLAS ISLAND

5.1 Introduction

Rolas island (12°08'48"S 40°33'42"E) is relatively small (1.0km by 0.5km) and situated close to the northern point of Matemo island to the south (Fig. 5.1). The island supports no permanent population but is regularly used by fishermen as a temporary base and basic shelters were constructed along the beach on the western side of the island. The vegetation is sparse, being generally a mixture of low-lying scrub and grass land with a few Casuarina trees along the southern shoreline. In the centre of the island, large holes in the coral rag form water-filled grottoes. There is no freshwater on the island.

Figure 5.1 Location of Rolas Island



5.2 Intertidal Surveys

5.2.1 Overview

The intertidal flat of an estimated area of 1.5 km^2 can be characterised by the predominance of macroalgal assemblages and a virtual absence of seagrass beds. The intertidal zone is typically narrow and slopes abruptly to less than 200m from the cliff. Only in the north eastern area are there relatively large, flat expanses.

A total of 71 species of macroalgae: Cyanophyta (1 species), Chlorophyta, (20 species) Phaeophyta (15 species) and Rhodophyta (35 species), and 18 species of invertebrates were recorded. A checklist of seagrass and macroalgae for the N.I.G. is presented in Appendix A2. Around Rolas the macroalgal flora was dominated by Rhodophyta.

5.2.2 Area Reports

A total of 2 transects were surveyed (Figure 5.2): 'North West' area, 'East' area. In general these transects showed great similarity in zonation patterns.

'North West' area
A typical cross-sectional profile for the 'North West' area is illustrated in Figure 5.3. The proportions of substratum types are summarised in Table 5.1. Three zones were identified within which a total of 25 species of macroalgae (Table 5.2) and 9 invertebrate species (Table 5.3) were recorded.

Table 5.1 Percentage cover of substratum along a typical transect within the 'north-east Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 1	Zone 2	Zone 3
Sand	0 (0-5)	0 (0-5)	4 (0-40)
Rock	100 (95-100)	100(95-100)	8- (60-100)

Zone 1 was a rock flat colonised predominantly by the gastropod *Thais* sp. Zone 2 comprised shallow lagoon which was dominated by *Laurencia obtusa* (0-30% cover), *Ulva reticulata* (0-60% cover) and *U. pulchra* (0-30% cover). The reef crest (Zone 3) supported the highest algal species richness, but the macroalgal cover was low. The most common invertebrates within this zone were *Perna perna* and *Cypraea annulus.*

Table 5.2 Percentage cover of macroalgae along a typical transect within the 'North West' Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3
Macroalgae			
Acanthophora muscoides	0	0	(0-P)
Centrocera clavulatum	0	0 (0-2)	0 (0-2)
Champia sp.	0	0	(0-P)
Cistoseira myrica	0	0 (0-1)	0
Cladophora mauritiana	0	0 (0-3)	0
Dictyosphaeria cavernosa	(0-P)	0 (0-2)	(0-P)
Dictyota divaricata	0	(0-P)	0
Gelidiella acerosa	0	(0-P)	0
Gracilaria sp.	0	0	(0-P)
Halimeda opuntia	0	0 (0-1)	0 (0-2)
Hydroclathrus clatrathus	0	0 (0-1)	1 (0-5)
Hypnea sp.	0	(0-P)	(0-P)
Kappaphycus sp.	0	(0-P)	0
Laurencia obtusa	0	10 (0-30)	0
Laurencia papillosa	0	2 (0-20)	2 (0-10)
Liagora ceranoides	0	0	(0-P)
Lyngbya majuscula	(0-P)	0 (0-4)	0 (0-10)
Microdyction montagnei	0	0	(0-P)
Padina boryana	0	0	0.2 (0-2)
Poritiera pulvinata	0	0	(0-P)
Sargassum duplicatum	0	0	(0-P)
Ulva pulchra	0	10 (0-30)	5 (0-25)
U. reticulata	(0-P)	10 (0-60)	(0-P)
Valonia aegagrophila	0	0 (0-2)	0
Vanvoorstia spectabilis	0	0	0 (0-2)

Table 5.3 Abundance (individuals/m^2, n=10) of invertebrate taxa along a typical transect within the 'North West' area.

Taxonomic group	Zone 1	Zone 2	Zone 3
Gastropods			
Calliostoma sp.	0	0	0 (0-1)
Cypraea annulus	0	0 (0-1)	6 (0-17)
C. felina	0	0	0 (0-1)
Marginella sp.	0	0	0 (0-1)
Nerita textilis	0	0	0 (0-1)
Thais sp.	20 (0-A+)	0 (0-1)	0
Turritella sp.	0	1 (0-3)	0
Hermit crabs			
Calcinus laevimanus	0	0	0 (0-2)
Bivalves			
Perna perna	0	0	8 (0-A)

'East Area'

Three zones were identified (Fig. 5.4) and the typical zonation pattern is presented in Figure. 5.4. A total of 28 species of macroalgae and 8 species of invertebrates were recorded. The substratum composition is summarised in Table 5.4 and the distribution of taxa across zones is presented in Tables 5.5 and 5.6.

Table 5.4 Percentage cover of substratum along a typical transect within the East Area (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 1	Zone 2	Zone 3
Sand	0	1 (0-10)	20 (0-70)
Rock	100 (100)	95 (90-100)	70(5-100)
Shell	0	0	5 (0-25)

Zone 1 was a narrow rock beach colonised by species of gastropods from 8 genera of which *Thais* sp. and *Rhinoclavis* sp. were the most abundant. Zone 2 consisted of a macroalgae dominated lagoon with few coral colonies. The dominant macroalgae species was *Ulva pulchra* (4 - 70%). The reef crest (Zone 3) comprised a mixture of rock, sand and broken shell colonised by diverse macroalgae with low cover and few invertebrates.

Table 5.5 Percentage cover of macroalgae along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic group	Zone 1	Zone 2	Zone 3
Macroalgae			
Caulerpa racemosa	0	0	(0-P)
Champia spp.	(0-P)	0	0
Cladophora sibogae	0 (0-2)	0 (0-4)	0
Dictyosphaeria cavernosa	(0-P)	0 (0-4)	(0-P)
Dictyota divaricata	0	(0-P)	(0-P)
Enteromorpha cf. *kylinii*	(0-P)	0	0
Eucheuma dendiculatum	0	0	(0-P)
Gelidiella acerosa	0	0	(0-P)
Gracilaria fergussoni	0	0	(0-P)
Halimeda cilindracea	0	0	(0-P)
H. opuntia	0	(0-P)	(0-P)
Hydroclathrus clatrathus	0	0	0(0-1)
Hypnea sp.	0.1 (0-1)	0 (0-1)	0 (0-P)
Jania adhaerens	0 (0-P)	0 (0-1)	0 (0-P)
Laurencia obtusa	0 (0-2)	0 (0-12)	0 (0-1)
L. papillosa	0	(0-P)	0
Lyngbya majuscula	(0-P)	(0-P)	2 (0-8)
Padina gymnospora	0	0	(0-P)
Pterocladia parva	0	(0-P)	0
Sarconema filiformis	0	0	(0-P)
Sargassum aquifolium	0	0 (0-8)	0
S. asperifolium	0	(0-P)	0
S. swartz	0	0	0 (0-4)
Spyridia sp.	0	0	0 (0-4)
Turbinaria ornata	0	0	0 (0-2)
Ulva pulchra	2 (0-8)	20 (4-70)	10 (4-50)
Valonia aegagrophila	(0-P)	0	0
Vanvoorstia spectabilis	0	0	(0-P)

Table 5.6 Abundance (individuals/m^2, n=10) of invertebrates along a typical transect within the 'East Area'.

Taxonomic group	Zone 1	Zone 2	Zone 3
Gastropods			
Conus sp.	0	0 (0-1)	0
Cypraea annulus	5 (0-15)	0	0
Oliva sp.	0 (0-2)	0	0
Rhinoclavis sp.	10 (0-25)	0	0
Thais sp.	40 (0-100)	0	0 (0-1)
Turritela sp.	0 (0-2)	0	0
Bivalves			
Perna perna	0	0 (0-2)	0
Echinoderms			
Echinometra mathaei	0	0 (0-2)	0 (0-1)

Figure 5.2 Location of intertidal transects, Rolas.

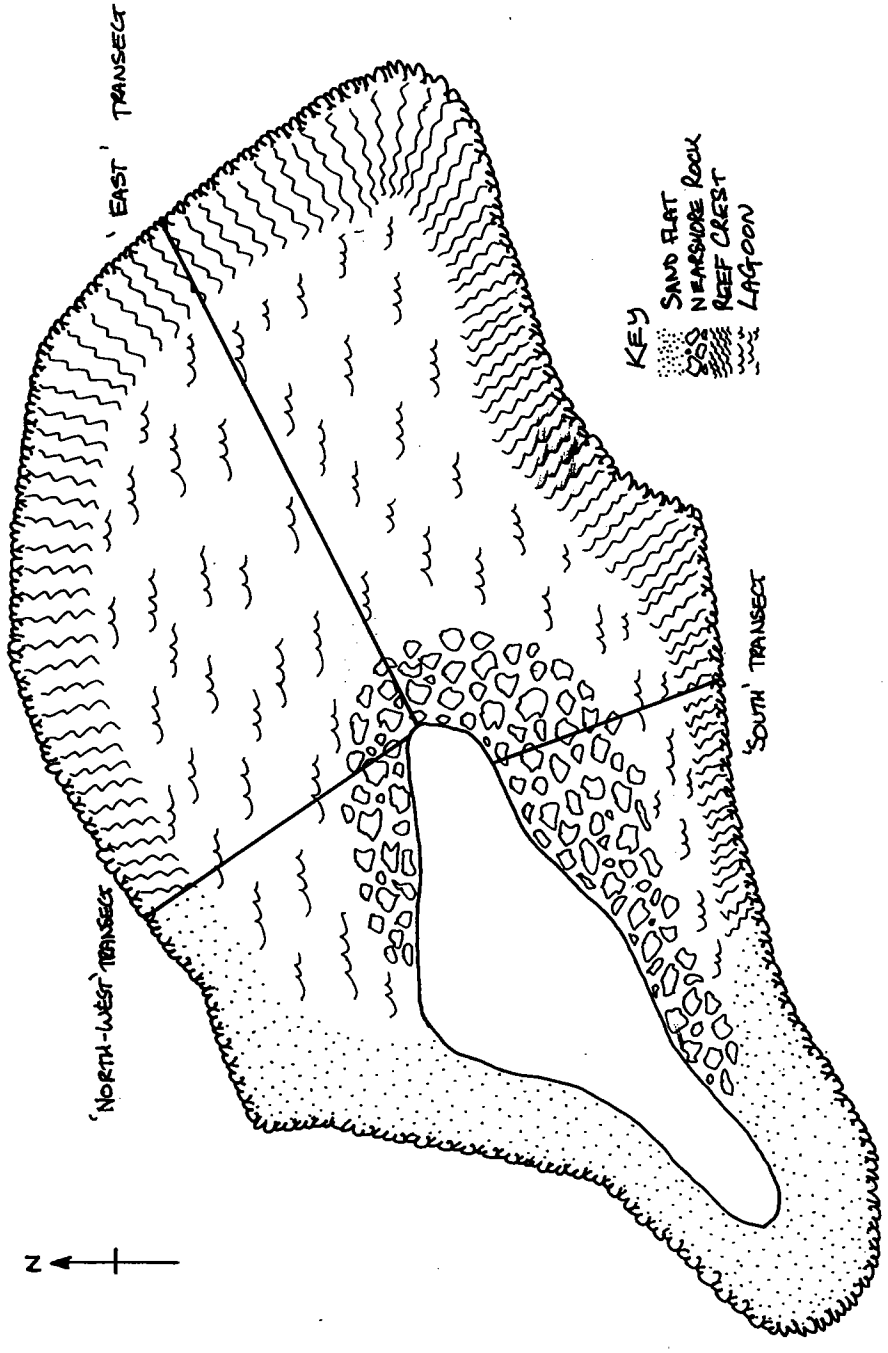


Figure 5.3 Cross section of the 'North West' intertidal transect, Rolas.

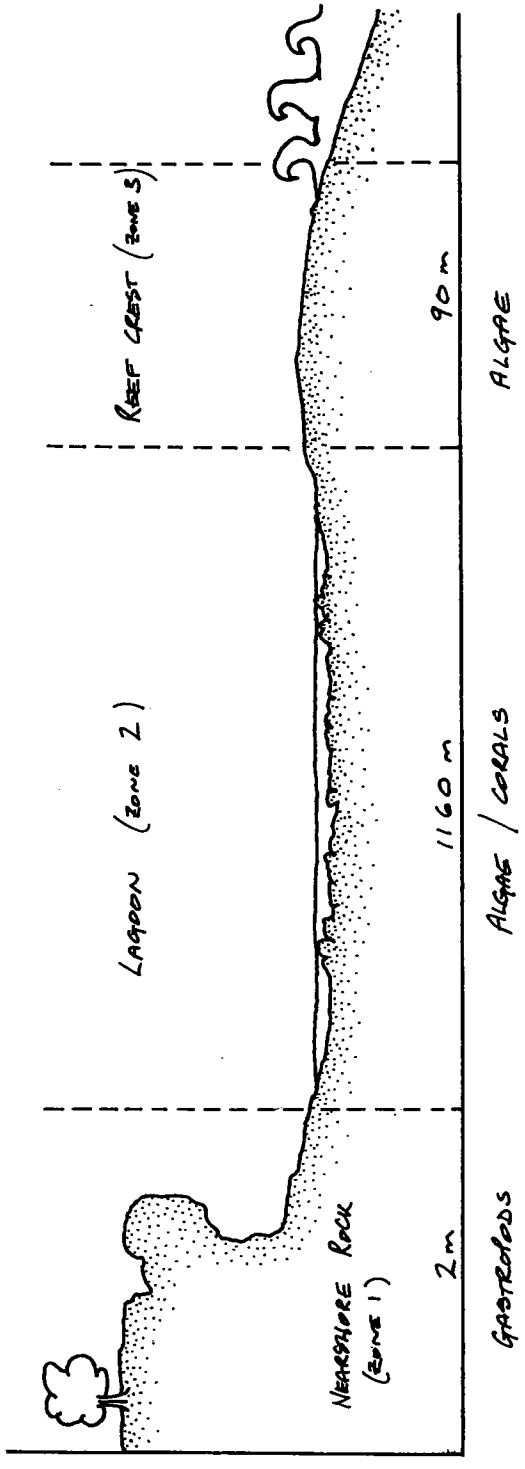
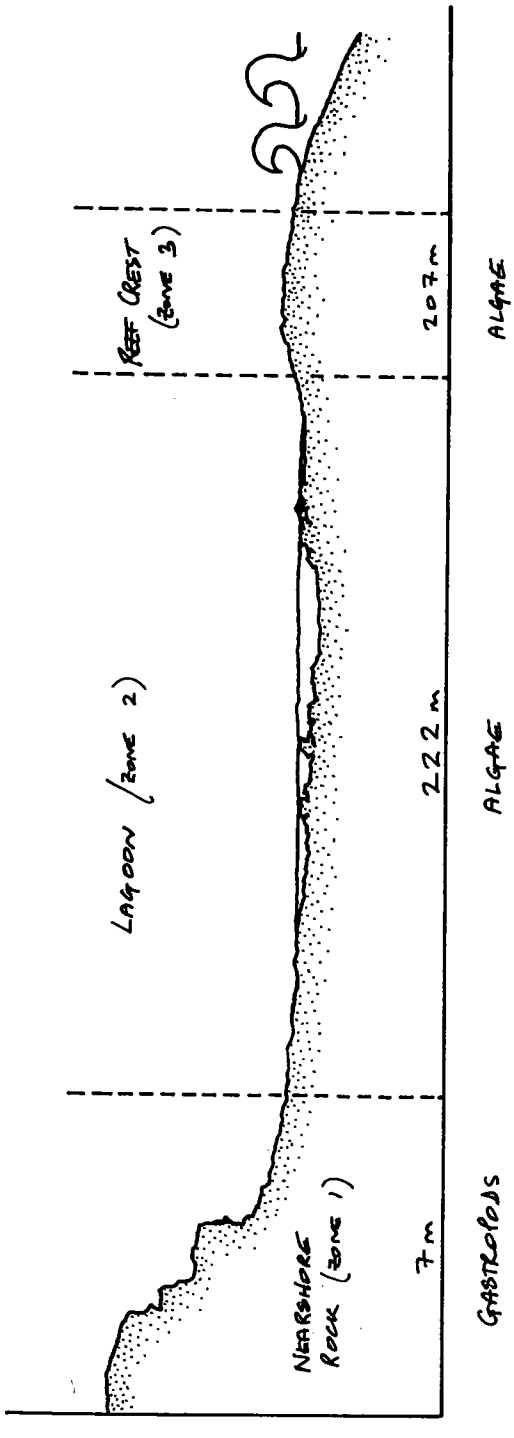


Figure 5.4 Cross section of the 'East' intertidal transect, Rolas.



5.3 Mangrove Surveys

No stand of mangrove was observed on Rolas island. The absence of mangroves is probably due to a combination of a short, steep intertidal area and the exposure of much of the island's shoreline to the prevailing winds and wave action.

5.4 Subtidal Habitat Survey

5.4.1 Overview

Reef Structure and Composition
The fringing reefs were poorly developed, characterised by low rugosities and a typically gentle reef slope. At all sites and most depths the reef was constructed from an approximately equal mixture of sand, rock and rubble. Subtidal survey sites are illustrated in Fig. 5.5.

Hard corals were the dominant biota on the reefs, but were absent from the extensive areas of loose substratum (sand and rubble) that were common at some sites. Soft corals were generally less abundant than hard corals, but were common at all sites. Seagrasses were abundant only at site R1. At the other sites seagrasses, together with macroalgae and *Halimeda* spp., were uncommon. 'Staghorn' form hard corals were generally dominant and formed several homogenous stands at sites R2-R4, being most widespread at R4.

5.4.2 Site Reports

Site R1:
The reef structure and community composition are summarised in Table 5.7 and Figure 5.6 and are described below.

Reef Structure
The reef at this site was shallow, with the reef base at a depth of 7m and with corals only extending to 5m. It was also poorly developed; composed of patches of broken coral and bommies, surrounded by areas of bare rock and rubble. There was a gentle and consistent reef slope.

Substratum Composition
Most of the reef area was composed of a relatively equal mix of sand, rock and rubble. Off-reef the substratum was entirely composed of sand.

Biotic Cover
Seagrasses were the dominant biota over much of the site, with other biota covering less than 1 % of the area. On the shallower, hard substratum areas, corals had relatively high abundances with macroalgae and *Halimeda* spp. also present. Of the hard coral forms noted, only 'massive' and 'branching' forms were abundant.

Table 5.7 A summary of the structure, composition and biotic cover at R1 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	5	0-10	0	0
	Rugosity	3	2-3	0	0
Substratum	Rock	3	2-3	-	-
	Rubble	3	1-4	-	-
	Sand/Shell	3	2-4	6	6
	Mud	-	-	-	-
Biota	Hard Coral	2	P-3	-	-
	Soft Coral	P	0-1	P	P
	Seagrass	2	0-4	3	3
	Macroalgae	2	P-2	0	-
	Halimeda spp.	1	1	0	-
Coral State	Heterogeneity	0	0	0	0
	Dominance	Massive/Branching		None	

Site R2:
The reef structure and community composition are summarised in Table 5.8 and described below.

Reef Structure
A broad, flat, rubble zone (with coral bommies) existed at this site. The slope was minimal and rugosity was low.

Substratum Composition
Substratum composition was observed to change with small increases in depth. At about 4 m, the reef was composed almost entirely of rock. At 5-6m, there was a generally even mix of rock and rubble and at 8m, rock and sand were co-dominant.

Biotic Cover
Both hard and soft corals were abundant biota over the whole site, although their respective abundances varied. Seagrasses, macroalgae and *Halimeda* spp. were recorded from the deeper sections in small abundances. 'Staghorn' and 'branching' form coral formed small homogenous stands in the shallower sections of the site, although most areas supported a mix of hard coral forms.

Table 5.9 A summary of the structure, composition and biotic cover at R3 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	0	0	10	0-20
	Rugosity	3	2-4	2	0-3
Substratum	Rock	3	2-3	3	0-3
	Rubble	3	2-4	2	0-3
	Sand/Shell	2	0-3	3	0-4
	Mud	-	-	-	-
Biota	Hard Coral	3	2-3	2	0-2
	Soft Coral	2	0-2	1	0-1
	Seagrass	-	-	-	-
	Macroalgae	-	-	P	P
	Halimeda spp.	-	-	-	-
Coral State	Heterogeneity	3	2-4	0	0
	Dominance	Staghorn/Mushroom		Staghorn/Encrusting	

Site R4:

The reef structure and community composition are summarised in Table 5.10 and Figure 5.8 and are described below.

Reef Structure

This site at the western tip of the island, consisted of a reef which changed dramatically over a short distance. Much of the site consisted of a shallow, relatively flat sand bank at a depth of 3-5m. On this otherwise bare area were low-lying coral patches (<20m wide) and bommies (typically 1-2m high). The other portion of the site consisted of a steep (40-50°), coral-covered slope, between a depth of 8-2m. Shallower than 2m, the reef became flat, but still supported an abundant coral cover. Rugosity was variable.

Substratum Composition

Rock was the dominant substratum over much of the reef, although sand and rubble were also abundant and the proportions of each substratum type varied considerably. Sand was the dominant substratum at shallower depths.

Biotic Cover

Both hard and soft corals were abundant over much of the reef, although their respective proportions varied considerably. The other biota type data elements were not recorded during the habitat surveys, although a few specimens of macroalgae were noted during subsequent survey work. 'Staghorn' form hard corals formed homogenous thickets over large areas of the reef.

Table 5.8 A summary of the structure, composition and biotic cover at R2 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	10	5-20	0	0
	Rugosity	3	0-3	1	0-3
Substratum	Rock	6	6	3	3-6
	Rubble	P	P	2	0-3
	Sand/Shell	1	P-1	3	0-5
	Mud	-	-	-	-
Biota	Hard Coral	4	3-4	2	0-4
	Soft Coral	1	P-1	2	0-4
	Seagrass	-	-	P	0-1
	Macroalgae	1	1	P	0-1
	Halimeda spp.	-	-	P	0-P
Coral State	Heterogeneity	0	0-1	0	0
	Dominance	Staghorn/Branching		None	

Site R3:

The reef structure and community composition are summarised in Table 5.9 and Figure 5.7 and are described below.

Reef Structure

The reef base at this site was in a depth of 8m with the reef sloping steeply up a short rise, composed of rock and rubble, to 6m. The slope also had a number of small bommies (1-5m in diameter and 0.5-3m high). Between 6-4m, the slope was <10° , and was composed of a mixture of rubble, sand patches and dead consolidated 'staghorn' form 'rock'. Shallower than 4m, the substratum was covered in macroalgae. Off-reef there was a vast seagrass bed.

Substratum Composition

The composition of the substratum cover differed with depth. Sand was the dominant substratum type at 3-6m, although both sand and rock at this depth exhibited high degrees of variation. At 5m there was an relatively even cover of rock and rubble and at 8m, there was a roughly equal mix of rock and sand.

Biotic Cover

Hard corals were dominant over much of the area, although 2-3 times more abundant at the shallower depths. Soft corals were not abundant and macroalgae was present only at greater depths. Seagrasses were abundant in small patches between the reef areas. 'Staghorn' form corals commonly formed homogenous bands and were dominant over much of the reef.

Table 5.10 A summary of the structure, composition and biotic cover at R4 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	30	20-40	30	0-40
	Rugosity	4	2-5	4	0-5
Substratum	Rock	3	2-4	3	0-4
	Rubble	2	2	2	0-3
	Sand/Shell	2	0-3	2	0-2
Biota	Hard Coral	3	2-4	3	0-4
	Soft Coral	1	0-1	1	0-2
Coral State	Heterogeneity	4	3-5	4	0-6
	Dominance	Staghorn		Staghorn	

5.4.3 Subtidal flora

Overview

An outstanding feature of subtidal macroalgal vegetation on Rolas was the relatively high diversity of the pantropical order Caulerpales. Three sites namely R1, R3 and R4 (Fig. 5.5) were surveyed within which 2 species of seagrass and 38 species of macroalgae: Cyanophyta (1 species), Chlorophyta (18 species), Phaeophyta (6 species) and Rhodophyta (13 species) were identified. Seagrass beds on Rolas Islands were restricted to the subtidal zone where *Thalassodendron ciliatum* was observed to be abundant, notably at sites R1 and R3. A checklist of seagrass and macroalgae taxa for the N.I.G. is presented in Appendix A2.

Area reports

Site R1:

The inner area consisted predominantly of sand/seagrass with sand/bommies beyond. Two seagrass species and 23 species of macroalgae were recorded.

Site R3:

This site comprised coral and sand in shallower areas and sand/seagrass in deeper water, within which 1 species of seagrass and 13 species of macroalgae were recorded.

Site R4:

This site was characterised by the occurrence of sand and small bommies on which macroalgae were attached. One species of seagrass and 6 species of macroalgae were recorded, with *Sargassum* spp. dominating the macroalgal vegetation.

Figure 5.5 Location of subtidal habitat survey sites, Rolas.

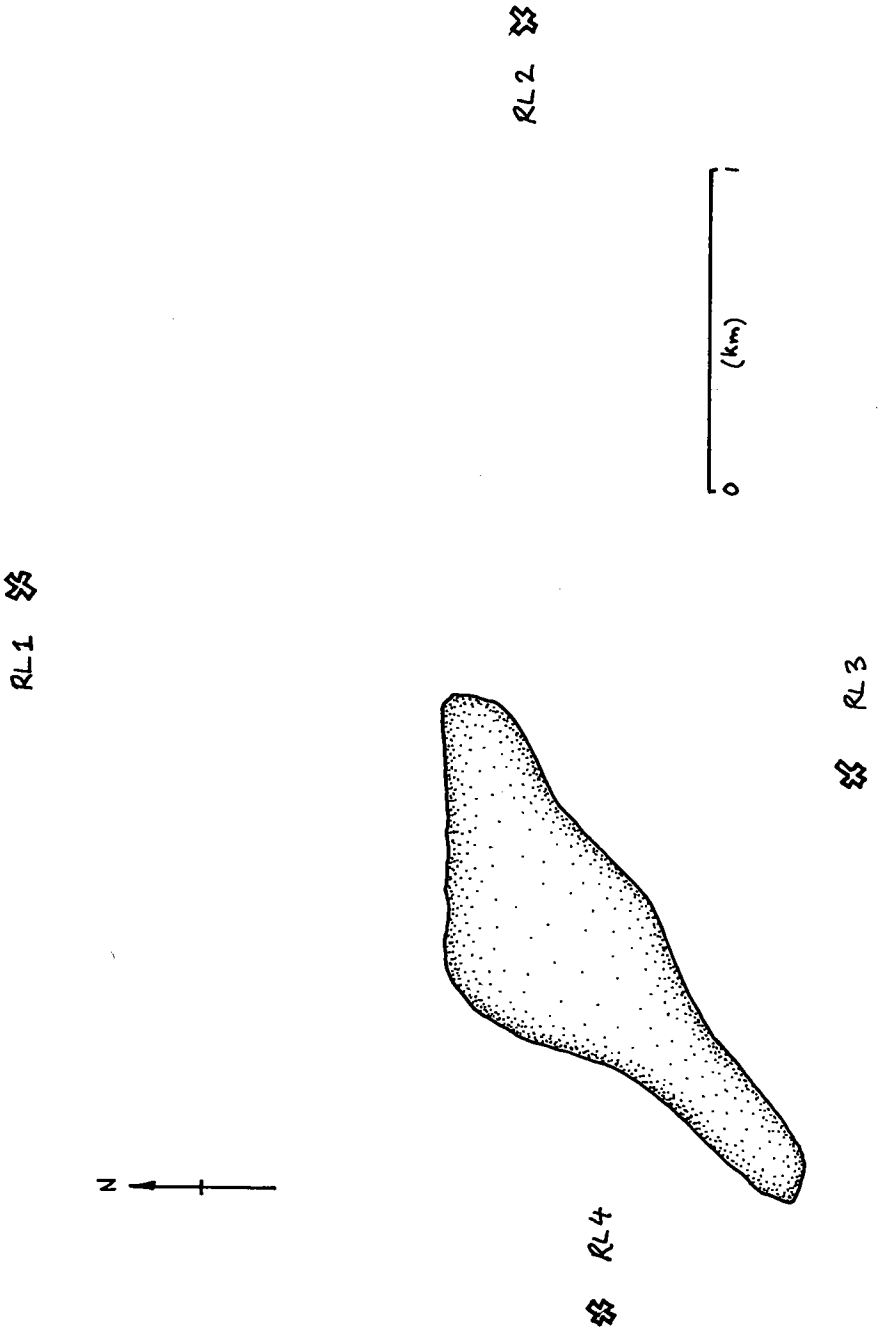


Figure 5.6 Habitat profile of Site R1, Rolas.

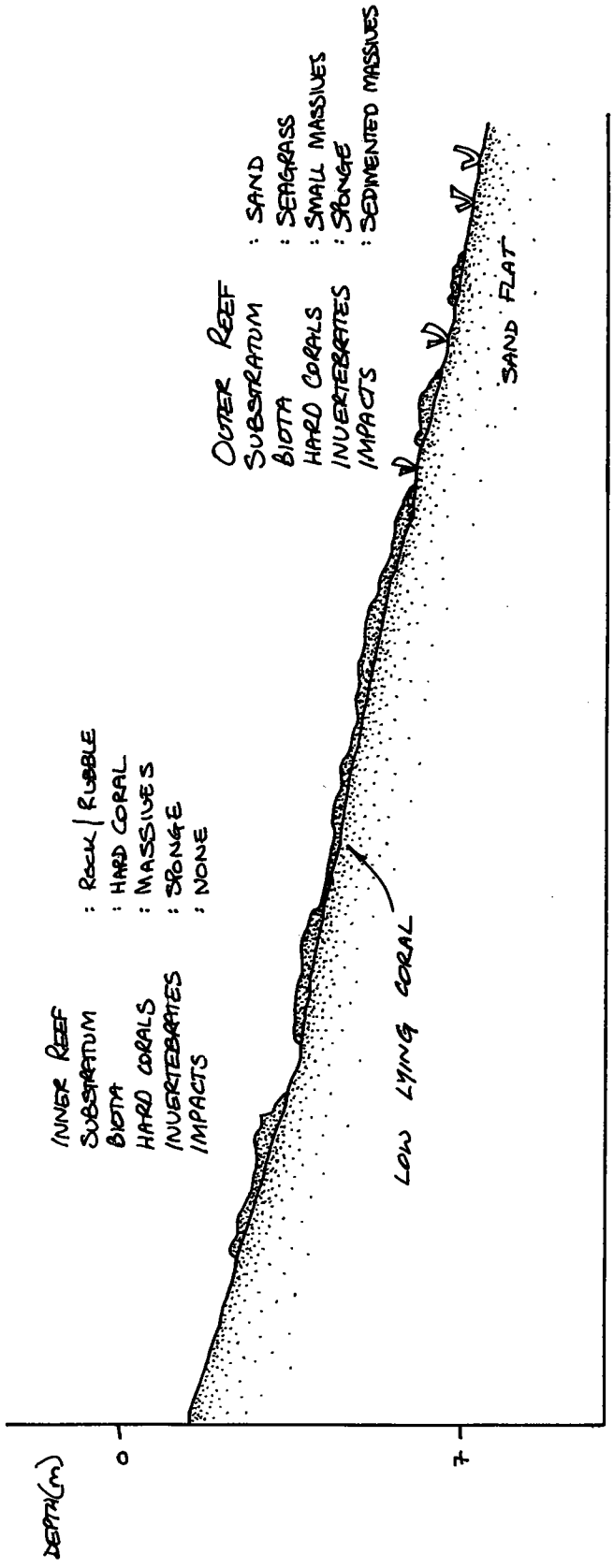


Figure 5.7 Habitat profile of Site R3, Rolas.

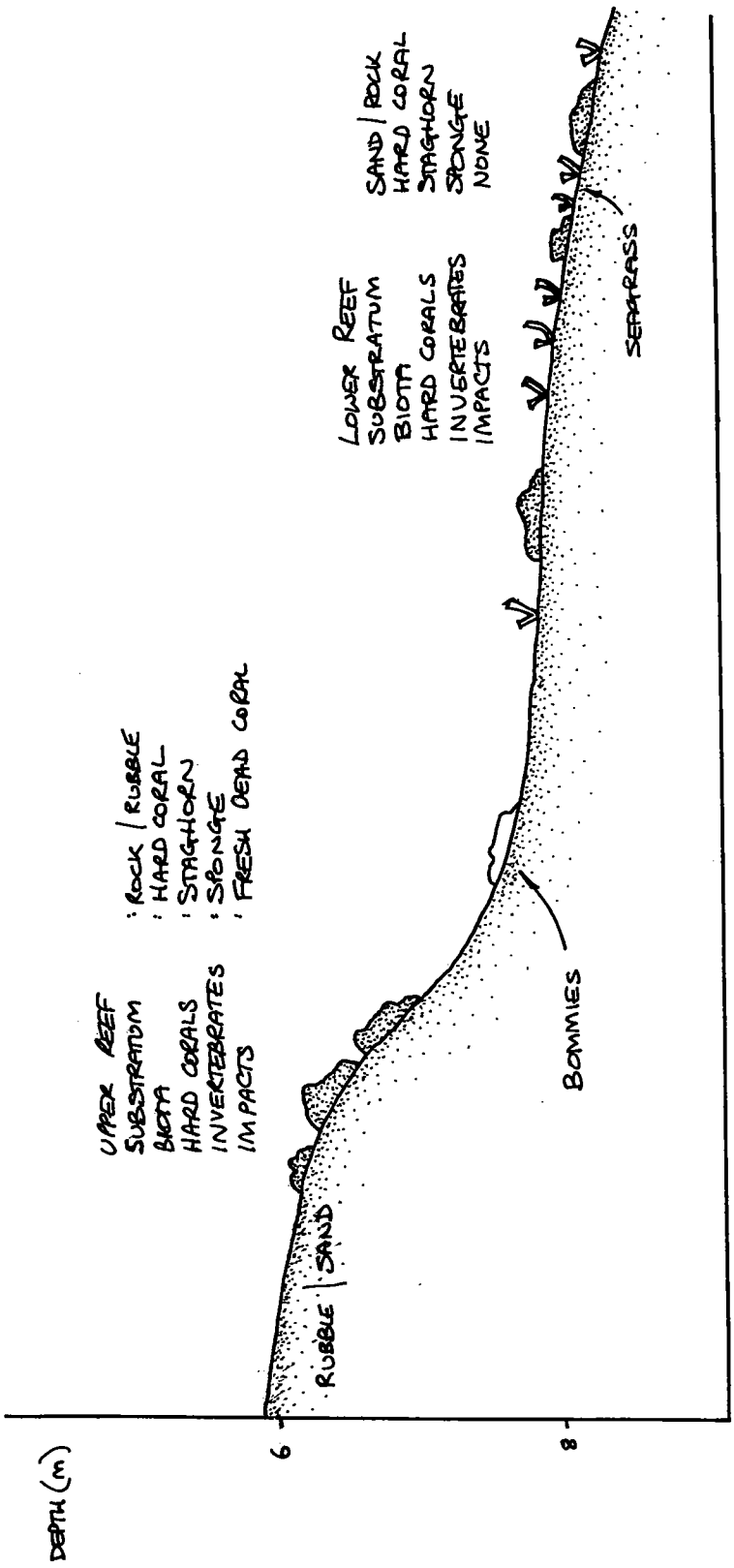
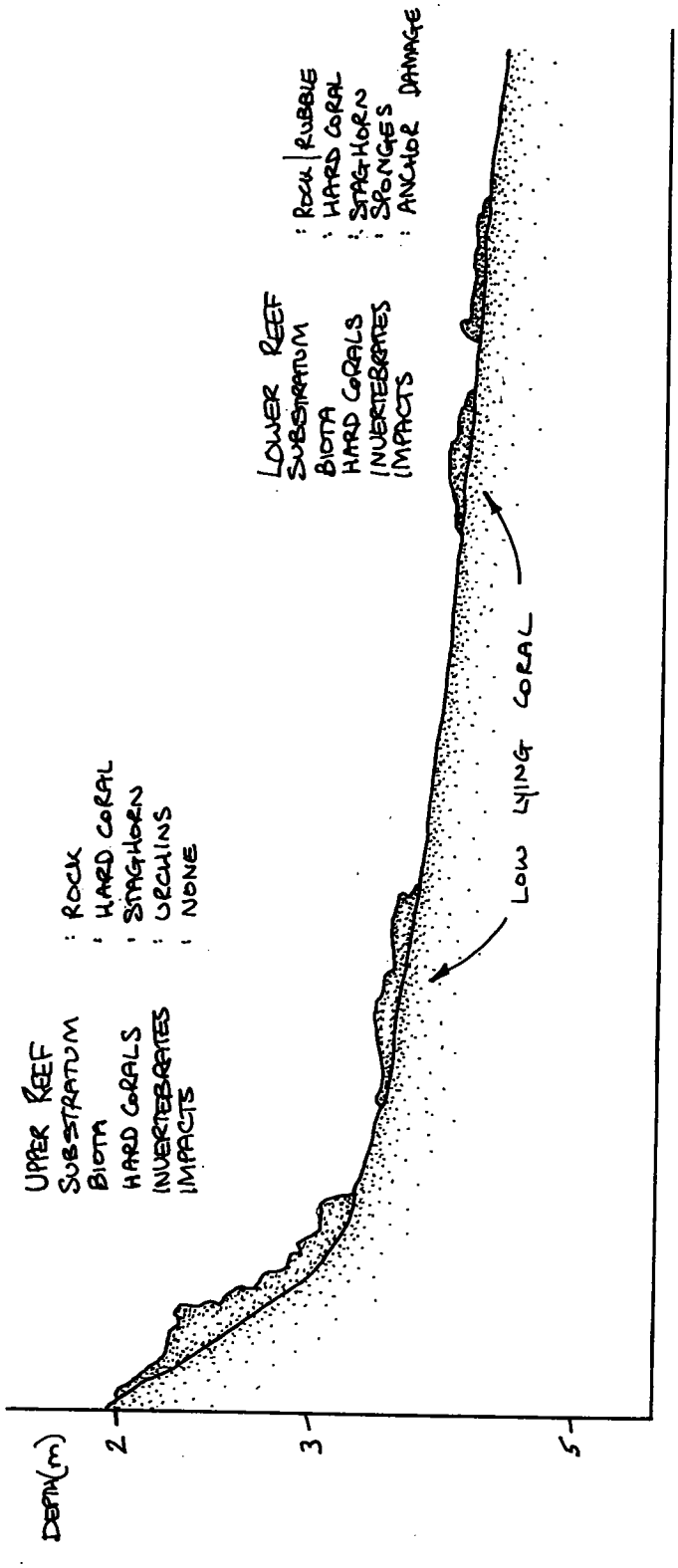


Figure 5.8 Habitat profile of Site R4, Rolas.



5.5 Subtidal Invertebrate and Impacts Surveys

Survey sites are as for the subtidal habitat surveys reported above (Fig. 5.5)

5.5.1 Overview

The reef around Rolas island supported relatively few of the survey invertebrates, probably reflecting the relatively poor development of much of the reef area. The upper sections of the reef were commonly dominated by urchins, which attained very high densities in localised areas (most of these urchins were small, possibly juveniles). Naturally caused coral damage was widespread and is probably the result of a combination of the presence of large areas of sand and rubble within the reef area, the shallow water around the island and the reefs' exposed aspects. Little evidence of human impacts on the reef was recorded.

5.5.2 Site Reports

Site R1:
The distributions and densities of invertebrates and incidences of reef damage are summarised in Table 5.11 and are described below.

The reef at this site supported relatively few invertebrates with macrosponges being most common, although restricted to the upper reef. The most notable feature of the reef was the large numbers of sedimented 'massive' form corals on the upper sections of the reef, probably resulting from the large areas of the sand and rubble observed at this site. No evidence of human impacts on the reef was noted.

Table 5.11 Invertebrates and Natural/Human Impacts at Site R1 (values are for 5 minutes of survey).

		Inner Reef (n=12)		**Outer Reef** (n=12)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		15	0-A	0.5	0-10
Bivalves	Giant Clams	0	0-1	-	-
Urchins		-	-	0	0-2
Sea Cucumbers	Holothuria	0	0-1	0	0-2
	Others	-	-	0	0-2
Dead Corals	Sed. Massives	-	-	1.5	0-A

Site R2:
The distributions and densities of invertebrates and incidences of reef damage are summarised in Table 5.12 and are described below.

In a similar pattern to that observed at site R1, there were very few invertebrate data elements recorded. Macrosponges were again the most common invertebrate, although urchins were more abundant on the upper sections of the reef. White band disease, sedimented 'massive' form corals and further examples of fresh dead coral (cause unknown) were all noted on the upper sections of the reef. Human impacts were limited to a few areas of damaged coral that were attributed to the action of boats' anchors.

Table 5.12 Invertebrates and Natural/Human Impacts at Site R2 (values are for 5 minutes of survey).

		Inner Reef (n=12)		Outer Reef (n=11)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		4.0	3-5	5.5	0-10
Gorgonians	Sea Whips	-	-	0	0-1
Urchins		3.5	2-8	0	0-8
Sea Cucumbers	Others	-	-	0	0-1
Dead Corals	White Band Dis.	1.0	0-1	0	0-2
	Sed. Massives	0	0-1	0	0-2
	Unknown	1.0	0-4	0	0-3
Human Effects	Anchor Damage	0	0-1	0	0-2

Site R3:

The distributions and densities of invertebrates and incidences of reef damage are summarised in Table 5.13 and are described below.

Macrosponges and urchins dominated the invertebrates recorded on the reef at this site, although the latter was limited to the shallower parts of the reef. Crown of Thorns starfish (*Acanthaster plancii*) and their feeding scars were both seen towards the top of the reef. Other natural impacts observed were sedimented 'massive' form corals and fresh dead coral (cause unknown). Human impacts were limited to a few areas of damaged coral that were attributed to the action of boats' anchors.

Table 5.13 Invertebrates and Natural/Human Impacts at Site R3 (values are for 5 minutes of survey).

		Inner Reef (n=12)		Outer Reef (n=12)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		2.5	0-A+	0	0-8
Gorgonians	Sea Whips	-	-	0	0-1
Urchins		0	0-A+	0	0-2
Sea Cucumbers	Holothuria	-	-	0	0-1
	Others	0	0-1	0	0-5
C-O-T	Individuals	0	0-1	-	-
	Scars	0	0-2	-	-
Dead Corals	Sed. Massives	0	0-1	-	-
	Unknown	1.0	0-5	0	0-1
Human Effects	Anchor damage	0	0-3	-	-

Site R4:

The distributions and densities of invertebrates and incidences of reef damage are summarised in Table 5.14 and are described below.

In a similar pattern to site R3, macrosponges and urchins dominated the invertebrates of the reef at this site, with the latter forming very high densities in the shallow water at the top of the reef. Natural impacts were restricted to the upper reef and consisted of examples of sedimented 'massive' form corals and fresh dead coral (cause unknown). No evidence of human impacts on the reef was noted.

Table 5.14 Invertebrates and Natural/Human Impacts at Site R4 (values are for 5 minutes of survey).

		Inner Reef (n=6)		Outer Reef (n=15)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		0	0-2	A	0-A+
Gorgonians	Sea Whips	-	-	0	0-5
Bivalves	Giant Clams	0.5	0-1	-	-
Urchins		13.5	0-A	0	0-1
Sea Cucumbers	Holothuria	0	0-1	0	0-3
Dead Corals	Sed. Massives	-	-	0	0-1
	Unknown	-	-	0	0-6

5.6 Reef Fish Census

Survey sites are as for the subtidal habitat surveys reported above (Fig. 5.5)

5.6.1 Overview

The reefs around the island supported a relatively low diversity and abundance of reef fish which was probably a direct reflection of the relatively poor reef development observed at most sites. The diversity of reef fish at each site is given in Table 5.15 below. For a complete list of the censused species present at each site, refer to Appendix A3.

Table 5.15 The number of replicates, Relative Species Richness indices (R.S.R.i.), Shannon-Weaver indices (S.W.i.) and total number of reef fish species observed. Numbers are for those fish observed from the 73 species censused.

Site	Reps	Spp	RSRi	SWi
R1	12	7	0.10	1.10
R2	12	21	0.29	2.37
R3	11	19	0.26	2.11
R4	18	20	0.27	2.15

5.6.2 Site Reports:

Site R1:
Site abundance and diversity were low (8 species), with only two families, Acanthuridae and Balistidae represented. Over 90% of the fish were Acanthurids, mainly the Dusky surgeonfish *Acanthurus nigrofuscus* (<14 fish/5 mins.) and the Convict surgeonfish *A. triostegus* (<10 fish/5 mins.). The poor reef development at this site was probably the cause of the observed pattern or reef fish abundance and diversity. The relative abundance and species richness of reef fish recorded are shown in Fig. 5.9.

Site R2:
This site supported the highest diversity of reef fish recorded around Rolas island (23 species). Abundance was also relatively high, particularly the Acanthurids: Dusky surgeonfish *Acanthurus nigrofuscus* (<12 fish/5 mins.), Convict surgeonfish *A. triostegus* (<20-50 fish/5 mins.), Goldring bristletooth *Ctenochaetus strigosus* (<20-50 fish/5 mins.) and Brown tang *Zebrasoma scopas* (<8 fish/5 mins.). The relative abundance and species richness of reef fish recorded are shown in Fig. 5.10.

Site R3:

There was a marked difference between the reef fish abundance and diversity with depth at this site (6 species at 2m and 22 species at 6m), despite the relatively short reef slope. In the shallow areas of the reef, only the Dusky surgeonfish *Acanthurus nigrofuscus* (<10 fish/5 mins.) and the Dash-dot goatfish *Parapeneus barberinus* (<15 fish/5 mins.) were present in significant numbers. The greater abundance and diversity of fish at deeper sections of the reef was produced by surgeonfish (Acanthurids) and butterflyfish (Chaetodontids). The relative abundance and species richness of reef fish recorded are shown in Fig. 5.11.

Site R4:

In contrast to site R3, there was little variation in the abundance or diversity of reef fish with depth at this site. The Yellow-striped goatfish *Mulloidichthys flavolineatus* (<20-50 fish/5 mins.) and the Brown tang *Zebrasoma scopas* (<17 fish/5 mins.) dominated the reef fish assemblage at the shallower portions of the reef, whilst the deeper portions were dominated by the Dusky surgeonfish *Acanthurus nigrofuscus* (<20-50 fish/5 mins.) and the Convict surgeonfish *A. triostegus* (<10 fish/5 mins.). The relative abundance and species richness of reef fish recorded are shown in Fig. 5.12.

Figure 5.9 The abundance and species richness of reef fish at site R1.

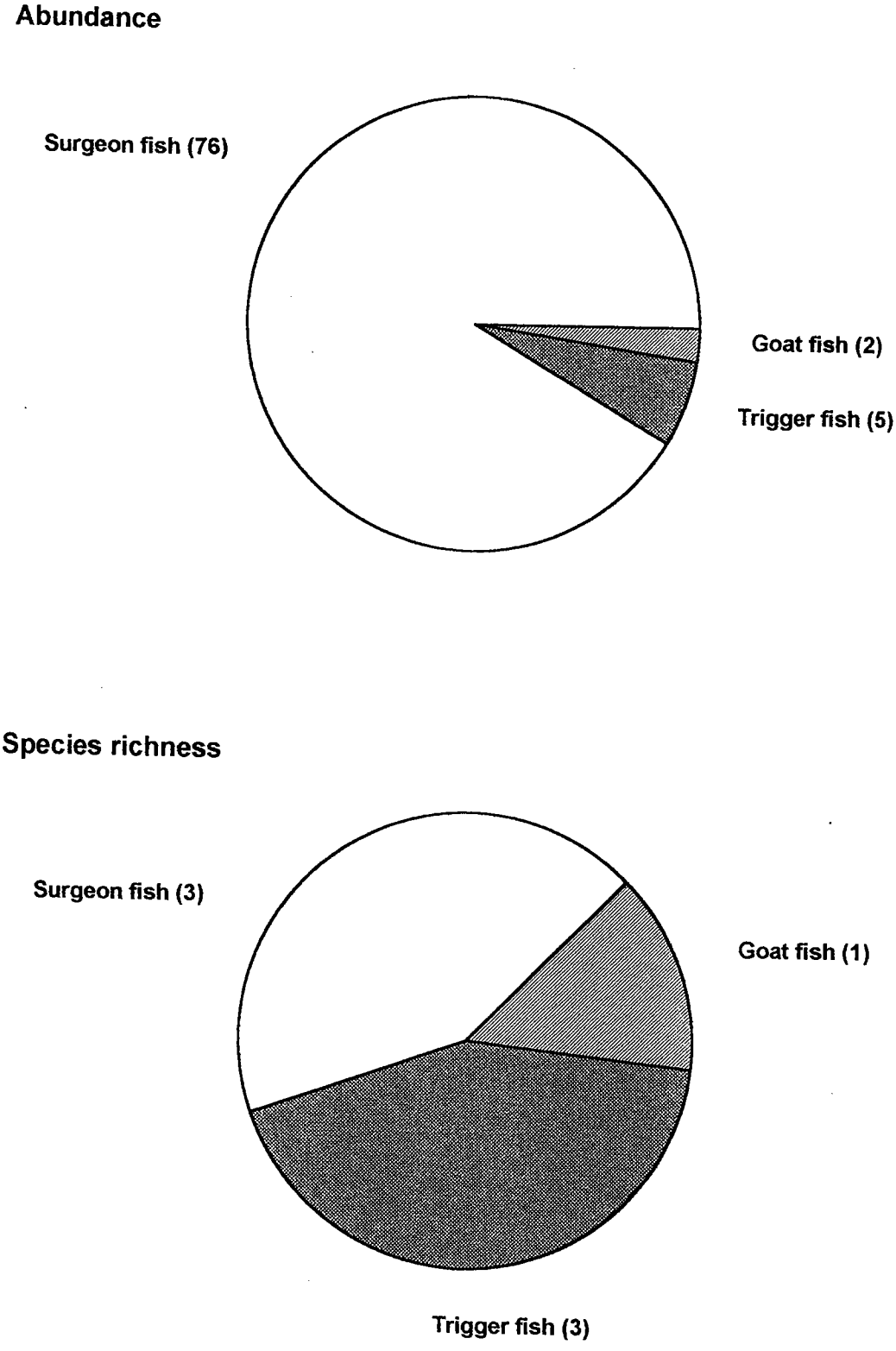


Figure 5.10 The abundance and species richness of reef fish at site R2.

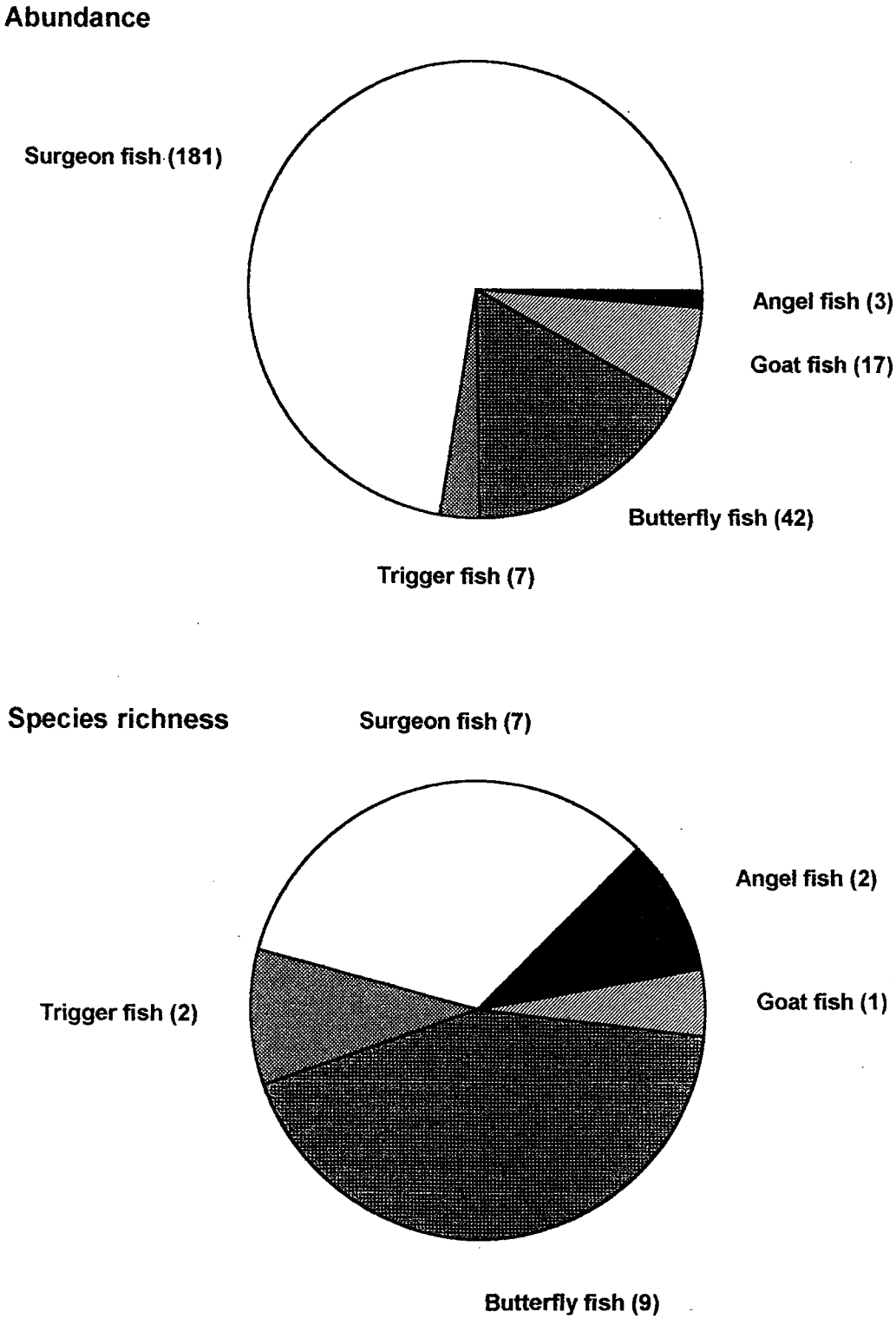


Figure 5.11 The abundance and species richness of reef fish at site R3.

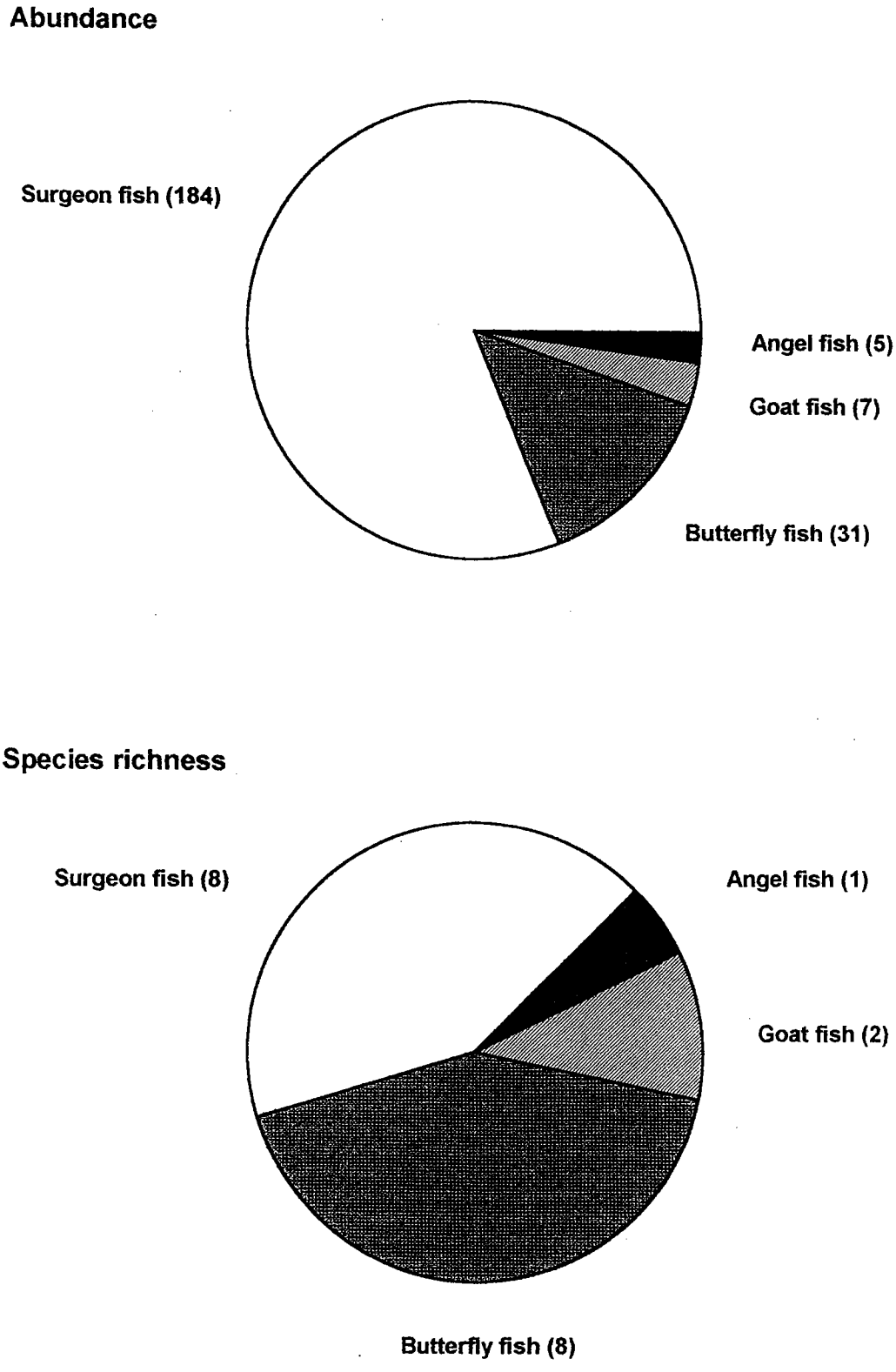
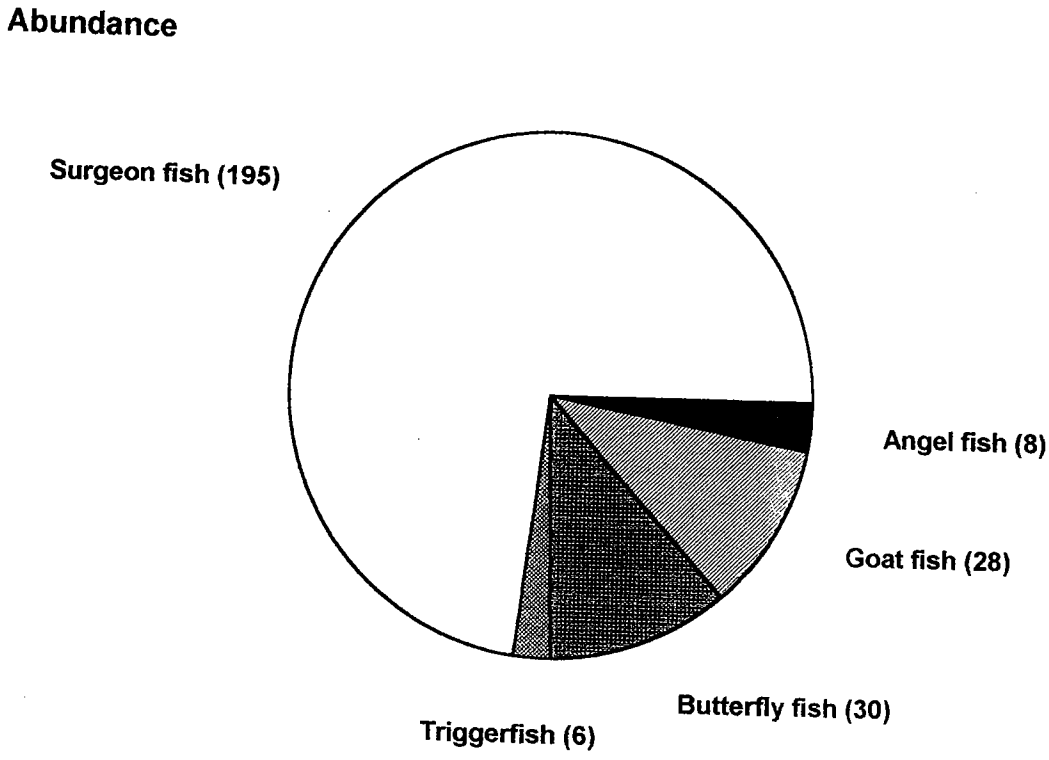
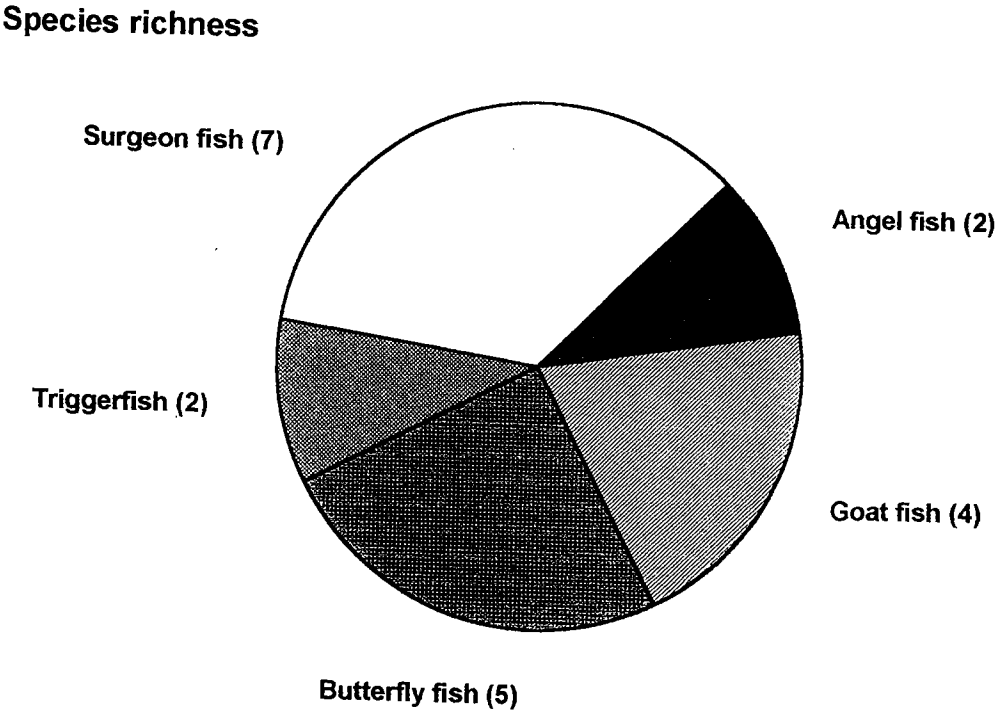


Figure 5.12 The abundance and species richness of reef fish at site R4.





5.7 Commercial Fish Census

Survey sites as for the subtidal habitat surveys reported above (Fig. 5.5).

5.7.1 Overview

The generally poor reef development around much of the island most probably contributed to the low observed abundance and diversity of commercial fish, the exception being site R4 where fish abundance was relatively high. At this site, although a continuous reef was absent, there were a large number of coral 'bommies' and this may have resulted in a commercial fish population more typical of the fringing 'outer reef' of adjacent islands. Parrotfish (Scarids) dominated the commercial fish populations of sites R1-R3.

5.7.2 Site Reports

Site R1:
The low abundance of commercial fish at this site probably reflected the low coral cover and predominance of sand and seagrass. Parrotfish (Scarids: Indian Ocean longnose *Hipposcarid harid,* Blue barred *Scarus ghobban,* Bullethead *S. sordidus*) were dominant over the reef areas. The seagrass fish assemblage was dominated by the Seagrass parrotfish *Leptoscarus vaigiensis* and the Seagrass wrasse *Novaculichthys macrolepidopterus*. In addition, the Cigar wrasse *Cheilio inermis* and Three ribbon wrasse *Stethojulis strigiventer*, the Dash-dot goatfish *Parapeneus barberinus* and Black striped goatfish *Upeneus tragula*, the Variegated emperor *Lethrinus variagatus* and the African whitespotted rabbitfish *Siganus sutor* were identified. These fish species were generally solitary and were observed at a rate of less than 4 individuals encountered per five minutes surveying. Results have been presented graphically in Fig. 5.13.

Site R2:
Few commercial fish were observed at this site and those recorded were mainly Scarids, including: Bicolour parrotfish *Cetoscarus bicolor,* Indian Ocean longnose parrotfish *Hipposcarid harid,* Bridled parrotfish *Scarus frenatus,* Bullethead parrotfish *S. sordidus,* Greenlip parrotfish *S. viridifucatus* (estimated length < 40 cm).

Site R3:
Although few commercial fish were recorded, a relatively high diversity of parrotfish (Scarids) was identified, and included: Blackcrescent parrotfish *Scarus atrinula,* Bridled parrotfish *S. frenatus,* Bluebarred parrotfish *S. ghobban,* Swarthy parrotfish *S. niger,* Palenose parrotfish *S. psitticas* and Bullethead parrotfish *S. sordidus*. Within the areas of seagrass, a similar low abundance and diversity of fish were observed. Those identified included; the Cigar wrasse *Cheilio inermis* and Seagrass wrasse *Novaculichthys macrolepidopterus*, and the Seagrass parrotfish *Leptoscarus vaigiensis* and Bluebarred parrotfish *Scarus ghobban* (estimated length < 80 cm). Results have been presented graphically in Fig. 5.14.

Site R4:

Parrotfish (Scarids) dominated the shallower parts (<4 m depth) of the reef, mainly *S. sordidus* (estimated length < 20 cm), with large shoals of snappers: Bluelined snapper *Lutjanus kasmira,* Onespot snapper *L. monostigma* and the Yellowspot emperor, *Gnathodentex aurolineatus* dominating the deeper parts of the reef. Additionally, a further six species of snappers including: Black snapper *Macolor niger,* Twinspot snapper *Lutjanus bohar,* Flametailed snapper *L. fulvus*, one species of Lethrinid; Bigeye emperor *Monotaxis grandoculis*, and numerous species of grouper, mainly Coral hinde *Cephalopholis miniata*; (estimated length < 40 cm) were identified. Results have been presented graphically in Fig. 5.15.

Figure 5.13 The abundance and distribution of commercial fish at site R1.

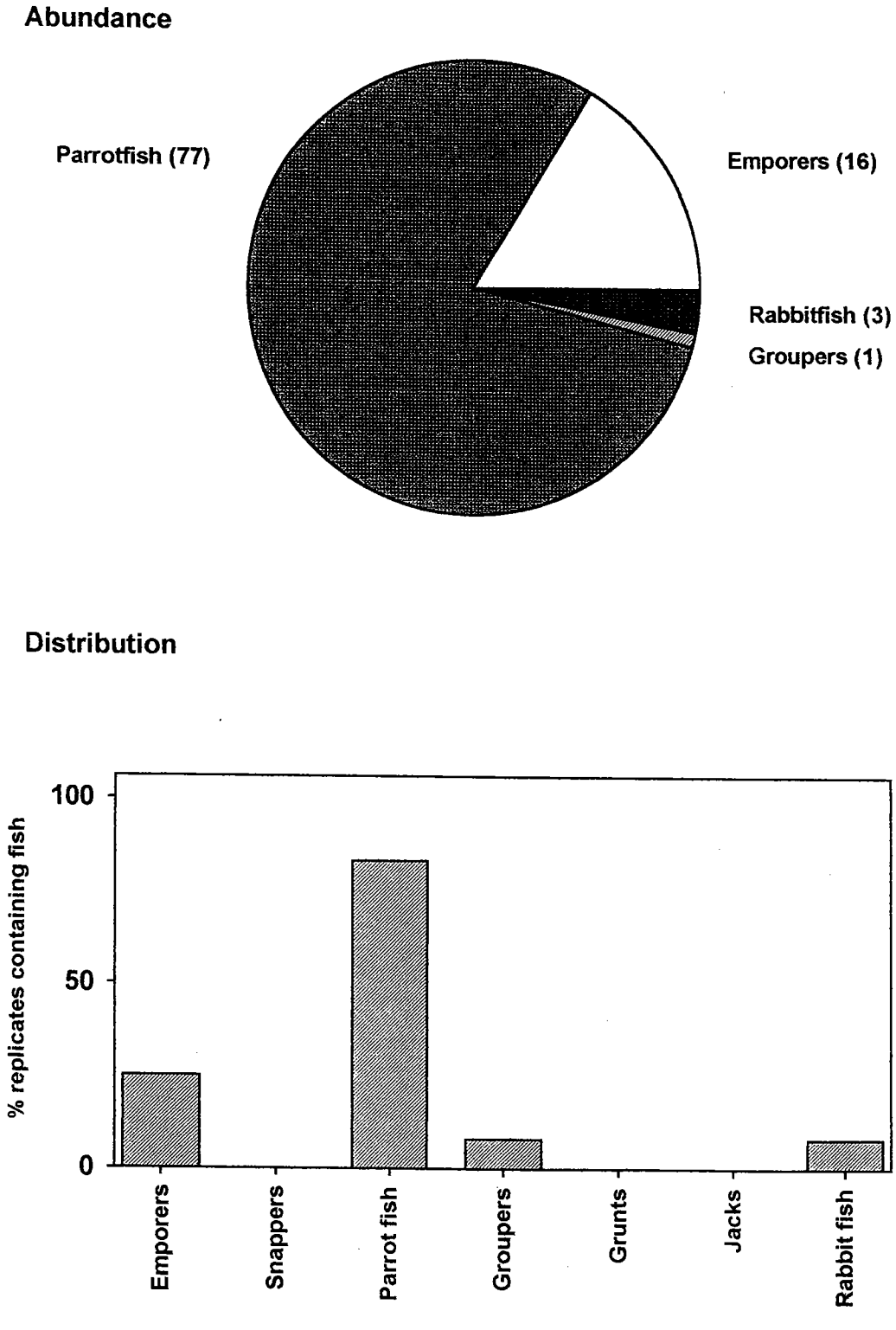
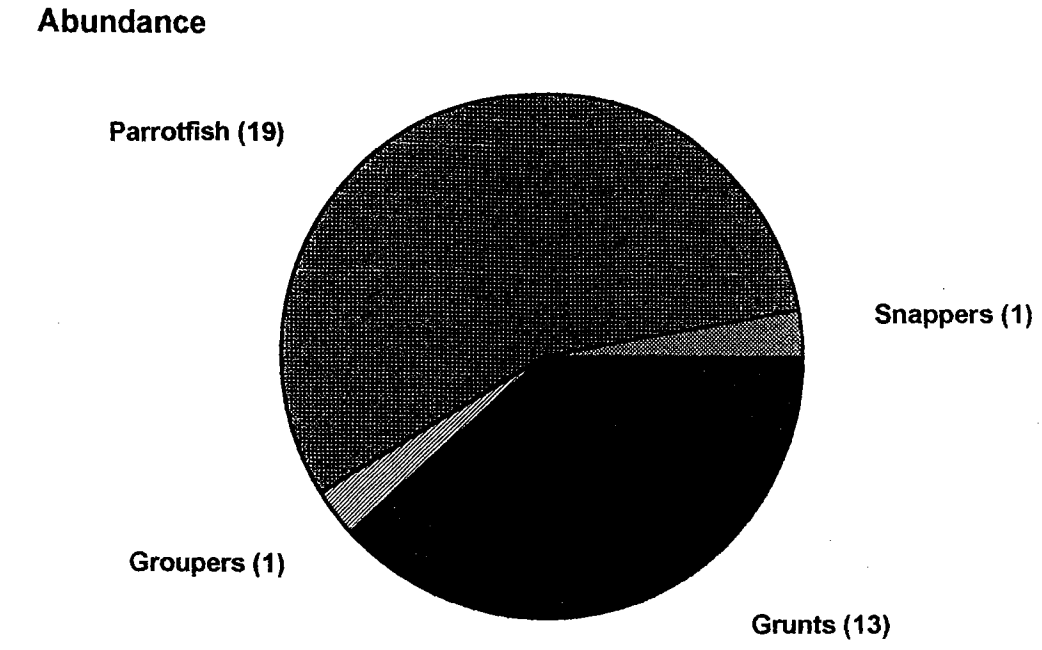


Figure 5.14 The abundance and distribution of commercial fish at site R3.



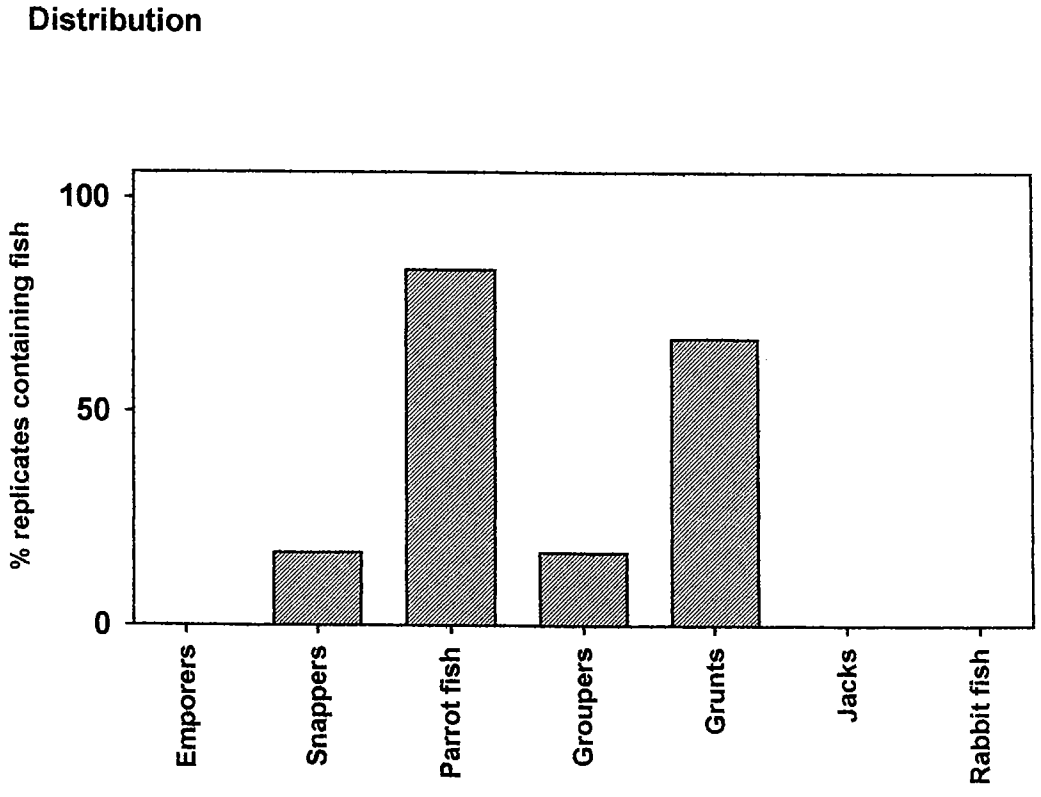
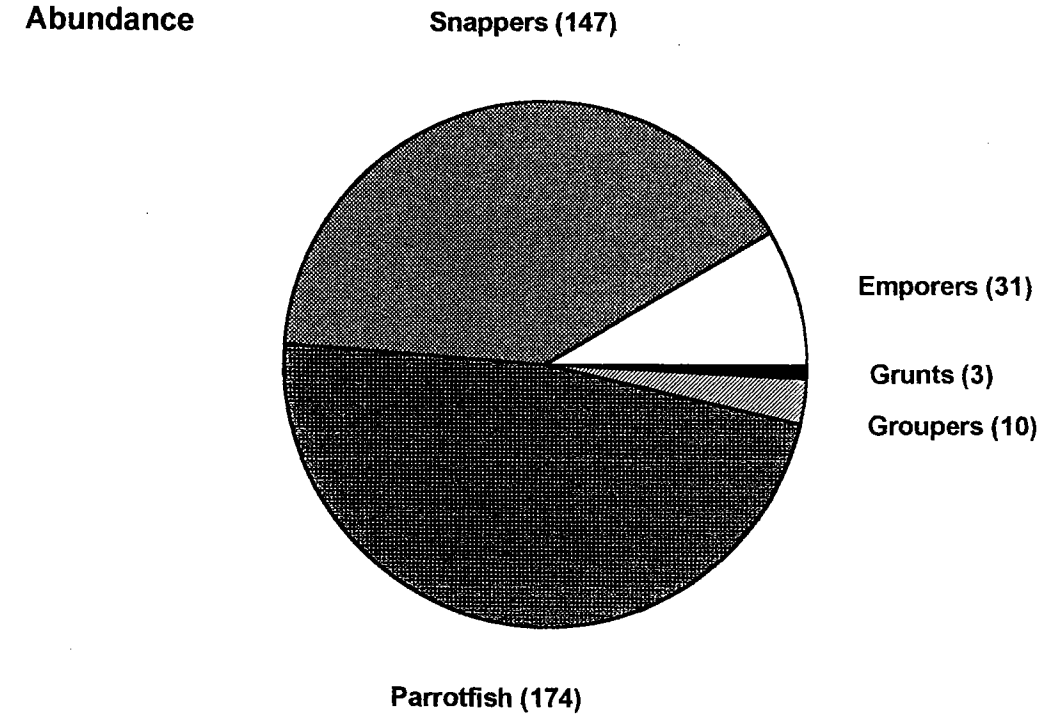
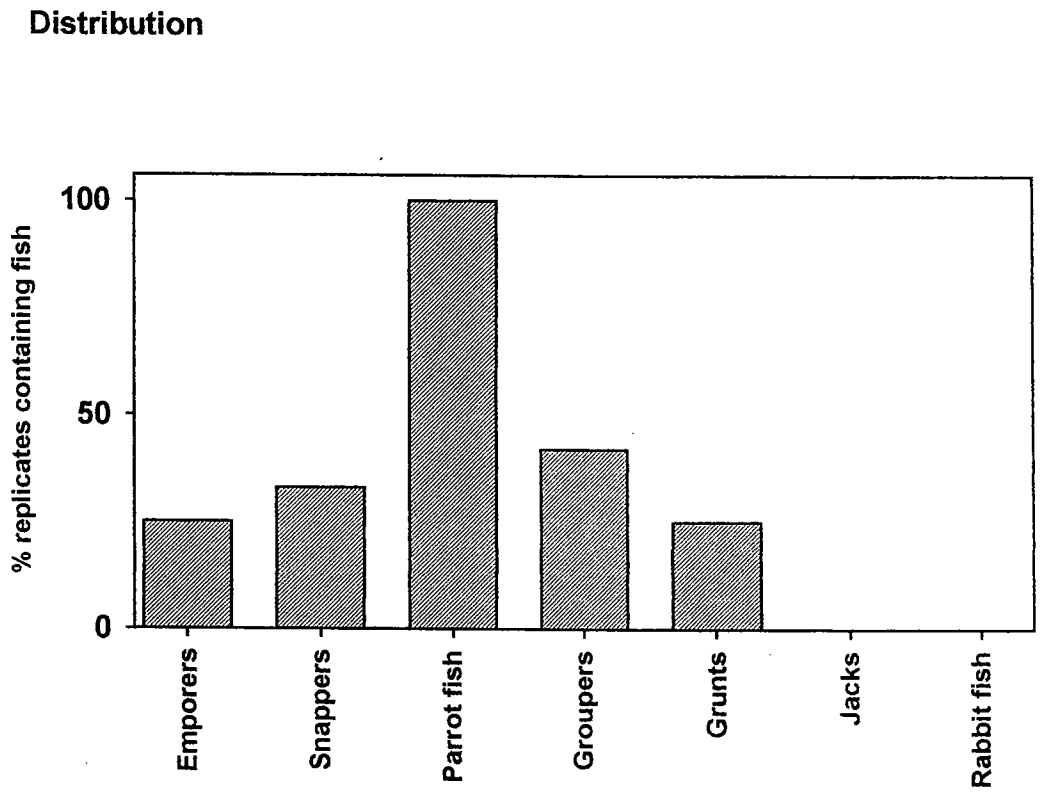


Figure 5.15 The abundance and distribution of commercial fish at site R4.





5.7.3 Size Distributions

The size distributions of the commercial fish recorded are summarised for all the sites in Table 5.16 below. Generally the commercial fish recorded from Rolas were of a smaller estimated median length than those recorded from many of the other islands. This is probably a reflection of the relatively low abundance of many of the families rather than an indication of fishing pressure.

Table 5.16 Size distribution summary for the commercial fish of Rolas island.

'Commercial' Fish Family	Number	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae	45	15	15-30
Lutjanidae	204	15	15-30
Scaridae	405	15	5-80
Serranidae	45	25	10-60
Haemulidae	25	30	20-60
Carangidae	0	-	-
Siganidae	3	15	15

5.8 Finfish Fisheries

Rolas (in Kimwani, Kiriowori) is a small island north of Matemo. The island is surrounded by fringing reef and areas of bommies beyond which lies fairly deep water.

Table 5.17 A summary of the population involvement with different fishing techniques.

Rolas Island	Number
Permanent population	0
Fishermen: resident	0
itinerant	30
Fishing Method	
Line	20
Seine net	0
Trap: Large Marema	1
Trap: Marema	2
Trap: Suri	2
Luwando	0
Spear	2
Sailing boats	1
Canoes	16

During the survey there were about 30 migrant fishermen living on Rolas (November 1996). Many of them were from villages on the adjacent mainland, and Pemba. As the fishermen were staying on Rolas temporarily, they did not bring their families with them.

The only fishing vessels based on the island were dug-out canoes ('casquinhas'). Occasionally large fishing boats were seen net fishing off the island but these boats were based on the mainland and it was not possible to look at their catches. Approximately sixteen canoes were seen in use during the week of study. The majority of these were used by individual line fishermen, although one 'suri' trap fisherman was seen and one fisherman who set the large 'marema' traps at the reef base and in bommie areas.

5.9 Resource Collection

5.9.1 Overview

The intertidal area of Rolas Island was narrow, with a low habitat diversity and was observed to support few resources. The scale and patterns of exploitation were assessed during 5 spring tides in November 1996 and the findings are described below.

Scale and Intensity of collection
The level of intertidal exploitation during the survey period was low, with 4 people involved. Of these only one exploited the intertidal on all 5 days of the study period, always in the lagoon/crest zones. The nearshore rocks were visited by collectors only 3 times, making exploitation pressure in this zone very low.

Gender of Collectors
All 4 collectors were adult males. Traditionally only adult males seem to become itinerant exploiters of the intertidal, whilst less mobile females and children remain in the place of origin.

Group Structure
All collectors exploited the resources as individuals, reflecting the independent nature of itinerant exploiters.

Origin of collectors
All were from Mucojo which is one of the nearest villages on the mainland.

Method of collection
The methods used reflected the catch being obtained, holothuria were collected by hand while the octopi were caught with the aid of iron rods.

Catch Composition

Octopus dominated the catch and this reflected firstly, their abundance on the reef intertidal and secondly, the potential to sell them, dried, in Mucojo and other mainland settlements. The catch of holothuria was carried out by 1 person who stated that he would sell them in Tanzania. The 'FO' gastropods *Chicoreus rumosus* and *Fasicolaria trapezium* were occasionally collected.

5.9.2 Distribution of Effort across Intertidal Zones

All collectors were commonly observed on the lagoon and reef crest areas. The areas where the resources were targeted within the intertidal zone are illustrated on Fig. 5.16.

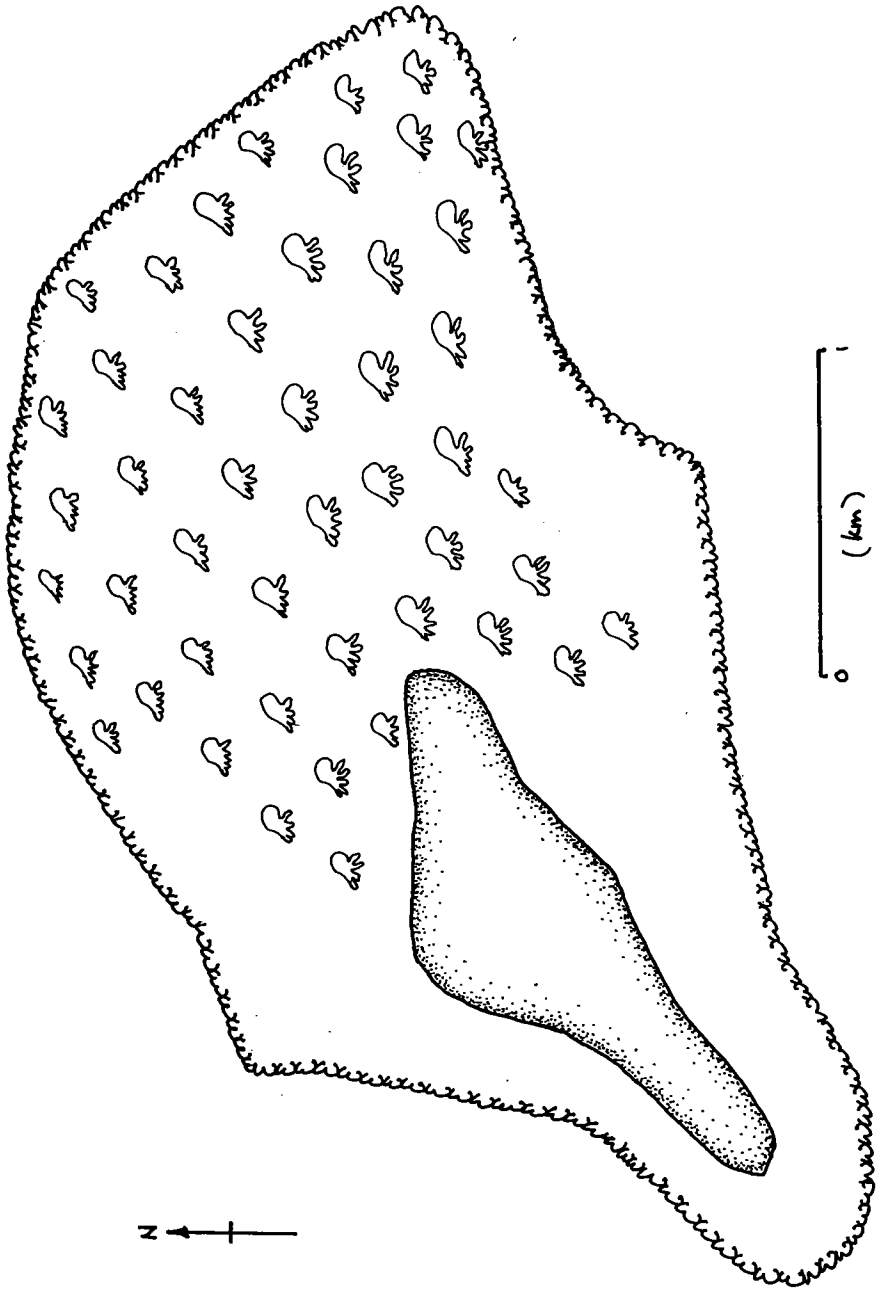
Subtidal Collection

Most of the fishermen were only interested in the fin fishery. Unlike Matemo and Macaloe islands, which receive large numbers of itinerant exploiters from mainland towns (e.g. Pemba and Nacala) on Rolas all of them were from the neighbouring mainland village of Mucojo. This has important implications for the catch composition. Exploiters from Pemba and Nacala are able to sell 'CT' gastropods and holothuria profitably and with relative ease, whereas those from Mucojo are not. Thus, there is little incentive to exploit these resources on Rolas.

Discussion

The main target resources were octopi which constituted an important source of food and income for the Mucojo collectors. The second most collected resources were holothuria which would be sold in Tanzania. The intensity of collection was highest in the lagoon and reef crest areas where these resources were most common.

Figure 5.16 Location of intertidal resource target areas, Rolas.



6.0 MATEMO ISLAND

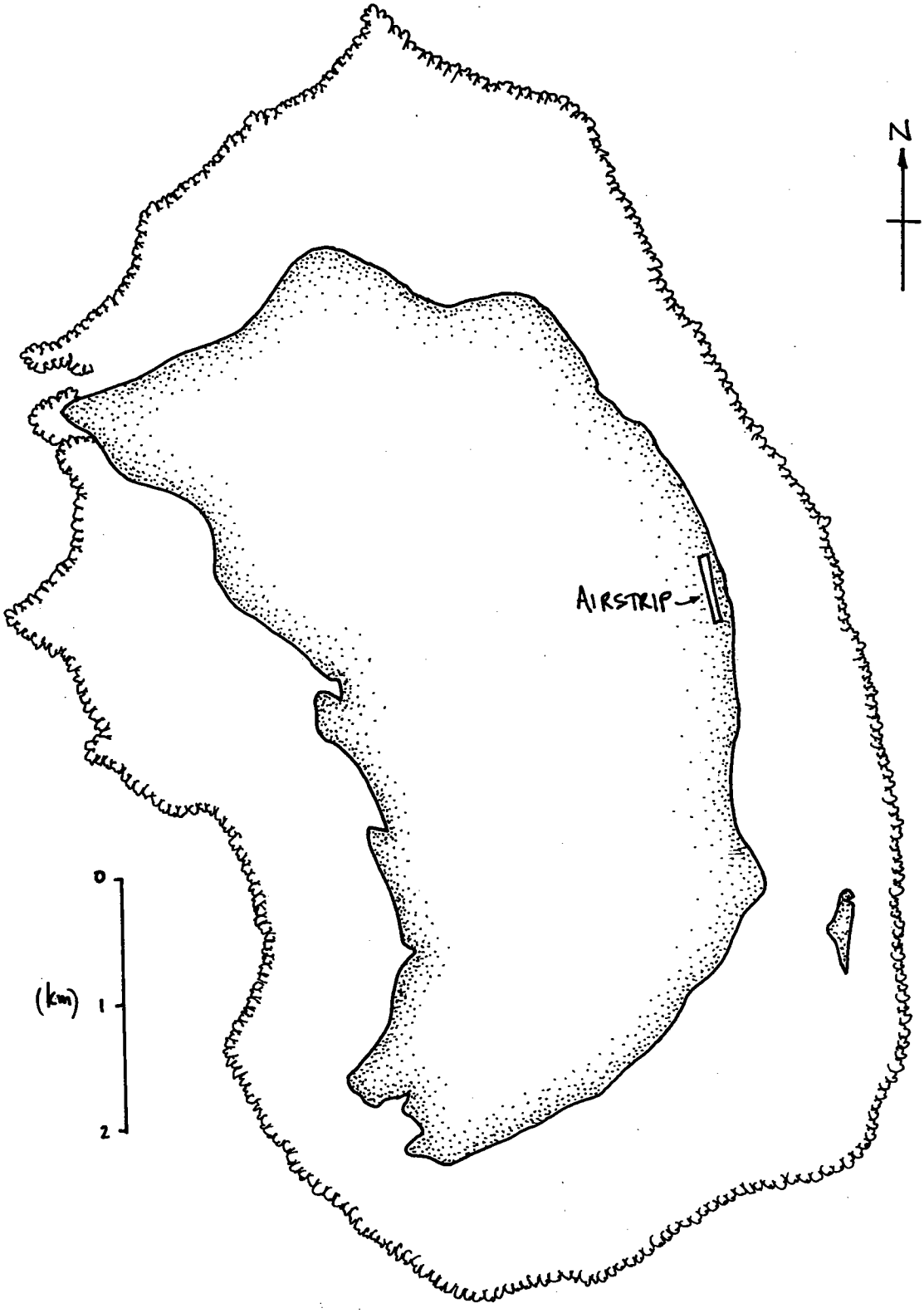
6.1 Introduction

Matemo island (12°12'30"S 40°36'00"E) is the largest island in the Programme's study area (7.4km by 3.3km) and is separated from Ibo island to the south by a deep channel and the Baixo de S^{t} Goncalo reef (Fig. 6.1). The island has a large resident population (2,000 people) that live in a series of settlements based mainly along the eastern coast of the island. The island lacks basic infrastructure but does have a local administrator. There is freshwater available from wells in the south of the island but the quality varies markedly with the seasons, becoming brackish towards the end of the 'dry' season (April-November). Close to the main village is a little-used airstrip.

The north-western point of the island is currently proposed as a site for a tourist concession but by February 1998 no building work had commenced. The area was however the site for a large semi-permanent settlement for migrant fishermen, most from Nampula Province and Tanzania. During the time of the Programme's work (April 1996-December 1997) the settlement had grown from less than 10 tents/rudimentary shelters to a 'village' for a few hundred fishermen.

The island supports a variety of vegetation types; scrub bush, woodland, grassland, marsh and mangrove. There are also several small, informal coconut plantations.

Figure 6.1 Location of Matemo Island



6.2 Intertidal Surveys

6.2.1 Overview

Matemo is the largest island within the N.I.G., with an estimated intertidal zone of 14.2 km^2. Five transect surveys were undertaken around the island (Fig. 6.2) Like Mogundula and Macaloe, the intertidal zone on Matemo was dominated by macroalgae. The seagrass beds were confined to small patches and typically consisted of *Thalassia hemprichii*. A total of 3 species of seagrass, 97 macroalgae and 78 invertebrate species were recorded. The surveyed fauna comprised 74 molluscs and 4 echinoderms. The macroalgal flora included Cyanophyta (1 species), Chlorophyta (36 species), Phaeophyta (19 species) and Rhodophyta (41 species). A checklist for seagrass and macroalgae is presented in Appendix A2.

6.2.2 Area Reports

'North Area'

The 'North Area', with an average width of approximately 2.2km, is the most exposed area of reef flat. The typical pattern of zonation is presented in Figure 6.3.
A total of 26 macroalgal and 7 invertebrate species were recorded. The representation of substratum types within each zone is summarised in Table 6.1. The distribution of taxa across zones is presented in Tables 6.2 and 6.3.

Table 6.1 Percentage cover of substratum along a typical transect within the 'North Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3	Zone 4	Zone 5
Sand	0	50 (0-100)	50 (0-100)	0 (0-5)
Mud	0 (0-8)	0	0	0
Rock	100 (92-100)	50 (0-100)	45 (0-100)	90 (5-100)
Rubble	0	0	0	5 (0-90)

Zone 1 was a bare sand beach. Zone 2 was undulating nearshore rock on which 4 species of macroalgae (with cover less than 15%) and 4 species of invertebrate were recorded. Zone 3 was a flat rock platform covered by a thin layer of sand in some areas. Most of this zone was devoid of vegetation and invertebrates. Zone 4 comprised a lagoon within which the substratum became a mixture of rock and sand. This zone was also colonised by a few macroalgae. The reef crest (Zone 5) supported the highest macroalgal diversity, with 20 species. The most common invertebrate was *Cerithium nodolosum*.

Table 6.2 Percentage cover of macroalgae along a typical transect within the 'North Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3	Zone 4	Zone 5
Macroalgae				
Acanthophora muscoides	0	0	0	(0-P)
Caulerpa lentillifera	0	0	0	0 (0-1)
Chlorodesmis sp.	0	0	0	(0-P)
Cladophora sp.	0 (0-5)	0	0 (0-6)	(0-P)
Dictyosphaeria cavernosa	0	0 (0-1)	0 (0-1)	(0-P)
Enteromorpha kylinii	2 (0-12)	0	0	0
Enteromorpha sp.	0 (0-4)	(0-P)	0	0
Gelidiella acerosa	0	(0-P)	0	(0-P)
Halimeda opuntia	0	0	0 (0-3)	2 (0-15)
Hydroclathrus clathratus	0	0	0 (0-1)	1 (0-4)
Hypnea cornuta	0	(0-P)	0	0 (0-2)
H.. hamulosa	0	0	0 (0-1)	0
H. nidifica	0	0	(0-P)	0
Jania adhaerens	0	0	0 (0-2)	0
Kappaphycus sp.	0	0	0	(0-P)
Laurencia obtusa	0	0	0 (0-1)	0
Lyngbya majuscula	0	0 (0-1)	0	1 (0-8)
Neomeris van bosseae	0	0	0 (0-P)	(0-P)
Padina sp.	0	0	0	0 (0-4)
Sargassum aquifolium	0	0	0	0 (0-1)
Sargassum spp.	0	0	1 (0-5)	0 (0-4)
Udotea indica	0	0	0	(0-P)
Ulva pertusa	(0-P)	0	0	0 (0-3)
U. pulchra	0	0	0 (0-1)	1 (0-10)
U. reticulata	0	0	0	0 (0-1)
Vanvoorstia spectabilis	0	0	0 (0-7)	(0-P)

Table 6.3 Abundance of invertebrate taxa along a typical transect within the 'North East Area'. Means and ranges (individuals/m^2, n=10) are presented.

Taxonomic group	Zone 2	Zone 3	Zone 4	Zone 5
Gastropods				
Cerithium crassilabrum	0 (0-28)	0	0	0
Thais savignyi	6 (0-15)	0 (0-1)	0	0
Thais sp.	3 (0-9)	8 (0-20)	0	0
Worms				
Cerithidium nodolosum.	0	0	0	0 (0-2)
Erythoe complanata	0	0	0	0 (0-1)
Scyllis sp.	0	0	0	0 (0-1)
Echinoderms				
Echinometra mathaei	0 (0-1)	0	0	0 (0-1)

'East Area'

A cross-sectional profile of typical transect is shown in Figure 6.4. Four distinct zones, a rocky beach, sand flat, lagoon and the reef crest, were identified. The representation of substratum types in each zone is summarised in Table 6.4. Within these zones a total of 22 species of macroalgae (Table 6.5) and 13 invertebrate species (Table 6.6) were recorded.

Table 6.4 Percentage cover of substratum along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 1	Zone 2	Zone 3
Sand	0	10 (0-32)	2 (0-20)
Mud	80 (0-100)	0	0
Rock	10 (0-100)	80 (0-100)	60 (0-100)
Rubble	0	5 (0-68)	20 (0-96)

Zone 1 consisted of undulated nearshore rock covered with silt/mud in some areas. Only 1 species of macroalgae was recorded, covering less than 5% of the available area. Zone 2 a narrow zone of flat sand which backed onto a lagoon. Zone 3 was a lagoon which was dominated by macroalgae, especially *Ulva pulchra, Sargassum binderi* and *Laurencia obtusa.* Zone 4 (reef crest) consisted of a mixture of sand, rock and rubble. This zone supported the highest diversity of invertebrates. As the reef crest was exposed and narrow the diversity and abundance of macroalgae was low.

Table 6.5 Percentage cover of macroalgae along a typical transect within the 'East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic group	Zone 1	Zone 3	Zone 4
Macroalgae			
Acanthophora muscoides	0	0	0 (0-12)
Boergesenia forbesii	0	0	(0-P)
Cladophora sp.	0	5 (0-40)	0
Cystoseira myrica	0	0 (0-4)	0 (0-12)
C. trinodis	0	0 (0-2)	0
Dictyosphaeria cavernosa	0	0	0 (0-4)
Dictyota cervicornis	0	(0-P)	0
Enteromorpha ramulosa	0 (0-4)	0	0
Gelidiella acerosa	0	0	2 (0-8)
Halimeda opuntia	0	(0-P)	0
Hydroclathrus clathratus	0	0	0 (0-2)
Hypnea nidifica	0	1 (0-8)	0
Kappaphycus spp.	0	(0-P)	0
Laurencia obtusa	0	5 (0-60)	0
Lyngbya majuscula	0	0	0 (0-1)
Neomeris van bosseae	0	0	(0-P)
Sargassum aquifolium	0	0 (0-2)	0 (0-4)
S. binderi	0	5 (0-40)	0
Turbinaria conoides	0	0 (0-2)	0
Ulva pertusa	0	0 (0-8)	0 (0-16)
U. pulchra	0	0 (0-40)	0
Valonia aegagrophila	0	0	(0-P)

Table 6.6 Abundance of (individuals/m^2, n=10) invertebrates along a typical transect within the 'East Area'.

Taxonomic Group	Zone 1	Zone 3	Zone 4
Gastropods			
Cerithium crassilabrum	0	0	10 (0-52)
Conus ebraeus	0	0	0 (0-1)
C. lividus	0	0	0 (0-1)
C. sp3.	0	0	0 (0-1)
C. sponsalis	0	0	0 (0-1)
C. vexillum	0	0 (0-14)	0 (0-1)
Cypraea annulus	0	0	0 (0-2)
Marginella sp2.	0	0	0 (0-3)
Marginella sp3.	0	0	0 (0-4)
Nerita albicilla	0 (0-2)	0	0
Echinoderms			
Echinometra mathaei	0	0 (0-7)	0
Bivalves			
Perna cf. *perna*	0	0	A
Hermit crabs			
Dardanus megistos	0	0 (0-1)	0

'South East Area'

A cross-sectional profile of a typical transect is shown in Figure 6.5. Four distinct zones, the beach, nearshore rock, lagoon and the reef crest, were identified. The representation of substratum types in each zone is summarised in Table 6.7. Within these zones, a single seagrass species, 25 species of macroalgae (Table 6.8) and 6 invertebrate species (Table 6.9) were recorded.

Table 6.7 Percentage cover of substratum along a typical transect within the 'South East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3	Zone 4
Sand	0	0 (0-8)	10 (0-50)
Rubble	0 (0-5)	1 (0-6)	10 (0-80)
Rock	99 (95-100)	95 (90-100)	75 (50-100)

Zone 1 was a bare sand beach. Zone 2 was a rock platform characterised by high densities of *Thais* sp. and *Cypraea moneta*. At approximately 330m from MHWS was a lagoon (Zone 3) dominated by *Lyngbya majuscula*. Four gastropods (*Perna perna, Calliostoma* sp., *Strombus mutabilis* and *Strombus gibberulus)* were recorded in the lagoon. Zone 4 comprised a reef crest which was colonised by diverse macroalgae. In contrast to macroalgal diversity, the diversity of invertebrates was low, with only 1 species of bivalve.

Table 6.8 Percentage cover of macroalgae along a typical transect within the 'South East Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3	Zone 4
Seagrass			
Thalassia hemprichii	0	2 (0-12)	0 (0-2)
Macroalgae			
Bryopsis sp.	0	0	(0-P)
Caulerpa racemosa	(0-P)	0	0
Cistoseira myrica	0	2 (0-10)	2 (0-20)
Cladophora sp.	0 (0-6)	0	0
Dictyosphaeria cavernosa	0 (0-8)	0	0 (0-30)
Gelidiella acerosa	0	0 (0-4)	0
Gelidiella spp.	2 (0-20)	0	0
Gracilaria fergusoni	0	0	(0-P)
Gracilaria sp.	0	0	(0-P)
Halimeda opuntia	0	0 (0-2)	(0-P)
Hypnea musciformis	0	0	(0-P)
Laurencia columellaris	0 (0-3)	0	0 (0-10)
L. distichophyla	0	0	1 (0-10)
L. obtusa	(0-P)	0	0
Lyngbya majuscula	1 (0-6)	12 (0-60)	10 (0-40)
Padina boryana	0	0 (0-1)	0
Sargassum aquifolium	0	0	0 (0-2)
S. binderi	0	0 (0-4)	1 (0-6)
Sargassum sp.	0	(0-P)	0 (0-2)
Turbinaria conoides	0	(0-P)	1 (0-10)
Udotea indica	0	(0-P)	(0-P)
Ulva pertusa	0	(0-P)	1 (0-6)
U. reticulata	0	0 (0-2)	0 (0-1)
Valonia fastigiata	(0-P)	0	0
Wurdemannia miniata	0	0	(0-P)

Table 6.9 Abundance (individuals/m^2, n=10) of invertebrate taxa along a typical transect within the 'South East Area'.

Taxonomic Group	Zone 2	Zone 3	Zone 4
Gastropods			
Calliostoma sp.	0	0 (0-1)	0
Cypraea moneta	4 (0-12)	0	0
Strombus gibberulus	0 (0-1)	0 (0-1)	0
S. mutabilis	0	1 (0-3)	0
Thais sp.	A	0	0
Bivalves			
Perna perna	0	0 (0-2)	5 (0-19)

'South Area'

The 'south area' consisted of three distinct zones, the beach, lagoon and the reef crest (Fig. 6.6). The representation of substratum types in each zone is summarised in Table 6.10. Within these zones, 1 seagrass species, 18 species of macroalgae (Table 6.11) and 9 of invertebrates (Table 6.12) were recorded.

Table 6.10 Percentage cover of substratum along a typical transect within the 'South Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3
Sand	1 (0-15)	1 (0-12)
Rock	95 (85-100)	95 (88-100)

Zone 1 was a rock beach backed by a cliff and covered by a thin layer of sand in some areas. Zone 2 was a very shallow macroalgae dominated lagoon. The most abundant macroalgae were *Laurencia papillosa*, *Ulva pulchra* and *Laurencia columellaris*. The reef crest (Zone 3) contained the highest species richness, with 1 species of seagrass, 15 species of macroalgae and 3 species of invertebrates.

Table 6.11 Percentage cover of macroalgae along a typical transect within the 'South Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3
Seagrasses		
Thalassia hemprichii	0	2 (0-22)
Macroalgae		
Champia sp.	0	0 (0-1)
Cistoseira myrica	0	0 (0-4)
Dictyosphaeria cavernosa	2 (0-6)	1 (0-4)
Gelidiella sp.	0	2 (0-24)
Halimeda opuntia	0	0 (0-2)
Hydroclathrus clathratus	(0-P)	0 (0-4)
Hypnea cornuta	0 (0-1)	(0-P)
Laurencia columellaris	2 (0-16)	10 (0-35)
L. obtusa	0 (0-3)	0
L. papillosa	5 (0-32)	0 (0-2)
L. poiti	0 (0-1)	0
Lyngbya majuscula	1 (0-10)	0 (0-8)
Spongocladia vaucheriaerformis	0	0 (0-1)
Udotea indica	0	0 (0-2)
Ulva pulchra	0 (0-35)	0
Valonia fastigiata	0	0 (0-2)
Vanvoorstia spectabilis	0	0 (0-1)
Wurdemannia miniata	0	0 (0-1)

Table 6.12 Abundance (individuals/m^2, n=10) of invertebrate taxa along a typical transect within the 'South Area'.

Taxonomic group	Zone 2	Zone 3
Gastropods		
Cypraea annulus	0	2 (0-5)
Mancinella alouina	0 (0-1)	0
Morula granulata	0 (0-1)	0
Rhinoclavis sinensis	0 (0-1)	0
Rhinoclavis sp.	5 (0-22)	0
Strombus mutabilis	0 (0-1)	0
Bivalves		
Atrina pectinata	0	0 (0-1)
Perna perna	2 (0-6)	0 (0-1)
Echinoderms		
Echinometra mathaei	0 (0-1)	0

'West Area'

Four distinct zones were identified (Fig. 6.7) on the basis of abundance of flora and fauna. 24 species of macroalgae and 9 species of invertebrates were recorded. The representation of substratum types in each zone is summarised in Table 6.13 The distribution of taxa across zones is presented in Tables 6.14 and 6.15. Although the seagrass *Thalassia hemprichii* was observed colonising some areas of the reef crest it was not recorded within quadrats.

Table 6.13 Percentage cover of substratum along a typical transect within the 'West Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Substratum	Zone 2	Zone 3	Zone 4
Sand	0	0	20 (0-100)
Mud	0 (0-4)	0	0
Rock	98 (96-100)	100 (100)	60 (0-100)

Zone 1 was a bare sand beach. Zone 2 comprised nearshore rocks characterised by low macroalgal diversity and cover, and great abundance of the gastropod *Thais* sp. Zone 3 was a very shallow lagoon within which *Cystoseira myrica* dominated the macroalgal vegetation (0 - 85%). The reef crest (Zone 4) was a mixture of rock and sand, and supported the highest macroalgal diversity, but with low cover.

Table 6.14 Percentage cover of macroalgae along a typical transect within the 'West Area'. (P<1% of cover). Median values and ranges (in brackets) are presented.

Taxonomic Group	Zone 2	Zone 3	Zone 4
Macroalgae			
Acanthophora muscoides	0	0	(0-P)
Bryopsis sp.	0	0	(0-P)
Caulerpa sertularioides	0	0	(0-P)
Centroceras clavulatum	0	0	0 (0-3)
Ceramium sp.	0	0	0 (0-2)
Champia sp.	0	0	(0-P)
Cistoseira myrica	0	10 (0-85)	0 (0-4)
Cladophora mauritiana	0	0 (0-1)	0 (0-2)
C. sibogae	0	(0-P)	0
Dasya pilosa?	0	0	(0-P)
Dictyosphaeria cavernosa	0	0 (0-6)	0 (0-20)
Enteromorpha sp.	(0-P)	0	(0-P)
Gelidiella acerosa	0	0	0 (0-3)
Halimeda opuntia	0	0	0 (0-2)
Hydroclathrus clathratus	0	0	0 (0-4)
Hypnea cornuta	0	0	0 (0-30)
H. hamulosa	0	(0-P)	0
Laurencia obtusa	0	0	0 (0-3)
L. papillosa	0 (0-8)	0 (0-10)	2 (0-21)
L. poiti	0	0	(0-P)
Lyngbya majuscula	0	0 (0-4)	0 (0-4)
Udotea indica	0	0	(0-P)
Ulva lactuca	(0-P)	0	0
Vanvoorstia spectabilis	0	0	0 (0-1)

Table 6.15 Abundance of (individuals/m^2) invertebrate taxa along a typical transect within the 'West Area'.

	Zone 2	Zone 3	Zone 4
Gastropods			
Cypraea annulus	1.5 (0-3)	1 (0-5)	0
C. caputserpentis	0	0	0 (0-1)
C. moneta	0	0 (0-1)	
Morula granulata	0	0 (0-4)	0
Strombus mutabilis	0	0	0 (0-2)
Thais savignyi	9 (0-A+)	0	8 (0-A)
Thais sp.	4 (0-11)	10 (0-36)	3 (0-9)
Bivalves			
Atrina pectinata	0	0	0 (0-1)
Perna perna	0	2 (0-6)	0 (0-1)

Figure 6.2 Location of intertidal transects, Matemo.

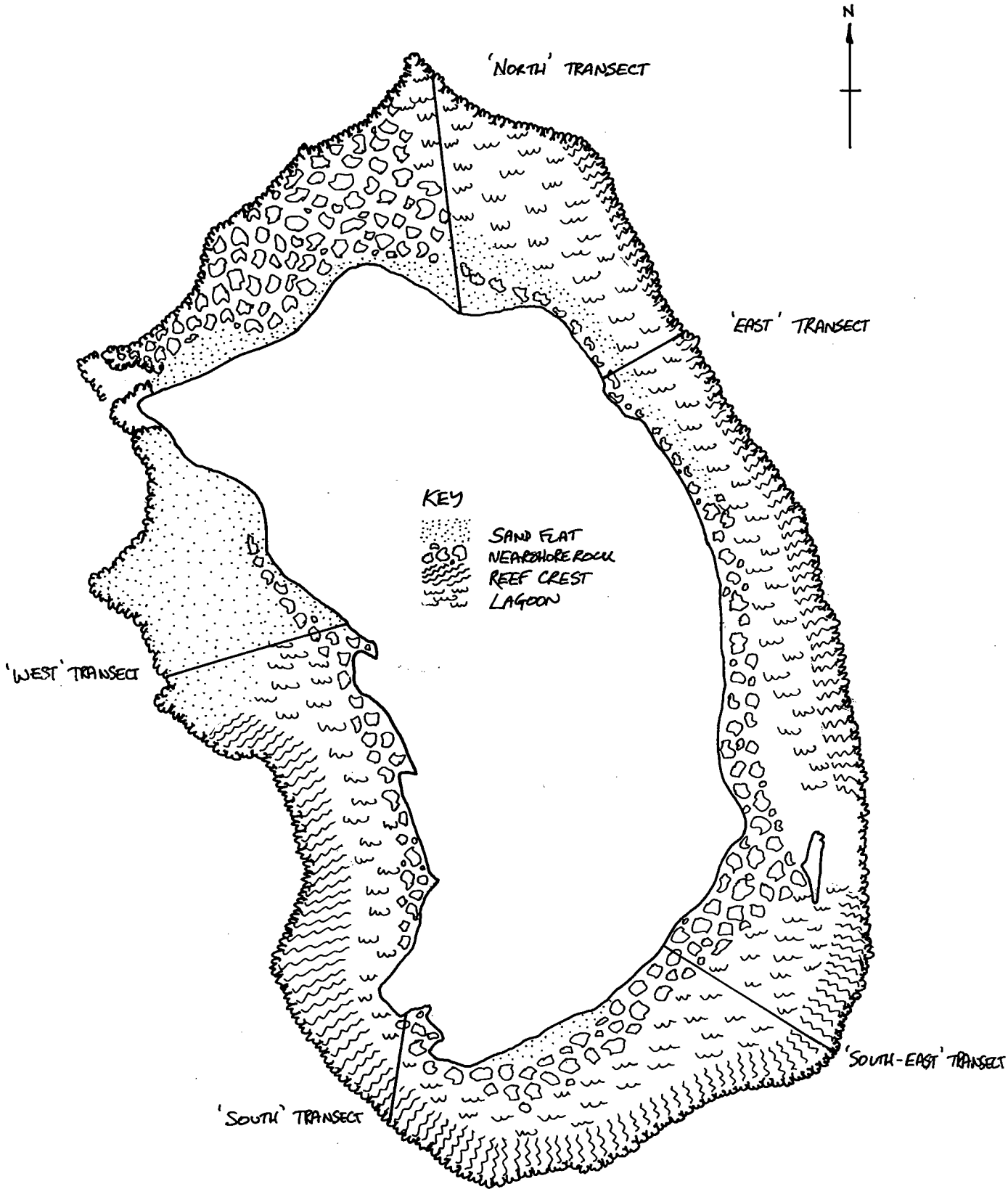


Figure 6.3 Cross section of the 'North' intertidal transect, Matemo.

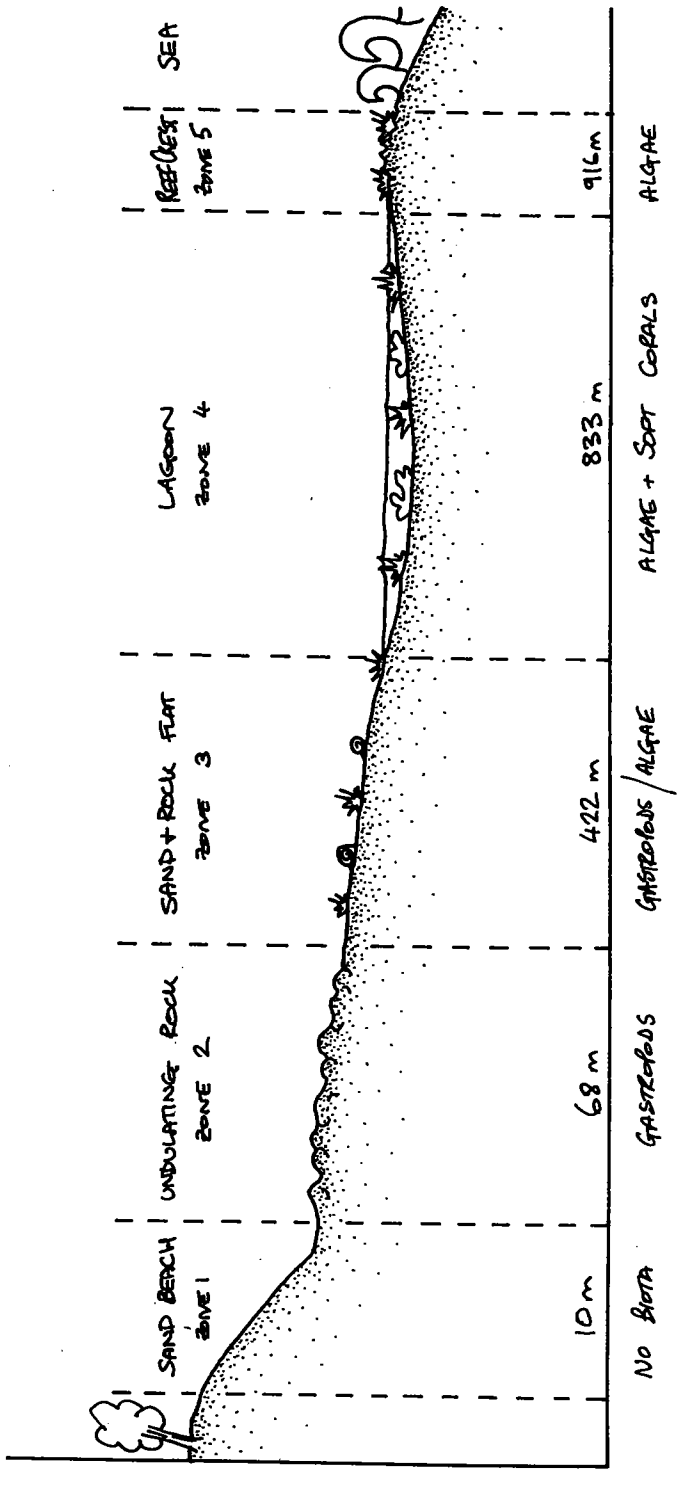


Figure 6.4 Cross section of the 'East' intertidal transect, Matemo.

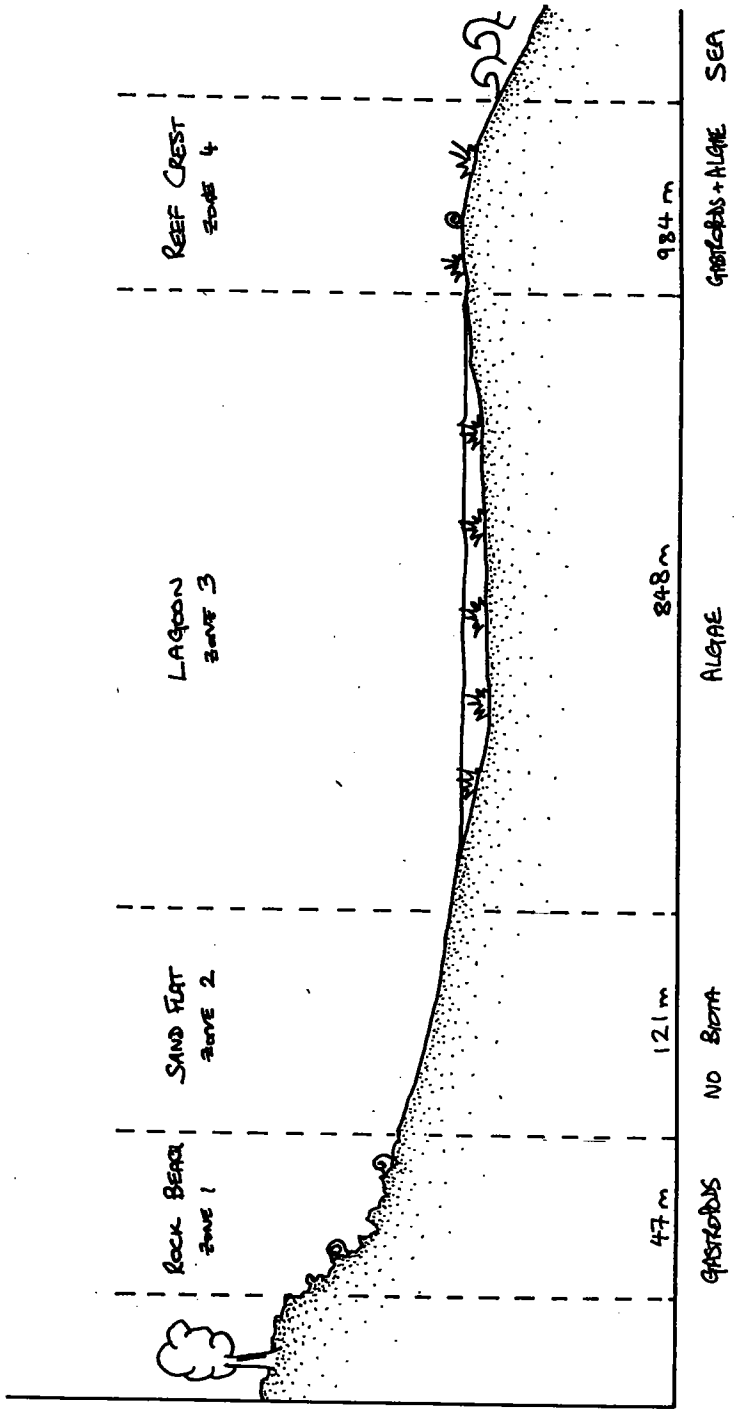


Figure 6.5 Cross section of the 'South East' intertidal transect, Matemo.

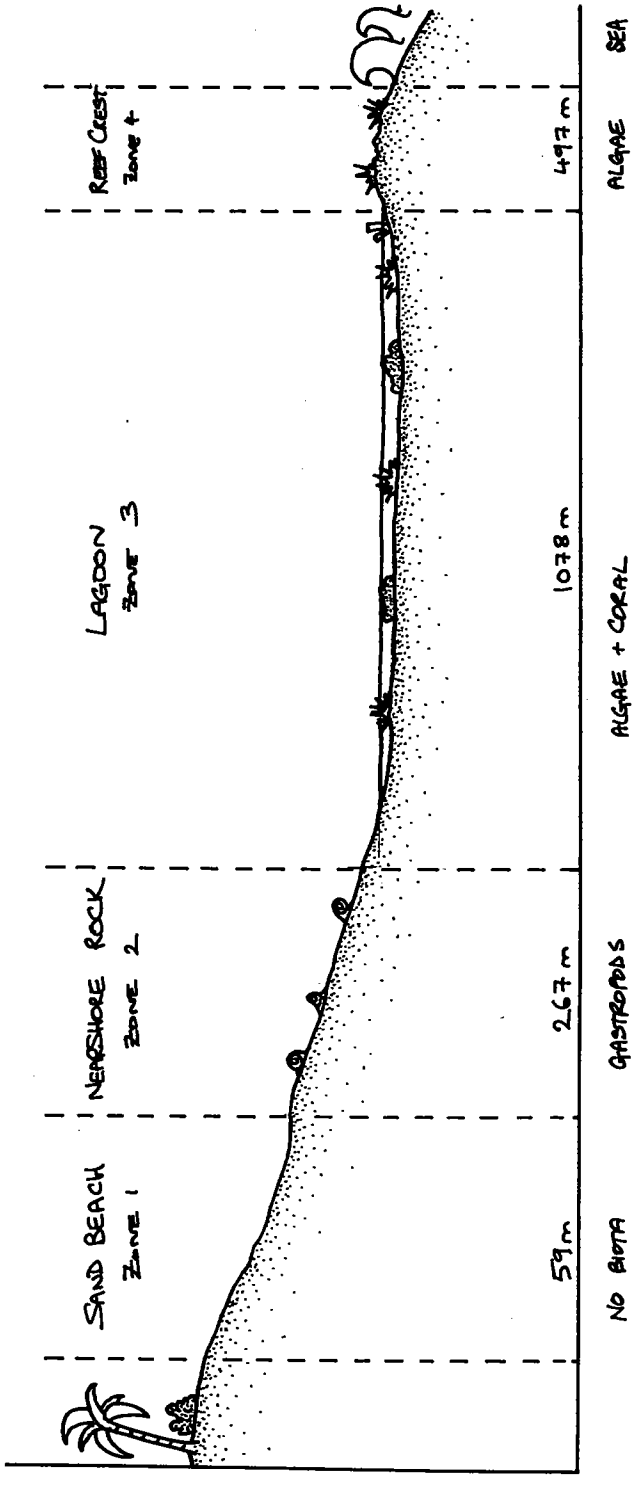


Figure 6.6 Cross section of the 'South' intertidal transect, Matemo.

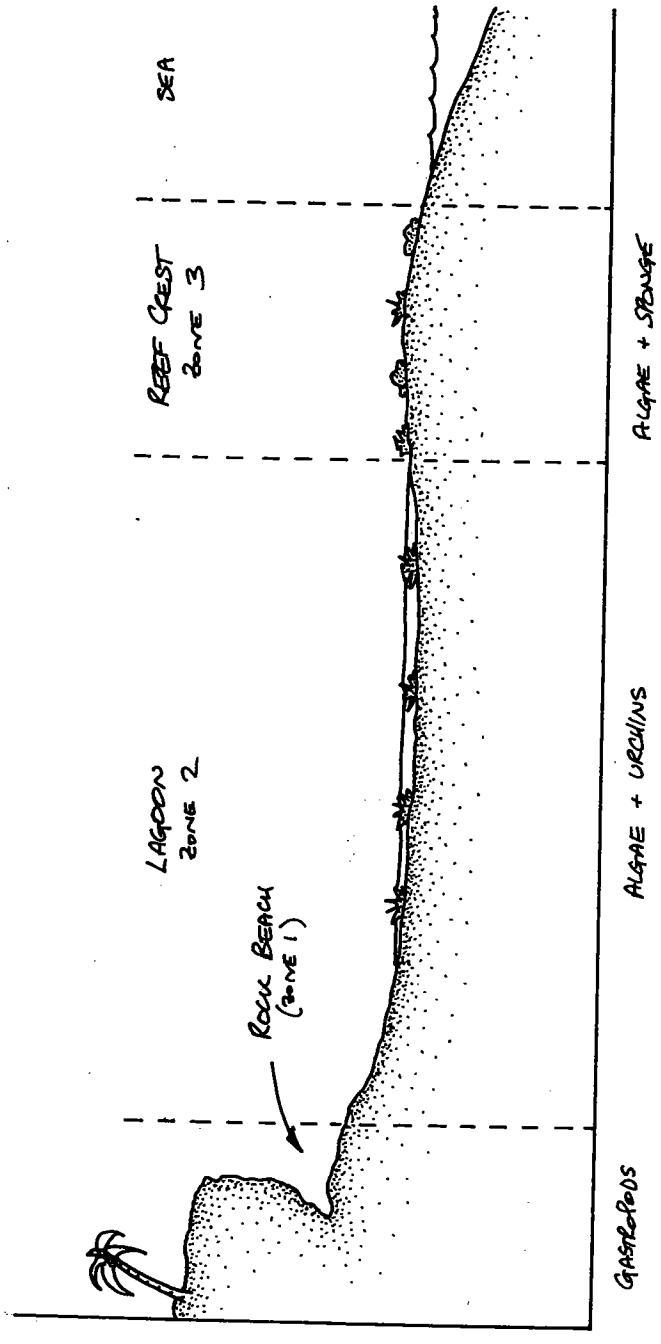
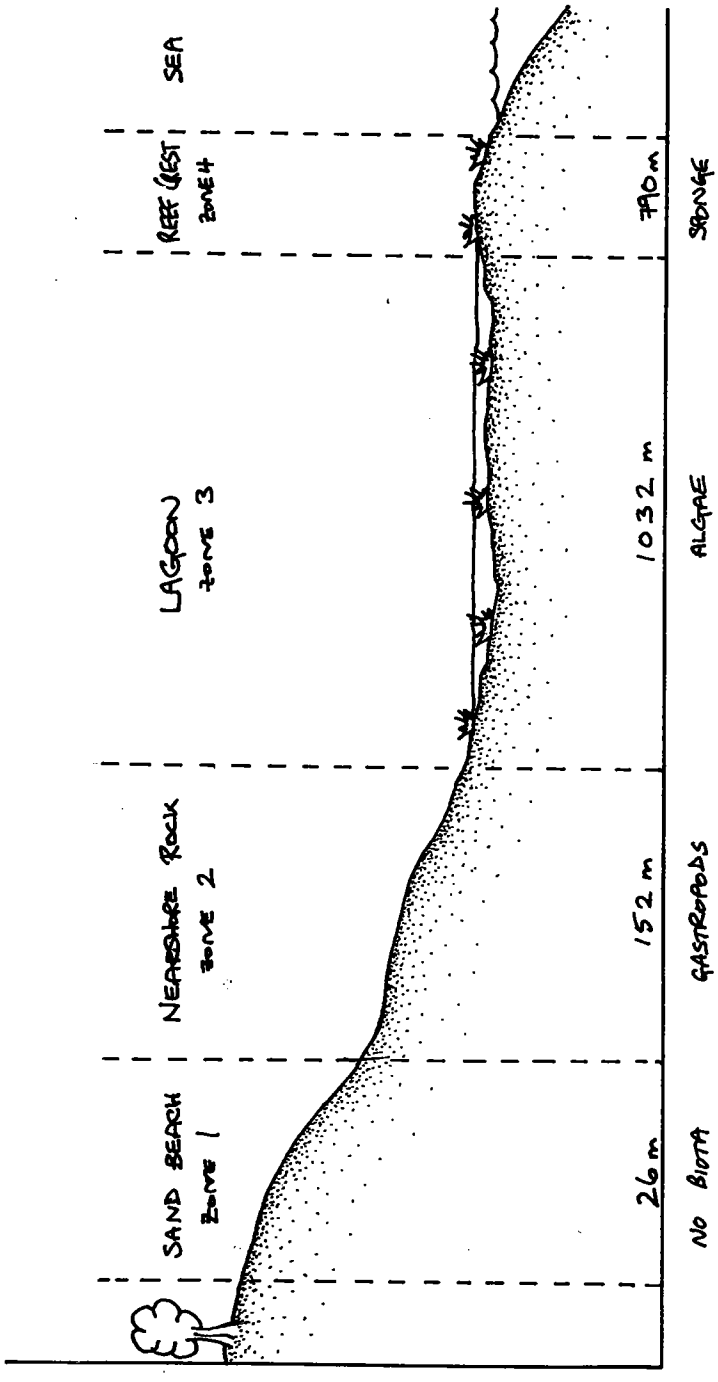


Figure 6.7 Cross section of the 'West' intertidal transect, Matemo.



6.3 Mangrove surveys

6.3.1. Overview

The mangrove on Matemo island occurs mainly in the south-western part of the island although a few trees are found scattered along the central western shoreline (Figure 6.8). The major stand is separated from the sea by a raised sand and coral rag ridge running along the top of the shore. Water drainage for the stand occurs along a series of large creeks which open to the sea through a single entrance along the western shore and two entrances along the southern shore of the island. There was little zonation of mangrove tree species observed with *Ceriops tagal* dominating most areas. Evidence of mangrove cutting was widespread throughout much of the stand.

6.3.2 Stand Description

The stand filled a large depression (approximately 2km long) bounded on most sides by a coral rag wall (<4m high). Large creeks and rock outcrops occurred frequently throughout the stand, with the former providing relatively easy access to most areas.

There was no observed zonation of mangrove tree species within the stand and consequently, the stand can be regarded as a single unit. The descriptive data presented in this section are the result of the analysis of a series of quadrats throughout the stand. The species composition and structure of mangroves within each zone are presented in Table 6.16 below (only areas with significant mangrove colonisation have been analysed).

Table 6.16 Mangrove species composition and structure within the Matemo stand. Mean values and 95% confidence limits are given (n=9).

Species	No. of trees/m^2	Relative density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings/m^2*
B. gymnorrhiza	0.08•0.10	7	3.0•3.1	9	0.2•0.2
R. mucronata	0.13•0.14	10	7.1•8.0	22	0.05•0.06
C. tagal	1.07•0.65	83	22.3•8.2	69	12.2•6.1

C. tagal dominated most of the areas surveyed, particularly in the drier, rocky sections of the stand. *R. mucronata* was limited to the areas close to the creeks and in the wetter depressions. *B. gymnorrhiza* was found in low densities throughout much of the stand. The data for the stand are summarised in Table 6.17.

Table 6.17 Estimates for the size and composition of the Matemo stand. All original figures were estimated to the nearest 100 and all basal area values have been calculated to the nearest $10m^2$. Mean values and 95% confidence limits are given (n=9).

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
B. gymnorrhiza	54000•61000	6.8	190•200
R. mucronata	82500•88000	8.4	450•510
C. tagal	682700•413600	5.2	1420•530
X. granatum	n/a	n/a	n/a

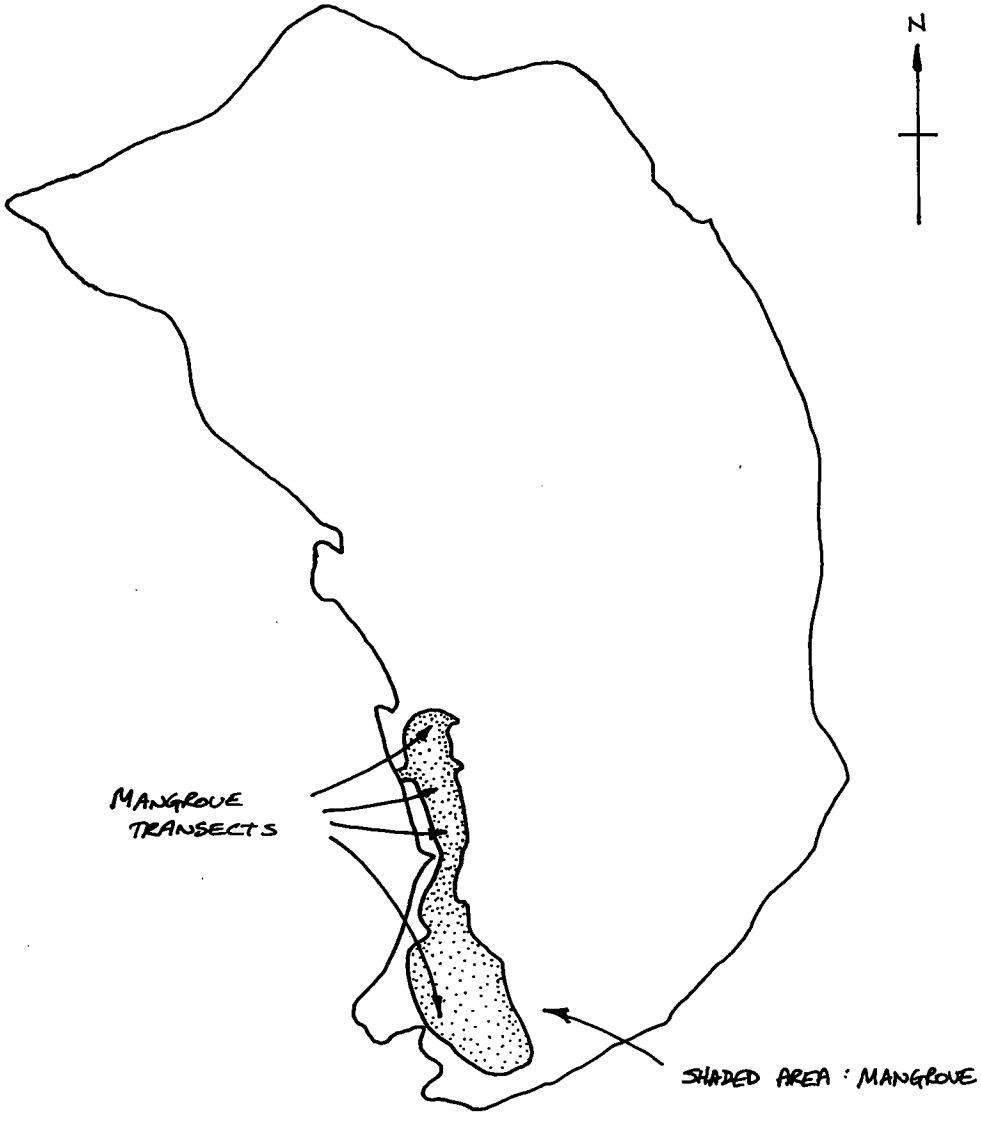
The large numbers of relatively large *C. tagal* trees and the accessibility of most areas of the stand mean that it has been favoured as an area for mangrove cutting. During the surveys (November 1997) there was a small camp of mangrove cutters at the creek entrance on the western shoreline. Around the camp, there were numerous piles of *C. tagal* and *B. gymnorrhiza* which were cut in sizes suitable for firewood and building materials. A further large pile of mangrove wood was observed close to the village towards the south of the stand.

It was clear that the mangroves formed an important resource for the islanders. Although evidence of cutting was observed throughout the stand, no areas were noted where over-cutting appeared to be occurring. However, with the relatively large scale of wood extraction, a managed approach to future cutting is probably required to ensure the sustainability of this resource use activity.

Fauna of the Matemo mangrove

Few animals were observed during the mangrove surveys. The density of active crab burrows was typically between 1-12 holes/m• but in localised areas dense aggregations of Fiddler crabs (*Uca* spp.) were noted. In contrast, in the areas of the stand that were most waterlogged, crab burrows were absent. In the creeks, shoals of juvenile fish, including the Thumbprint emperor (*Lethrinus harak*) and the Convict surgeonfish (*Acanthurus triostegus*), were observed.

Figure 6.8 Location of mangrove transect sites, Matemo.



6.4 Subtidal Habitat Surveys

Subtidal surveys were undertaken at seven sites around the island, MT1 to MT7. MT1 and MT5 were in the north and south respectively, while MT2, MT3 and MT4 were situated to the east of the island and MT6 and MT7 were to the west (Fig. 6.9) of the island.

6.4.1 Overview

Reef Structure and Composition
There were large differences between reef slopes of the eastern and southern reefs of the island. The exposed outer reef comprised of a gentle slope along almost the entire eastern profile of the island, while vertical walls and near-horizontal platforms were recorded in the south. Reef outcrops on flat sandy areas were typical in the north while large bommie fields could be found in the shallow waters of the west. Rugosity was varied, although never very high. Shallow areas in the south and south-east were most rugose while flat sandy areas between bommie fields in the west were the least rugose.

The composition of the substratum ranged from areas where rock was dominant (sites MT2, MT5), to areas of mixed substratum (site MT1 and bommie areas in the west), to non-reef areas composed entirely of sand in the west between bommie fields.

At sites MT3 and MT4 hard corals were the dominant biota, with abundance greatest in shallower waters. Soft corals were common at most sites, particularly on shallower parts of the reefs. Seagrasses, macroalgae and *Halimeda* spp. were also present at most sites but abundance were generally very low. Hard corals were dominated by 'branching' and 'massive' forms in all reef areas.

6.4.2 Site Reports

Site MT1:
The reef structure and community composition are described below and summarised in Table 6.18 and Figure 6.10.

Reef Structure
The reef at this site was not well-developed and composed of low lying rock outcrops on a very shallow slope (<10°). The incidence of these rocky outcrops decreased with depth. Bommie fields were also observed close to the reef crest.

Substratum Composition
Around patches of rock and coral the substratum was a mixture of rubble and sand, sand becoming more dominant with depth.

Biotic Cover

Hard and soft corals comprised the majority of the biotic cover at this site, being abundant over much of the reef. Soft corals were slightly more abundant than hard corals, often occurring in dense patches within some survey replicates. Macroalgae and *Halimeda* spp. were recorded but cover was always less than 5%. Hard corals were dominated by 'branching' forms.

Table 6.18 A summary of the structure, composition and biotic cover at MT1. (P<1 % cover).

Reef Features		Inner Reef (n=24) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	2	1-4
Substratum	Rock	3	P-4
	Rubble	2	P-3
	Sand/Shell	3	2-4
	Mud	0	0
Biota	Hard Coral	2	P-3
	Soft Coral	3	1-4
	Seagrass	0	0
	Macroalgae	P	0-1
	Halimeda spp.	P	0-1
Coral State	Heterogeneity	0	0
	Dominance	Branching	

Site MT2:

The reef structure and community composition are described below and summarised in Table 6.19 and Fig. 6.11.

Reef structure

The reef sloped gently (<10°) down to a depth of 18m, beyond which a sandy substratum descended (at 20°) towards the continental shelf. Rugosity tended to be slightly higher between 15m and 18m than in shallower waters.

Substratum Composition

Down to a depth of 18m the substratum was typically of rock with a few sand and rubble patches between coral formations. Beyond 18m sand dominated.

Biotic cover

Below the reef and greater than 18m the substratum was of sand with little biotic cover. Hard and soft coral cover was similar, each covering up to 90% of the reef surface within some survey replicates. 'Branching' forms of coral achieved dominance in most survey replicates. Macroalgae was present in small quantities throughout the reef with no evidence of zonation. *Halimeda* spp. was observed only occasionally.

Table 6.19 A summary of the structure, composition and biotic cover at MT2 (P<1 % cover).

Reef Features		Upper Reef (n=20) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	3	1-4
Substratum	Rock	4	2-4
	Rubble	1	0-4
	Sand/Shell	3	1-6
	Mud	0	0
Biota	Hard Coral	2	P-5
	Soft Coral	2	P-5
	Seagrass	0	0
	Macroalgae	P	P-2
	Halimeda spp.	0	0-1
Coral State	Heterogeneity	0	0
	Dominance	Branching	

Site MT3:
The reef structure and community composition are described below and summarised in Table 6.20 and Figure 6.12.

Reef Structure
The seabed sloped away from the island (<10°), although slightly steeper between 7 - 10m. Reef occurred down to a depth of 10m, beyond which sand and patchy seagrass dominated. Rugosities were higher in shallow areas.

Substratum Composition
Rock was dominant above 10m with patches of sand and rubble. In deeper areas sand became dominant with occasional bommies.

Biotic Cover
Hard and soft coral dominated the biotic cover (up to 75%) in the shallower waters of this site (<10m). Seagrass, macroalgae and *Halimeda* spp. were all recorded in low abundances throughout the survey above 6m, while only seagrass (and *Halimeda* spp. in one replicate) was noted towards the bottom of the reef. Hard corals were predominantly 'branching' in form.

Table 6.20 A summary of the structure, composition and biotic cover at MT3 (P<1% cover).

Reef Features		Upper Reef (n=24) Mode (0-6)	Upper Reef (n=24) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	0	0-10	10	1-10
	Rugosity	3	1-5	3	2-4
Substratum	Rock	5	1-5	1	P-4
	Rubble	2	0-3	0	0-2
	Sand/Shell	1	P-4	3	3-5
	Mud	0	0	0	0
Biota	Hard Coral	4	0-5	1	0-3
	Soft Coral	3	0-3	P	P-3
	Seagrass	0	0-3	1	0-3
	Macroalgae	P	0-3	P	P-1
	Halimeda spp.	P	0-P	0	0-P
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching/Small Massive		Branching/Small and Big Massive	

Site MT4:
The reef structure and community composition are described below and summarised in Table 6.21 and Figure 6.13.

Reef Structure
This site was located at the point where the gently sloping reefs of the east become vertical reef walls, typical of the south of the island. Survey replicates were undertaken just east of the walls. Here the slope was still gentle (<10°) with occasional steeper areas (<30°). Further from the island the slope descended into the deep channel running along the south of Matemo. The reef formed the most consistently rugose coral garden site on the island and boasted some large (>10m diameter) bommies in shallower water.

Substratum Composition
The substratum was predominantly of rock (up to 75%) with sand and rubble collecting in the furrows. Sand became more abundant with depth.

Biotic Cover
Hard coral was the dominant biota throughout the site, although soft corals reached 75% cover in some survey replicates. Macroalgae and *Halimeda* spp. were recorded in low abundances within most replicates but zonation was not evident.

Table 6.21 A summary of the structure, composition and biotic cover at MT4 (P<1% cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=20) Mode (0-6)	Lower Reef (n=20) Range (0-6)
Morphology	Slope (°)	0	0-10	0	0-30
	Rugosity	3	3	3	2-4
Substratum	Rock	4	4-5	4	3-5
	Rubble	2	1-2	1	0-3
	Sand/Shell	1	1-2	3	1-4
	Mud	0	0	0	0
Biota	Hard Coral	4	3-4	4	3-4
	Soft Coral	2	0-3	2	1-4
	Seagrass	0	0	0	0-P
	Macroalgae	P	P	P	0-1
	Halimeda spp.	P	P	P	0-P
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching		Branching/Big Massive	

MT5:

The reef structure and community composition are described below and summarised in Table 6.22 and Fig. 6.14. A profile of this site has been presented graphically, with a breakdown of the various coral forms (Fig. 6.15).

Reef Structure

The reef at this site was subject to strong currents, was extensive both vertically and horizontally and possessed well-defined morphological zones. A near vertical rock wall extended from 10m - 18m and in places was undercut to form large caves. Below the wall at 18-23m there was a rock platform, with a slope of between 0° and 45°. Beyond this platform the slope descended rapidly into the channel, which is recorded on charts as being greater than 50m deep in parts. Above the wall (<10m depth) was a plateau with minimal slope that extended up to the reef crest. Upper and lower horizontal survey transects were above the wall and at the base of the wall respectively. Rugosity was similar on both of these transects while below 23m and on the wall itself rugosity was low.

Substratum Composition

The vertical wall was constructed entirely of rock, above which the plateau was a mixture of rock, rubble and sand. The base of the 'wall' was also predominantly of rock, although rubble and sand was common. Beyond the reef, and into the depths of the channel, sand and rubble became dominant.

Biotic Cover

Hard and soft corals comprised the majority of the biotic cover, although cover was never greater than 50%. No *Halimeda* spp. was recorded, while macroalgae was present in almost all survey replicates. Seagrass was also seen in small patches, primarily in shallower waters. The hard corals were dominated by 'branching' forms both above and below the wall.

Table 6.22 A summary of the structure, composition and biotic cover at MT5 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=14) Mode (0-6)	Lower Reef (n=14) Range (0-6)
Morphology	Slope (°)	0	0	20	0-45
	Rugosity	2	2-3	2	1-3
Substratum	Rock	3	P-4	5	P-6
	Rubble	2	2-4	1	0-2
	Sand/Shell	2	P-4	1	P-6
	Mud	0	0	0	0
Biota	Hard Coral	2	P-3	1	P-2
	Soft Coral	2	1-3	1	0-3
	Seagrass	P	0-P	0	0-P
	Macroalgae	P	P-1	P	0-2
	Halimeda spp.	0	0	0	0
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching/Small Massive		Branching/Encrusting	

Site MT6:

The reef structure and community composition are described below and summarised in Table 6.23.

Reef Structure

Coral reef was limited to occasional bommies and small patch reefs on an otherwise flat sand area. Rugosities were high on these patches and bommies but elsewhere were low.

Substratum Composition

Sand was dominant in the shallower waters of the site, while in deeper waters (9m) where patch reefs were common, rock often formed up to 50% of the substratum in survey replicates.

Biotic Cover

Hard and soft coral cover was very similar on most bommies and patch reefs. Seagrass was occasionally recorded in dense patches in shallower waters. Macroalgae was uncommon but typically formed patches in the shallow waters of the site.

Table 6.23 A summary of the structure, composition and biotic cover at MT6 (P<1 % cover).

Reef Features		Upper Reef (n=12) Mode (0-6)	Upper Reef (n=12) Range (0-6)	Lower Reef (n=12) Mode (0-6)	Lower Reef (n=12) Range (0-6)
Morphology	Slope (°)	0	0	0	0
	Rugosity	0	0-4	1	0-3
Substratum	Rock	P	P-2	3	0-3
	Rubble	P	P-2	1	P-3
	Sand/Shell	6	4-6	3	2-5
	Mud	0	0	0	0-1
Biota	Hard Coral	P	P-2	2	0-3
	Soft Coral	P	P-2	2	0-3
	Seagrass	0	0	0	0-4
	Macroalgae	0	0-P	P	0-3
	Halimeda spp.	0	0	0	0
Coral State	Heterogeneity	0	0	0	0
	Dominance	Branching/Small and Big Massive		Branching	

Site MT7:
The reef structure and community composition are described below and summarised in Table 6.24.

Reef structure
Reef structures in this area were predominantly small and large bommies (often up to 5m in diameter). Rugosity on bommies was often high.

Substratum Composition
The substratum was mainly of sand (up to 100%) with rubble patches. Rock/bommie outcrops, as described above, interrupted this cover. Rubble was often recorded at the base of bommies.

Biotic cover
The abundance of hard and soft coral on bommies was similar. Away from the island and greater than 5m depth, the substratum was of sand with little biotic cover. 'Branching' and 'Small massive' forms of coral achieved dominance on bommies. Macroalgae, seagrass and *Halimeda* spp. were not abundant.

Table 6.24 A summary of the structure, composition and biotic cover at MT7 (P<1 % cover).

Reef Features		Upper Reef (n=6) Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0
	Rugosity	1	0-4
Substratum	Rock	2	P-5
	Rubble	P	0-2
	Sand/Shell	5	2-6
	Mud	0	0
Biota	Hard Coral	P	P-5
	Soft Coral	1	1-4
	Seagrass	0	0-P
	Macroalgae	P	0-1
	Halimeda spp.	P	0-1
Coral State	Heterogeneity	0	0
	Dominance	Branching	/Small massive

6.4.3 Subtidal flora

Matemo consisted of patch reefs on the eastern side of the island with a well developed wall in the south and sand/bommies in the northern section. The sheltered western subtidal zone supported bommies to the north and seagrass beds to the south. A total of 6 sites were surveyed within which 3 species of seagrass and 37 macroalgae species; Cyanophyta (1 species), Chlorophyta (15 species), Phaeophyta (7 species) and Rhodophyta (14 species) were recorded. A checklist of seagrass and macroalgae for the N.I.G. is presented in Appendix A2.

Area Reports

Site MT1:

This site was made up of sand/bommies and a total of 9 species of macroalgae: Chlorophyta (4 species), Phaeophyta (3 species) and Rhodophyta (2 species). The most common macroalgae in the shallower waters (< 4m) was *Sargassum duplicatum. Halimeda melanesica* was observed as being the dominant macroalgae species at depths from 4 - 6 metres.

Site MT2:

Twelve species of macroalgae: Chlorophyta (6 species) Phaeophyta (2 species) and Rhodophyta (4 species) were recorded. From 15 - 18m *Dictyota adnata* dominated the subtidal flora.

Site MT3:
This site comprised a mixture of sand/seagrass or sand/corals within which 10 species of macroalgae: Chlorophyta (5 species), Phaeophyta (2 species) and Rhodophyta (3 species) were recorded.

Site MT5:
At this site there was a strong current during the survey. The upper reef was colonised by the seagrass *Cymodocea rotundata* while the lower reef comprised a steep wall with sand/rubble at the base. Only 1 species of macroalgae was recorded.

Site MT6:
This site consisted of sand/seagrass in the south and to the north comprised sand/bommies. Within these habitats 2 species of seagrass and 18 of macroalgae: Cyanophyta (1 species), Chlorophyta (6 species), Phaeophyta (4 species), and Rhodophyta (7 species) were recorded. In the bommie areas the most abundant macroalgae was *Sargassum* sp.

Site MT7:
This site was predominantly sand with scattered bommies; 1 species of seagrass and 2 species of macroalgae (both Chlorophyta) were recorded.

Figure 6.9 Location of subtidal habitat survey sites, Matemo.

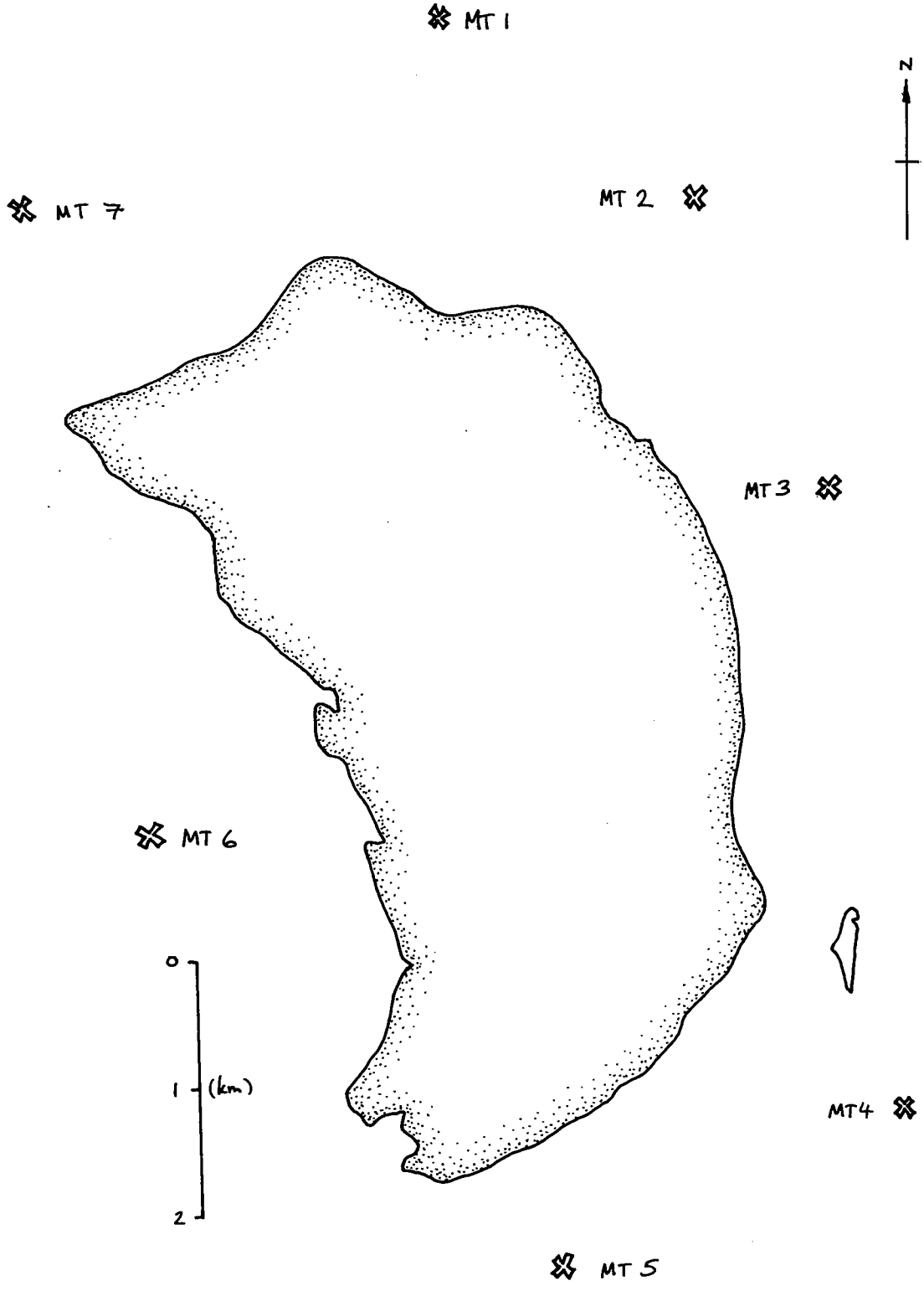


Figure 6.10 Habitat profile of Site MT1, Matemo.

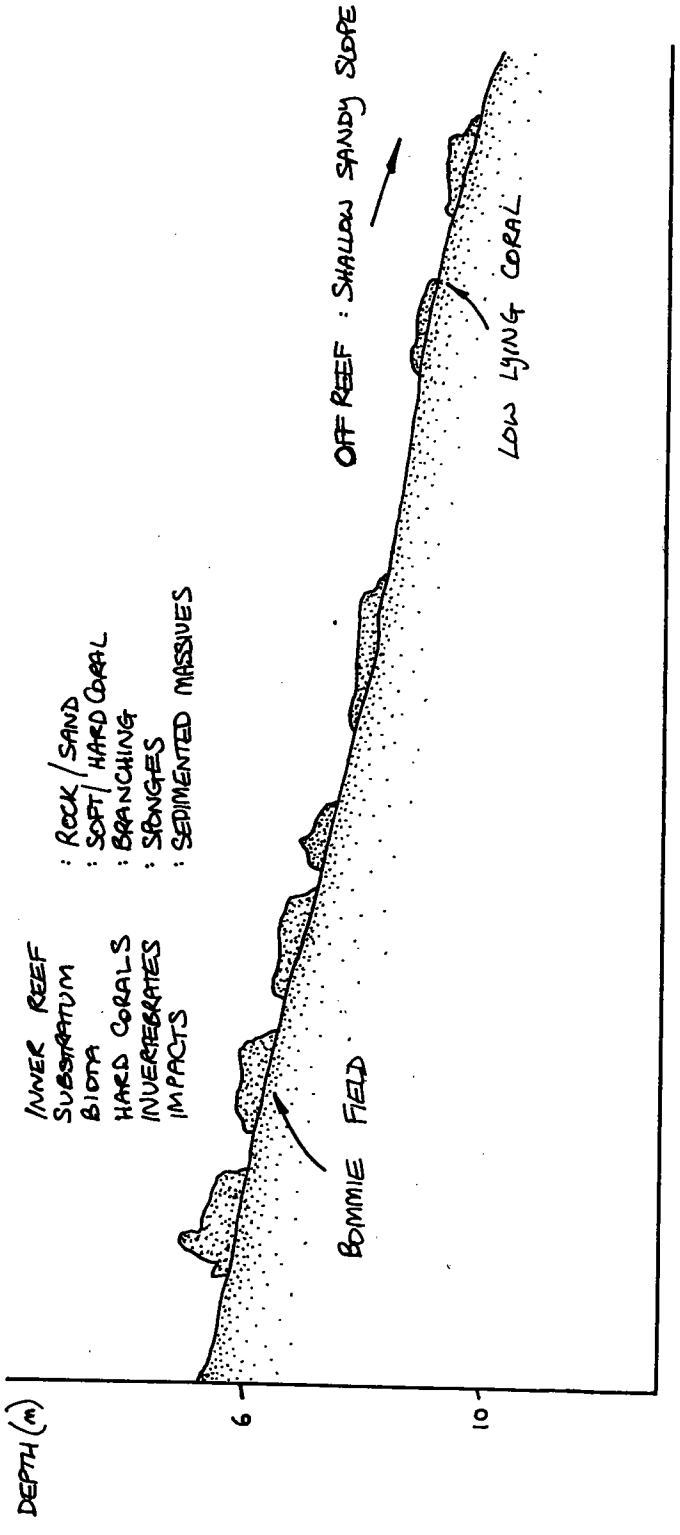


Figure 6.11 Habitat profile of Site MT2, Matemo.

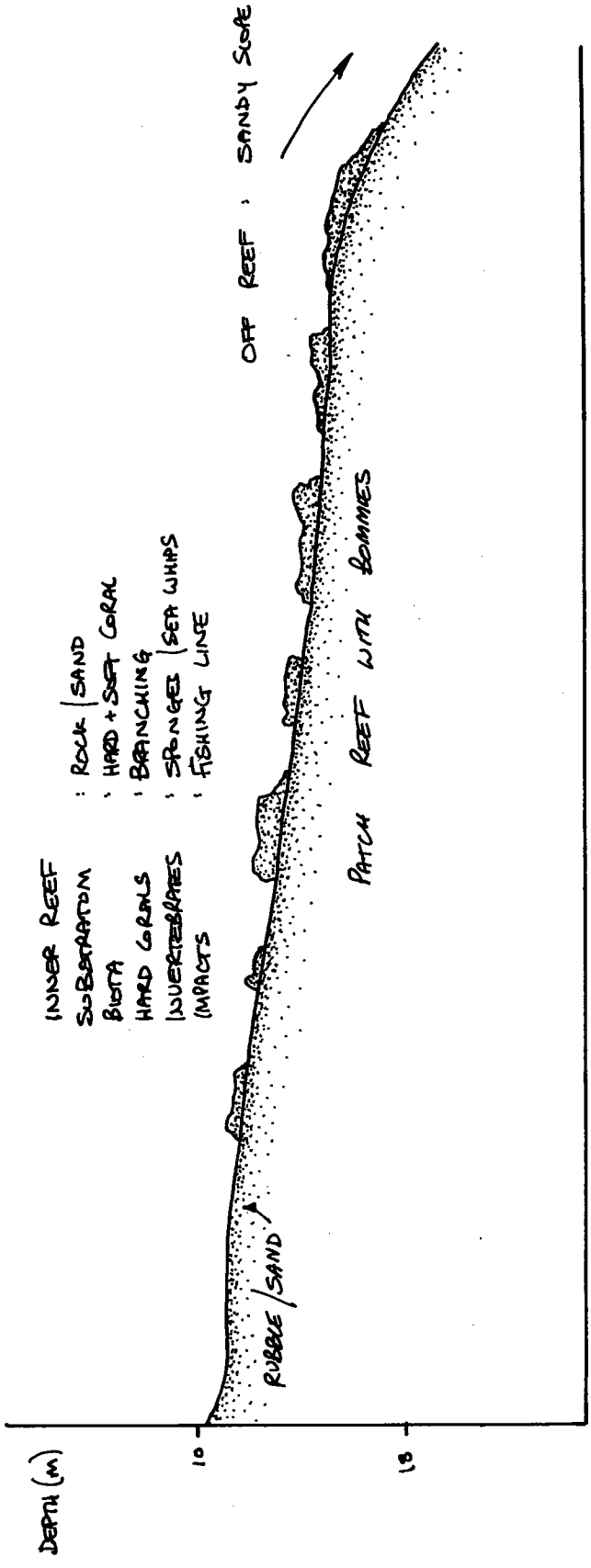


Figure 6.12 Habitat profile of Site MT3, Matemo.

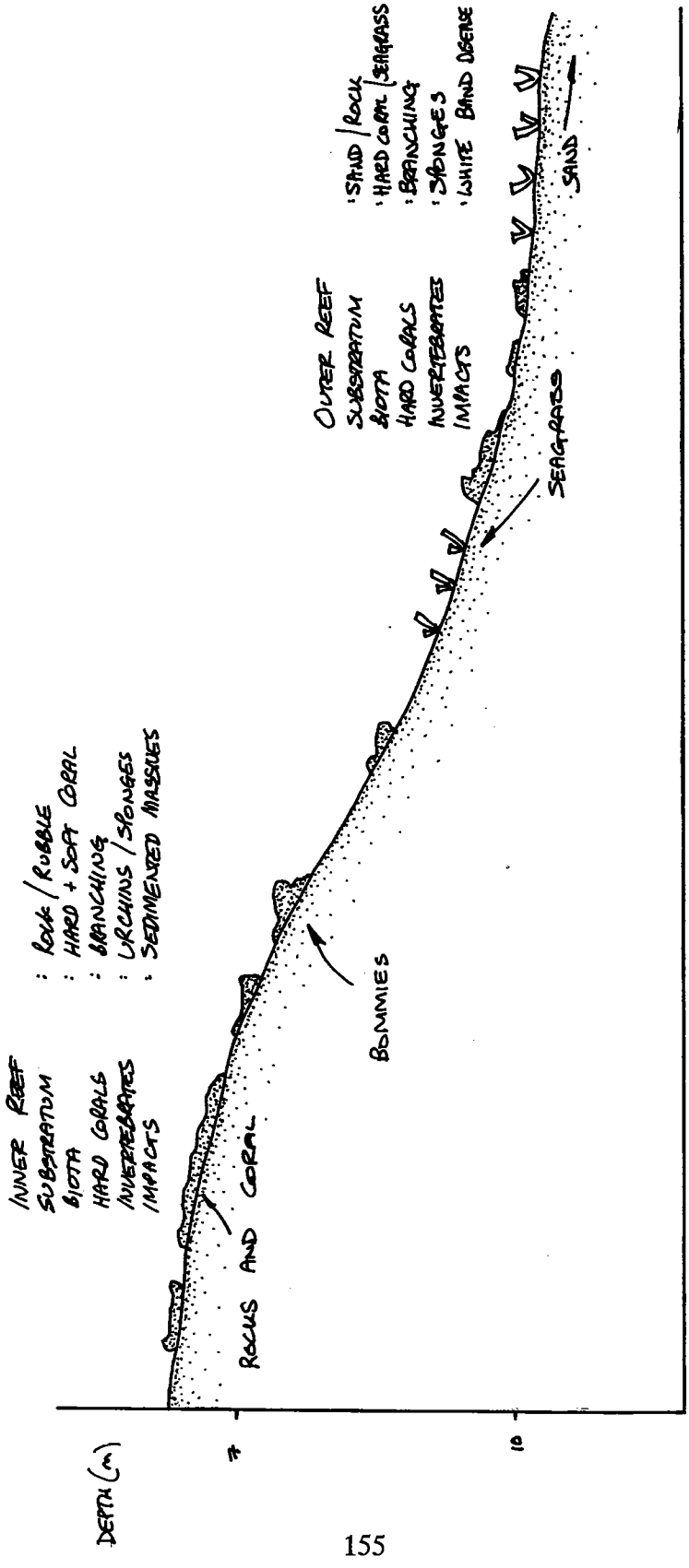


Figure 6.13 Habitat profile of Site MT4, Matemo.

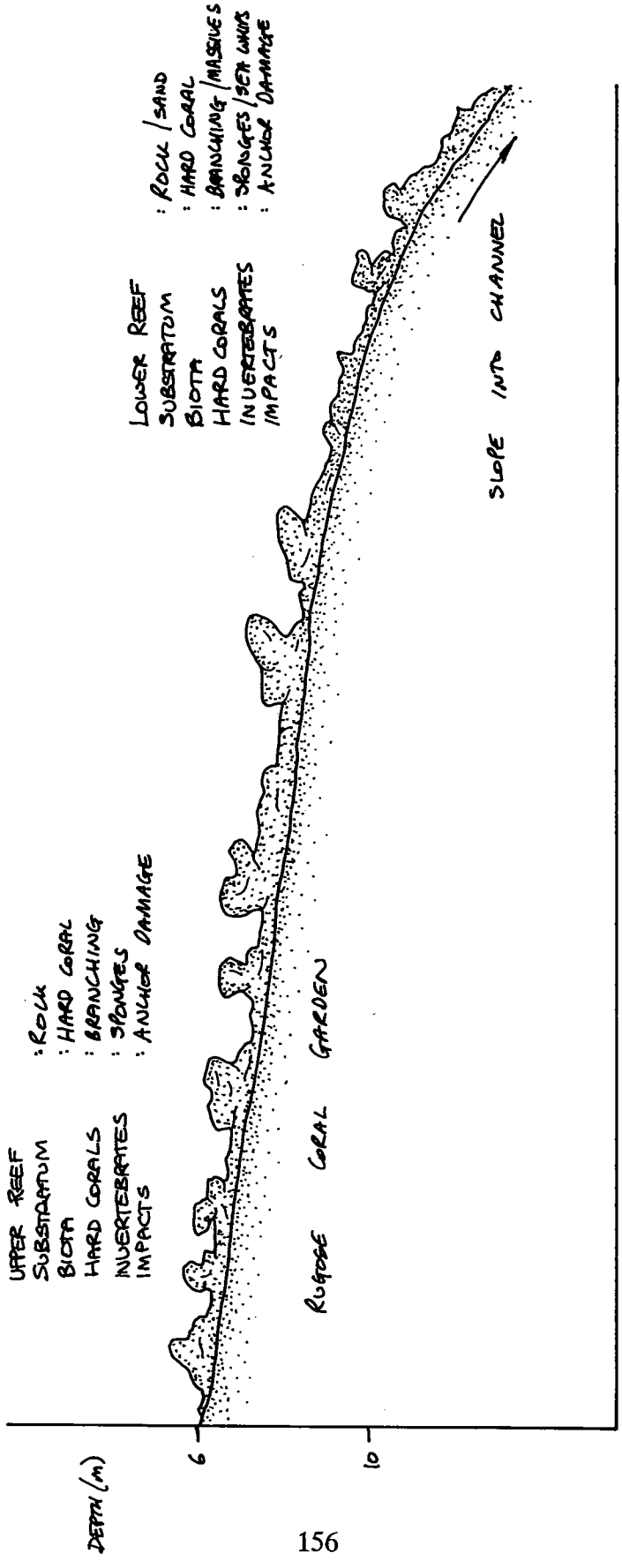


Figure 6.14 Habitat profile of Site MT5, Matemo.

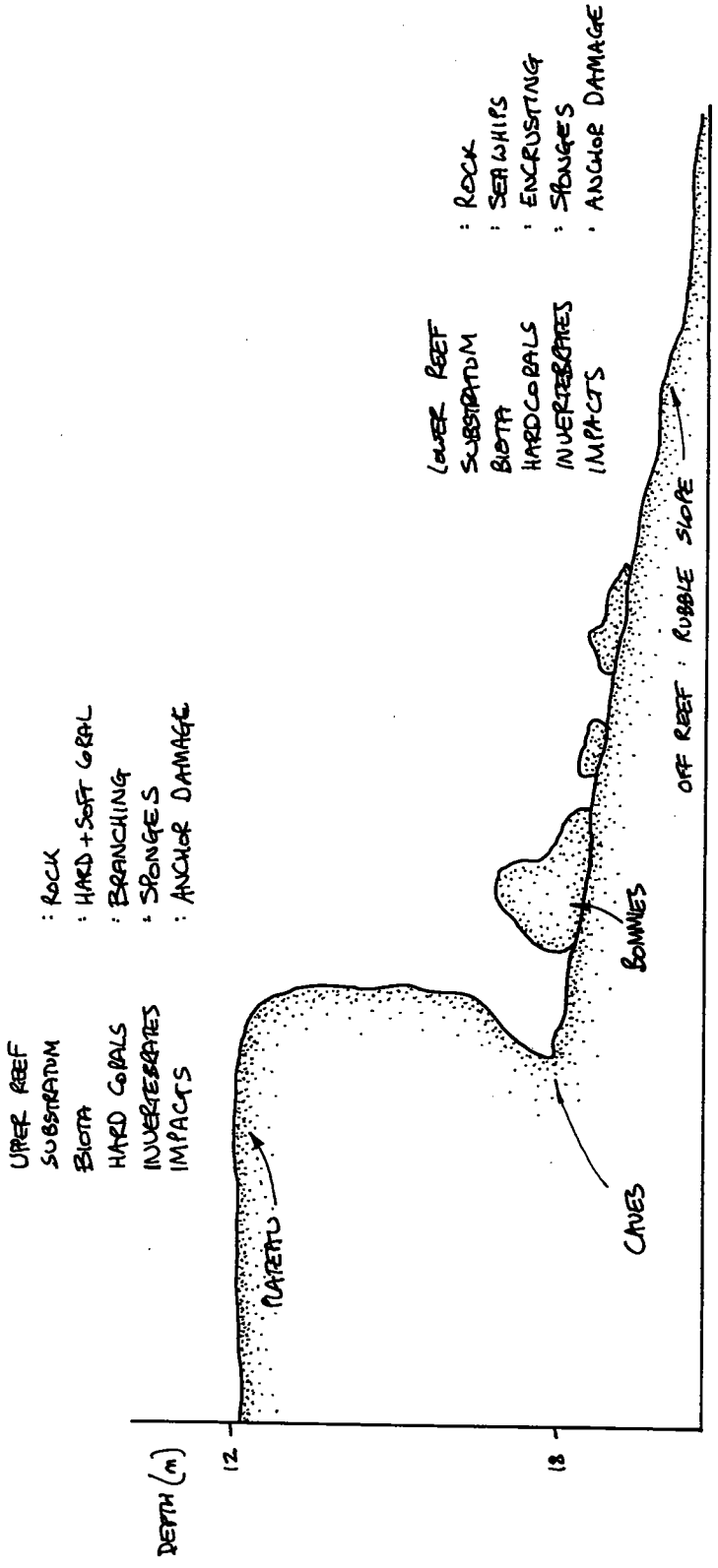
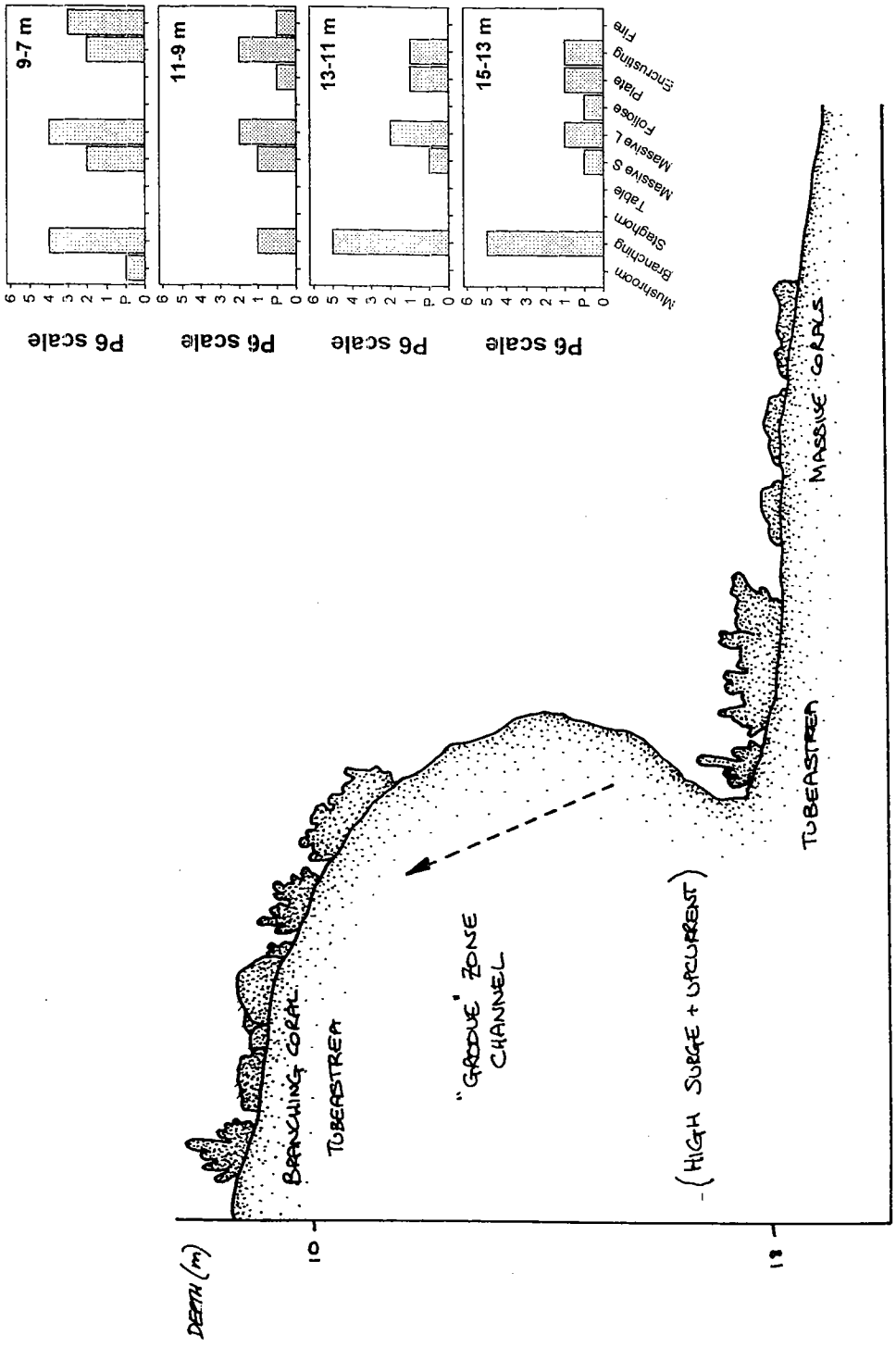


Figure 6.15 Coral profile of Site MT5, Matemo.



6.5 Subtidal Invertebrate and Impact Surveys

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 6.9).

6.5.1 Overview

Macrosponges were recorded on all sites, with abundances being smaller in eastern and southern areas. Urchins also occurred at all sites, but only formed dense aggregations on eastern and less protected reefs. Sea whips and Sea fans were often present on reef sites although highest numbers occurred on site MT5 in the south where currents were strong. Sea whips were noted to be most abundant in deeper waters. A variety of sea cucumbers were seen, but numbers were consistently low. This, combined with the total absence of sightings of Triton, Murex and Tulip shells and lobsters, indicate high fishing pressure. Some coral damage was attributed to boat anchors (especially in the south-east) whilst most was of indeterminate cause.

6.5.2 Site Reports

Site MT1:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 6.25.

Macrosponges were the most abundant invertebrates recorded on the predominantly sandy substratum of northern Matemo. Urchins, sea cucumbers and clams (*Tridacna* spp.) were only present in low numbers. Small fresh dead 'branching' forms of coral and sedimented 'massive' forms were recorded occasionally. The presence of a single anchor line may be evidence of fishing activity, although no further evidence of human impact was noted.

Table 6.25 Invertebrates and Natural/Human Impacts at Site MT1 (values are for 5 minutes of survey).

		Inner Reef (n=24)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		A	0-A+
Bivalves	Giant Clams	0	0-3
Urchins		0	0-14
Sea Cucumbers	Holothuria	0	0-1
	Others	0	0-2
Dead Corals	Sed. Massives	0	0-2
	Unknown	0	0-2

Site MT2:
The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 6.26.

Macrosponges and sea whips were the most abundant invertebrates recorded. Large basket sponges (<1m tall) formed a notable proportion of all macrosponges while sea whips were well dispersed throughout the area. Urchins, clams and a variety of species of sea cucumber were found to occur in low numbers. A few 'branching' forms of fresh dead coral and a single sedimented 'massive' coral were recorded within the 16 survey replicates. Evidence of human impacts at this site was in the form of a single discarded fishing line.

Table 6.26 Invertebrate and Natural/Human Impacts at Site MT2 (values are for 5 minutes of survey).

		Upper Reef (n=16)	
Inverts/Impacts	**Types/Cause**	**Mean**	**Range**
Macrosponges		17.5	0-A+
Gorgonians	Sea Whips	3.0	0-A
	Sea Fans	0	0-1
Bivalves	Giant Clams	0	0-2
Urchins		0.5	0-5
Sea Cucumbers	Holothuria	0	0-1
	Others	1.0	0-5
Dead Corals	Unknown	0	0-1
	Sed. Massives	0	0-1
Human Effects	Fishing Line	0	0-1

Site MT3:
The distribution and density of invertebrates and incidences of reef damage are discussed below, and summarised in Table 6.27.

Urchins and macrosponges were the most abundant invertebrates recorded, with greater numbers in outer/deeper regions (<12m depth). Urchins formed dense aggregations, especially below the reef. A variety of sea cucumbers were recorded in low numbers (<5 / 5 minutes), including *Synapta* spp. on the sand and seagrass area below 10m. Within the surveys White band disease was recorded on two separate occasions, as well as a few areas which contained several instances of fresh dead coral and sedimented 'massives'. Frequent sightings of anchor damage below the reef suggested relatively high intensity of fishing activity.

Table 6.27 Invertebrate and Natural/Human Impacts at Site MT3 (values are for 5 minutes of survey).

		Upper Reef (n=12)		Lower Reef (n=12)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		1.0	0-9	11.0	0-A
Gorgonians	Sea Fans	-	-	0	0-1
Bivalves	Giant Clams	0	0-1	0	0-3
Urchins		3.0	0-A+	A	0-A+
Sea Cucumbers	Holothuria	0	0-2	1.0	0-3
	Synapta spp.	-	-	0	0-3
	Others	0	0-5	0	0-2
Dead Corals	White Band Dis.	0	0-1	0	0-2
	Sed. Massive	1.5	0-2	1.5	0-6
	Unknown	2	0-A	1.5	0-6
Human Effects	Anchor Damage	-	-	1.0	0-3

Site MT4:

The distribution and density of invertebrates and incidences of reef damage are discussed below, and summarised in Table 6.28.

Numerous macrosponges (up to 20 individuals / 5 minutes) and urchins (up to 50 individuals / 5 minutes) were recorded at this site. Higher abundances for each were recorded in shallower waters. Clams were also common in these shallow waters. A few fresh dead corals were found throughout the site while human impact, in the form of anchor damage, were high in comparison to other sites around the island.

Table 6.28 Invertebrate and Natural/Human Impacts at Site MT4 (values are for 5 minutes of survey).

		Upper Reef (n=11)		Lower Reef (n=18)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		3.0	0-A	3.0	0-11
Gorgonians	Sea Whips	-	-	1.0	0-14
	Sea Fans	-	-	0	0-1
Bivalves	Giant Clams	0	0-4	0	0-2
Urchins		0	0-A+	0	0-A
Sea Cucumbers	Holothuria	-	-	1.0	0-1
	Synapta spp.	-	-	0	0-1
	Others	0	0-2	0	0-2
Dead Corals	Unknown	0	0-1	0	0-3
Human Effects	Anchor damage	1.0	0-4	0	0-3

Site MT5:

The distribution and density of invertebrates and incidences of reef damage are discussed below, and summarised in Table 6.29.

Macrosponges, sea whips and sea fans were common in the area of high current above the reef wall. Below the wall sea fans were not recorded and sponges became less frequent, while sea whips occurred in great abundance. Giant clams (*Tridacna* spp.) and sea cucumbers were recorded in low numbers throughout the site. Urchins were not found in the deeper water and only occasionally above the wall. Freshly dead coral and sedimented 'massive' forms of coral were regularly noted above 12m depth, as well as two incidences of White band disease. Human impacts were limited to a few areas of anchor damage above and at the base of the reef.

Table 6.29 Invertebrates and Natural/Human Impacts at Site MT5 (values are for 5 minutes of survey).

		Upper Reef (n=12)		Lower Reef (n=10)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**	**Median**	**Range**
Macrosponges		4.5	0-A	12.0	0-4
Gorgonians	Sea Whips	0.5	0-A+	11.5	0-A+
	Sea Fans	0	0-A	-	-
Bivalves	Giant Clams	0	0-1	1.0	0-3
Urchins		0	0-8	-	-
Sea Cucumbers	Holothuria	0	0-1	0	0-2
	Others	0	0-1	0	0-5
Dead Corals	White Band Dis.	0	0-1	-	-
	Unknown	0	0-2	-	-
	Sed. Massive	0	0-2	-	-
Human Effects	Anchor damage	0	0-2	0	0-1

Site MT6:

The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 6.30.

Macrosponges were the most abundant invertebrates recorded on this sand and bommie site off western Matemo. Sea whips, sea fans, urchins, sea cucumbers and clams were present but uncommon. Small colonies of fresh dead 'branching' forms of coral and a single incidence of White band disease were recorded. Evidence of anchor damage was found on a few separate occasions.

Table 6.30 Invertebrates and Natural/Human Impacts at Site MT6 (values are for 5 minutes of survey).

		Inner Reef (n=18)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		A	0-A+
Gorgonians	Sea Whips	0	0-1
	Sea Fans	0	0-1
Bivalves	Giant Clams	0	0-1
Urchins		0	0-3
Sea Cucumbers	Others	0	0-1
Dead Corals	White Band Dis.	0	0-1
	Unknown	0	0-2
Human Effects	Anchor	0	0-1

Site MT7:

The distribution and density of invertebrates and incidences of damage are discussed below, and summarised in Table 6.31.

Similar to site MT6, macrosponges were the most abundant invertebrates. Sea whips, urchins, sea cucumbers and clams were present but not common. Small fresh dead 'branching' forms of coral and sedimented 'massive' forms were frequent. Evidence of human impact was present in the form of two fish traps (Marema), one of which was in use.

Table 6.31 Invertebrates and Natural/Human Impacts at Site MT7 (values are for 5 minutes of survey).

		Inner Reef (n=18)	
Inverts/Impacts	**Types/Cause**	**Median**	**Range**
Macrosponges		3.0	0-A+
Gorgonians	Sea Whips	0	0-4
Bivalves	Giant Clams	0	0-1
Urchins		0	0-5
Sea Cucumbers	Holothuria	0	0-2
	Others	0	0-2
Dead Corals	Unknown	0	0-8
	Sed. Massive	0	0-4
Human Effects	Old fish traps	0	0-1
	New fish traps	0	0-1

6.6 Reef fish census

6.6.1 Overview

Matemo island was the largest of the Northern Quirimbas to be surveyed. The survey sites are the same locations as for the habitat survey (section 6.4). It had an extensive reef to the east of the island, with dramatic coral walls to the south. The north and west were sandy, with occasional scattered bommies. Most of the reef fish observed were associated with the reef slopes and walls, as might be expected. Despite this trend, the site with most species recorded was to the north of the island. The species richness and diversity at all Matemo survey sites are presented in Table 6.32.

Table 6.32 The number of 5 minute replicates, total species count, relative species richness indices (RSRi) and Shannon Weaver diversity indices (SWi) calculated from the Matemo reef fish assemblage.

Site	Reps	Spp	RSRi	SWi
MT1	25	38	0.52	3.10
MT2	14	34	0.47	3.16
MT3	22	38	0.52	3.26
MT4	14	12	0.16	1.78
MT5 upper	24	36	0.49	2.78
MT5 lower	23	35	0.48	2.74
MT6 upper	25	37	0.51	2.75
MT6 lower	19	24	0.33	2.67
MT7 inner	12	23	0.32	2.88
MT7 outer	24	29	0.40	2.95

3.6.2 Site reports

Site MT1:
This was a gradual coral and seagrass slope which supported a rich and diverse reef fish assemblage, on which 647 fish, from 37 species were recorded. Of these, 12 species were surgeonfish and 13 species were butterflyfish. The high species richness of surgeonfish was also reflected in their numerical dominance. In particular, the Blackstreak surgeonfish *Acanthurus nigricauda* and Dusky surgeonfish *Acanthurus nigrofuscus*, and the Twospot bristletooth *Ctenochaetus binotatus* were abundant. In addition, the Multispined angelfish *Centropyge multispinus* was common. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 6.16.

Site MT2:
This site was a shallow reef slope, on which 316 fish were recorded, of 34 species. The butterflyfish were particularly rich at this site, with 15 species seen, including many Dot-dash butterflyfish *Chaetodon kleinii* and Black pyramid butterflyfish *Hemitaurichthes zoster.* The Dash dot goatfish *Parupeneus barberinus* was also common. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 6.17.

Site MT3:
This was another shallow reef slope site, also supporting a species-rich assemblage of reef fish. As with site MT2 butterflyfish were diverse, although not in such high numbers. Only the Threadfin butterflyfish *Chaetodon auriga* was seen in high numbers, with the most common reef fish at this site being the Tennents Surgeonfish *Acanthurus tennenti* and the Multispined angelfish *Centropyge multispinus*. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 6.18.

Site MT4:
This site was a reef slope, that had a coral garden. Surprisingly few species of reef fish were recorded, as the corals were well developed. A total of 202 fish were seen, from 14 species. The only common fish were the Dot-dash butterflyfish *Chaetodon kleinii*, and the Long barbel goatfish *Parupeneus macronema* and Dash-dot goatfish *Parupeneus barberinus*. In addition a pod of 14 dolphins swam with the surveying divers for several minutes. The abundance and species richness of reef fish at this site have been presented graphically in Fig. 6.19.

Site MT5:
This site was a dramatic coral wall, with abundant reef fish. The site was subdivided into upper and lower reef areas. On the upper area, 36 species were recorded, with a total of 48 fish seen. Of these, there were 10 species of surgeonfish and 13 species of butterflyfish. Surgeonfish numerically dominated the observed assemblage, in particular the Powderblue surgeonfish *Acanthurus leucosternon* and the Twospot bristletooth *Ctenochaetus binotatus*. The lower reef area had a similar species count and abundance (35 species, 347 fish), although the common fish were the Halfmoon triggerfish *Sufflamen chrysopterus*, the Long barbel goatfish *Parupeneus macronema*, and the Twospot bristletooth *Ctenochaetus binotatus*. The abundance and species richness of reef fish for both areas at this site have been presented graphically in Figs. 6.20, 6.21.

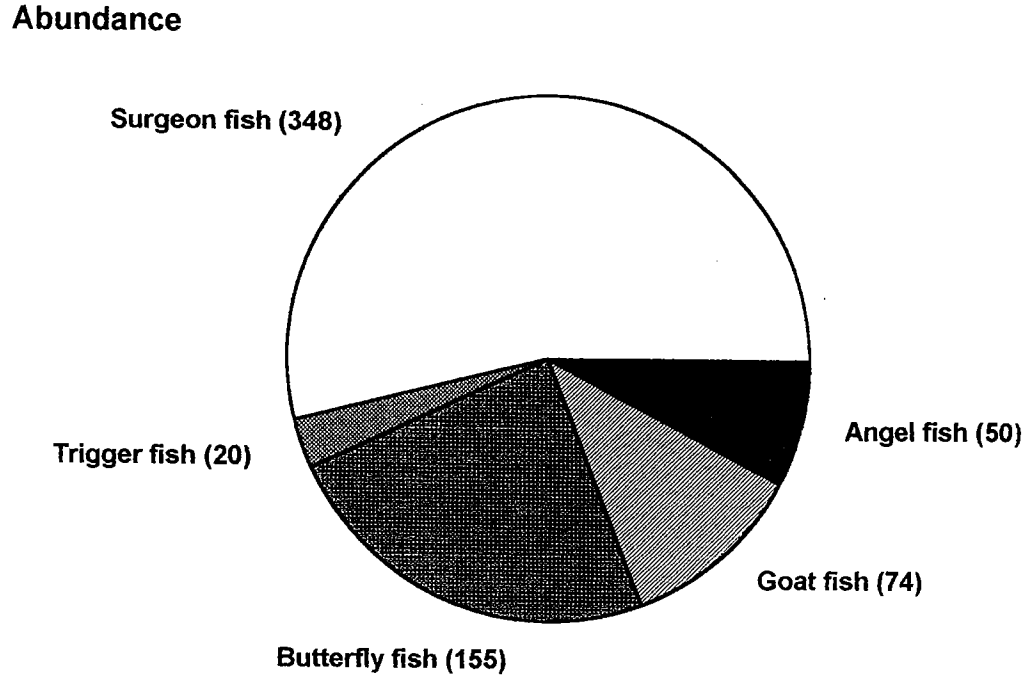
Site MT6:

This site was a transitional area between a coral wall and a shallow reef slope. It was subdivided into upper and lower reef areas. The upper area was species-rich and abundant in reef fish, interestingly of species not seen often at other sites. The most common fish were the Earspot angelfish *Pomacanthus chrysurus*, the Redtooth triggerfish *Odonus niger* and the Spotted unicornfish, *Naso brevirostris*. The lower area was sparser in both abundance and species richness. The ubiquitous Halfmoon triggerfish *Sufflamen chrysopterus* and the Dot-dash butterflyfish *Chaetodon kleinii* were the most common encounters. The abundance and species richness of reef fish for both areas at this site have been presented graphically in Figs. 6.22, 6.23.

Site MT7:

This was a sandy site with scattered coral bommies, around which most reef fish were associated. The site was subdivided into inner and outer reef areas. No one species of even family of reef fish were particularly common here, although several of the following species were seen: Black-backed butterflyfish *Chaetodon melannotus* and Redfin butterflyfish *Chaetodon trifasciatus,* and the Multispined angelfish *Centropyge multispinus*. The outer reef area had a very similar assemblage, with slightly higher abundance. In addition, the Brown tang *Zebrosoma scopas* was common. The abundance and species richness of reef fish for both areas at this site have been presented graphically in Figs. 6.24, 6.25.

Figure 6.16 The abundance and species richness at site MT1.



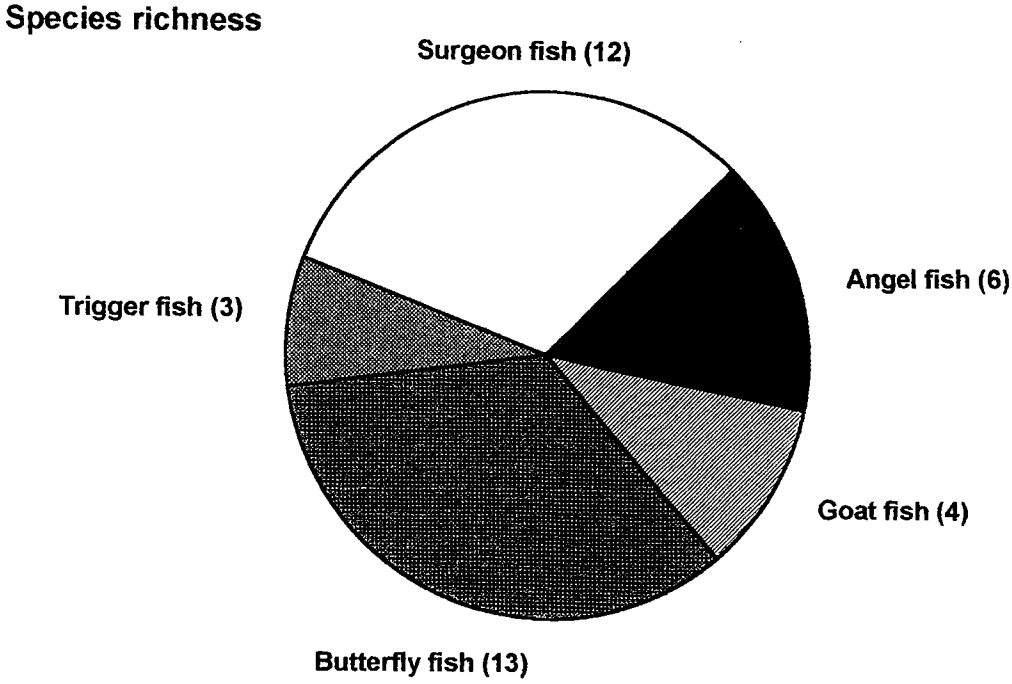
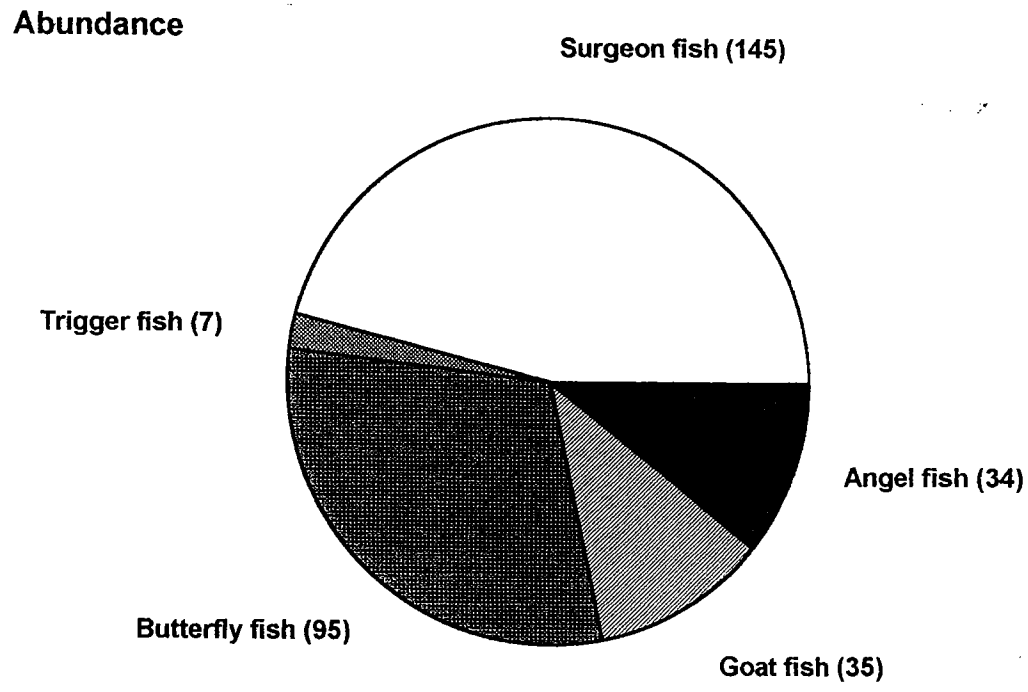


Figure 6.17 The abundance and species richness at site MT2.



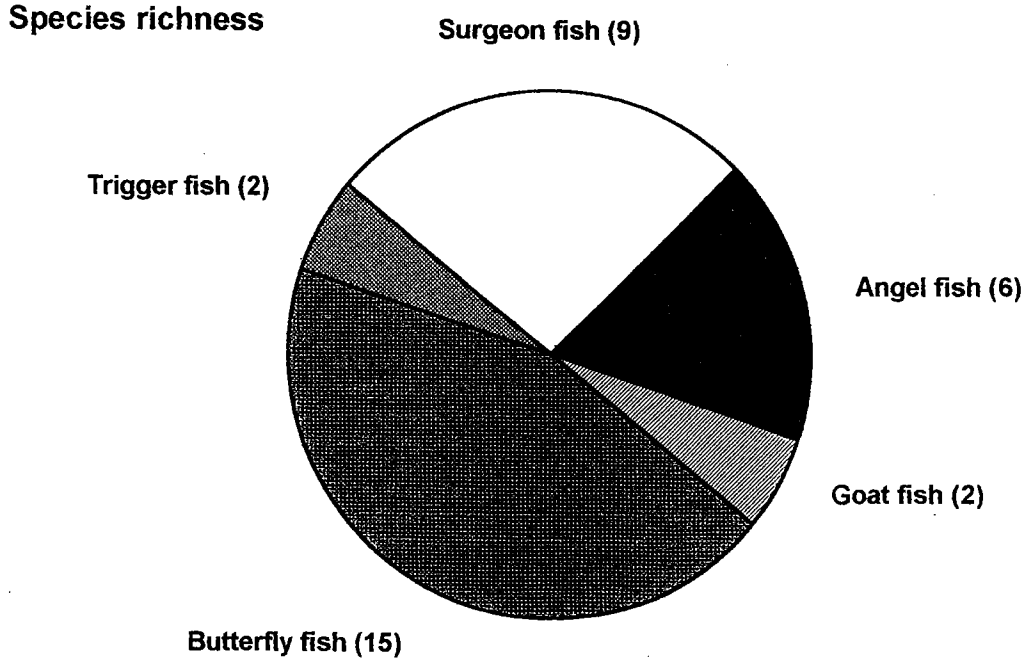
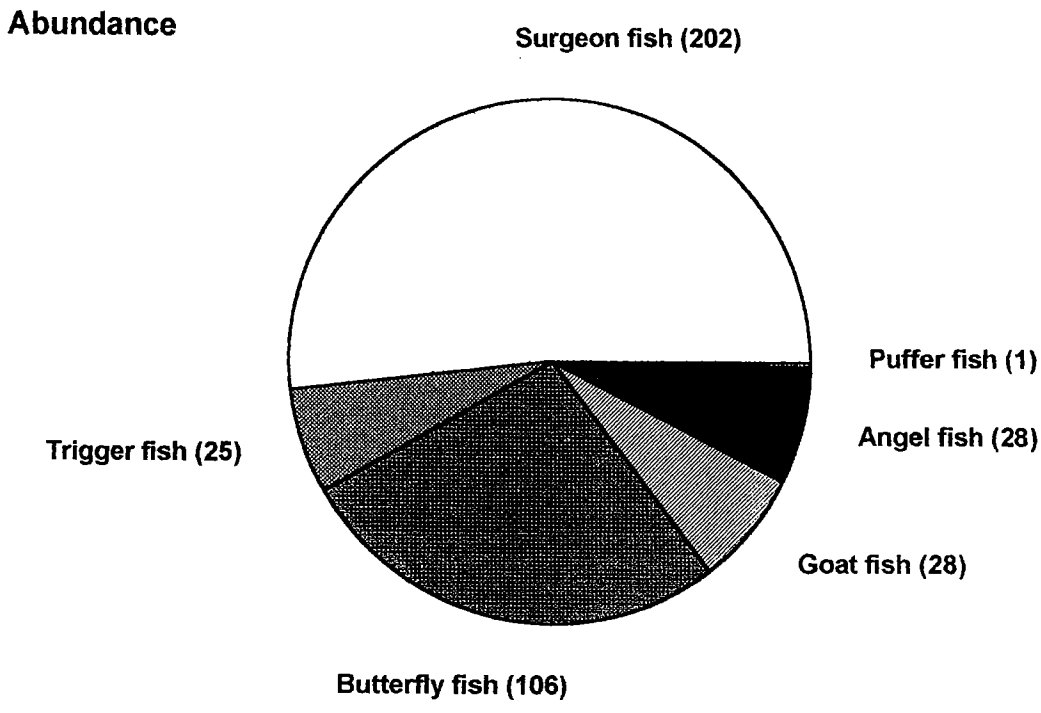


Figure 6.18 The abundance and species richness at site MT3.



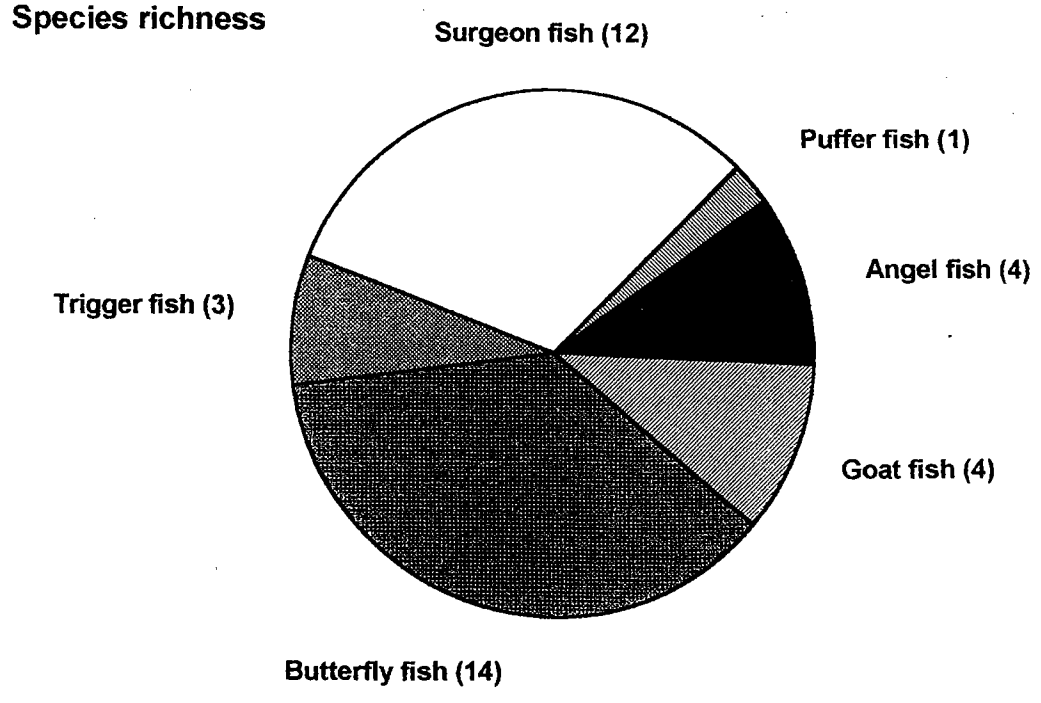


Figure 6.19 The abundance and species richness at site MT4.

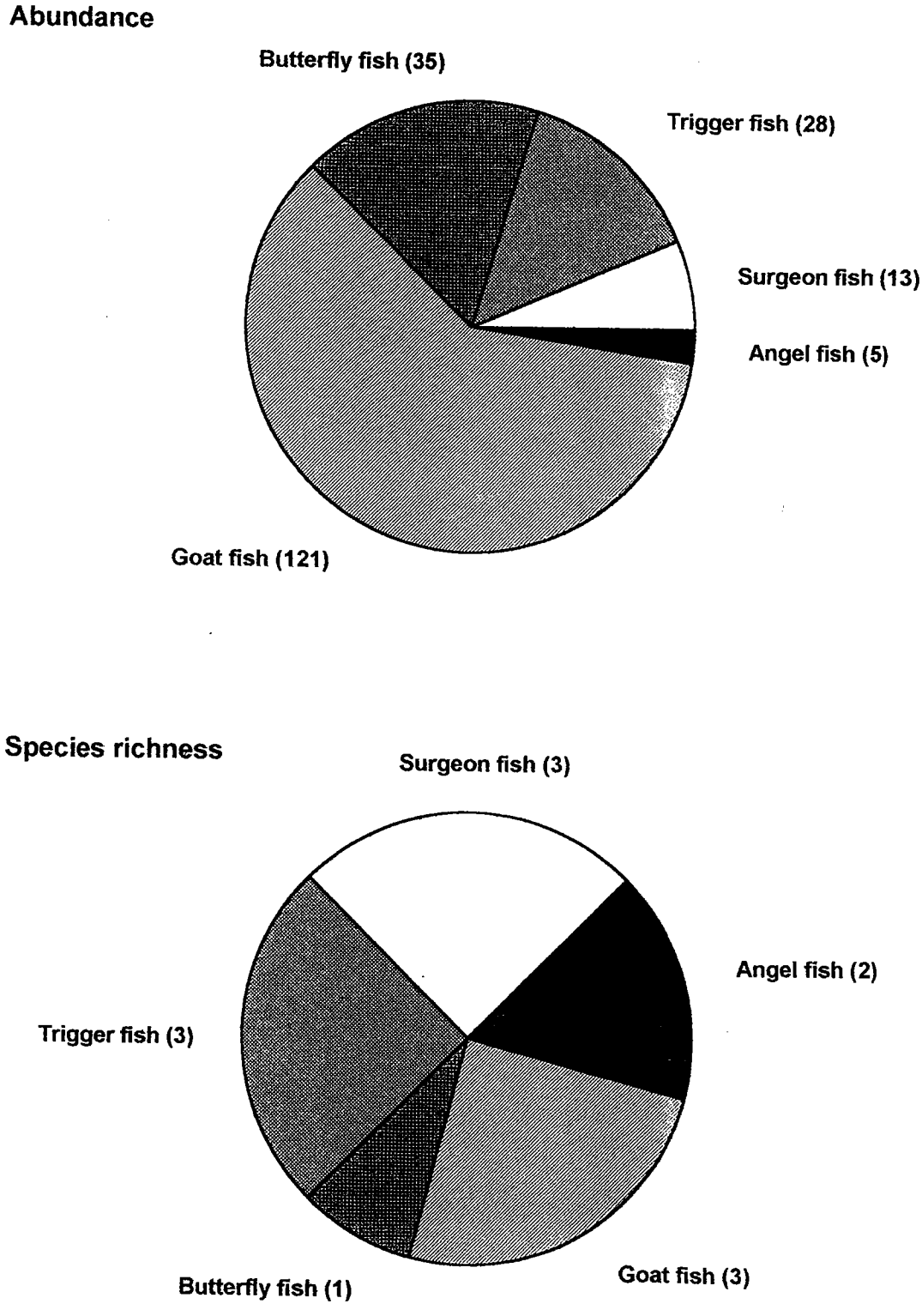
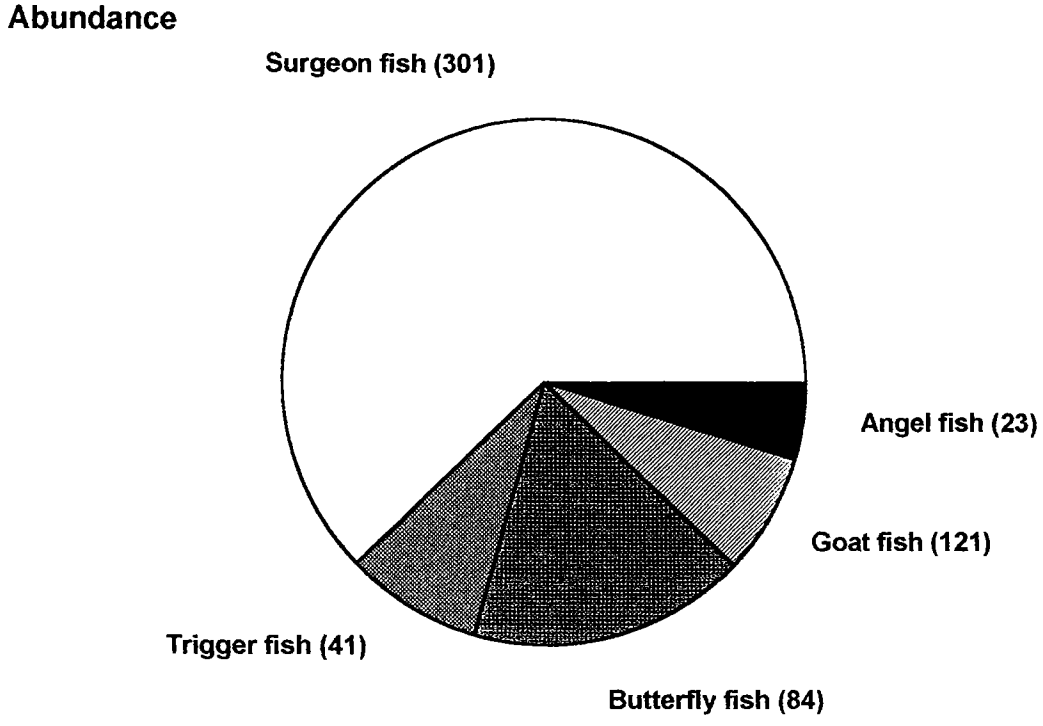


Figure 6.20 The abundance and species richness at site MT5 (inner).



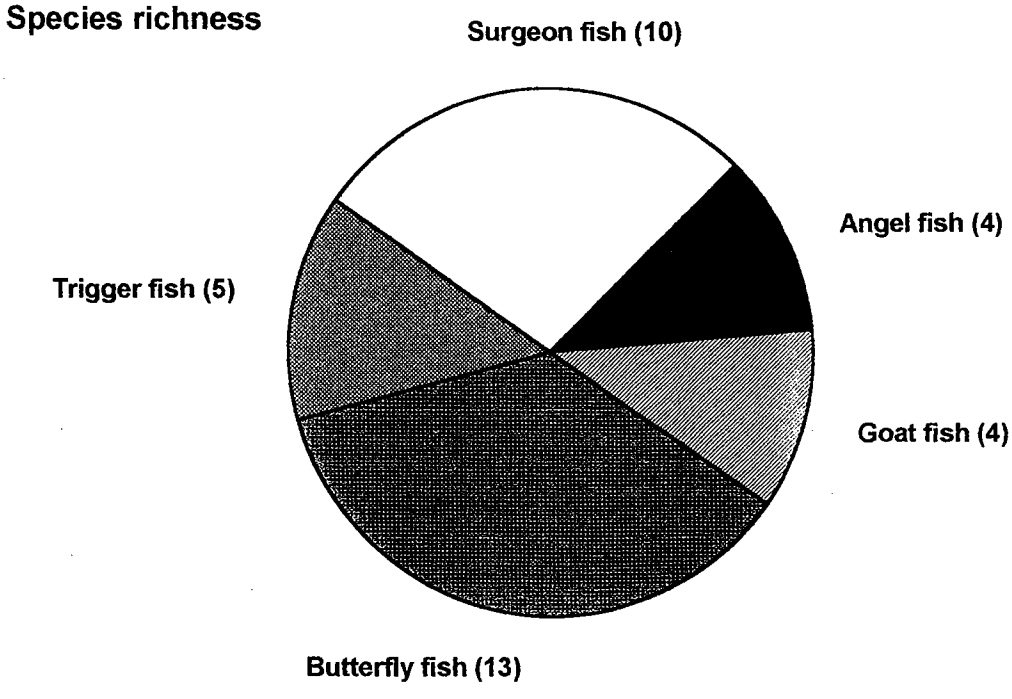


Figure 6.21 The abundance and species richness at site MT5 (outer).

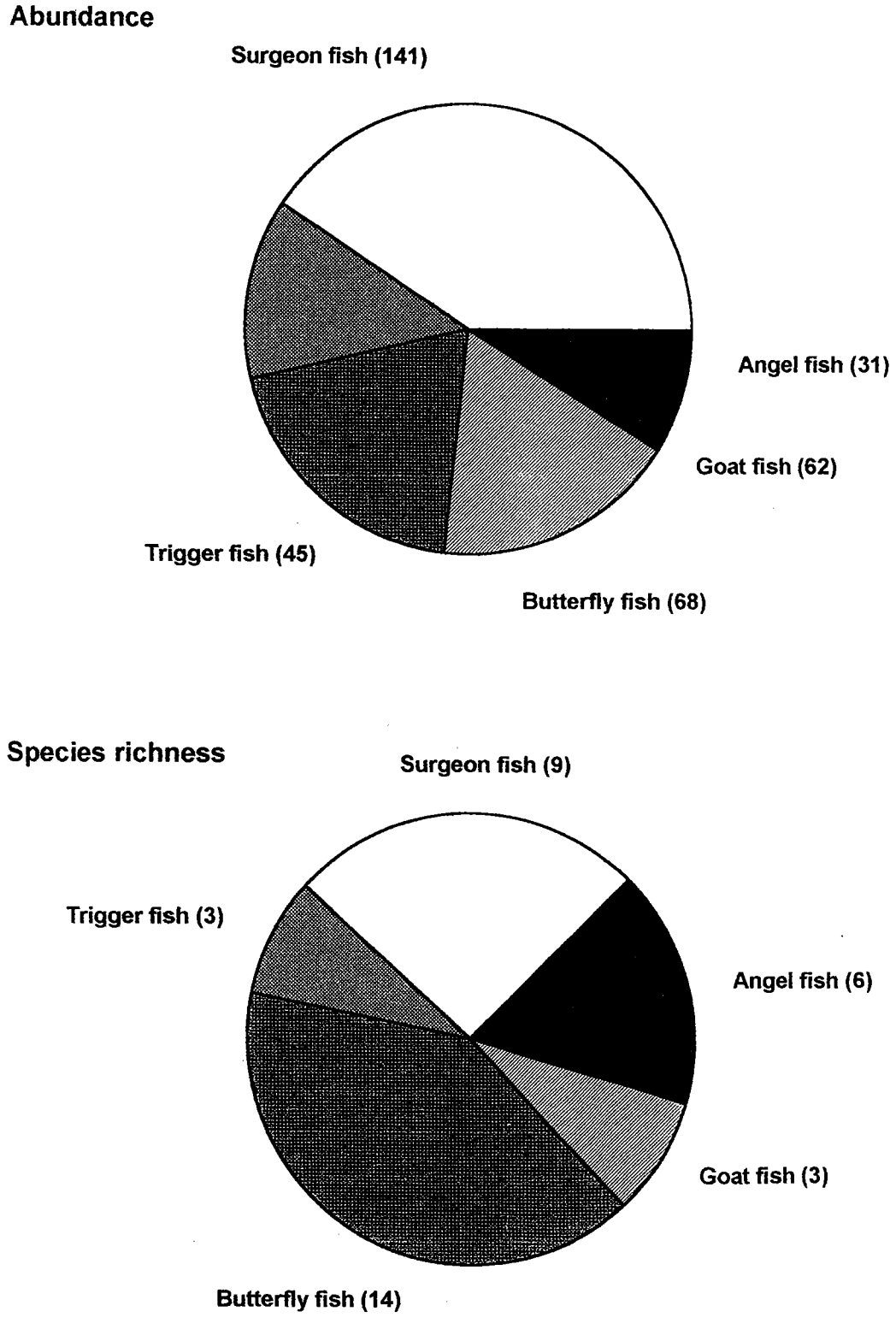
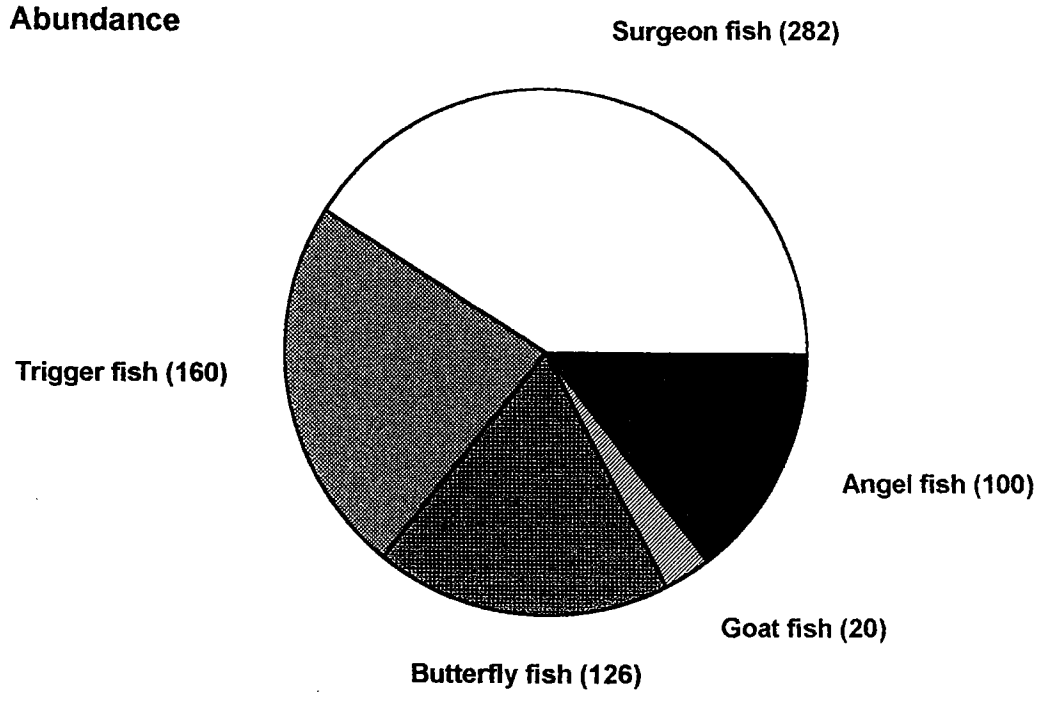


Figure 6.22 The abundance and species richness at site MT6 (inner).



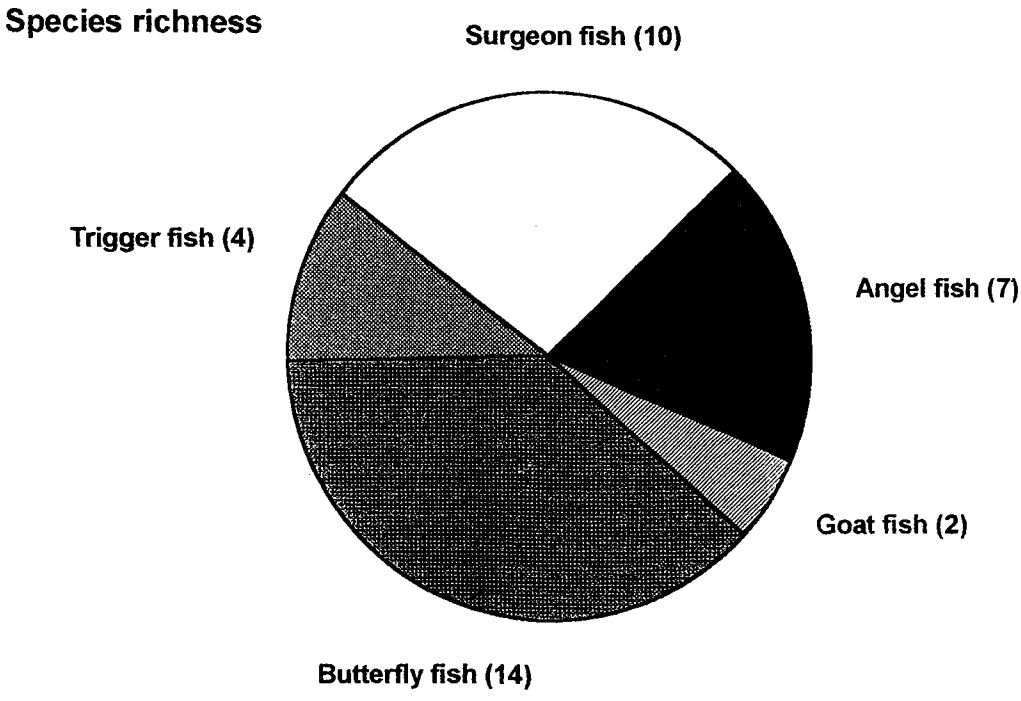


Figure 6.23 The abundance and species richness at site MT6 (outer).

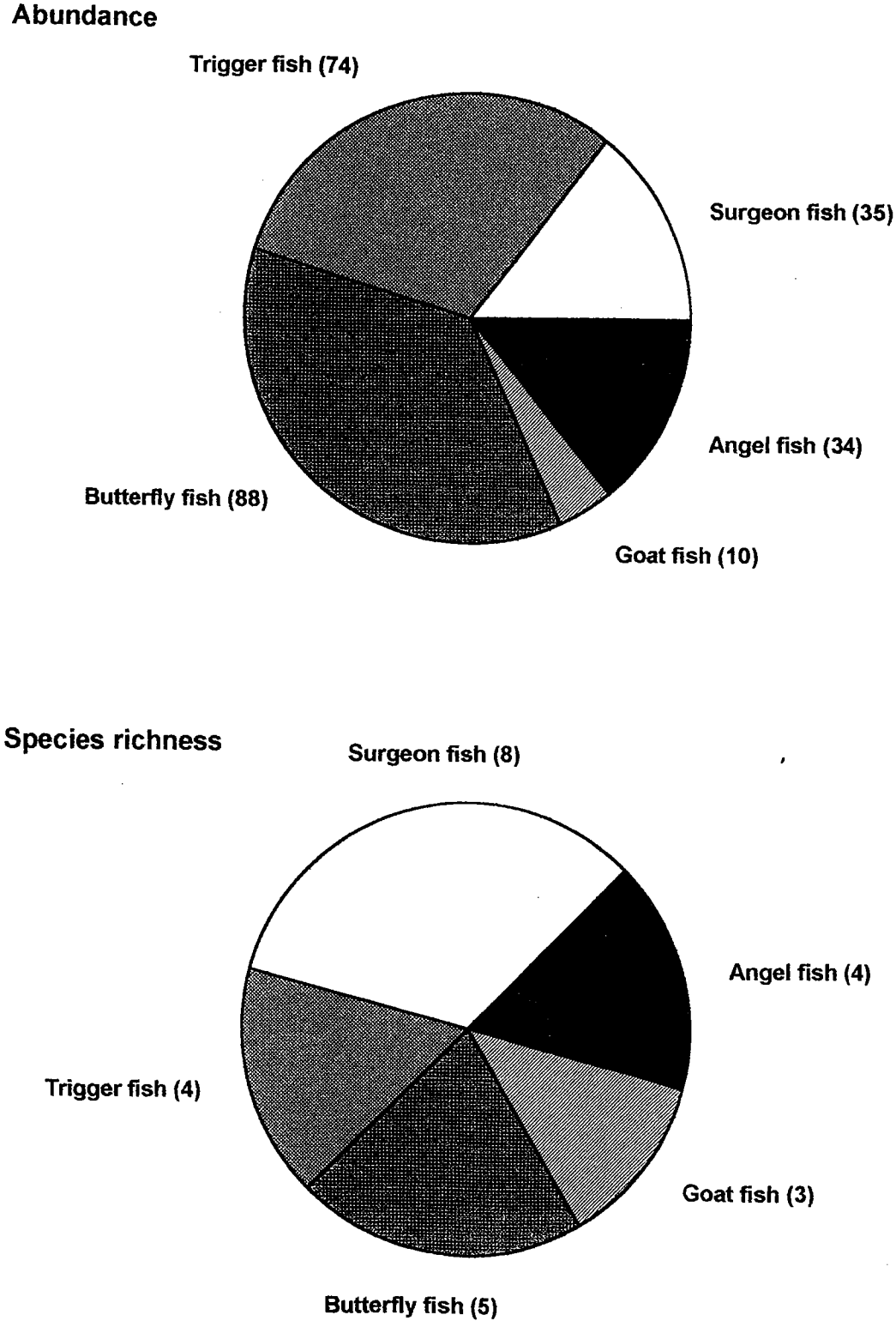
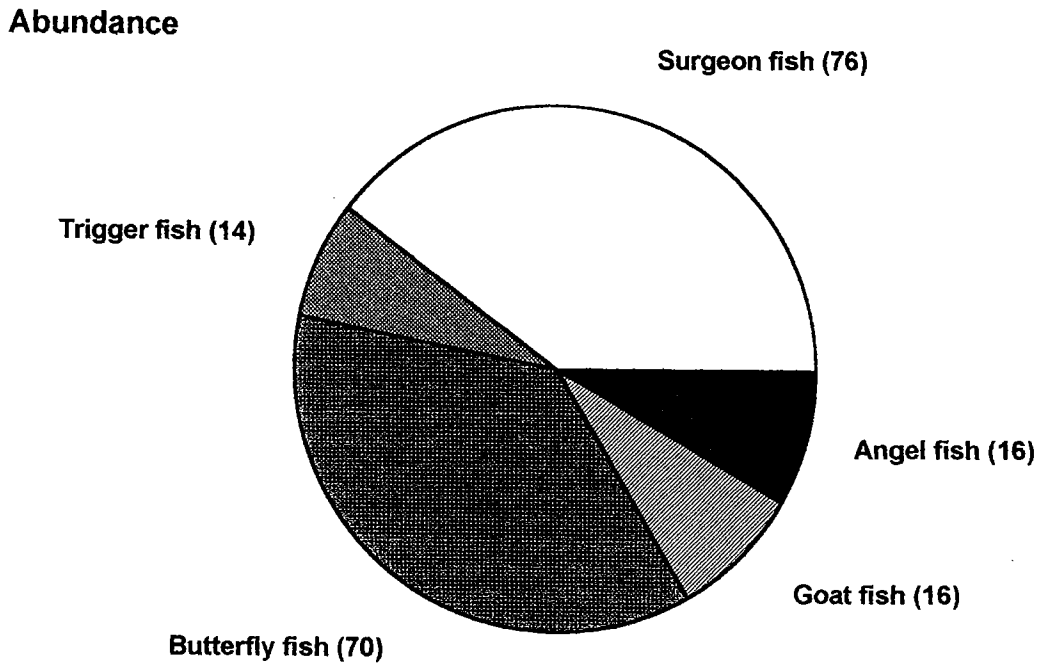


Figure 6.24 The abundance and species richness at site MT7 (inner).



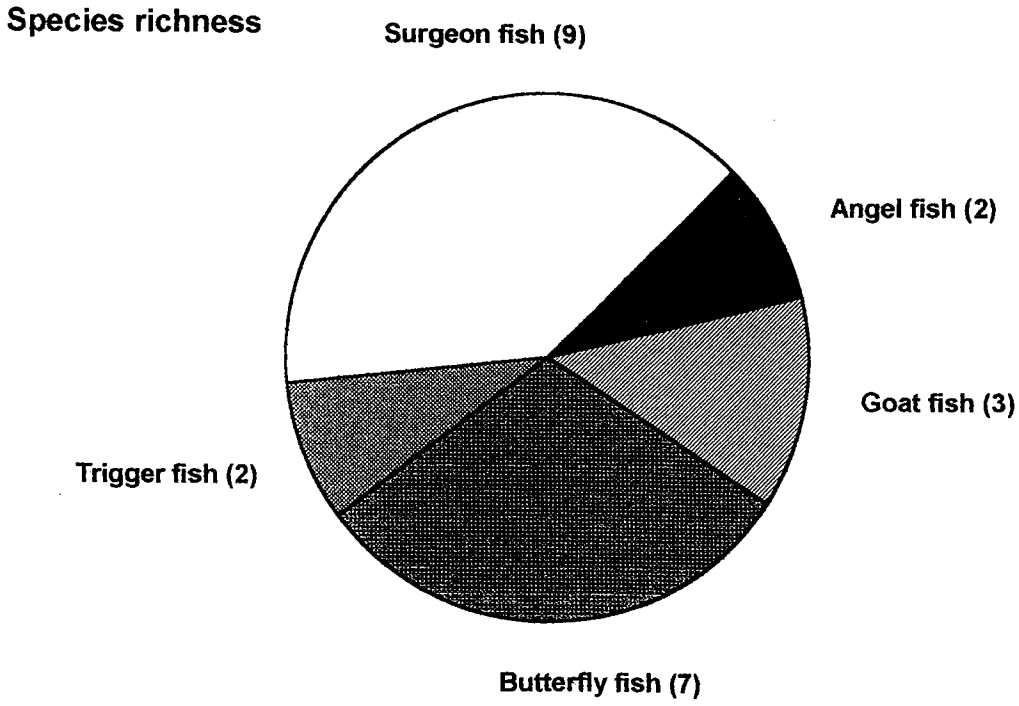
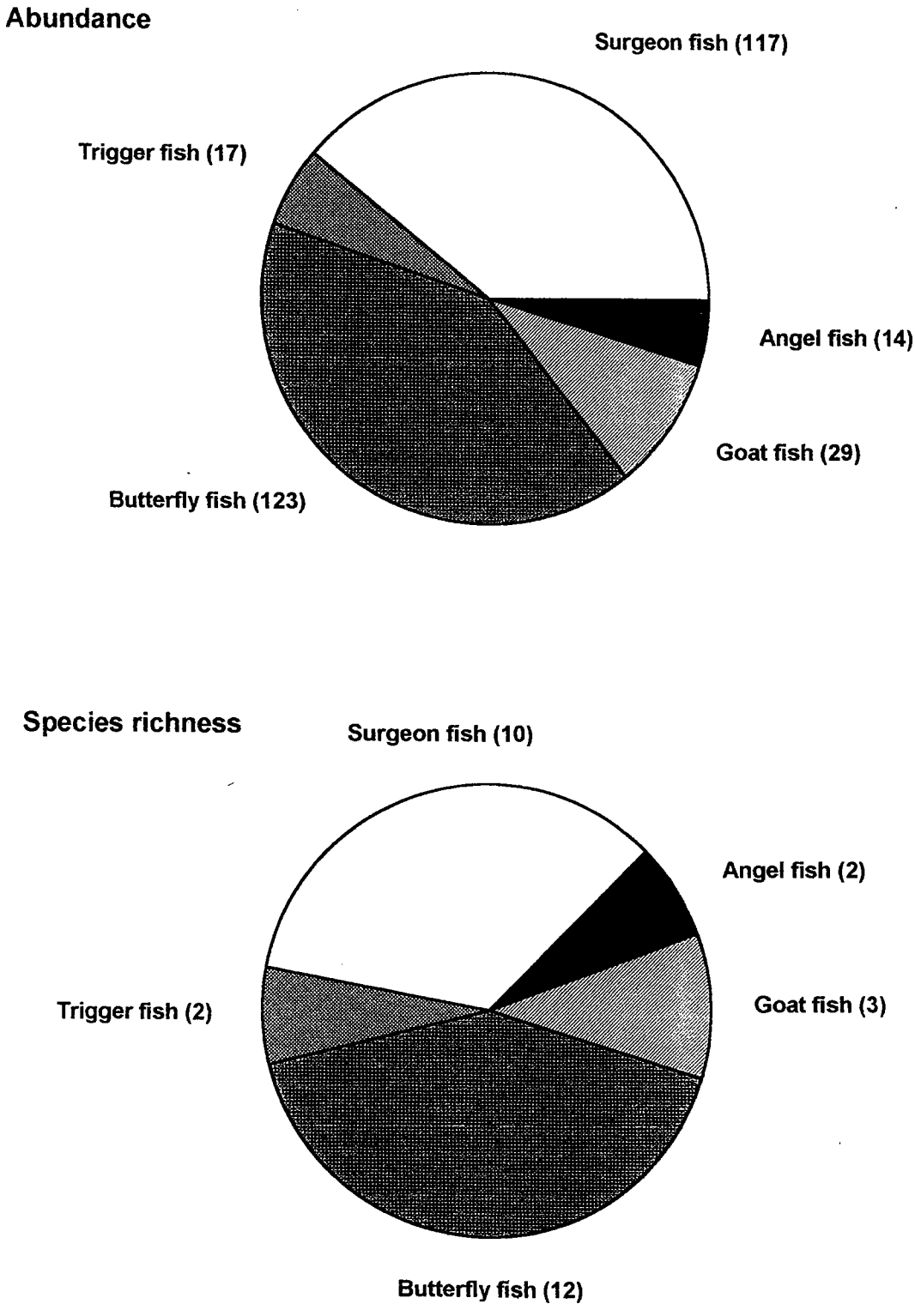


Figure 6.25 The abundance and species richness at site MT7 (outer).



6.7 Commercial fish census

6.7.1 Overview

Matemo island is the largest island in the Quirimba archipelago, with a well developed reef on its southern and eastern shores. As such, it supports a healthy and species-rich commercial fish assemblage. Four sites were surveyed, the location names for which are the same as the subtidal habitat survey (Fig. 6.9). Notably, the coral wall to the south of the island had abundant jacks (Carangidae).

6.7.2 Site reports

Site MT4:
A total of 599 fish from 19 species were seen at this site, the majority of which were parrotfish (Scaridae) and shoaling snappers (Lutjanidae). In particular, the Onespot snapper *Lutjanus monostigma* was abundant as was the Blackspotted sweetlips *Plectorhinchus gaterinus*. The abundance and distribution of commercial fish at this site are presented graphically in Fig. 6.26.

Site MT5:
This site had such a plentiful assemblage of commercial fish that surveying was difficult. In addition, strong currents were present. However to add to the 462 fish from 34 species recorded, there was anecdotal description of "immense numbers of all families of commercial fish being censused". Snappers (Lutjanidae) and jacks (Carangidae) were the most numerous, in particular the Bluelined snapper *Lutjanus kasmiri* and Giant trevally *Caranx ignoblis*. In addition many Slatey sweetlips *Diagramma pictum* were observed, as was a single Great barracuda *Sphyraena barracuda*. The abundance and distribution of commercial fish at this site are presented graphically in Fig. 6.27.

Site MT6:
Only two species made up the entire observed commercial fish at this site. These were 68 of the Onespot snapper *Lutjanus monostigma* and 100 of the Blackspotted sweetlips *Plectorhinchus gaterinus*. For completeness, the abundance and distribution of commercial fish at this site are presented graphically in Fig. 6.28.

Site MT7:
This was a relatively poor site for commercial fish, with 104 fish from 9 species being recorded. As at site MT6, the Onespot snapper *Lutjanus monostigma* was numerous. In addition, the Seagrass parrotfish *Leptoscarus vaigiensis* was often seen. The abundance and distribution of commercial fish at this site are presented graphically in Fig. 6.29.

Figure 6.26 The abundance and distribution of commercial fish at site MT4.

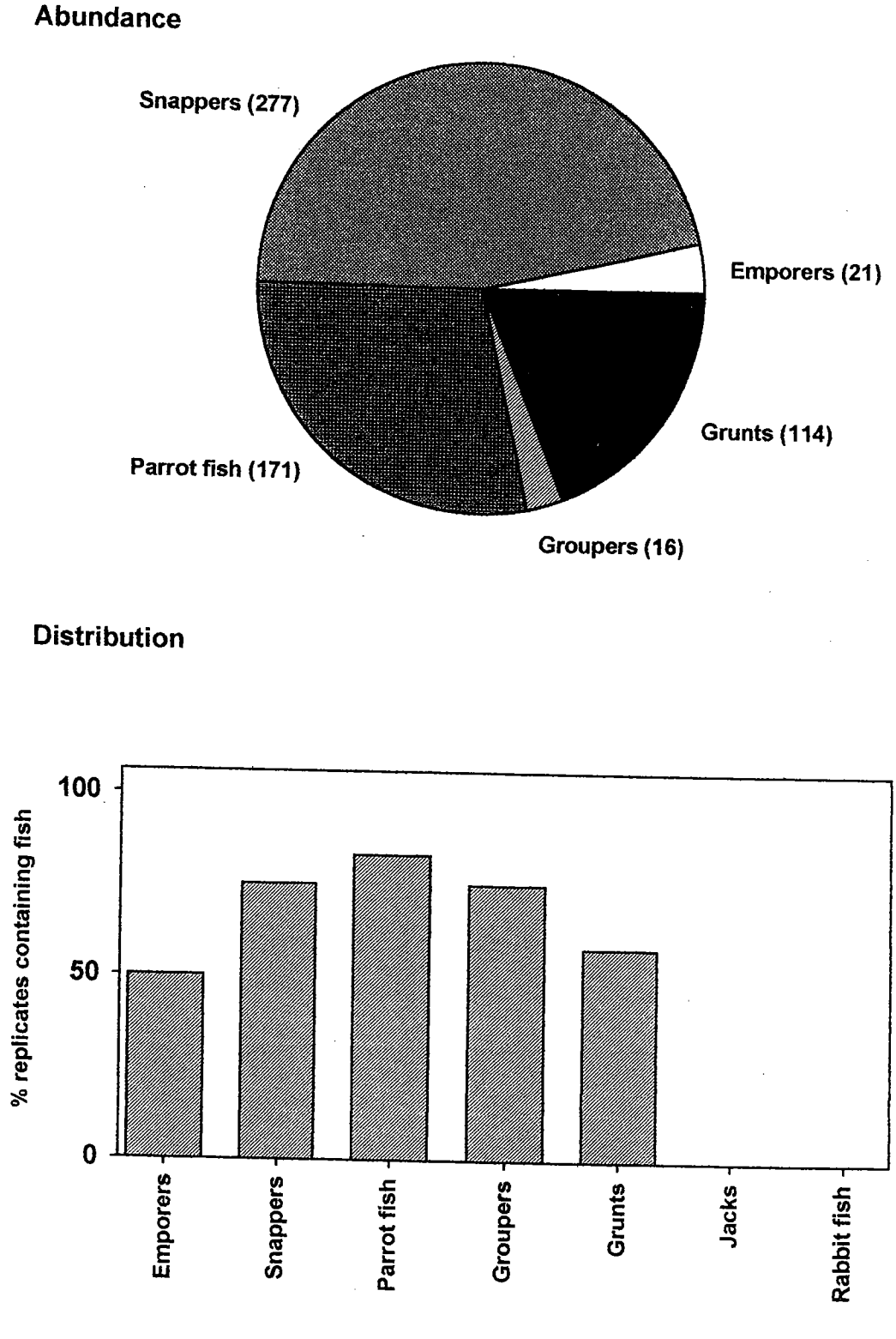
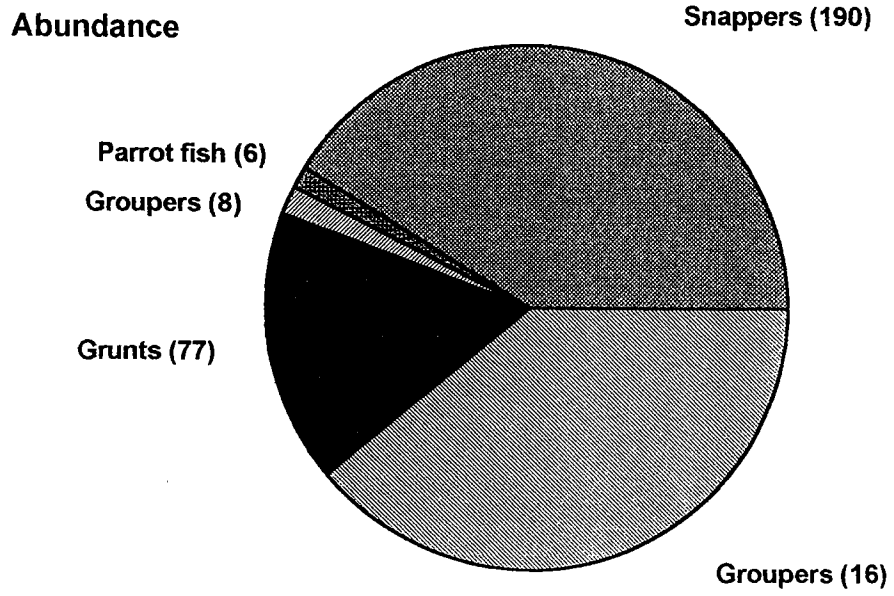


Figure 6.27 The abundance and distribution of commercial fish at site MT5.



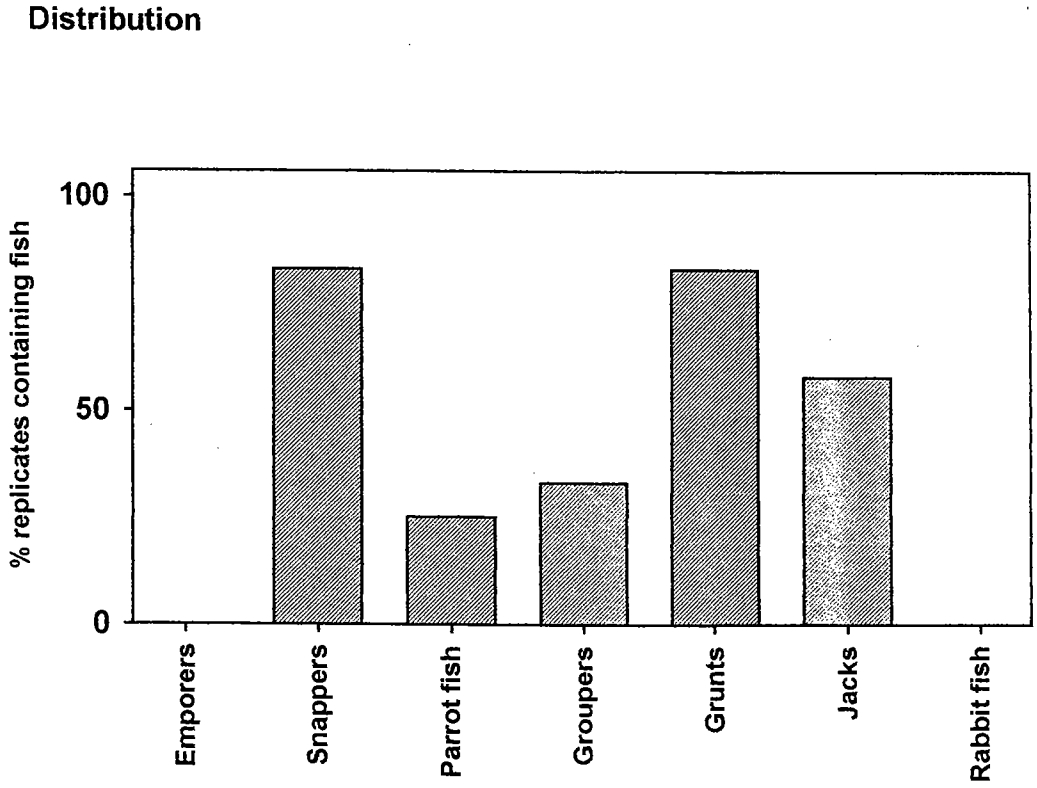


Figure 6.28 The abundance and distribution of commercial fish at site MT6.

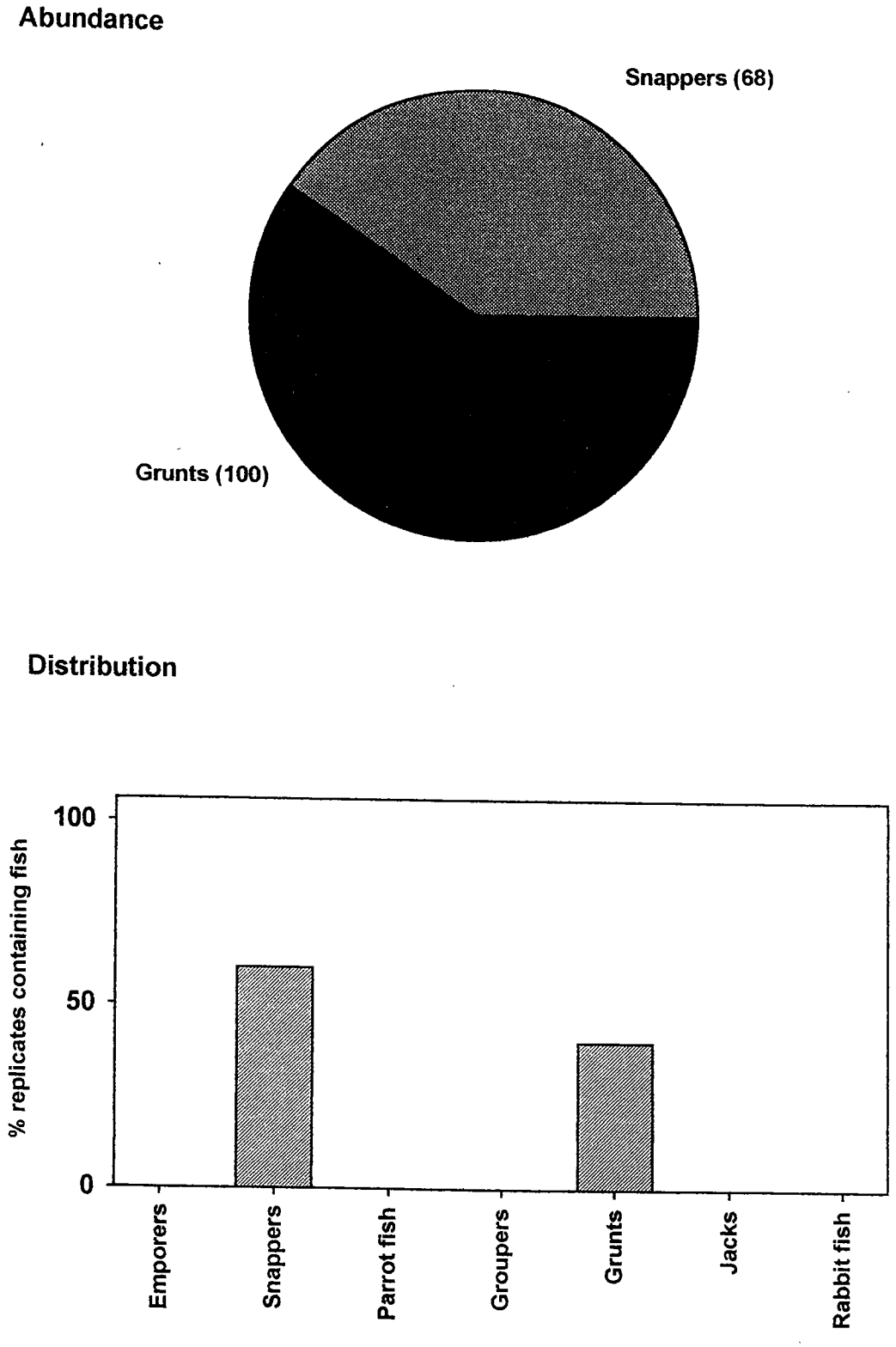
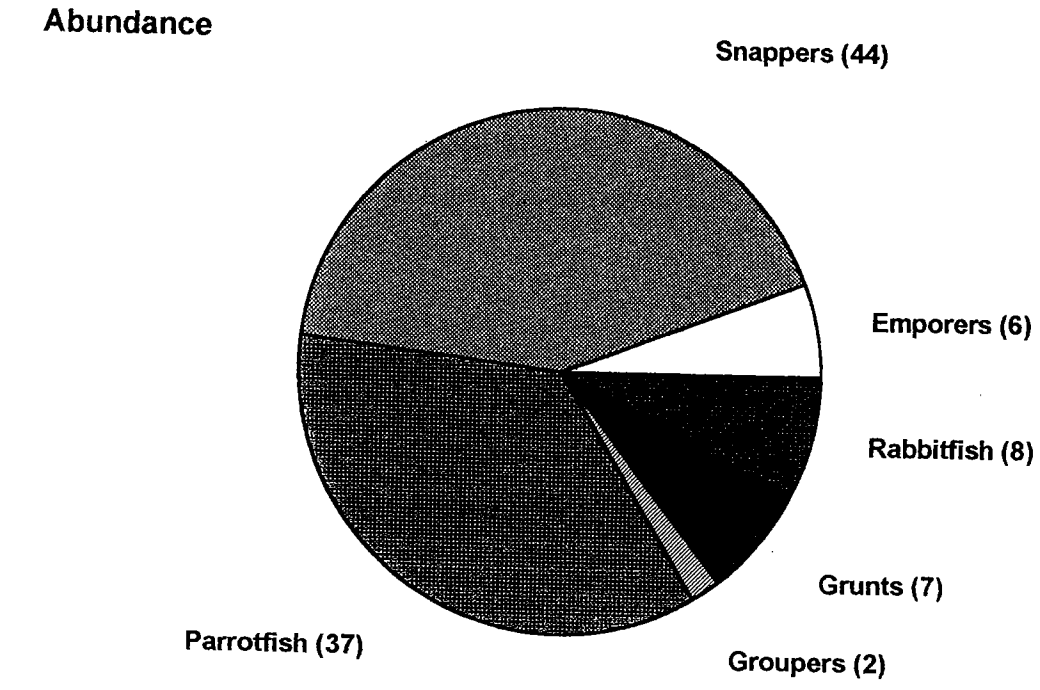
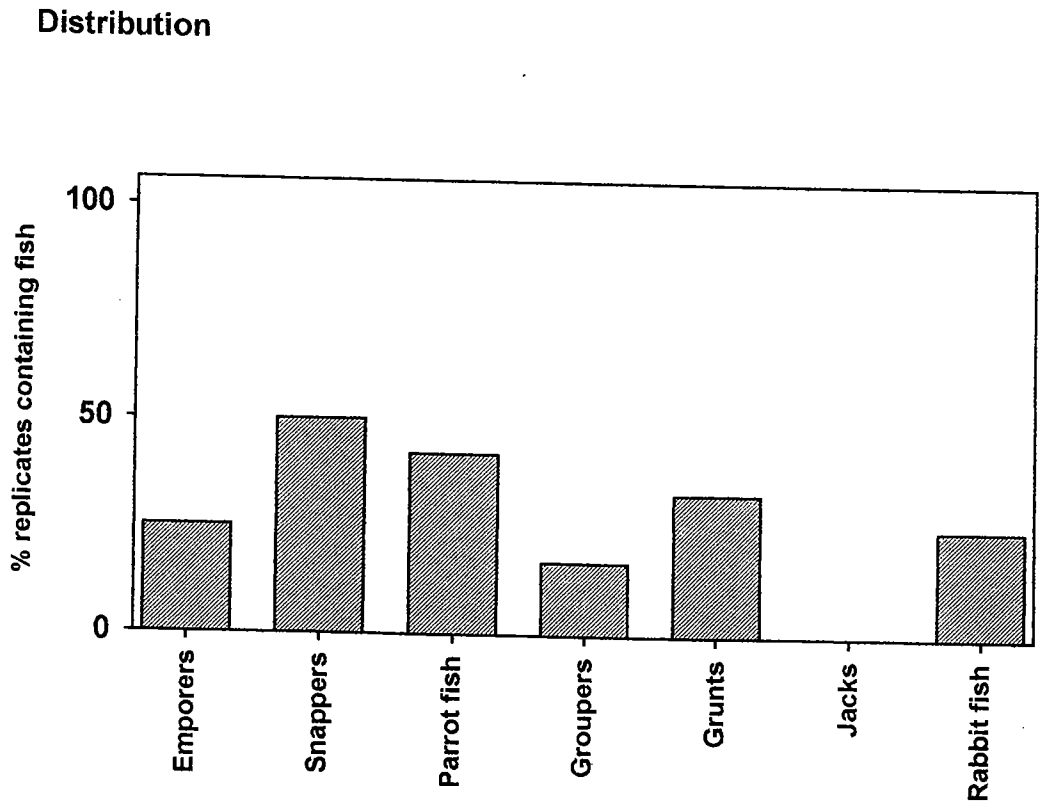


Figure 6.29 The abundance and distribution of commercial fish at site MT7.





6.7.3 Size distribution

A summary of the size distributions of commercial fish families recorded at Matemo island has been presented in Table 6.33. The sizes were typical of the censuses carried out in the Quirimbas.

Table 6.33 Size distribution summary for the commercial fish of Matemo island.

'Commercial' Fish Family	Number	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae	28	30	10-35
Lutjanidae	593	30	15-60
Scaridae	214	25	15-50
Serranidae	25	30	20-50
Haemulidae	263	30	15-80
Carangidae	108	40	30-60
Siganidae	8	20	10-20
Sphyraenidae	1	120	-

6.8 Finfish Fisheries

There were a number of small villages around the coast of Matemo and many permanent houses dotted along the coastal path between them, especially close to eastern and southern shores. Other semi-permanent, itinerant fishing camps also existed around the island, although the largest concentration of itinerant fishermen was on the north-western point where a beach provided excellent access for boats. Poor supplies of freshwater on the island necessitate frequent trips to the continent, especially in the dry season.

There are approximately 2000 permanent residents on the island but this is known to swell with the annual influx of itinerant fishermen during the dry season. Of the local population there are between 400 and 500 people directly involved in fishing (according to one village elder), but it was impossible at the time of this study (October, 1997) to estimate the involvement of the island's population with different fishing techniques and it is assumed that people collecting on the intertidal are also included in this group. It was suggested (by the same village elder) that many of the local fishermen go away to fish on other islands while the area becomes busy. The surveyors were not able, however, to confirm or deny this suggestion.

During the study 32 boats and 72 canoes were counted around the island, as well as a single motorised fishing boat belonging to a group of sea cucumber fishermen. The visiting groups of fishermen encountered included approximately 75 net fishermen (from six boats), 30 spear fishermen (from two boats) and a rough estimate of 30 spear, gillnet and line fishermen in canoes (Table 6.34). It appeared that most were from the mainland (mainly from Nacala and Pemba). The group of 12 sea cucumber fishermen were from Tanzania and were equipped with full SCUBA diving equipment and processing apparatus. It is clear that approximately 24 of the total count of boats and a rough estimate of 42 canoes were

permanently based on the island. Note that by November 1997 the population of itinerant fishermen had increased to approximately 400 people.

Table 6.34 A summary of the population involvement with different fishing techniques on Matemo.

Matemo Island		**Number**
Permanent Population		2000
Fishermen:	resident	400?
	itinerant	135
Fishing Method		
Line		31
Seine net		30
Trap: Marema		12
Trap: Suri		1
Trap: Large Marema		0
Luwando		1
Spear		31
Boats		
Sailing boats		30
Canoes		72
Rowing Boats		2

* number present in October 1997 during survey.

The major fishing method for sailing boats was seine netting, while many of the fishermen using canoes utilised a combination of fishing methods with spear fishing and simple hook and line fishing being the most popular. Gill nets were also evident at the large itinerant camp where many of the canoes were based. Two of the visiting rowing boats were primarily for spear fishermen and sea cucumber collection.

Spear and Line fishermen were generally catching similar, but bigger fish than those working on the larger boats. It was indicated that approximately 10kg of fish was caught each day per person in a canoe, while in the larger boats catches were highly variable. The methods of fishing in canoes allowed access closer to bommie areas around the island and, on occasion, east of the island on the outer reef. The main species caught included the Variegated emperor (*Lethrinus variegatus*), the Pink Ear emperor (*L. lentjan*), the Snubnose emperor (*L. barbonicus*), the Blackspotted sweetlips (*Plectorhinchus gaterinus*), the Oriental sweetlips (*P. orientalis*) and a variety of species of Scaridae, Serranidae and Mullidae.

Those fish not eaten by the fishermen or family members were either bartered or sold fresh or dried. Most fish were sun dried by the fishermen and taken in bulk to the mainland, smaller fish were preferred for the ease of drying. Markets included Pemba, Arimba and Nacala and prices were said to be approximately 25,000 Mt./kg, with approximately 3kg of fresh fish needed to give 1kg of dried fish.

6.9 Resource Collection

6.9.1 Overview

The intertidal zone covered an area of approximately 14km^2 and was composed of a variety of habitats which provided diverse resources for the islanders. The distribution and extent of the major intertidal habitats are presented in Figure 6.2. The nearshore intertidal strip was typically devoid of macroalgae, being covered by sand. A lagoon ran most of the length of the fringing reef on the east side of the island. The lagoon was shallow (maximum depth 1.0m), with a substratum composed of a mixture of sand, rubble and rock, with occasional small coral colonies and micro-atolls. The reef crest was typically 650m wide and composed of a mixture of rubble and flat rock.

The intertidal resource collection patterns on Matemo Island were assessed over a period of 6 spring tides in November 1997, during which time a total of 408 people were observed collecting on the intertidal and 94 of these were interviewed.

Scale and Intensity of Collection
The high number of collectors was thought to be a reflection of relatively high number (approximately 2000 habitants) of permanent residents on the island combined with a high dependence on intertidal resources.

Gender of Collectors
Adult women were the main collectors, representing 79% of the collectors, with lesser numbers of children (15%) and adult men (6%). Intertidal resource collection was one of the most important activities for adult women on the island. The primary employment for adult men was in the artisanal finfish fishery which was undertaken primarily around the neighbouring islands, notably Quieronuni.

Group Structure
The majority of people collected in groups, reflecting the high proportion of women collectors, who traditionally prefer to work with relatives or friends.

Origin of Collectors
All 94 collectors interviewed were from the island indicating a total absence of itinerant intertidal collectors on the island.

Collection Methods
The majority (over 70%) of the collectors used iron rods, a reflection of the high effort directed towards the collection of octopus and fish in the lagoon and reef crest zones. Snorkelling and seine netting were practised in the lagoon, but the catches were exclusively fish and thus were not included in this study.

Catch Composition

The primary target resource was Octopus *Octopus vulgaris*, which occupied 51% of the collectors interviewed (a total of 202 specimens collected). About 23% of people collected 'FO' (food) gastropods, namely *Fasciolaria trapezium* (6 specimens), *Fasciolaria lugubris* (22 specimens), *Chicoreus ramosus* (8 specimens), *Lambis lambis*, (2 specimens) and *Cypraea tigris* (2 specimens).

Other resources collected from the intertidal zone included; *Atrina pectinata* (50 specimens; 1 person), *Holothuria* spp (12 specimens; 8 people) *Charonia tritonis* (2 specimens; 2 people), *Pinctada capensis* (51 specimens; 5 people), *Tridacna* sp. (1 specimen; 1 person), *Acanthopleura* sp. (2 specimens; 1 person), *Pinna muricata* (1 specimen; 1 person), *Cypracassis rufa* (1 specimen; 1 person); *Barbatia fusca* (1 specimen; 1 person), *Strombus mutabilis* (over 500 specimens).

6.9.2 Distribution of Effort across Intertidal Zones

Two zones were observed as being intensively exploited. On the eastern side of the island the most heavily exploited zone was the lagoon, involving 80% of collectors. The reef crest was the second most exploited zone. On the sheltered western shore the most exploited area was from the extreme low water areas. The nearshore rock zone was not observed as being exploited. Both adult women and adult men exploited both the lagoon and reef crest areas. The young collectors were most commonly active in the eastern lagoon. The areas where resources were targeted within the intertidal zone are illustrated in Fig. 6.30.

6.9.3 Subtidal Collection

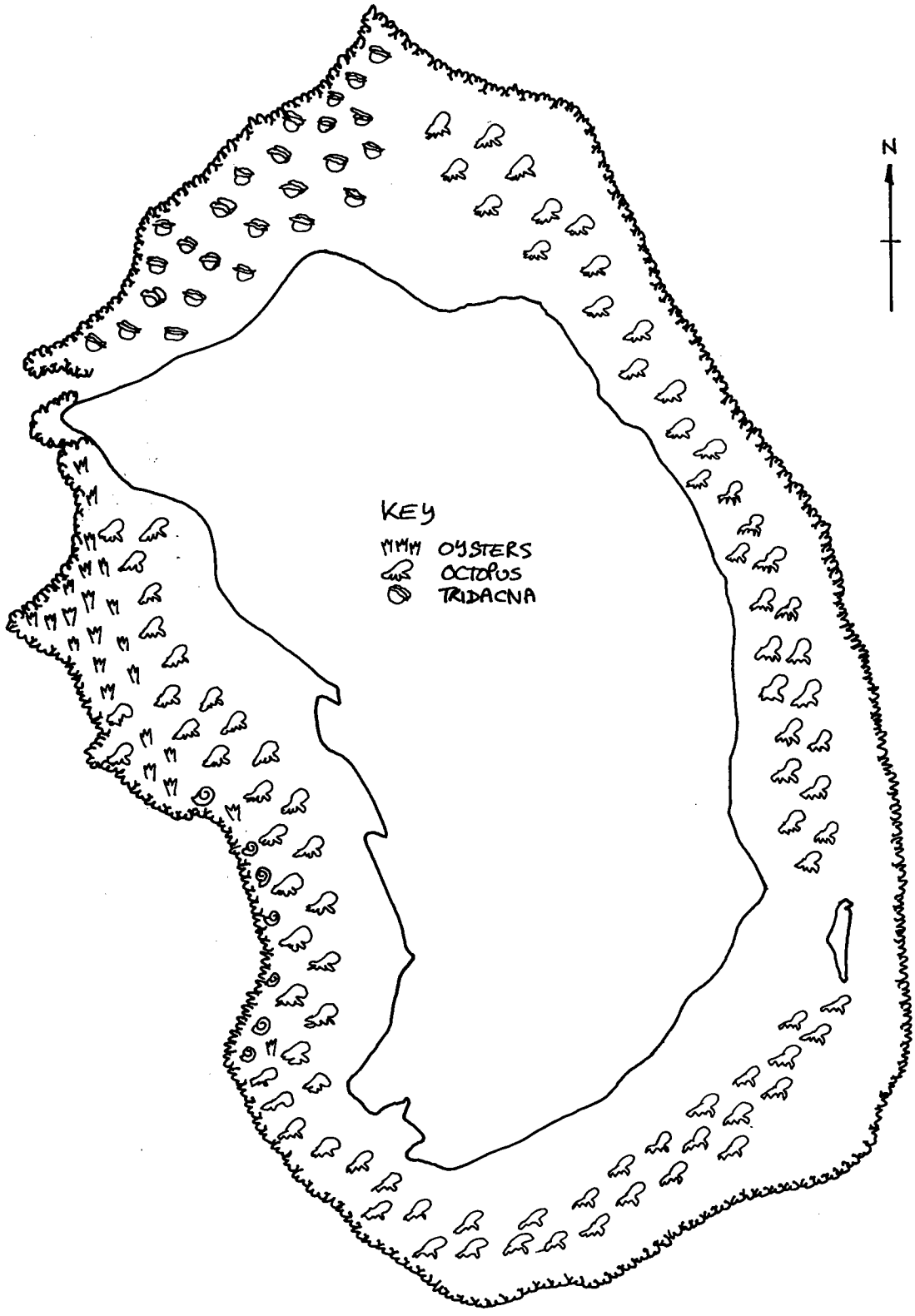
During the study no subtidal collection of molluscs or crustaceans was observed. Sea cucumbers were the only invertebrates recorded as being collected subtidally. This was being undertaken by a group of Tanzanians using SCUBA equipment from a motorised boat.

6.9.4 Discussion

The level of exploitation of intertidal resources was found to be relatively high for many resources when compared with other N.I.G. islands, namely Rolas, Mogundula and Macaloe. The 408 recorded collectors represents 21% of the permanent residents living on Matemo.

The lack of non-resident collectors suggests that the itinerant fishermen based on the island were more interested in the finfish fishery and collection of holothuria, leaving the exploitation of intertidal resources to the islanders.

Figure 6.30 Location of intertidal resource target areas, Matemo.



7.0 DISCUSSION

The findings reported indicate that the N.I.G. contained highly diverse habitat types, flora and fauna. The remote location of the islands, the topography of the region, the recent political instability and its associated prevention of coastal development have all combined to preserve the islands (and the Quirimba Archipelago as a whole) as an area of national importance for marine habitats. The following sections discuss the various habitats and resource use activities studied by the Programme within the N.I.G. in terms of threats to their status and/or sustainability, requirements for management and further study.

7.1 The Mangrove Habitat

Of the four N.I.G. islands, only Mogundula and Matemo islands could be regarded as possessing significant stands of healthy mangrove; Rolas supported no mangrove and Macaloe's mangrove was poorly developed. This contrasts markedly with the extensive stands of mangrove found within the Central Islands Group (C.I.G.) (see Technical Report 3: Central Islands Group). A total of six species of mangrove tree were identified, with *Ceriops tagal, Brugiera gymnorrhiza* and *Rhizophora mucronata* the most common.

The mangrove areas surveyed on Macaloe island were of particular interest. In many areas, the trees were growing on a dry sand substratum suggesting that the original intertidal areas where the stand stood had been covered by a build up of sediment. In the damper stands, water exchange with the open sea was very limited, with the base of the trees themselves constantly submerged. Large numbers of the trees in these areas were dead and decaying. These observations indicated that the mangrove on the island was diminishing through natural processes.

Most of the mangrove areas surveyed exhibited evidence of cutting, particularly in the more accessible areas close to creeks and footpaths. The scale of cutting was greatest on Matemo where a temporary camp was set up as a base for cutting activities. However, the overall threats to the mangroves of the N.I.G. were thought to be relatively low, with none of the clear felling or intensive wood extraction seen elsewhere in the archipelago (e.g. Quiwandala stand, Quirimba Island, Technical Report 3: Central Islands Group).

7.2 The Intertidal Flats

Macroalgae

The species richness of macroalgae within the N.I.G. was high with a total of 158 taxa (140 identified to species level and a further 18 specimens identified to genus level). This was a similar number to those found in both the C.I.G. (195 taxa) and the S.I.G. (153 taxa) (see Technical Report: 3 and 4). This level of species richness compares

favourably with those areas studied further south in Mozambique (C.M. António, pers. obs.).

No species of macroalgae were observed to be utilised by the islands' population and the obvious human impacts were limited to trampling by invertebrate collectors and by the dragging of nets in the lower zones of the intertidal. Consequently, the threats to macroalgae richness and diversity were considered low.

Invertebrates

Assessment of the intertidal invertebrate populations resulted from a combination of the findings from the biological surveys of the intertidal zone and investigations into the activities of collectors targeting intertidal invertebrates. Given the wide variety of invertebrates inhabiting the intertidal areas, the limits on the taxonomic expertise available and logistical and time constraints, a full study of intertidal invertebrate fauna was not possible.

The collection of invertebrates from the intertidal areas was a common activity although the scale and nature of the exploitation varied considerably between the islands and was dependent on: the overall size and characteristics of the intertidal area; the size of the island's population, and; the scale of other resource use activities based on the island. The majority of invertebrates were collected on a subsistence basis for consumption at home or barter on the islands for other staple food items. However, there is an increasing numbers of migrant fishermen within the islands operating on a more commercial basis which may threaten the sustainability of this resource.

There is currently no management of the collection of intertidal invertebrates within the archipelago. Given the importance of this resource activity to many of the islanders, there is a real need for management initiatives to both safeguard the sustainability of the resource and to maintain the status of invertebrate populations.

7.3 Seagrass Meadows

Seven seagrass species (from 5 genera) were identified within the N.I.G. from the 11 species so far recorded in northern Mozambique (S. Bandeira pers. comm.). The largest area of seagrass meadows surveyed was to the north of Macaloe where they extended to a depth of 22m. This was the greatest depth that seagrass meadows had been recorded by the Programme within the archipelago and is indicative of particularly clear waters close to Macaloe.

Fishing activity was witnessed in seagrass meadow areas but was limited in scale, with most fishermen in the N.I.G. targeting reef areas. Marema trap fishing and handlining were the most common methods employed. This is markedly different from the C.I.G. (Technical Report 3: Central Islands Group) where the majority of fishing activity was carried out using seine nets in seagrass meadow areas.

7.4 Reef Habitat

Reef structure

Coral reef was found in a variety of forms around all of the N.I.G. islands with the exception of some of the sites to the west of islands where the sheltered waters supported seagrass meadows and areas of sand. Two major forms of reef structure were identified; the steep reef wall which was often found off the south east of islands and was typified by site MT5 (Fig. 6.15), and the shallow slope, coral garden of the outer fringing reef which was typified by site MC3 (Fig. 3.9). In other areas where reef development was poor, coral was usually limited to bommies.

Natural threats to the coral, e.g. Crown of thorns starfish (*Acanthaster planci*) and White band disease, were rarely recorded during the surveys. Human impacts were also limited, although most reef areas, particularly the more sheltered ones, showed evidence of anchor damage. On the steeper reef areas, short lengths of snagged fishing line were regularly noted. The reefs of the N.I.G. can consequently be considered to be, at most sites, close to their 'natural state'. Management controls to protect the reefs are therefore not an urgent requirement but should be included as an important component to any overall management plan for the islands.

Reef invertebrates

Few of the molluscs listed on the survey sheets were observed, with the exception of the Giant clam *Tridacna* spp. which was common in localised reef areas. Large piles of discarded clam shells were noted on the seabed, in particular close to Mogundula island, indicating previous exploitation of these bivalves. These observations, together with the survey results, suggest a high intensity of fishing pressure on molluscs in the N.I.G.

Holothuria collection was noted to occur throughout the N.I.G. Some islanders collecting on the intertidal zone purposefully targeted sea cucumbers or collected them incidentally to their main catch. However, the greatest numbers of holothuria were taken by teams operating from boats using SCUBA and snorkelling equipment. The majority of these teams of collectors were comprised of Tanzanian fishermen operating illegally within Mozambican waters and were based at a camp on the northern point of Matemo.

Logistical constraints and available taxonomic expertise, limited the extent to which further detailed assessments of reef invertebrates could be made.

Reef-associated fish

The majority of sites surveyed showed a consistency in the relative levels of 'reef fish' diversity and in the abundance and diversity of 'commercial fish' populations. This is most probably a direct reflection of the similarity in the reef structure and composition at the survey sites. Of the 73 species of 'reef fish' on the census list devised for the fish survey, a total of 69 were observed (confirming the suitability of the Programme's fish

census sheet). The fish tended to be more diverse at those sites with greatest hard coral development (e.g. sites: MC3, MT1 and R2), although no single site was observed to be particularly species rich.

The 'commercial' fish were noted to concentrate on the reef areas to the south-east of each island where currents were likely to be strongest (e.g. site MT5). The two most common 'commercial' fish families were the snappers (Lutjanids) and the parrotfish (Scarids).

The reef based fishery within the N.I.G. was mainly limited to the more sheltered areas (e.g. to the south of Macaloe and Rolas islands and around the north of Matemo). A variety of methods were employed the most common being boat-based seine netting, handlining and spearing. Fishing on outer reef areas was limited by exposure to the large waves of the open ocean, preventing the safe use of canoes and traditional sailing vessels close to reef edge.

Given the existing fishing pressure on much of the reef areas, the status 'commercial' fish populations were judged to be currently under little threat. However, improvements in available fishing technology and fishing vessels or an increase in fishing pressure could quickly alter this situation.

7.5 Key sites for flora and fauna within the N.I.G.

The reef south of Matemo

The reef to the south of Matemo was a fine example of a steep wall reef. A high diversity of hard coral forms and reef fish existed on the platform above the wall and close to the wall itself large shoals of commercial fish congregated in the strong currents. The site had very little evidence of human impact and would be attractive to diving tourists.

The reef south of Mogundula

The coral garden south of Mogundula covered an extensive area and supported a well-developed reef, with a high diversity of coral and fish life. Evidence of human impacts were low and the area would be attractive to diving tourists.

7.6 Key threats within the N.I.G.

Intertidal resource use around Macaloe

The low numbers of invertebrates on the intertidal zone of Macaloe, particularly the northern area indicated that collection pressure could already be causing over-exploitation of these resources. Most of the collectors arrived by boat from the mainland villages of Mucojo and Pangane (up to three mashuas per Spring tide). Protection measures are required urgently to safeguard the sustainability of this resource.

Fishing camp on Matemo

The build up of migrant fishermen at the camp on the north western point of Matemo island has been marked during the study period (April 1996-December 1997). The camp has grown from less than 6 temporary shelters supporting approximately 30 people to a large semi-permanent settlement with as many as 400 fishermen and their families. This increase is indicative of the ever greater numbers of migrant fishermen build-up visiting the archipelago. The accompanying increase in fishing pressure in the islands directly threatens the sustainability of a number of resource use activities.

7.7 Recommendations for future studies within the N.I.G.

1) An assessment of the effects of various management strategies that could be employed to safeguard the flora and fauna of the islands and ensure the sustainability of the resource use activities in the N.I.G. is required. However, the formulation and implementation of an integrated management plan for the Quirimba Archipelago as a whole, should be the ultimate aim of work in this field.

2) A series of ecological studies on the inter-dependency and roles of the different habitat types with concern to the factors maintaining the biodiversity of the area.

3) The communities of the N.I.G. are heavily reliant on the natural resources of the islands for their food, building materials and income. More detailed socio-economic studies are required to evaluate this dependency and to assess the effects of the introduction of resource management schemes to the islands. Further to this, environmental education initiatives are required to create a better understanding by the islands' community and administration of the processes that affect the resources they exploit and the marine environment in general.

APPENDICES

A1 Geographic data for the Northern Islands Group

i) Grid References for the islands of the N.I.G.

Island	Latitude	Longitude
Macaloe*	12°59'00"S	40°35'00"E
Mogundula*	12°02'36"S	40°32'36"E
Rolas*	12°08'48"S	40°33'35"E
Matemo*	12°12'30"S	40°36'00"E

ii) Dimensions of the islands of the N.I.G. (Units are kilometres and are based on the maximum dimensions)

Island	North-South	East-West
Macaloe*	2.7	2.4
Mogundula*	0.5	0.7
Rolas*	1.0	0.3
Matemo*	7.3	3.3

iii) Subtidal survey sites in the N.I.G.

Macaloe Site	Latitude	Longitude
MC1	11°56'99.4''S	40°35'80.7''E
MC2	11°59'40.2''S	40°36'64.3''E
MC3	12°00'50.7''S	40°35'29.4''E
MC4*	12°00'17''S	40°34'02''E
MC5	12°00'28.2''S	40°34'04.3''E
Mogundula		
MD1	12°03'04.3''S	40°32'23.3''E
MD2	11°02'54.9''S	40°33'09.9''E
Rolas		
R1*	12°07'59''S	40°33'52''E
R2*	12°08'20''S	40°34'39''E
R3*	12°09'00''S	40°33'09''E
R4*	12°09'09''S	40°33'17''E
Matemo		
MT1	12°09'45.1''S	40°34'52.5''E
MT2	12°10'30.5''S	40°36'41.4''E
MT3	12°12'20.3''S	40°37'27.7''E
MT4	12°15'28.6''S	40°37'23.4''E
MT5	12°15'82.6''S	40°36'04.7''E
MT6*	12°14'02''S	40°34'02''E
MT7	12°11'14.9''S	40°33'33.7''E

*Grid references, island dimensions and survey sites were taken from the nautical chart 'Direcção Principal de Navegação e Oceanografia do Ministério da Defésa de URSS. No 46605-M and 46604-M. 1.ª Ediçao II-X-1986. 1:50 000. Additional site positions were recorded using Global Positioning System (GPS).

A2 Seagrass and macroalgae

Seagrass and macroalgae taxa recorded during surveys of the N.I.G.

i) Intertidal Flora

Seagrasses

Thalassia hemprichii
Halodule wrightii
Thalassodendron ciliatum

Macroalgae

Cyanophyta

Lyngbya majuscula

Chlorophyta

Anadyomene wrigthii
Avrainvillea erecta
Boergesenia forbesii
Boodlea composita
Bornetella oligospora
Bryopsis spp.
Caulerpa lentillifera
C. occidentalis
C. racemosa var. *clavifera*
C. racemosa var. *turbinata*
C. sertularioides
Chaetomorpha aerea
C. crassa
Chamaedoris delphinii
Chlorodesmis sp.
Cladophora fascicularis
C. mauritiana
C. sibogae
Cladophora sp.
Codium sp.
Dictyosphaeria cavernosa
D. verluysii
Enteromorpha kylinii
E. ramulosa
Enteromorpha sp.
Halimeda cilindracea
H. discoidea
H. opuntia
H. renschii
H. tuna
Microdictyon montagnei
Neomeris van bosseae
Spongocladia vaucheriaerformis
Udotea indica
Ulva fasciata
U. lactuca
U. pertusa
U. pulchra

Chlorophyta (continued)

Ulva reticulata
U. rigida
Valonia aegagrophila
V. fastigiata
V. macrophysa
Valoniopsis pachynema
Ventricaria ventricosa

Phaeophyta

Chonoospora implexa
Cistoseira myrica
C. trinodis
Dictyota adnata
D. cervicornis
D. ceylanica
D. divaricata
Hormophysa triquetra
Hydroclathrus clatrathus
Padina boryana
Padina gymnospora
P. tetrastomatica
Pocockiella variegata
Sargassum asperifolium
S. aquifolium
S. binderi
S. duplicatum
S. ilicifolium
S. latifolium
S. *swartz*
Sargassum sp.
Turbinaria conoides
T. ornata var. *ornata*

Rhodophyta

Acanthophora deodorised
A. muscoides
A. specifera
Acrocistis nana
Actinotrichia fragilis
Amphiroa anceps
A. beauvoise
A. fragilissima
A. cf.. *tribulus*
Bostrychia tenella
B. tenella
Caulacanthus ustulatus
Centroceras clavulatum

Rhodophyta (continued)

Ceramium sp.
Champia sp.
C. dasyphylla
C. sedifolia
Dasyopsis cf. *pilosa*
Digenia simplex
Endosiphonia clavigera
Eucheuma dendiculatum
Gelidiella acerosa
G. fasciculata
G. myrioclada
Gracilaria arcuata
G. edulis
G. fergusoni
G. folifera
Gracilaria sp.
Griffithisia rhizophora
Kappaphycus striatum
Kappaphycus sp.
Halymenia sp.
Halymenia venusta
Hypnea cornuta
H. hamulosa
H. musciformis
H. cf. *nidifica*
H. cf. *nidulans*
H. pannosa
Jania adhaerens
Laurencia columellaris
L. complanata
L. distichophyla
L. obtusa
L. papillosa
L. poiti
Liagora ceranoides
Liagora sp.
P. pulvinata
Pterocladia parva
Rabdonia cf. *africana*
Sarconema filiformis
S. scianaioides
Soliera robusta
Spyridia sp.
Vanvoorstia spectabilis
Wurdemannia miniata

A2 Seagrass and macroalgae (Continued)

ii) Subtidal Flora

Seagrasses

Cymodocea rotundata
Halodule uninervis
Halophila ovalis
Halophila stipulacea
Thalassia hemprichii
Thalassodendron ciliatum

Macroalgae

Cyanophyta

Lyngbya majuscula

Chlorophyta

Acetabularia sp.
A. obscura
Bornetella oligospora
Caulerpa sp.
C. cupressoides var. *flabellata*
C. cupressoides var. *typica*
C. mexicana
C. racemosa cf. *macrodisca*
C. racemosa var. *turbinata*
C. racemosa var. *typica*
C. selago
C. serrulata
C. sertularioides
C. taxifolia
Chamaedoris delphinii
Chlorodesmis sp.
Codium sp.
Dictyosphaeria cavernosa
Halimeda cilindracea
H. gigas
Halimeda sp.
H. milanesica
H. opuntia
H. renschii
H. tuna
Halimeda sp.
Microdictyon montagnei
Neomeris van bosseae
Udotea indica
U. orientalis
U. flabellum f. *longifolia*
U. flabellum f. *flabellum*
U. glauscens
Valonia macrophysa

Phaeophyta

Dictyopteris cf.. *deliculata*
Dictyota adnata
D. pardalis
Padina gymnospora
P. tetrastomatica
Padina sp.
Pocockiella variegata
Sargassum aquifolium
S. duplicatum
S. polycystum
Sargassum sp.
Turbinaria ornata var. *ornata*
T. ornara var. *serrata*

Rhodophyta

Acanthophora muscoides
A. cf.. *tribulus*
Amphiroa sp.
Chondrococcus harvey
Endosiphonia clavigera
Eucheuma dendiculatum
Galaxaura breviarticulata
G. fasciculata
G. tenera
Gracilaria sp.
G. verrucosa
Kappaphycus sp.
Hypnea cornuta
H. pannosa
Hypnea sp.
Jania adhaerens
Laurencia obtusa
Laurencia sp.
Liagora ceranoides
L. mauritiana
Liagora sp.
Poritiera harvey
P. pulvinata
Rabdonia cf. *africana*
Sarcodia sp.
Trichogloea sp.

A3 Reef fish surveys

Summary data for the reef fish surveys of the N.I.G. ('**% rate**' is the ratio of replicates in which the species was seen to the total replicates at each island; '**total**' is the number of species from the census list seen at each island). Numbers of replicate observations for each island: Macaloe 146; Mogundula 36; Rolas 53; Matemo 202. Total number of species recorded from census list in N.I.G. was 69 (+ indicates species present).

Scientific name	Common name	Macaloe		Mogundula		Rolas		Matemo		
		%rate	total	%rate	total	%rate	total	%rate	total	P/A
Acanthuridae	**Surgeonfish**									
Acanthurus leucosternon	Powderblue	11	22	31	1	4	4	13	139	+
Acanthurus lineatus	Lined	7	63	8	23	0	0	0	0	+
Acanthurus tennenti	Lieutenant (Tennents)	11	29	0	0	8	16	17	87	+
Acanthurus nigricauda	Blackstreak	12	45	0	0	4	2	18	108	+
Acanthurus nigrofuscus	Dusky	55	44	65	53	66	248	42	291	+
Acanthurus thompsoni	Thompson's	3	8	0	0	8	5	17	87	+
Acanthurus triostegus	Convict	7	88	25	44	28	72	5	57	+
Ctenochaetus binotatus	Twospot Bristletooth	52	589	39	105	0	0	38	289	+
Ctenochaetus stigosus	Goldring Bristletooth	14	54	17	14	45	142	18	100	+
Ctenochaetus striatus	Striped Bristletooth	26	197	11	36	0	0	14	71	+
Naso brevirostris	Spotted Unicornfish	1	1	0	0	4	6	5	153	+
Naso hexacanthus	Sleek unicorn	0	0	8	7	0	0	5	64	+
Naso lituatus	Orangespine Unicornfish	0	0	0	0	0	0	1	5	+
Paracanthus hepatus	Palette Surgeonfish	0	0	0	0	0	0	1	8	+
Zebrasoma desjardinii	Sailfin Tang (Desjardin's)	1	4	0	0	0	0	3	6	+
Zebrasoma scopas	Brown Tang (Brushtail)	16	67	47	85	45	125	29	138	+
Zanclus cornutus	Moorish Idol	7	26	25	12	13	16	15	57	+
Balistidae	**Triggerfish**									
Balistapus undulatus	Orangestriped	3	4	3	1	4	2	8	24	+
Balistoides conspicillum	Clown	0	0	0	0	0	0	0	0	
Balistoides viridescens	Titan (Moustached)	2	5	0	0	0	0	0	0	1+
Melichthys vidua	Black	1	2	0	0	0	0	1	4	1+
Odonus niger	Red-Tooth	4	17	0	0	2	6	6	143	1+
Pseudobalistes fuscus	Blue & Gold	0	0	0	0	0	0	0	1	1+
Rhinecanthus aculeatus	Wedge Picasso	2	9	6	6	0	0	2	5	1+
Rhinecanthus rectangulus	Picasso	0	0	0	0	2	1	0	0	1+
Sufflamen chrysopterus	Half-moon	63	233	58	44	13	8	55	240	1+
Sufflamen bursa	Scythe	0	0	0	0	2	1	4	14	1+
Chaetodontidae	**Butterflyfish**									
Chaetodon auriga	Threadfin	23	61	53	54	11	13	40	180	+
Chaetodon bennetti	Bennett's	0	0	0	0	0	0	1	3	+
Chaetodon blackburnii	Blackburn's	1	1	0	0	0	0	0	1	+
Chaetodon dolosus	African	0	0	0	0	0	0	0	0	
Chaetodon falcula	Double-Saddled	0	0	0	0	6	4	7	27	+
Chaetodon guttatissimus	Spotted	3	6	0	0	2	1	10	36	+
Chaetodon kleinii	Dot-Dash (Klein's)	32	104	14	7	8	10	46	212	+
Chaetodon leucopleura	Somali	0	0	0	0	0	0	0	2	+
Chaetodon lineatus	Lined	1	1	0	0	2	1	1	4	+
Chaetodon lunula	Racoon	8	18	42	42	4	2	13	42	+
C. madagascariensis	Madagascan	1	2	0	0	2	2	6	24	+
Chaetodon melannotus	Black-Backed	1	3	6	2	0	0	15	78	+
Chaetodon meyeri	Meyer's	5	10	0	0	4	2	4	11	+
Chaetodon trifiscialis	Chevron	10	18	31	22	23	24	6	17	+
Chaetodon trifasciatus	Redfin	20	67	33	20	28	36	30	133	+
Chaetodon unimaculatus	Teardrop	1	1	0	0	2	1	1	4	+
Chaetodon vagabundus	Vagabond	5	11	3	1	0	0	4	13	+
Chaetodon xanthocephalus	Fried-Egg	0	0	0	0	4	4	8	27	+
Chaetodon zanzibariensis	Zanzibar	1	1	0	0	2	1	0	1	+
Forcipiger longirostris	Big-Long-Nose	0	0	0	0	2	2	2	7	+
Hemitaurichthys zoster	Black Pyramid	0	0	0	0	0	0	8	43	+
Heniochus acuminatus	Pennant Bannerfish	5	14	0	0	0	0	12	49	+
Heniochus monoceros	Masked Bannerfish	1	2	0	0	0	0	3	9	+

A3 Reef fish surveys (Continued)

Scientific name	Common name	Macaloe		Mogundula		Rolas		Matemo		
		%rate	total	%rate	total	%rate	total	%rate	total	P/A
Mullidae	**Goatfish**									
Mulloidichthys flavolineatus	Yellow Stripe	1	5	0	0	2	20	1	4	+
Parupeneus barberinus	Dash-Dot	44	144	28	19	23	27	35	218	+
Parupeneus bifasciatus	Double Barred	5	18	3	1	0	0	2	10	+
Parupeneus cyclostomus	Yellow Saddled	0	0	0	0	2	1	1	3	+
Parupeneus macronema	Long Barbel	35	134	31	21	9	6	30	139	+
Upeneus tragula	Black Striped	5	18	0	0	0	0	0	0	+
Parupeneus pleurostigma	Sidespot	7	18	0	0	0	0	13	57	+
Pomacanthidae	**Angelfish**									
Apolemichthys trimaculatus	Yellow	0	0	0	0	0	0	7	20	+
Centropyge acanthops	African Pygmy	1	2	0	0	2	1	1	4	+
Centropyge bispinosus	Two-Spined	11	30	28	17	0	0	7	24	+
Centropyge flavicauda	White-Tail	1	1	0	0	0	0	1	5	+
Centropyge multispinus	Multi-Spined	18	50	39	29	15	14	39	164	+
Pomacanthus chrysurus	Earspot	2	3	8	3	0	0	4	59	+
Pomacanthus imperator	Emperor	8	13	3	1	0	0	13	32	+
Pomacanthus maculosus	Yellow-Bar	0	0	0	0	0	0	1	4	+
Pomacanthus rhomboides	Old Woman	0	0	3	3	0	0	0	1	+
Pomacanthus semicirculatus	Semi-circle	0	0	0	0	0	0	3	7	+
Pygloplites diacanthus	Royal	6	18	0	0	2	1	5	15	+
Tetradontidae	**Pufferfish**									
Arothron hispidus	White-Spotted	3	5	3	1	0	0	0	1	+
Arothron immaculatus	Immaculate	1	2	0	0	0	0	0	0	+
Arothron meleagris	Guineafowl	0	0	0	0	0	0	0	0	
Arothron nigropunctatus	Black-Spotted	0	0	0	0	0	0	0	0	
Arothron stellatus	Star	1	1	0	0	0	0	0	0	+

A4 Commercial fish surveys

Summary data for the commercial fish surveys of the N.I.G. Figures are the total number of individuals observed (numbers of replicate observations: Macaloe 76; Mogundula 6; Rolas 30; Matemo 41).

Species	Macaloe	Mogundula	Rolas	Matemo
Lethrinidae				
Lethrinus harak	4	0	0	6
Lethrinus mahsenoides	0	0	0	0
Lethrinus obsoletus	3	0	0	0
Lethrinus xanthochilus	0	0	0	0
Monotaxis grandoculis	11	0	1	15
Gnathodentex aurolineatus	2	0	30	0
Other emperors	1	0	16	6
Lutjanidae				
Aprion virescens	4	0	0	19
Macolor niger	2	0	1	0
Lutjanus bohar	1	0	6	22
Lutjanus ehrenbergii	0	0	0	0
Lutjanus fulviflamma	0	0	0	7
Lutjanus fulvus	38	0	4	40
Lutjanus gibbus	29	0	0	1
Lutjanus kasmiri	150	0	110	223
Lutjanus monostigma	85	16	26	267
Other snappers	150	0	1	0
Scaridae				
Cetoscarus bicolor	0	0	0	0
Hipposcarus harid	0	0	25	2
Leptoscarus vaigiensis	1	0	22	30
Scarus capistratoides	0	0	0	0
Scarus caudofasciatus	47	0	0	6
Scarus frenatus	0	0	6	0
Scarus ghobban	118	26	24	31
Scarus japanensis	0	0	0	0
Scarus niger	0	0	1	0
Scarus psitticas	0	0	9	0
Scarus rubroviolaceus	35	0	0	3
Scarus scaber	0	0	4	0
Scarus sordidus	519	0	101	9
Scarus strongylocephalus	1	0	0	0
Scarus tricolor	0	0	0	0
Scarus viridifucatus	11	0	2	0
Other parrotfishes	66	9	76	133

A4 Commercial fish surveys (Continued)

Species	Macaloe	Mogundula	Rolas	Matemo
Serranidae				
Aethaloperca rogaa	0	0	0	0
Cephalopholis argus	3	0	3	0
Cephalopholis miniata	9	0	8	20
Cephalopholis nigripinnis	4	1	0	1
Cephalopholis sexmaculata	1	0	0	0
Cephalopholis sonnerati	1	0	0	0
Cephalopholis spiloparaea	0	0	0	0
Epinephelus caeruleopunctatus	0	0	0	0
Epinephelus fasciatus	5	0	0	0
Epinephelus hexagonatus	3	0	0	0
Epinephelus malabricus	1	0	0	0
Epinephelus ongus	0	0	0	0
Epinephelus polyphekadion	1	0	0	1
Epinephelus tukula	0	0	1	0
Plectropomus laevis	0	0	0	0
Plectropomus punctatus	3	0	0	0
Variola louti	2	0	0	1
Variola albimarginata	0	0	0	0
Other groupers	2	0	0	3
Haemulidae				
Diagramma pictum	4	0	0	68
Plectorhinchus flavomaculatus	15	0	1	0
Plectorhinchus gaterinus	38	7	15	219
Plectorhinchus gibbosus	0	0	0	0
Plectorhinchus orientalis	2	0	0	0
Plectorhinchus plagiodesmus	0	0	0	9
Plectorhinchus playfairi	0	0	0	1
Other grunts	0	0	0	1
Carangidae				
Carangoides ferdau	0	0	0	0
Caranx ignobilis	0	0	0	71
Caranx melampygus	1	0	0	24
Other jacks	0	0	0	85
Sphyraenidae				
Sphyraena sp.	300	0	0	1
Siganidae				
Siganus sutor	175	0	3	8
Siganus stellatus	2	0	0	0

A5 Biological resources

Local and Regional Use and Cost of the Islands' Biological Resources.

Latin name	Use	Quirimba Cost/unit	Quirimba Cost/kilo	Pemba Cost/unit	Pemba Cost/kilo
Bivalvia					
Arcinella sp.	Food			1,000 (Nacala)	
Barbatia sp.	Food		1,000/handful		
Gafrarium sp.	Food		1,000/cup		
	Curio trade			1,000	
Mytilidae sp.	Food	Not sold	Not sold	Not sold	Not sold
Pinctada sp.	Food	1,000/string dried; 2,000/cup	5,000 *4 10,000		
Pinna sp.	Food; Bait		2,000 *7		
Atrinia sp.	Food		1,000		
Saccostrea sp.	Food	Not sold	Not sold	Not sold	Not sold
Striostrea sp.	Food	Not sold	Not sold	1,000	
Telina sp.	Curio trade			10,000	
	Food	Not sold	Not sold	Not sold	Not sold
Trachycardium sp.	Food	Not sold	Not sold	Not sold	Not sold
Tridacna sp.	Curio trade	3,000 large			
		1,000 small			
	Food	3,000 large			
Gastropoda					
Chicoreus ramosus	Operculum Food	250			75,000 (Tanzania)
Fasciolaria trapezium	Food Operculum	250			75,000 (Tanzania)
Haliotis sp.	Food	Not sold	Not sold	Not sold	Not sold
Mancinella alouina	Food	Not sold	Not sold	750	
Marginella sp.	Food	Not sold	Not sold	Not sold	Not sold
	Operculum	100*1			
Morulla granulata	Food	Not sold	Not sold	Not sold	Not sold
Natica gualteriana	Food	Not eaten	Not eaten	1,000/ 10	
Nerita sp.	Food	Not sold	Not sold	Not sold	Not sold
Terebralia palustris	Food/ bait				
Strombus mutabilis	Food	Not sold	Not sold	Not sold	Not sold
Turbo coronatus	Food	Not sold	1000	Not sold	Not sold

A5 Biological resources (Continued)

Latin name	Use	Quirimba Cost/unit	Quirimba Cost/kilo	Pemba Cost/unit	Pemba Cost/kilo
Gastropoda					
Cassis cornuta	Curio trade	5-15,000 *3			
Charonia tritonis	Curio trade			120,000	
Chicoreus chicoreus	Curio trade	2,500		10,000	
Conus spp.		1000	1000 *8		
Cypraea tigris	Curio trade	1000			10,000
Cypraecassis rufa	Curio trade	Class Price 1st 15,000 2nd 7,000 3rd 3750	30, 000		30,000 *5
Harpa spp.	Curio trade			5,000	
Lambis chiragra	Curio trade				
Lambis lambis	Curio trade	250 (small) 1,000-1,500 (large)	50,000	10-15,000*7	
Littorina spp.	Curio trade			250	
Marginella sp.	Curio trade			5,000/100	
Mitra spp.	Curio trade	Not sold	Not sold	2,000/5	
Mitra sp.	Curio trade			8,000	
*Monodonta australis*1	Curio trade	1,000			
Murex pecten	Curio trade	1,000			
Nassarius coronatus	Curio trade			250/10	
Patella spp.	Curio trade Food			250/10	
Peristernia forskalii	Curio trade			8,000	
Phalium glaucum	Curio trade			1,000 (N) *7	6,500 (N) *7
Strombus sp. (bottom spike)	Curio trade			15,000	
Strombus sp. (top spike)	Curio trade			2,000	
Terebra spp.	Curio trade	Not sold	Not sold	10,000	
Tonna spp.	Curio trade			5,000	
Trochus spp.	Curio trade			2,000	
	Food	Not sold	Not sold	Not sold	Not sold

A5 Biological resources (Continued)

Latin name	Use	Quirimba Cost/unit	Quirimba Cost/kilo	Pemba Cost/unit	Pemba Cost/kilo
Octopus vulgaris	Food		3,000 fresh; 10-13,000 dry; *8		
Holothuria					
General	Food			Tanzania	50,000 *2
B. marmorata (Namunya)	Food	250			
S. variegatus (Bosi)	Food	1,000			
A. miliaris (Namwali)	Food	500-1,000	10,000		
Ningi	Food	1,000	15,000		
H. nobilis (Grife)	Food	100			
Pwazi	Food	100			
Crustacea					
Scylla serrata	Food		5,000 *6		
Panulirus ornatus	Food	5-10,000 *6			

NOTES:

Prices were given by Saidi Kashim, a shell collector and vendor in the Quirimbas and Pemba, in 9/96. Prices of holothuria were given by various exploiters. The currency exchange rate was at 12,000 meticais/ US Dollar.

*1 given by intertidal exploiter on 15/9/96.
*2 given by intertidal exploiter on 16/8/96.
*3 given by Quiwandala fisherman on 2/8/96.
*4 given by intertidal exploiter on 17/8/96.
*5 given by intertidal exploiter on 15/8/96.
*6 is the usual price that is paid on camp.
*7 given by intertidal exploiter on 28/8/96, on Quisiva.
*8 given by intertidal exploiter on 23/9/96 on Quilaluia.
*9 given by intertidal exploiter on 15/8/96.
*10 given by ITR User on 15/8/96.

A6 Names of biological resources

Scientific, common English and local names of the biological resources utilised by the people of the Northern Island Group.

Bivalves (Bivalvia)

Scientific Name	Common Name	Kimwani Name	Makua Name
Atrina vexillum	Giant Pen	Nyeta	Nyeta
Barbatia fusca	Almond Ark	Ombe	Ikope
Gafrarium sp.	Venus clam	Namesa/Kauri	Kamesa
Malleidae sp.	Oyster	Ulumbe/Soka	Uwala
Mytilidae spp.	Mussel	Jojobwe	Jojobwe
Pecten spp.	Scallop	Ulumbe/Ombe lume	Uwala
Pinctada nigra	Pearl oyster	Saja	Mbare
Pinna muricata	Pinna	Kaza	Ipazo
Saccostrea sp..	Rock oyster	Ulombe/ Enlumbe	Uwala
Striostrea sp.	Rock oyster	Kipambama maulu	
Telina sp.	Tellin	Kauri lume	Komrobwe
Trachycardium sp.	Cockle	Ombe lume	Ikope
Tridacna squamosa	Fluted giant clam	Nyeta	Nyeta

Gastropods (Gastropoda)

Scientific Name	Common Name	Kimwani Name	Makua Name
Cassis cornuta	Horned Helmet		
Charonia tritonis	Trumpet Triton		Nimbululu
Chicoreus ramosus	Ramose Murex	Kome muka	
Conus spp.	Cones	Nkindo	Epata
Cypraea spp.	Cowries	Pwazi	Ucana
Cypraecassis rufa	Bullmouth Helmet	Mbana	Nafundo
Fasciolaria trapezium	Tulip whelk	Kome lume	Ninkome
Haliotis spp.	Abalone		Nanrododo
Harpa major	Harp		
Lambis chiragra	Arthritic spider	Spulapondo	Shidikamondo
Lambis lambis	Common spider	Spulapondo	Shidikamondo
Littorina spp.	Periwinkle		
Mancinella alouina	Salmon-lipped whelk	Nadoda	Namalukumi
Marginella spp.	Marginella	Ofu	Ofu
Mitra mitra	Mitre		
Monodonta australis	Toothed Top	Singinya	
Morulla granulata	Mulberry shell	Nadoda	Natota
Murex pecten	Venus comb Murex	Nikome	
Nassarius coronatus	Shielded Dogwhelk		Nsoro
Natica gualteriana	Comma necklace		Mweri
Nerita spp.	Nerite		Nankusero
Patella spp	Limpet		Anakikombe
Peristernia forskalii	Forskals whelk		
Phalium glaucum	Grey bonnet	Sebulalu	
Polinices tumidus	Pear moon		
Strombus mutabilis	Humpback conch	Sololandimo	Nansolola
Terebra spp.	Auger		
Terebralia palustris	Mangrove whelk	Nonde	Kolote
Tonna spp.	Ton		
Trochus spp.	Top	Ukindo	Irauwe
Turbo coronatus	Turban	Opolo	Singine

A6 Names of biological resource (Continued)

Chiton (Polyplacophora)

Scientific Name	Common Name	Kimwani Name	Makua Name
Polyplacophora spp.	Chiton	Nyamata	

Octopus (Cephalopoda)

Scientific Name	Common Name	Kimwani Name	Makua Name
Octopus vulgaris	Common Octopus	Pweza	Pweza

Sea cucumber (Holothuria)

Scientific Name	Common Name	Kimwani Name	Makua Name
Holothuroidea	Sea Cucumbers	Kojojo	Nikojojo
Actinopyga mauritiana	Red surf cucumber	Mingui	
Actinopyga miliaris	Black pear cucumber	Namwali	
Bohadschia marmorata	Chalky cucumber	Namunya	
Holothuria nobilis	Mammy cucumber	Grife	
Holothuria fuscogilia	White mammy cucumber	Umvua	
Holothuria scabra	Sand cucumber	Namwali	
Stichopus chloronotus	Green cucumber	Espinho	
Stichopus variegatus	Yellow prickly cucumber	Bosi	
Thelenota ananas	Red prickly cucumber	Espinho	

Further sea cucumbers not identified but having Kimwani names were; Kufulie, Mwelupa, Ningi, Pula, Pwazi, Safiya,Supedi

Sea Urchins (Echinodermata)

Scientific Name	Common Name	Kimwani Name	Makua Name
Tripneutes gratilla	Short-spined urchin	Unsunkuru	

Crustacean (Crustacean)

Scientific Name	Common Name	Kimwani Name	Makua Name
Panulirus ornatus	Ornate spiny lobster	Mwambamba	
Portunus pelagicus	Pelagic swimcrab		
Scylla serrata	Green mangrove crab		
Lepas spp.	Barnacle	Ulumbe/Umkoe	Uwala

Notes:

Names given by Saidi Kashim, a shell collector and vendor in the Quirimbas and Pemba; and other exploiters.