Frontier Mozambique Environmental Research

REPORT 3

Central Islands Group - Ibo, Quirimba, Sencar and Quilaluia Islands.

Marine Biological and Resource Use Surveys of the Quirimba Archipelago

Frontier Mozambique
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Whittington, M.W., António C.M., Corrie, A. and Gell, F. (eds)

Ministry for the co-ordination of Environmental Affairs, Mozambique

Darwin Initiative: Department for Environment and Rural Affairs, UK.

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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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Executive Summary

The following report details the findings of the Darwin/Frontier-Moçambique Quirimba Archipelago Marine Research Programme's surveys of the Central Islands Group (C.I.G.): Ibo; Quirimba; Sencar and Quilaluia islands. The surveys were completed between April 1996 and December 1996 by the Programme's staff, research assistants, visiting scientists from the UK and Mozambican Programme participants. This report is one of a series produced by the Programme 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 "Marine Biological and Resource Surveys of the Quirimba Archipelago, Mozambique. Technical Report 1: Introduction and Methods".

The C.I.G. covers an area of approximately 125 km^2 close to the coastline of Cabo Delgado Province, northern Mozambique. It includes: extensive areas of mangrove (the largest 'stand' of mangrove in the archipelago is situated to the south and west of Ibo island); seagrass beds, particularly in the shallow Montepuez Bay to the west of Quirimba island; fringing and patch reefs around most of the more exposed lengths of shoreline and deep oceanic water close to the eastern shores of Ibo, Quirimba and Sencar islands. This high concentration and variety of habitat types was found to support a correspondingly rich and abundant flora and fauna.

Ibo, Quirimba and Sencar islands all supported mangrove stands, totalling an area of approximately 1,900 hectares, over 90% of which was associated with the stand south of Ibo island. The total area of mangrove of the C.I.G. was doubled if the mangrove of the adjacent coastline was included. Eight species of mangrove tree were recorded, with *Rhizophora mucronata* (Rhizophoraceae) the most common. The mangroves supported large populations of decapod crustacea and gastropod molluscs. The scale of mangrove cutting was relatively small in proportion to the overall area of the mangrove present but in localised areas, particularly on Quirimba island, extensive cutting has led to a significant reduction in the number of trees and an associated erosion problem for the adjacent shoreline.

The islands of the C.I.G. are subject to a maximum tidal range in excess of 4 m which, combined with the topography of the region, has created large expanses of intertidal area. The upper reaches of the intertidal flat were, in most cases, bordered by a raised, ancient 'coral rag' with a low abundance of flora and fauna. The characteristics of the mid and lower reaches were largely determined by the degree of exposure to wave action. For example, most sheltered areas had a sand substrate supporting numerous algae and seagrass species in contrast to the more exposed areas characterised by lagoon and reef crest habitats supporting a rich diversity of algae and intertidal fauna, primarily gastropod molluscs and decapods.

The exposed, fringing reefs of the C.I.G. extend in an almost unbroken line along the eastern shores of Ibo, Quirimba and Sencar islands. The structure of these reefs was fairly consistent throughout. A typical reef profile followed an initial gently sloping platform to a depth of approximately 10 m leading into a steeper mid-section which

may include a short vertical wall, followed by a more gently sloping lower slope to the reef base at 16-20 m. Hard corals commonly dominated the biotic cover with the Genus *Acropora* widespread over much of the reef areas. To the north of Ibo island and around Quilaluia island more sheltered fringing and patch reefs were recorded.

A high diversity of 'reef' and 'commercial' fish species were observed with over 330 fish species recorded, including; 19 species of Acanthuridae (Surgeonfish), 11 species of Balistidae (Triggerfish), 21 species of Chaetodontidae (Butterflyfish) and 11 species of Pomacanthidae (Angelfish). On the exposed reefs, where the fishing pressure was minimal, a diverse and abundant fish fauna was recorded including an abundance of the larger 'commercial' fish families such as Lethrinidae (Emperors), Lutjanidae (Snappers), and Serranidae (Groupers).

The islanders were found to be heavily dependent, mainly for subsistence, on the marine resources of the islands, particularly the fish. The majority of fishing activity was concentrated in the shallow Montepuez Bay to the west of Quirimba island, where seine netting from sailing boats and trap fishing from canoes were the preferred fishing methods (a detailed description of this fishery is presented in "Marine Biological and Resource Surveys of the Quirimba Archipelago, Mozambique. Technical Report 5: Quirimba Island Seagrass Seine Net Fishery".). Catches were diverse with a total of 192 species recorded. The Scaridae (Parrotfish), Labridae (Wrasse) and Lethrinidae (Emperors) formed the dominant part of the catch. Most notable was the high proportion of small and juvenile fish in the catch, all of which were retained. Capture of so many juveniles is of concern with regard to the long-term sustainability of the fishery. Large numbers of migrant fishermen were observed to visit the islands to fish during the dry season from Nampula Province. These fishermen often employed larger nets and, in contrast to many local fishermen, were fishing for profit rather than for subsistence. The recent increased pressure from commercially oriented fishing is considered a potential threat to the sustainability of the fisheries.

Collection of molluscs, primarily gastropods, bivalves and octopii, from the intertidal areas was an important activity, especially for women, children and the older islanders who were not able to work on the fishing boats. Bivalve collection was concentrated in areas of soft substrate and was carried out mainly around the spring tide periods. Gastropod and octopii were collected from the lagoon and reef crest areas of the more exposed shores, with gastropods taken for both food and for sale to the curio trade. A significant activity, particularly in terms of financial considerations, was the collection of seacucumbers (Holothuria) for sale and export. A small-scale, seacucumber buying operation was based on Ibo island but the largest buyers and collectors were groups of Tanzanian fishermen operating illegally amongst the islands. The numbers taken and bought by these groups, although not counted directly, were known to be very large and are almost certainly unsustainable.

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

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 Ibo, Quirimba, Sencar and Quilaluia, have been collectively grouped and named as the 'Central Islands Group' and will be abbreviated to C.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. These surveys were completed between April-December 1996.

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, almost no 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.

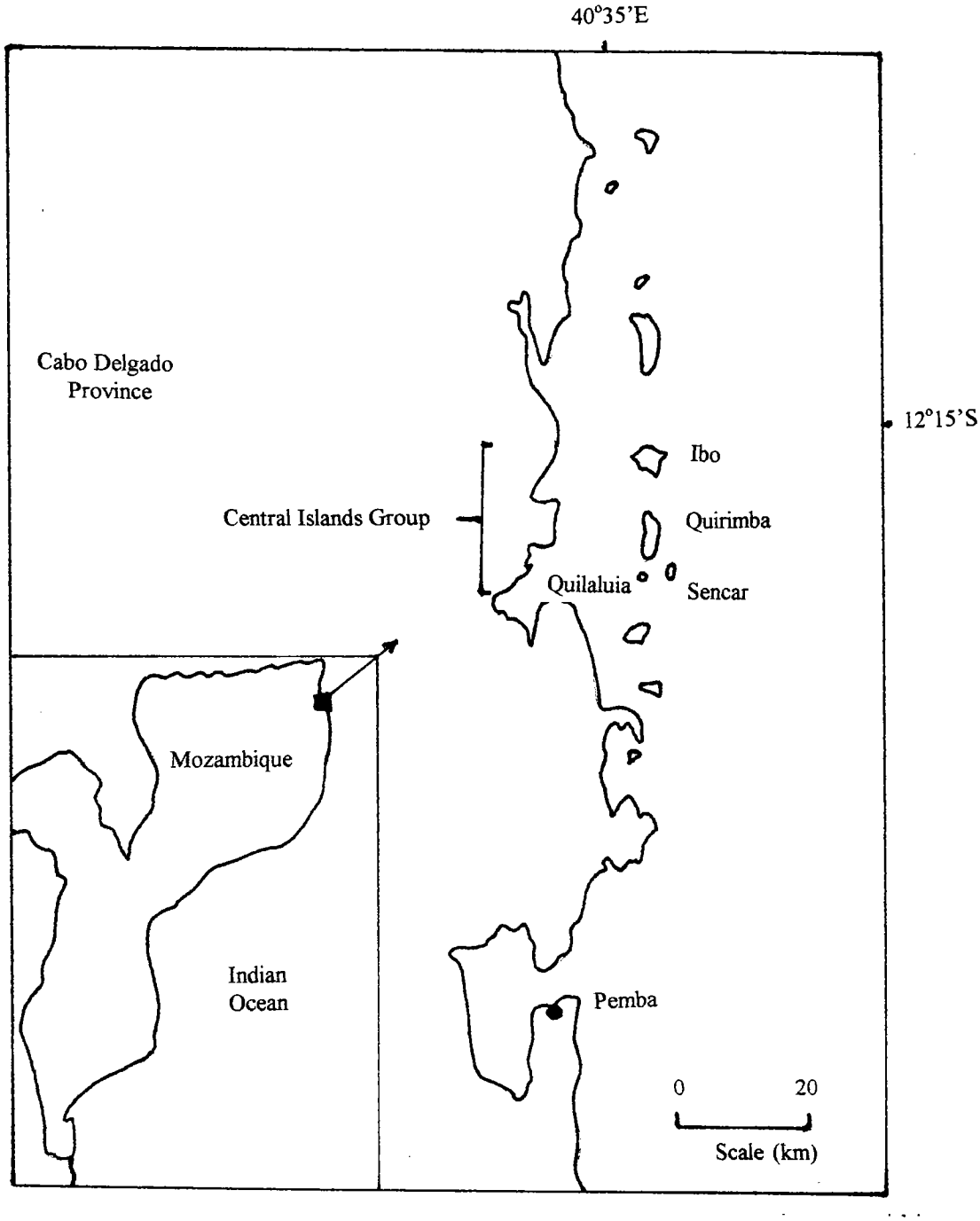


Figure 1. A map illustrating the position of the Central Islands Group study area within the Quirimba Archipelago, northern Mozambique.

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: "Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Moçambique. 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 1.

2.2 Intertidal Surveys

The Quirimba Archipelago is subject to a tidal range in excess of 4 m which, combined with the shallow topography on the western side (continental side) of many of the islands, has lead 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 substrate 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 C.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 mean 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.

The local names for each mangrove species within the C.I.G. are given in Appendix 17.

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 targetted 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 C.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', 'Substrate 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 0-6 abundance scale which is summarised below:

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

A detailed analysis of the hard corals is presented separately as follows. An 'Overview' summarises the main features of the corals found. 'Site reports' detail the coral composition of the reef in terms of 'coral form' and genera. For the detailed analysis of hard corals, an abundance estimate of percentage cover (to the nearest 5% is given) is given.

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 C.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 presented represents 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 Diversity Indices and Total Species Number for each site. The Relative Diversity Indices (R.D.I.) were calculated for each site using the following formula:

R.D.I = No. of Reef Fish Observed/Total No. of Reef Fish Censused

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 Acantharidae (Surgeonfish) and Zanclidae, the Moorish Idol (*Zanclus cornutus*) was included in the former group. All the species included in the species survey list given in 'Technical Report 1: Introductions and Methods' (Whittington & Myers, 1997) were used in the analysis, with the exception of 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 amongst diving tourists 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 C.I.G. through an assessment of the commercial fish populations.

Although species 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 'encounter' rates (numbers of fish seen during a sample interval) 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 C.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 C.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 C.I.G. With the exception of Quirimba island (see Technical Report 5 for details of the Quirimba island fisheries), 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 11 lists the common names of each of the resources exploited and Appendix 12 gives an indication of the monetary value of each resource at the time of this study.

3.0 IBO ISLAND

3.1 Introduction

Ibo island (12°41'S 40°35'E) is the central island of the southern Quirimba Archipelago (Fig. 1). The layout of the island and its associated habitats are shown in Figure 2. The island is approximately 3.6 km by 4.5 km and, with the exception of the old 'Stone' town and the surrounding village and 'shambas' at its western end, remains largely unpopulated and uncultivated. Heading west from the town the northern and eastern shores border the open sea, the eastern shore supporting an exposed, fringing outer reef. To the south and south-west lies a vast expanse of mangrove, penetrated by numerous channels, that stretches south approximately 4.5 km to near the northern end of Quirimba island.

The town on Ibo, which is the administrative centre for the C.I.G., supports the largest resident human population and was historically the major port for the region (Pemba has now taken over that role). A field station for IDPPE (Institute for the Development of Small-Scale Fisheries) is based in the town in addition to a representative of the provincial Ministry of Agriculture responsible for the monitoring of fishing activity, and a fish buying and freezing centre for local catches. There is freshwater available from wells and bore holes over much of the island.

3.2 Intertidal Surveys

3.2.1 Overview

The intertidal area stretching from the north-western shore down the eastern side of the island comprised an estimated 26 km^2 of exposed flat. The more sheltered western and south-western areas supported an extensive mangrove stand with a narrower fringe of exposed intertidal flat. Macroalgae dominated the eastern intertidal area and seagrass dominated the northern and more sheltered western shores and mangrove channels.

Nine seagrass species (the highest site diversity recorded within the C.I.G.), 126 taxa of macroalgae (1 Cyanophyta, 54 Chlorophyta, 22 Phaeophyta and 49 Rhodophyta) and 19 taxa of associated invertebrates were recorded. Check lists for recorded taxa are presented in Appendices 2 (algae and seagrass) and 3 (Invertebrates). The 126 taxa of macroalgae make Ibo the site of the second highest species diversity within the C.I.G. The most notable feature of the algal flora on Ibo was the dominance of Chlorophyta (Green algae) in contrast to a dominance of Rhodophyta (Red algae) in the other C.I.G. islands. The pantropical Order Caulerpales was well represented.

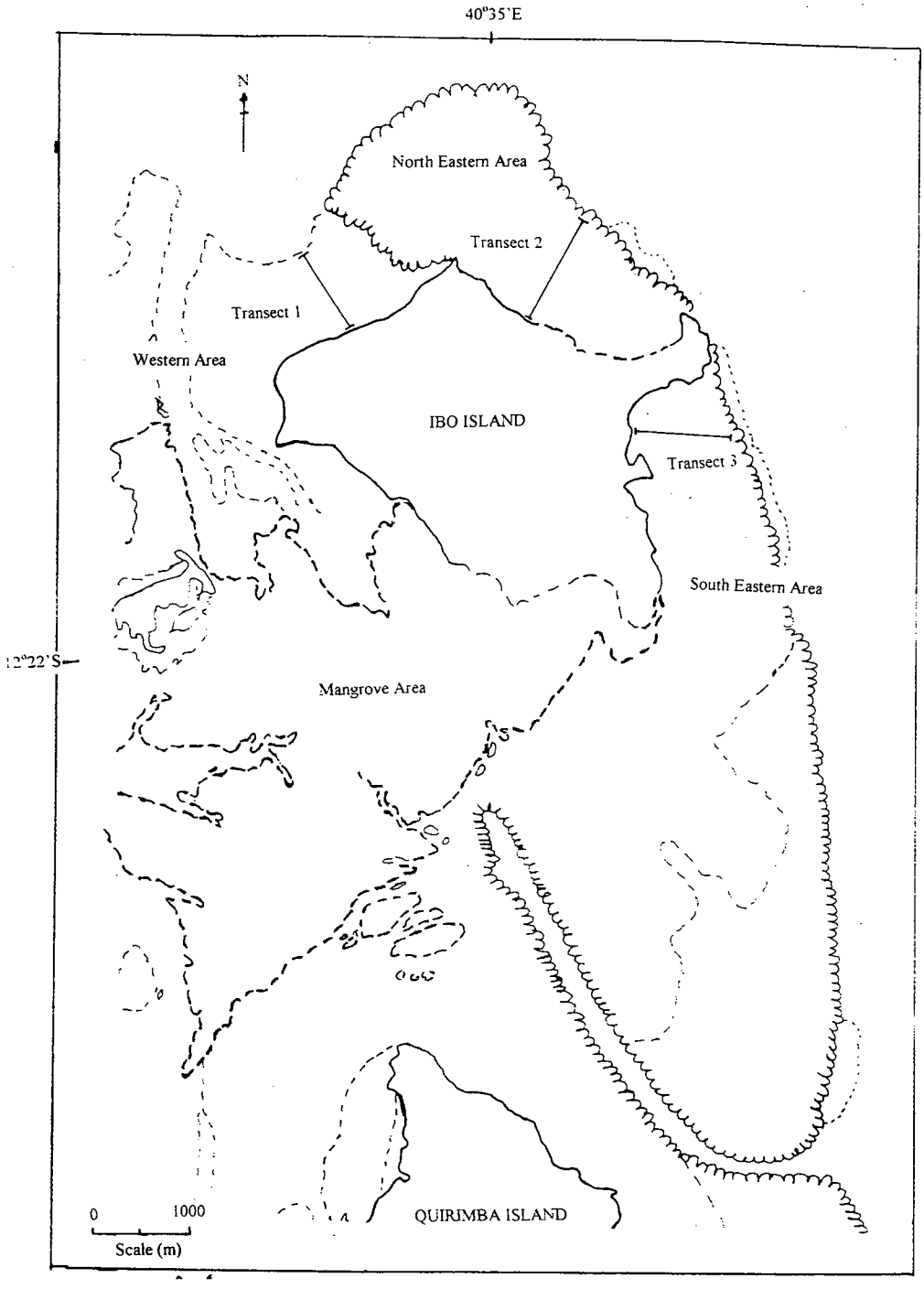


Figure 2: A map indicating the position of the intertidal transects surveyed on Ibo island

3.2.2 Area Reports

Transect surveys revealed three distinct patterns of zonation of floral communities. Each pattern was discrete to one of the following three areas as shown in Figure 2: 'Western Area' (transect 1), 'North Eastern Area' (transect 2) and 'South Eastern Area' (transect 3). Cross-sectional profiles are presented for each area in figures 3, 4 and 5.

'Western Area'

Three distinct zones were identified (Fig. 3) within which five seagrass species, 11 taxa of macroalgae and six of invertebrates were recorded. The distributions of taxa across zones are presented in Tables 1 and 2. The representation of substrate types within each zone are summarised in Table 3. Zone 1 consisted of a short sand beach with no vegetation or invertebrates. Zone 2 consisted of a sand substrate on which *Thalassia hemprichii* dominated (0-75 % cover) and *Enhalus acoroides* grew in small patches. Zone 3, the seaward zone, comprised a tidal channel which contained a predominantly mud substrate with a moderate cover of *Enhalus acoroides.*

The 'Western Area', with a species composition and zonation similar to that found on the western shore of Quirimba Island, had the most diverse flora of all sites surveyed within the C.I.G.

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

Taxonomic Group	Zone 1	Zone 2	Zone 3
Seagrasses			
Enhalus acoroides	0	0.9 (0-90)	46 (P-80)
Halodule wrigthii	0	0.5 (0-4)	0
Halophila ovalis	0	0-P	0
Halophila stipulacea	0	0-P	1.0 (0-10)
Thalassia hemprichii	0	31 (0-75)	15 (0-70)
Macroalgae			
Acanthophora muscoides	0	0-P	0
Caulerpa sertularioides	0	0-P	0
Caulerpa sp.	0	4.8 (0-40)	0
Cladophora sp.	0	1.5 (0-15)	0
Gracilaria crassa	0	1.2 (0-10)	0
Gracilaria folifera	0	0-P	0.5 (0-5)
Halimeda opuntia	0	8.8 (0-85)	0
Hydroclathrus clathratus	0	4.2 (0-40)	0
Jania adhaerens	0	6.5 (0-40)	5.0 (0-15)
Lyngbya majuscula	0	0-P	0
Udotea orientalis	0	0-P	0

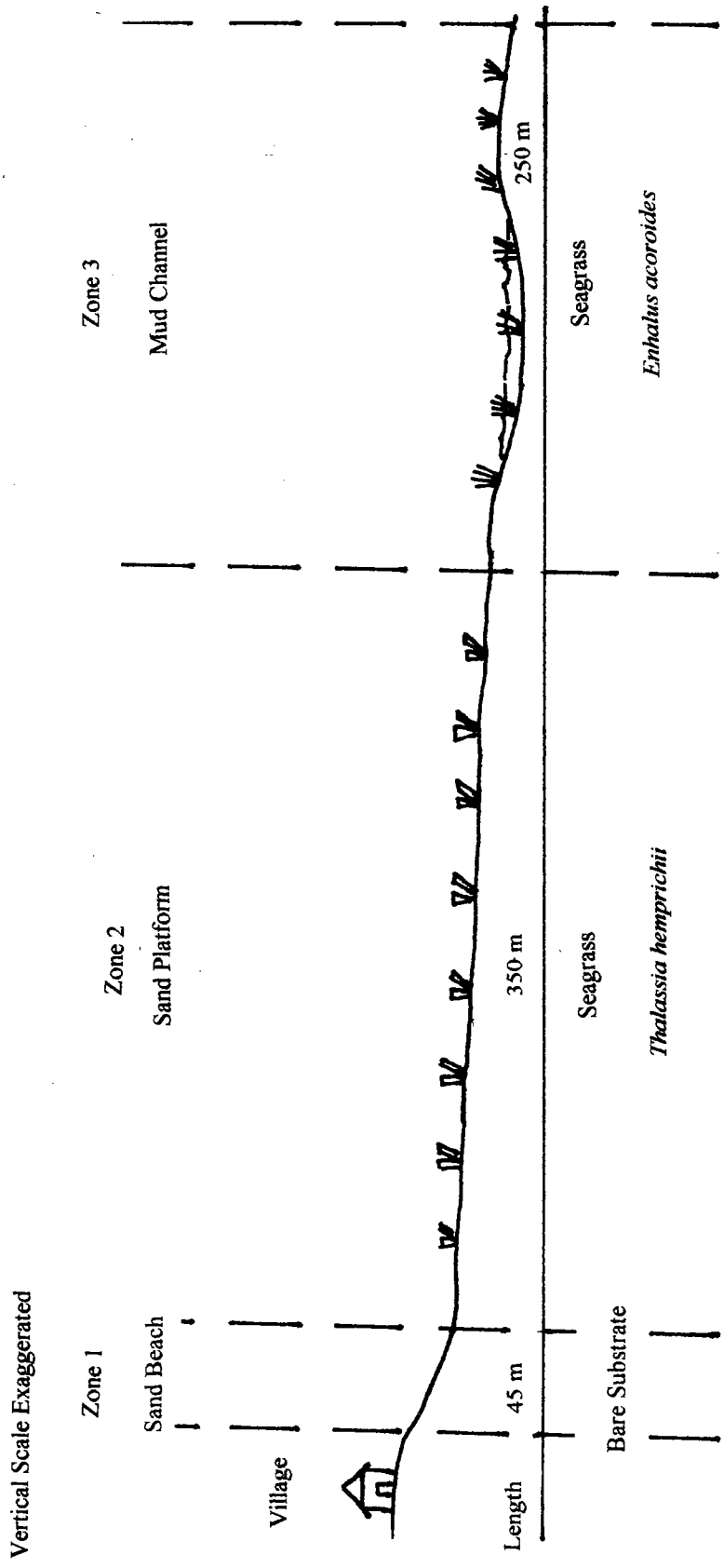


Figure 3. A diagrammatic representation of the "Western Area" intertidal transect, Ibo island.

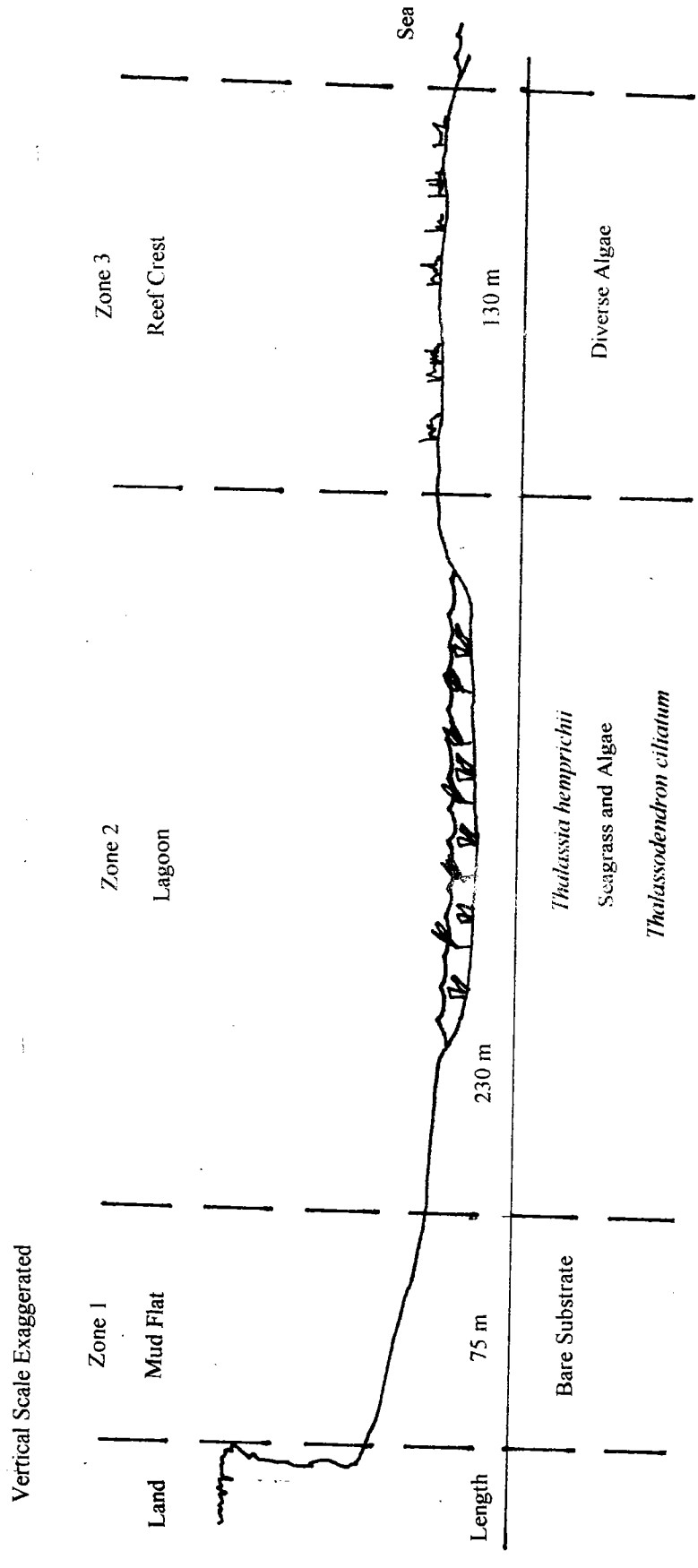


Figure 4: A diagrammatic representation of the "North Eastern Area" intertidal transect, Ibo island.

Table 2. Abundance of invertebrates along a typical transect within the 'Western Area'. Means and ranges (numbers/m^2) are presented.

Invertebrates	Zone 1	Zone 2	Zone 3
Echinoderm			
Echinometra muthaei	0	0.4	0
Synapta cf. *maculata*	0	0	0.4
Gastropods			
Cypraea annulus	0	0.8	0
Rhinoclavis sp.	0	0.4	0.4
Bivalve			
Pinna sp.	0	1.2	0
Jelly fish			
Cassiopia sp.	0	0	0.4

Table 3. Percentage composition of substrate along a typical transect within the 'Western Area'. Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3
Sand	100	79.5 (30-95)	50 (20-70)
Mud	0	20.5 (5-70)	50 (30-80)

'North Eastern Area'

The northern intertidal flat, with an average width of approximately 1.3 km, was considerably wider than that of the western shore. Four zones were identified and a total of one seagrass species, 23 taxa of macroalgae and 16 of invertebrates were recorded. The distributions of taxa across zones are presented in Tables 4 and 5. The representation of substrate types within each zone are summarised in Table 6.

Table 4. Percentage cover of seagrass and macroalgae taxa along a typical transect within the 'North Eastern Area'. (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3	Zone 4
Seagrass				
Thalassia hemprichii	0	18 (0-80)	59 (40-90)	49 (10-90)
Macroalgae				
Acanthophora muscoides	0	0	0-P	0-P
Centroceras clavulatum	0	0	0	0-P
Chaetomorpha crassa	0	0	2.0 (0-20)	0
Champia sp.	0	0	0	0-P
Chondria dasyphylla	0	0	0	0-P
Cistoseira myrica	0	0.5 (0-4)	1.0 (0-10)	0
Cladophora mauritiana	0-P	0.5 (0-5)	0.1(0-1)	1.2 (0-10)
Dictyosphaeria cavernosa	0	0	0-P	0-P
Dictyota adnata	0	0	0-P	0
Dictyota pardalis	0	0	0.4 (0-4)	0
Gelidiella acerosa	0	0-P	0.4 (0-4)	0
Gelidiella myrioclada	0	0	0.9 (0-5)	0-P
Gracilaria crassa	2.7 (0-25)	5.9(0-50)	0	0
Halimeda opuntia	0	0	0-P	0
Hydroclathrus clathratus	0	0-P	15 (P-35)	11.3(0-50)
Hypnea musciformis	0	0	0-P	0-P
Hypnea cf. *nidifica*	0	0	0.5 (0-5)	0-P
Jania adhaerens	0	0	0-P	0.1 (0-1)
Laurencia collumelaris	0	0	0-	0-P
Laurencia papillosa	0-P	0.2 (0-2)	0.1 (0-1)	0
Microdictyon montagney	0	0	0-P	0-P
Padina boryana	0	0	0-P	0
Udotea indica	0	0	0-P	0

Zone 1, closest to the shoreline, was characterised by a rocky beach and an abundance of gastropods, notably *Littoraria glabrata* (20+ individuals/m^2), *Rhinoclavis sinensis* (mean 5.6 individuals/m^2), and *Thais* sp. (mean 6.0 individuals/m^2). Zone 2 was dominated by the seagrass *Thalassia hemprichii* (0-80 %) and the macroalga *Gracilaria crassa* (0-50 %). At approximately 300 m from the HWM there was a lagoon (Zone 3) in which only the seagrass *Thalassia hemprichii* was abundant (40-90 % cover). Few corals were observed in the lagoon. The common invertebrates within this zone were *Cypraea annulus* (mean 8.0 individuals/m^2), *Strombus mutabilis* and *Echinometra muthaei*. Zone 4, bordering onto the LWM, was also dominated by *Thalassia hemprichii* but the cover was generally lower (10-90 % cover).

A notable feature of this area was the abundance of macroalgae such as *Hypnea nidifica, Hydroclathrus clathratus* and *Gracilaria* cf. *corticata* within the seagrass meadows.

Table 5. Abundance of invertebrates along a typical transect within the 'North Eastern Area'. Means and ranges (numbers/m^2) are presented.

Invertebrate	Zone 1	Zone 2	Zone 3	Zone 4
Gastropods				
Mitra sp.	0	0	0.4	0
Trochus sp.	0	0	0.4	0
Gafrarium pectinatum alfredense	0	0	0.4	0
Strombus mutabilis	0	0	0.8	0.4
Cypraea annulus	0	0	8.0	5.6
Cypraea moneta	0	0	0	0.4
Thais sp.	6	1.6	0	0
Nerita textilis	1.2	0.8	0	0
Morulla granulata	0.4	1.6	0	0
Rhinoclavis sinensis	5.6	0	0	0
Littoraria glabrata	20+	0	0	0
Conus sp.	0.4	0	0	0
Bivalve				
Pinna sp.	0	0	0.4	0
Echinoderm				
Echinometra muthaei	0	0	0	2.0
Holothuria sp.	0	0	0.4	0.4
Synapta cf. *maculata*	0	0	0.4	0

Table 6. Percentage composition of substrate along a typical transect within the 'North Eastern Area'. Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3	Zone 4
Rock	100	50 (0-100)	8 (0-80)	10 (0-95)
Rubble	0	0	0	8 (0-80)
Sand	0	50 (0-100)	92 (20-100)	83 (5-100)

'South Eastern Area'

The 'South Eastern Area' is the most exposed area of reef flat leading onto the outer fringing reef. The typical pattern of zonation is presented in figure 5. One species of seagrass, 34 taxa of macroalgae and 8 taxa of invertebrates were identified within the three zones. The distributions of taxa across zones are presented in Tables 7 and 8. The representation of substrate types within each zone are summarised in Table 9.

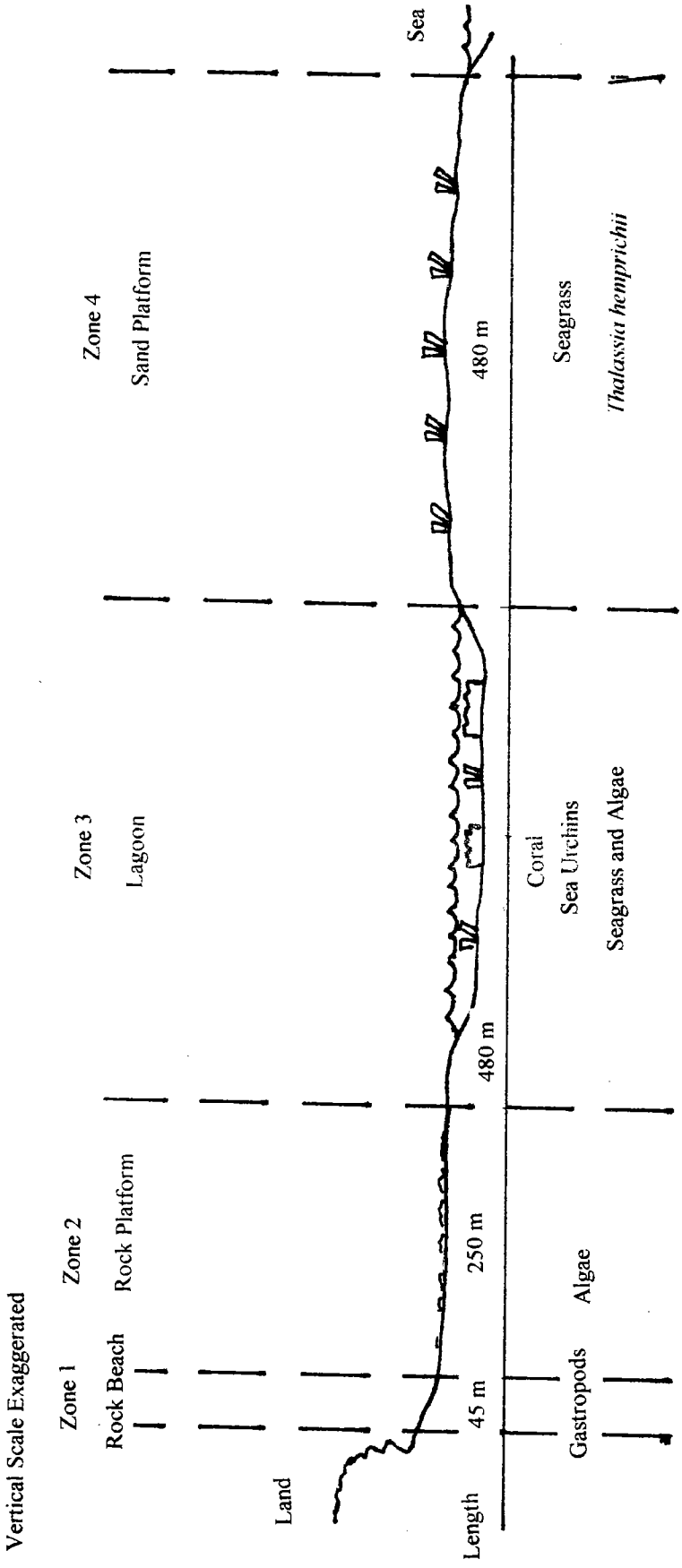


Figure 5: A diagrammatic representation of the "South Eastern Area" intertidal transect, Ibo island.

It differs from neighbouring 'North Eastern Area' mainly in the absence of *Thalassodendron ciliatum* from the lagoon area and in the position of the seagrass *Thalassia hemprichii* on the shore.

Table 7. Percentage cover of seagrass and macroalgae along a typical transect within the 'South Eastern Area'. (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3
Seagrass			
Thalassia hemprichii	0	2.0 (0-20)	0
Macroalgae			
Amphiroa beauvoise	0	0	0.4 (0-4)
Anadyomene wrigthii	0	0	0-P
Boergesenia forbesii	0	0.1 (0-1)	0-P
Caulerpa racemosa var. *clavifera*	0	0	0.1 (0-1)
Cistoseira myrica	0	3.3 (0-25)	0-P
Cistoseira trinodis	0	0	0-P
Cladophora mauritiana	0	6.3 (0-20)	0
Dasyopsis sp.	0	0.2 (0-2)	0
Dictyosphaeria cavernosa	0	0.1 (0-1)	0.3 (0-3)
Dictyota pardalis	0	0-P	0.1 (0-1)
Gelidiella acerosa	0	0.2 (0-2)	2.0 (0-20)
Gelidium sp. ?	0	0	0-P
Gracilaria fergusoni	0	0	0-P
Halimeda opuntia	0	0	3.1 (0-25)
Hydroclathrus clathratus	0	0.2 (0-1)	0.4 (0-4)
Hypnea cf. *nidifica*	0	0. (0-1)	0.2 (0-2)
Laurencia complanata	0	0	0-P
Laurencia obtusa	0	0	1.0 (0-10)
Laurencia papillosa	0	0-P	0
Lyngbya majuscula	0	0.4 (0-4)	0
Padina boryana	0	0	0.3 (0-2)
Sargassum asperifolium	0	0-P	0
Sargassum binderi	0	0	0.6 (0-6)
Sargassum duplicatum	0	0	0.4 (0-4)
Sargassum swartz	0	0	0-P
Sargassum sp.	0	0	0-P
Turbinaria conoides	0	0	0.2 (0-1)
Turbinaria ornata	0	0	0.1 (0-1)
Udotea indica	0	0-P	0-P
Ulva pertusa	0	0	0.4 (0-4)
Ulva reticulata	0	0.2 (0-2)	0
Ulva pulchra	0	0.8 (0-2)	0
Valonia aegagrophila	0	0-P	0

Table 8. Abundance of invertebrate taxa along a typical transect within the 'South Eastern Area'. Means and ranges (numbers/m^2) are presented.

Invertebrates	Zone 1	Zone 2	Zone 3
Gastropods			
Cypraea annulus	0	0	1.6
Morulla granulata	0	0	0.8
Strombus mutabilis	0	0	3.6
Thais sp.	0	0	6.0
Echinoderm			
Echinometra muthaei	0	0	0.8
Fromia sp.?	0	0	0.8
Stomopneustes variolaris?	0	0.8	0
Bivalve			
Perna perna	0	2.0	20+

Table 9. Percentage cover of substrate along a typical transect within the 'South Eastern Area' (P <1% of cover). Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3
Rock	0	93 (50-100)	99 (95-100)
Sand	0	7 (0-50)	P (0-5)
Shell	0	0-P	0
Mud	100	0	0

Zone 1 was predominantly a bare mud flat devoid of conspicuous biota. Zone 2 constituted a lagoon colonised by *Thalassia hemprichii* on its landward side and by *Cystoseira myrica* on its lower side. The reef crest (Zone 3) supported a higher diversity but lower density of invertebrates and macroalgae (<5 % cover for a single species). The most common invertebrates were *Thais* sp., *Strombus mutabilis* and *Cypraea annulus*.

3.3 Mangrove Surveys

3.3.1 Overview

The largest area of mangrove is located south and west of Ibo island (Fig. 6) representing what is arguably the largest stand of mangrove in Cabo Delgado, especially when considered in combination with the mangrove located on the western side of Quissanga channel. The small island of Quirimba is contained within the north west of this and comprises a large, low-lying sandbank, a small village, and associated shambas. The following five species of mangrove were recorded within the stand; *Rhizophora mucronata, Brugiera gymnorrhiza, Ceriops tagal, Sonneratia alba* and *Avicennia marina.*

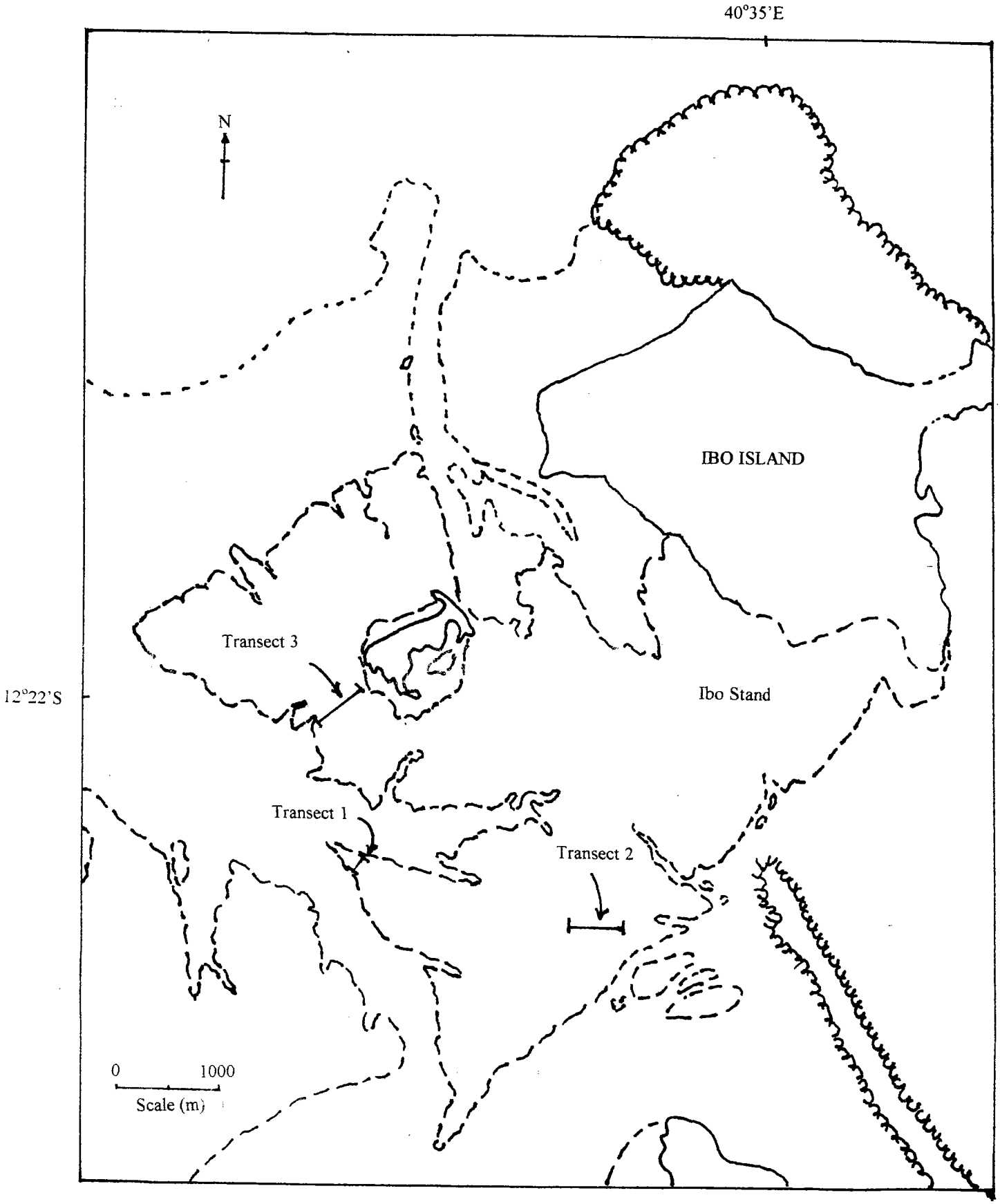


Figure 6: A map indicating the position of the mangrove transects surveyed on Ibo island.

An additional small area of mangrove was found towards the eastern promontory of Ibo Island known as the 'Farol'. Here, the mangrove is scattered between large rock masses and numerous creeks with no continuous single stand. *Rhizophora mucronata* and *Ceriops tagal* were the dominant species observed. No evidence of cutting was noted, most probably due to its distance from the island's village and the closer proximity of the much larger and more easily accessible mangrove area to the south of the island. Consequently, no formal survey work was carried out on this smaller mangrove area, efforts being concentrated on the island's primary stand.

In surveying the main Ibo stand it was not logistically feasible to undertake a standard survey transect through its widest part, a distance of approximately 6 km, due to time constraints and safety considerations. Instead, smaller representative transects were surveyed and the results later extrapolated for the mangrove stand as a whole. The locations of transects surveyed are shown on Figure 6.

3.3.2 Transect Reports

Transect 1

Transect 1 cut a cross-section through a narrow promontory of dense mangrove stretching into the Quissanga Channel (Fig. 6). Two species of mangrove were recorded; *Rhizophora mucronata*, and *Sonneratia alba*. In terms of species composition and structure an almost mirror image of zonation occurred about the centre of the transect, with *R. mucronata* dominant in all three zones and *S. alba* only becoming significant towards the outer edges of the transect. A diagrammatic representation of species zonation within the transect is illustrated in Figure 7 and is described below.

Zone 1 (north) supported both *S. alba* and *R. mucronata*, *S. alba* dominating the edge of the stand and *R. mucronata* becoming more dominant with increasing distance from the stand edge. **Zone 2 (central)** was a homogeneous stand of mature *R. mucronata* trees, although saplings of both *S. alba* and *R. mucronata* were observed. **Zone (south) 3** was similar to Zone 1 but with a lower density of mature trees and a higher density of saplings, particularly of *R. mucronata*.

Quantitative Description
The species composition and structure for each zone is presented in Table 10 below.

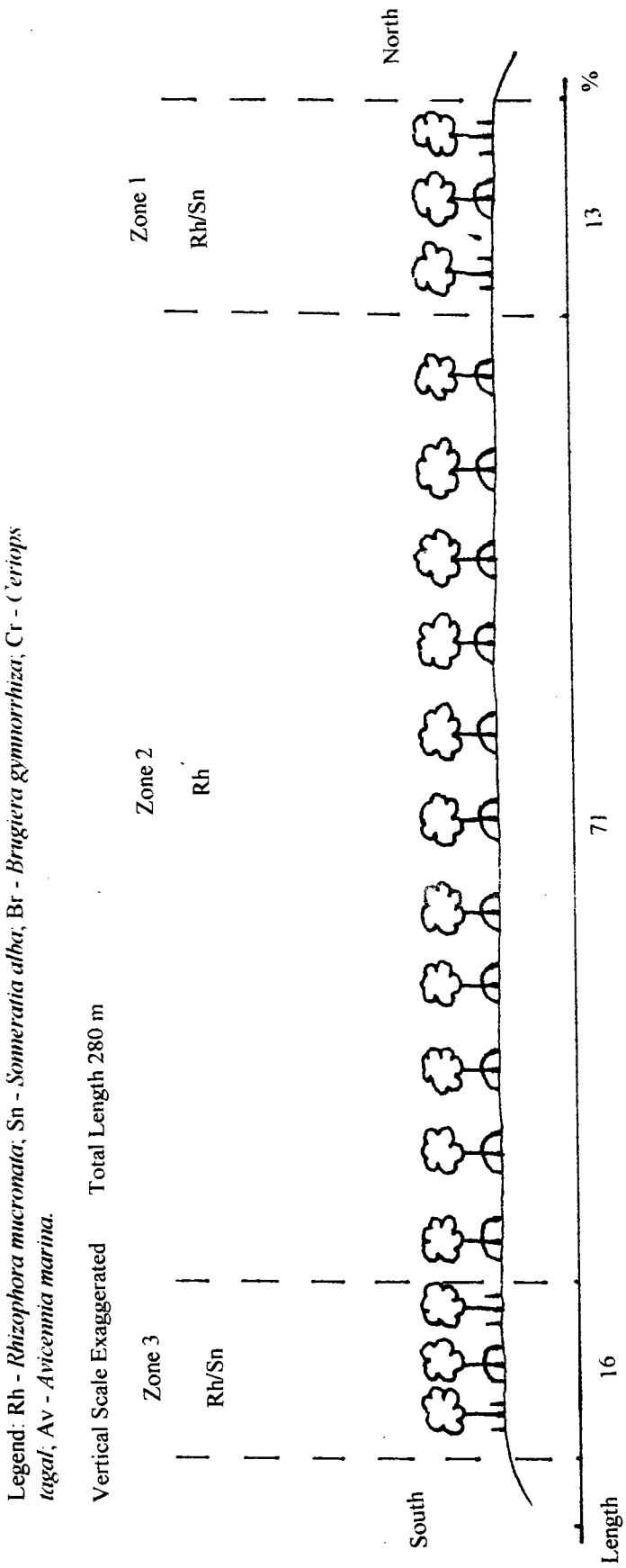


Figure 7: A diagrammatic representation of the mangrove transect 1, Ibo island.

Table 10. Mangrove species composition and structure: transect 1.

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*R. mucronata*	0.24	60	25.1	78	0.24
	S. alba	0.16	40	7.0	22	1.80
Zone 2	*R. mucronata*	0.96	100	34.2	100	0.60
	S. alba	-	-	-	-	0.08
Zone 3	*R. mucronata*	0.12	50	112.6	83	3.40
	S. alba	0.12	50	23.3	17	0.00

Transect 2

Transect 2 cut across a narrow channel deep within the main stand (Fig. 6).Three species of mangrove were recorded; *Rhizophora mucronata*, *Sonneratia alba* and *Avicennia marina*. The basic pattern of the transect was similar to that observed in 'Transect 1', with almost homogeneous stands of *R. mucronata* in the central portions of the mangrove and a mixture of *R. mucronata* and *S. alba* forming a band adjacent to open areas of open water. In the mixed stands along the waters edge *S. alba*, due to it's greater size, was dominant in terms of biomass despite being less abundant. A diagrammatic representation of species zonation within the transect is illustrated in Fig. 8 and is described below.

Zone 1 comprised a mature stand of *R. mucronata* trees averaging 3-4 m in height with occasional large individual *A. marina* trees (<6 m high). This zone was assumed to be representative of much of the inner mangrove of that area. **Zone 2**, a narrow zone bordering the NW side of the narrow channel, contained a mixture of relatively tall *R. mucronata* and *S. alba* trees, both species growing to a height of approximately 8 m. **Zone 3**, similar to Zone 2, formed the SE boundary to the channel also supporting a mixture of *R. mucronata* and *S. alba* trees (<8 m high). **Zone 4** on the eastern side of the channel was similar to Zone 1 with a homogeneous stand of *R. mucronata* (<4 m high) but with no *A. marina* trees observed.

Quantitative Description

A quantitative analysis of the species composition and structure for each zone is presented in Table 11 below.

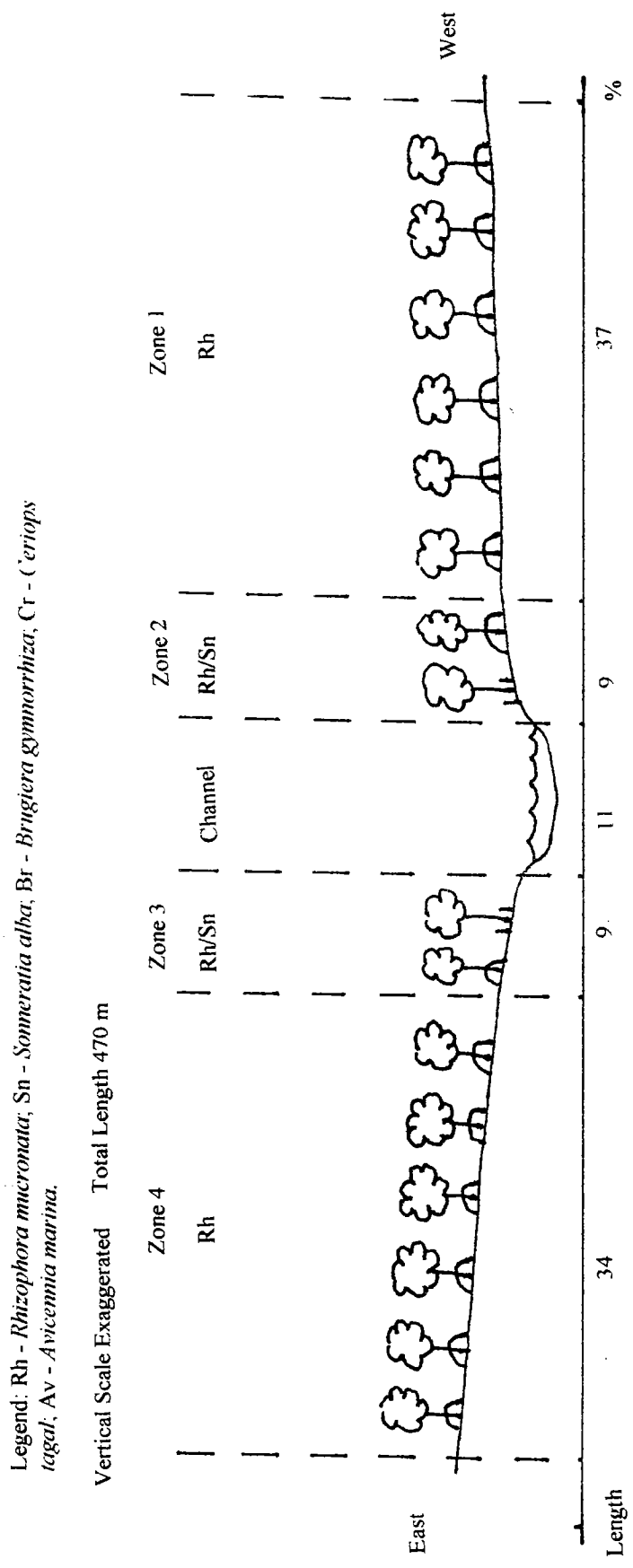


Figure 8: A diagrammatic representation of the mangrove transect 2, Ibo island.

Table 11. Mangrove species composition and structure: transect 2.

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*R. mucronata*	0.70	95	26.4	93	3.68
	A. marina	0.04	5	2.0	7	0.00
Zone 2	*R. mucronata*	0.40	53	28.6	48	2.68
	S. alba	0.36	47	31.2	52	1.12
Zone 3	*R. mucronata*	0.12	60	6.9	29	0.56
	S. alba	0.08	40	17.3	71	0.00
Zone 4	*R. mucronata*	0.84	100	9.29	100	0.56

Transect 3

Transect 3 spanned a belt of mangrove running between the Quirimba Channel and Quirimba Island. Four species of mangrove were observed, namely; *Rhizophora mucronata*, *Ceriops tagal*, *Avicennia marina* and *Sonneratia alba*, although the latter species was not recorded during the surveys. The seaward edge of the stand was adjacent to a sheltered creek off the main channel. On the more elevated, drier ground towards the centre of the transect *C. tagal* was the most abundant species becoming dominant close to Quirimba island. Close to the HWM a homogeneous broad band of *A. marina* grew on the more sand dominated substrate. A diagrammatic representation of species zonation within the transect is illustrated in Figure 9 and is described below.

Zone 1 (near to Quirimba Is.), adjacent to the HWM, supported a few large (<4 m high), isolated *A. marina* trees separated from the main mangrove stand by an irregular bare area of sand/mud. This zone also supported numerous stunted (<1.5 m high) *A. marina* trees which were not saplings and had apparently not regrown from stumps of previously cut trees. They were a short form of 'adult' tree. **Zone 2** contained a mixture of *C. tagal* (<2 m high), *R. mucronata* (<3 m high) and small *A. marina*, the former being dominant. A similar composition of saplings was found making the vegetation in places was quite dense. **Zone 3** comprised of a series of channels and bare sand/mud banks where a number of villagers from Quirimba island kept their boats. The high level of human activity in this area may possibly explain the absence of mature mangrove trees. Although not recorded in the transect, isolated areas of small *C. tagal* and *S. alba* were observed with up to 50% showing signs of cutting. **Zone 4**, on higher ground away from any channels supported a mixture of *R. mucronata* (<3 m high) and *C. tagal* (<2 m high) trees. Evidence of cutting was observed with *C. tagal* the target species. **Zone 5** bordered the creek at the south end of the transect. The edge of the stand was irregular with a number of small channels

penetrating the mangrove. These channels were fringes with *R. mucronata* (<4 m high) and *C. tagal* (<3 m high). The substrate was predominantly mud with considerable quantities of standing water in pools.

Quantitative Description

A quantitative analysis of the species composition and structure for each zone is presented in Table 12 below.

Table 12. Mangrove species composition and structure: transect 3.

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*A. marina*	0.24	60	25.1	78	0.36
Zone 2	*R. mucronata*	0.16	22	1.55	29	0.08
	C. tagal	0.48	67	1.01	52	1.60
	A. marina	0.08	11	2.79	19	0.20
Zone 3	*R. mucronata*	-	-	-	-	0.04
	C. tagal	-	-	-	-	1.20
Zone 4	*R. mucronata*	0.08	22	9.7	67	0.32
	C. tagal	0.28	78	4.7	33	7.56
Zone 5	*R. mucronata*	0.40	100	28.8	100	0.08
	C. tagal	-	-	-	-	0.48

Analysis of the 'Ibo Stand'

The information obtained from the individual transects described above, in combination with satellite imagery and local knowledge, was used to extrapolate estimates for tree numbers, stand diameter and basal area for the whole stand (Table 13). The estimates obtained for the whole stand should consequently only be taken as a guide to its overall composition and development.

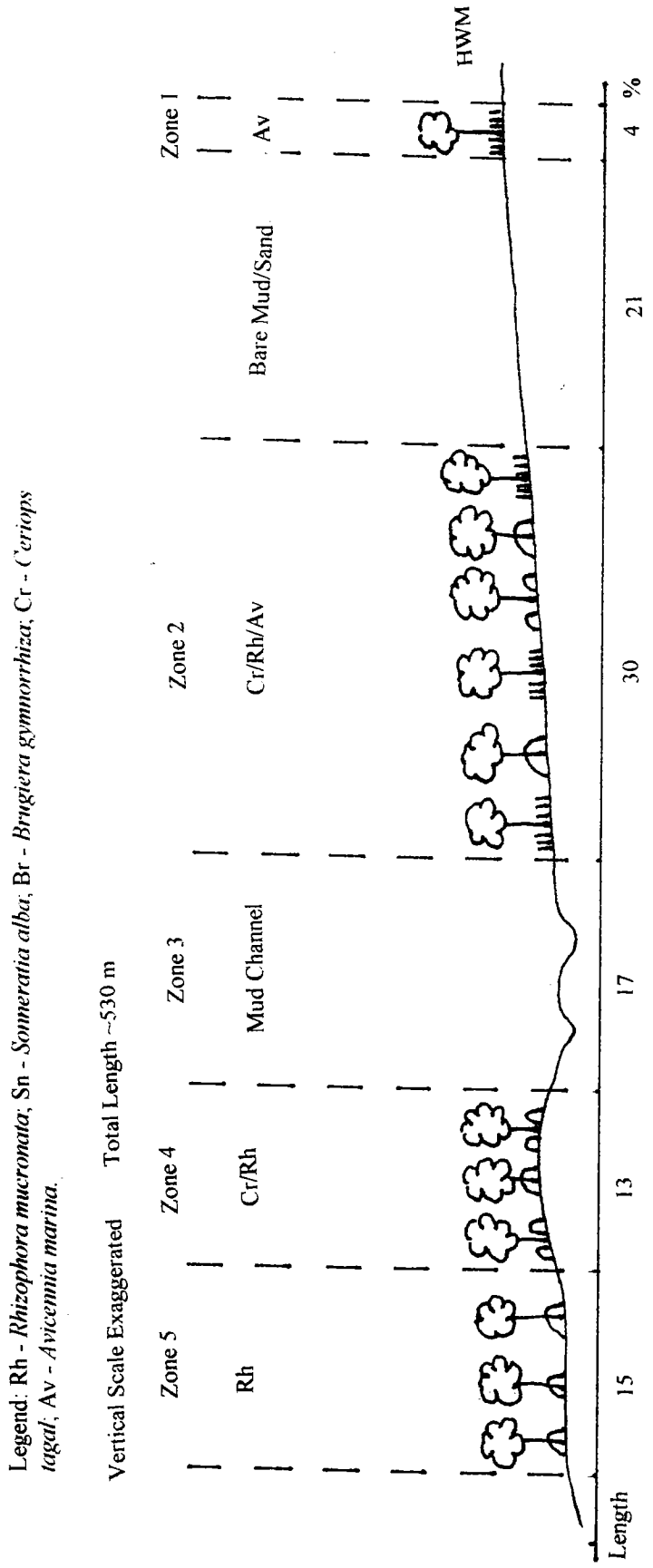


Figure 9: A diagrammatic representation of the mangrove transect 3, Ibo island.

Table 13. Estimates for the size and composition of the 'Ibo Stand'. All original figures have been estimated to the nearest 100 and all basal areas have been calculated to the nearest 10 m^2. 'n/a' denotes present in the stand but not recorded within survey quadrats.

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	10,340,900	6.8	37,490
S. alba	384,200	17.2	8,940
A. marina	33,400	5.5	80
C. tagal	445,300	4.0	550
B. gymnorrhiza	n/a	n/a	n/a

It should be noted that, in comparison with published figures for the mean stand diameter of other mature mangrove stands, the figures obtained here are relatively low and might suggest that the stand is immature. However, general impressions combined with an apparent lack of human disturbance, suggest the stand to be well established and fully mature. It is therefore suggested that the transects surveyed, being in most cases towards the edge of the stand, were the cause of this apparent anomaly. An additional survey of the centre of the stand would be beneficial.

Fauna of the 'Ibo Stand'

The faunal survey was mainly limited to a census of gastropods molluscs and crabs, being the dominant and most easily observed faunal groups. Faunal distributions across zones within each transect are summarised in Table 14 and are described below.

Transect 1 supported a generally low abundance of fauna with only a few crabs, possibly *Sesarma* sp., and no gastropods recorded within the survey quadrats. **Transect 2** supported high densities of active crab burrows along the latter portion of the transect and these were attributed to both *Uca* sp. and *Sesarma* sp. which were observed in this area. Although not found close to the channel, the Mangrove whelk, *Terebralia palustris*, was recorded amongst the *R. mucronata* trees of Zones 1 and 4. On **Transect 3** gastropods were restricted to the mangrove zones close to Quirimba island and included; *Terebralia palustris*, *Cerithidea decollata* (Truncated mangrove snail) and *Littoraria subvittata* (Estuarine periwinkle),. In addition to a few brachyuran (true crabs) crabs, possibly *Sesarma* sp., the anomuran crab (hermit crab), *Clibanarius longirostris* was noted.

Table 14. Summary of the distribution of Benthic fauna within the 'Ibo Stand'.

Transect	Zone	Number of Crab Holes /m^2	Number of Crabs /m^2	Number of Gastropods /m^2
Ibo: 1	Zone 1	1.5	0.9	0.0
	Zone 2	1.8	0.4	0.0
	Zone 3	1.5	0.3	0.0
Ibo: 2	Zone 1	2.2	0.5	0.1
	Zone 2	2.5	0.8	0.0
	Zone 3	6.8	0.2	0.0
	Zone 4	10.4	0.2	0.4
Ibo: 3	Zone 1	2.2	0.2	0.6
	Zone 2	1.2	0.0	1.6
	Zone 3	2.8	0.5	0.0
	Zone 4	2.4	0.6	0.0
	Zone 5	4.5	1.3	0.0

3.4. Subtidal Habitat Survey

Subtidal surveys were concentrated on the northern and eastern shores where the main areas of coral reef were found. The surveys were grouped into five areas as marked on Figure 10.

3.4.1 Overview

Reef Structure and Composition

The reef slopes were typically gently sloping with the exception of a short, near vertical, wall at the eastern tip of the island at site I3. Most sites were dominated by a rock substrate, typically forming 25-50 % of the reef substrate and most dominant on the steeper walls. Sand was common at a range of depths and sites, as was rubble, although to a lesser extent. There was a high degree of variability in substrate composition and distribution with both depth and site. Mud was absent from all sites.

Hard corals were the dominant biota at most sites, in places forming an almost complete cover, particularly on the outer reef sites (I3-I5). Soft corals were less abundant, although on the deeper parts of the reef at I5 they were the dominant biota., Staghorn corals covered extensive areas at I1 and I2 and were also prevalent at I4 and I5. Branching and foliose forms were also common at I5. Massive and encrusting forms, although rarely the dominant forms, were common over small sections of reef.

Seagrasses were absent from the outer reef sites, but were present along the northern reef even becoming the dominant biota in some areas (I1). *Thalassodendron ciliatum* and *Syringodium isoetifolium* were the most common species.

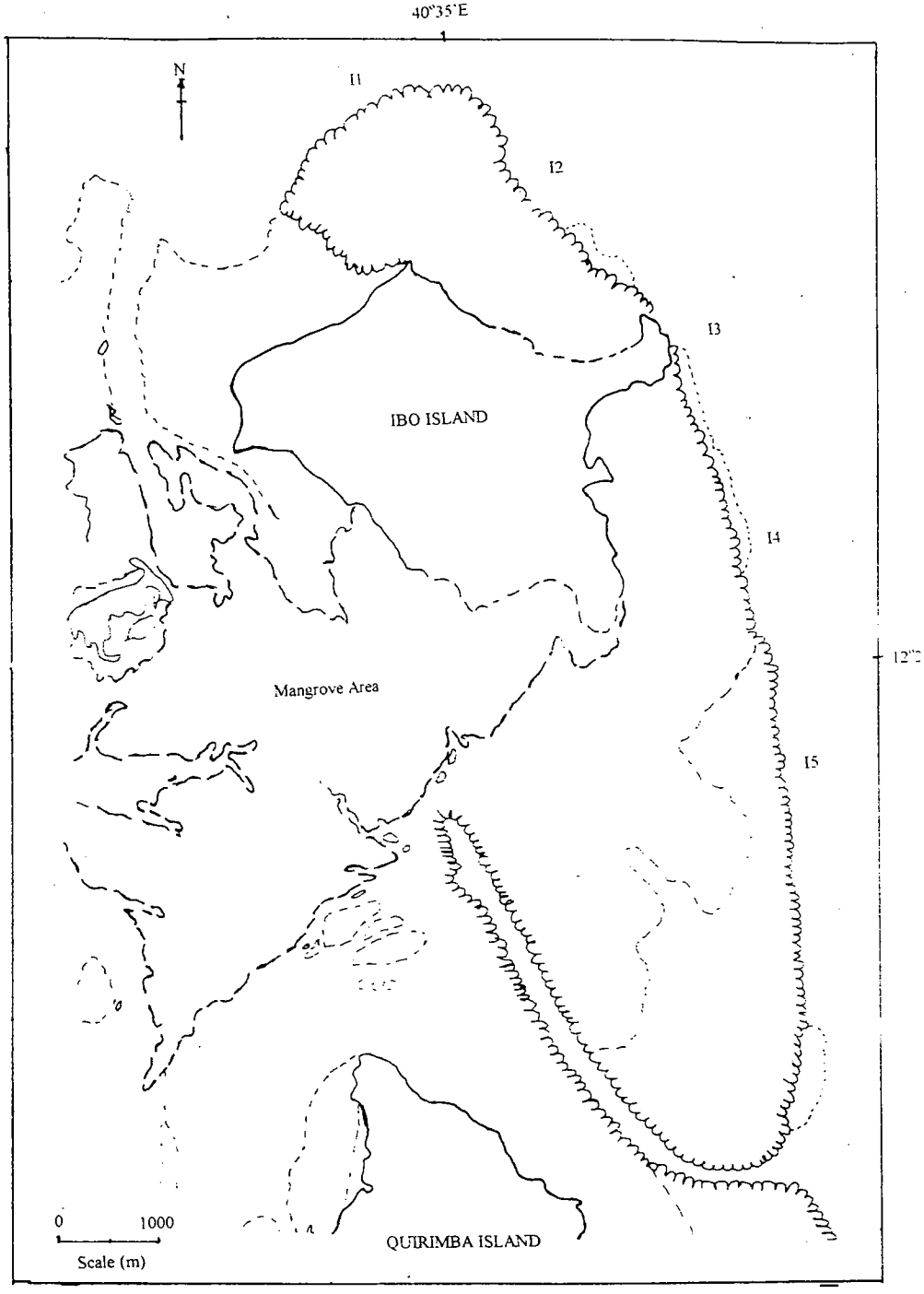


Figure 10: A map indicating the position of the subtidal survey sites around Ibo island.

Macroalgae were not conspicuous on coral reefs with the exceptions of sites I1 and I2 where luxuriant growths of macroalgae were observed, notably brown algae such as *Sargassum duplicatum, Turbinaria ornata, Dictyota* sp. and *Rosenvingea intricata.* No obvious reason was found for the abundance of algae.

Coral Composition

'Large massive' corals, predominantly of the *Porites* and *Diploastrea* genera, were abundant on the wide and gentle sloping reefs (I2, I4 and I5) but were, however, absent from the steep reef slopes. 'Small massive' forms were composed of a high diversity of genera dominated by *Porites* and *Galaxea.* The genus *Acropora* was present in a wide variety of forms throughout the reef although the 'Staghorn' form was dominant at sites I2 and I4. *Echinopora* was the dominant 'Encrusting' form and *Pachyseris* was the dominant 'Foliose' form at I3 which was most common at I3. The 'Large polyp' coral *Lobophyllia* was present at all sites, except I3. 'Solitary' corals were only observed at I4 where Fungiids were common. *Tubastrea* was present at low densities. The 'fire' coral *Millepora* was absent from all sites.

Soft corals were present throughout with a surface cover ranging from 1-15 %. The only notable feature was the absence of *Dendronephthya* from all sites.

3.4.2 Site Reports

Site I1:

The reef structure and community composition are summarised in Table 15 and Figure 11 and are described below.

Reef Structure
The reef was poorly developed being patchy and broken and more typical of a line of coral bommies than a fringing reef. The maximum reef depth was approximately 2 m, forming a narrow bank between the intertidal area and extensive seagrass beds. The coral patches were interspersed with areas of bare sand and seagrass beds.

Substrate Composition
Sand was the dominant substrate with rock limited to about 25 % of the area. Little rubble was recorded. Due to the patchiness of the reef, the substrate composition varied greatly.

Biotic Cover
Seagrass dominated with a surface cover of about 50 %. On the rock substrate, a mixture of hard and soft corals, and small quantities of macroalgae and *Halimeda* sp. existed. Where a proper reef structure existed, hard corals were dominant and were heterogeneous in form.

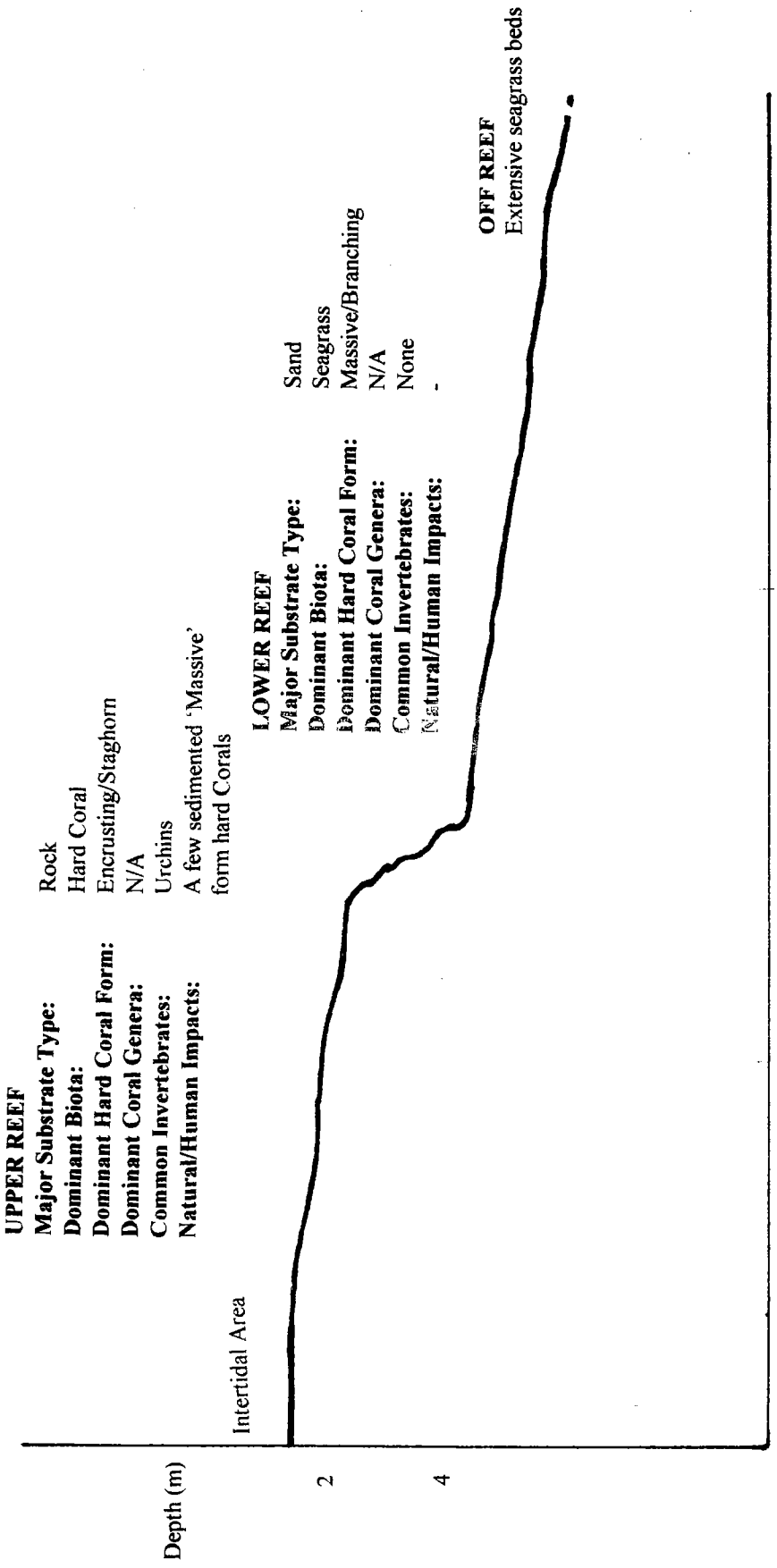


Figure 11: A diagrammatic representation of the "Reef Profile" at site 11. A summary of the major features of this site is presented (N/A: not assessed).

Table 15. A summary of the structure, composition and biotic cover at I1 (P=<1 % cover; Ma-Massive form; En-Encrusting form; Br-Branching form; St-Staghorn form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	20	0-30	0	0
	Rugosity	3	2-4	2	0-5
Substrate	Rock	4	3-4	3	0-4
	Rubble	2	2-3	1	0-2
	Sand	2	2-3	4	2-6
	Mud	-	-	-	-
Biota	Hard Coral	3	2-4	3	0-4
	Soft Coral	1	P-1	2	0-2
	Seagrass	1	P-2	4	0-6
	Macroalgae	2	P-2	-	-
	Halimeda sp.	P	P	-	-
Coral state	Heterogeneity	0	0	0	0
	Dominance	Ma, Br	-	St, Ma, En	-

Site I2:

The reef structure and community composition are summarised in Table 16 and Figure 12 and are described below.

Reef Structure

The base of the reef was at 8 metres depth with a gradual slope up to the intertidal. Rugosity was generally low but in places large hard coral structures created a very rugose reef surface. Beyond the reef base was an extensive bare sand plateau with no coral colonisation.

Substrate Composition

The reef slope was of rock and sand in variable proportions with occasional patches of rubble.

Biotic Cover

Hard corals were the dominant biota, with soft corals and macroalgae also present. Biotic cover was more extensive on the deeper parts of the reef, except in the case of *Halimeda* sp., which were only observed at the top of the reef. Although a wide range of coral forms were present staghorn dominated over much of the reef.

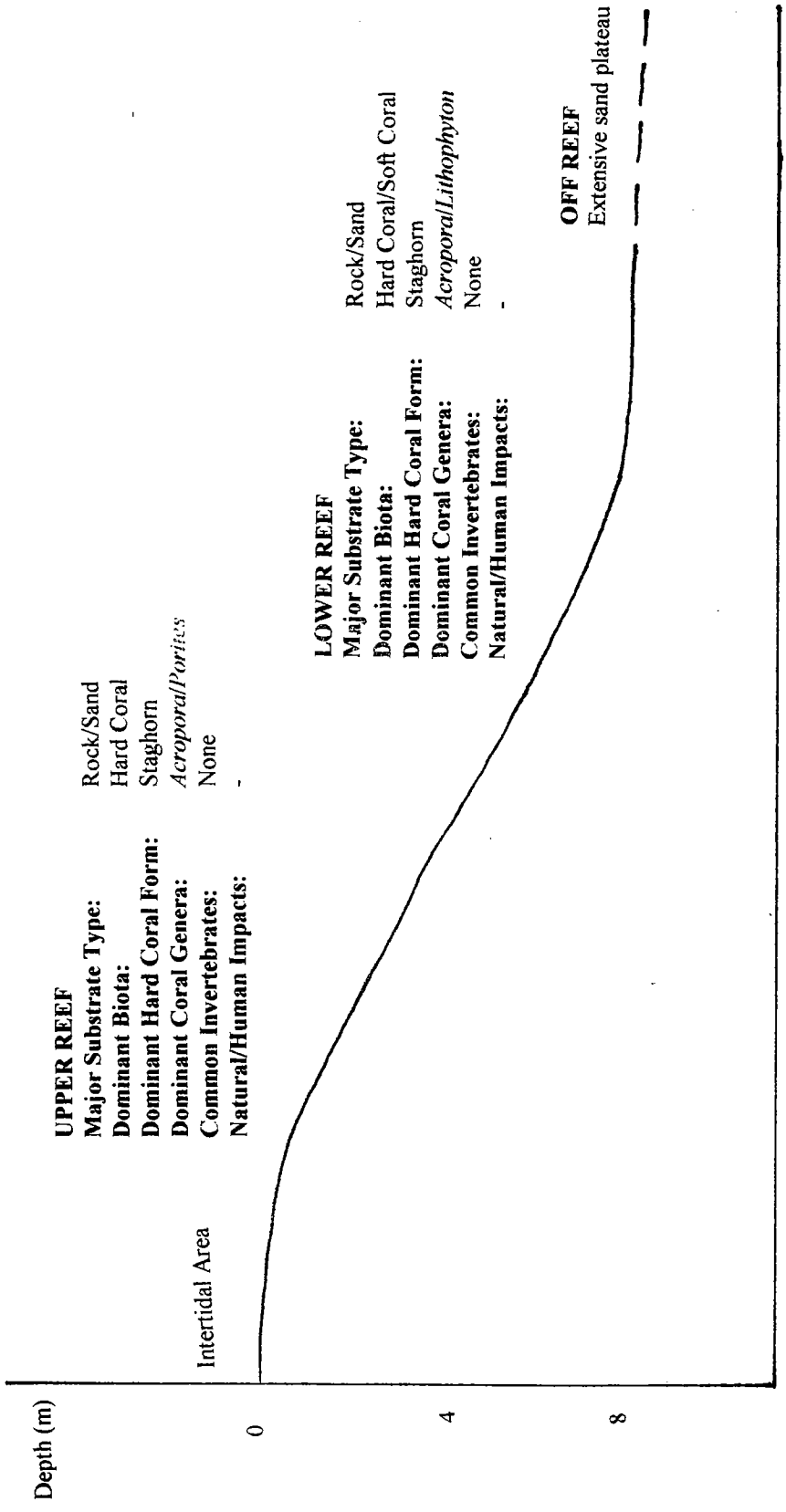


Figure 12: A diagrammatic representation of the "Reef Profile" at site 12. A summary of the major features of this site is presented.

Table 16. A summary of the structure, composition and biotic cover at I2 (P=<1 % cover; Ma-Massive form; Br-Branching form; St-Staghorn form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	10	0-30	0	0
	Rugosity	2	0-3	1	0-3
Substrate	Rock	3	0-4	3	0-4
	Rubble	2	0-4	2	0-3
	Sand	3	0-3	3	0-6
	Mud	-	-	-	-
Biota	Hard Coral	2	0-3	2	0-4
	Soft Coral	1	0-1	2	0-3
	Seagrass	-	-	-	-
	Macroalgae	P	0-P	1	0-1
	Halimeda sp.	P	0-P	-	-
Coral state	Heterogeneity	0	0	0	0
	Dominance	Br, St	-	St, Ma	-

Coral Composition:

Massive Forms: 'Large massive' forms, with an average surface cover of 10-20 %, were almost entirely of the genus *Porites* which was also one of the most abundant of all corals. In places *Porites* sp. formed large 3 m high domes. Large *Favia* colonies (<5 % cover) were common at 8 m. 'Small massive' forms were more diverse although *Porites* was again the most abundant genus (cover 10-15 %). Small massive forms of *Platygyra*, *Galaxea*, *Favia* and *Favites* were most abundant at the reef base (cover 5-10 %).

Branching Forms: 'Bush' and 'Staghorn' forms of *Acropora* were most abundant in the shallower parts of the reef (cover 0-20 %) as were *Pocillopora* colonies.

Table/Plate Forms: 'Small tables' were most abundant at the reef base (10 % surface cover) with 'Large table' forms more common in the middle zone (5% cover).

Other Forms: *Millepora* and *Pachyseris* genera were absent. The only 'Large polyp' coral present was *Lobophyllia* (cover 1-5 %). 'Solitary' corals and Fungiids were rare, the latter forming <1 % cover at the base of the reef. *Montipora*, *Turbinaria* and *Echinopora* colonies were rare (cover 0-1 %).

Soft Corals: *Lithophyton* was the most abundant and widespread 'soft' coral (10 % surface cover), whilst *Dendronephthya*, *Heteroxenia* and *Sinularia* were present at lower densities on the shallower reef (0- 5 % cover).

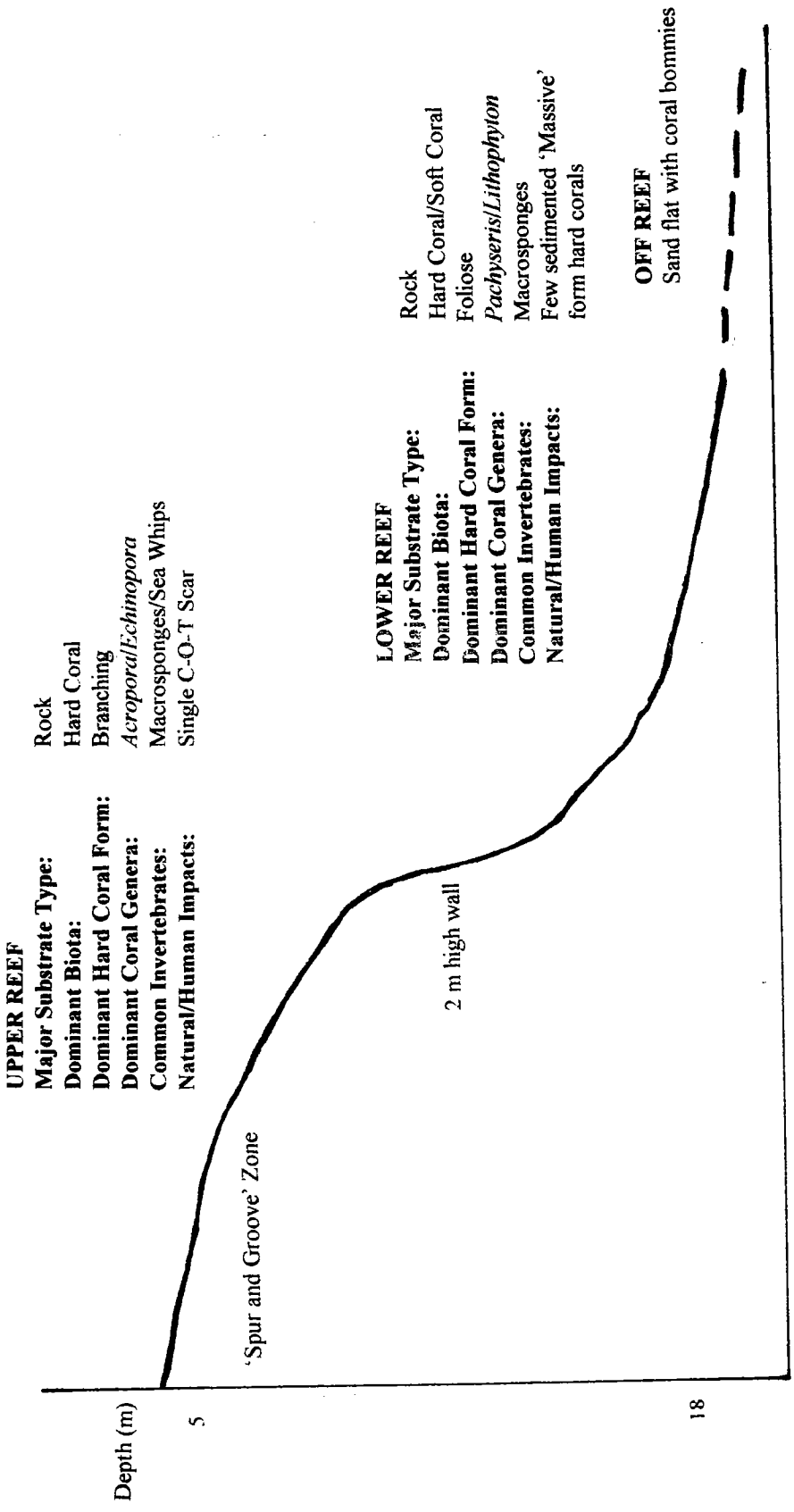


Figure 13: A diagrammatic representation of the "Reef Profile" at site 13. A summary of the major features of this site is presented (C-O-T: Crown of Thorns starfish).

Site I3:

The reef structure and community composition are summarised in Table 17 and Figure 13 and are described below.

Reef Structure

The reef at this site was well developed following a distinct zonation with depth. The shallow upper reef graded into a 'spur and groove' zone running from 6-8m depth. This zone led down into a gently sloping plateau to 12 m at which point it dropped off sharply over a 2 m high vertical rock 'wall'. The reef sloped downwards (20^0) from the base of the wall to the base of the reef at 18 m. Beyond the reef base was a sandy area with occasional small bommies (1 m in diameter, 0.5 m high).

Substrate Composition

Rock was the dominant substrate throughout, with rubble and sand only present in small patches.

Biotic Cover

The shallow part of the reef was dominated by branching hard corals (66% surface cover). On the mid and lower reef both hard and soft corals were abundant. Foliose corals formed homogenous stands towards the base of the reef although elsewhere the coral forms were heterogeneous. Seagrasses, macroalgae and *Halimeda* sp. covered less than 1 % of the reef.

Coral Composition

Massive Forms: No 'Large massive' forms were observed and 'Small massive' forms were present only in low abundance. *Porites* covered approximately 5 % of the lower reef slopes whereas *Favia* was more abundant on the reef crest (10 % cover) whilst less abundant on the 'spurs' (5 % cover) and wall (1 % cover). *Platygyra* was present at all depths (1-5 % cover) and *Galaxea* was noted on the 'spurs' (5 % cover) and lower reef slope (1 % cover).

Branching/Table Forms: A different form of *Acropora* was dominant (10 % in each case) in each of the different reef areas. The lower slope was dominated by 'Bush' forms (*Acropora* and *Pocillopora*), the wall by 'Small table' forms, the crest by 'Large table' forms and the 'spurs' by a combination of 'Large table' and 'Staghorn' forms.

Plate/Foliose Forms: The 'Foliose-plate' form of *Pachyseris* was abundant on the deeper sections of the reef with a 15-20 % cover on the lower slope and wall and a 10% cover on the reef crest. *Turbinaria* was present in low abundances (<5 %) on the wall.

Encrusting Forms: *Echinopora* was common on the reef crest (10 % cover) and on the lower slope and 'spurs'. *Montipora* was also present on the 'spurs'.

Other Forms: 'Large polyp' corals were absent and 'Solitary' corals were restricted to Fungiids (1-5 % cover).

Soft Corals: 'Soft' corals exhibited marked zonation with depth. *Lithophyton* was common on the wall (10 % cover) and on the lower reef slope (<1 % cover). *Heteroxenia* was common in the 'spur and groove' zone and was present on the lower reef slope. A sparse cover (<5 %) of *Sarcophyton* was found on the reef crest and 'spur and groove' zone. *Sinularia* was common on the crest and becoming less common on the wall and the lower slope. *Dendronephthya* was not recorded.

Table 17. A summary of the structure, composition and biotic cover at I3 (P=<1 % cover; Fo-Foliose form; Br-Branching form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0	30	0-50
	Rugosity	3	2-4	2	0-4
Substrate	Rock	5	4-5	3	0-5
	Rubble	-	-	2	0-2
	Sand	2	2-3	2	0-2
	Mud	-	-	-	-
Biota	Hard Coral	5	4-5	2	0-3
	Soft Coral	2	1-2	2	0-3
	Seagrass	-	-	-	-
	Macroalgae	1	1	P	0-P
	Halimeda spp.	-	-	1	0-1
Coral state	Heterogeneity	0	0	0	-
	Dominance	Br	-	Fo	-

Site I4:

The reef structure and community composition are summarised in Table 18 and Figure 14 and are described below.

Reef Structure.
A gentle slope ran down from the intertidal edge to a depth of 6-8m. Beyond this the reef dropped off more steeply on a 10-15° gradient to the reef base at 16-17m. The edge of the reef base was distinct with a dense covering of corals giving way to an extensive, flat, rubble dominated area beyond.

Substrate Composition
Rock was the major component of the reef structure with sand and rubble observed in patches. Substrate composition was fairly consistent throughout.

Biotic Cover
Hard and soft corals were the dominant biota on the reef, although the former were normally the most abundant. Although the staghorn form dominated much of the hard coral cover the composition of forms was, in general, mixed throughout. Macroalgae and *Halimeda* spp. were present throughout.

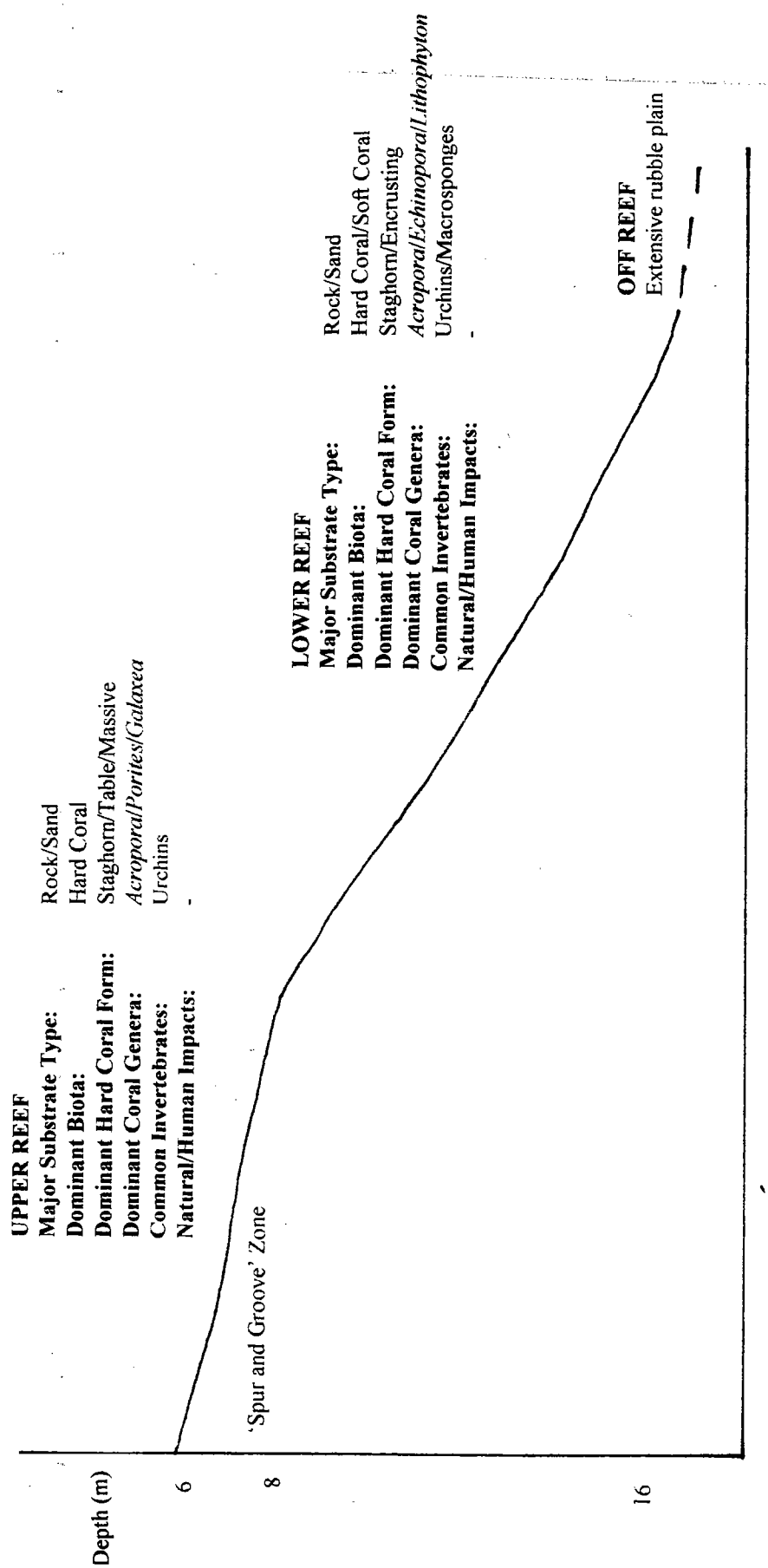


Figure 14: A diagrammatic representation of the "Reef Profile" at site 14. A summary of the major features of this site is presented.

Table 18. A summary of the structure, composition and biotic cover at I4 (P=<1 % cover; St-Staghorn form; Ta-Table form; Ma-Massive form; Br-Branching form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0	30	0-40
	Rugosity	3	0-4	3	0-4
Substrate	Rock	3	0-4	4	0-4
	Rubble	1	0-1	1	0-2
	Sand	2	0-2	2	0-3
	Mud	-	-	-	-
Biota	Hard Coral	3	0-4	3	0-4
	Soft Coral	1	0-2	2	0-3
	Seagrass	-	-	-	-
	Macroalgae	1	0-1	-	-
	Halimeda spp.	-	-	P	0-P
Coral state	Heterogeneity	0	0	0	0
	Dominance	St, Ta, Ma	-	St, En	-

Coral Composition

Massive Forms: 'Large massive' forms, dominated by *Porites*, covered up to 10 % of the reef. *Favia* was present (1-5 % cover) in the shallow reef areas (10-6 m) and *Platygyra* was present in small quantities. The 'Small massive' coral forms present were also predominantly of the genus *Porites* (<10 % cover). *Galaxea* was common (<10 % cover) between 6-13 m and *Favia*, and *Favites* each covered an estimated 5 % of a reef.

Branching/Table Forms: *Acropora* spp. were widespread, with 'Bush', 'Staghorn' and 'Small table' forms dominating (5-20 % cover over most of the reef). 'Large table' forms were more restricted in distribution, covering up to 5 % of the mid-reef slope.

Encrusting Forms: *Echinopora* was the most abundant 'Encrusting' form present (5-10 % cover on the reef slope) with *Turbinaria* and *Montipora* also occurring in most areas (0-5 % cover).

Other Forms: *Lobophyllia* was the only 'Large polyp' coral present (<1 % cover). Fungiids were common in places (0-10 % cover). *Pachyseris* and *Millepora* were notably absent.

Soft Corals: *Lithophyton* was the dominant 'soft' coral, with 10-15 % cover on the reef slopes and the off-reef rubble zones. *Sarcophyton* and *Heteroxenia* typically covered 5-10 % and *Sinularia* 1-5 % of the reef.

Site I5:

The reef structure and community composition are summarised in Table 19 and Figure 15 and are described below.

Reef Structure
The reef was composed of a short slope, steeper in the upper sections, which flattened off to join a flat, sand/rubble area beyond the reef base. Rugosity was moderate over much of the reef slope.

Substrate Composition
Rock dominated throughout although sand and rubble were also fairly abundant, the former increasing towards the base of the reef.

Biotic Cover
Hard and soft corals were abundant on the mid and upper reef areas. On the lower reef soft corals were approximately twice as abundant as hard corals. The hard corals were heterogeneous in form, with fire and massive forms dominant on the lower reef. A sparse cover of macroalgae and *Halimeda* spp. were found throughout.

Table 19. A summary of the structure, composition and biotic cover at I5 (P=<1 % cover; Fo-Foliose form; Ma-Massive form;).

Reef Features		**Mid Reef Mode (0-6)**	**Range (0-6)**
Morphology	Slope (°)	10	0-10
	Rugosity	2	0-4
Substrate	Rock	4	0-5
	Rubble	2	0-3
	Sand	2	0-3
	Mud	-	-
Biota	Hard Coral	2	0-3
	Soft Coral	3	0-3
	Seagrass	-	-
	Macroalgae	P	0-P
	Halimeda spp.	P	0-1
Coral state	Heterogeneity	0	0
	Dominance	Fo, Ma	-

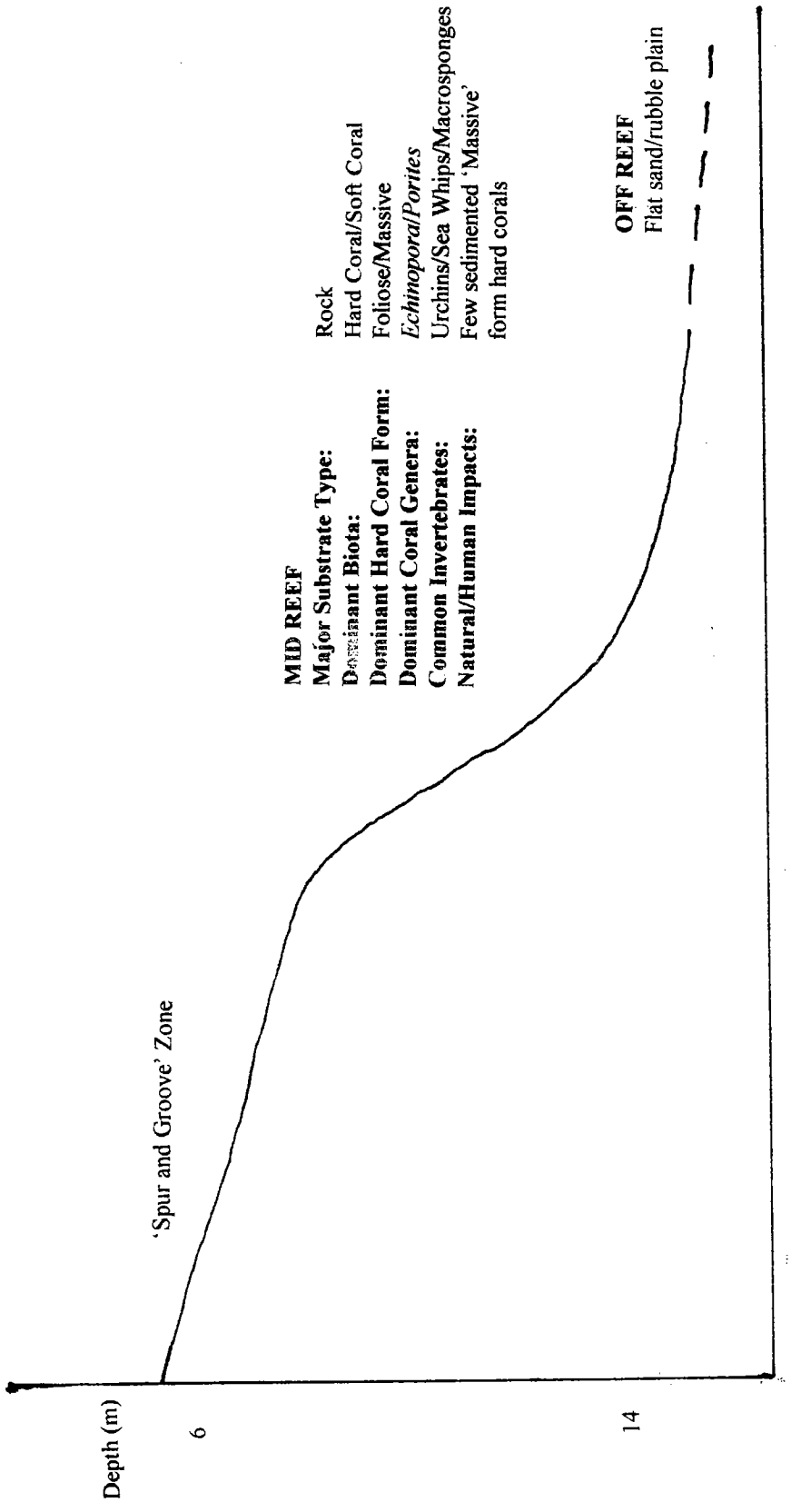


Figure 15: A diagrammatic representation of the "Reef Profile" at site 15. A summary of the major features of this site is presented.

3.5 Subtidal Invertebrate and Impacts Surveys

Survey sites are as for the subtidal habitat surveys reported above (Fig. 10).

3.5.1 Overview

Sea urchins were common over much of the reef and were the dominant invertebrate at most sites. Macrosponges and Sea whips (*Leptogorgonia* spp.) were widespread towards the base of the reef at the more exposed sites. In most cases the other invertebrates surveyed occurred in relatively low numbers. Examples of coral damage were uncommon and were largely limited to occasional sedimented 'Massive' form corals towards the base of the reef. No evidence of human impacts on the reefs were found.

3.5.2 Site Reports

Site I1:

The distributions and densities of invertebrates and incidences of reef damage are summarised in Table 20 and are described below.

Most notable was the high density of sea urchins recorded, many of which were juveniles. Urchins and other invertebrates were observed to show a marked gradation in abundance with depth, this despite the shallowness of the reef. For example, the abundance of urchins at 7 m was observed to be four times lower than at 5m. A similar 50% decrease in abundance with depth was noted for Giant clams (*Tridacna* spp.). Sea whips were only found towards the top of the reef. A single Sea fan (*Gorgonia* spp.) and two Crown of Thorns starfish (C-O-T; *Acanthaster plancii*) were observed. Coral damage was limited to a few sedimented 'Massive' form corals. No evidence of human impact was found.

Table 20. Invertebrate and Natural/Human Impacts at Site I1 (values are for 5 minutes of surveying; A=20-50 individuals; A+=50-100 individuals).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Sea Whips		2.8	0-5		
Sea Fans					
Bivalves	Giant Clams	6.0	1-9	2.8	0-6
Urchins		37.3	4-A+	10.0	0-A
C-O-T	Individuals			0.3	0-1
Impacts	**Causes**				
Dead Corals	Sedimentation	0.3	0-1	0.5	0-1

Site I2:

The distributions and densities of invertebrates and incidences of reef damage are both summarised in Table 21 and described below.

Relatively few invertebrates were observed and, of those, most were found towards the bottom of the reef. Sea whips and Macrosponges were the most numerous invertebrates. No signs of natural coral damage or human impacts were found.

Table 21. Invertebrate and Natural/Human Impacts at Site I2 (values are for 5 minutes of surveying).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		0.2	0-1	1.3	0-5
Sea Whips		0.2	0-1	2.0	0-10
Sea Fans				0.2	0-1
Bivalves	Giant Clams			0.3	0-2
Urchins		0.3	0-2	0.3	0-2
Lobsters				0.3	0-1

Site I3:

The distributions and densities of invertebrates and incidences of reef damage are both summarised in Table 22 and described below.

Macrosponges were abundant throughout the reef and Sea whips were abundant towards the reef base. Urchins were abundant on the upper reef. Coral damage was limited to a single Crown of Thorns starfish scar group, a few sedimented 'Massive' form corals towards the top of the reef, and a small quantity of dead coral (cause not determined). No evidence of human impacts was found.

Table 22. Invertebrate and Natural/Human Impacts at Site I3 (values are for 5 minutes of surveying; A=20-50 individuals).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		15.2	5-A	16.7	0-A
Sea Whips		0.3	0-1	16.7	0-A
Urchins		13.3	0-1	0.2	0-1
Lobsters				0.3	0-2
Sea Cucumbers	Holothuria	0.2	0-1		
	Others	0.3	0-1		
Impacts	**Causes**				
C-O-T	Feeding Scars	0.1	0-1		
Fresh Dead Corals	Sedimentation	0.2	0-1		
	Unknown				

Site I4:

The distributions and densities of invertebrates and incidences of reef damage are both summarised in Table 23 and described below.

Urchins dominated and were abundant over much of the reef. Other invertebrates were present but at much lower densities spread evenly over the reef. Coral damage was minimal and no evidence of human impacts were found although a single example of white band disease was noted.

Table 23. Invertebrate and Natural/Human Impacts at Site I4 (values are for 5 minutes of surveying; A=20-50 individuals; A+=50-100 individuals).

Invertebrates	Types	Upper Reef Mean	Range	Lower Reef Mean	Range
Macrosponges		0.7	0-2	2.2	0-3
Sea Whips				0.2	0-1
Urchins		4.3	0-10	31.7	0-A+
Bivalves	Giant Clams	0.3	0-1		
Lobsters				0.3	0-2
Sea Cucumbers	Holothuria	0.2	0-1		
	Synapta spp.	0.5	0-1	0.2	0-1
	Others				
Impacts	**Causes**				
Fresh Dead	White band				
Corals	Sedimentation				
	Other/Unknown			0.5	0-2

Site I5:

The distributions and densities of invertebrates and incidences of reef damage are both summarised in Table 24 and described below.

Urchins were the dominant invertebrates with densities greatest on the lower reef where Macrosponges and Sea whips were also commonly. Coral damage was limited to a few sedimented 'Massive' form corals at the base of the reef. No evidence of human impacts were found.

Table 24. Invertebrate and Natural/Human Impacts at Site I5 (values are for 5 minutes of surveying; A=20-50 individuals; A+=50-100 individuals).

Invertebrates	Types	Upper Reef Mean	Range	Lower Reef Mean	Range
Macrosponges		0.7	0-2	6.5	0-10
Sea Whips				5.8	0-8
Bivalves	Giant Clams	0.3	0-2		
Urchins		4.3	0-10	24.3	0-A+
Sea Cucumbers	Holothuria	0.2	0-1	0.5	0-1
	Others			0.3	0-2
Synapta	All	0.5	0-1		
Impacts	**Causes**				
Dead Corals	Sedimentation			0.5	0-3

3.6 Reef Fish Census

Survey sites are as for the subtidal habitat surveys reported above (Fig. 10).

3.6.1 Overview

The high diversity of habitats which included extensive areas of exposed, fringing, outer reef and smaller areas of more sheltered, patch reef has led to a correspondingly high diversity of reef fish assemblages. In general, the outer reef sites supported the highest diversity and abundance of reef fish. The diversity of reef fish on each site is given in Table 25. For a complete list of the censused species present at each site, refer to Appendix 4. A comprehensive list of all fish species recorded during the surveys of the C.I.G. is presented in Appendix 8

Table 25. Relative Diversity Indices (R.D.I.) and total numbers of reef fish species observed. Numbers are for those fish observed from the 72 species censused.

Site	R.D.I.	Total No. Species
I1	0.13	9
I2: Shallow	0.31	22
I2: Deep	0.11	8
I3: Shallow	0.31	22
I3: Deep	0.17	22
I4: Shallow	0.21	15
I4: Deep	0.39	28
I5	0.48	52

3.6.2 Site Reports

Site: I1

Site diversity and abundance were low with only 9 of the census species recorded. Chaetodontids and Acanthurids were the only families present in significant numbers with the Dot-Dash butterflyfish (*Chaetodon kleinii*) the most abundant (20-50 individuals encountered every 5 minutes). Most of the reef fish observed were thought to be juveniles; it was probable this site was a nursery area for many species. The relative abundance and diversity of reef fish recorded are shown in Fig. 16.

Site I2:

The greatest diversity and abundance was recorded on the upper reef slopes where 22 species were observed in comparison to only 8 species on the lower slopes. The Dash-Dot goatfish, (*Parupeneus barberinus*) and Dusky surgeonfish (*Acanthurus nigrofuscus*) were the dominant species identified with an average of 9 and 14 fish encountered every five minutes respectively. The relative abundance and diversity of reef fish recorded on the upper and lower reef slopes are shown in Figs. 17 and 18 respectively.

Site I3:

The diversity and abundance of species was again higher on the upper shallow reef. Thompson's surgeonfish (*Acanthurus thompsoni*) was the only species present in significant numbers on the deeper reef where a maximum of 4 fish were encountered every five minutes. On the shallower reef Acanthurids (*Acanthurus thompsoni*, <20-50 fish/5 mins.; *A. nigrofuscus*, <8 fish/5 mins.), Balistids (*Odonus niger*, <10 fish/5 mins.) and Chaetodontids (*Chaetodon melannotus*; *C. lineolatus*, <5 fish/5 mins.) were all present in significant numbers. 3 Napoleon wrasse (*Cheilinus undulatus*, estimated lengths 140-160 cm) were also observed. The relative abundance and diversity of reef fish recorded on the upper and lower reef slopes are shown in Figures 19 and 20.

Site I4:

In contrast to observations made on sites I2 and I3 reef fish abundance and diversity increased with depth in this case. Only the Goldring bristletooth (*Ctenochaetus strigosus*) and the Dusky surgeonfish (*Acanthurus nigrofuscus)* were present in significant numbers (20-50 fish/5 mins) in the shallower waters. On the deeper reef a number of species were common including Chaetodontids (*Heniochus acuminatus*, <6 fish/5 mins.; *Chaetodon guttatissimus*, <11 fish/5 mins.) and Acanthurids (*Zebrasoma scopas*, <9 fish/5 mins.; *Naso brevirostris*, <20-50 fish/5 mins.). The relative abundance and diversity of reef fish recorded on the upper and lower reef slopes are shown in Figures 21 and 22, respectively.

Site I5:

This site recorded the highest diversity of reef fish (42 species) of all the sites around Ibo island. Acanthurids comprised more than half the reef fish recorded (*Naso hexacanthus*, <20-50 fish/5 mins; *Acanthurus dussumieri*, <20-50 fish/5 mins.; *A. nigrofuscus*, <10 fish/5 mins.) although the Chaetodontids were more diverse (including; *Chaetodon auriga*; *C. melanotus*; *C. trifasciatus* at <6 fish/5 mins.). The relative abundance and diversity of reef fish recorded are shown in Figure 23.

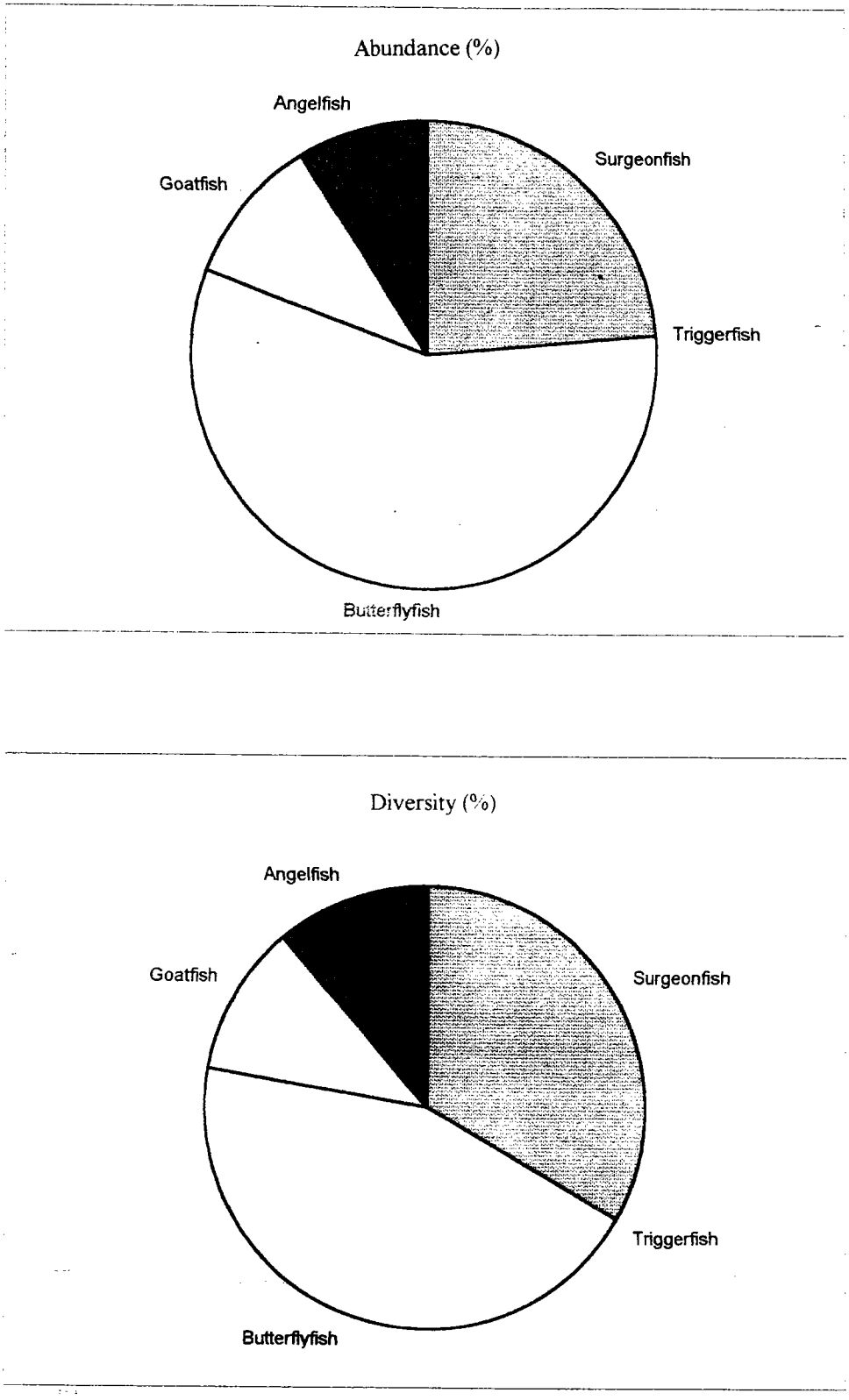


Figure 16: The relative diversity and abundances of reef fish families at site 11

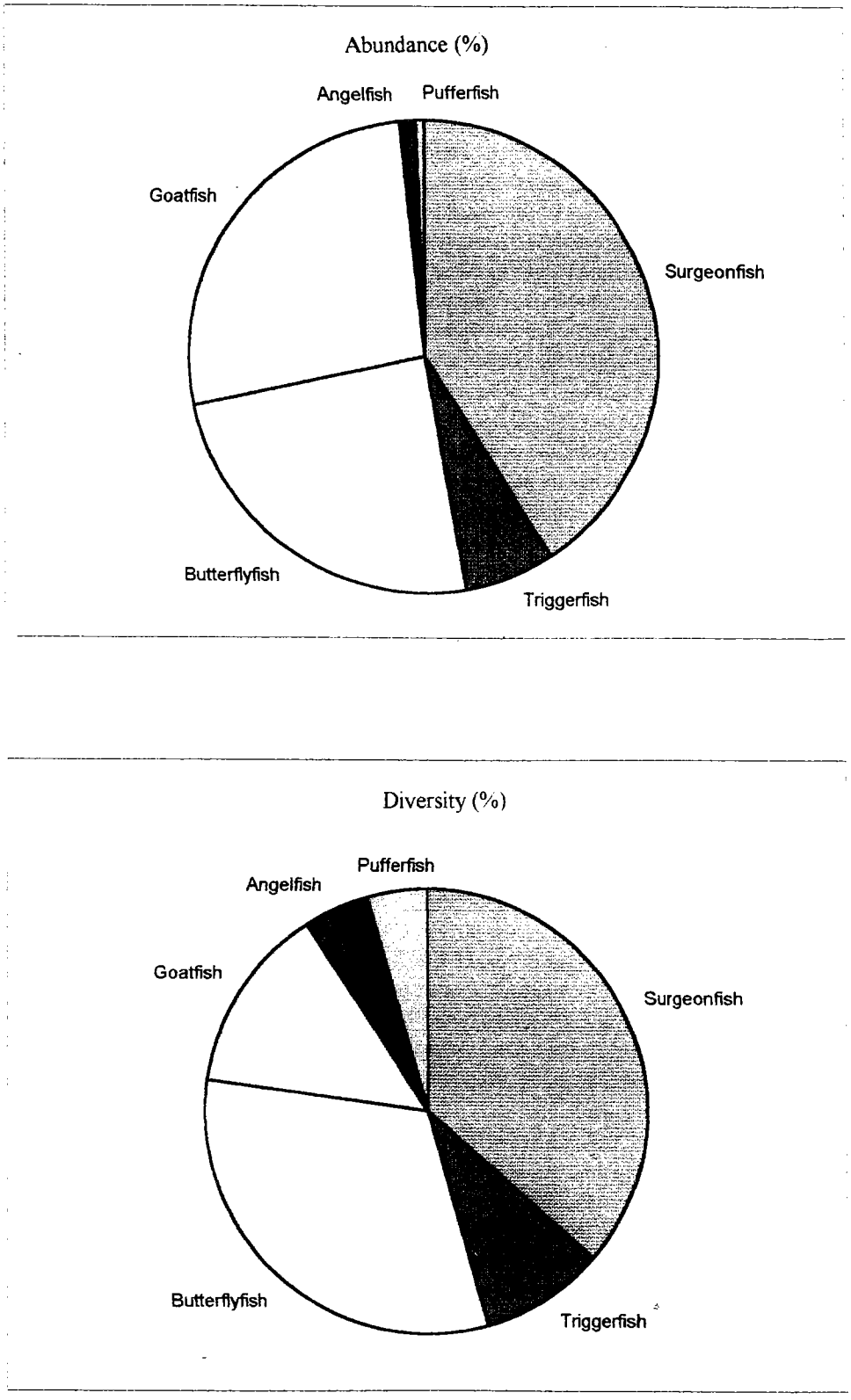
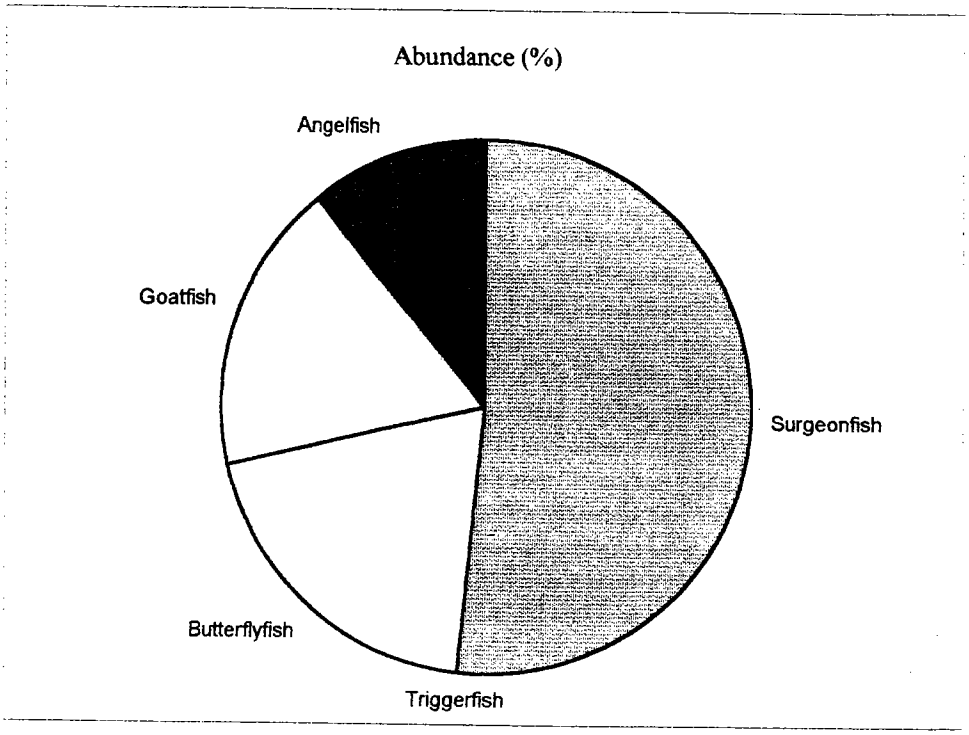


Figure 17: The relative diversity and abundances of reef fish families at site 12, upper reef



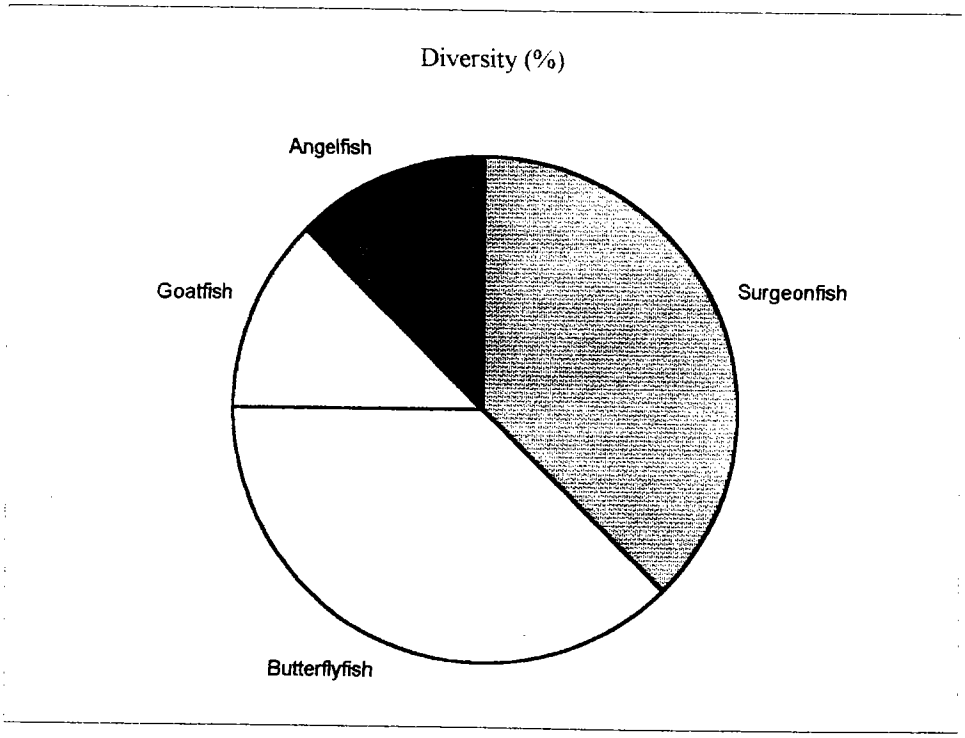


Figure 18: The relative diversity and abundances of reef fish families at site 12, Lower reef

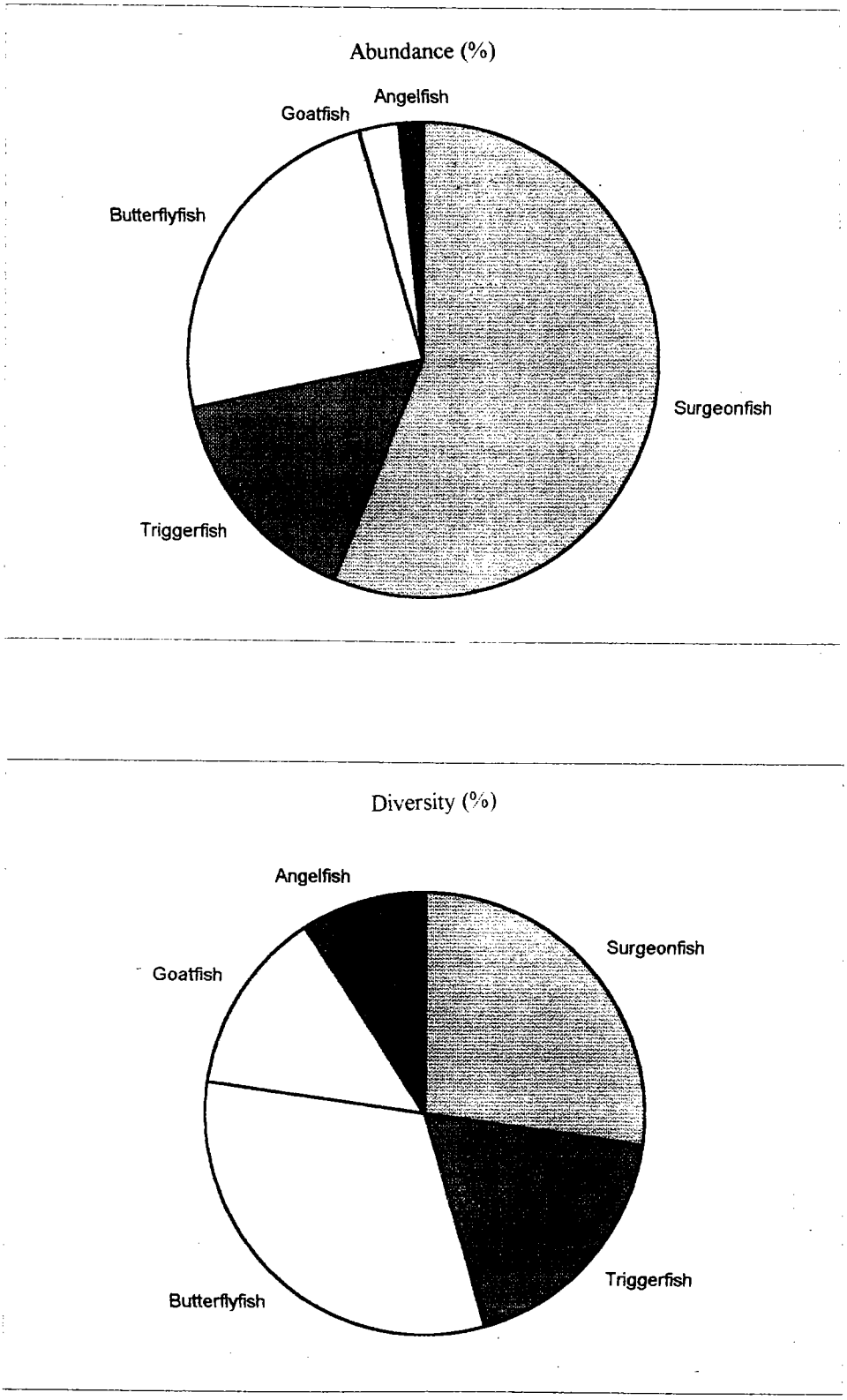


Figure 19: The relative diversity and abundances of reef fish families at site 13, Upper reef

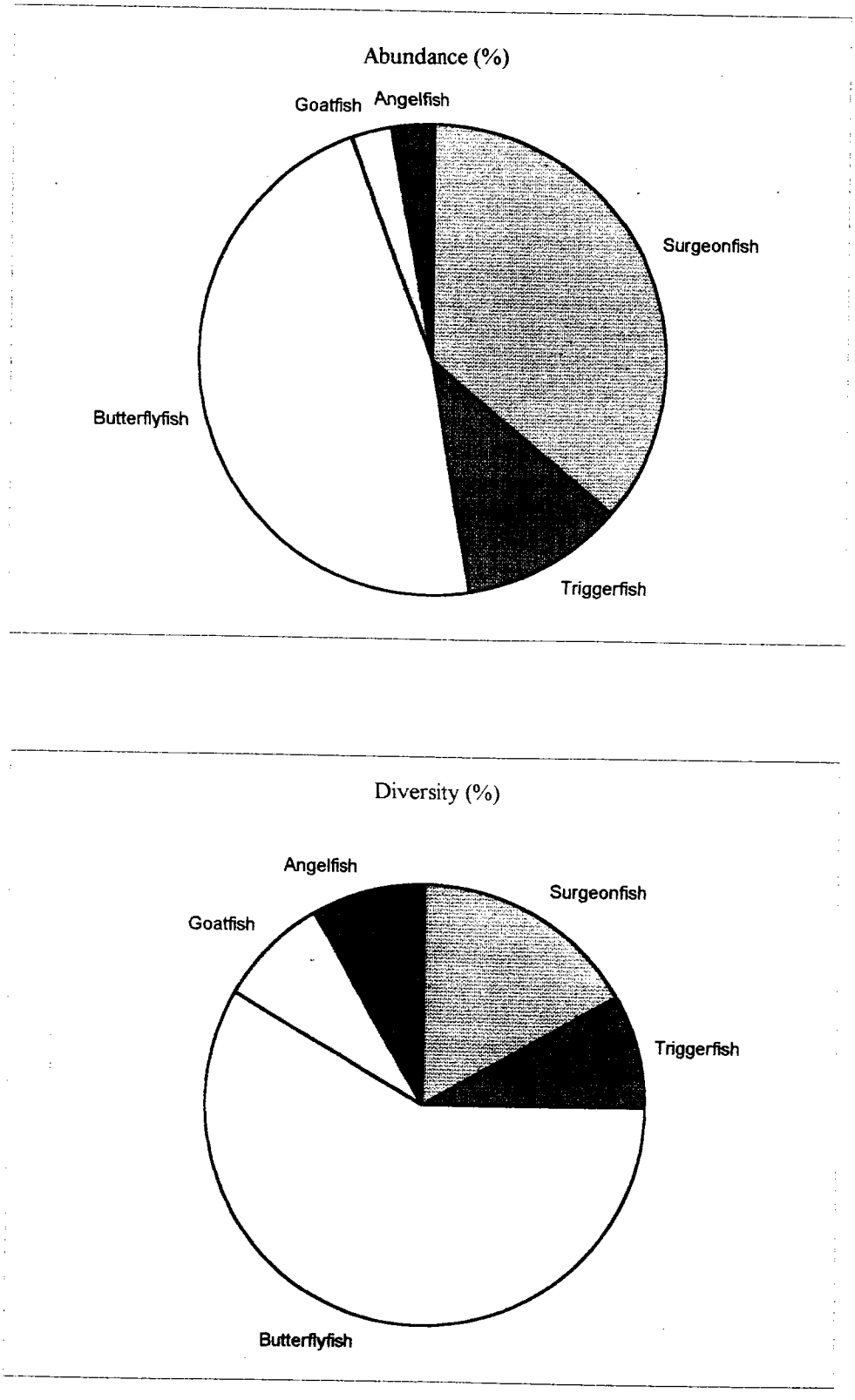


Figure 20: The relative diversity and abundances of reef fish families at site 13, Lower reef

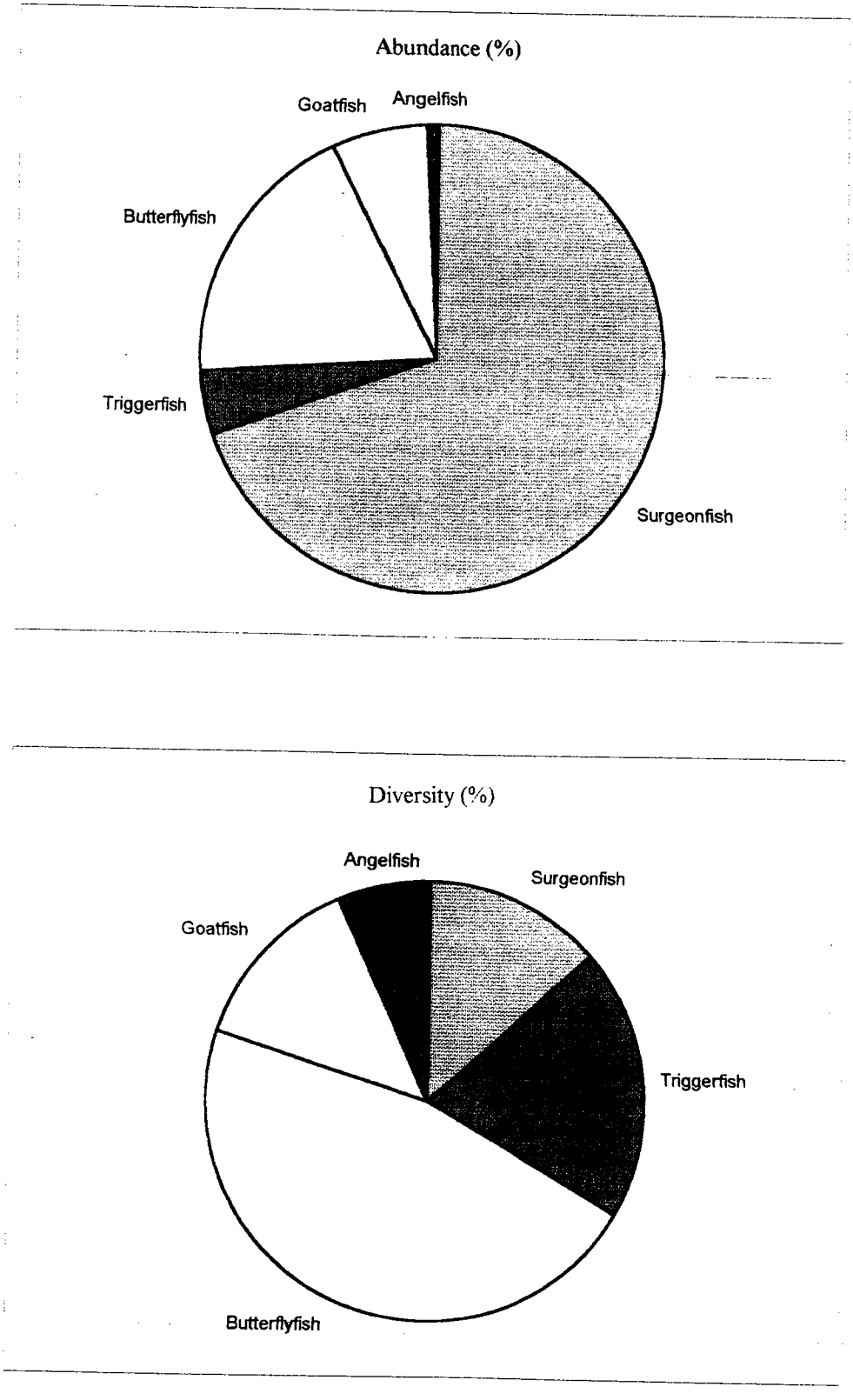


Figure 21: The relative diversity and abundances of reef fish families at site 14, Upper reef

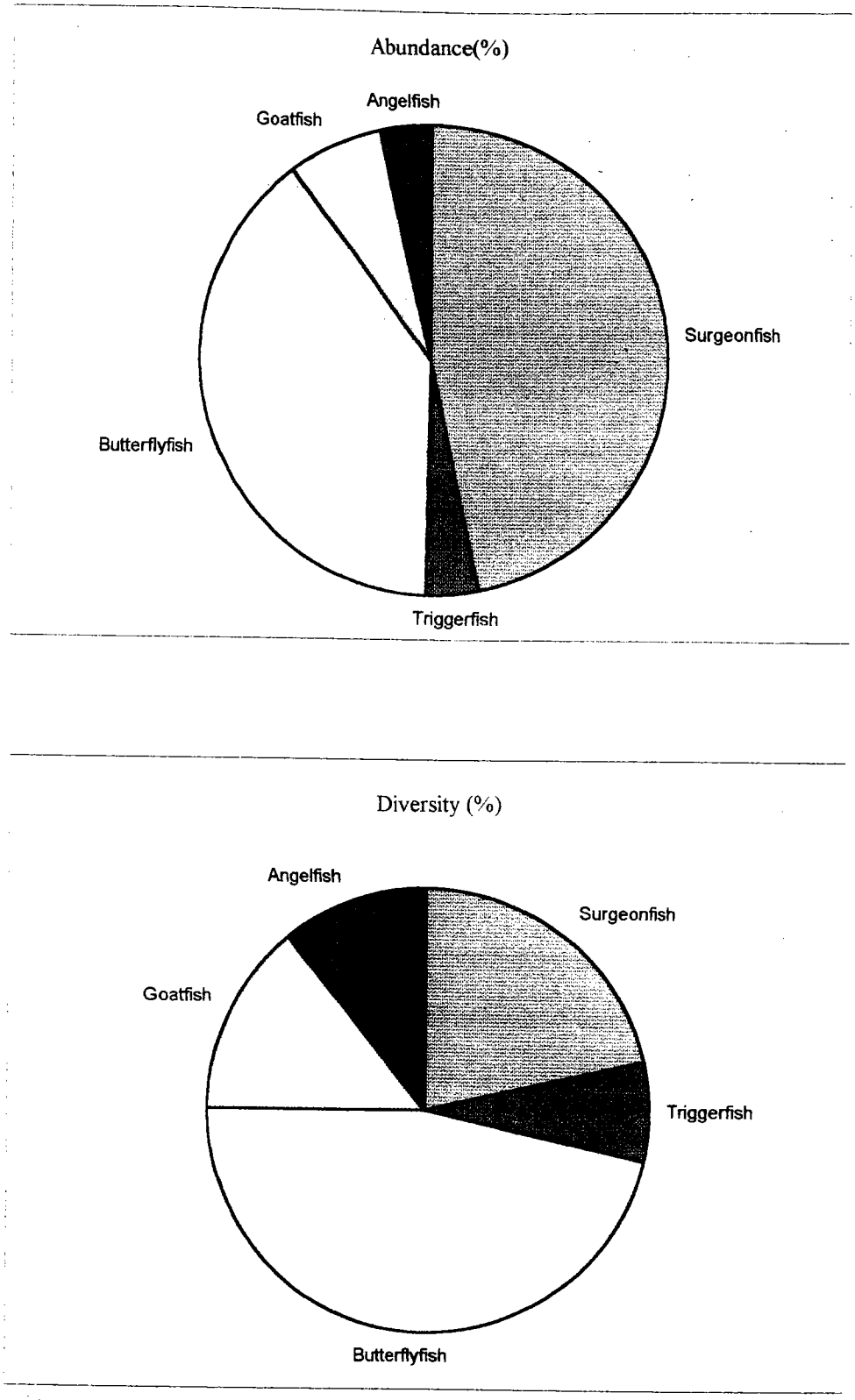


Figure 22: The relative diversity and abundances of reef fish families at site 14, Lower reef

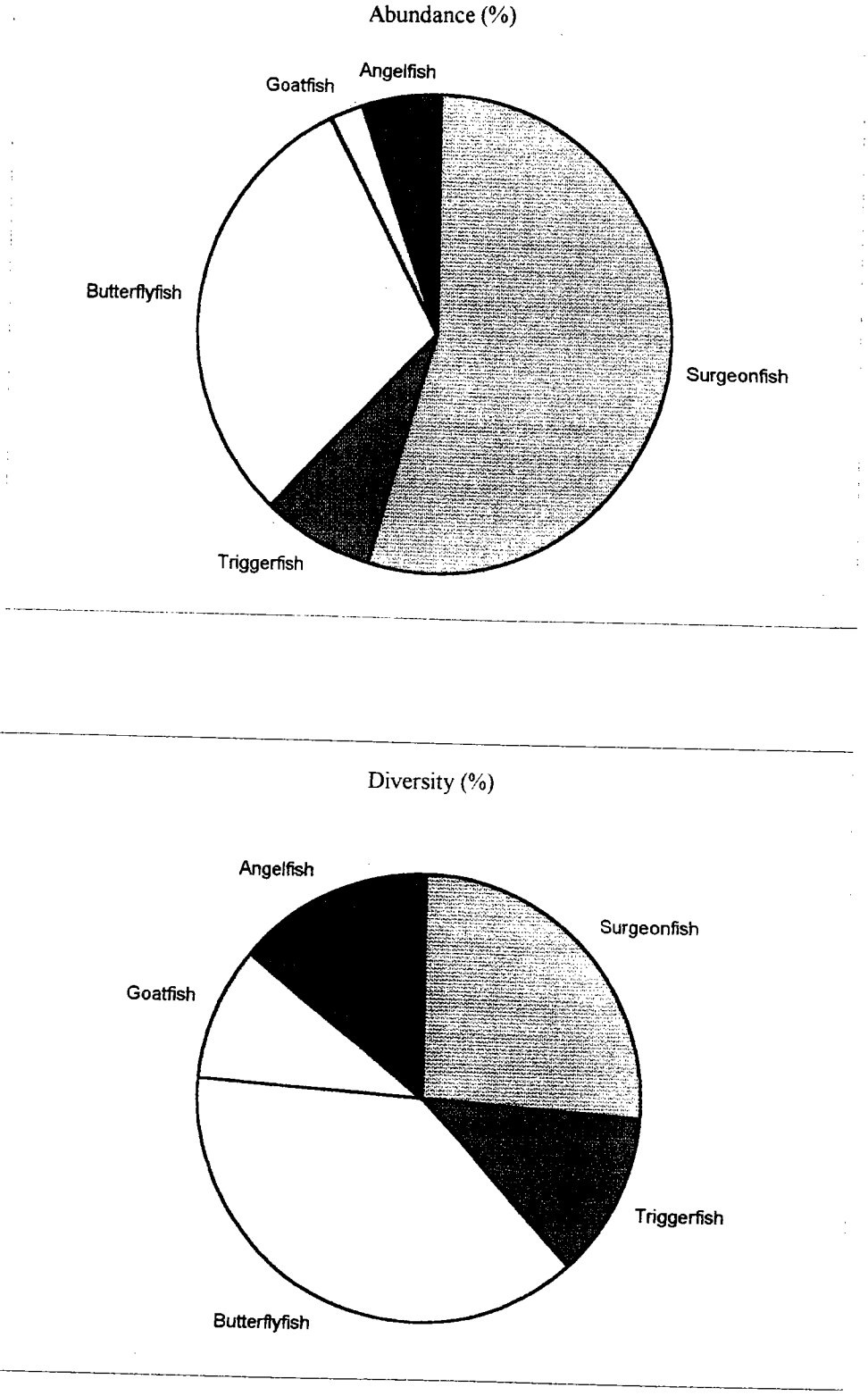


Figure 23: The relative diversity and abundances of reef fish families at site 15

3.7 Commercial Fish Census

Survey sites are as for the subtidal habitat surveys reported above (Fig. 10).

3.7.1 Overview

Commercial fish densities were found to be related to the development and situation of the reef. Around the north of the island where the reef was shallow, poorly developed and relatively sheltered (sites: I1; I2) a relatively low abundance and diversity of commercial fish were recorded. In contrast, the well-developed, relatively exposed reefs (sites: I3; I4; I5) supported a high diversity and abundance of fish. The relatively low abundance and diversity of commercial fish at the northern sites is probably a reflection of the poor development of the reef rather than past fishing activity.

3.7.2 Site Survey Reports

Site: I1
No commercial fish were observed at this site. The reef was poorly developed and most fish observed were juvenile reef fish species.

Site: I2
The commercial species were more common in the shallower parts (<6 m) of the reef where parrotfish (Scarids) dominated (mainly *Scarus sordidus* and *S. ghobban*) along with small shoals of the Lethrinid, *Gnathodentex aurolineatus* (estimated average length 20 cm) and occasional groupers (Serranids: *Cephalopholis argus*, *C. nigripinnis* and *Epinephelus fasciatus*). Solitary individuals of *Scarus sordidus* and *Plectorhinchus gaterinus* were occasionally seen. Large shoals (>50) of the fusilier (Caesionid), *Pterocaesio pisang*, were noted above the reef. At the reef base (8 m) were large areas of sand where a single Bluespotted ribbontail ray (*Taeniura lymna*) was observed. The family compositions and rates of encounter are summarised for the upper and lower reef slopes in Figures 24 and 25, respectively.

Site: I3
Groupers (Serranids) were the most abundant commercial fish seen at this site with 3-4 individuals observed every 5 minutes. Many of these were small (< 30 cm) fish especially the specimens of *Cephalophilis miniata, C. nigripinnis* and *C. fasciatus*. A single, large (est. length 100cm) Bluefin trevally (*Caranx melampygus*) was observed. The family compositions and rates of encounter are summarised in Figure 26.

Site: I4
The majority of commercial species were observed near the reef base (14 m) with numerous shoals of *Lutjanus kasmira* and *Plectorhinchus gaterinus* and a solitary Lyretail grouper (Serranid), *Variola louti* (estimated length 60 cm) recorded. Those fish recorded in the shallower parts of the reef (< 8 m) were relatively small with the parrotfish, *Scarus sordidus* (10-40 cm), the most common. Large shoals (>20 individuals) of fusiliers (Caesionids: *Caesio teres* and *Caesio xanthanota*) were also

observed. The family compositions and rates of encounter are summarised for the upper and lower reef slopes in Figures 27 and 28, respectively.

Site: I5
Large shoals (>50 individuals) of snappers (Lutjanids), primarily *Lutjanus kasmira,* a few grunts (Haemulidae: *Plectorhinchus gaterinus*) and a single grouper (Serranid) *Epinephelus tukula* (~60 cm) were recorded. Large shoals (>50 individuals) of Caesionidae (*Pterocaesio pisang, Caesio xanthonota* and *C. teres*) were also observed. The family compositions and rates of encounter are summarised in Figure 29.

3.7.3 Size Distributions

The size distributions of the commercial fish recorded are summarised for all the sites Table 26 below. Most families showed a wide range of lengths with the larger specimens normally observed on the fringing 'outer reef' (I3-I5).

Table 26. Size distribution summary for the commercial fish of Ibo island

'Commercial' Fish Family	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinids	20	20-30
Lutjanids	20	10-30
Scarids	20	10-70
Serranids	20	10-60
Siganids	-	-
Haemulids	25	10-40
Carangids*	40	40

* based on 2 fish only.

3.8 Finfish Fisheries

Ibo Island has a permanent field station for fisheries officers from IDPPE (Institute for Small-Scale Fisheries) who are involved in the collection of fishery data for the island. In order to avoid unnecessary repetition of their work this Programme has limited its surveys to a brief census and description of the types of fisheries employed.

Ibo is probably the most established community in the Archipelago, having for some time been the administrative centre for the area, and this was reflected in the more commercial structure of its fisheries. Economically much of the income from fisheries in recent times has come from the seacucumber collection and resale business. Information is currently being collected on this fishery in collaboration with one of the companies involved. However, due to the 'sensitive' commercial nature of the fishery the results of the study will be presented in a separate report.

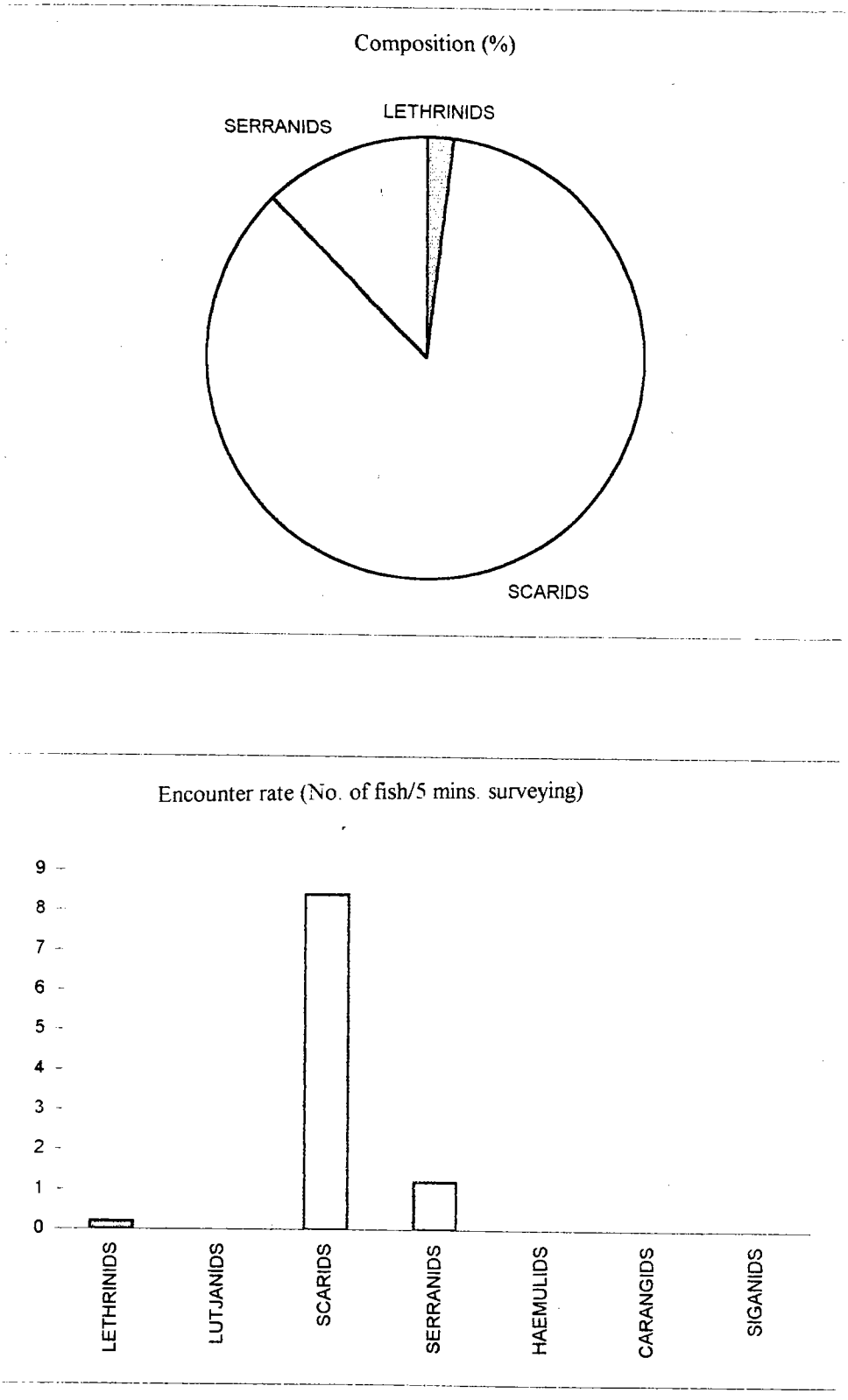


Figure 24: The composition and encounter rates of commercial fish recorded at site 12, Upper reef

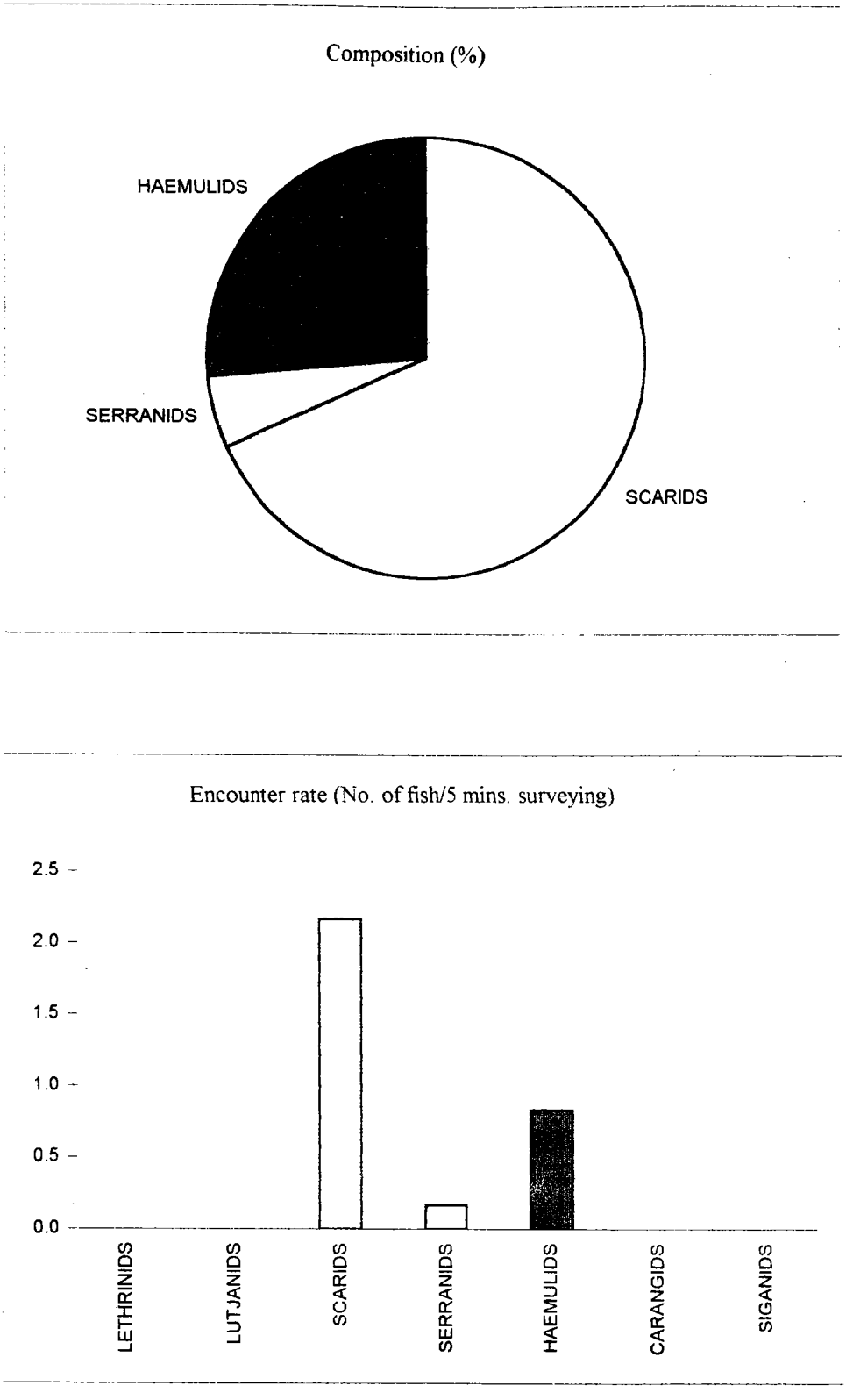


Figure 25: The composition and encounter rates of commercial fish recorded at site 12, Lower reef

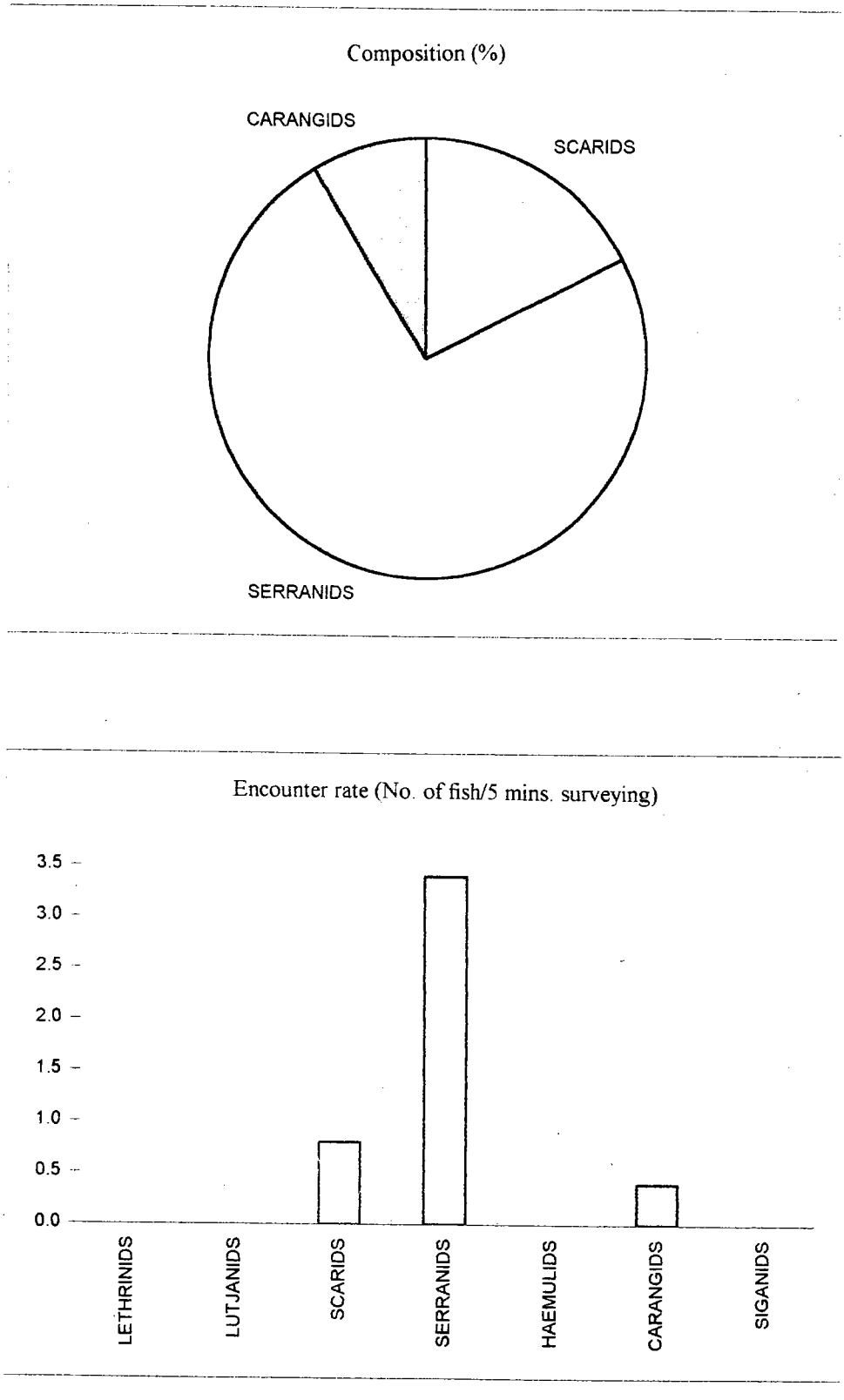


Figure 26: The composition and encounter rates of commercial fish recorded at site 13

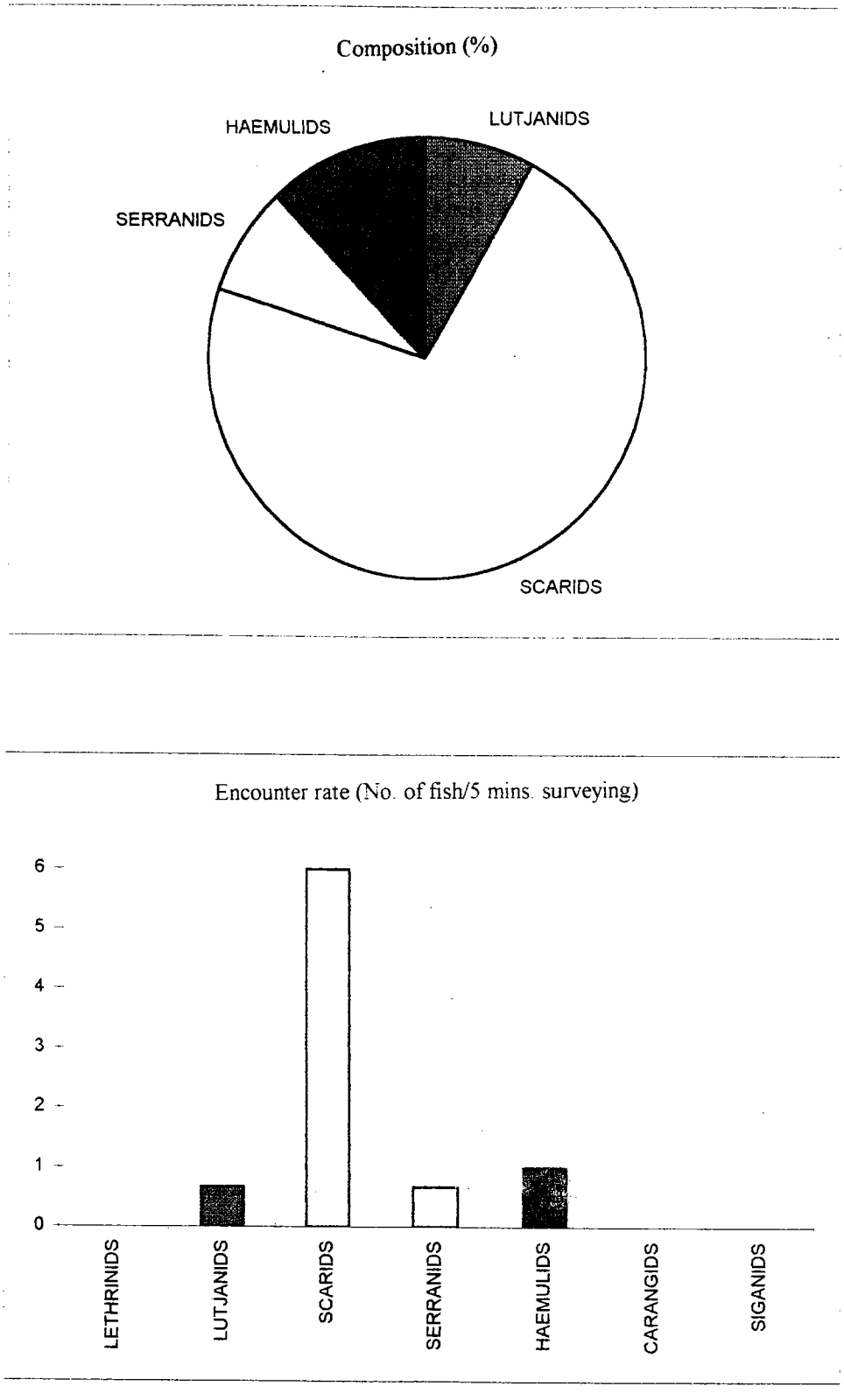


Figure 27: The composition and encounter rates of commercial fish recorded at site 14, Upper reef

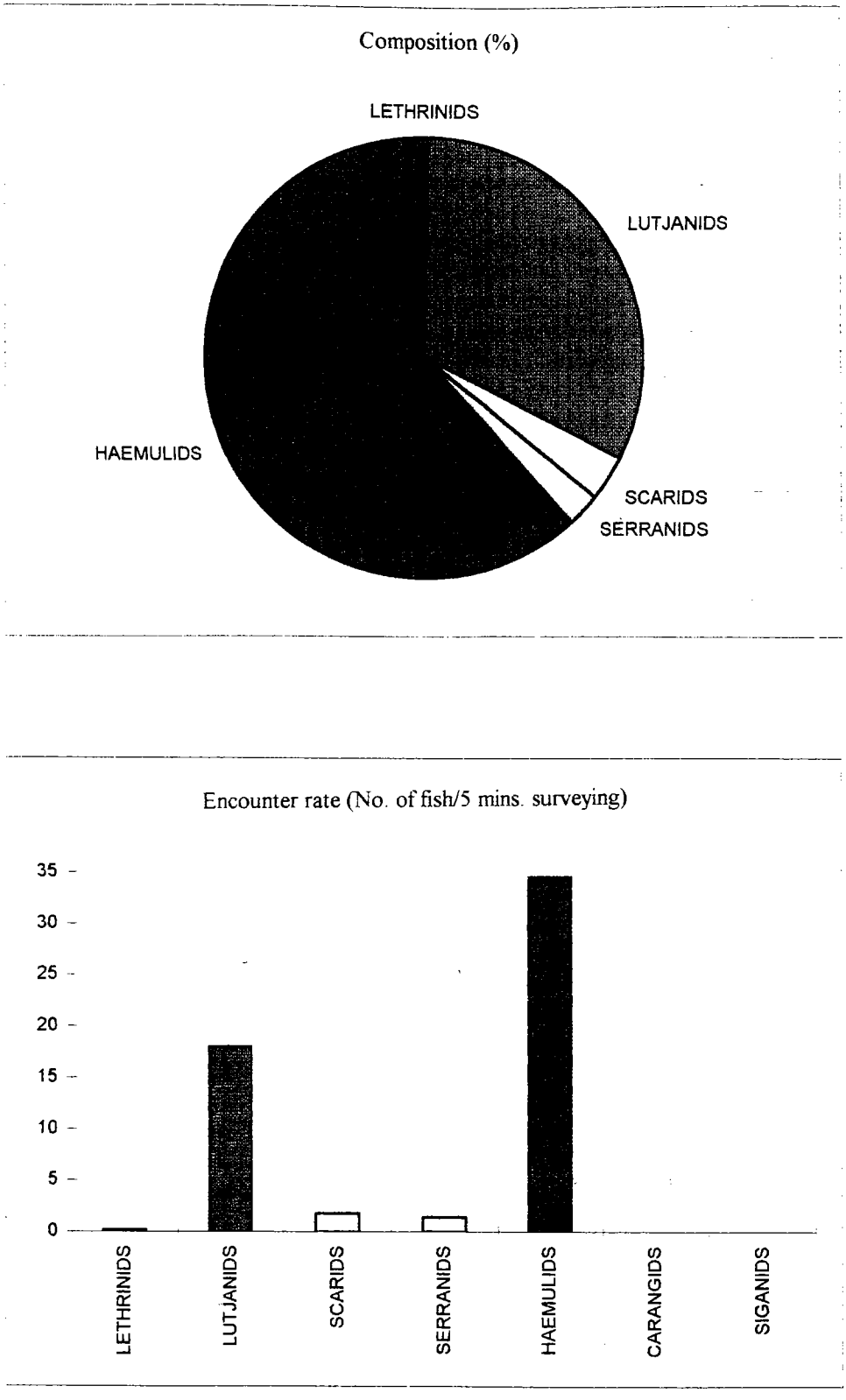
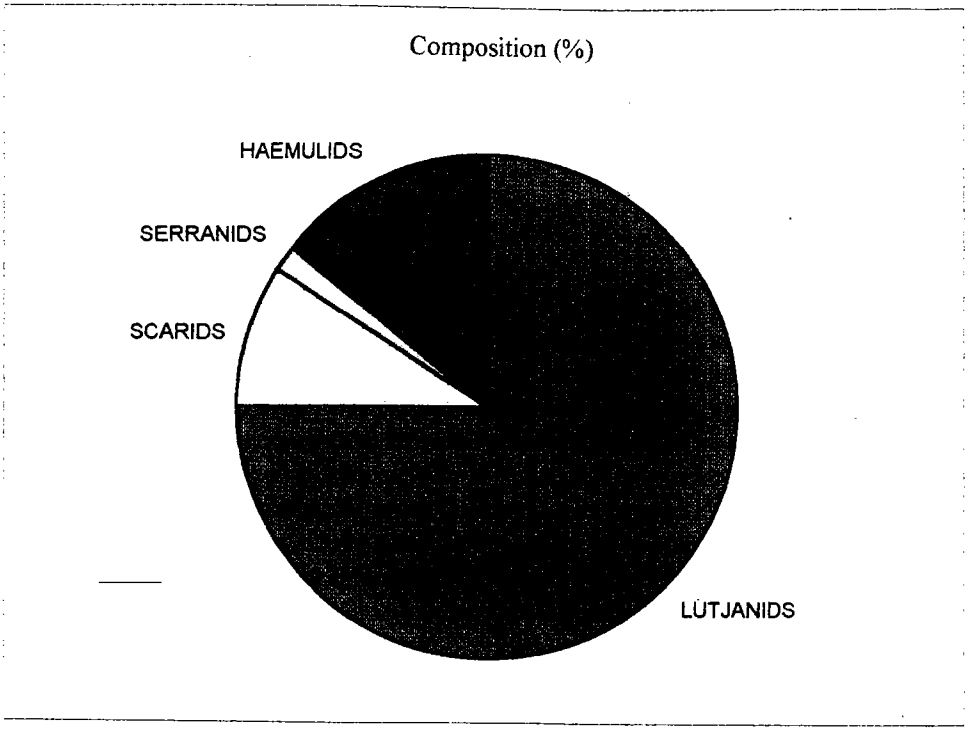


Figure 28: The composition and encounter rates of commercial fish recorded at site 14, Lower reef



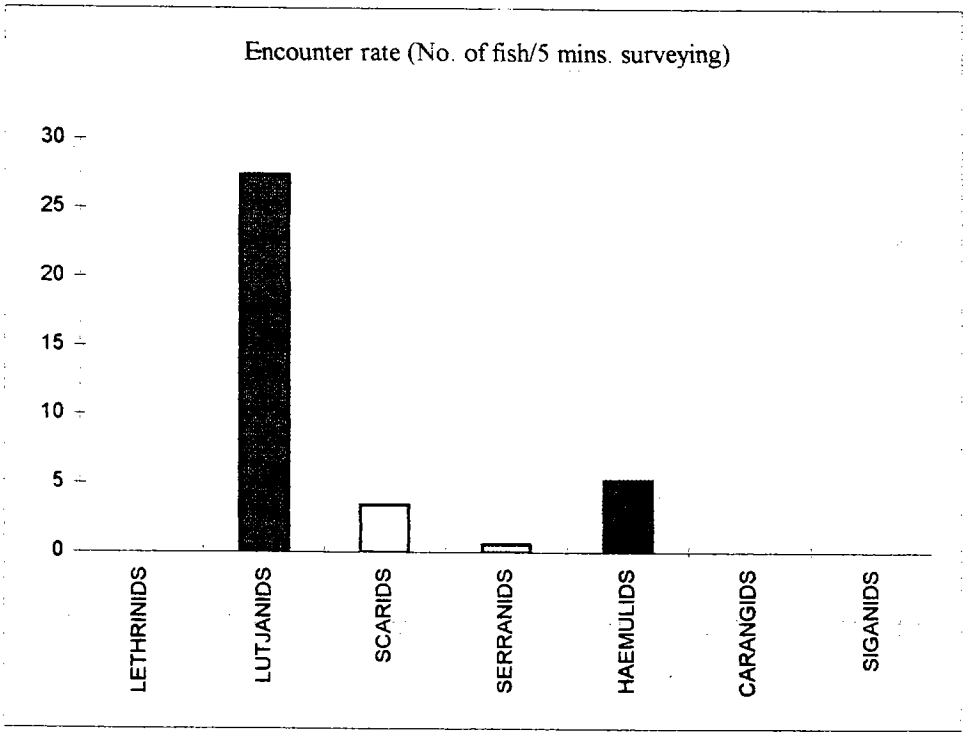


Figure 29: The composition and encounter rates of commercial fish recorded at site 15.

The finfish fishery is also well established and is of a more commercial nature than that observed on other islands.

With its established population most of the fishing was carried out by permanent residents of the island. The main fishing method employed was seine netting from sailing boats in areas of coral bommies, and in some cases coral reefs, with catches dominated by relatively large reef fish such as parrotfish and snappers. Line fishing from canoes and trolling for large pelagic fish off the outer reef was also common. Most of the fish are landed close to the village where there is a fisheries co-operative which operates a fish market and storage facility. This is equipped with a freezing facility which is used to store fish, particularly squid and large pelagic fish such as Marlin and Tuna, before transportation and later sale in Pemba and Nampula.

The resident fisheries officers on the island have recently initiated programmes of fisheries development on the island in an attempt to increase productivity. This has been mainly targeted at the small-scale lobster fishery.

3.9 Intertidal Resource Collection

3.9.1 Overview

For those without boats the intertidal flats and shallow lagoons provided a wide variety of resources which are collected on foot. The distribution of intertidal habitats is given in Figure 30. The scale and patterns of collection are described below.

Scale and Intensity of Collection
Figures from IDPPE on Ibo, taken in June 1996, showed that there are a total of 78 intertidal collectors on the island. This gives a density for the entire intertidal of 2-3 people/km^2. The majority (80%) of these were based at Kumuamba, the remainder (20%) coming from Rituto. Over the two-days of the Programme's study period 35 people were surveyed in the north-western and north-eastern parts of the island's intertidal area. In the zones in which they were found, these collectors were distributed at a density of 10 collectors/km^2. However, there were large areas not censused, especially on the reef intertidal, where the density appeared to be less than 1 collector/km^2.

Gender of Collectors
The majority (57%) of the collectors were adult females, with the remainder being an equal mix between young males and females. No adult males were recorded collecting on the intertidal.

Group Structure
Many of the collectors were organised into groups. Of those censused there were 9 groups making up 28/35 of the total. The high occurrence of grouping of collectors on Ibo (all zones) was mainly taken to be an effect of the predominance of women and children (15/35 people), all of whom tend to prefer working in groups for social reasons.

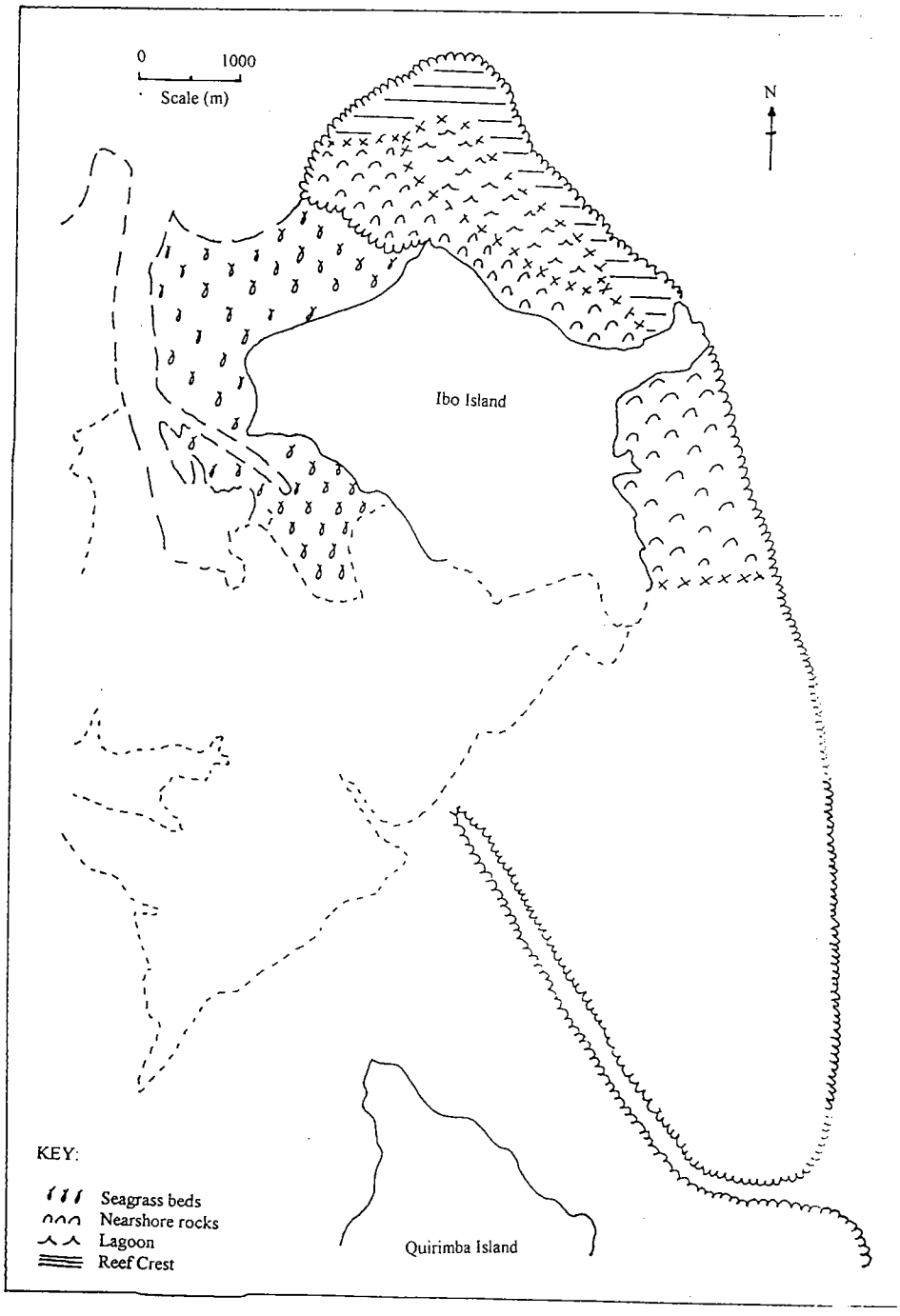


Figure 30: The intertidal zones distinguished on Ibo island in relation to the resource use surveys

Origin of Collectors
All collectors interviewed were long-term residents of Ibo island. The absence of itinerant collectors was presumably due to the availability of alternative collection sites where the level of exploitation was lower (such as Sencar Is.). Many residents of Ibo, especially adult males, also travel to other islands and settlements in the region for the fisheries and intertidal gleaning.

Collection Methods
Intertidal products were either collected by hand (45% of collectors) or with the assistance of short iron rods (55% of collectors). No other collection methods were observed. Bivalves, gastropods taken as food items ('FO' gastropods), and seacucumbers were collected by hand whereas octopii, fish, chitons and gastropods taken for the curio trade ('CT' gastropods) were collected using the iron rods.

Catch Composition
A large and variable catch was produced by the Ibo intertidal. A full checklist of species collected is given in Appendix 10. The main target resource group was the 'FO' gastropods with 69% of collectors involved. Six species, including *Strombus mutabilis* (310 specimens), *Fasciolaria trapezium* (17 specimens), *Marginella* sp. (21 specimens), *Turbo coronatus* (5 specimens), *Polinices tumidus* (2 specimens) and *Chicoreus ramosus* (1 specimen) were collected during the two-day survey. Also important was the collection of bivalves, largely *Pinna* sp., by 18 people, 'CT' gastropods (including 29 specimens of *Cypraea tigris*, 16 specimens of *Lambis lambis*, 2 specimens of *Lambis chiragra* and single specimens of *Cypraea carneola*, *Cypraea vitellus* and *Cypraecassis rufa*) by 17 people, and 10 species of holothurians (92 specimens) collected by 17 people. Few people collected other resources, e.g. octopii (5 people), fish (9 people), crustaceans (1 person), urchins (3 people) and chitons (6 people). Ibo was unique in that it was the only island where the collection of urchins and chitons was observed.

3.9.2 Distribution of Effort across Intertidal Zones

Over one third of the collectors interviewed were found in the sand/seagrass beds in the far southern corner of the island's intertidal, the majority in the small bay opposite Ibo town. No collectors were observed in the northern sand/seagrass beds making the overall the density of collectors in this zone relatively low at 4/km^2. A higher collection pressure was found on the central zone of the reef intertidal where densities of collectors observed were 17/km^2 in an unspecified lagoon-crest zone, 16/km^2 in the lagoon, and 4/km^2 on the reef crest. However, it was noted that, large expanses of the reef intertidal to either side of this central section were not utilised at all.

There were no adult males involved in collection and young males were only found in the sand/seagrass zone and in the lagoon. Numbers of adult women were greatest in the sand/seagrass (9) and lagoon-crest (7) zones where they formed the majority of resource users. Young women almost exclusively restricted themselves to the lagoon/crest (6/7 people). Adult women collected in all zones but most effort was concentrated in the sand/seagrass (collection of bivalves, 'FO' gastropods and urchins) and lagoon/crest (collection of octopii, 'FO' gastropods and 'CT' gastropods)

zones. Young women showed a similar pattern of distribution and catches with the inclusion of chitons. Young men were primarily catching holothuria in both the sand/seagrass and lagoon areas.

Method of Collection
In general, collection was by hand in both the sand/seagrass and lagoon zones, whilst in the lagoon/crest zone iron rods were employed.

Catch Composition
The distribution of catches within each zone are summarised in Figure 31. In the sand/seagrass zones the dominant components of catches were, bivalves (1080 specimens of *Pinna* sp. and 9 specimens of *Barbatia* sp.), 'FO' gastropods (especially *Strombus mutabilis* and *Marginella* sp.) and urchins (60 specimens). In the lagoon zone, holothuria (85% of catch), and fish (17% of the catch) were the main catch components. In the lagoon/crest zone, 'FO'/'CT' gastropods (particularly, *Strombus mutabilis*, *Lambis lambis* and *Cypraea tigris*) and chitons (a total of 1000 individuals representing the entire catch for Ibo) were the primary catch. On the reef crest only octopii were collected. Catch diversity was greatest in the sand/seagrass zone.

3.9.3 Subtidal Collection

During the study period there was no observed subtidal collection of molluscs, holothuria or crustaceans. However IDPPE figures show that there were 14 snorkellers on the island (13 from Kumuamba, 1 from Rituto).

3.9.4 Discussion

Whilst the collection intensity for Ibo may appear high in some areas, large expanses of reef intertidal in the northern and southern ends were only lightly exploited with collection densities estimated to be less than 1 person/km^2. The concentration of collection pressure in localised areas close to the village is thought likely to be a product of the limitation of travel as many of the collectors were women in their 50's and 60's and children and therefore not suited to long walks. It is also possible that resources are more concentrated in these areas and that there is no need to waste time collecting in the more distant sites. In order to fully evaluate the potential productivity and sustainable use of the intertidal further surveys of resource densities in the many more distant, as yet unexploited, sites are needed.

The predominance of adult women among intertidal collectors is thought mainly due to a traditional division of labour between men and women where men generally concentrate on the finfish fisheries. The large number of young women collecting may be an artefact of the survey being conducted over a weekend when there was no school. The total absence of adult men on the intertidal is most probably due to a combination of their alternative involvement in the finfish fishery, which is well developed on Ibo, and their emigration from the island (as confirmed by IDPPE). Many men have left Ibo to look for work in Pemba and on other islands such as

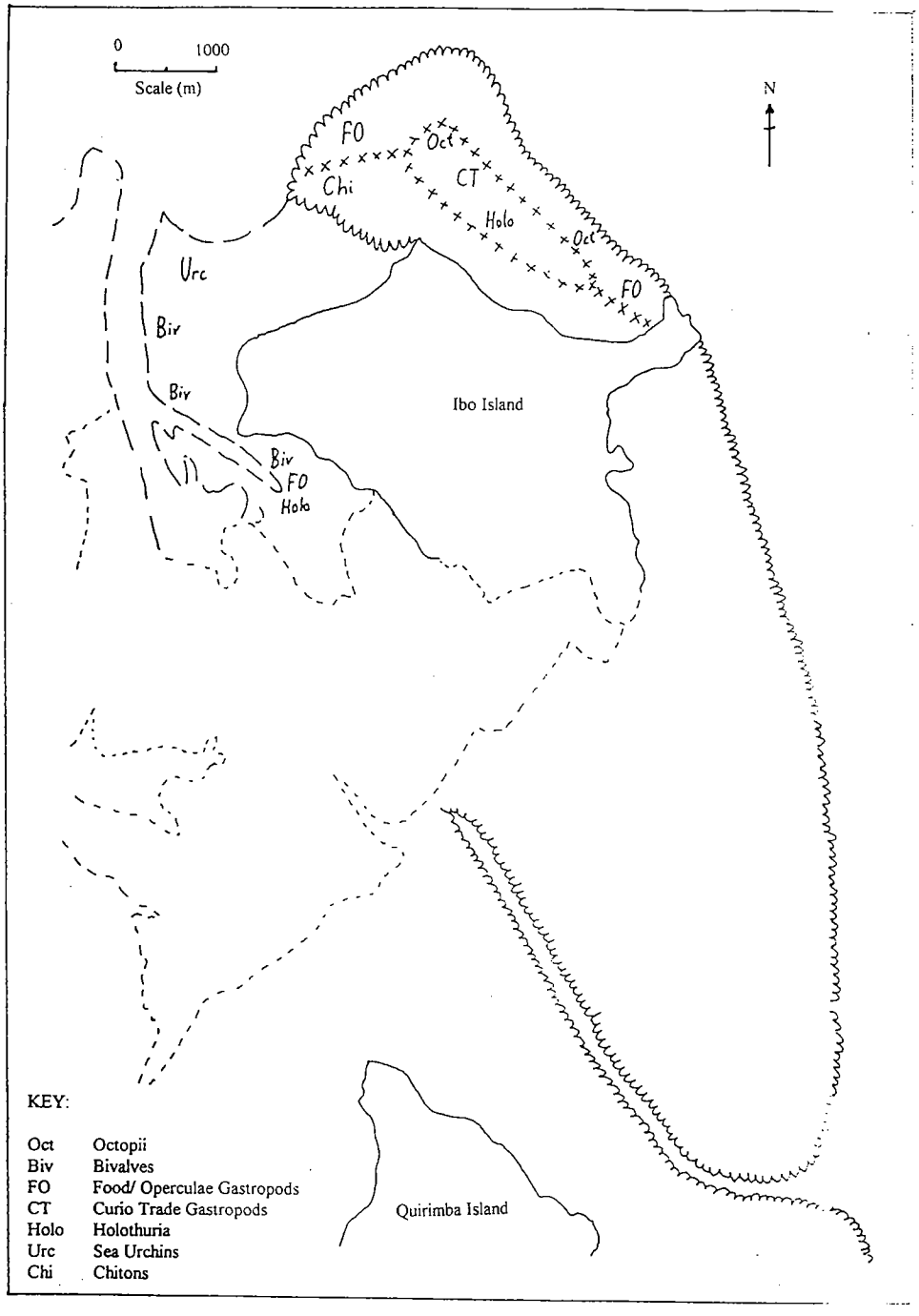


Figure 31: The main areas for the collection of intertidal invertebrates on Ibo island.

Sencar and Quilaluia where marine resources are more plentiful. It is this emigration of men which is thought to have had the greatest impact by creating a drain of expertise on intertidal resource use on Ibo.

'FO' gastropods were collected most widely as they were the most abundant resource on the intertidal. In areas of great abundances, such as in the sand/seagrass zone, they were exploited heavily and in large quantities forming an important food source. The intensity of collection of holothuria and 'CT' gastropods is variable being related to their ease of sale on Ibo. The practice of urchin collection has been brought from Pemba where they have been collected for a long time. The reason given for the absence of urchin collection on the other islands was a lack of willingness to eat these animals, possibly because of underlying traditional beliefs.

Although no subtidal mollusc/holothuria/crustacean collection was observed, it is thought likely to exist on a small scale. However, the exposed nature of the outer reefs of the island would make collection difficult. In an effort to increase exploitation of this sector IDPPE currently has a lobster trapping programme underway.

3.10 Mollusc Biodiversity Study

3.10.1 Overview

A total of 9 bivalve species and 40 gastropod species were recorded. The gastropods species belonged to 17 Families, the most abundant being the Cowries (Cypraeidae) and Whelks, with 7 species of each recorded. A full list of species recorded is given in Appendix 13.

3.10.2 Habitat Distributions

The sand/seagrass zone
6 bivalve species and 19 gastropod species (from 13 Families) were identified. Within the gastropods the most diverse Family was the Whelks (4 species).

The nearshore rock zone
Seven species of gastropods (from 3 Families) were identified. The most diverse Families were the Conidae, Neritidae and Whelks. No bivalves were recorded.

The lagoon zone
Two bivalve species (*Brachidontes* sp. and *Tridacna squamosa*) and 14 species (from 5 Families) of gastropods were identified. Within the gastropods the most diverse Family was Cypraeidae (4 species recorded).

The reef crest zone
Three bivalve species and 11 species (from 6 Families) of gastropods were identified. Within the gastropods the most diverse Family was Cypraeidae (4 species recorded).

The subtidal zone
A single bivalve species (*Tridacna squamosa*) and 3 species of gastropods were identified including; *Cypraea tigris, Cassis cornuta* and *Fasciolaria trapezium.*

3.10.3 Discussion

Overall Diversity
The bivalve and gastropod diversity of Ibo island was very similar to that recorded for Quilaluia island. Despite the islands not being located close to each other and having significantly different areas of (2.25 km^2 on Quilaluia compared to 26.5 km^2 on Ibo), but both support similar habitats. Species diversity may therefore be determined by habitat diversity, as opposed to intertidal area size. However, it must be noted that due to its large area not all of the Ibo intertidal could be surveyed and it is therefore likely that further surveys would produce a number of new species for the island.

Zonal Diversity

The diversity of bivalves was greatest in the sand/seagrass zone, followed by the lagoon, reef crest and subtidal zones which shared similar species (e.g. *Brachidontes* sp., *Striostrea* sp. and *Tridacna squamosa*). The nearshore rocks had no bivalve species. The pattern of diversity appeared to be closely linked to habitat, with the nearshore rock zone being very exposed to the sun, and unsuitable for bivalves.

The greatest diversity of gastropods was in the sand/seagrass zone where almost as many species as families were found (a pattern observed in this zone in all the C.I.G.). Conversely, the lagoon and reef crest had fewer families, but more species. Few species were found in more than one zone and none were found in all zones. This suggested a high species/habitat specificity, as found in the other study islands.

4.0 QUIRIMBA ISLAND

4.1 Introduction

Quirimba island (12°25'S 40°37'E) is the largest island (6.2 km long and 2.9 km wide) within the C.I.G. of the southern Quirimba Archipelago (Fig. 1). The layout of the island and its associated habitats are shown in Figure 32. The island's resident population of approximately 3,000 people are concentrated in the single village at the northern point of the island. Almost 75% of the island is occupied by a coconut plantation (approximately 60,000 trees) which stretches from the village in the north to a small collection of 'mashambas' and areas of scrub bush at the south-western point of the island.

To the north of the island a shallow channel separates the island from the extensive mangrove area that runs north to Ibo island. To the east is a continuous, fringing outer reef bordering the edge of the Continental Shelf. To the south of the island is a large area of intertidal that includes the islands of Sencar and Quilaluia. To the west is the Montepuez Bay, an extensive shallow area dominated by seagrass beds and supporting the major finfish fishery for the islanders.

The population of the island has increased dramatically in recent years as a result of the settling of displaced people from inland areas of fierce fighting during the civil war. At the time of Independence there were an estimated 60 houses and today there are more than 200. Almost all the islanders are involved with subsistence fishing which is concentrated in the Montepuez Bay, the plantation workers being primarily migrant workers from the continent. The island shared none of the historical development that occurred on Ibo island during the Portuguese colonial rule and consequently there is no 'stone' town on the island. The island possesses a small administration, health centre and police presence, but in general, the infrastructure of the island is poorly developed. A fish processing unit close to the village beach was briefly operational a few years ago but is now abandoned and in a state of poor repair. All year around freshwater is available in the village from bore holes.

The Programme's permanent field base (April 1996-April 1998) for the study of the southern Quirimba Archipelago was at Santa Maria Beach in the south-west of the island.

4.2 Intertidal Surveys

4.2.1 Overview

The extensive intertidal area (29.5 $km^{2)}$ is predominantly exposed flat supporting three small stands of mangroves (see section 4.3 below). The average width of intertidal flat was 2.5 km on the eastern side and 1 km on the western side which was predominantly sand and seagrass.

A total of 9 seagrass species, 141 taxa of macroalgae and 36 of invertebrates (intertidal species) were recorded from Quirimba island. The full lists of these taxa are presented in Appendices 2 and 3.

The most extensive seagrass beds were found in sheltered, shallow waters on the western side of the island, where extensive, multispecific meadows were observed. These beds were dominated by *Thalassia hemprichii* and *Enhalus acoroides* in the intertidal and subtidal zones, respectively. The number of seagrass species recorded was typical of the relatively high diversity recorded for the C.I.G. The diversity and abundance of seagrass species, together with the associated invertebrates, was highly varied between the survey sites, in particular between sites on the eastern and western shores.

Despite their relatively high diversity the algal communities were, in general, poorly developed, typically covering less than 25% of the available substrate. Significant areas of seaweed were however found in the reef lagoon and in rocky pools where dominant species were *Sargassum* spp. and *Cystoseira myrica.*

Of the 141 algae taxa recorded, one belonged to Cyanophyta (Blue-green algae), 56 to Chlorophyta (Green algae), 25 to Phaeophyta (Brown algae) and 69 to Rhodophyta (Red algae). The algal flora was dominated primarily by Rhodophyta, and secondly by Chlorophyta. 141 taxa represents the highest diversity found on any single island and comprises almost 70 % of the total algal diversity (195 taxa) of the C.I.G.

4.1.2 Area Reports

Nine transects were surveyed and their locations are shown in Fig. 32. Transects 2-5 were on the 'outer reef' intertidal zone (eastern zone) and the remainder were on the western shore with the exception of transect 9 to the north. A significantly greater similarity of species compositions was found between transects from the same side than for transects from different sides of the island. These results indicate that the island had two distinct intertidal patterns, one covering the eastern shore and dominated by macroalgae communities, and the other covering the western shore and dominated by seagrass meadows.

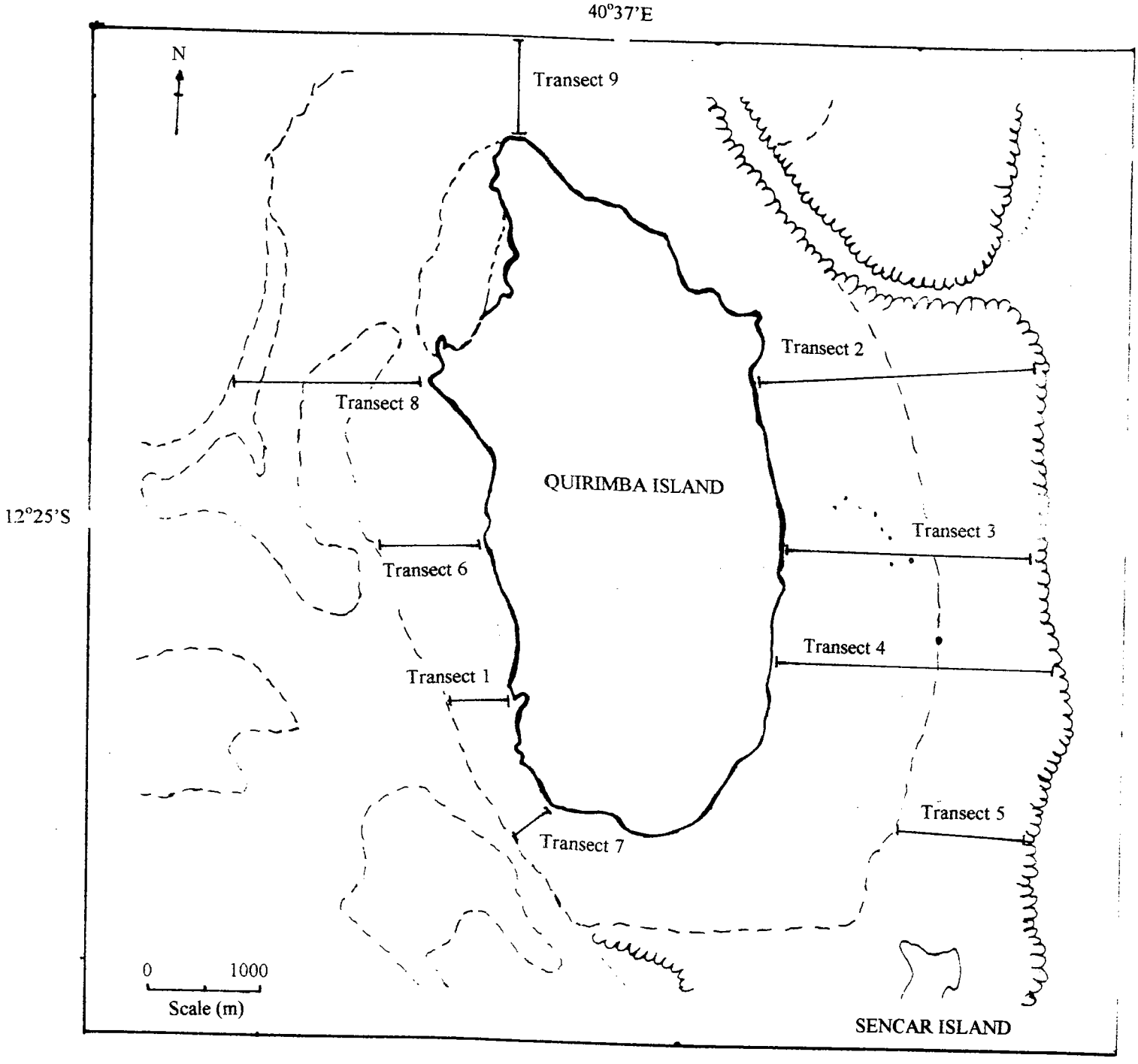


Figure 32: A map indicating the position of the intertidal transects surveyed on Quirimba island

'Eastern Area'

Five distinct zones were identified (Fig 33) on the basis of species compositions of both seagrasses and macroalgae as well as associated invertebrates. The distributions of taxa across zones are presented in Tables 27 and 28. The representation of substrate types in each zone are summarised in Table 29.

The reef platform sloped gently for approximately 1.3 km from the HWM and included (at about 370 m) a shallow reef lagoon. The reef lagoon contained 25 taxa of macroalgae, one species of seagrass and six taxa of invertebrates, the dominant algae being *Sargassum* spp. and *Cystoseira* spp., with the surface cover of each species ranging from 0 to 50 %. Corals were also present in the lagoon. The upper 350m of the platform was backed by mud flats on which *Enteromorpha clathrata* (6.1 % cover) and *Lyngbya majuscula* (5.3 % cover) dominated.

In general, algal diversity increased along a seaward gradient, being highest at the reef crest. Surface cover was, however, highest in the lagoon. Community compositions were very similar between transects within the upper zones and in the reef lagoon. However, variation in exposure to wave action has led to a greater variability in community composition between transects at the reef crest.

Seagrasses were not conspicuous on the eastern intertidal area, with *Thalassia hemprichii* covering less than 5% of the substrate. The only other seagrass species that occurred in significant quantities was *Thalassodendron ciliatum*, but only on the upper subtidal zone and on the reef crest in depressions and rock pools and not within the transect summarised in Table 27.

The most common invertebrates included *Terebralia palustris, Cypraea annulus, Thais* spp. and hermit crabs (unidentified) in **Zone 2**; *Cypraea annulus, Cypraea tigris, Conus ebraeus, Echinometra mathaei* and *Tridacna squamosa* in **Zone 3**; *Cypraea annulus* and *Conus ebraeus* in **Zone 4**; and *Cypraea annulus, Cypraea tigris* and *Conus ebraeus* in **Zone 5**.

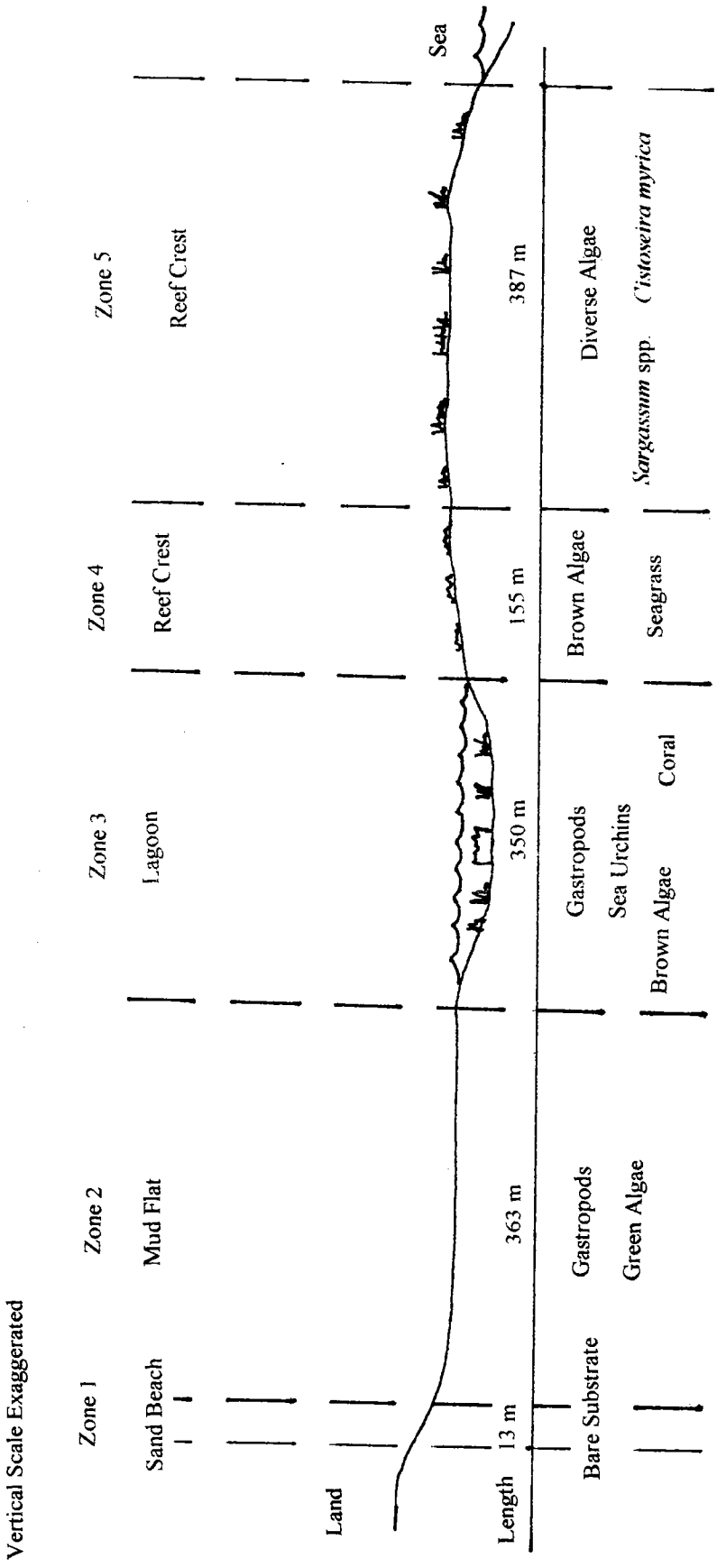


Figure 33: A diagrammatic representation of the "Eastern Area" intertidal transect, Quirimba island

Table 27. Percentage cover of seagrass and macroalgae along a typical transect within the 'Eastern Area'. (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Seagrass					
Thalassia hemprichii	0	0	0	0	1.7 (0-5)
Macroalgae					
Boergesenia forbesii	0	0	0	0-P	0
Chlorodesmis sp.	0	0	0-P	0	0
Chondria sedifolia	0	1.2 (0-3)	0	0	0
Cistoseira myrica	0	0	0	2.9 (0-12)	0.2 (0-2)
Cladophora mauritiana	0	0-P	0	0	0
Dictyosphaeria cavernosa	0	0	0.1 (0-1)	0-P	0.7 (0-5)
Dictyota sp.	0	0	0	0-P	0-P
Enteromorpha clathrata	0	6.1 (0-36)	0	0	0
Enteromorpha flexuosa	0	1.6 (0-7)	0	0	0
Galaxaura tenera	0	0	0	0-P	0-P
Gelidiella acerosa	0	0-P	0	0	0
Halimeda opuntia	0	0	5.8 (0-20)	10.1 (0-40)	7.4 (0-40)
Hydroclathrus clatrathus	0	0	0	0	3.3 (0-30)
Jania adhaerens	0	0	1.0 (0-10)	0.3 (0-2)	0-P
Laurencia obtusa	0	0	0-P	0	P (P)
Lyngbya majuscula	0	5.3(0-50)	0	0	0
Laurencia papillosa	0	2.5(0-10)	0	0	0
Padina gymnospora	0	0	0	0-P	1.6 (0-10)
Sargassum aquifolium	0	0	0-P	3.4 (0-9)	6.6 (0-25)
Turbinaria conoides	0	0	0	0.3 (0-2)	0
Udotea indica	0	0	0-P	0-P	0
Ulva reticulata	0	0	0	2.4 (0-6)	0
Valonia aegagrophila	0	0	0	0-P	0.1 (0-1)
Vanvoorstia spectabilis	0	0	0-P	0	0

Table 28. Abundance of invertebrate along a typical transect within the 'Eastern Area'. Means and ranges (numbers/m^2) are presented.

Invertebrates	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Gastropods					
Conus sp.	0	0.4	0	0	0.4
Cypraea annulus	0	1.6	1.2	0	0
Cypraea moneta	0	0	3.2	0	0
Mitra sp.	0	0	0.4	0	0
Bivalves					
Perna perna	0	0	0	8.0	0
Echinoderms					
Stomopneustes variolaris	0	0	2.4	0	0

Table 29. Percentage composition of substrate along a typical transect within the 'Eastern Area'. Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Rock	0	29 (0-100)	100 (100)	72 (0-100)	78 (60-100)
Rubble	0	0	0	0	5 (0-30)
Sand	100 (100)	41 (0-100)	0	28 (0-100)	7 (0-40)
Mud	0	30 (0-100)	0	0	0

'Western Area'

Four distinct zones were identified (Fig 34) on the basis of species compositions of both seagrasses and macroalgae as well as associated invertebrates. The distributions of taxa across zones are presented in Tables 30 and 31. The representation of substrate types in each zone are summarised in Table 32.

The area was basically rock on the upper shore, covered by a thin layer of sand in some areas. At about 230 m from the HWM the substrate became sand dominated (typically 98.8% surface cover) before becoming a mixture of sand (90%) and mud (10%) on the lower shore.

Three seagrass species, 13 taxa of macroalgae and 13 of invertebrates were recorded (although *Chicoreus ramosus* was noted as being abundant in the seagrass bed it was not recorded within survey quadrats). The upper zones were generally bare of visible biota whereas extensive beds of seagrass, predominantly *Thalassia hemprichii* and *Enhalus acoroides*, covered the lower slopes in zones 3 and 4.

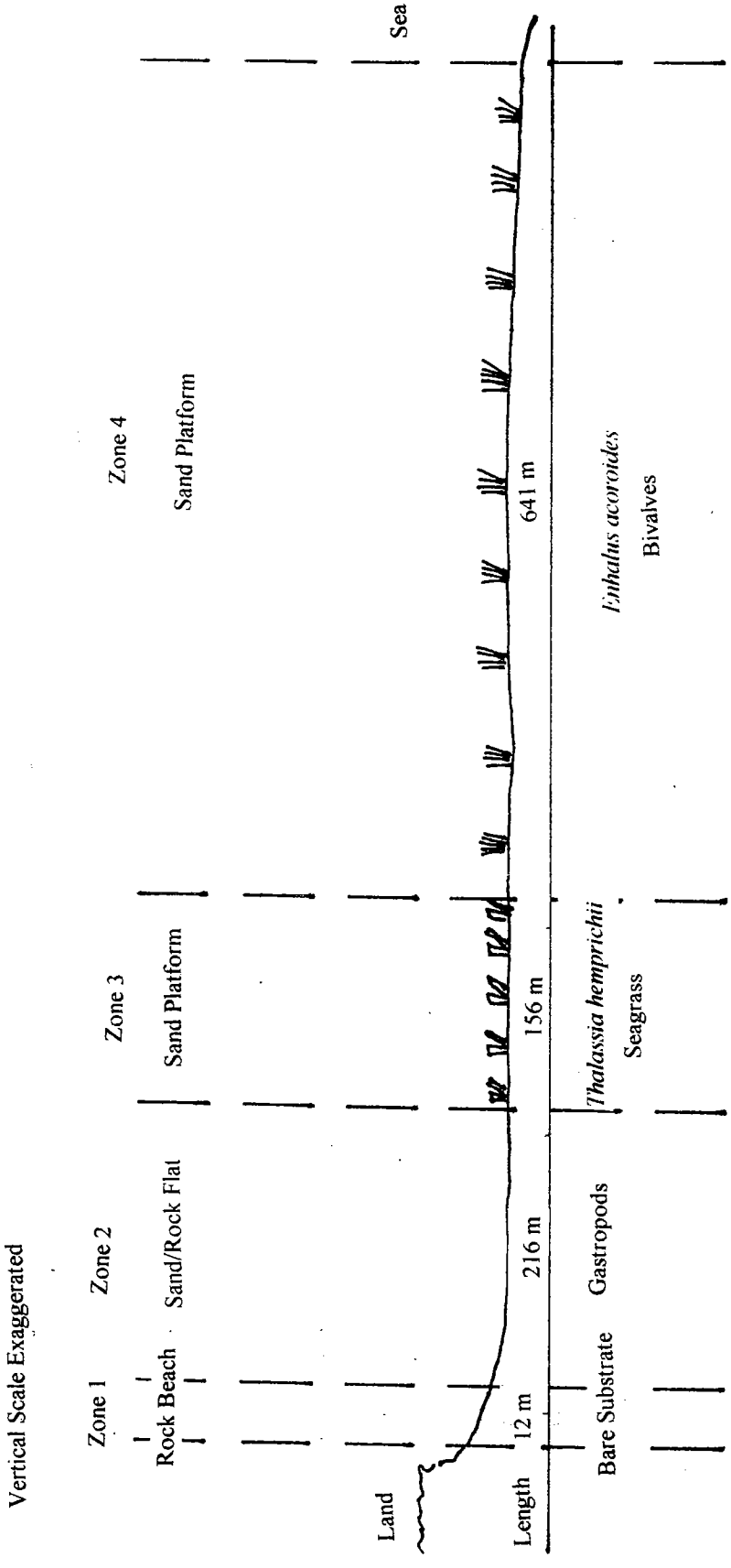


Figure 34: A diagrammatic representation of the "Western Area" intertidal transect, Quirimba island

Table 30. Percentage cover of seagrass and macroalgae along a typical transect within the 'Western Area'. (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3	Zone 4
Seagrass				
Enhalus acoroides	0	0	0	32.5 (0-50)
Halophila ovalis	0	0	0	1.6 (0-16)
Thalassia hemprichii	0	0	11.4 (0-50)	1.5 (0-15)
Macroalgae				
Centroceras clavulatum	0	0	0-P	0
Cladophora sp.	0	0	0	0.3 (0-3)
Dictyota ciliolata	0	0	0	0.4 (0-4)
Gracilaria corticata	0	0	0	1. (0-12)
Halimeda macrolaba	0	0	0	0-P
Hydroclathrus clatrathus	0	0	3.8 (018)	0
Hypnea musciformis	0	0	0.6 (0-3)	0.4 (0-2)
Jania adhaerens	0	0	0-P	0.6 (0-6)
Laurencia papillosa	0	0.1 (0-1)	0	0
Lyngbya majuscula	0	0.2 (0-2)	0	0.4 (0-4)
Padina gymnospora	0	0	0	0-P
Ulva pertusa	0	0.6 (0-6)	0	0

Table 31. Abundance of invertebrates along a typical transect within the 'Western Area'. Means and ranges (numbers/m^2) are presented.

Invertebrates	Zone 1	Zone 2	Zone 3	Zone 4
Gastropods				
Turbo coronatus	0	0.4	0	0
Thais sp.	0	8.0	0	0
Rhinoclavis sinensis	0	5.2	0.4	0
Nerita spp.	0	0.4	0	0
Strombus mutabilis	0	0	0.4	0
Cypraea annulus	0	0	1.2	0
Cypraea tigris	0	0	0.4	0
Decapods				
Clibinarius longitanus	0	2.4	0	0
Calcinus brevimanus ?	0	0.4	0	0
Cnidarians				
Cassiopia	0	0	0	2.0
Bivalves				
Pinna sp.	0	0	0	0.8
Pinctada sp.	0	0	0	0.8
Echinoderms				
Stomopneustes variolaris?	0	0	0	3.2

Table 32. Percentage composition of substrata along a typical transect within the 'Western Area'. Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3	Zone 4
Rock	100 (100)	67 (0-100)	0	0
Sand	0	33 (0-100)	99 (88-100)	90 (90-100)
Shell	0	0	1.2 (0-12)	0
Mud	0	0	0	10 (10)

4.3 Mangrove Surveys

4.3.1 Overview

Quirimba island supports 3 significant areas of mangrove (Fig. 35). The largest stand ('Quiwandala Stand') is on the north-western side of the island and extends north from the fish-landing site at Quiwandala to approximately 100 m south of the northern most point of the island. The second stand ('Santa Maria Stand') extends north 750 m from Santa Maria beach on the south-western side of the island and the third stand ('Eastern Stand') extends for approximately 1 km along the central eastern side of the island.

Along the shoreline adjacent to the village obvious examples of land erosion are evident. Talks with the islanders suggest that the rate of erosion has advanced in recent years and the cause of this is perceived to be the increased cutting of the mangrove in the Quiwandala Stand. Whether or not this is the main cause it is likely that mangrove cutting has contributed to the problem. At the time of writing the erosion is not directly threatening any structures but if it continues then a number of homes and buildings will be in danger of being undermined. The local administration reported that a number of old graves had already been uncovered by the erosion and that they fear similar problems in the near future.

In order to help combat the problem of erosion, the administration have attempted to introduce a series of restrictions on the cutting of mangroves, arguing that there is a large supply of mangrove wood available close by in the extensive stand south of Ibo island. Special emphasis has been put on leaving the small, thin trees which are popular for use in the construction of fences. The restrictions appear to be largely unsuccessful with many of the islanders continuing to regularly cut mangrove on the island, especially in the 'Quiwandala Stand' close to the village. The 'Eastern Stand' is afforded some protection as it is adjacent to the house of Sr. and Sra. Gessner, strong supporters of the restrictions. The 'Santa Maria Stand', due to its relative isolation from the village, is also spared from large amounts of cutting.

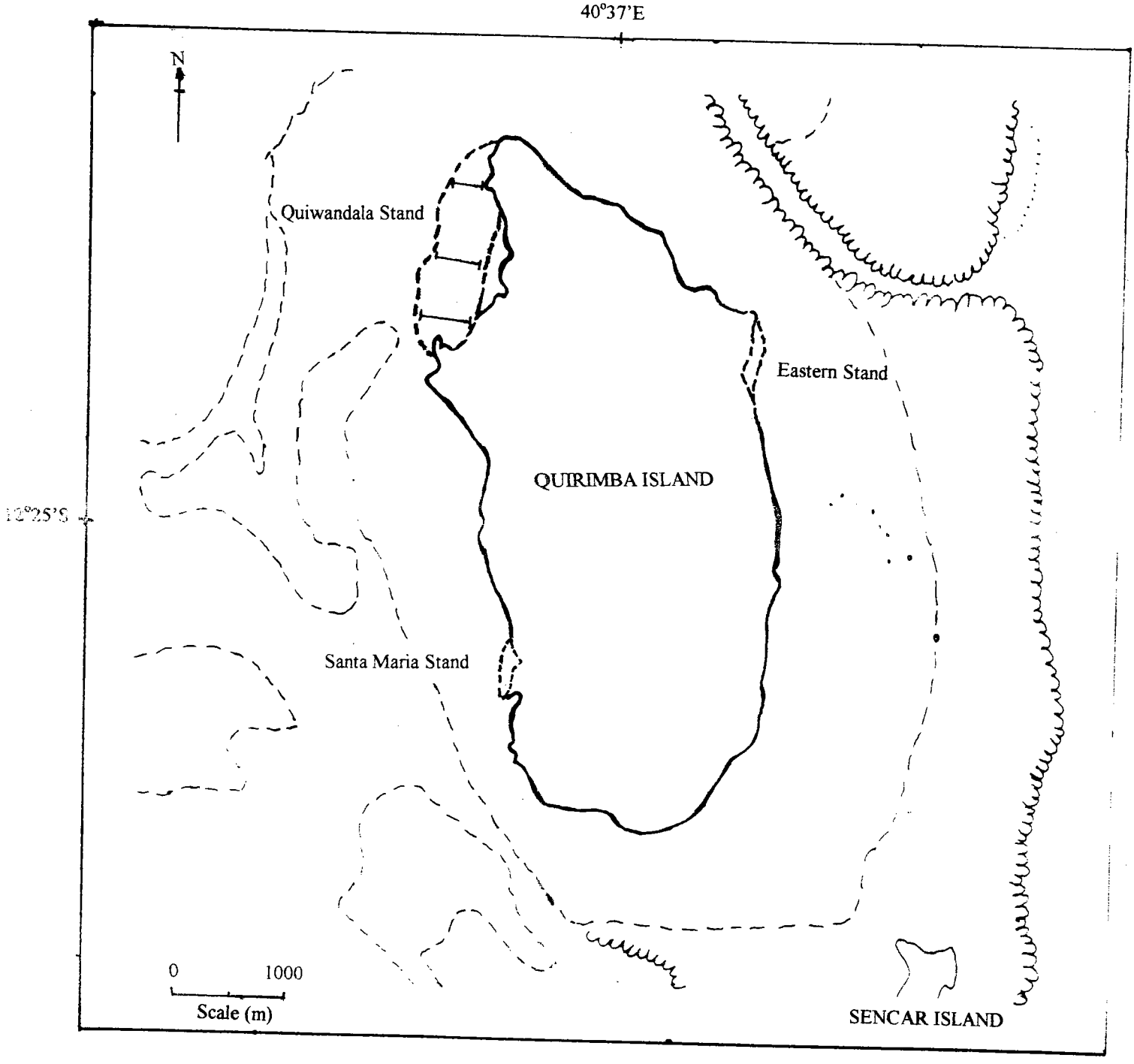


Figure 35: A map indicating the position of the mangrove transects surveyed on Quirimba island

On a number of the older nautical charts of the study area a strip of mangrove is shown joining the northern point of Quirimba island with the extensive mangrove areas south of the island of Ibo. There is in fact a clear channel, approximately 600 m wide, running around the north of Quirimba and local opinion (J. Gessner, pers. comm.) suggests that it is likely that this channel has existed for many years and the charts are erroneous rather than indicating the recent removal of a relatively large quantity of mangrove.

4.3.2 Quiwandala Stand

Overview

In addition to being the largest area of mangrove on the island, the 'Quiwandala Stand' is also the closest to the main population centre on the northern point of the island. This has resulted in a considerable amount of tree cutting and the survey transects were typified by extensive cleared areas and numerous damaged trees. Along the High Water Mark (HWM) there were a number of areas where there was erosion of the land and, although the major cause of this was unclear, the passage of people from the island down to the mangrove was obviously having a considerable effect.

Five species of mangrove were observed, including; *Rhizophora mucronata*, *Brugiera gymnorrhiza*, *Ceriops tagal*, *Sonneratia alba* and *Avicennia marina*. *Avicennia marina* was less widespread and was only recorded a few transects.

Transect Report

A diagrammatic representation of a transect through the stand is illustrated in Fig. 36 and described below.

Transect Description (HWM to seaward edge of stand)

Zone 1 started off near the HWM with a band, approximately 60-70 m wide, of mud and sand that supported no vegetation. Numerous paths crossed the area which is between the village and the fish landing site. A thin line of large (<7 m high), widely spaced *A. marina* was observed along the landward edge of the stand in the southern section. This line of trees became more patchy towards the northern end of the stand. Inside this line of trees was a mixed stand of *R. mucronata* and *C. tagal*.

Zone 2 comprised an equal mixture of large *R. mucronata* (<8 m high) and smaller *C. tagal* (<2.5 m high) trees, although *R. mucronata* became noticeably more dominant towards the centre of the stand. Large *B. gymnorrhiza* tree were rare and not recorded along the transect although saplings of this species were numerous. In most areas of the zone evidence of cutting was widespread with 1-4 stumps recorded in each 5 m x 5 m quadrat. Cleared areas of up to 7 m in diameter and woodstacks of freshly cut mangrove were also observed.

Zone 3 supported a homogeneous stand of *R. mucronata* (<10.5 m high) trees. Widespread evidence of cutting was again present and cleared areas of 50 m x 30 m

where almost all the large trees had been cut down were observed close to the survey transect.

Zone 4 included a mixture of *S. alba* (dominant) and *R. mucronata* trees with a canopy height of 6-7 m. In some areas over 90% of trees exhibited some form of damage due to cutting, although the number of felled trees (stumps) was much lower.

Zone 5 was dominated by a few large (<7-8 m high) *S. alba* and numerous saplings of the same species. Cutting was evident especially towards the northern end of the stand.

Quantitative Description

The species composition and structure for each zone is presented in Table 33. *R. mucronata* was the most widespread species and was recorded in all zones (although only as saplings in the seaward zone). *C. tagal* was the most abundant species in the drier areas close to the HWM, *R. mucronata* most abundant throughout the central portion of the stand, and *S. alba* was most common along the exposed seaward edge of the stand.

Table 33. Mangrove species composition and structure of the 'Quiwandala Stand'

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*R. mucronata*	0.24	40	101.8	98	2.27
	C. tagal	0.36	60	1.9	2	1.92
	B. gymnorrhiza	-	-	-	-	0.13
Zone 2	*R. mucronata*	0.92	79	22.2	97	10.62
	C. tagal	0.25	21	0.6	3	3.43
	B. gymnorrhiza	-	-	-	-	5.91
Zone 3	*R. mucronata*	0.62	100	51.1	100	11.24
Zone 4	*R. mucronata*	0.12	60	10.6	12	1.58
	S. alba	0.08	40	80.9	88	0.10
Zone 5	*S. alba*	0.28	100	47.9	100	0.36
	R. mucronata	-	-	-	-	0.12

The saplings were most dense in the central portion of the stand and, generally, the abundance of each species followed the same pattern as for the larger trees. The exception was *B. gymnorrhiza* which was not recorded along the transect although saplings were recorded in considerable numbers in Zone 2.

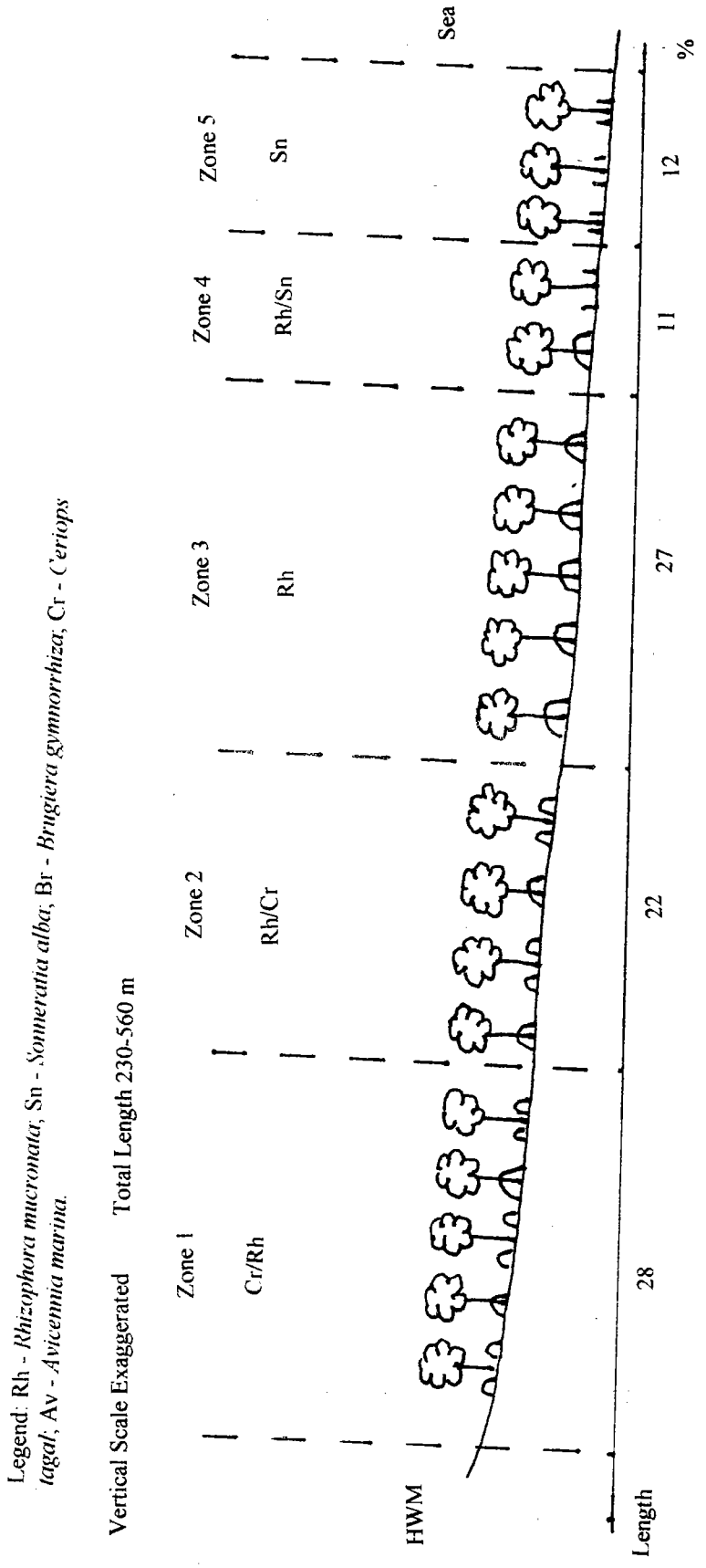


Figure 36: A diagrammatic representation of a typical mangrove transect, Quiwandala Stand, Quirimba island.

diameter and were therefore not ready to be used as a resource. It is probable that the larger *C. tagal* trres had been cut in the extensive cleared areas of Zones 1-2.

Table 34. 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 10 m^2. 'n/a' denotes present in stand but not recorded within survey quadrats.

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	378,300	11.7	4,060
S. alba	35,600	21.0	1,230
C. tagal	130,900	2.3	60
B. gymnorrhiza	n/a	n/a	n/a
A. marina	n/a	n/a	n/a

Fauna of the 'Quiwandala Stand'

Faunal distributions across zones are summarised in Table 35. On the bare sand/mud area in zone 1 there were numerous shallow creeks and standing pools of saltwater where large numbers of the brachyuran crab, *Uca* spp. (both *U. chlorophthalmus* and *U. inversa*) were observed. Fauna was less abundant inside the mangrove and no zonation in the abundance of crabs or gastropods was observed. Oysters, *Saccostrea* sp. (possibly *S. cucullata*), periwinkles, *Littoraria subvittata*, sponges and barnacles (both *Balanus* sp. and *Chthamalus* sp.) became increasingly common epiphytes on the branches and foliage of trees towards the outer edge of the stand, especially on *S. alba* trees. The crabs observed were mainly *Sesarma* spp. and, due to their size, probably responsible for the majority of burrows. A single mudskipper, *Periophthalmus* sp., was also noted.

Table 35. Benthic fauna of the 'Quiwandala Stand'

Zone	Number of Crab Holes /m^2	Number of Crabs /m^2	Number of Gastropods /m^2
Zone 1	1.4	0.1	0.0
Zone 2	4.4	0.9	0.1
Zone 3	4.9	0.4	0.0
Zone 4	2.9	0.4	0.0
Zone 5	4.3	0.1	0.0

4.3.4 Santa Maria Stand

Overview

The 'Santa Maria Stand', the smallest of the three significant stands on the island, is also the furthest from the village. In addition to the main body of the stand on the intertidal north of Santa Maria beach, there was a creek area/embayment behind the mangrove containing a few small trees, primarily *Ceriops tagal,* and a thin strip (<5 m) of assorted mangrove trees running approximately 100 m south of the beach.

Observations through the stand suggested that mangrove cutting was relatively limited and in most cases the areas which had been subject to cutting in the past had been regenerated with a high density of new young trees. However, during the latter half of 1996 an escalation in cutting was noted that was targeting *Avicennia marina*, a relatively uncommon tree in the stand, and small areas of *Rhizophora mucronata* and *Ceriops tagal*. It is unclear as to the reason for this recent cutting as there is apparently plenty of firewood to be cut close by on land. However, good quality wood (e.g. *A. marina*) in the north of the island, close to the village, is becoming increasingly scarce and people are forced to travel further to obtain it.

Six species of mangrove were observed, including; *Rhizophora mucronata*, *Brugiera gymnorrhiza*, *Ceriops tagal*, *Sonneratia alba*, *Avicennia marina* and *Xylocarpus moluccensis** (*identification to be confirmed), although the latter two species were not recorded within the survey transects.

Transect Report

A diagrammatic representation of a transect through the stand is illustrated in Fig. 37 and described below.

Transect Description (HWM to seaward edge of stand)

Zone 1 contained a mixture of *C. tagal* (<2 m high), *B. gymnorrhiza* and *R. mucronata* (4-7 m high), the former being dominant. There was evidence of widespread cutting of mature *C. tagal* in the past and the relatively high density of small *C. tagal* trees appeared to be a direct result of this. On the landward edge of the zone a thin line of widely spaced *A. marina* (<7 m high) trees were found in places. Subsequent to the surveying of this stand many of the *A. marina* have been cut down and the numbers of remaining trees of this species have not yet been determined.

Zone 2 comprised mainly *R. mucronata* trees up to 11 m high and smaller numbers of smaller *C. tagal* trees. Saplings of *R. mucronata* were dense in places.

Zone 3 was, in general, a homogenous zone of large (<14 m) *R. mucronata* trees, although a small number of *B. gymnorrhiza* and *R. mucronata* trees were also

observed. The substrate had a high mud content and towards the seaward edge of the zone there were numerous small, muddy creeks.

Zone 4 was dominated by a few mature (<4 m) *S. alba* trees and a mixture of *R. mucronata* and *S. alba* saplings. Substrate composition was predominantly sand. No evidence of cutting was seen in this zone.

Quantitative Description

A quantitative analysis of the species composition and structure for each zone is presented in Table 36 below. In the landward portion of the stand *C. tagal* was most abundant tree but with a lower biomass than both *R. mucronata* and *B. gymnorrhiza.* The remaining portion of the stand was dominated by *R. mucronata* with the exception of the seaward edge where a homogeneous band of *S. alba* was found.

Table 36. Mangrove species composition and structure of the 'Santa Maria Stand'

Zone	Species	No. of trees/ m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*R. mucronata*	0.17	21	54.2	56	6.28
	B. gymnorrhiza	0.12	15	24.7	25	1.90
	C. tagal	0.52	64	18.8	19	10.36
Zone 2	*R. mucronata*	0.60	73	87.5	92	2.80
	C. tagal	0.16	27	7.36	8	0.04
Zone 3	*R. mucronata*	0.52	100	40.8	100	0.92
Zone 4	*S. alba*	0.12	100	1.6	100	0.00

Saplings, primarily *C. tagal* and *R. mucronata,* were abundant throughout much of Zone 1, but were more restricted to localised patches in the other zones. The apparent absence of saplings from Zone 4 is an artefact of a low number of survey quadrats in this zone where *S. alba* saplings were observed to occur in reasonable numbers.

Considered as a whole (Table 37) the 'Santa Maria Stand' was clearly dominated by *R. mucronata* both in terms of abundance and structural dominance. Of the other tree species, *C. tagal* and *B. gymnorrhiza,* whilst occurring in significantly different numbers, had an overall similar structural dominance. The occurrence of *A. marina* was limited to a thin line in places along the HWM. The relatively low total basal area estimated for *S. alba* was a result of an unbalanced sampling (see above) and is almost certainly a considerable underestimation.

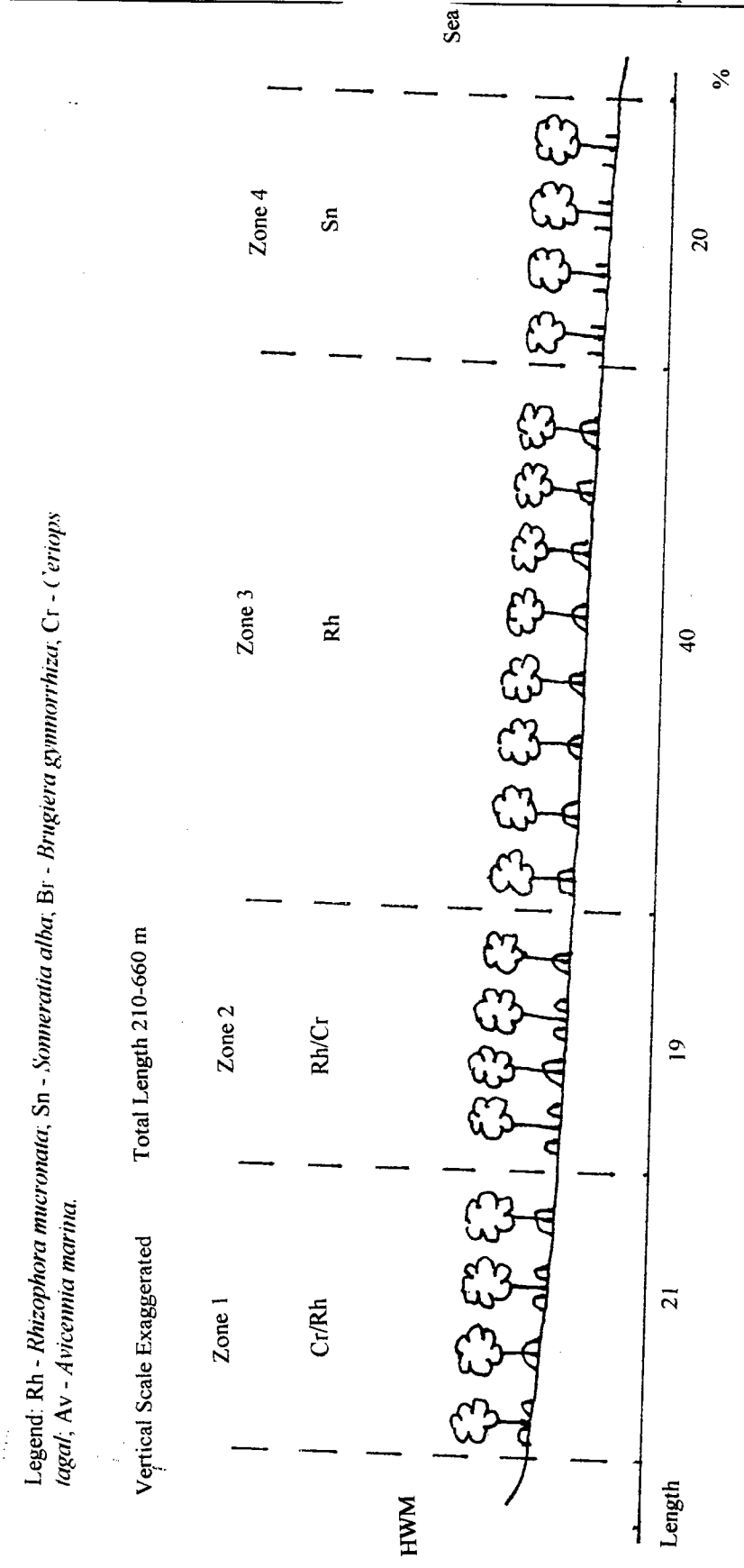


Figure 37: A diagrammatic representation of a typical mangrove transect, Santa Maria Stand, Quirimba island.

Table 37. Estimates of the size and composition 'Santa Maria Stand'. All original figures have been estimated to the nearest 100 and all basal area values have been estimated to the nearest 10 m^2. 'n/a' denotes present in stand but not recorded within survey quadrats.

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	42,900	12.6	530
B. gymnorrhiza	3,000	16.2	60
S. alba	2,900	4.1	0*
C. tagal	16,800	7.0	60
A. marina	n/a	n/a	n/a

**Sonneratia alba* total basal area for the stand was estimated at approximately 4 m^2.

Fauna of the 'Santa Maria Stand'

Faunal distributions across zones are summarised in Table 38. Gastropods and crabs were scarce although a number of species were noted outside the survey quadrats. The active crab burrows in Zone 1 were attributed to *Uca* spp.. Numerous oysters, *Saccostrea* sp., and barnacles (*Balanus* sp. and *Chthamalus* sp.) were observed on the branches of *S. alba*. The Truncated mangrove snail, *Cerithidea decollata,* and a single Mud crab, *Scylla serrata* were noted in Zone 4.

Table 38. Benthic fauna of the 'Santa Maria Stand'.

Zone	Number of Crab Holes /m^2	Number of Crabs /m^2	Number of Gastropods /m^2
Zone 1	1.7	0.0	0.1
Zone 2	0.1	0.1	0.0
Zone 3	0.5	0.0	0.0
Zone 4	1.6	0.0	0.2

On a number of occasions a small troop of Green monkeys, *Cercopithecus aethiops*, was seen actively foraging in the stand and from evidence, in the form of small diggings left behind, it would appear that they were attempting to capture crabs in their burrows. The extent to which the monkeys make use of the mangrove has not been determined.

4.3.5 Eastern Stand

Overview

The Eastern Mangrove is on the exposed side of the island where it is subjected to a high degree of wave action. However, the reef crest, lagoon and extensive intertidal flat have helped to dissipate the energy of the waves and have enabled the

establishment of a substantial mangrove stand. A scattering of mangrove trees extends north from the current tip of the stand until close to the northern point of the island. It is probable that there was, in the past, a more extensive area of mangrove here which has since disappeared. The cause of the disappearance is not clear but mangrove cutting probably played a significant role.

Six species of mangrove were observed, including; *Rhizophora mucronata, Brugiera gymnorrhiza, Ceriops tagal, Sonneratia alba, Avicennia marina* and *Lumnitzera racemosa* although the latter two species were not recorded along the survey transects.

Transect Report

A diagrammatic representation of a transect through the stand is illustrated in Figure 38 and described below.

Transect Description (HWM to seaward edge of stand)
The transect was quite variable in terms of species composition with six distinct zones identified.

Zone 1 started off at the HWM with a thin strip (approximately 20 m wide) of sand and a few mature, widely spaced *A. marina* (up to 7 m high) trees. Inside this the stand comprised a homogeneous zone of *R. mucronata* trees, the majority being mature and up to 6 m high, with relatively few saplings present. The substrate was predominantly dark grey mud.

Zone 2 was dominated by *B. gymnorrhiza* trees, 4-6 m high, in addition to a number of non-mangrove tree species able to survive due to the dry nature of the substrate. Vegetation density was generally low.

Zone 3 was a narrow strip dominated by widely spaced and slightly smaller (<4m) *B. gymnorrhiza* trees and a few saplings growing on a dry, black soil substrate.

Zone 4 followed on from the base of a short, steep, sandy beach and narrow scrub zone that contained a few *A. marina* trees. It comprised a narrow band of dense, medium height (approximately 3 m) trees dominated by *R. mucronata,* but with *B. gymnorrhiza* and *C. tagal* present.

Zone 5 was a wider band of dense mangrove dominated by *B. gymnorrhiza* with *S. alba, C. tagal* and *R. mucronata* also present but at lower densities. The maximum tree height was 4 m and the substrate was a mixture of sand and mud.

Zone 6, on the seaward side of the stand, was dominated by widely spaced *S. alba* trees, up to 3 m high, interspersed with numerous saplings. The substrate was predominantly sand.

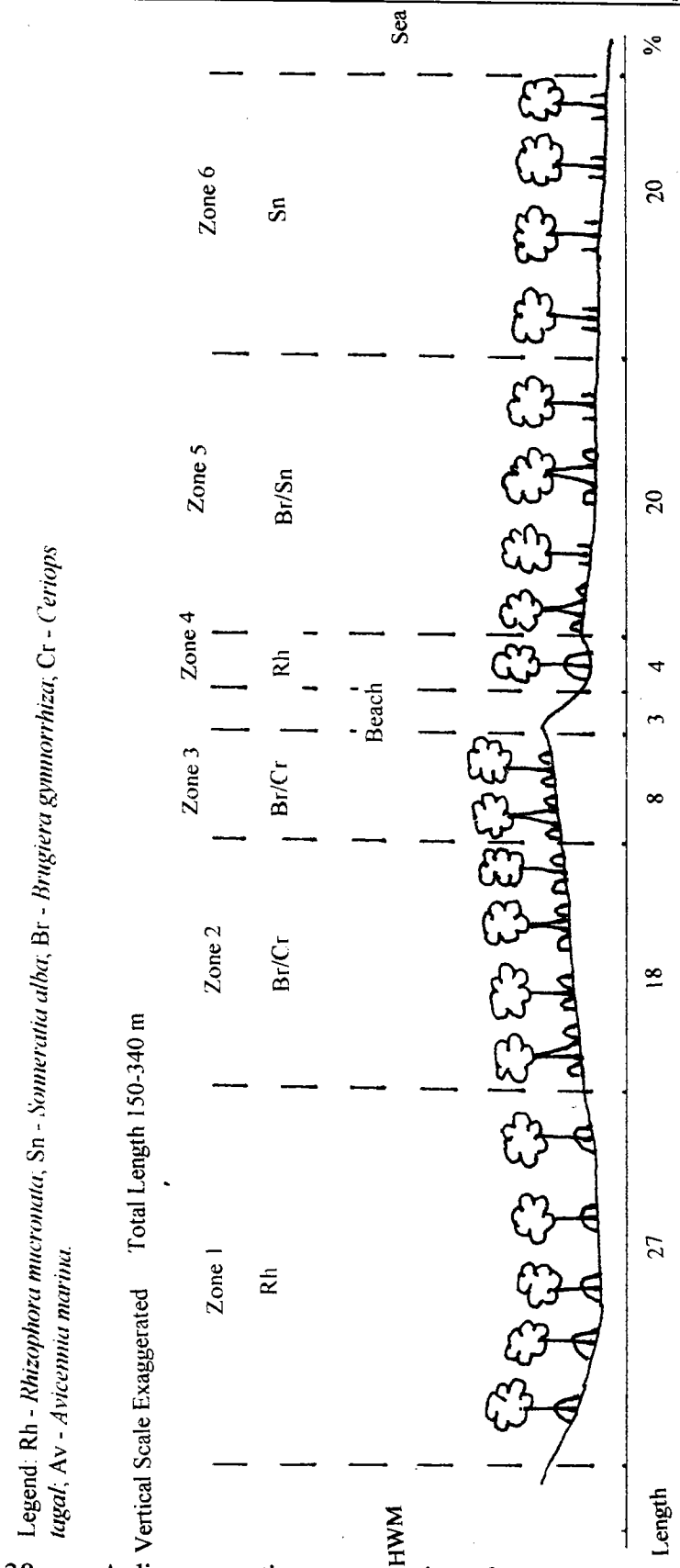


Figure 38: A diagrammatic representation of a typical mangrove transect, Eastern Stand, Quirimba island.

Quantitative Description

The species composition and structure for each zone is presented in Table 39 below.

Table 39. Mangrove species composition and structure of the 'Eastern Stand'

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Zone 1	*R. mucronata*	0.08	100	392.2	100	0.00
Zone 2	*B. gymnorrhiza*	0.36	82	150.8	98	0.24
	C. tagal	0.08	18	2.3	2	0.00
Zone 3	*B. gymnorrhiza*	0.32	94	39.1	99	0.04
	C. tagal	0.20	6	0.4	1	0.00
	R. mucronata	-	-	-	-	0.04
Zone 4	*R. mucronata*	0.24	100	125.3	100	0.12
	C. tagal	-	-	-	-	0.24
Zone 5	*B. gymnorrhiza*	0.24	46	58.4	86	0.40
	C. tagal	0.16	31	0.5	1	0.32
	S. alba	0.12	23	9.1	13	0.00
	R. mucronata	-	-	-	-	0.28
Zone 6	*S. alba*	0.32	100	369.0	100	2.00

The species compositions between zones did not follow the expected pattern as found in other stands. This was attributed to the varied topography observed along the transect, particularly the elevated sandbank in Zone 4. A number of similar sandbanks were noted throughout the stand.

S. alba typically dominated the seaward edge of the stand with *R. mucronata* and *B. gymnorrhiza* alternatively dominant within the main body of the stand. *R. mucronata* favoured the wetter substrate with a high mud content whereas *B. gymnorrhiza* was more prevalent where the substrate was drier with a high sand content. A thin line of *A. marina* was observed along the landward edge of the stand but was not recorded along the transect. Saplings were uncommon throughout the stand.

Further analysis of the stand as a 'whole' (Table 40) showed the mean stand diameters for *R. mucronata*, *B. gymnorrhiza* and *S. alba* to be similar and representative of relatively large trees and a well developed mangrove stand. The high number of *B. gymnorrhiza* trees makes this by far the largest population of the species on the island and an important source of house building material for the islanders.

Table 40. Estimates for the size and composition of the Eastern Stand. All original figures have been estimated to the nearest 100 and all basal area values have been calculated to the nearest 10 m^2. 'n/a' denotes present in stand but not recorded within survey quadrats.

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	5,700	19.7	170
B. gymnorrhiza	25,100	19.7	760
S. alba	15,600	19.4	460
C. tagal	11,200	3.4	10
A. marina	n/a	n/a	n/a

Fauna of the 'Eastern Stand'

Observed fauna with the stand was similar to the other mangrove stands on the island, with few animals being recorded (Table 41). The most conspicuous fauna were the large land crabs, *Cardisoma carnifex*, that inhabited the drier mangrove areas close to the HWM and the adjacent coastal vegetation. Despite their size, they are not collected by the local people (unlike the large Mud crab, *Scylla serrata*) who regard them as inedible. The density of active burrows of the smaller crab species was low throughout the stand and the few crabs (possibly *Sesarma* sp.) observed were in Zone 3. The African periwinkle, *Nodilittorina africana*, and the Mangrove whelk, *Terebralia palustris* were noted on the seaward side of the stand.

Table 41. Benthic fauna of the 'Eastern Stand'.

Zone	Number of Crab Holes /m^2	Number of Crabs /m^2	Number of Gastropods /m^2
Zone 1	1.0	0.0	0.0
Zone 2	1.1	0.0	0.0
Zone 3	0.2	0.2	0.0
Zone 4	1.0	0.0	0.2
Zone 5	1.1	0.0	1.3
Zone 6	1.4	0.0	0.0

4.4 Subtidal Habitat Surveys

Subtidal surveys were concentrated on the eastern shores of the island where the main areas of coral reef were found. The surveys were grouped into four areas as marked on figure 39.

4.4.1 Overview

Reef Structure and Composition

The sites surveyed on the fringing outer reef all shared similar characteristics with the reef base at 15-18 m and the reef slope gradient fairly shallow (5-10°) in the upper and

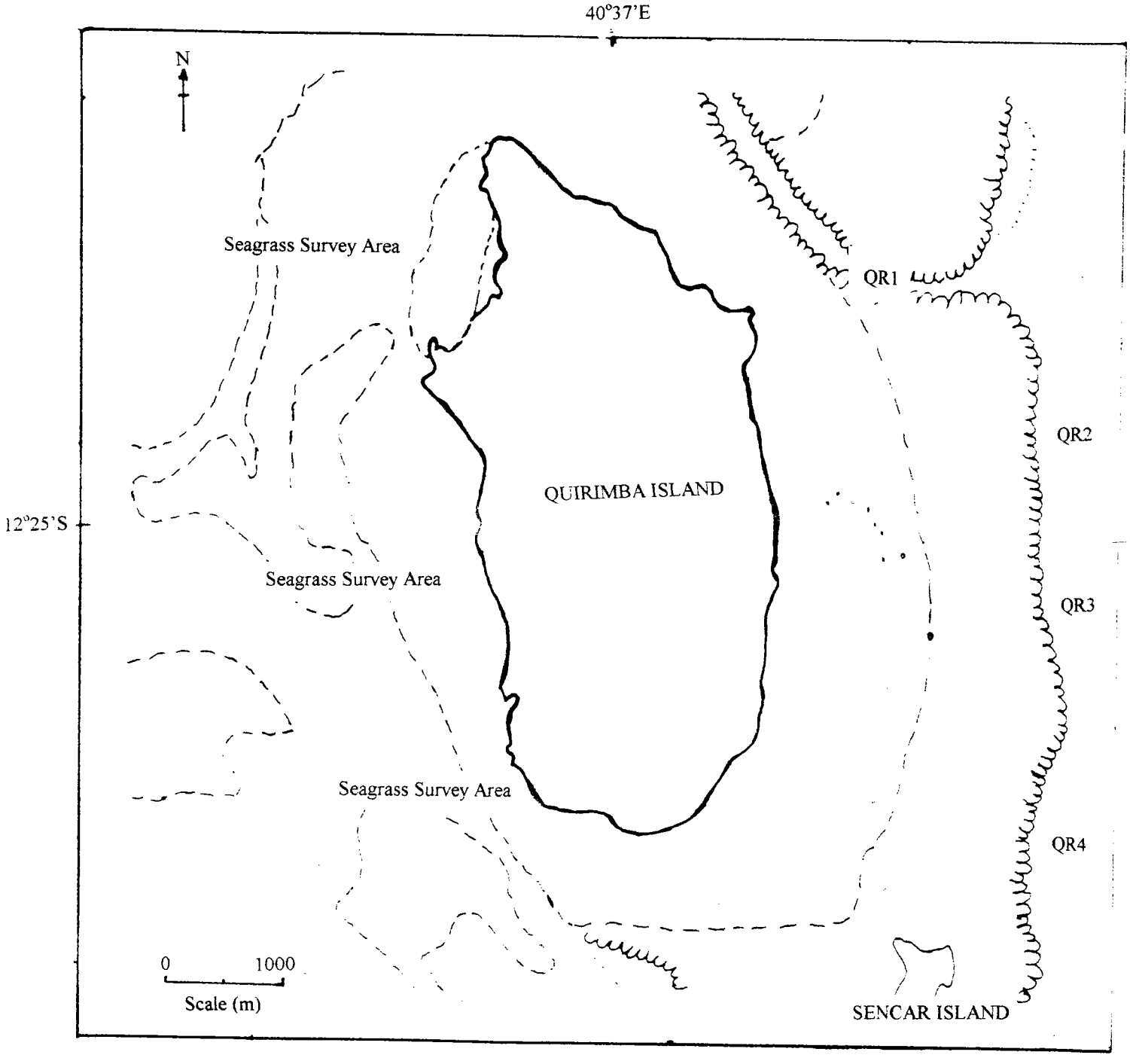


Figure 39: A map indicating the position of the subtidal survey sites around Quirimba island.

lower reaches but often becoming considerably steeper in the mid section. Rugosity tended to be moderate throughout.

Substrate composition was also similar between sites. The deeper reef was composed of a roughly equal mixture of rock and sand. Rock was dominant on the shallower reef, with both sand and rubble present in occasional patches.

The benthic biotic shared similarities not only between sites but also between depths. On the lower reef hard corals were dominant with soft corals less abundant. On the upper reef hard and soft corals were present in similar proportions. Coral forms were generally mixed throughout although encrusting forms were observed to dominate a part of the reef at each of the 3 sites. Seagrasses, macroalgae and *Halimeda* spp. were all sparse with average surface covers of <1 % on each of the sites

Coral Composition

'Large massive' coral forms, although present at both sites (QR3 and QR4), were restricted to the bottom of the wall and rubble slope where the diversity was low with only *Porites*, *Platygyra* and *Diploastrea* recorded. 'Small massive' coral forms were more diverse (6-7 genera) and were widespread at all depth zones on the reef. *Acropora* spp. were found throughout the outer reef although most abundant in the 'spur and groove' zone. *Pocillopora* spp. were also present throughout. 'Encrusting' and 'Foliose' coral forms (including the genera; *Pachyseris*, *Echinopora* and *Montipora*) had similar compositions and patterns of distribution. Fungiids were also present all sites on the outer reef.

The composition of 'soft' corals was similar throughout, with *Lithophyton*, *Sarcophyton* and *Sinularia* widespread.

4.4.2 Site reports:

Site QR1:

This site was on the edge of a sand channel running towards the outer reef. Along the southern edge of the channel there were a series of coral bommies and patches of seagrass. No areas of continuous reef were observed. Due to the very poor visibility encountered it was not possible to complete a meaningful survey of the habitat at this site.

Site QR2:

The reef structure and community composition are summarised in Table 42 and Figure 40.

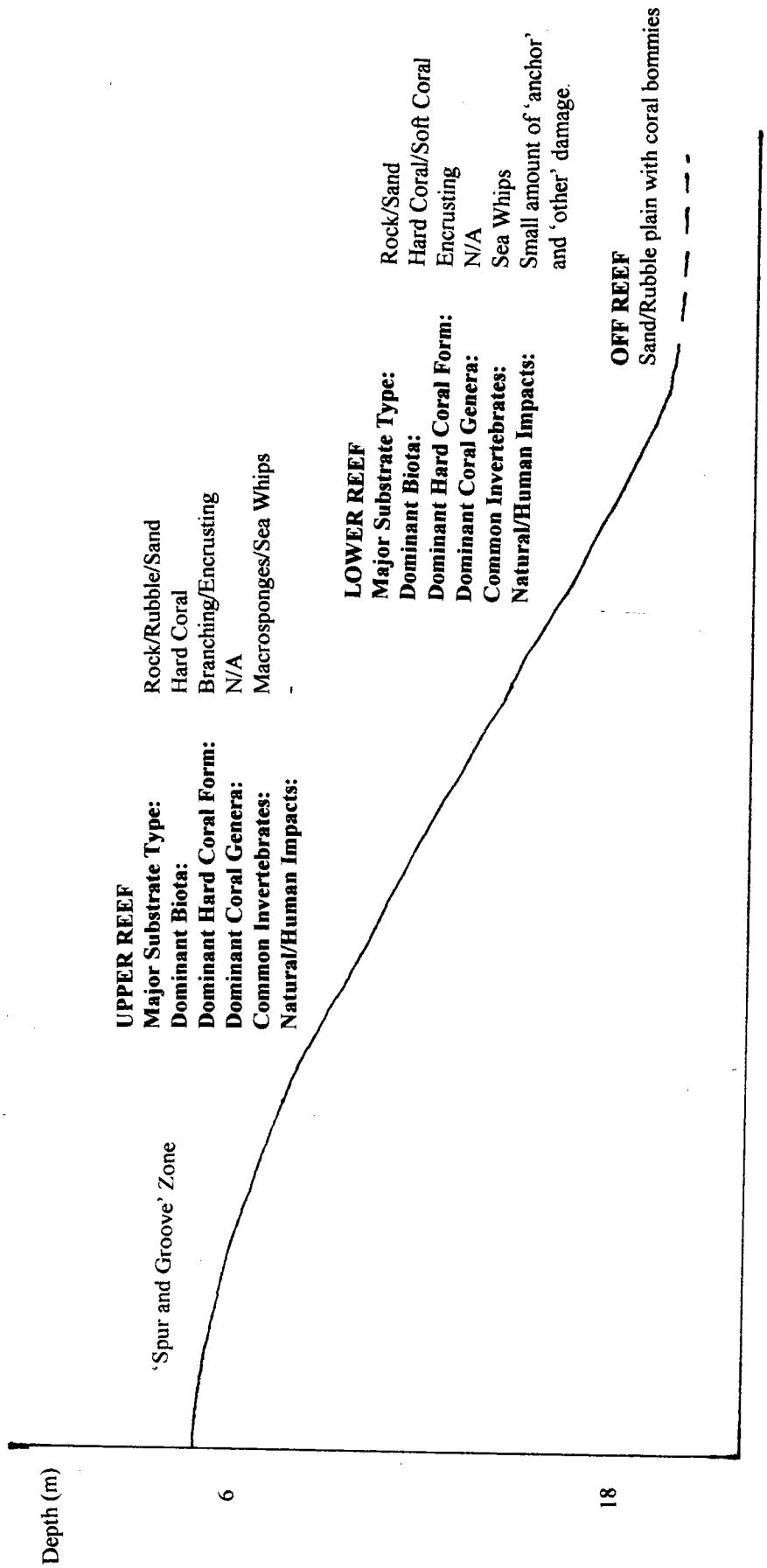


Figure 40: A diagrammatic representation of the "Reef Profile" at site QR2. A summary of the major features of the site is presented (N/A: not assessed).

Reef Structure

The reef was characterised by a generally shallow slope with little variation over the site. Rugosity was moderate at all locations and showed high variation only towards the reef base at 16-18 m.

Substrate Composition

Rock was the dominant substrate although it exhibited high rates of variation towards the reef base. Sand was common, although the surface cover was variable. Rubble was found in scattered patches throughout.

Biotic Cover

Biotic cover was similar over much of the reef with hard corals covering over 1/3 of the substrate and soft corals, macroalgae and *Halimeda* spp. considerably less abundant. Hard coral composition was mixed, with the exception of patches of encrusting, branching and plate forms.

Table 42. A summary of the structure, composition and biotic cover at QR2 (P=<1 % cover; En-Encrusting form; Br-Branching form; Pl-Plate form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (°)	5	5-10	5	0-10
	Rugosity	2	2	2	0-4
Substrate	Rock	3	3-4	4	1-5
	Rubble	2	2	P	P-2
	Sand	2	2-3	3	2-5
	Mud	-	-	-	-
Biota	Hard Coral	3	3	3	P-4
	Soft Coral	P	P-1	2	P-2
	Seagrass	-	-	-	-
	Macroalgae	P	0-P	P	0-P
	Halimeda spp.	P	0-P	P	0-P
Coral state	Heterogeneity	0	0	0	0
	Dominance	En, Br, Pl	-	En	-

Site QR3:

The reef structure and community composition are summarised in Table 43 and Figure 41.

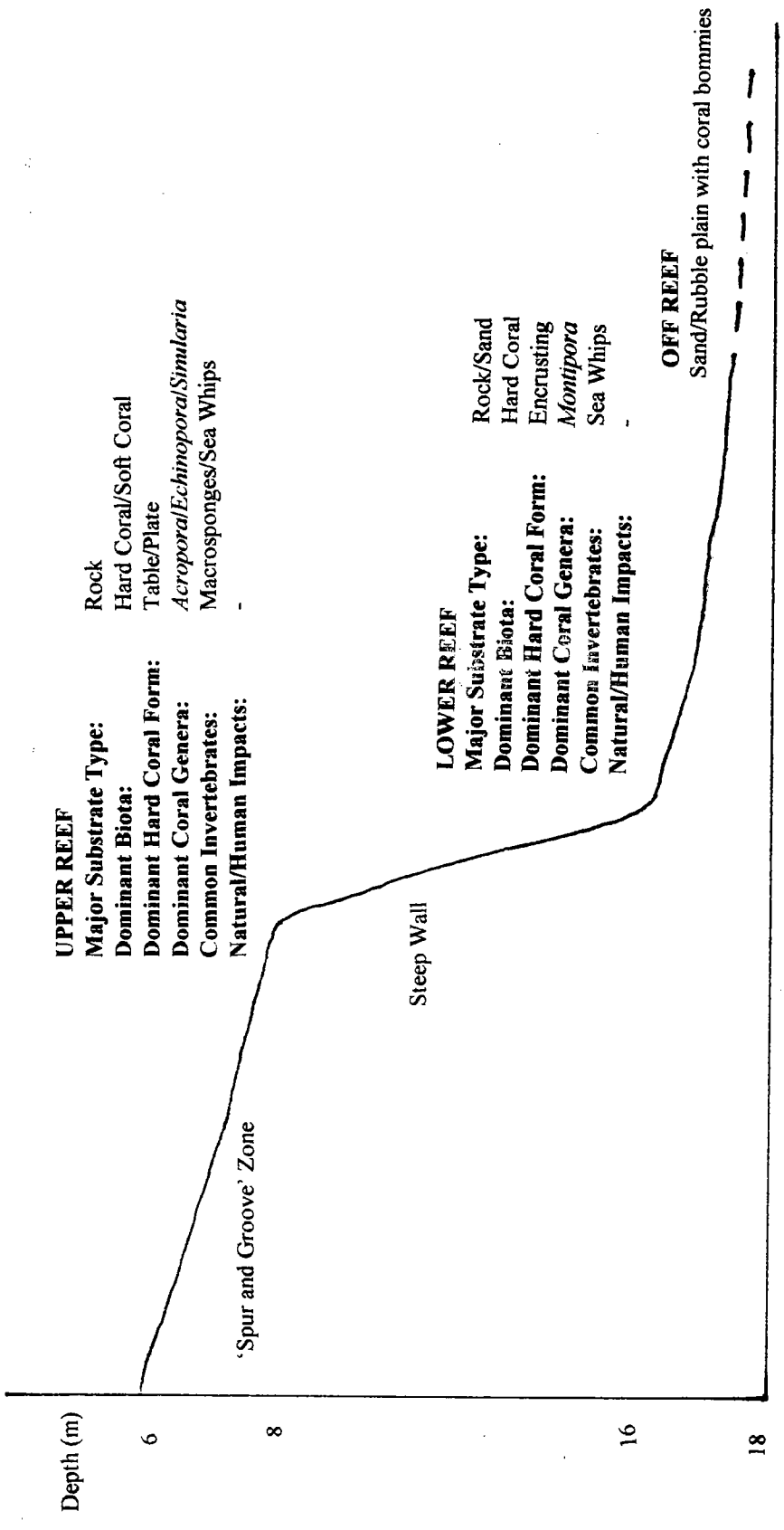


Figure 41: A diagrammatic representation of the "Reef Profile" at site QR3. A summary of the major features of the site is presented.

Reef Structure

The reef morphology at this site was very similar to that at QR4 with a near vertical 'wall' from 8-16 m (80-90 ° slope), a gentler lower slope at 16-18 m and an upper 'plateau' at 6-8 m. Rugosity was variable over the reef profile but persistently high on the lower reef at around 15 m.

Substrate Composition

Rock was the dominant substrate at all depths, with rubble recorded in low quantities throughout and sand most abundant at 15 m.

Biotic Cover

Hard corals were dominant throughout. Similarly, a moderate surface cover of soft corals, remained consistent throughout. Coral forms were diverse and well mixed. Encrusting, foliose, plate and table forms were dominant over small areas of the reef. Seagrasses were present on the upper reef but were absent elsewhere. Macroalgae and *Halimeda* spp. were present at low levels over most of the reef.

Table 43. A summary of the structure, composition and biotic cover at QR3 (P=<1 % cover; Pl-Plate form; En-Encrusting form; Ta-Table form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (^{0})	60	40-70	10	10
	Rugosity	3	3	4	3-4
Substrate	Rock	4	3-4	3	3-4
	Rubble	1	P-1	1	P-1
	Sand	2	1-2	3	3-4
	Mud	P	0-P	-	-
Biota	Hard Coral	4	3-4	3	2-3
	Soft Coral	2	1-2	1	P-1
	Seagrass	P	0-1	-	-
	Macroalgae	1	P-1	P	0-P
	Halimeda spp.	1	1-2	P	0-P
Coral state	Heterogeneity	0	0	0	0
	Dominance	Pl, Ta	-	En	-

Coral Composition

Massive Forms: 'Large massive' forms were restricted to the presence of *Porites*, *Platygyra* and *Diploastrea* towards the base of the 'wall'. 'Small massive' forms were more diverse and widespread with *Porites*, *Platygyra* and *Galaxea* found at all depths. *Favia* was limited to the base of the 'wall'; whilst *Favites* and other *Faviids* were limited to the crest of the 'wall' and the upper platform.

Branching/Table Forms: *Acropora* was most developed on the shallow reef platform, but some 'Small table' forms were also present on the reef 'wall' and base. *Pocillopora* was present on the 'wall' and upper platform.

Other Forms: *Pachyseris* was dominant at the base of the reef slope, whilst *Montipora* and *Echinopora* were present at all depths. Both 'large polyp' corals *Lobophyllia* and *Plerogyra* were present, and most widespread at the base of the reef and the lower 'wall'. *Tubastrea* was present at a depth of 10-12 m on the 'wall'.

Soft Corals: Five 'soft' coral genera were present. *Sinularia* was present at all depths, whilst *Lithophyton*, *Dendronephthya*, *Sarcophyton* and *Heteroxenia* were restricted to the 'wall' and upper platform.

Site QR4:

The reef structure and community composition are summarised in Table 44 and Figure 42 and are described below.

Reef Structure

The reef extended from 4-18 m and consisted of three distinct sections. The deep section, between 18-16 m, had a relatively shallow (15°) slope and an underlying substrate of sand/rock/rubble colonised by a band of abundant 'foliose' corals. The seabed beyond the reef base at 18 m was bare sand. The middle section, from 16-8 m was a steep (60°) rock 'wall', colonised by a diverse array of corals. The shallow section, from 8-4 m, was a flat 'plateau' composed of alternating patches of bare sand and rocks colonised by a variety of corals. Shallower than this the sand and rock patches became organised into a parallel 'spur and groove' pattern perpendicular to the reef and shore.

Rugosity was relatively high towards the base of the reef and above the wall in the mid section, reflecting a well-developed hard coral community.

Substrate Composition

The 'spur and groove' and wall sections of the reef were formed primarily from rock, although significant areas of rubble were observed at 8 m. The presence of sand and rock was variable throughout the reef profile, with sand most abundant at the deeper portions of the reef.

Biotic Cover

Hard corals were dominant covering approximately 50 % of the reef surface. Soft corals were also abundant and surface cover was consistent throughout. Hard coral forms were diverse and well mixed. Only branching, plate and encrusting forms achieved dominance in occasional patches. There was a sparse cover of macroalgae and *Halimeda* spp.

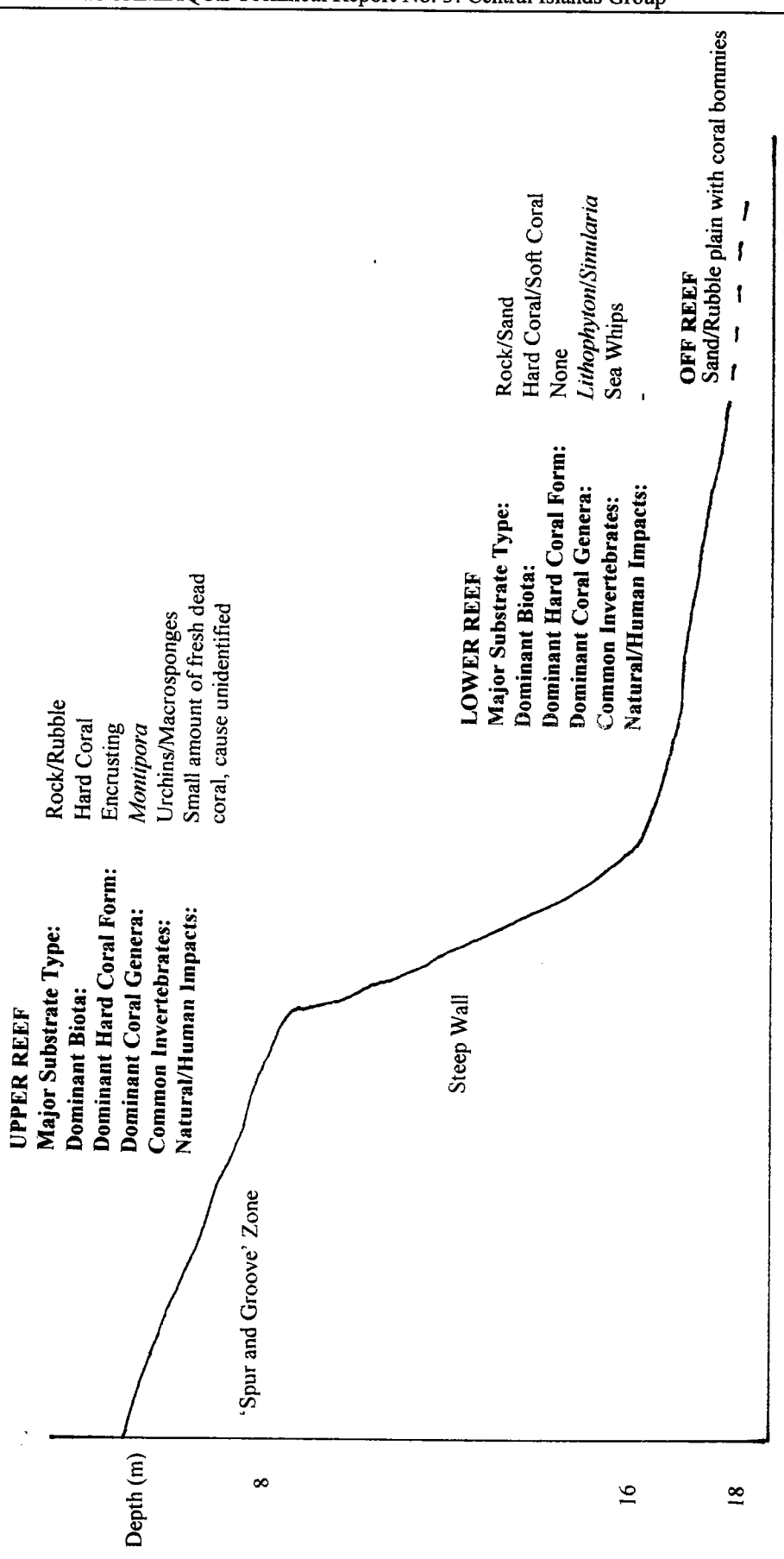


Figure 42: A diagrammatic representation of the "Reef Profile" at site QR4. A summary of the major features of the site is presented.

Table 44. A summary of the structure, composition and biotic cover at QR4 (P=<1 % cover; En-Encrusting form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (°)	5	0-5	10	0-20
	Rugosity	3	3-4	2	3-4
Substrate	Rock	5	4-5	3	2-3
	Rubble	2	0-3	1	P-1
	Sand	1	0-2	3	3-4
	Mud	-	-	P	0-1
Biota	Hard Coral	4	3-4	3	3-4
	Soft Coral	2	0-2	2	0-2
	Seagrass	-	-	-	-
	Macroalgae	P	0-P	-	-
	Halimeda spp.	P	P-1	1	0-1
Coral state	Heterogeneity	0	-	0	-
	Dominance	En	-	-	-

Coral Composition

Massive forms: 'Large massive' coral forms were limited to *Porites* and *Platygyra*. *Porites* was present in the deeper areas (18-12 m), and *Platygyra* at two separate depth intervals (14-16 m and 8-10 m). 'Small massive' coral forms were more diverse with *Porites* again limited to a depth of 18-12 m and *Favia*, *Platygyra* and *Galaxea* were also found on these lower slopes, although the latter two genera were also found in the shallow upper plateau. *Goniastrea* was most developed on the reef 'wall'.

Branching/Table Forms: *Acropora* was limited to 'Staghorn' and 'Small table' forms, with the 'Staghorn' forms present on the 'wall' and in abundance on the shallower 10-6 m plateau. 'Small table' forms were found at all depths from 6-18 m. *Pocillopora* was also found at the site, particularly at the base of the reef.

Foliose Forms: The deepest reef areas were colonised by 'foliose' form *Pachyseris*, which formed monospecific stands over large areas. It was also found on the reef 'wall'.

Other Forms: *Montipora* was found in all zones, whilst *Echinopora* was limited to the reef 'wall'. 'Solitary' fungiids were limited to the zone below the 'wall'.

Soft Corals: *Lithophyton, Sarcophyton* and *Sinularia* were present at all depths. *Heteroxenia* was limited to the crest of the wall.

4.5 Subtidal Invertebrate and Impacts Surveys

4.5.1 Overview

With the exception of a high density of urchins on the upper reef of Site QR4, most invertebrates were observed in relatively small numbers. Some coral damage was attributed to Crown of Thorns starfish and White Band disease, whilst most was of indeterminate cause. Damage thought to caused by boat anchors was observed at all sites (except QR1, see below).

4.5.2 Site Reports

Site QR1:

Very poor visibility prevented the completion of any surveys at this site. However, superficial survey found the reef mainly composed of coral bommies which supported a few Macrosponges and Sea whips. The coral damage observed was limited to a few sedimented 'Massive' form corals. No evidence of human impacts was found.

Site QR2:

The distribution and density of invertebrates, and incidences of reef damage are summarised in Table 45 and are discussed below.

Relatively few invertebrates were observed with Sea whips being the most abundant (<7 individuals/5 mins.). In general, there was a greater abundance of invertebrates towards the base of the reef although the Giant clams (*Tridacna* spp.) and single Triton (*Charonia tritonis*) observed were on the upper reef. Coral damage was limited and of indeterminate cause. The only evidence of human impact was a single area thought to have been damaged by a boat anchor.

Table 45. Invertebrate and Natural/Human Impacts at Site QR2 (values are for 5 minutes of survey).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		1.0	0-2	0.6	0-2
Sea Whips		1.0	0-2	3.6	1-7
Sea Fans				0.8	0-2
Bivalves	Giant Clams	0.4	0-1		
Gastropods	Triton	0.2	0-1		
Sea Cucumbers	Holothuria	0.4	0-1	0.4	0-2
	Others			0.2	0-1
	Synapta spp.			0.4	0-1
Impacts	**Causes**				
Dead Coral	Unknown			0.6	0-2
Human Effects	Anchor damage			0.2	0-1

Site QR3:

The distribution and density of invertebrates, and incidences of reef damage are summarised in Table 46 and are discussed below.

In general, there was a greater abundance of invertebrates towards the top of the reef with Sea whips the most common over the whole reef (<23 individuals/5 mins.). A number of Crown of Thorns starfish (<0.15 starfish/m^2) were observed close to the base of the reef (15-17 m) and a few feeding scars were recorded towards the top of the reef (<0.10 scars/m^2). Other coral damage noted were a few cases of White Band disease and some freshly dead coral (cause unknown). Other areas of damaged coral on the upper reef slopes (<3 sites/5 mins.) were thought to have resulted from boat anchors.

Table 46. Invertebrate and Natural/Human Impacts at Site QR3 (Values are for 5 minutes of survey).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		4.2	0-7	0.6	0-2
Sea Whips		15.0	8-A	6.2	3-10
Sea Fans		2.0	1-4	0.2	0-1
Bivalves	Giant Clams	0.6	0-2	1.4	1-2
Lobsters		0.2	0-1		
Sea Cucumbers	Others	0.6	0-1		
Impacts	**Causes**				
Fresh Dead	White band	0.2	0-1		
	Other	0.2	0-1	0.8	0-2
Human Effects	Anchor damage	0.8	0-3		

Site QR4:

The distribution and density of invertebrates, and incidences of reef damage are summarised in Table 47 and are discussed below.

A large variety of invertebrates were recorded although only urchins occurred in large numbers (<50-100 individuals/5 mins.) with many small individuals on the upper part of the reef. A few Crown of Thorns starfish were noted at the base of the reef but no feeding scars were seen. White Band disease was quite common in places on the deeper sections of the reef (<5 examples/5 mins.) and other freshly dead coral was regularly noted over the whole reef profile. Human impacts were limited to a few damaged sites on the upper reef attributed to boat anchors and some lost fishing line at the base of the reef.

Table 47. Invertebrate and Natural/Human Impacts at Site QR4 (values given are for 5 minutes of survey)

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		3	2-4	0.3	0-1
Sea Whips		0.4	0-1	4	1-8
Sea Fans		0.2	0-1		
Bivalves	Giant Clams	0.8	0-1		
Gastropods	Murex			0.3	0-1
	Triton			0.3	0-1
Urchins		12	0-A+		
Sea	Holothuria			0.8	0-2
Cucumbers	*Synapta* spp.			0.5	0-1
	Others	0.4	0-1	2.3	0-4
Impacts	**Causes**				
Fresh Dead	White Band			3.8	2-5
	Other	1.6	1-4	0.8	0-2
Human Effects	Anchor damage	0.2	0-1		
	Lines			0.3	0-1

4.6 Reef Fish Census

Survey sites are as for the Subtidal habitat surveys reported above (Fig. 40).

4.6.1 Overview

All sites surveyed were on the exposed, fringing outer reef and had similar reef profiles. The patterns of diversity within sites were found to be similar between sites (see Table 48).

Table 48. The Relative Diversity Indices (R.D.I.) and total number of reef fish species observed. Numbers are for those fish observed from the 72 species censused.

Site	R.D.I.	Total No. Species
QR2	0.23	16
QR3: Shallow	0.35	24
QR3: Deep	0.26	18
QR4: Shallow	0.33	23
QR4: Deep	0.38	26

For a complete list of the census species present at each site refer to Appendix 5. A fully comprehensive list of all fish species recorded during surveys of the C.I.G. is presented in Appendix 8.

4.6.2 Site reports

Site QR1:
The poor visibility at this site prevented the completion of a full survey. However, the reef fish that were observed were found closely associated with coral 'bommies' and appeared to be a mix of Acanthurids, Chaetodontids and Mullids, many of them small, possibly juveniles. No reef fish were observed over the sand areas.

Site QR2:
This site had a relatively low reef fish abundance and diversity, in comparison to the other Quirimba island sites. This was probably a reflection of the poorer state of reef development and lower surface cover of coral. Acanthurids (including *Acanthurus lineatus*, <20-50 fish/5 mins.) accounted for more than half the reef fish recorded. Chaetodontids were the most diverse family (including, *Chaetodon kleinii*, <12 fish/5 mins.). The relative abundance and diversity of reef fish recorded are shown in Figure 43.

Site QR3:
Acanthurids, primarily *Acanthurus nigrofuscus* and *A. thompsoni* (both <20-50 fish/5 mins.), and Chaetodontids, *Chaetodon kleinii* (<9 fish/5 mins.) and *Hemitaurichthys zoster* (<8 fish/5 mins.) were the most abundant species present. Little variation was observed in reef fish abundance or diversity with depth and the relative proportions of each family remained similar. The relative abundance and diversity of reef fish recorded on the upper and lower slopes are shown in Figures 44 and 45 respectively.

Site QR4:
The reef profile at this site was very similar to that at QR3 and, as such, supported a similar diversity and abundance of species. There was little variation in reef fish abundance or diversity with depth and Acanthurids were again the most abundant family with *Acanthurus thompsoni* (<17 fish/5 mins.) and *A. nigrofuscus* (<14 fish/5 mins.) the most abundant species. The relative abundance and diversity of reef fish recorded on the upper and lower slopes are shown in Figures 46 and 47 respectively.

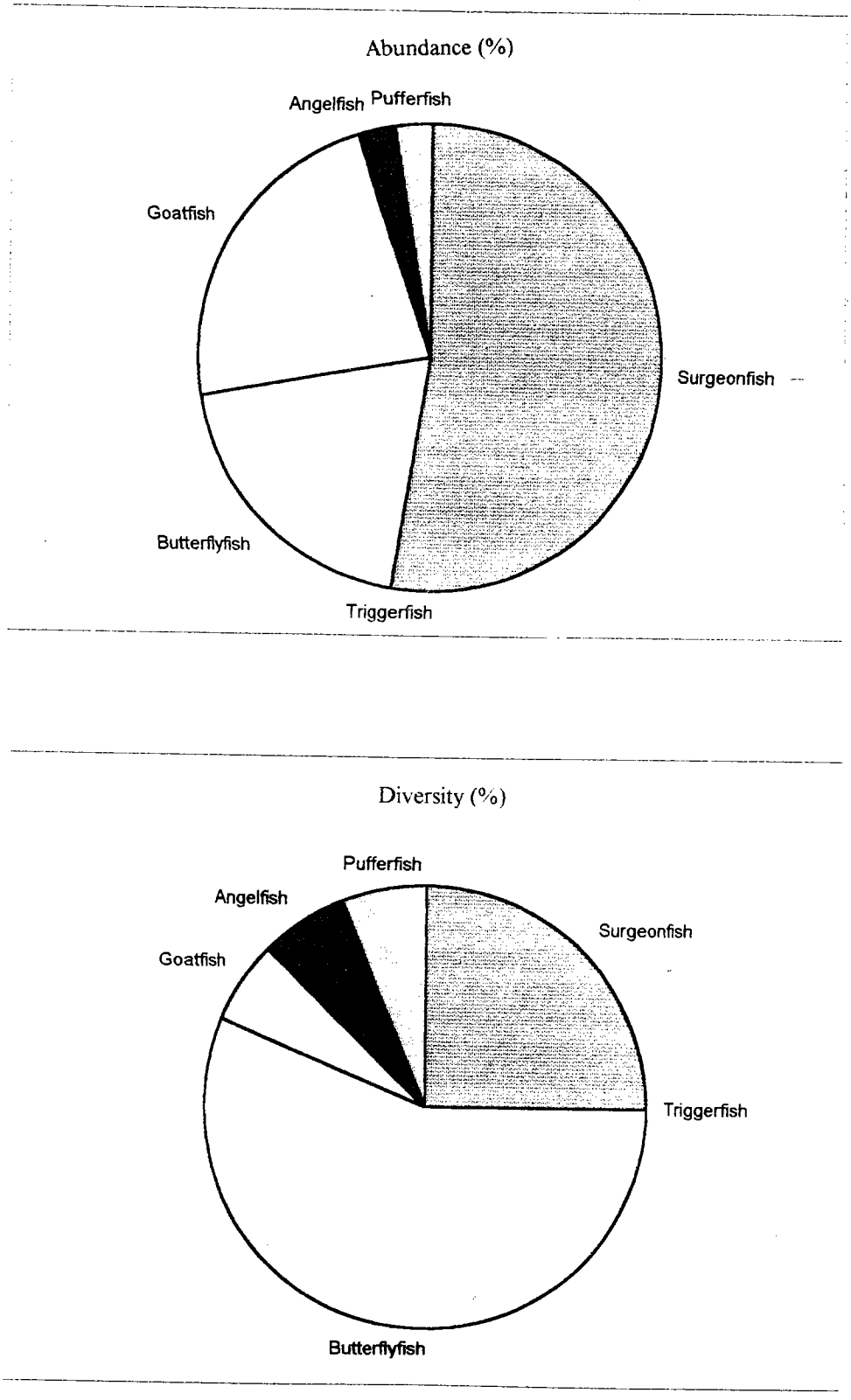


Figure 43: The relative diversity and abundance of reef fish families at site QR2.

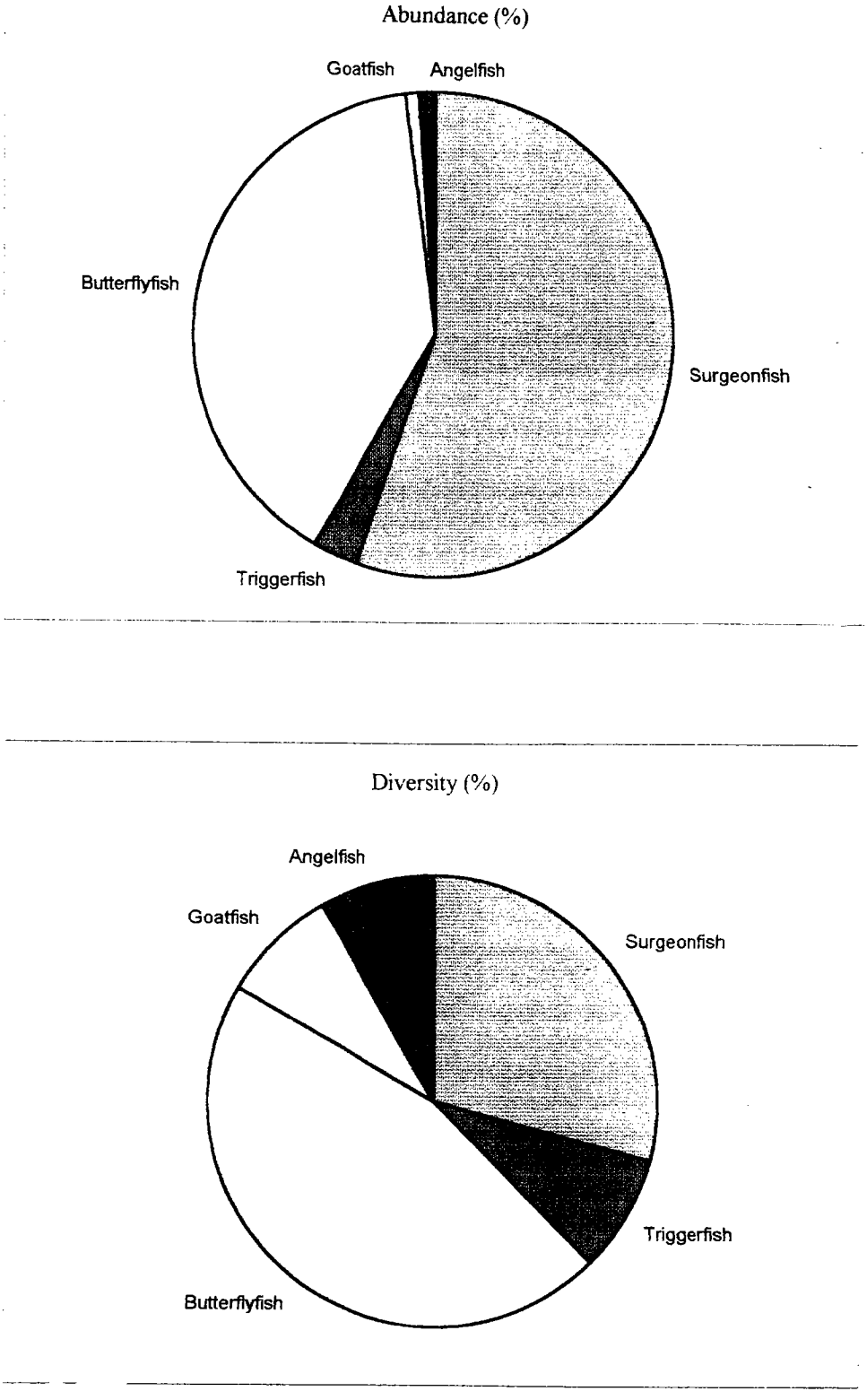


Figure 44: The relative diversity and abundance of reef fish families at site QR3, Upper reef.

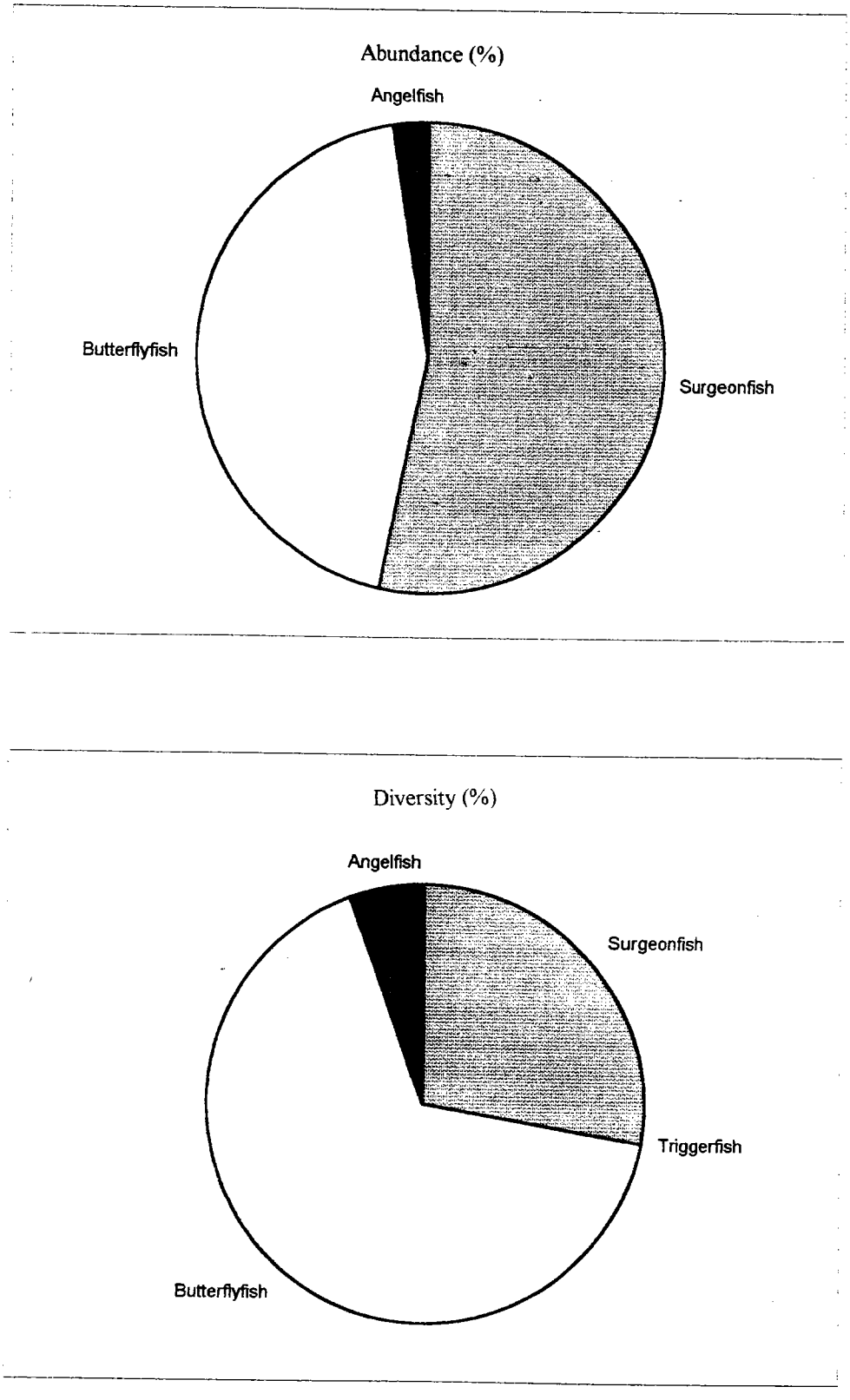


Figure 45: The relative diversity and abundance of reef fish families at site QR3, Lower reef.

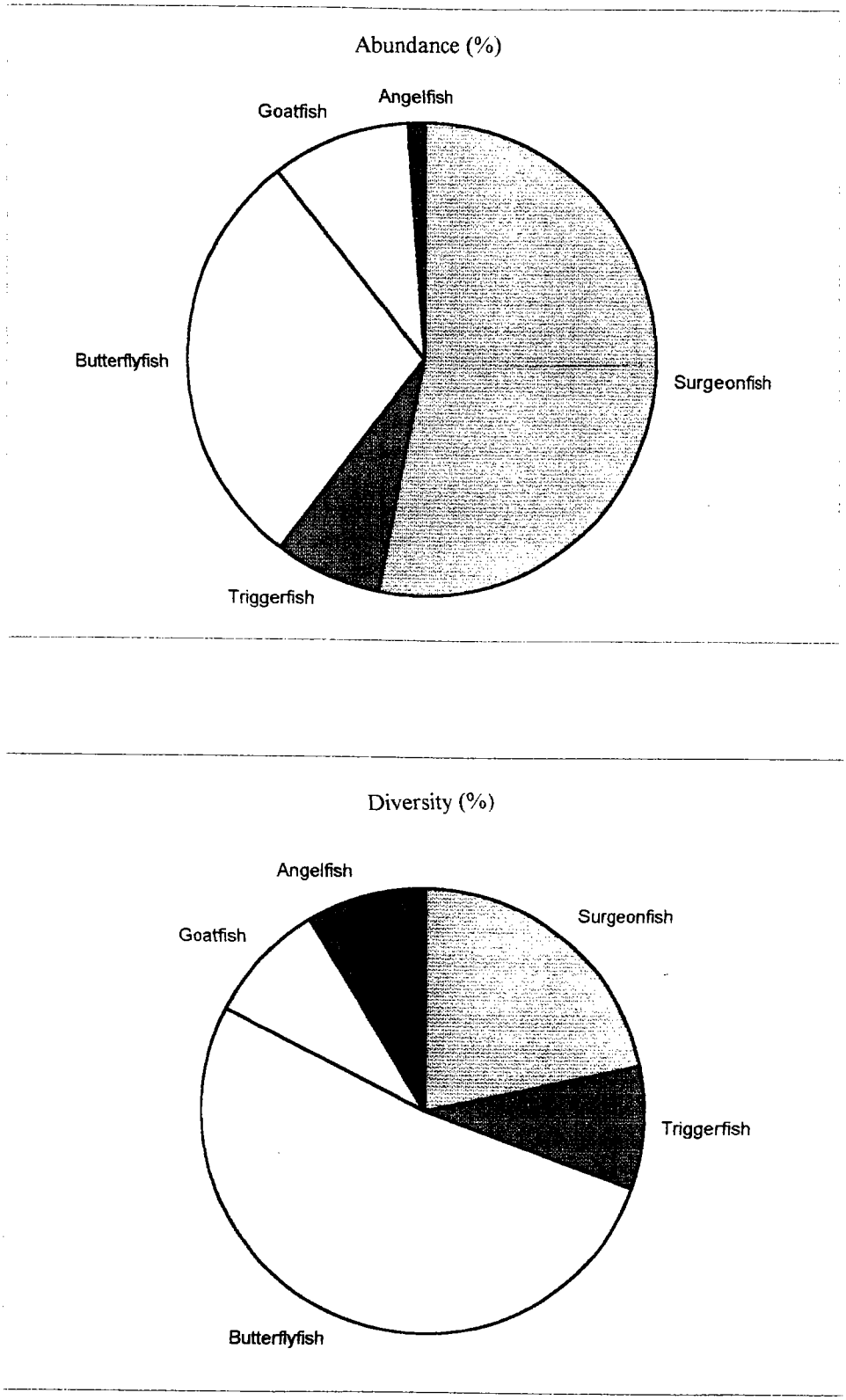


Figure 46: The relative diversity and abundance of reef fish families at site QR4, Upper reef.

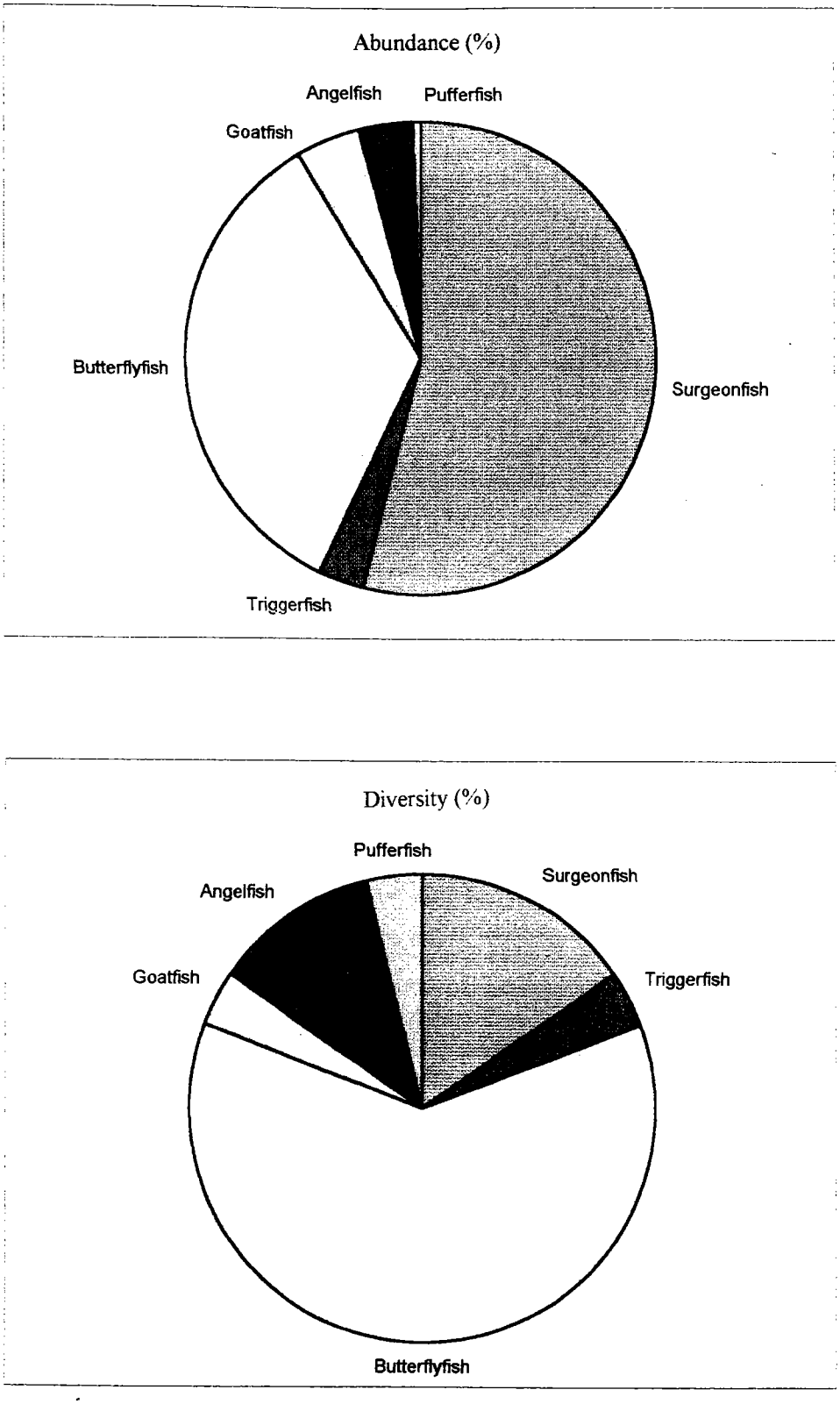


Figure 47: The relative diversity and abundance of reef fish families at site QR4, Lower reef.

4.7 Commercial Fish Census

Survey sites are as for the subtidal habitat surveys reported above (Fig. 40) and include a more general survey of the seagrass beds on the western side of the island.

4.7.1 Overview

A relatively high abundance and diversity of commercial fish species were observed at each of the sites surveyed (excepting site QR1 - see below). The large and numerous shoals of snappers (Lutjanids) and the abundance of many species of groupers (Serranids) suggests these sites have been subject to low fishing intensity.

4.7.2 Site Reports

Western sites: general survey.
Extensive seagrass beds, supporting a number of commercial fish species, occurred at all locations surveyed along the western side of the island. Most species were observed in low abundances with an average of 1-2 fish observed for every 5 minutes of survey. However, a few species commonly formed shoals of up to 20 individuals. These shoaling species included *Mulloidichthys flavolineatus* (Mullidae: estimated average length 10 cm), *Lethrinus variegatus* (Lethrinidae: estimated average length 10-15 cm) and, around small coral outcrops or rocks, *Chrysiptera annulata* (Pomacentridae). The majority of species observed were those commonly caught by the fishermen in the area (see Technical Report 5 for a full species list for this area) and were generally of a small size (estimated average length < 15 cm). Those species recorded during the subtidal seagrass bed surveys were:

Family	***Species***
Apogonidae	*Cheilodipterus quinquelineatus*
Dasyatidae	*Taeniura lymna*
Gobiidae	*Amblygobius sphynx*
Haemulidae	*Plectorhinchus gaterinus*
Labridae	*Stethojulis strigiventer*
Lethrinidae	*Lethrinus harak*
	Lethrinus variegatus
Lutjanidae	*Lutjanus fulviflamma*
	Lutjanus gibbus
	Lutjanus monostigma
Mullidae	*Mulloidichthys flavolineatus*
	Parupeneus macronema
Nemipteridae	*Scolopsis ghanam*
Pomacentridae	*Amphiprion* sp.
	Chrysiptera annulata
	Dasyllus trimaculatus
Scaridae	*Calotomus spinidens*
	Leptoscarus vaigiensis
Scorpaenidae	*Pterois miles*
Siganidae	*Siganus sutor*
Synodontidae	*Synodus* sp.
Tetraodontidae	*Canthigaster corunata*

Eastern Sites:

Site: QR1
This site was within a relatively narrow channel, subjected to considerable tidal flushing. Visibility was very poor and it was not possible complete the full survey. However, a few large emperors (Lethrinids: possibly *Lethrinus nebulosus*) and some small parrotfish (Scarids: unidentified) were noted.

Site: QR2
The abundance of commercial fish at this site, excepting the few shoals of snappers (Lutjanids: *Lutjanus monostigma* and *L. kasmira* formed shoals of 50+ individuals), was low. A few relatively large, solitary species such as *Scarus ghobban* (estimated length <40 cm) and the groupers (Serranids) *Variola louti* (estimated length <70 cm) and *Cephalopholis argus* (estimated length <50 cm) were observed. The family compositions and rates of encounter are summarised in Figure 48.

Site: QR3
Large shoals of snappers (Lutjanids) were seen at all depths (6-18 m) over the reef. *Lutjanus fulviflamma* formed shoals of 100+ individuals (estimated average length 20 cm) and Lutjanus *kasmira* shoals of 200+ individuals (estimated average length 10-20 cm). The emperor (Lethrinid), *Gnathodentex aurolineatus* also formed sizeable shoals (50+ individuals). Six species of groupers were identified: *Aethaloperca rogaa, Cephalophilis argus, C. miniata, C. sexmaculata, Epinephelus malabaricus* and *Variola louti*. A few small scaridae (<30 cm) and a solitary Great barracuda (*Sphyraena barracuda*), estimated at 100 cm in length, were also noted. The family compositions and rates of encounter are summarised for the upper and lower reef slopes in Figures 49 and 50.

Site: QR4
Large numbers of commercial fish were observed, especially close to the reef base at 14-16 m. Five species of snappers (Lutjanids) were identified: *Macolor niger* (estimated length < 60 cm), *Lutjanus bohar, L. gibbus, L. kasmira* (forming shoals of 50+ individuals) and *L. monostigma*. The estimated average length for these species was in the range 20-30 cm. Additionally, a few small groupers (Serranids) and parrotfish (Scarids) (estimated length <30 cm) and rabbitfish (*Siganus stellatus*) were recorded. Although fewer commercial fish were seen on the shallow reef, some relatively large groupers (Serranids): *Plectropomus punctatus* (estimated length <100 cm), *Cephalophilis miniata* and *Variola louti* (estimated length <50 cm for both species) and parrotfish (Scarids) (est. length <60 cm) were noted. Large shoals (50 + individuals) of fusiliers (Caesionids), mainly *Caesio xanthonota*, were also observed. The family compositions and rates of encounter are summarised in Figure 51.

4.7.3 Size Distributions

The size distributions of the commercial fish recorded are summarised for all the sites in Table 49 below. A wide range of sizes were observed for most families with large fish relatively common. This may indicate a relatively low fishing intensity as the larger specimens are normally the targeted first.

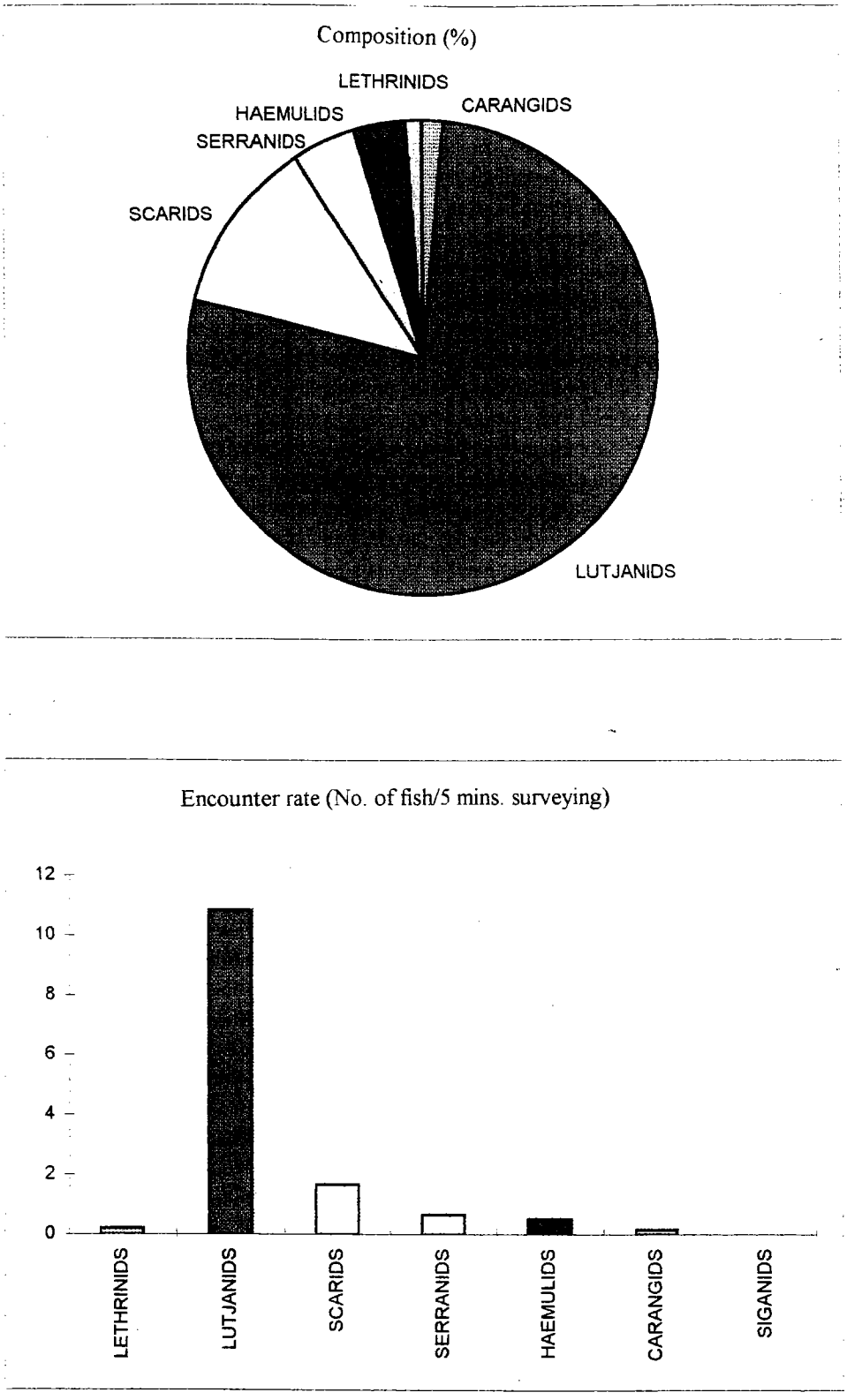


Figure 48: The composition and encounter rates of commercial fish recorded at site QR2.

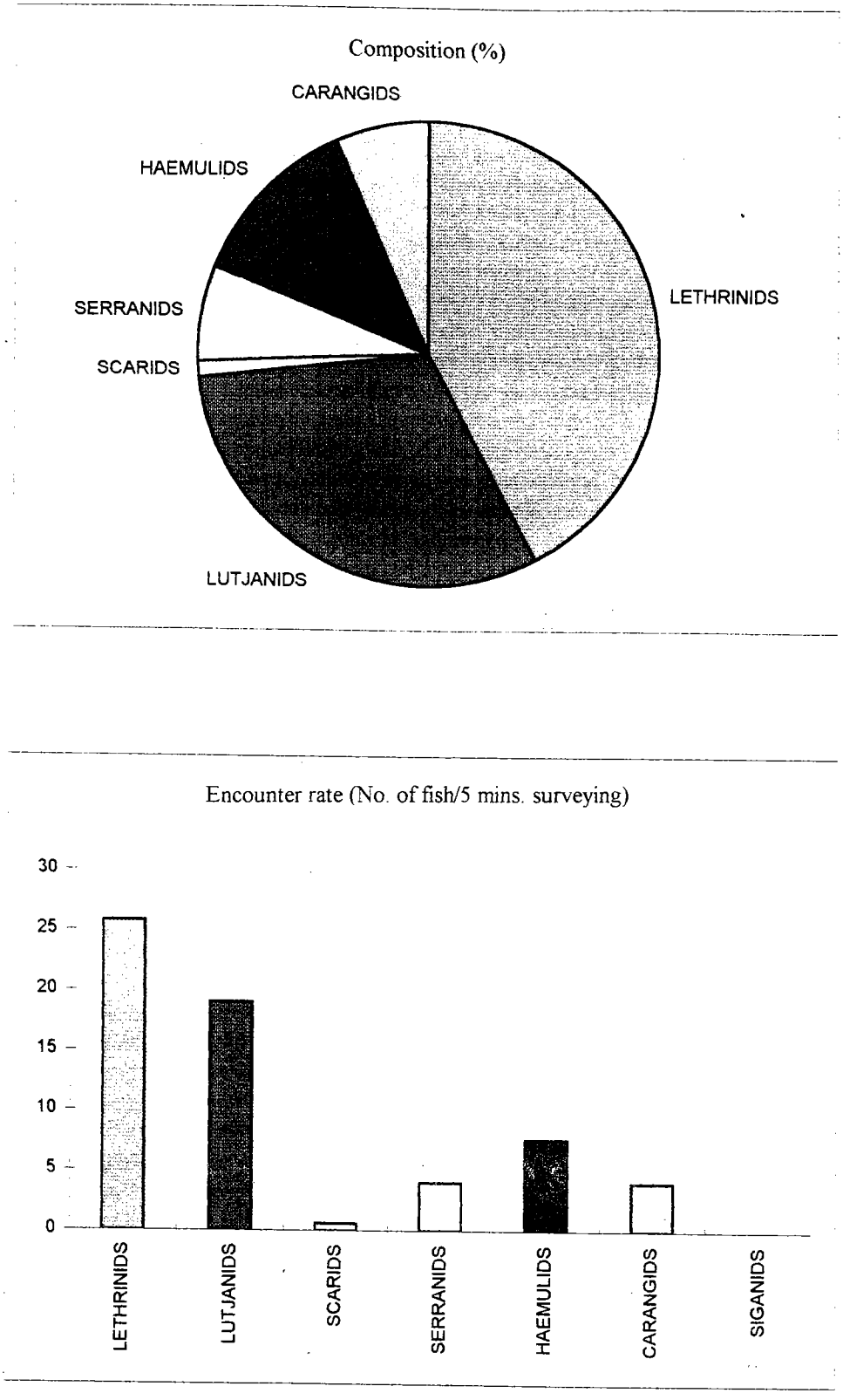
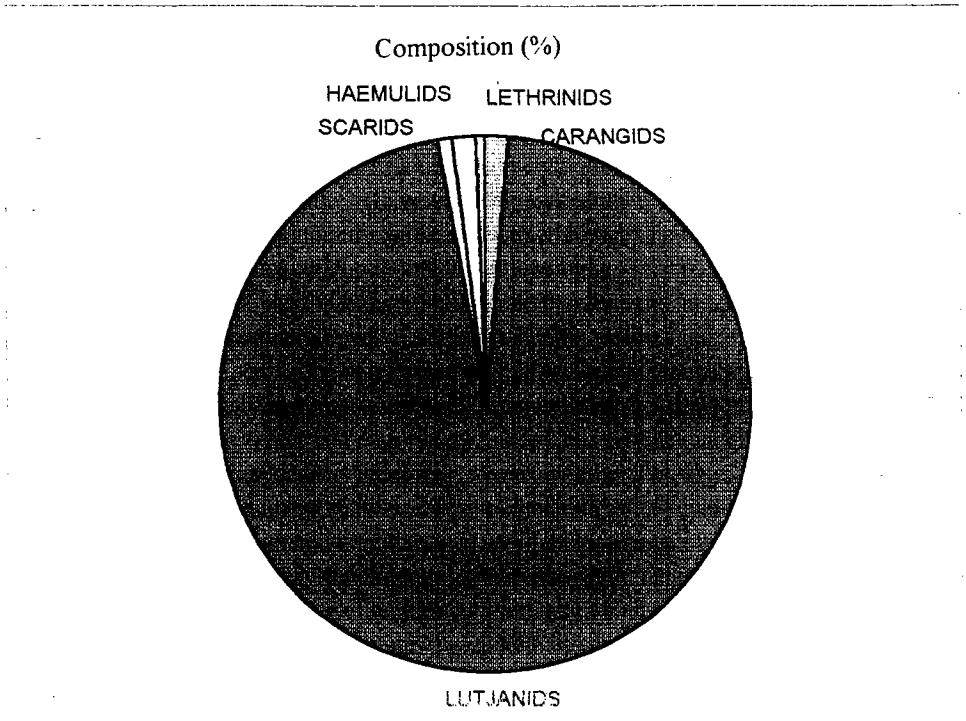


Figure 49: The composition and encounter rates of commercial fish recorded at site QR3, Upper reef.



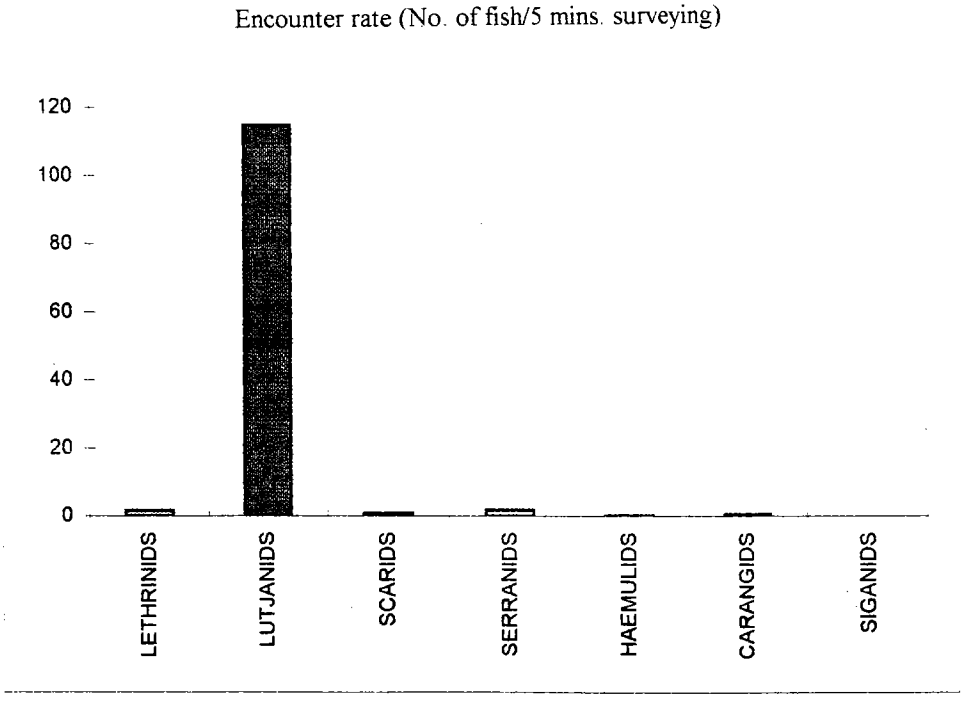


Figure 50: The composition and encounter rates of commercial fish recorded at site QR3, Lower reef.

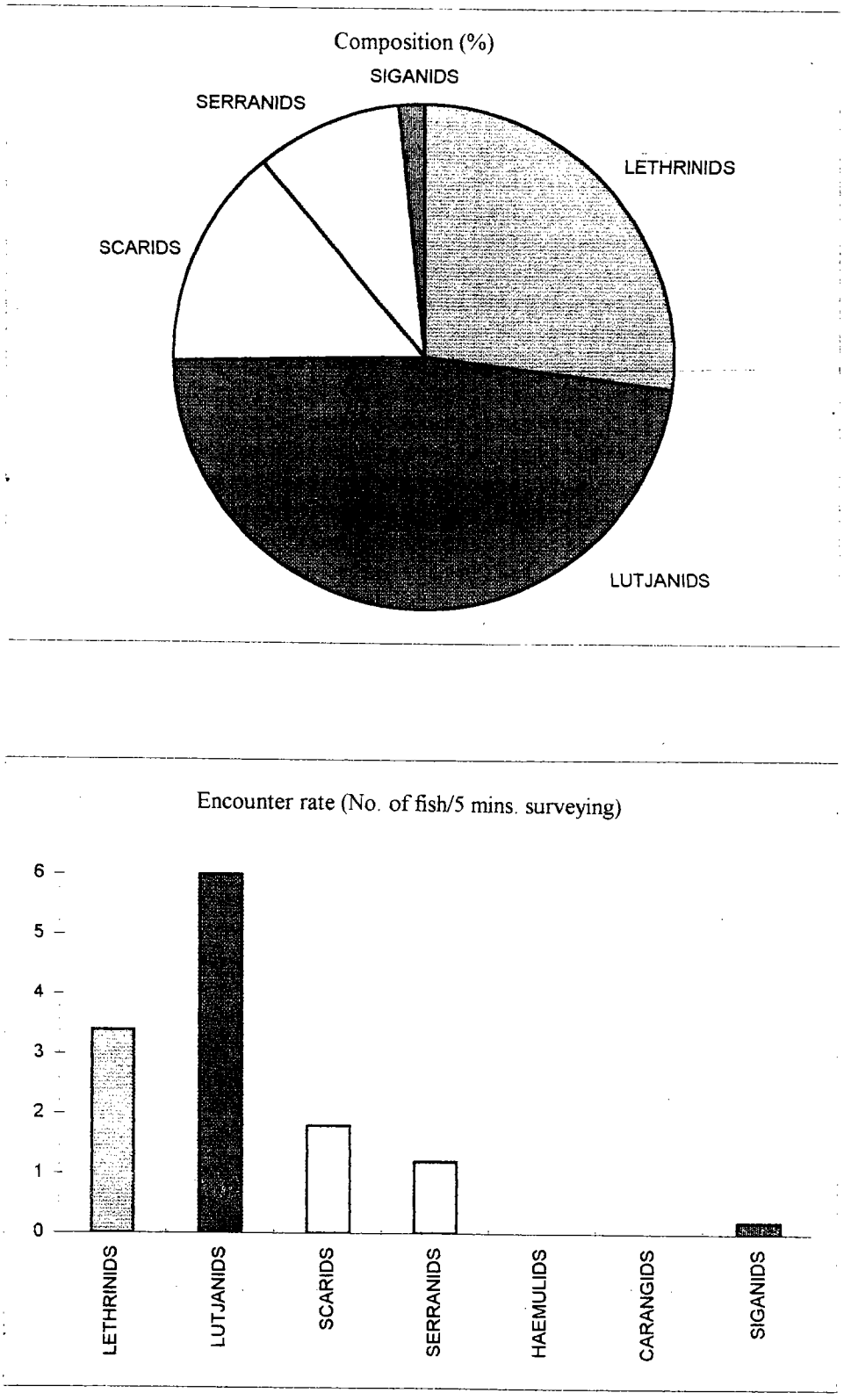


Figure 51: The composition and encounter rates of commercial fish recorded at site QR4.

Table 49. Size distribution summary for the commercial fish of Quirimba island

'Commercial' Fish Family	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae	20	10-40
Lutjanidae	20	10-60
Scaridae	30	10-60
Serranidae	30	10-100
Siganids*	20	20
Haemulidae	30	20-30
Carangidae**	60	60

* 2 specimens only ** a single specimen

4.8 Finfish Fisheries

The fishing on Quirimba island was dominated by the seine net fishery based in the seagrass beds to the west of the island (see Technical Report 5 for details of this fishery). However, a number of other finfish fishing techniques were employed by the island's fishermen and are described below. A breakdown of the numbers fishermen employing each technique is given in table 50.

Table 50. A summary of the number of fishermen using each fishing technique.

Quirimba Island	Number
Permanent population	3000
Fishermen: resident	400
itinerant	20
Fishing Method	
Line	10
Seine net	300
Surround net	15
Trap: Marema	50
Trap: Suri	10
Trap: Large Marema	0
Luwando	15
Spear	5
Intertidal	0
Boats	
Sailing Boats	30
Canoes	45
Rowing Boats	0

4.8.1 Net Fishing

Seine netting in the seagrass channel (Summary from Technical Report 5)

An estimated twenty sailing dhows (6-8 m in length) operated from a landing centre called Quiwandala to the south-west of the island's village. Each boat had a crew of between six and twelve fishermen. The nets used were approximately 100 metres long with an average mesh size of 40 mm and 2 m cod-end with a mesh size 20 mm. The net was deployed by the fishermen, either by walking or swimming, in shallow water. On occasion two boats worked together with one large net. One haul of the net took between 30 minutes and one hour and between three and six hauls were usually made on a fishing trip. The boats were sail-powered and usually took about one hour to reach the fishing ground.

The catch composition was predominantly small fish (50-200 mm). The main species caught included the Variegated Emperor (*Lethrinus variegatus*), the Seagrass Parrot (*Leptoscarus vaigiensis*), the African White Spotted Rabbitfish (*Siganus sutor*), the Tailspot Goby (*Amblygobius albimaculata*) and the Cigar Wrasse (*Cheilio inermis).* A huge variety of other species of fish were also caught but in low quantities. A number of juvenile forms of coral reef species such as butterflyfish (Chaetodontidae), snappers (Lutjanidae) and wrasses (Labridae) were also caught. Although the catch of such small and bony fish may appear unfavourable, the fishermen prefer to catch these small fish because they are much easier than larger fish to dry and sell. No fish were rejected on the basis of size with the only fish rejected being puffer fish, (Tetraodontidae) which are highly toxic, and small, inedible filefish and pipefish.

The same fishing method was employed in other areas including the channel between Quirimba and Quilaluia, an area of coral bommies. Catches around the bommies were normally dominated by large emperors (Lethrinids) and grunts (Haemulids) of over 200 mm in length.

In terms of CPUE (catch per unit effort) the efficiency of this form of fishing was relatively low. Boats usually had a crew of eight and each fishing trip lasted an average of five hours. The average catch was estimated to be around 60kg of fish per trip. This gives an estimated CPUE of 1.5 kg of fish caught per "man hour". However, this type of fishing does have its advantages as no initial outlay has to be made by the individual fishermen. The boats are usually privately owned by a non-fishing patron (estimated cost: $500), along with the nets, floats, marker buoys and diving masks. This type of fishing was also fairly reliable with fishing trips run on most days apart from on extreme neap tides or when winds were particularly high. As the boat crews have to work as a team it makes this form of fishing highly sociable and they often talk and tell stories sing traditional songs. It could therefore be argued that, even though the economic returns may not be as great as for some other fishing methods, this form of fishing has considerable social and cultural value.

Gill netting on the reef flat

This was a much less common form of fishing and was only witnessed being employed by five different groups of people. Normally three people are involved. The fishermen walk out to sea at low tide and wade into the water to a depth of one metre. Two of them stretch the net, about 30 m in length, between them and the third fisherman approaches the net from the shore side beating the surface of the water with a stick. Each "haul" takes between five and thirty minutes and fishermen made anything from one to twenty hauls depending on the success of the catch. The main species caught during the day were rabbitfish (Siganidae) and mojarras (Gerridae). At night catches were often dominated by snappers (Lutjanidae) and emperors (Lethrinidae). Total catches from this type of fishing were highly variable, ranging from nothing after many hauls to 30 kg after just one haul. The average catch was approximately 15 kg after 2 hours work giving a CPUE of approximately 2.5 kg fish per man hour. The main investment was the net and some thick-soled shoes. This type of fishing is thought to only involve around 20 fishermen.

4.8.2 Trap fishing

Marema traps

Marema fishing was by far the most common type of trap fishing. Maremas are hexagonal box traps with a funnel entrance and a shape which insures that fish rarely escape. A marema fisherman will usually set his traps in shallow water at low tide using a casquinha (dugout canoe with outriggers). They are weighted with stones and marked above the surface with branches marking the beginning and end of the lines of traps. The traps are left in place overnight and emptied the next day.

Most fishermen owned between 30 and 40 traps. When maremas were new they appeared to attract fish purely by their resemblance to a place of shelter or refuge to the fish. However, old traps seemed to lose this attraction and needed to be baited with crushed *Terebralia* spp. of gastropods. The time spent fishing (emptying and relaying traps) was fairly constant at approximately 3-4 hours. Catches ranged from a few kilogrammes to a maximum recorded catch of 27 kg. This equates to an average catch of around 15 kg for one trip and a CPUE ranging from one to greater than 10 kg per man hour.

The individual fishermen have a fairly large initial outlay in purchasing a canoe (around $30) and a set of traps but after that they have a good chance of big catches and an independent schedule. Maremas primarily catch Scarids (*Leptoscarus vaigiensis* and *Calatomus spinidens*), Siganids (*Siganus sutor*) and Mullids (*Parupeneus barberinus* and *Parupeneus macronema*).

Suri traps

Suri traps are smaller versions of maremas, however they were fished in a different way. A suri fisherman fished from a casquinha but often only had between two and four traps. The traps were baited with crushed *Pinna* spp. shells or pieces of octopus and were then weighted and tied to a long piece of cord with a float on the end. They were taken out to areas of seagrass and submerged for perhaps half an hour at a time to allow fish to enter before being retrieved.

Suris only caught very small fish, almost exclusively the snapper, *Lethrinus variegatus*, and wrasses (Labridae). Catches were occasionally fairly large, comprising hundreds of small fish. Initial outlays for suri fisherman were largely similar to those of the marema fishermen but the fishermen had the additional on-going effort of collecting their bait each day.

Fence traps

Quirimba had a number of large fence traps, known locally as 'luwando'. They were relatively large constructions built of mangrove and other local wood and consisted of fences a few hundred metres long with a funnel trap at the end. The fences can take a few months to build and are usually only built by the island's old men who are often the only people who can afford to invest this amount of time with a small return.

Luwando trap sites were often traditionally owned by one family and the rights to fish were handed down from generation to generation. Some owners paid for the trap to be built but employed other fishermen to actually go out and collect the fish. There were a number of traditions associated with this practice which include that the first catch of the trap goes to the fishermen rather than the trap owner.

Luwando traps can theoretically make two catches per day, one with each falling tide. The species compositions of day catches and night catches were often different. The traps targeted large mobile fish such as emperors (Lethrinidae), snappers (Lutjanidae) and cornet fish (Fistularidae) with night catches also including considerable numbers of squid. The actual effort involved in fence trap fishing once the trap had been set up was relatively low, with the fishermen needing only to go out on each low tide to collect the fish that had been stranded inside the trap. Fish collection could often be completed by two or three people within an hour. The main difficulty in this type of fishing was the nocturnal collection of fish which could be at any hour of the night depending on tides. Fishermen went out to collect the fish with huge torches of coconut fibres that illuminated large areas of the intertidal.

Of all finfish fishing methods on Quirimba island luwando fishing seemed to have the most traditions and rules about usage. The owners of traps seemed to have the undisputed right to use the area of shoreline their trap was on. People also respected the need for a large area of shore in between traps. At the time of this survey there were five active luwando traps around the island.

4.9. Intertidal Resource Collection

4.9.1 Overview

The estimated 29.5 km^2 of intertidal area was shared almost equally between the 1 km wide sand and seagrass beds that lie in the shelter of the island (facing Montepuez Bay) and the 2.5 km wide exposed reef intertidal on the eastern side of the island. This intertidal area provided a diversity of habitats with a variety of resources collected by the local population. The local names for collection areas are shown in Figure 52. The distribution and extent of intertidal habitats are given in Figure 53 and Table 50. The nearshore intertidal strip (1 km wide) on the eastern side was predominantly bare, muddy sand leading into the lagoon which ran for most of the length of the fringing reef. The lagoon was shallow, reaching a maximum depth of 1 m, with a substrate composed of a mixture of sand, rubble and rock, with occasional small coral colonies and micro-atolls. The reef crest was typically 500 m wide and composed of a flat rock surface, with occasional pools averaging 1 m in depth.

The collection of resources on the intertidal area of Quirimba island was surveyed over a period of 11 spring tides, between 28/7/96 and 28/9/96, during which time 128 people were interviewed. The main collection areas for different resources are shown in Figure 54.

Table 51. The extent of different habitat types within the intertidal zone. Figures are given in km^2.

Sand/Seagrass	Nearshore reef intertidal	Lagoon	Reef Crest
14.75	8.25	3.25	2.00

Scale and Intensity of Collection
The collection intensity on Quirimba was the highest of the four islands surveyed, with an average of 81 people (density of 3/km^2) on the intertidal each day. The maximum number recorded collecting on a single day was 203 people. The high number involved is thought to be largely a reflection of the relatively high population on the island (approximately 3,000), the large intertidal area, and the high diversity of habitats supporting a variety of resources.

Gender of Collectors
Adult women were the main collectors (77%) with lesser numbers of adult men (16%), young men (10%), and young women (6%). The gathering of intertidal resources was amongst one of the most important work components for adult women on the island, following housework, bringing up children, and tending the fields (kimwani: 'shambas') that most families own. The primary employment for adult men was in the artisanal finfish fisheries based at Quiwandala, Quirimba village and Kumelamba. Additionally, an estimated 60 men worked in the coconut plantation on

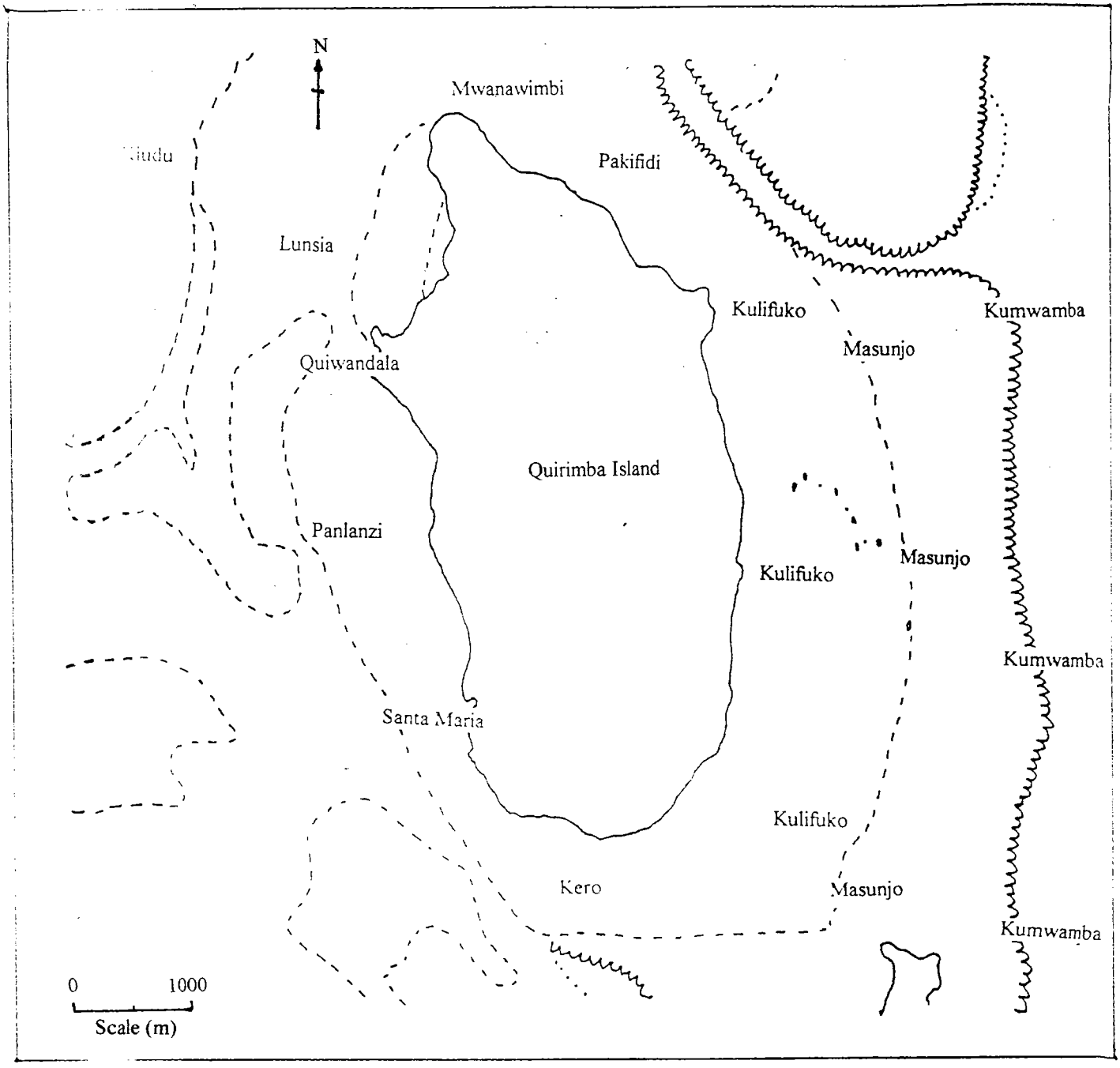


Figure 52: A map indicating the local names (Kimwani) for the intertidal resource collecting areas on Quirimba island.

the island. The involvement of young men and women was unexpectedly low as, traditionally, the young, especially if not at school during the day, usually help in the collection of food in addition to helping with regular household tasks.

Group Structure

The majority of collectors operated in groups (77%). This appeared to be the result of the high proportion of women exploiters, many of whom preferred to work with relatives, friends and children. For example, in the sand/seagrass zone all women were operating in some form of group, and they represented 98% of the collectors in that zone. Conversely, all of the collectors on the reef crest operated as individuals, probably a result of the greater proportion of adult males operating in this zone.

Origin of Collectors

Only one of the 128 collectors interviewed was not from the island indicating an almost total absence of itinerant collectors from other islands or from outside the region. Interestingly, it was noted that the collectors from Kumelamba (21%), restricted their activities to areas close to their houses, such as the sand/seagrass areas of Santa Maria, Kero and the southern reef intertidal. This is possibly because women from that settlement are mostly targeting bivalves which are most common in the above mentioned zones. All other areas were dominated by collectors from Quirimba village (79%), with some of those walking long distances to reach the southern reef intertidal where the collection of holothuria (seacucumbers) was favoured.

Collection Methods

Much collection (59%) was by hand, a reflection of the high effort directed towards the collection of bivalve molluscs in the sand/seagrass zone. There was also a large proportion individuals employing iron rods (40%), most of whom were operating in the lagoon, used to extract octopii from their holes, turn over rocks and corals that hid holothuria and gastropods, and to kill fish. The lack of use of other methods, with the exception of one snorkeller/speargunner from Pemba, may be due to the absence of itinerant collectors who normally employ a variety of methods, including snorkelling, speargunning and 'marema' trap fishing. Seine netting was practised in the lagoon, but catches were limited to fish and thus were not included in this study.

Catch Composition

Bivalves were the main target group, comprising 77% of the catches, with the following four species collected, three of which were particularly important: *Pinna* sp. (1501 individuals); *Barbatia* sp. (6,816 individuals) and *Pinctada* sp. (5,480 individuals). Additionally, 11 *Tridacna* sp. were collected. Bivalves formed an important household food component, supplementing the catch of fish. The predominance of *Barbatia* sp. in the catches resulted from their collection in all three sand/seagrass areas (i.e. Quiwandala, Santa Maria and Kero) although it is not clear whether this is due to their being especially abundant or specifically targetted as a favoured species. *Pinctada* sp. were also caught in great abundance near the LSWM of Quiwandala. Although a few collectors were observed to collect *Pinna* sp. for fishing bait, several collectors stated that collection was most important in the wet season, December-April. Very few *Tridacna* sp. were collected, these being less abundant and restricted to the lagoon and reef crest areas.

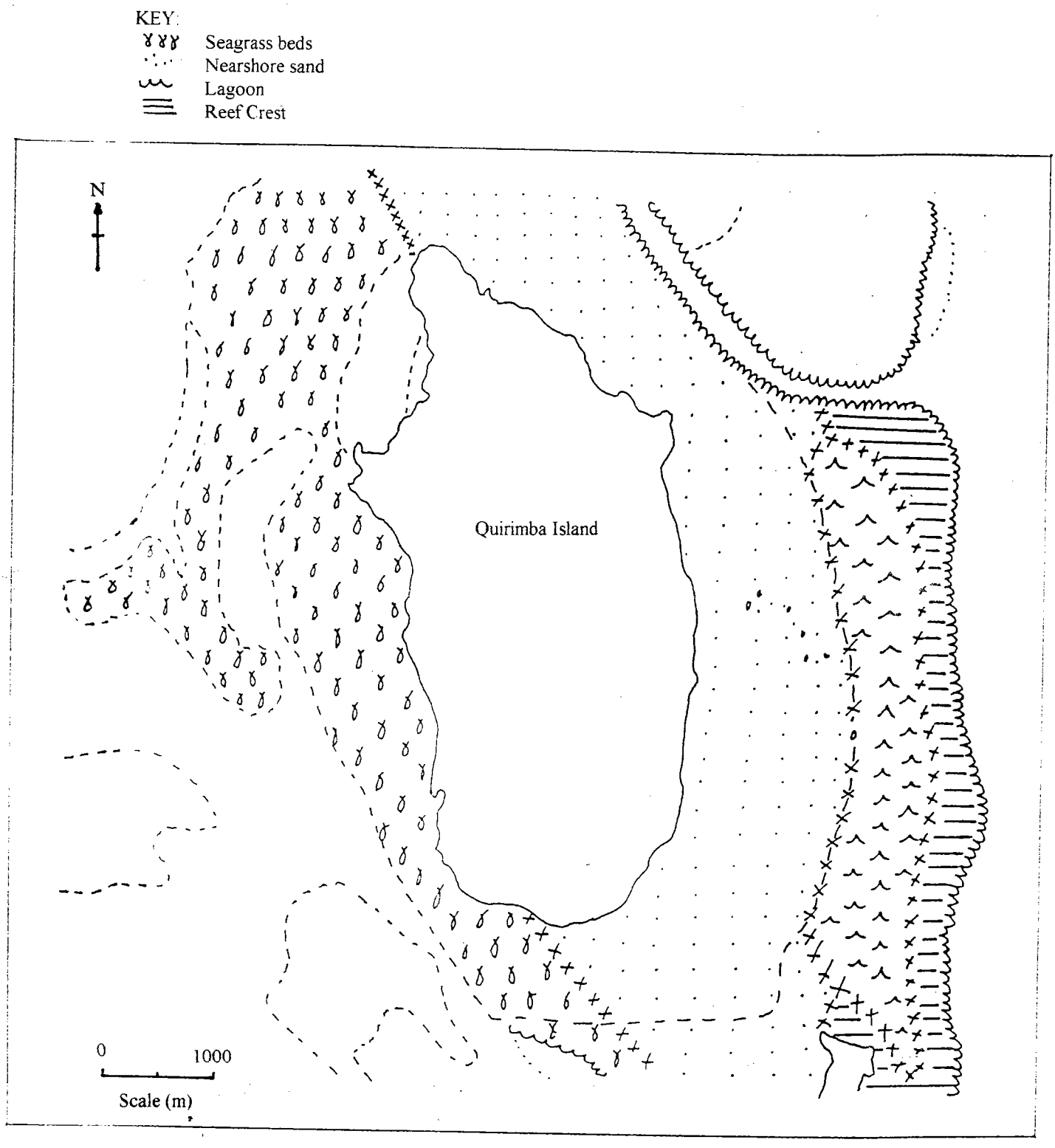


Figure 53: The intertidal zones distinguished on Quirimba island in relation to the resource use surveys.

Holothuria (seacucumber) collection was also important with 39% of people observed collecting this resource. A total of 19 species (see Appendix 10) making a total of 816 individuals were collected. The dominant species were *Holothuria nobilis* (468 individuals) and *Stichopus variegatus* (136 individuals). Holothuria collection was the second most important resource use, being exploited by groups of adult women and children who purposefully searched the lagoon targeting this catch in addition to many other who collected a few holothuria as incidental to their main catch. The intense collection of holothuria is explained firstly by the ease of sale of dried stocks to buyers on Quirimba, Ibo, Pemba and in southern Tanzania, and secondly, by their ease of collection leading to a high participation of children (especially males).

Octopus collection (30% of collectors) was also significant with a total of 341 observed caught. The catch area was restricted to the lagoon and outer reef. However, within these zones it was one of the dominant catches being an important household food source and a good source of income when dried.

30% of people were observed collecting 'FO' gastropods (gastropods taken for food), which included 6 species: *Turbo coronatus* (607 individuals collected); *Chicoreus ramosus* (328 individuals collected); S*trombus mutabilis* (299 individuals collected); *Fasciolaria trapezium* (78 individuals collected); *Mancinella alouina* (18 individuals collected); and *Marginella* sp. (9 individuals collected). Twenty-two people collected 'CT' (curio trade) gastropods, with a total of 8 species represented. In order of importance, these were *Cypraea tigris* (86 individuals); *Monodonta australis* (35 individuals); *Lambis lambis* (32 individuals); several *Conus* spp. (19 individuals); 3 *Cypraecassis rufa* (3 individuals); *Murex pecten* (1 individual); *Mitra* sp. (1 individual) and *Cypraea carneola* (1 individual). Of these collectors nine were observed to also collect 9 species of fish, 46 crabs (*Phallium labiatum* and *Portunus* sp.) and 2 people each collected a lobster, *Panilurus ornatus*.

Although the number of people collecting 'FO' gastropods was the same as those collecting octopii, the former were almost always collected on an incidental basis being present in all zones but at insufficient densities to warrant targetted collection. Only *Strombus mutabilis* and *Turbo coronatus*, which had greater abundances, could be collected as the main catch. 'CT' gastropods, fish, and crustaceans were also incidental catches, presumably also due to their relatively lower abundance on the intertidal.

4.9.2 Distribution of Effort across Intertidal Zones

Total numbers and density

The density of collectors across intertidal zones is presented in Table 52. The density was always highest in the sand/seagrass zone, on all occasions making up just over half of the total (56-60%) for the whole of Quirimba. Within this zone, almost equal numbers of collectors were found at Quiwandala and Kero. The lagoon was the next most heavily exploited zone (21-25% of observed collectors). The reef crest usually had a low density of collectors although 44 individuals were observed here on one particular day. The nearshore sand zone was rarely exploited.

KEY:

Oct	Octopii
Biv	Bivalves
FO	Food/Operculae Gastropods
CT	Curio Trade Gastropods
Holo	Holothuria

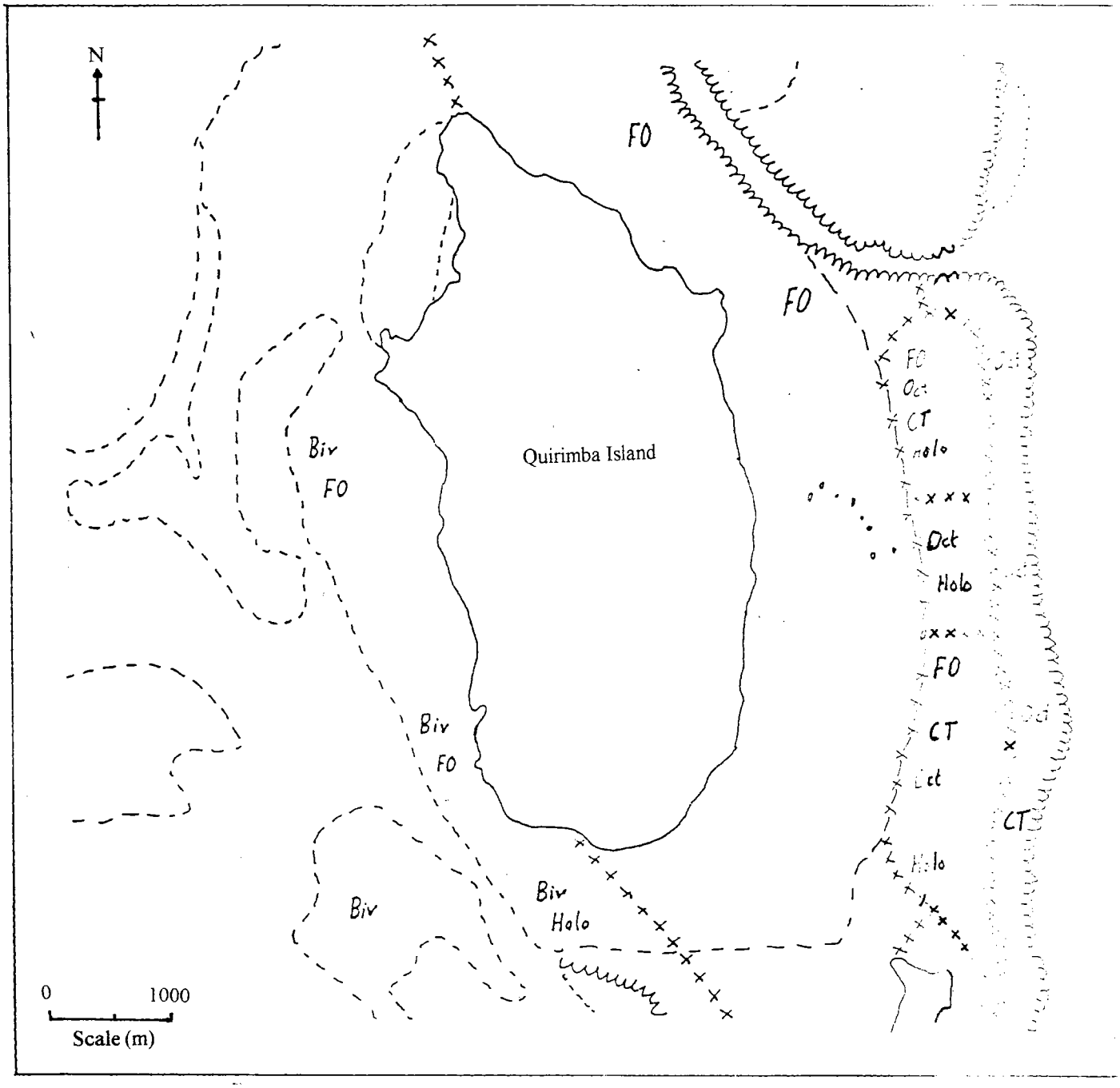


Figure 54: The main areas for the collection of intertidal invertebrates on Quirimba island.

Table 52. Distribution of collection effort across zones (numbers in brackets are total numbers of collectors observed).

Zone	Local Area	Average Density /km	Spring tide Density /km	Maximum Density /km
All zones	**All areas**	**3.0 (81)**	**7.0 (203)**	**10.0 (300)**
Sand/ seagrass	**Total area**	**3.0 (45)**	**8.0 (121)**	**11.0 (172)**
	Quiwandala	4	9	18
	Santa Maria	6	4	22
	Kero	3	13	17
Nearshore sand	**Total area**	**0.3 (2)**	**3.0 (19)**	**3.0 (21)**
Lagoon	**Total area**	**5.0 (20)**	**11.0 (46)**	**15.0 (63)**
Crest	**Total area**	**7.0 (14)**	**9.0 (17)**	**22.0 (44)**

Adult women were the dominant collectors across all zones. The small numbers of young collectors were restricted to the sand/seagrass and lagoon zones. Most adult men were found in the lagoon, with a few in the sand/seagrass and crest zones.

Most collectors in the sand/seagrass beds were from Quirimba village with a lesser number of individuals from Kumelamba. Although, the northern part of this zone was frequented by people from Quiwandala, the southern areas of Santa Maria and Kero were exploited by those people from the southern Kumelamba settlement. In other zones, almost all collectors were from Quirimba village, with the exception of one individual from Sencar on the nearby lagoon.

Method of Collection

In the sand/seagrass zone all people collected by hand. In the nearshore sand and crest zones there was an equal reliance on collection by hand and with iron rods, with a single additional snorkeller/speargunner on the crest. Conversely, in the lagoon, the preferred method was the use of iron rods (79%), as opposed to hands (21%).

Catch Composition

In the sand/seagrass zone people were overwhelmingly concentrating on bivalves, with 100% of people collecting *Barbatia* sp., *Pinna* sp., and *Pinctada* sp. *Pinctada* sp. and *Barbatia* sp. were most often obtained at Quiwandala; *Pinna* sp. and *Barbatia* sp. at Santa Maria; and *Barbatia* sp. at Kero. Little else was exploited in this zone. The bivalve *Barbatia* sp., the 'FO' gastropods, *Strombus mutabilis* and *Fasciolaria trapezium*, and octopii, were collected in the nearshore sand zone.

The dominant catch within the lagoon included 'FO' gastropods, octopii and holothuria (collected by 41%; 59% and 79% people respectively). The gastropods collected in the lagoon included the following 6 species: *Turbo coronatus, Strombus mutabilis, Fasciolaria trapezium, Mancinella alouina, Chicoreus ramosus,* and *Marginella* sp.. 'CT' gastropods were also collected within the lagoon with the following 6 species most common: *Cypraea tigris, Monodonta australis, Lambis lambis,* several *Conus* spp., *Cypraecassis rufa* (2 individuals collected) and *Cypraea carneola* (1 individual collected). Eight people were also observed to collect finfish, including Groupers (Serranids), Snappers (Lutjanids) and Surgeonfish (Acanthurids).

The crest zone was only exploited for octopii and fish, with some incidental interest in 'CT' gastropods and holothuria.

4.9.3 Subtidal Collection

Two forms of subtidal collection of molluscs and holothuria were identified. The first was through incidental capture in fishing nets and collection by snorkelling whilst laying and retrieving nets.

The second method involved the collection of gastropods for the curios trade by small groups of men. Two 'sets' of these particular collectors were known and both operated from the village beach and collecting in the shallow (up to 6 m depth) waters of the northern outer reef. The first 'set' included three men (one of whom would snorkel) using a small 5 metre 'lancha'. This group targeted *Lambis lambis, Cypraecassis rufa, Cassis cornuta* and *Cypraea tigris.* The second 'set' comprised a single individual who also targeted these species, but also collected the rarer *Lambis chiragra* and *Oliva caroliniana.* These 'CT' gastropods were sold in Nacala and Pemba from where these collectors originated.

4.9.4 Discussion

Exploitation levels were found to be highly variable with the maximum number recorded on a single day (300 individuals) far exceeding the average number out on a typical spring tide. When compared with other sites, such as Quilaluia island, the density of collectors was relatively low at 7/km^2 as compared to 9/km^2 with very little collection on the neap tides.

The lack of non-resident collectors was probably due to two main factors. Firstly, there was a lack of available land on which to camp, most of it being planted with an extensive coconut plantation, and with a sizeable village in the north of the island and cultivated fields in the south. Secondly, some of the less heavily populated islands were thought likely to provide more productive collecting areas.

The lack of involvement by Quirimba residents in the trade of curio shells was thought to result from a variety of factors including a lack of personal trade connections with mainland towns, limited expertise in snorkelling and collection of 'CT' gastropods, and a shortage of boats to reach the collection sites, most being involved in the more traditional finfish fishery.

The relatively low level of exploitation was mainly due to people collecting the intertidal resources for subsistence rather than commercial purposes.

4.10 Mollusc Biodiversity Surveys

4.10.1 Overview

The diversity of bivalves and gastropods on Quirimba island was found to be high relative to the other C.I.G. islands studied and included 19 bivalve species and 92 gastropod species. This diversity amounted to 90% of bivalve species, 76% of gastropod species and 93% of mollusca families found within the C.I.G. A full list of species recorded is given in Appendix 14.

4.10.2 Zone Reports

Reef Zone 2:
Two bivalve species, *Brachidontes* sp. and *Tridacna squamosa,* and 37 species (from 15 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Conidae and Winkles (6-7 species in each).

Southern sand/seagrass zone
Nine bivalve species and 26 species (from 14 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Terebridae and Whelks (3 species each).

South-western sand/seagrass zone
11 bivalve species and 39 species (from 20 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Nassaridae, Neritidae, Potamididae, Turrets and Whelks (3-4 species each).

North-western sand/seagrass zone
Nine bivalve species and 33 species (from 19 Families) of gastropods were identified. Within the gastropods the most diverse Families were Nassaridae and Whelks (5-8 species each).

Northern sand/seagrass zone
Two bivalve species (one unidentified sp. belonging to the Family Malleidae and *Pinna muricata*) and 12 species (from 9 Families) of gastropods were identified. Within the gastropods the most abundant Families were Nassaridae, Strombidae and Whelks (2 species each).

Subtidal
One bivalve species (*Tridacna squamosa*) and 10 species (from 6 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cassidae (3 species).

4.10.3 Discussion

Overall Diversity

There are several possible reasons for the high diversity of molluscs observed on Quirimba island. Firstly, it has a relatively large intertidal area (29.5 km^2) and some biogeographical theories suggest that the area of habitat is positively correlated to species diversity as larger areas are not only able to support greater rates of successful immigration, but also have lower rates of local extinction. Secondly, the intertidal and shallow subtidal areas of Quirimba island have a wide range of habitats, including the sand/seagrass beds of the sheltered Montepuez Bay side and the reef-associated lagoon and crest of the oceanic side. Further, there are important habitat variations within each zone. Alternate biogeographical theories postulate that high habitat diversity can produce high species diversity. Although these two biogeographical theories are based specifically with island terrestrial fauna (rather than island intertidal marine fauna), the ideas behind them may explain the high diversity of bivalves and gastropods seen on Quirimba. It should of course be noted that, due to survey logistics, Quirimba was the most intensively studied island, and therefore the rarer species are more likely to have been found thus adding to the overall level of recorded diversity.

Zonal Diversity

The highest diversity of bivalves was found in the southern, south-western and north-western sand/seagrass areas of the western intertidal. These areas support extensive sand flats up to 1 km in width and 6 km in total length, with diverse and abundant seagrass and algal communities. Most of the bivalves found in the study (14 species out of a total of 22) were sand-dwelling. Therefore, a large and diverse sand-based habitat is also likely to be associated with a diverse bivalve population. Areas with low bivalve diversity included the northern sand flats, the reef intertidal and the subtidal outer reefs. The northern sand flats are characterised by an extensive bare sandy cover prone to high rates of disturbance due to a lack of binding surface flora, a network of deep tidally flushed channels, exposure to intense wave action and high levels of sand deposition and movement from the flats themselves and outside sources, such as Montepuez Bay and intertidal areas. Both of these geomorphological processes are likely to hinder the development of bivalve communities, interfering with colonisation, growth and spread of species. The reef intertidal and subtidal outer reef areas were characterised by a rocky and wave-swept environment which was suitable for species of the Family Malleidae and *Tridacna squamosa*, but for few other species.

Gastropod diversity was highest in the reef intertidal and the south-western sand/seagrass areas. The former was characterised by relatively low diversity of families (15) with high species diversity within them, particularly the Families Cypraeidae, Conidae and Winkles with 6-7 species within each. The only family observed to have a high diversity across all zones was Cypraeidae, which contains both sand/seagrass species (such as *Cypraea annulus* and *C. moneta*) and reef species (*C. caputserpentis* and *C. isabella*). Otherwise, there was little family/species overlap (only 9 species common to both areas), suggesting high habitat specificity for most

species, with few generalists. Gastropod diversity was lowest in the southern sand/ seagrass and subtidal reef environments. The former was characterised by large bare sand flats and patches of seagrass, providing little shelter for most of the gastropod species. The relatively limited gastropod community of the subtidal reflects the preferences of this Class for the intertidal environment. Thus, low diversity was linked to the presence of unsuitable habitats.

Overall it was found that the central, south-west and north-west sand/seagrass areas, with the most abundant seagrass beds and algal communities, held the greatest diversity of gastropods. Thus it was found that abundance, through provision of suitable habitats, was correlated with diversity.

5.0 SENCAR ISLAND

5.1 Introduction

Sencar Island (12°28.7'S 40°39'E) is approximately 1.6 km long and 0.6 km wide and situated on a south-eastern extension of the Quirimba island intertidal area (Fig. 1). The layout of the island and its associated habitats are shown in Figure 55. The north and north-western sides of the island border an extensive intertidal area. To the east of the island runs a continuous fringing outer reef and a subtidal platform which at approximately 2 km from the reef base drops over the edge of the Continental Shelf. The western and south-western sides of the island border a sheltered inner reef which at its southern point forms the northern boundary of the Montepuez Channel.

The population of the island is small, approximately 60 people, and many of these are transient having come for the fishing in the adjacent waters. During the dry season (April-October), fishermen from Nampula province may set up fishing camps on the island. There is no administration, infrastructure or fresh water on the island.

A considerable portion of the central and southern areas of the island is intertidal and covered in mangrove. The stands are separated by rock promontories and buttresses covered by dry scrub bush which produces a highly irregular series of 'grottoes'. The land available for building dwellings and cultivation is limited to a small area at the northern point of the island.

5.2 Intertidal Surveys

5.2.1 Overview

Although the intertidal area around Sencar Island is continuous with that of Quirimba, an area of approximately 3.75 km^2 which is closely associated with Sencar Island has been surveyed separately. Within this area 69 taxa of macroalgae (1 Cyanophyta, 26 Chlorophyta 15 Phaeophyta and 27 Rhodophyta), two species of seagrasses and 9 taxa of invertebrates were recorded. The algal flora of the island was co-dominated by members of the Rhodophyta and Chlorophyta. In comparison with the total number of algal taxa recorded for the C.I.G. (a total of 195) Sencar's diversity was relatively poor with approximately a third of these species present. However, in contrast to the majority of islands, the macroalgae were the dominant flora of the intertidal area except on part of the western side of island where the seagrass, *Thalassia hemprichii,* formed extensive meadows on the lower shore. Checklists of the recorded taxa are presented in Appendices 2 (algae and seagrass) and 3 (invertebrates).

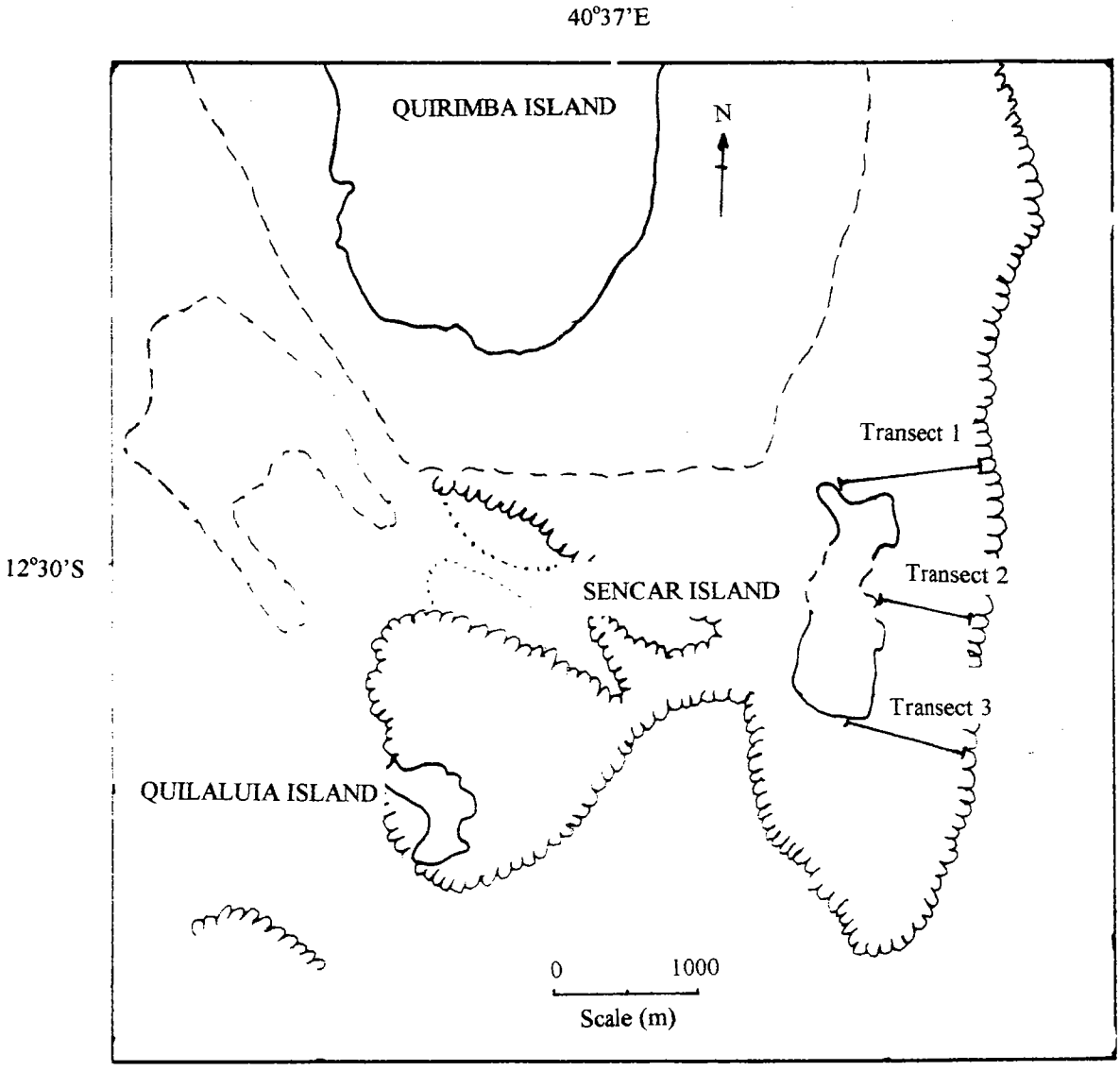


Figure 55: A map indicating the position of the intertidal transects surveyed on Sencar island.

5.2.2 Area Reports

Three transect surveys were completed along the exposed eastern shore (Fig 55). The results of these studies indicated a great similarity in species composition between the transects, with differences confined to the abundance and zonation of the flora and fauna. Given these similarities the results of surveys have been pooled. The seagrasses and macroalgae recorded for a typical transect are presented in Table 53.

Table 53. Percentage cover of seagrass and macroalgae along a typical intertidal transect (transect 2). (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2
Macroalgae		
Boergesenia forbesii	0-P	0.4 (0-5)
Caulerpa racemosa var. *clavifera*	0	0-P
Champia sp.	0	0-P
Cistoseira myrica	7.6 (0-15)	4.5 (0-30)
Dictyosphaeria cavernosa	1.0 (0-5)	0-P
Dictyota sp.	0	4.9 (0-30)
Gelidiella acerosa	0-P	0
Gelidiella ?	10 (0-60)	0
Halimeda opuntia	3.5 (0-10)	5.0 (0-40)
Hydroclathrus clathratus	0-P	1.3 (0-15)
Jania adhaerens	0	0.8 (0-10)
Laurencia papillosa	0.5 (0-5)	0-P
Padina gymnospora	0	0-P
Sargassum spp.	1.3 (0-8)	6.9 (0-20)
Turbinaria ornata	2.2 (0-10)	0-P
Udotea indica	0	0-P
Ulva pertusa	0	0-P

A cross-sectional profile of a typical transect is shown in Figure 56 Two distinct zones, the rock platform and the reef crest, were identified within which a total of 17 taxa of macroalgae and nine of invertebrates (Table 54) were recorded. The rock platform (zone 1) consisted of a number of depressions and numerous rock pools colonised by the brown algae *Cistoseira myrica* (0-15% surface cover). The intricate leaves of this macroalgae, together with *Sargassum* spp., are known to serve as a spawning habitat for various invertebrates, notably gastropods and echinoderms. This was partly corroborated by the relatively high abundance of some invertebrate species which included, gastropods of the genera *Cypraea, Conus* and *Strombus,* hermit crabs and the sea urchins, *Stomopneustes variolaris* and *Echinometra muthaei.* Seacucumbers (*Holothuria* spp.) were also common. The reef crest (zone 2) was characterised by a relatively high diversity but low abundance of algae.

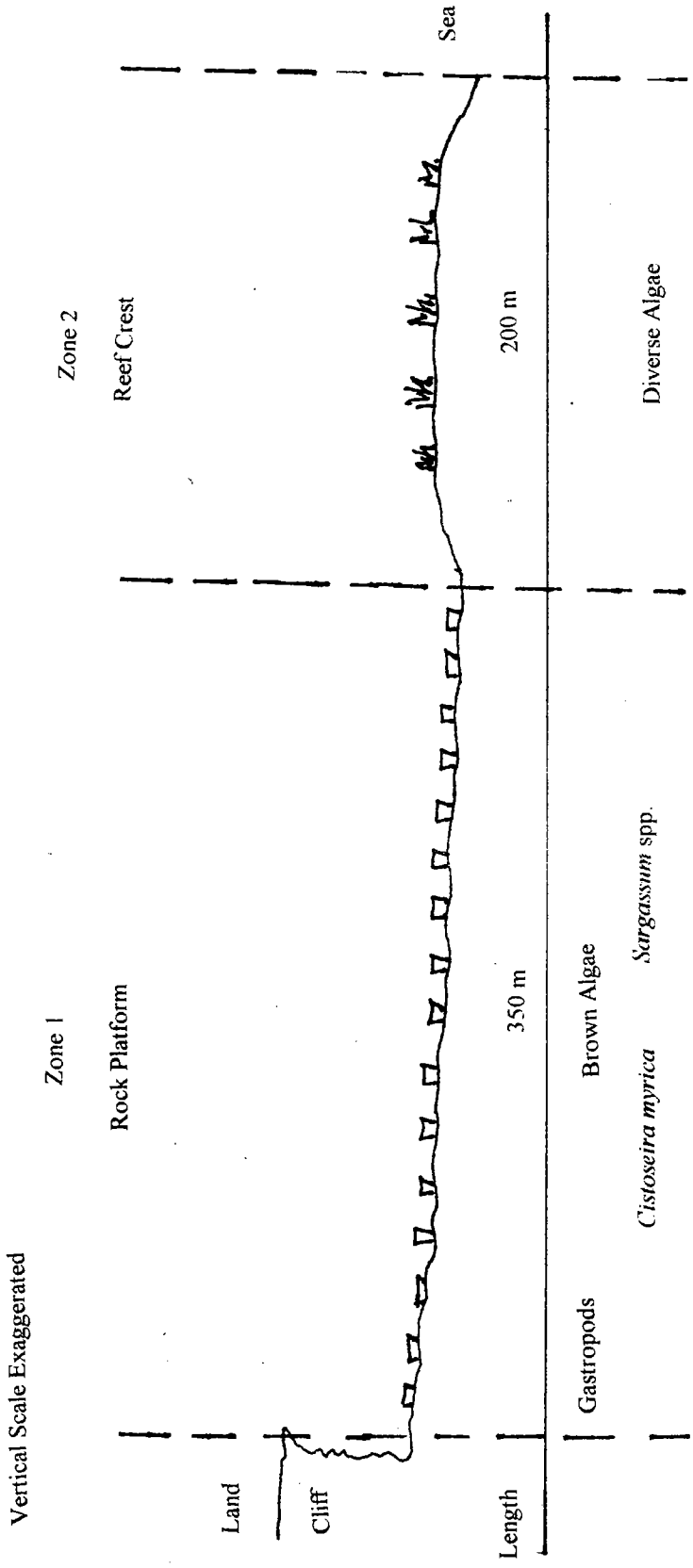


Figure 56: A diagrammatic representation f the intertidal transect, Sencar island.

Table 54. Abundance of invertebrates along a typical intertidal transect (transect 2). Means and ranges (numbers/m^2) are presented.

Invertebrates	Zone 1	Zone 2
Gastropods		
Conus ebraeus	0.4	0
Conus sp.	0	8.0
Cypraea annulus	0.8	0
Cypraea sp.	0.4	0
Rhinoclavis sinensis	0.4	0
Strombus mutabilis	0.4	0
Decapods		
Clibanarius virescens?	0.8	0
Calcinus haevinianus?	0.4	0
Echinoderms		
Stomopneustes variolaris?	8.4	0

The representation of substrate types across zones are presented in Table 55.

Table 55. Percentage composition of substrate along a typical intertidal transect (transect 2). Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2
Rock	87 (20-100)	91 (50-100)
Rubble	0	8 (0-50)
Sand	13 (0-80)	1 (0-10)

5.3 Mangrove Surveys

5.3.1 Overview

The unusual topography of Sencar Island has allowed mangrove colonisation throughout the central parts of the island in addition to the more commonly found fringe around the islands shoreline. The mangrove cannot be described as a single stand as each section is cut off into small pockets by 2-4 m high rock walls. However, as the various pockets are interconnected via numerous small creeks and passages between each of the 'grottoes' the mangroves throughout the island will be described as a single unit.

Transect Report

A single transect was surveyed through the centre of the island. The transect location is shown in figure 57 and a diagrammatic cross-sectional profile is given in Figure 58. Zonation along the transect was determined through physical separation of mangrove areas rather than by changes in community composition.

Area 1 included the beach on the western side of the island which backed onto a ridge of coral rubble, approximately 2 m high and 10 m wide, behind which a substantial mangrove stand began. On the upper shore a few isolated *A. marina* grew to about 4 m high.

Area 2 comprised a mixture of mature *B. gymnorrhiza* and *R. mucronata* trees up to 3 m high with small clumps of large (<8 m high) *X. granatum* and small *C. tagal* trees in places. This zone was bordered by a second ridge of coral rubble approximately 5 m wide.

Area 3, behind the second coral ridge, supported a homogeneous stand of dense *R. mucronata* trees, from 2-7 m in height, and a few *C. tagal* saplings. The coral rubble ridges were obviously used as pathways through the mangrove by the islanders and some large trees had been cut and laid horizontally to make walkways further into the mangrove stand. Alongside these paths and walkways evidence of cutting was widespread and was probably the reason for the lack of large trees in this area. The zone finished at a 5 m high rock wall on top of which was 'dry scrub' type vegetation. This continued for about 5 m before dropping back down into a grotto and a further zone of mangrove.

Area 4 comprised a grotto approximately 12 m wide containing a mixture of large *B. gymnorrhiza* and *R. mucronata* (<15 m high) trees and a small creek. The far side of the grotto ended at a 4 m rock wall. This led to a 50 m wide strip of highly irregular 'coral rag' with 'dry scrub' before another 4 m drop into a 15 m wide grotto.

Area 5 supported a homogeneous stand of large (<13 m high), widely spaced *R. mucronata* trees with numerous small saplings. A 4 m rock wall led up to another area of 'dry bush' type vegetation before a further 3 m drop into another pocket of mangrove.

Area 6 contained numerous small *C. tagal* (<2 m high) trees together with a few widely spaced, medium height (approximately 3 m high) *R. mucronata* trees. This area continued for approximately 120 m with many small creeks and rock outcrops splitting the groups of mangrove trees. The larger *R. mucronata* (<12 m high) trees occurred along the edges of the walls. A further short wall and a 70 m wide strip of dry land led to a short rock wall dropping back to the intertidal area on the eastern side of the island.

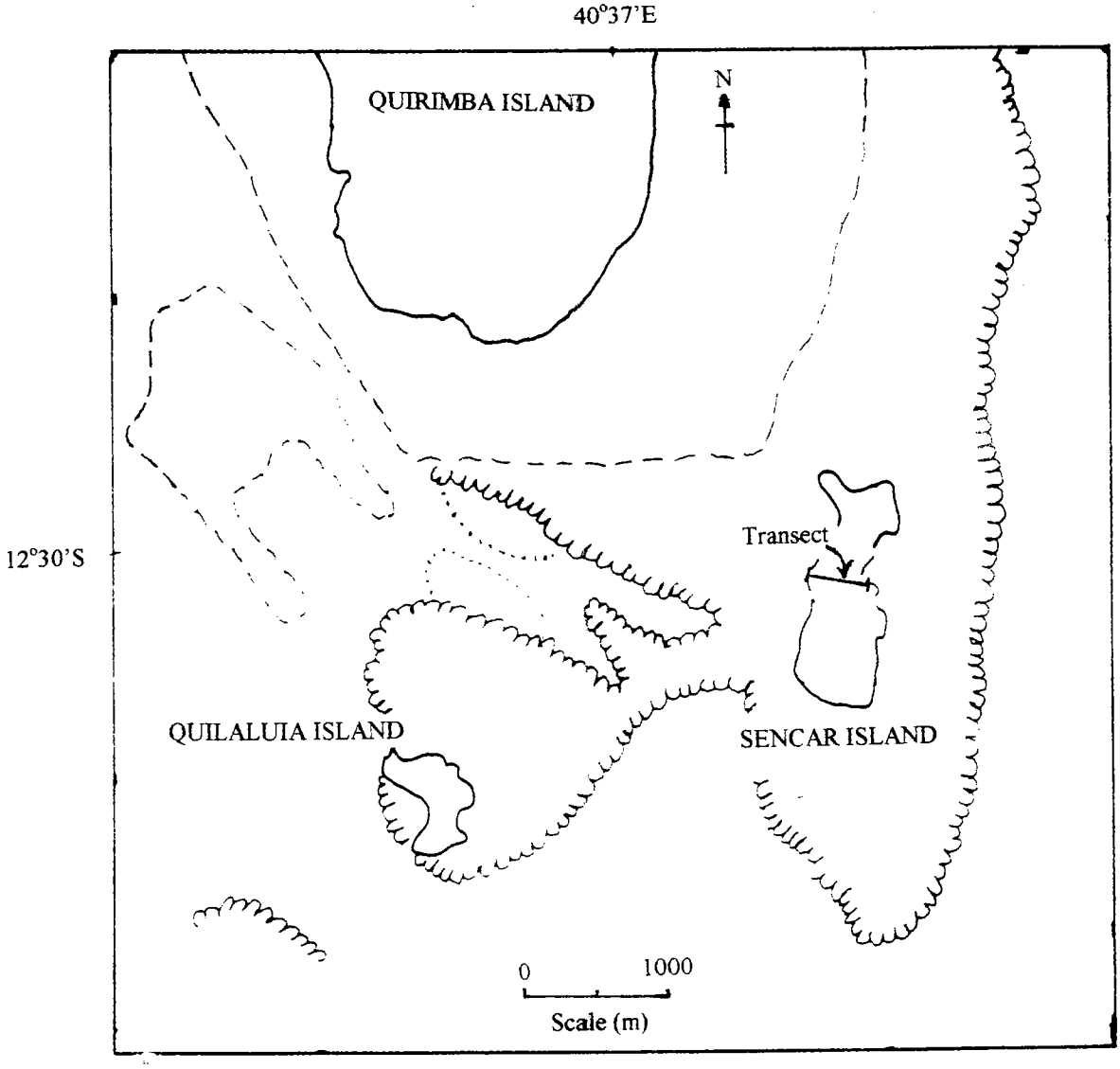


Figure 57: A map indicating the position of the mangrove transects surveyed on Sencar island.

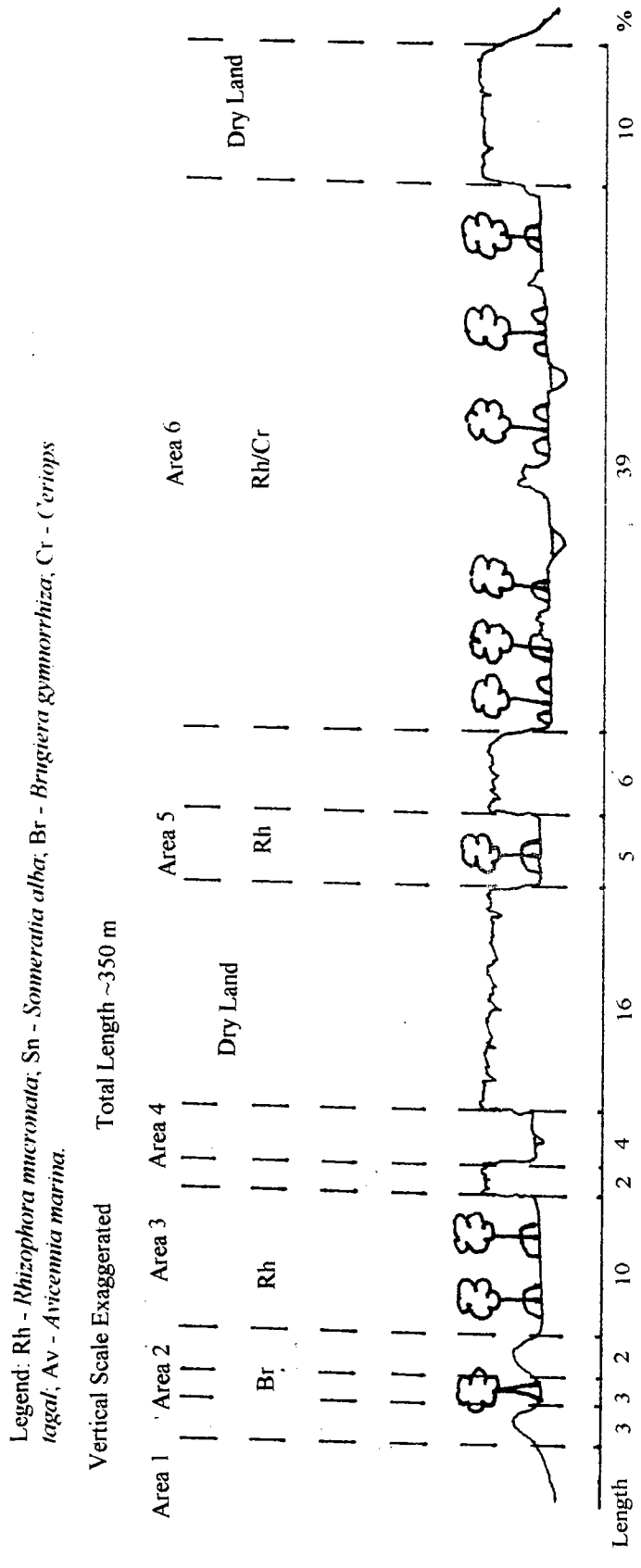


Figure 58: A diagrammatic representation of the Sencar island mangrove transect.

Quantitative Description

The species composition and structure of mangroves within each area are presented in Table 56 below (only areas with significant mangrove colonisation have been analysed).

Table 56. Mangrove species composition and structure along the Sencar Island transect.

Zone	Species	No. of trees/m^2	Relative Density	Basal Area (m^2/ha)	Relative Dominance	No. of saplings /m^2
Area 2	*R. mucronata*	0.40	37	4.2	12	0.16
	B. gymnorrhiza	0.64	59	0.7	2	1.68
	X. granatum	0.04	4	29.9	86	0.68
	C. tagal	-	-	-	-	0.72
Area 3	*R. mucronata*	5.52	100	38.4	100	1.56
	C. tagal	-	-	-	-	0.12
Area 5	*R. mucronata*	0.40	100	74.8	100	2.20
Area 6	*R. mucronata*	0.24	25	0.3	35	0.52
	C. tagal	0.80	75	0.6	65	1.72

X. granatum, despite its low abundance, was dominant in Area 2, the only area in all the mangrove areas surveyed in the "CIG" where this species was found in significant numbers. Generally, *R. mucronata* dominated the mangrove-filled grottoes in the centre of the island.

The relative isolation and variation observed between the pockets of mangrove made it difficult extrapolate results to estimate the overall composition and development of the mangrove for the central part of the island (Table 57). However, it was probable that *R. mucronata* was the dominant species and the estimate of mean stand diameter is probably low due to the inclusion of the very dense thickets of young trees that were found in Area 3.

Table 57. Estimates for the size and composition of the 'Sencar Stand'. All original figures were estimated to the nearest 100 and all basal area values have been calculated to the nearest 10 m^2. 'n/a' denotes present in the stand but not recorded within survey quadrats.

Mangrove Species	Total number of trees	Mean Stand Diameter (cm)	Total Basal Area (m^2)
R. mucronata	325,400	3.8	370
B. gymnorrhiza	9,200	1.2	0*
C. tagal	149,800	1.0	10
X. granatum	600	30.8	40
A. marina	n/a	n/a	n/a

**B. gymnorrhiza* total basal area was approximately 1 m^2.

Fauna of the 'Sencar Stand'

No live animals were recorded within the survey quadrats (Table 58). However, a few of the fiddler crabs, *Uca* sp., were seen in Area 2 and a number of unidentified brachyuran crab, possibly *Sesarma* sp., were observed in some of the grottoes in the centre of the island.

Table 58. Benthic fauna of the 'Sencar Stand'.

Zone	Number of Crab Holes (/m^2)	Number of Crabs (/m^2)	Number of Gastropods (/m^2)
Area 2	2.9	0.0	0.0
Area 3	3.2	0.0	0.0
Area 5	4.2	0.0	0.0

5.4 Subtidal Habitat Surveys

Subtidal surveys were conducted in five areas along the eastern and south-western reefs of the island (Fig. 59).

5.4.1 Overview

Reef Structure and Composition

The reef morphology differed considerably between sites with reef slopes generally steeper and narrower at the more sheltered sites and forming gently sloping (0-5°) reef platforms at the outer reef sites. Rugosity was highly variable within and between sites and followed no identifiable pattern.

Rock was the most abundant of all the substrate types, typically forming up to half of the reef area (maximum ~90 %) although there were often large variations in the proportion of rock substrate with depth at a given site. However, no correlation was identified between substratum and depth. Rubble and sand were observed in lower concentrations and shared a similar high level of variation both with depth on the reef and between sites.

Hard corals were the dominant biota at all sites and all depths on the reef, with a typical surface cover of <50 %, although variation within a site was often high. In comparison, soft corals were generally not abundant, although they were observed to be present at all sites and depths. Seagrasses were absent from all 5 sites. Macroalgae and *Halimeda* spp. were both found in low abundances.

Coral cover at most sites was of mixed forms with no dominants observed. However, the lower reef at Site SC2 exhibited an area of homogenous branching form corals.

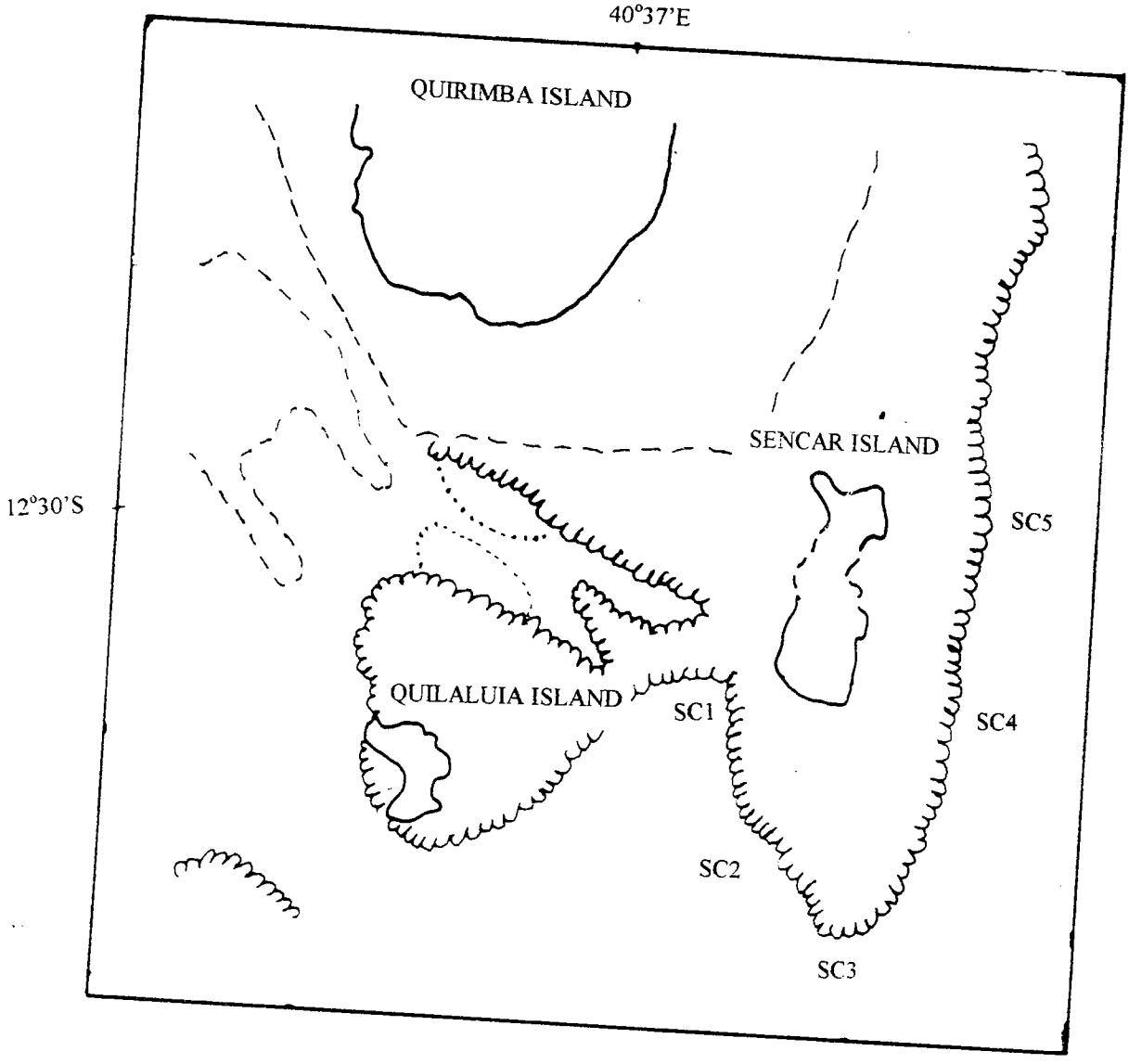


Figure 59: A map indicating the position of the subtidal survey sites around Sencar island.

Coral Composition

Sites SC1 and SC2 were relatively sheltered areas where the reef included large coral bommies on extensive sand and rock slopes. Sites SC3 and SC4, located on the exposed outer reef, were typified by broad flat plateaux with extensive 'spur' and 'groove' formations.

'Large massive' coral forms were poorly developed or absent at all sites and, where found, *Porites* and *Platygyra* were the most common genera. At all sites, the 'Small massive' forms were more diverse and widespread than the 'Large massives', particularly *Porites*. *Favia* was limited to the sites of the southern 'corner' (SC2, SC3 and SC4). *Favites*, *Platygyra*, *Goniastrea* and *Galaxea* were limited to the northern site (SC4), whilst the other Faviids were limited to the outer reef (sites SC3 and SC4).

Acroporas were found at all sites although not in the 'Bush' form. 'Staghorn' forms were abundant at the southern 'corner' sites (SC2 and SC3), the shallowest areas of the northern site (SC4) and were absent from the most sheltered site (SC1). 'Small tables' were the dominant hard coral form at all sites and at all depths. 'Large tables' were also found at all the sites, but were less common than the 'Small tables'. The larger tables were most abundant at the exposed sites. *Pocillopora* was only present at SC2 and SC3.

The 'Encrusting' forms of *Echinopora* and *Montipora* were present at all sites, whilst the 'Encrusting' form of *Turbinaria* was only found at SC2. The 'foliose-plate' form of *Pachyseris* was only present at the sheltered sites. The 'Large polyp' coral *Lobophyllia* was widespread, whilst *Plerogyra* was limited to the sheltered SC1 and SC2. 'Solitary' Fungiids and *Tubastrea* were only present at site SC2.

The composition of 'soft' corals at each sites differed considerably, but with most genera recorded, relatively abundant at each site.

5.4.2 Site Reports

Site SC1:

The reef structure and community composition are summarised in Table 58 and Figure 60 below.

Reef Structure

The reef was best developed at 4-6 m below which it graded into a steep (30°) sand slope with large bommies, up to 20-50 m in diameter, at 10-12 m. These bommies covered approximately 20 % of the total slope area, the rest being bare sand. Rugosity was highest on the reef at the top of the slope.

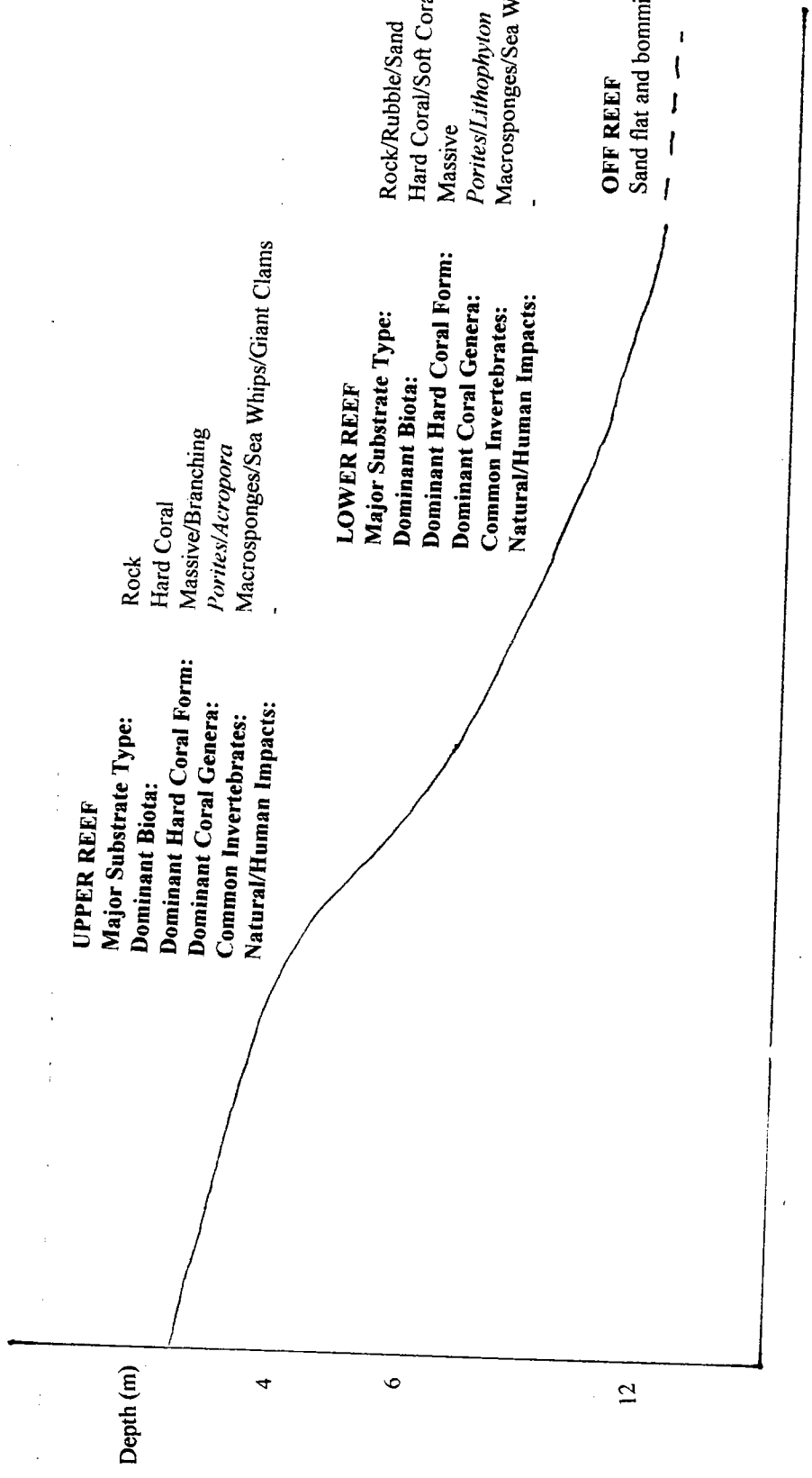


Figure 60: A diagrammatic representation of the "Reef Profile" at site SC1. A summary of the major features of the site is presented.

Substrate Composition

Substrate composition varied significantly with depth (Table 58) with the upper slopes almost entirely rock and the lower slopes a more equal mix of rock, rubble and sand.

Biotic Cover

Hard coral cover was approximately 3 times greater on the upper slopes than on the lower slope. The abundance of soft corals, macroalgae and *Halimeda* spp. were low throughout. Although most of reef was covered in a heterogeneous mix of hard coral forms, small patches at the top of the reef were dominated by massive and branching forms.

Table 59. A summary of the structure, composition and biotic cover at SC1 (P=<1 % cover; Ma-Massive form; Br-Branching form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (°)	20	5-40	30	30-40
	Rugosity	4	3-4	2	0-3
Substrate	Rock	5	4-6	3	1-4
	Rubble	1	P-1	2	1-2
	Sand	2	P-3	3	2-5
	Mud	-	-	-	-
Biota	Hard Coral	4	4-5	2	P-3
	Soft Coral	1	P-1	1	P-1
	Seagrass	-	-	-	-
	Macroalgae	0P	0-P	P	0-P
	Halimeda spp.	1	P-1	P	0-P
Coral state	Heterogeneity	-	-	-	-
	Dominance	Ma, Br	-	Ma	-

Coral Composition

Massive Forms: 'Large massive' forms were the dominant coral type on the bommies, with *Porites* particularly abundant and covering up to 20 % of the rock surface. *Goniastrea* and *Diploastrea* were also widespread, with an estimated 5 % surface cover. *Favia* and *Platygyra* were present at low densities. *Porites* was also the most abundant of the 'Small massive' forms, with a surface cover on the bommies of up to 10 %. *Favites* and *Platygyra* had an estimated 5 % surface cover and *Galaxea* was more scarce with less than 1 % cover.

Branching/Table Forms: *Acropora* was restricted to the 'Small table' form, which comprised up to 10 % of the coral cover on the bommies. A few 'Large tables' were observed on a single bommie.

Encrusting/Foliose/Plate Forms: There were virtually no 'Encrusting', 'Foliose' or 'Plate' corals, except for the 'Encrusting' form of *Echinopora* which was observed at 5 % surface cover on a single bommie. The 'large polyp' corals *Plerogyra* covered 5 %, and *Lobophyllia* 1 % of the bommies.

Soft Corals: Five 'soft' coral genera were identified; *Lithophyton*, *Heteroxenia* and *Sinularia* with approximately 5 % surface cover on the bommies, and *Dendronephthya* and *Sarcophyton* with less than 1 % surface cover.

Site SC2:

The reef structure and community composition are summarised in Table 59 and Figure 61 below.

Reef Structure

The lower rocky slope rose from the reef base at 16 m at an angle of 30° to 14 m over a distance of approximately 20 m. Above 14 m the slope became shallower with an extensive, flat sand area that rose gradually to 12 m. A few coral bommies (approximately 3 m diameter by 2 m high) were present on the sand slope. Above the sand platform the reef again became rocky rising, on a similar gradient to the lower slope, to 10 m. Rugosity was variable throughout.

Substrate Composition

Rock was the dominant substrate type over much of the reef slope, with sand dominant on the platform at the mid reef. Rock, rubble and sand were present at all depths, with rubble most common at the base of the reef.

Biotic Cover

Hard coral was the dominant cover at all sites, being most abundant on the upper reef and with more variable cover towards the base of the reef. Soft corals were most abundant on the deeper reef. Macroalgae and *Halimeda* spp. were present at low levels over much of the reef although in small areas at the top of the reef *Halimeda* spp. covered up to 10 % of the substrate. Coral forms were most diverse at the top of the reef, whilst towards the bottom of the reef, branching, encrusting and foliose form corals were dominant and, on occasion, formed small homogenous stands.

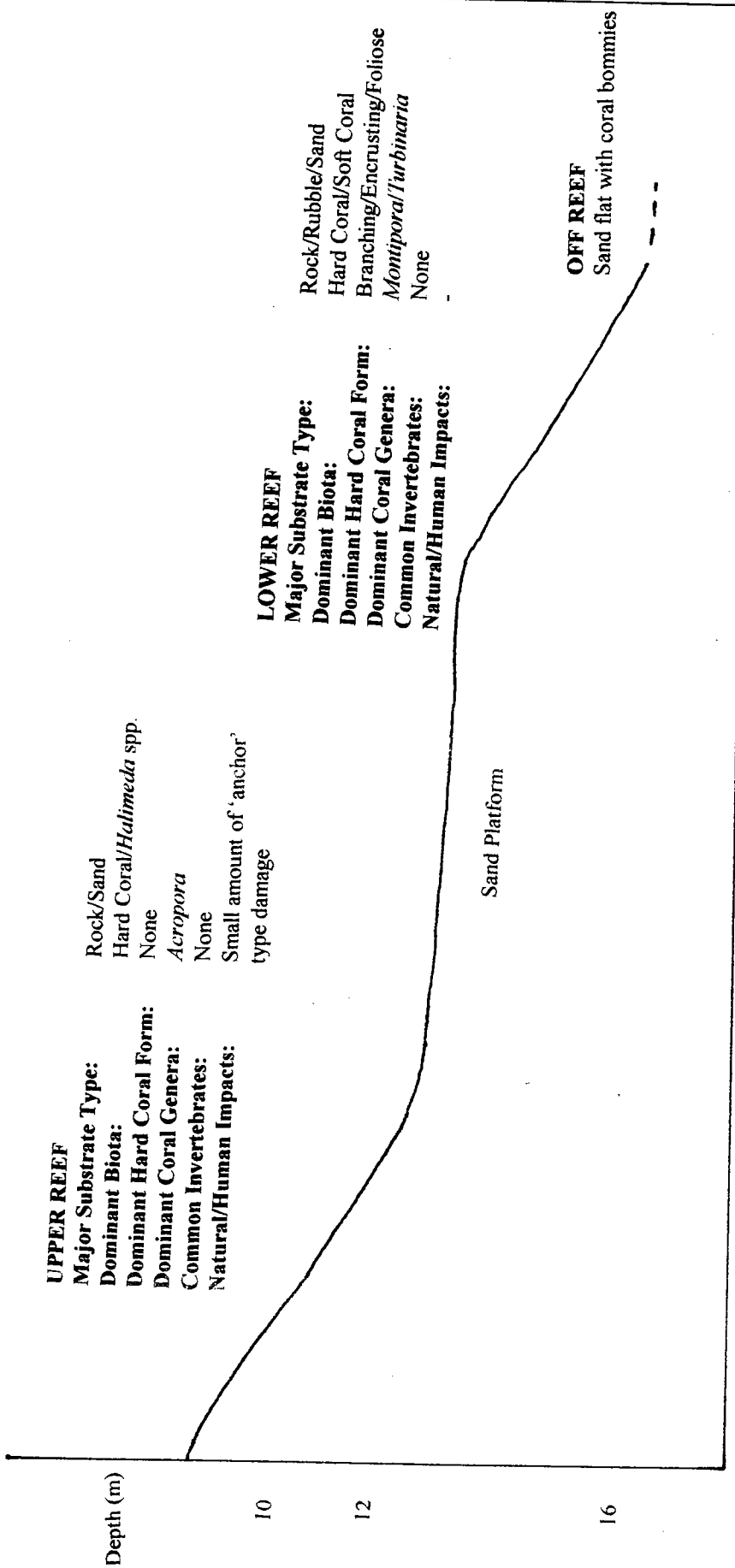


Figure 61: A diagrammatic representation of the "Reef Profile" at site SC2. A summary of the major features of the site is presented.

Table 60. A summary of the structure, composition and biotic at SC2 (P=<1 % cover; En-Encrusting form; Br-Branching form; Fo-Foliose form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (°)	0	0	6	0-10
	Rugosity	3	3-4	2	0-4
Substrate	Rock	4	3-4	3	0-5
	Rubble	1	P-1	2	0-3
	Sand	3	1-3	3	0-5
	Mud	-	-	-	-
Biota	Hard Coral	4	3-4	2	0-4
	Soft Coral	1	P-1	2	0-3
	Seagrass	-	-	-	-
	Macroalgae	1	P-1	P	0-1
	Halimeda spp.	2	1-2	-	-
Coral state	Heterogeneity	0	0	0	0-1
	Dominance	-	-	Br, En Fo	

Coral Composition

Massive Forms: 'Large massive' coral forms were scarce, with only *Porites* present and restricted to a depth of 14-10 m. 'Small massive' forms were totally absent from sand platform but at other depths *Porites*, *Favia*, *Favites*, *Platygyra* and *Galaxea* were widespread. Similarly, *Acropora* was absent from the sand platform, but 'Staghorn', small and large 'Table' forms of the genus were found over the rest of the reef. *Pocillopora* was restricted to the deeper parts of the reef (16-13 m).

Encrusting Forms: *Echinopora* was found between 14-10 m. *Montipora* and *Turbinaria* were limited to the deeper 16-14 metre rock slope. Conversely, *Pachyseris* was limited to the upper 10-13 m.

Other Forms: The 'large polyp' corals, *Lobophyllia* and *Plerogyra*, were observed to be most abundant in the deeper 13-16 metre depth range (*Lobophyllia* was also found on the upper slope). Fungiids were found on the lower slope.

Soft Corals: The 'soft' corals *Lithophyton*, *Dendronephytha*, *Heteroxenia* and *Sinularia* were widespread but absent in the sand/bommie zone at 13 m.

Site SC3:

The reef structure and community composition are summarised in Table 61 and Figure 62 below.

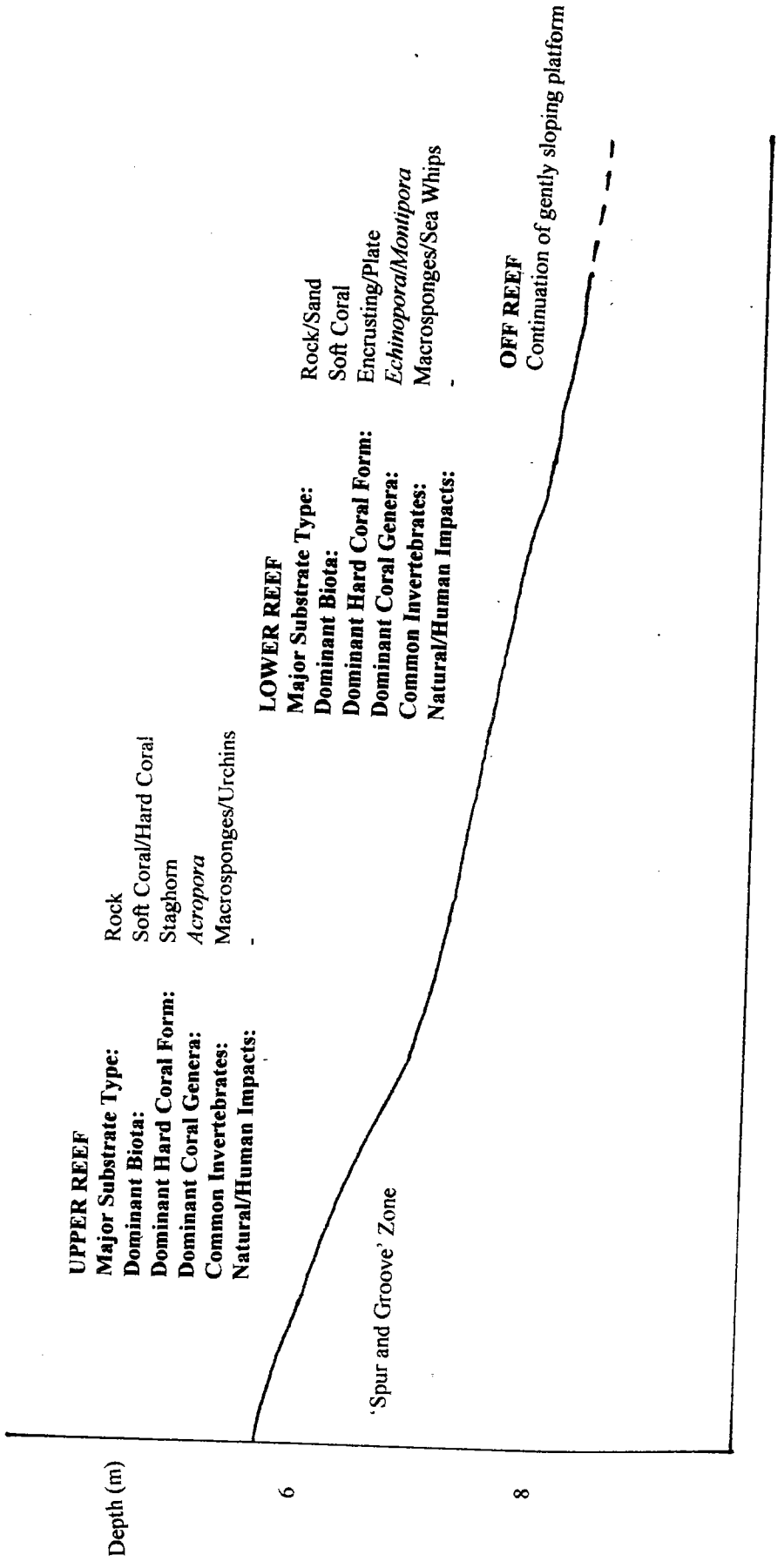


Figure 62: A diagrammatic representation of the "Reef Profile" at site SC3. A summary of the major features of the site is presented.

Reef Structure

The main feature of the reef was a broad platform at 6-7 m with a well developed formation of 'spurs and grooves' and an area of flat rocks and low-lying corals. The 'grooves' were between 2-4 m deep and 5 m wide, and the width of the spurs averaged 20 m.

Substrate Composition

Rock was the dominant substrate with rubble present in moderate sized patches, and sand present in small patches. Substrate composition was more variable in the deeper sections of the reef.

Biotic Cover

Hard corals were dominant over the majority of the reef although soft corals dominated on the shallower parts of the reef (<7 m). Hard coral cover was reduced on the deepest sections of the reef. Macroalgae and *Halimeda* spp. were present over the whole reef. There was a marked zonation of coral forms with depth, with staghorn dominant at the top of the reef, branching on the mid reef and encrusting, foliose and plate forms on the lower reef.

Table 61. A summary of the structure, composition and biotic cover at SC3 (P=<1 % cover; En-Encrusting form; St-Staghorn form; Pl-Plate form).

Reef Features		Upper Reef Mode (0-6)	Upper Reef Range (0-6)	Lower Reef Mode (0-6)	Lower Reef Range (0-6)
Morphology	Slope (°)	10	5-20	10	10-30
	Rugosity	4	3-4	3	2-4
Substrate	Rock	5	4-5	3	2-5
	Rubble	2	2-3	2	0-4
	Sand	1	P-1	3	2-4
	Mud	-	-	-	-
Biota	Hard Coral	3	3	2	P-2
	Soft Coral	4	1-5	4	4
	Seagrass	-	-	-	-
	Macroalgae	P	P	P	0-P
	Halimeda spp.	P	0-P	P	P
Coral state	Heterogeneity	0	0	0	0
	Dominance	St	-	En, Pl	-

Coral Composition

Massive Forms: 'Large massive' forms were absent from the site. 'Small massive' coral forms, primarily *Porites* and *Platygyra*, covered 10 % of the reef at this site. *Favia* and *Favites* were present in small quantities.

Branching/Table Forms: *Acropora* was the dominant coral and the 'Staghorn' form covered up to 20 % of the area, whilst 'Small' and 'Large tables' covered approximately 15 %. of the reef. *Pocillopora* covered approximately 10 % of the reef.

Encrusting Forms: *Echinopora* and *Montipora* covered 5-10 % of the reef.

Other Forms: *Lobophyllia* was the only 'large polyp' coral, covering approximately 5 % of the reef. 'Solitary' Fungiids and *Tubastrea* were absent.

Soft Corals: Four 'soft' coral genera were present. *Lithophyton* and *Sinularia* covered approximately 15 % and *Heteroxenia* and *Sarcophyton* approximately 10 % of the reef.

Site SC4:

The reef structure and community composition are summarised in Table 61 and Figure 63 below.

Reef Structure

The reef formed a gently sloping reef platform from 6-14 m, which could be divided into 2 zones. The lower zone, between 14 and 10 m, was a sand plain with occasional small bommies. The upper zone, between 10 and 6 m, had a greater cover of coral and was more rugose although large patches of sand were still present.

Substrate composition

Substrate composition was highly variable with an equal mix of sand and rock on much of the upper and mid reef although there were some areas where rock was dominant. The lower reef was predominantly sand.

Biotic Cover

Hard corals were dominant over much of the reef and most abundant at 7-8 m. Soft corals were less abundant, but again were most abundant at 7-8 m. Macroalgae and *Halimeda* spp. were present but uncommon. Hard coral forms were heterogeneous throughout.

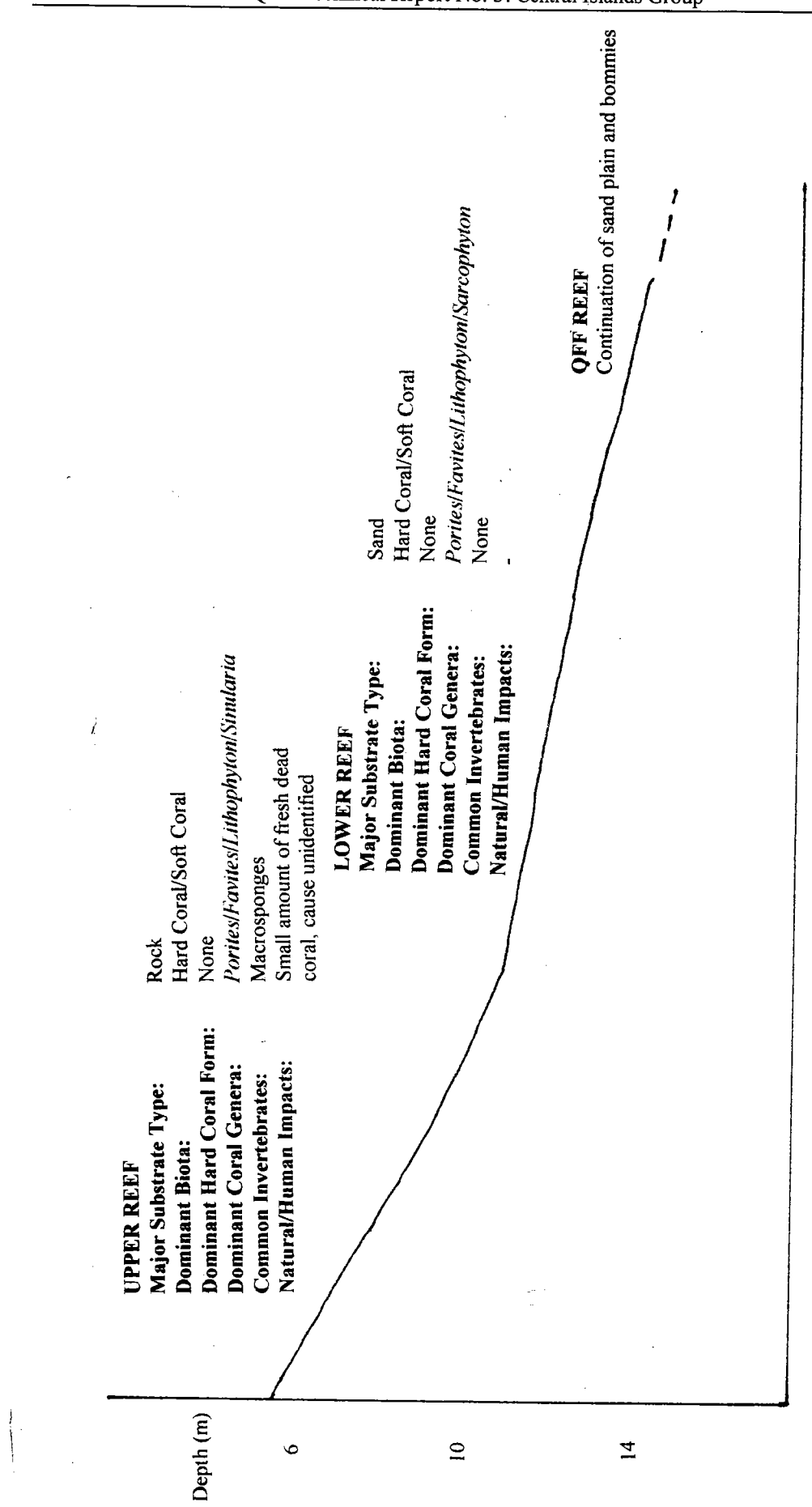


Figure 63: A diagrammatic representation of the "Reef Profile" at site SC4. A summary of the major features of the site is presented.

Table 62. A summary of the structure, composition and biotic cover reef at SC4 (P=<1 % cover).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	3	0-5	3	0-5
	Rugosity	4	3-5	3	2-4
Substrate	Rock	4	1-5	2	1-4
	Rubble	2	2	1	0-1
	Sand	2	1-4	5	2-6
	Mud	-	-	-	-
Biota	Hard Coral	3	2-4	2	1-4
	Soft Coral	2	1-2	2	1-2
	Seagrass	-	-	-	-
	Macroalgae	1	P-1	1	P-1
	Halimeda spp.	1	1	1	P-1
Coral state	Heterogeneity	0	0	0	0
	Dominance	-	-	-	-

Coral Composition

Massive Forms: Although 'Large massive' coral forms were absent 'Small massive' forms were diverse and widely distributed. *Porites* and *Favites* were present throughout. *Goniastrea* and *Galaxea* were most developed in the 'spur and groove' zone whilst *Platygyra* and other Faviids colonised the small bommies of the deeper reef.

Branching/Table Forms: 'Small' and 'Large table' forms of *Acropora* were widespread, with the 'Staghorn' forms limited to the 'spur and groove' zone.

Encrusting Forms: 'Encrusting' forms were generally poorly developed, with *Montipora* restricted to a depth of 10-8 m and *Echinopora* to 14-12 m.

Other Forms: Both 'Large polyp' and' Solitary' forms and *Millepora* were absent.

Soft Corals: The 'soft' corals *Lithophyton*, *Sarcophyton* and *Sinularia* were conspicuous throughout whilst *Heteroxenia* was limited to a depth of 14-12 m.

5.5 Subtidal Invertebrate and Impacts Surveys

Survey sites are as for the subtidal habitat surveys in Figure 59.

5.5.1 Overview

The reefs around Sencar island supported relatively few invertebrates, although in a few localised areas at the more sheltered sites (sites SC1 and SC2) the densities were quite high. The exposed sites were particularly poor in both the diversity and abundance of invertebrates. Coral damage attributed to natural causes was not common and human impacts were limited to isolated areas where damage may have been caused by boat anchors.

5.5.2 Site Reports

Site SC1:

The distribution and density of invertebrates and the incidences of reef damage are summarised in Table 63 and are described below.

The diversity of invertebrates was relatively low, although both Macrosponges and Sea whips were common over much of the reef (the former more common on the upper reef and the latter on the lower reef). Natural coral damage was not recorded but damage attributed to boat anchors and lost pieces of fishing line were found.

Table 63. Invertebrate and Natural/Human Impacts at Site SC1 (values are for the number of individuals observed in 5 mins. of surveying).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		9.5	5-14	3.3	1-7
Sea Whips		4.7	0-11	17.0	8-A
Sea Fans				0.2	0-1
Bivalves	Giant Clams	3.2	2-5	0.7	0-2
Sea cucumbers	Holothuria			0.3	0-1
Impacts	**Causes**				
Human Effects	Anchor damage	0.2	0-1		
	Fishing lines			0.2	0-1

Site SC2:

The distribution and density of invertebrates and the incidences of reef damage are summarised in Table 63 and are described below.

Although not observed during the surveys, a high abundance of both Macrosponges and Sea whips (<50-100 individuals/5 mins. and <20-50 individuals/5 mins. respectively) were observed in localised areas towards the bottom of the reef. The other invertebrates recorded occurred at much lower densities (typically <4 individuals/5 mins.). Coral damage was confined to the upper reef where sedimented massive corals and small areas of anchor damage were observed.

Table 64. Invertebrate and Natural/Human Impacts at Site SC2 (values are for the number of individuals observed in 5 mins. of surveying).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		0.4	0-2	0.2	0-1
Sea Whips		0.4	0-2	1.0	0-4
Sea Fans				1.2	0-4
Bivalves	Giant Clams	0.6	0-1	0.6	0-2
Sea	Holothuria	0.4	0-1		
Cucumbers	*Synapta* spp.			0.2	0-1
	Other			0.2	0-1
Impacts	**Causes**				
Fresh Dead	White band				
Corals	Sedimentation	0.4	0-2		
Human Effects	Anchor damage	0.6	0-2		

Site SC3:

The distribution and density of invertebrates and the incidences of reef damage are summarised in Table 65 and are described below.

Relatively few invertebrates were recorded although Sea whips were common on the lower reef and urchins on the upper reef. Damage was very limited, with a single example of fresh dead coral (cause unknown) observed. No evidence of human impacts were found.

Table 65. Invertebrate and Natural/Human Impacts at Site SC3 (values are for the number of individuals recorded during 5 mins. of surveying).

		Upper Reef		Lower Reef	
Analysis		**Mean**	**Range**	**Mean**	**Range**
Macrosponges		1.8	1-3	1.6	0-4
Sea Whips				3.4	0-5
Bivalves	Giant Clams	0.2	0-1		
Urchins		2.8	1-13		
Sea Cucumbers	Others	0.2	0-1	0.8	0-2
Dead Coral	Other	0.2	0-1		
Human Effects	Anchor damage				

Site SC4:

The distribution and density of invertebrates and the incidences of reef damage are summarised in Table 65 and are described below.

A greater number of invertebrates were recorded on the upper reef slope, with only sea cucumbers observed on the lower reef. Macrosponges were the most abundant invertebrate on the upper reef (<7 individuals/5 mins.). Little coral damage was noted and that seen was limited to a combination of fresh dead coral (cause unknown) and small areas of anchor damage.

Table 66. Invertebrate and Natural/Human Impacts at Site SC4 (values are for numbers of individuals recorded during 5 mins. of surveying)

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		4.2	1-7		
Sea Whips		0.2	0-1		
Bivalves	Giant Clams	2.0	0-4		
Lobsters		0.2	0-1		
Sea Cucumbers	Others	0.1	0-2	0.3	0-2
Impacts	**Causes**				
Dead Corals	Sedimented			0.6	0-2
	Unknown	0.8	0-1	0.3	0-1
Human Effects	Anchor damage	0.2	0-1		

5.6 Reef Fish Census

Sites surveyed are as for the subtidal habitat surveys shown in Figure 66 above.

5.6.1 Overview

Reef fish assemblages differed significantly between sites in reflection of the wide range of reef habitats present. The diversity of reef fish on each site is given in Table 67. In general, the sites surveyed on the outer reef supported the highest diversity and abundance of reef fish. For a complete list of the censused species present at each site refer to Appendix 6. A comprehensive list of all fish species recorded during the surveys of the C.I.G. is presented in Appendix 8.

Table 67. Relative Diversity Indices (R.D.I.) and total numbers of reef fish species observed. Numbers are for those fish observed of the 72 species censused.

Site	R.D.I.	Total No. Species
SC1	0.17	12
SC2: Shallow	0.27	19
SC2: Deep	0.33	23
SC3: Shallow	0.31	22
SC4: Shallow	0.41	29
SC4: Deep	0.23	16

5.6 Site Reports

Site SC1:
With only 12 species recorded this site held the lowest diversity of reef fish of all sites around Sencar Island. However, the abundance of some species was still relatively high, including the surgeonfish, *Acanthurus nigrofuscus*, (<20-50 fish/5 mins.), *Ctenochaetus strigosus* (<19 fish/5 mins.) and *Zebrasoma scopas* (<10 fish/5 mins.). The low diversity may be a reflection of the limited cover of coral at this site. The relative abundance and diversity of reef fish recorded are shown in Figure 64.

Site SC2:
Acanthurids, particularly *Acanthurus nigrofuscus* (<0-50 fish/5 mins.), and Chaetodontids, including *Chaetodon auriga* (<10 fish/5 mins.) and *C. trifasciatus* (<10 fish/5 mins.), were the most abundant species recorded. There was little variation in reef fish abundance or diversity with depth, although a small increase in diversity on the deeper sections of the reef resulted from an increased occurrence of goatfish (Mullids) and angelfish (Pomacanthids) species. Three Napoleon wrasse (*Cheilinus undulatus*, estimated lengths 60-130 cm) were observed. The relative abundance and diversity of reef fish recorded on the upper and lower reef slopes are shown in Figures 65 and 66 respectively.

Site SC3:
Surgeonfish (Acanthurids) accounted for over 60% of the reef fish observed (mainly *Acanthurus nigrofuscus*, <20-50 fish/5 mins. and *A. leucosternon*, <8 fish/5 mins.) whilst butterflyfish (Chaetodontids) accounted for half of all species identified. The relative abundance and diversity of reef fish recorded are shown in Figure 67.

Site SC4:
The diversity of reef fish species on the shallower (<10 m) reef slopes was almost double that on the deeper sections (approximately 15 m) of the reef (29:16 species respectively). This was accounted for by the absence of goatfish (Mullids) and angelfish (Pomacanthids) at depth and an increase in the diversity of butterflyfish (Chaetodontids) in the shallower water. The abundance of reef fish was also higher in the shallower water with the Spotted unicornfish (*Naso brevirostris*, <20-50 fish/5 mins) the most common. The relative abundance and diversity of reef fish recorded on the upper and lower reef slopes are shown in Figures 68 and 69 respectively.

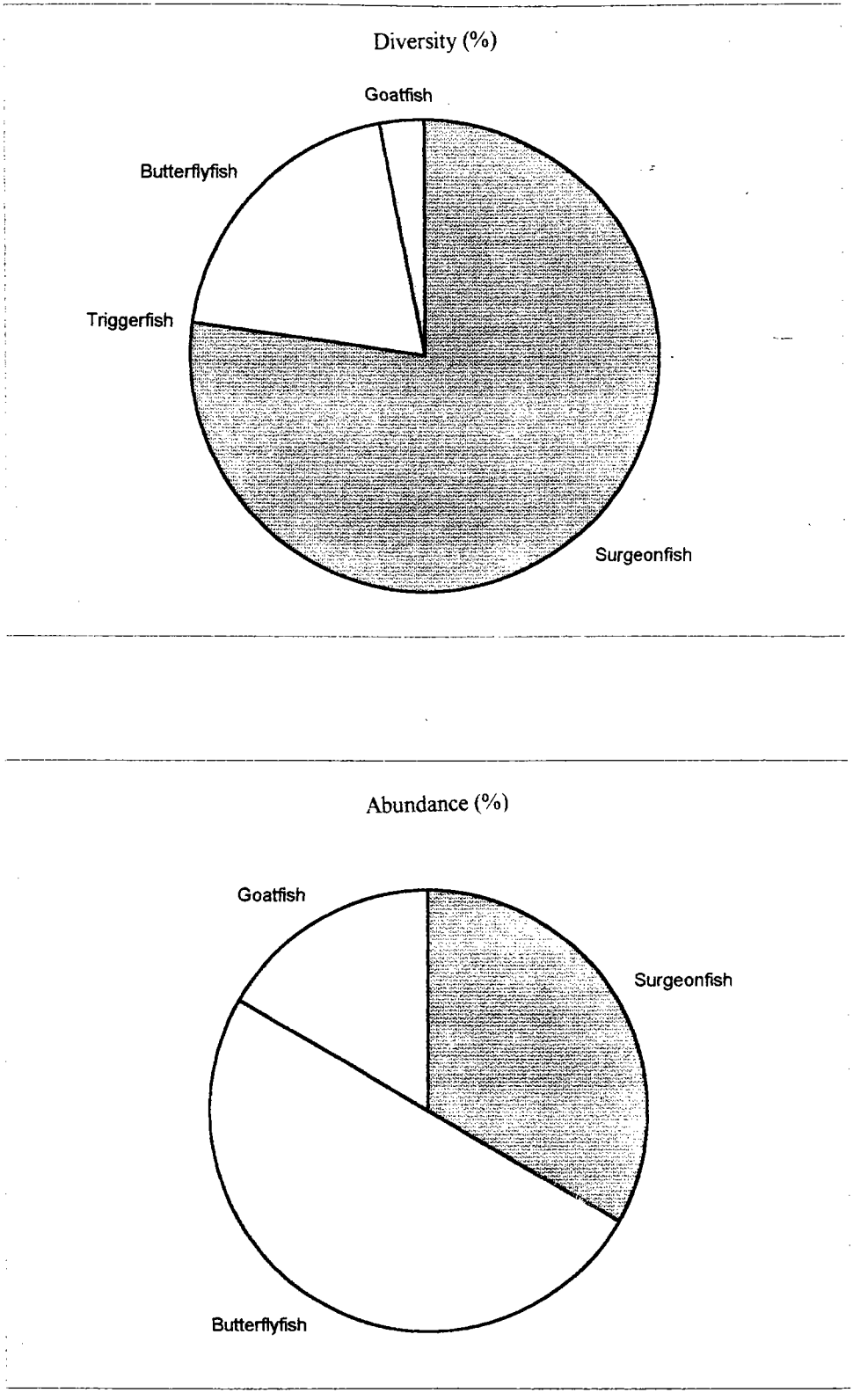


Figure 64: The relative diversity and abundances of the reef fish families at site SC1.

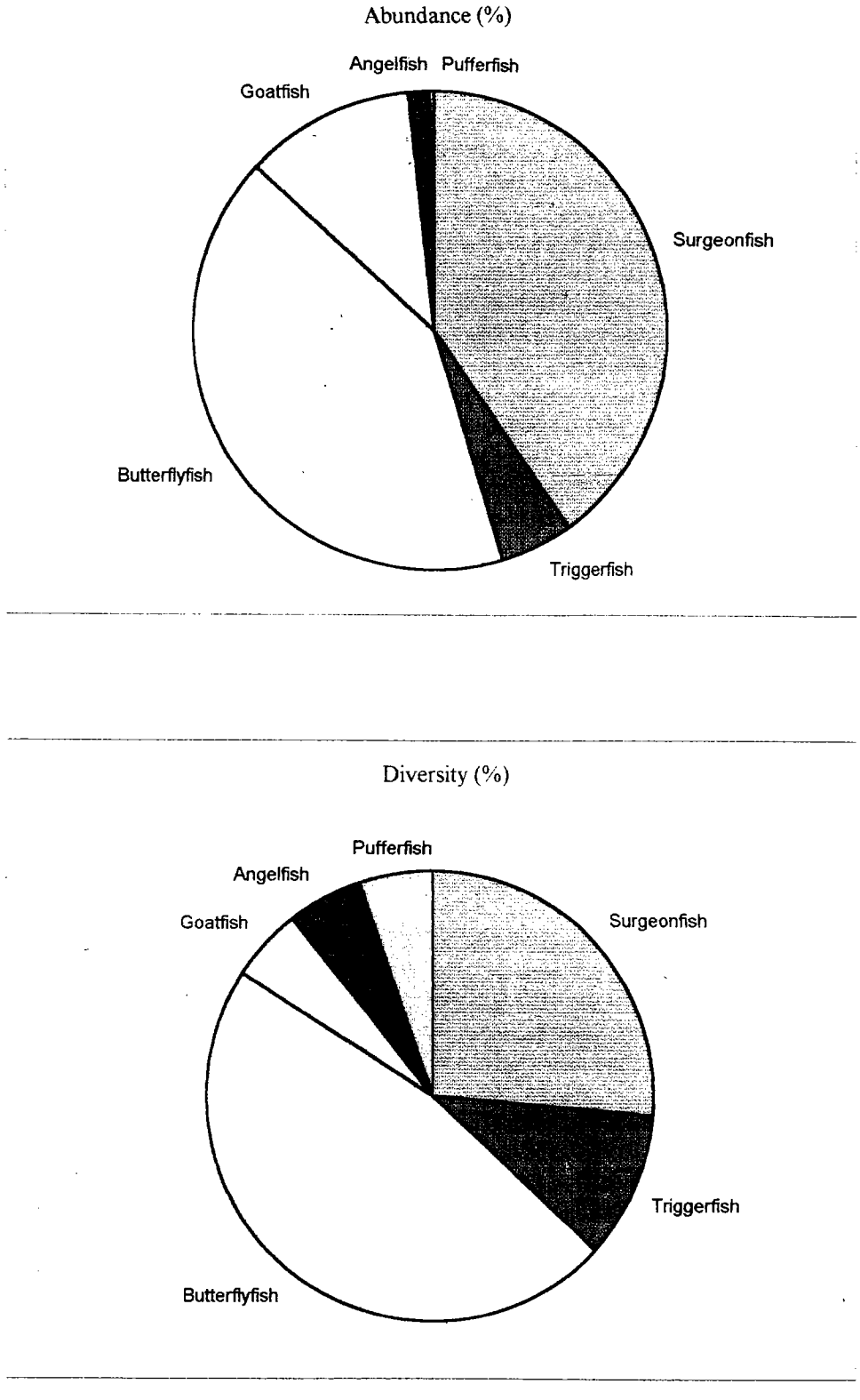


Figure 65: The relative diversity and abundances of reef fish families at site SC2, Upper reef.

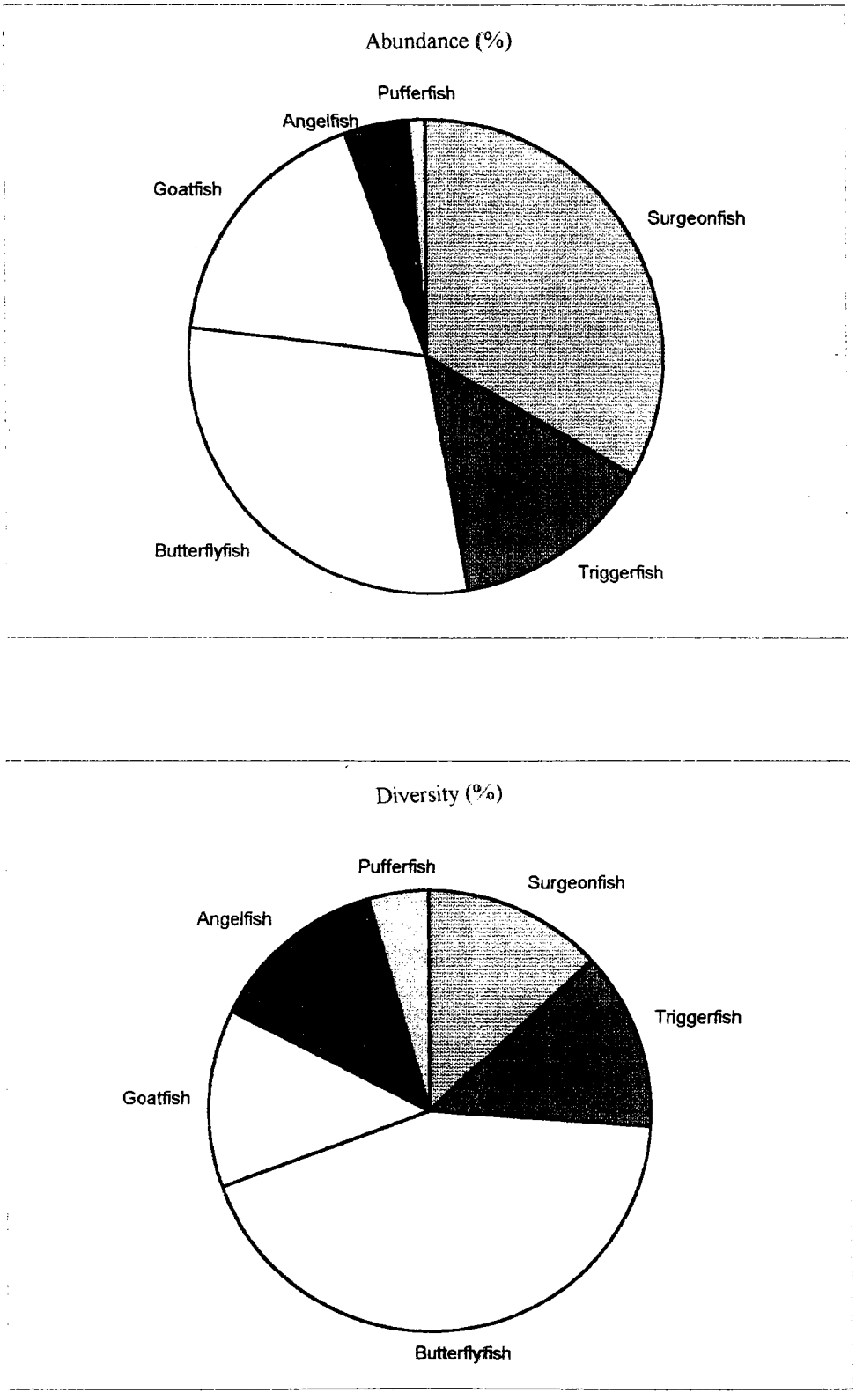
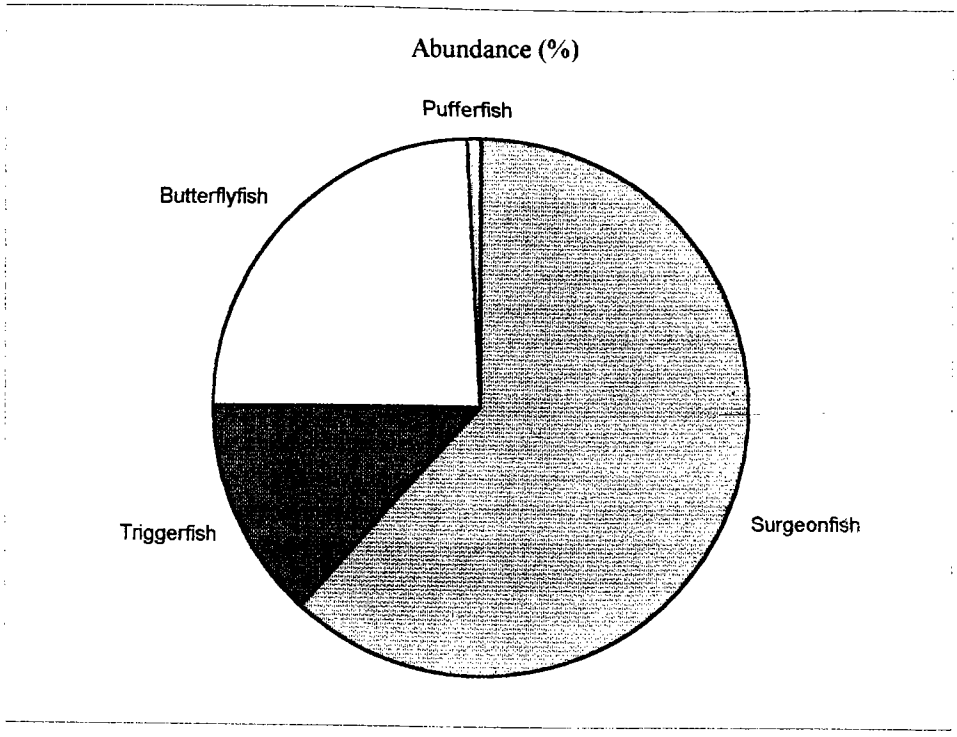


Figure 66: The relative diversity and abundances of reef fish families at site SC2, Lower reef.



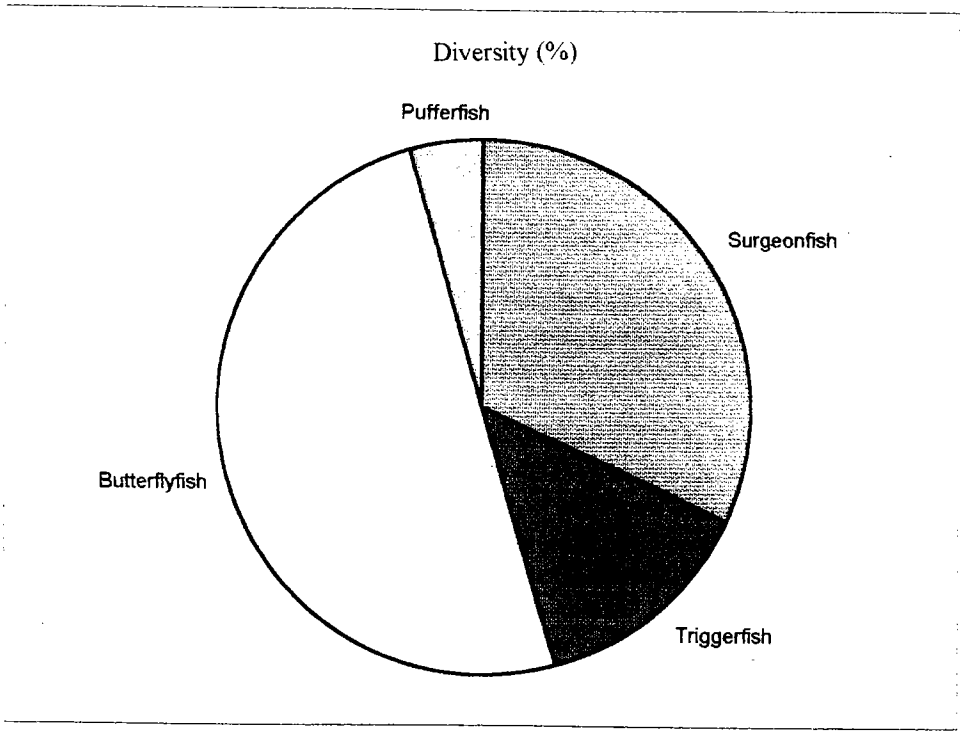


Figure 67: The relative diversity and abundances of reef fish families at site SC3.

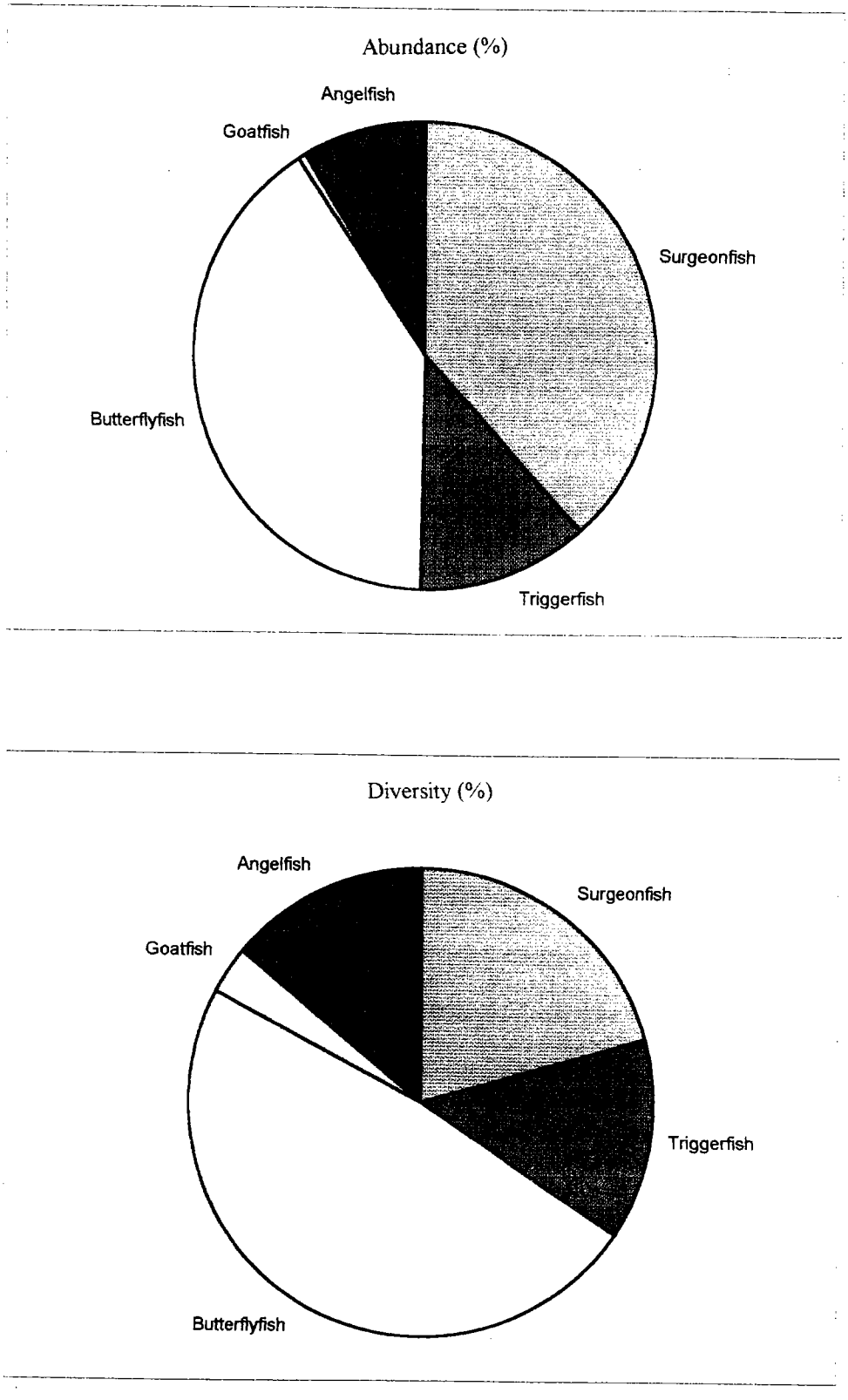


Figure 68: The relative diversity and abundances of reef fish families at site SC4, Upper reef.

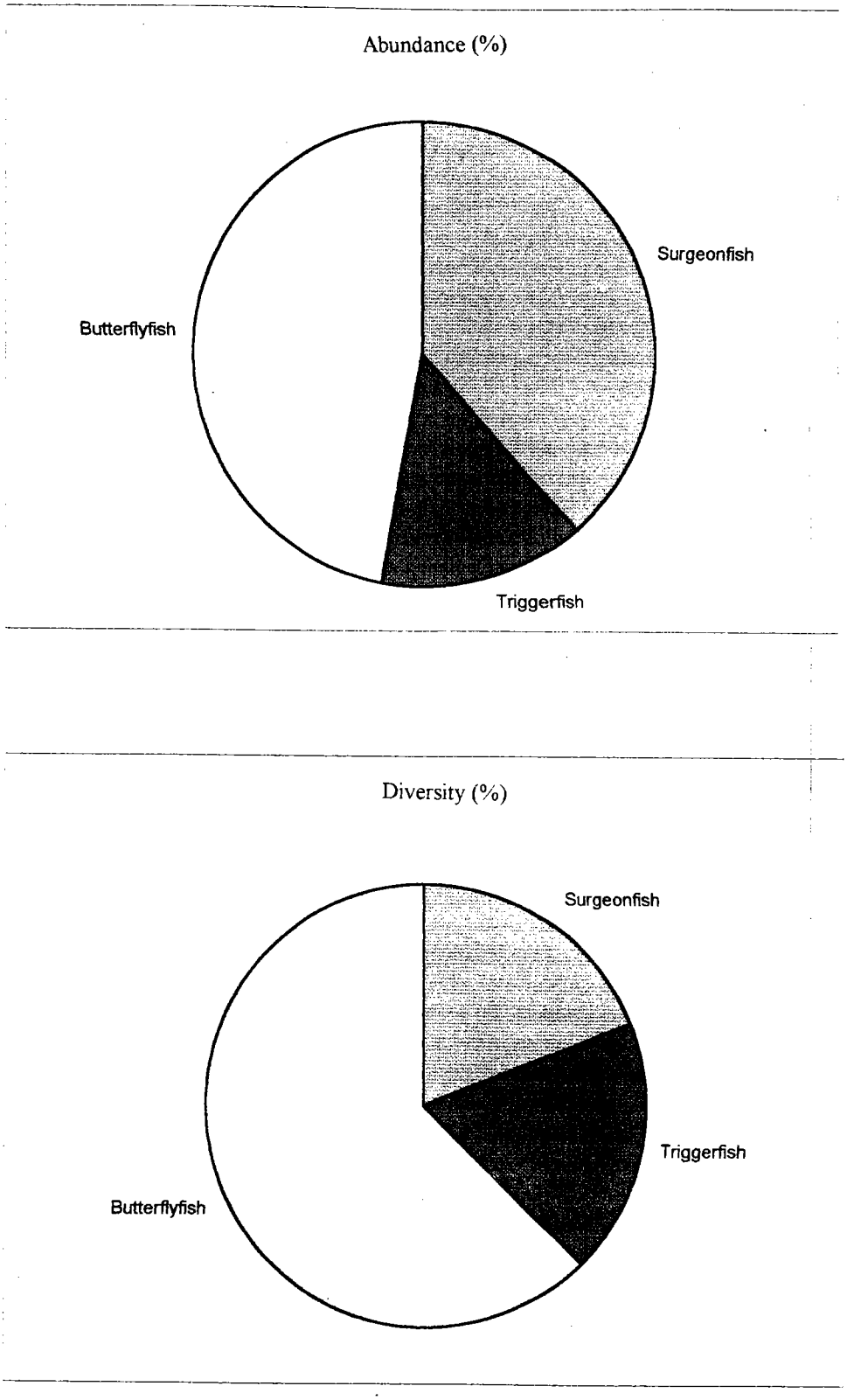


Figure 69: The relative diversity and abundances of reef fish families at site SC4, Lower reef.

5.7 Commercial Fish Census

Survey sites are as for the subtidal habitat surveys shown in Figure 59 above.

5.7.1 Overview

The reef around Sencar island alters considerably in structure and exposure to wave action and this was reflected in the changes observed in the abundance and diversity of commercial fish recorded during the surveys. Site SC4 is situated on the fringing 'outer reef' where the large shoals of snappers (Lutjanids) and general composition of commercial fish was similar to that observed at other 'outer reef' sites in the C.I.G. (see QR7 - QR9). A gradual decline in reef development and decrease in exposure to wave action occurred from site SC3-SC1 with a corresponding decrease in commercial fish abundance and diversity. Although this reduction in abundance and diversity may be a response to changing ecological factors the increased fishing activity witnessed at these more sheltered sites may also be a contributing factor.

5.7.2 Site Reports

Site: SC1
Although a relatively shallow site (<7 m), several shoals of the snapper, *Lutjanus monostigma* (20+ individuals), and an unidentified Carangid (20+ individuals, estimated average length 30 cm) were observed. Solitary and paired parrotfish, mainly *Scarus sordidus*, were the dominant commercial species observed. The family compositions and encounter rates are summarised in Figure 70.

Site: SC2
This site supported a low abundance of commercial fish, with the exception of a few shoals of *Lutjanus bohar* (estimated length 50-80 cm, 20-50 individuals). A few solitary parrotfish, *Scarus ghobban* and *S. sordidus* (estimated length < 40 cm) and rabbitfish, *Siganus stellatus* (estimated length 25 cm) were recorded. In addition, large shoals (50+ individuals) of Caesionids were observed. The family compositions and encounter rates are summarised for the upper and lower slopes in Figures 71 and 72 respectively.

Site: SC3
Few commercial fish were recorded with only a few parrotfish (Scarids, estimated length < 40 cm), emperors (Lethrinids), *Monotaxis grandoculis* (estimated length < 40 cm), snappers (Lutjanids) and a single grouper (Serranid, unidentified) recorded. The family compositions and encounter rates are summarised in Figure 73.

Site: SC4
Snappers (Lutjanids) dominated with many large shoals (50+ individuals) of *Lutjanus kasmira* and smaller shoals (20+ individuals) of *Lutjanus gibbus*. A few solitary

parrotfish (Scaridae) including *Scarus ghobban, S. frenatus* and *S. scaber* (estimated length 20-30 cm), a number of groupers (Serranids), *Plectropomus punctatus* and *Variola louti*, and a small group (10 individuals) of grunts (Haemulids), *Plectorhinchus gaterinus*, were also recorded. The family compositions and encounter rates are summarised for the upper and lower slopes in Figures 74 and 75 respectively.

5.7.3 Size Distributions

The size distributions of the commercial fish recorded are summarised for all the sites surveyed around Sencar island in Table 68 below. The range of fish lengths was generally smaller than that recorded for Ibo and Quirimba islands, although the estimated median length was greater. This could be an artefact of the smaller number of fish sampled.

Table 68. Size distribution summary for the commercial fish of Sencar island.

'Commercial' Fish Family	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae*	30	30
Lutjanidae	30	10-80
Scaridae	30	20-40
Serranidae*	30	30
Siganids	25	25
Haemulidae*	30	30
Carangidae	-	-

* based on less than 6 individual fish ** based on a single specimen

5.8 Finfish Fisheries

Sencar was unusual in having very limited boat-based fishing, which was probably because of the vast intertidal areas all around the island. The island had a semi-permanent population of around eighty people, living in twenty houses, of which approximately fifty of them were fishermen. Many of the houses contained family groups but there were also more temporary households of fishermen. The majority of residents were originally from the mainland. The island does not have a supply of fresh water and although it was possible to grow papaya the rocky ground was not suitable for the production of other crops. The numbers of fishermen using each of a range of gear types is summarised in Table 69.

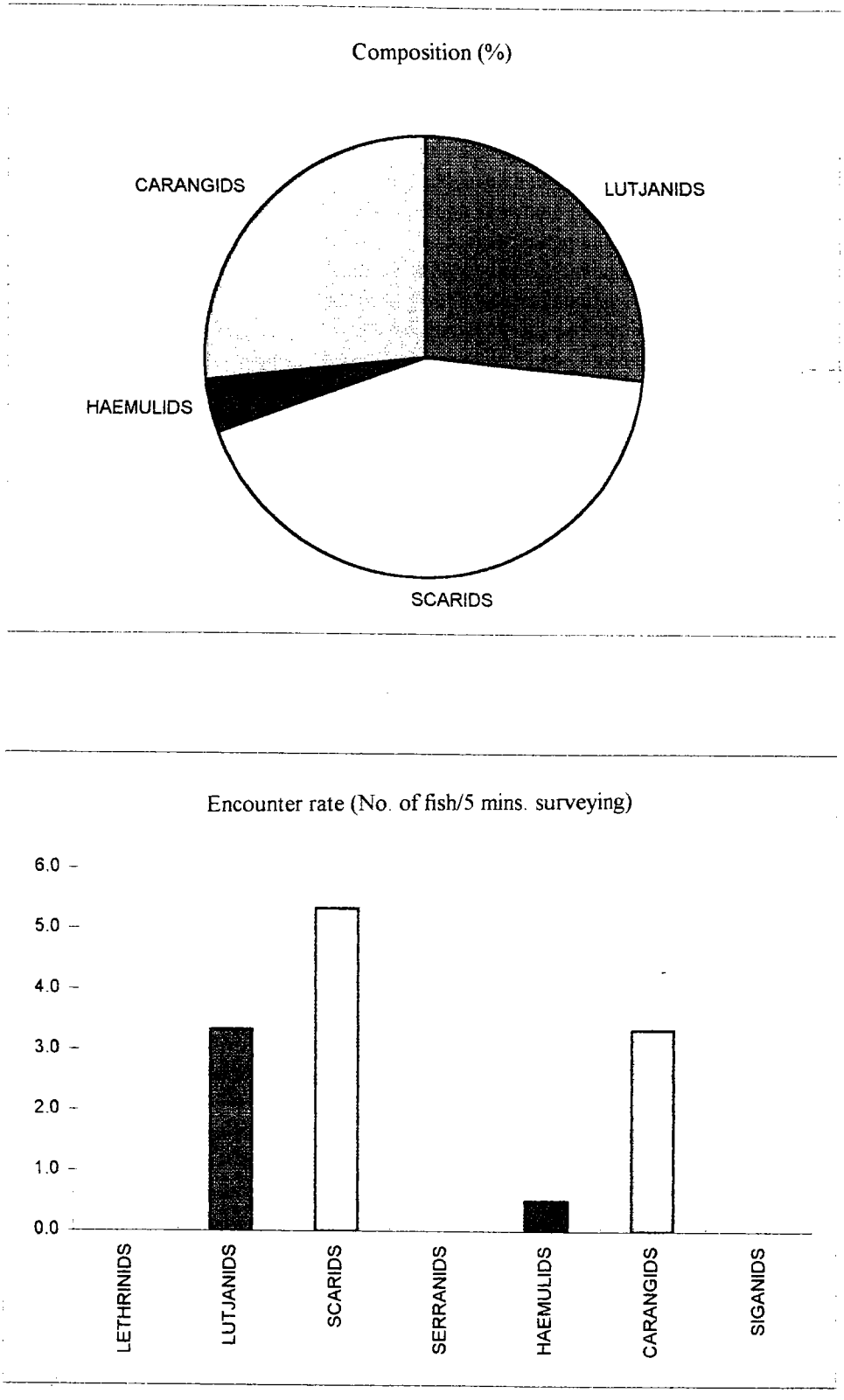


Figure 70: The composition and encounter rates of commercial fish recorded at site SC1.

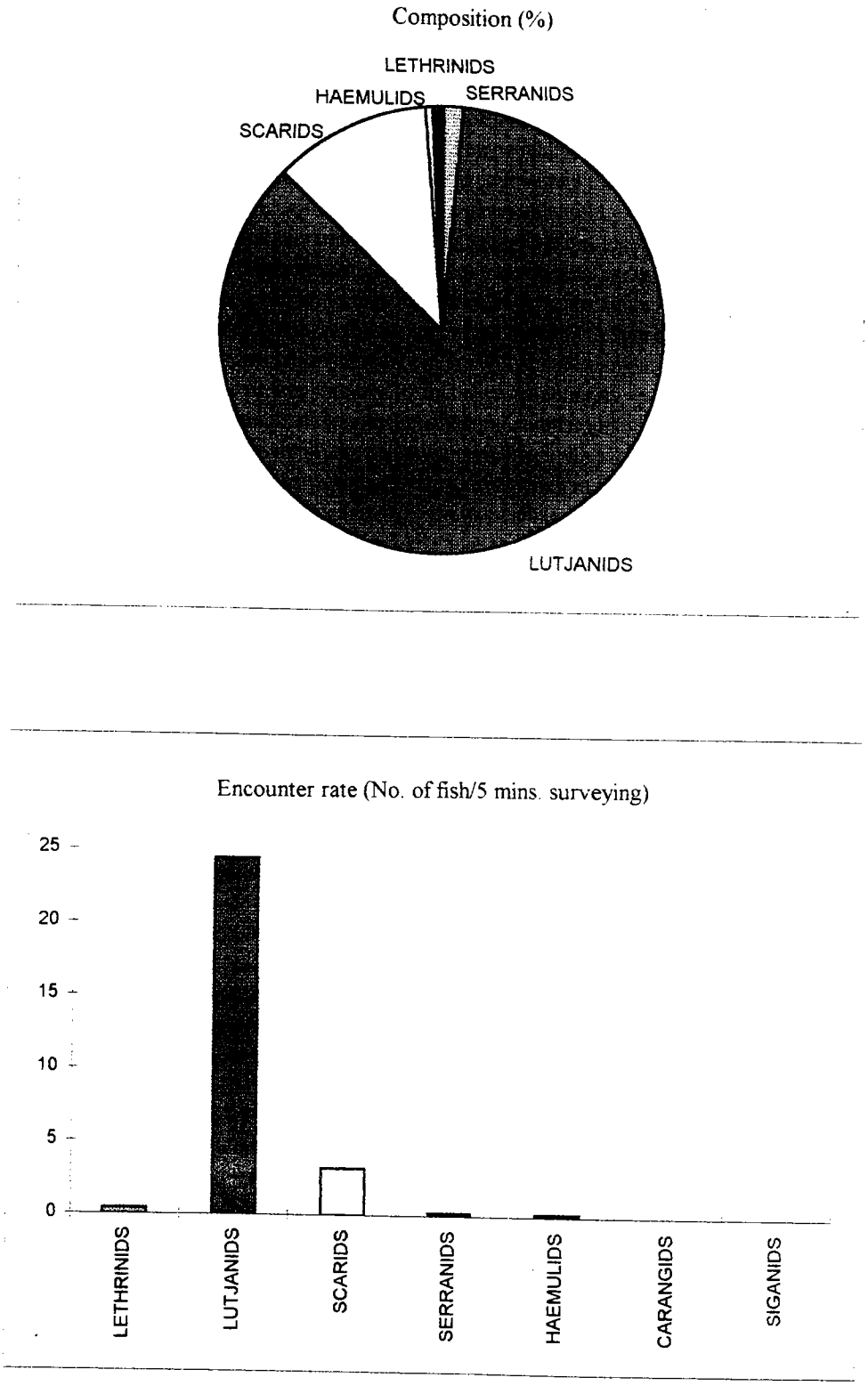


Figure 71: The composition and encounter rates of commercial fish recorded at site SC2, Upper reef.

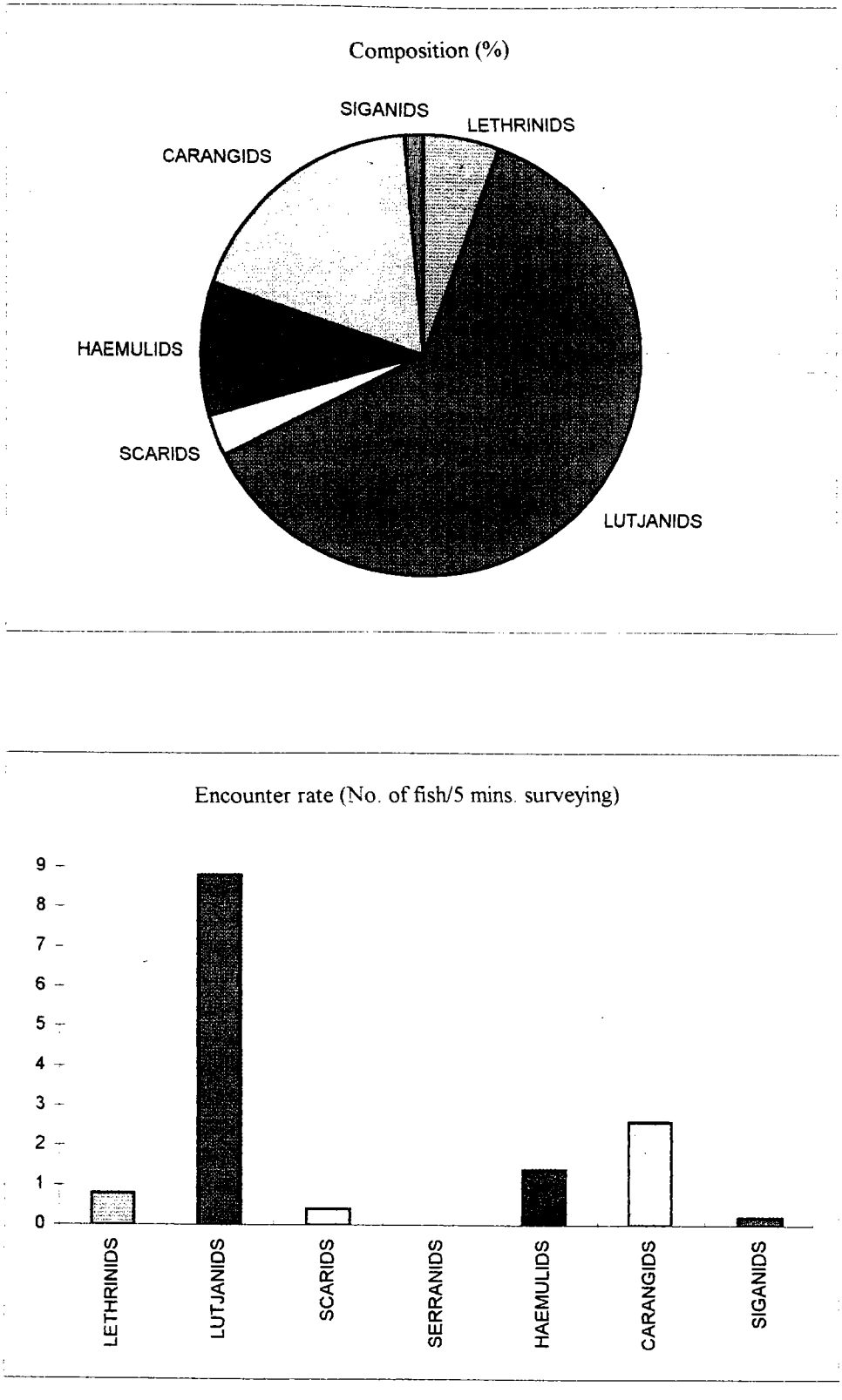


Figure 72: The composition and encounter rates of commercial fish recorded at site SC2, Lower reef.

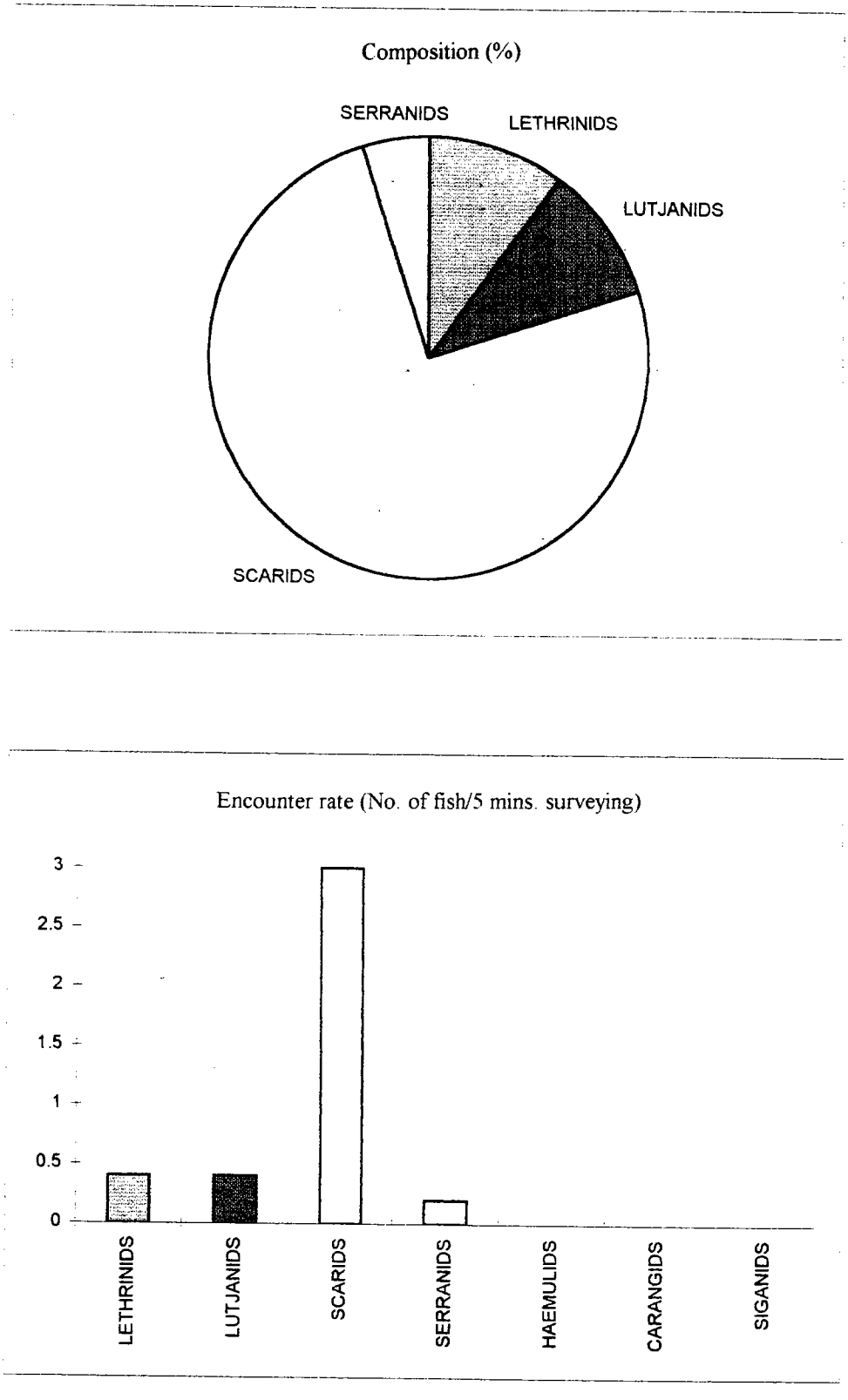


Figure 73: The composition and encounter rates of commercial fish recorded at site SC3.

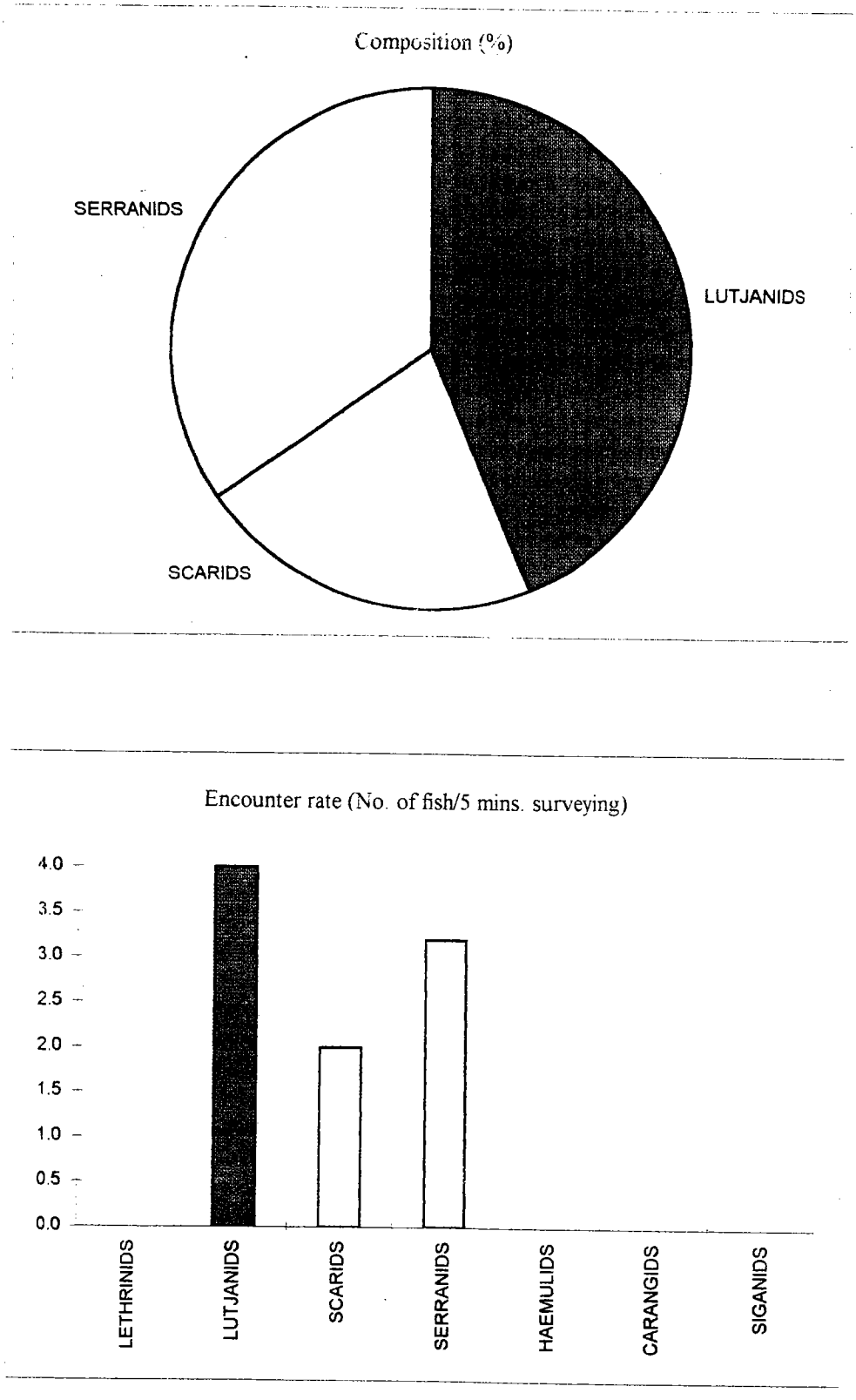


Figure 74: The composition and encounter rates of commercial fish recorded at site SC4, Upper reef.

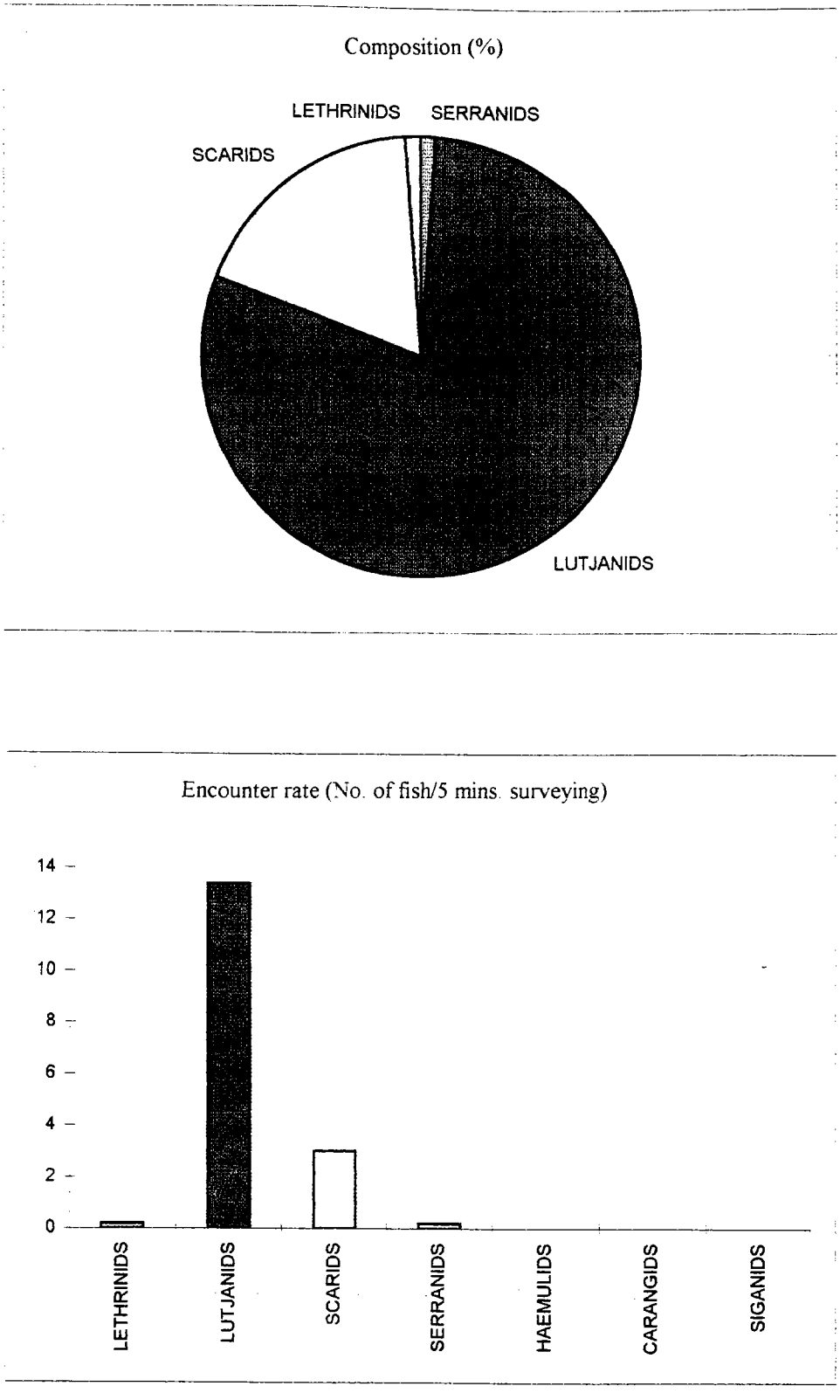


Figure 75: The composition and encounter rates of commercial fish recorded at site SC4, Lower reef.

Table 69. A summary of the population involvement with different fishing techniques.

Sencar Island		**Number**
Permanent population		80
Fishermen:	resident	50
	Itinerant	50
Fishing Method		
Line		5
Seine net		0
Surround net		30
Trap: Marema		4
Trap: Suri		0
Trap: Large Marema		0
Luwando		0
Spear		10
Intertidal		1
Sailing Boats		1
Canoes		8
Rowing Boats		0

The predominant fishing method was surround netting on the reef flat which was carried out by small groups of fishermen on foot. A wide variety of relatively large fish were caught using this method but snappers (Lutjanidae) and unicornfish (Acanthuridae) dominated the catch. One net fishermen interviewed had a drying rack outside his home with a large quantity of fish caught fairly recently. He said that most of his dried fish was for sale on the island and that he would sell it for 12 000 Meticais per kilo.

Spearfishing was carried out in shallow water from canoes, and in pools and inlets on foot. The catch was mainly of small to medium-sized reef fish. Small groupers (Serranidae) and surgeonfish (Acanthuridae) were commonly caught. The less permanent spear fishermen would usually use canoes and land relatively large catches of perhaps 10 kg of fish, whereas a spear fisherman with a family on the island would usually fish for a short time and catch just a few small fish sufficient to meet the families daily needs.

The only sail boat observed on Sencar was usually used for transport of water and foodstuffs, and was only occasionally used for net fishing.

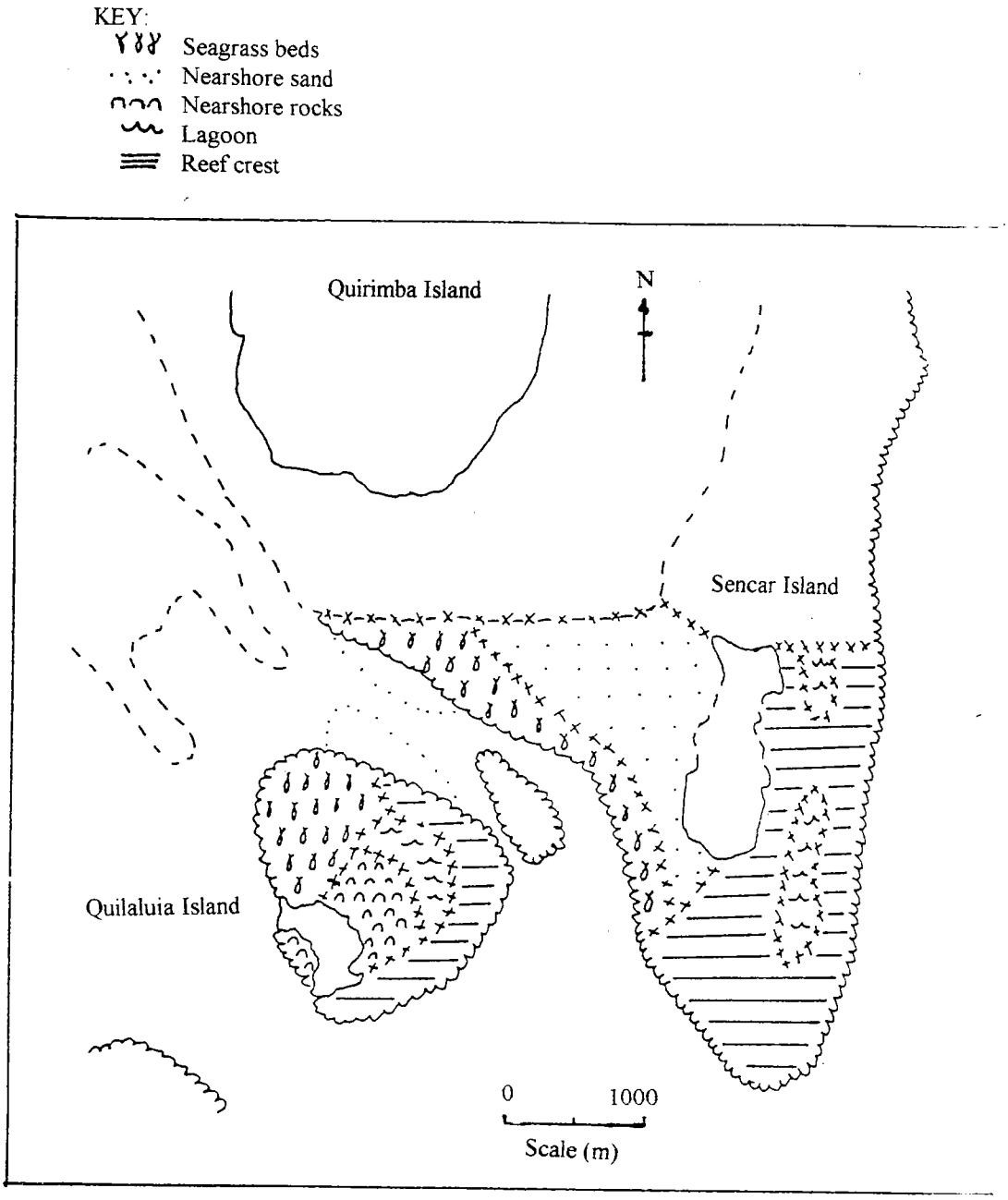


Figure 76: The intertidal zones distinguished on Sencar island in relation to the resource use surveys.

5.9 Intertidal Resource Collection

5.9.1 Overview

The distribution of intertidal habitats is shown in Figure 76. 17 collectors were interviewed on 15/8/96 and 29/10/96. The scale and patterns of resource collection are described below.

Scale and Intensity of Collection
This two-day study found the level of exploitation relatively low (4 people/km^2) over the entire intertidal area.

Gender of Collectors
There was an equal ratio of adult women and men (8:9 respectively) and a total absence of younger individuals.

Group Structure
The majority of collectors operated as individuals (10/17 individuals). The high rates of individuality on Sencar (especially in the exposed corals) are in marked contrast to the other islands where most collection is by groups of adult women.

Origin of Collectors
All interviewees stated that they lived on Sencar itself.

Collection Methods
The majority of collectors (82%) used iron rods, although one individual combined the use of iron rods with a handline, and two individuals used wooden poles. The reliance on the use of iron rods was a reflection in the targeting of octopii by 94% of individuals, for which iron rods seem the preferred and most effective. Interestingly, the use of wooden poles also appeared to be successful in the catch of octopii.

Catch Composition
Most emphasis was on the collection of 'CT' gastropods and octopii, with little interest in the collection of bivalves, 'FO' gastropod species, holothuria or fish. Sixteen of the seventeen people surveyed collected a total of 89 octopii (an average of 5.5 each), but with some individuals collecting up to 13 octopii. The 12 people observed collecting 'CT' gastropods caught a total of 6 species, with most emphasis on *Cypraea tigris* (38 collected by 3 people) and *Lambis lambis* (13 collected by 5 people). Other species were collected on an incidental basis, such as *Ovula ovum* (7 collected by 3 people), *Charonia tritonis* (1 collected by 1 person), *Cypraecassis rufa* (1 collected by 1 person), and *Cymatium pileare* (1 collected by 1 person). Other incidental collections included 9 bivalves (*Tridacna* and *Pinctada* spp.), 12 'FO' gastropods (*Chicoreus ramosus* and *Fasciolaria trapezium*), 18 holothuria (5 species), and 11 fish (4 species).

5.9.2 Distribution of Effort across Intertidal Zones

Collection effort was distributed equally between the reef crest (8 people) and the south-west coral fringe (7 people). The eastern lagoon and the western sand/seagrass and rock flats were not observed to be exploited at all. The reef crest, used by a total of 10 people on the two days surveyed, had a relatively low overall level of exploitation (3 people/km^2) as it covers a relatively large area. The maximum collection effort was centred on the western coral fringe (28 people/km^2).

Interestingly, collectors on the reef crest were predominantly male (8/10 people), whilst collectors on the exposed coral zone were mainly female (6/7 people). Most women collected as individuals, whilst on the reef crest, where men were the dominant collectors most collected in groups.

The Resource Catch

The distribution of resources across zones is shown in Figure 77. Octopus was the main catch in both zones. The collection of gastropods for the curio trade was equally spread across zones with 5/7 people collecting on the exposed coral zone and 7/10 on the reef crest. However, the catch of 'CT' gastropods was relatively small in both zones with the 13 specimens of *Lambis lambis* collected on the exposed coral zone (4 collectors) and 38 specimens of *Cypraea tigris* on the crest (3 collectors) making up the major component of the catch, in addition to the occasional *Charonia tritonis tritonis. Pinctada* sp. were only collected on the SW corals zone, whilst *Tridacna* sp. were only collected from the crest. 'FO' gastropods and fish were slightly more abundant in the catches from the SW corals zone and holothuria catches were greater from the reef crest.

5.9.3 Subtidal Collection

Only one men was observed collecting subtidally and in this case he had collected a single *Charonia tritonis*, from his 'casquinha'.

5.9.4 Discussion

The relatively low level of collection at Sencar (in total numbers and density) compared to the other islands is thought due to a combination of the low population resident on the island and the long distances to travel from Quirimba. In effect the collection pressure is limited to the resident population of the island which is currently very low. However, it was observed that 7 new permanent houses were being built on the northern side of the village and the resident population is likely to rise and collection pressure with it. The recent settlement of most individuals on Sencar also increases the likelihood of further immigration by family members left behind.

The preference for collection of octopii and shells for the curio trade may be a product of the relatively recent origin of the village which has meant that many of the residents still have strong ties with their previous homes which are thought to include Ibo and

mainland towns such as Pemba. These towns are amongst the most important regional centres for the sale of gastropod shells for the tourist and export industry, and for dried octopii.

There are two possible explanations for the absence of young collectors on Sencar. Firstly, as observed throughout all surveys in the C.I.G., young collectors were under-represented on the more distant and exposed intertidal areas which characterise Sencar. This may be due to traditions which prevent the young from exploiting these zones, both due the long walking distances, deep pools and fast, incoming tides, and the relatively difficult collection techniques, iron rods and snorkels/spearguns, as opposed to gathering by hand. Secondly, it is likely that children are under-represented on the island, being left with families in the place of origin. Also interesting, is the fact that Sencar was the only island of the C.I.G. with a majority of adult males, as opposed to adult females as on the other islands.

It was surprising that so little subtidal collection of molluscs was seen, considering the fact that there were relatively large numbers of itinerant fishermen on the island. The reefs around the neighbouring Quilaluia island are more sheltered than those surrounding Sencar and perhaps richer in 'CT' gastropods, so that collectors of these resources preferred to camp on Quilaluia instead of Sencar. Nevertheless, the single *Charonia tritonis tritonis* collected by one man, even though probably collected incidentally, would have been an important source of money, being the most highly valued gastropod fetching 120, 000 Meticais/ £8 in Pemba.

KEY:

Oct	Octopii
Biv	Bivalves
FO	Food/Operculae Gastropods
CT	Curio Trade Gastropods

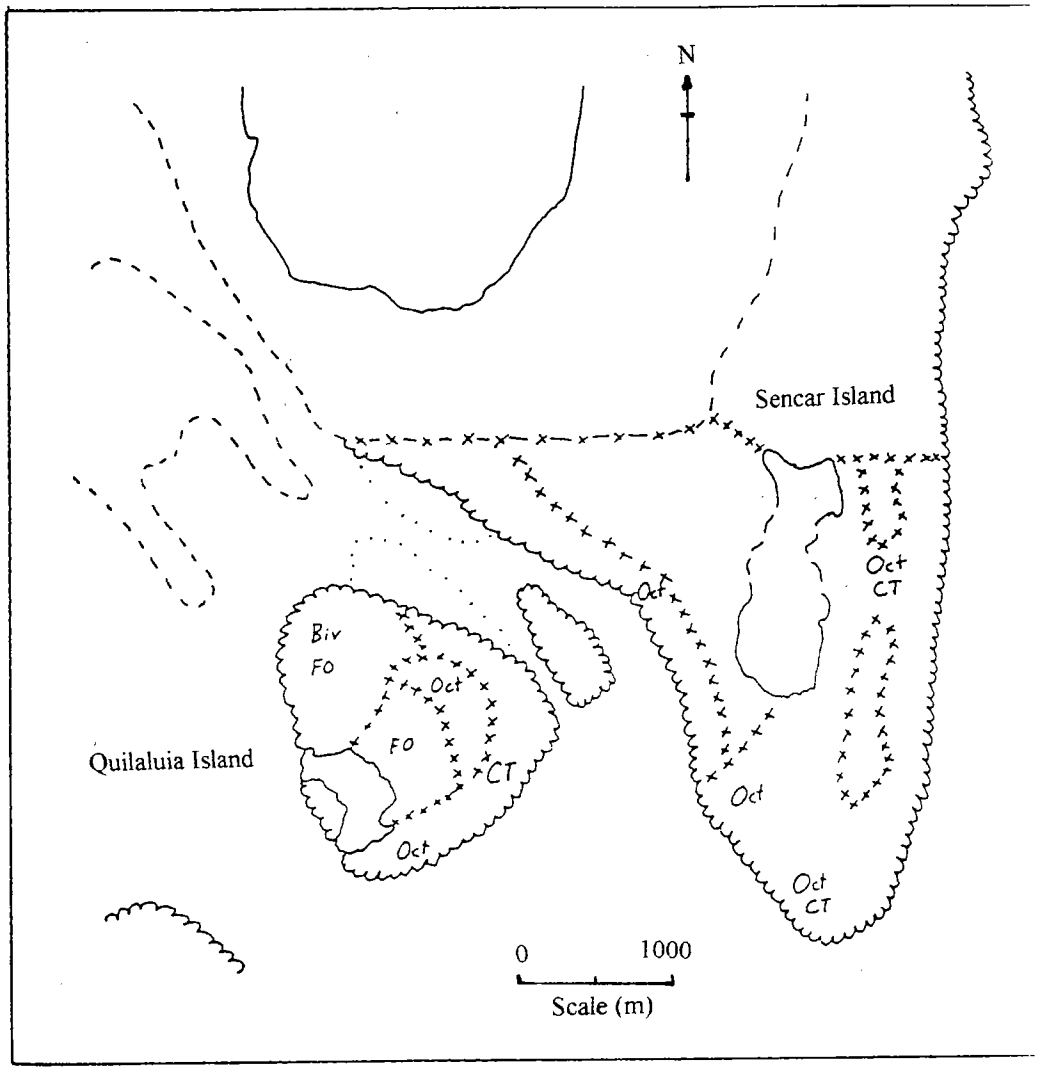


Figure 77: The main areas for the collection of intertidal invertebrates on Sencar island.

5.10 Mollusc Biodiversity Survey

5.10.1 Overview

Two species of bivalves (*Brachidontes* sp. and *Tridacna squamosa*) and 40 species of gastropods from 15 Families were recorded from Sencar island. The most diverse of these Families were Cypraeidae, Conidae, Whelks and Winkles (each with 5-7 species). A full list of species recorded is given in Appendix 15.

5.10.2 Habitat Distributions

Northern Reef Crest
Two bivalve species, *Brachidontes* sp. and *Tridacna squamosa* and 18 species (from 9 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Conidae (4-6 species in each).

Central Reef Crest
Two bivalve species and 27 species (from 11 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Conidae and Whelks (4-7 species in each).

Southern Reef Crest
One bivalve species (*Brachidontes* sp.)and 16 species (from 10 Families) of gastropods were identified. Within the gastropods the most diverse Families were Cypraeidae, Conidae and Winkles (3 species in each).

5.10.3 Discussion

Overall Diversity
There was a relatively low total diversity of bivalves on Sencar with only two species found compared to the 19 recorded on Quirimba island. This low diversity probably results from the lack of a sand/seagrass zone most suited to bivalves. Both species found, *Brachidontes* sp. and *Tridacna squamosa* are specialists of rocky reef habitats. Few other bivalves inhabit this habitat, most being restricted to sand/seagrass zones.

Conversely, gastropod diversity was relatively high, particularly within the Families Cypraeidae, Conidae and the Whelks and Winkles. These families were also the most species-rich on the Quirimba reef intertidal and included the same dominant species, namely *Cypraea caputserpentis, C. helvola* and *Haliotis* sp..

Zonal Diversity
A comparison between the three reef crest sites indicated few significant variations in species diversity.

6.0 QUILALUIA ISLAND

6.1 Introduction

Quilaluia Island (12°29.6'S 40°36.2'E) is approximately 0.65 km long and 0.35 km wide and situated on the end of a southern extension of the Quirimba Island intertidal area that includes Sencar Island (Fig. 1). The layout of the island and its associated habitats are shown in Figure 78. A shallow channel to the north and east separates the island from the greater intertidal area and Sencar, while to the south and west there is a developed reef and relatively deep water. The southern side of the island forms the northern boundary of the Montepuez Channel.

The population of the island is very small (<50 people) and there are no permanent residents. During the dry season (April-October) however, the population may increase significantly with the arrival of fishermen from Nampula Province who establish temporary camps on the island, due to the good access for boat launching at all states of the tide and the sheltered shoreline. There is no administration, infrastructure or freshwater on the island.

6.2 Intertidal Surveys

6.2.1 Overview

Quilaluia had an estimated 1.5 km^2 of intertidal flat, mostly concentrated on the eastern side of the island. In contrast to the neighbouring island of Quirimba, which supported a distinct seagrass dominated habitat on its western coast and an algae dominated habitat on its eastern shore, on Quilaluia island, the eastern shore supported both seagrass and algal habitats. The seagrasses tended to dominate the northern half and macroalgae the southern half (although not in the extreme south). The low abundance of macroalgae and the absence of seagrasses on the west shore of Quilaluia is possibly linked to the steep topography and the presence of coral reefs neashore. The absence of seagrasses is directly related to the absence of soft substrate which is required for seagrass attachment.

From the surveys completed, four seagrass species and 90 taxa of macroalgae (see Appendix 2 for checklist) and three invertebrate species (Appendix 3) were recorded.

The algal flora included a single Cyanophyta (Blue green algae), 25 Chlorophyta (Green algae), 13 Phaeophyta (Brown algae) and 51 Rhodophyta (Red algae). Like the majority of the islands of the C.I.G., the algal flora on Quilaluia was dominated by Rhodophyta and contributed to over half the species recorded for this island. The overall diversity (90 taxa) relative to the C.I.G. as a whole was low, comprising less than 50 % of total algal diversity recorded (195 taxa).

6.2.2 Area Reports

A single transect was surveyed on the south east intertidal area (Fig. 78). Within this transect were recorded two species of seagrasses, 30 taxa of macroalgae (Table 70) and three of invertebrates (Table 71).

The shoreline to the west was but in east the intertidal slopes gently to the LWM about 600m from HWM. A diagrammatic cross-section of the transect is presented in Figure 79. Four narrow zones were identified on the basis of community structure and substrate composition (Table 72). Zone 1 was a bare sand beach. Zone 2 was a rock platform colonised by the seagrass *Thalassia hemprichii* (<40 %). No invertebrates were found in this community. Zone 3 was predominantly bare rock with a virtual absence of biota. Zone 4 included the reef crest with a relatively high but sparse algal diversity, but with no individual taxa covering more than 25% of the available substrate (the majority covering <1 %). The three invertebrates found during the survey were recorded in this zone giving this intertidal area the lowest invertebrate diversity found on any of the C.I.G. islands.

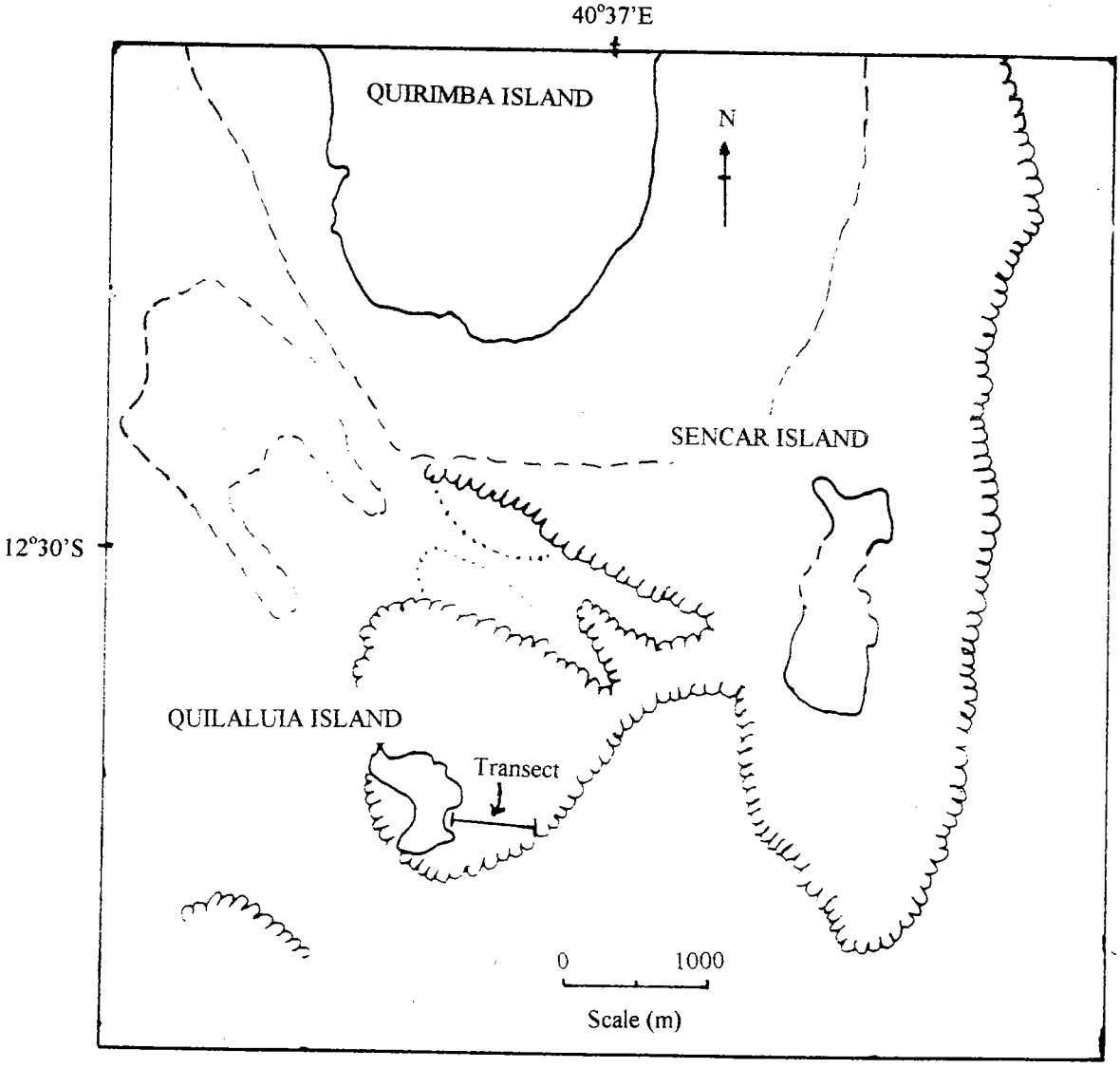


Figure 78: A map indicating the position of the intertidal transects surveyed on Quilaluia island.

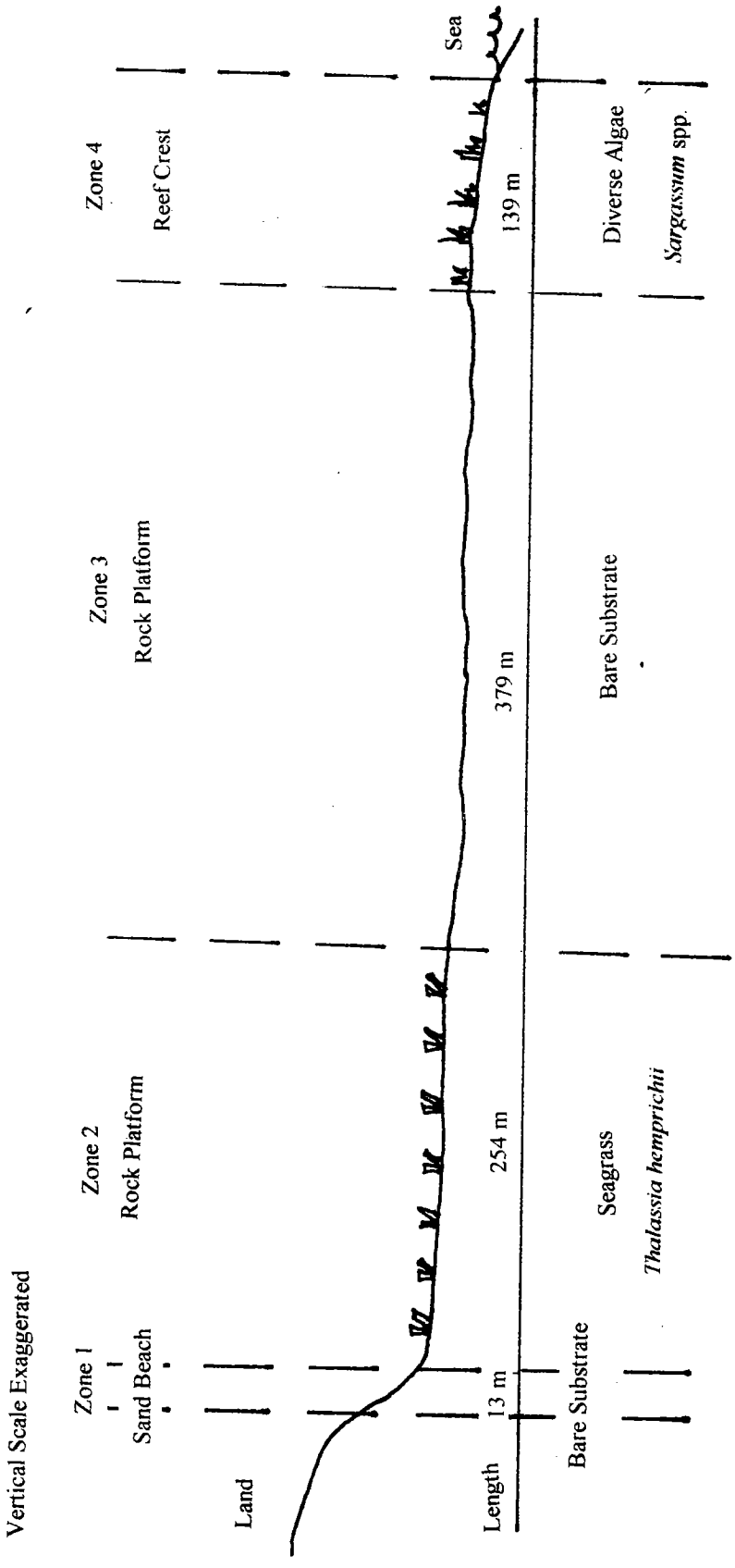


Figure 79: A diagrammatic representation of the intertidal transect, Quilaluia island.

Table 70. Percentage surface cover of seagrass and macroalgae along a typical Quilaluia transect. (P <1% of cover). Mean values and ranges (in brackets) are presented.

Taxonomic Group	Zone 1	Zone 2	Zone 3	Zone 4
Seagrass				
Thalassia hemprichii	0	40	20 (0-40)	0
Thalassodendron ciliatum	0	0	0	2.5 (0-25)
Macroalgae				
Amphiroa anceps	0	0	0	0-P
Anadyomene wrigthii	0	0	0	0-P
Boergesenia forbesii	0	0-P	0	0
Bryopsis sp.	0	0	0	0-P
Chaetomorpha crassa	0	2.0 (0-30)	0	0
Champia sp.	0	0	0	P (P)
Chondria cf. *Armata*	0	0	0	0-P
Cistoseira myrica	0	14.8 (0-50)	0	0
Dasyopsis sp.	0	0	0	0-P
Dictyosphaeria cavernosa	0	0	0	0-P
Dictyota divaricata	0	0	0	0-P
Digenia simplex	0	0	0	0-P
Enteromorpha kylini	0	0	0	0-P
Eucheuma dendiculatum	0	0	0	0-P
Gelidiella acerosa	0	0	0	0-P
Gracilaria fergusoni	0	0	0	0-P
Halimeda renschii	0	0	0	1.6 (0-15)
Hydroclathrus clathratus	0	0	0-P	1.3 (0-10)
Jania adhaerens	0	0	0	0-P
Laurencia distichophyla	0	0	0	0-P
Laurencia papillosa	0	1.0 (0-10)	0	0
Lyngbya majuscula	0	6.0 (0-30)	0	7.1 (0-25)
Neomeris van bosseae	0	0	0	0-P
Padina boryana	0	0	0	0.3 (0-3)
Sargassum duplicatum	0	0	0	0-P
Turbinaria ornata	0	0	0	0-P
Udotea indica	0	0	0	0-P
Vanvoorstia spectabilis	0	0	0	0-P
Vidalia fimbriata	0	0	0	0-P

Table 71. Abundance of invertebrates along a typical Quilaluia island transect. Means and ranges (numbers/m^2) are presented.

Invertebrate	Zone 1	Zone 2	Zone 3	Zone 4
Gastropods				
Cypraea annulus	0	0	0	1.2
Echinoderms				
Echinometra muthaei	0	0	0	2.8
Fromia sp.?	0	0	0	0.4

Table 72. Percentage composition of substrata along a typical Quilaluia transect. Mean values and ranges (in brackets) are presented.

Substrate	Zone 1	Zone 2	Zone 3	Zone 4
Rock	0	85 (60-100)	100	100 (95-100)
Sand	100	15 (0-40)	0	P (0-5)

6.3 Mangrove Surveys

No mangrove trees were observed. The absence of mangroves is probably due to a combination of a short intertidal area and the exposure to strong currents around much of the island making settlement of seedlings unlikely.

6.4 Subtidal Habitat Surveys

Subtidal surveys were concentrated at four separate sites covering all sides of the island. The location of survey sites are shown on Figure 80.

6.4.1 Overview

Reef Structure and Composition

The reef morphologies differed significantly between the 4 sites surveyed. Reef slopes were well developed at QL2 and QL3 and included areas of vertical reef walls. QL1 was a predominantly flat area although it also contained a narrow, shallow band of steeper reef slope. The reef slope at QL4 was also relatively flat.

Substrate compositions tended to be divided equally between sand, rock and rubble at all sites although rubble was prevalent on the upper slopes at QL3 where it had a surface cover of 70%.

Hard corals were the dominant biota, although most sites had a few areas dominated by soft corals. Seagrasses were absent from all areas, except at the reef edge at QL1 where there is a transition zone from coral reef to seagrass bed. Macroalgae was present in low densities at all sites and *Halimeda* spp. were present in patches on some of the sites. Most reef areas had a mixed diversity of coral forms with the exception of a single area of pure massive form corals on the mid reef slope at QL4.

Coral Composition

'Large massive' corals were generally found at low density, except at sites QL3 and QL4, where *Porites* became abundant at the shallower depths. 'Small massive' forms

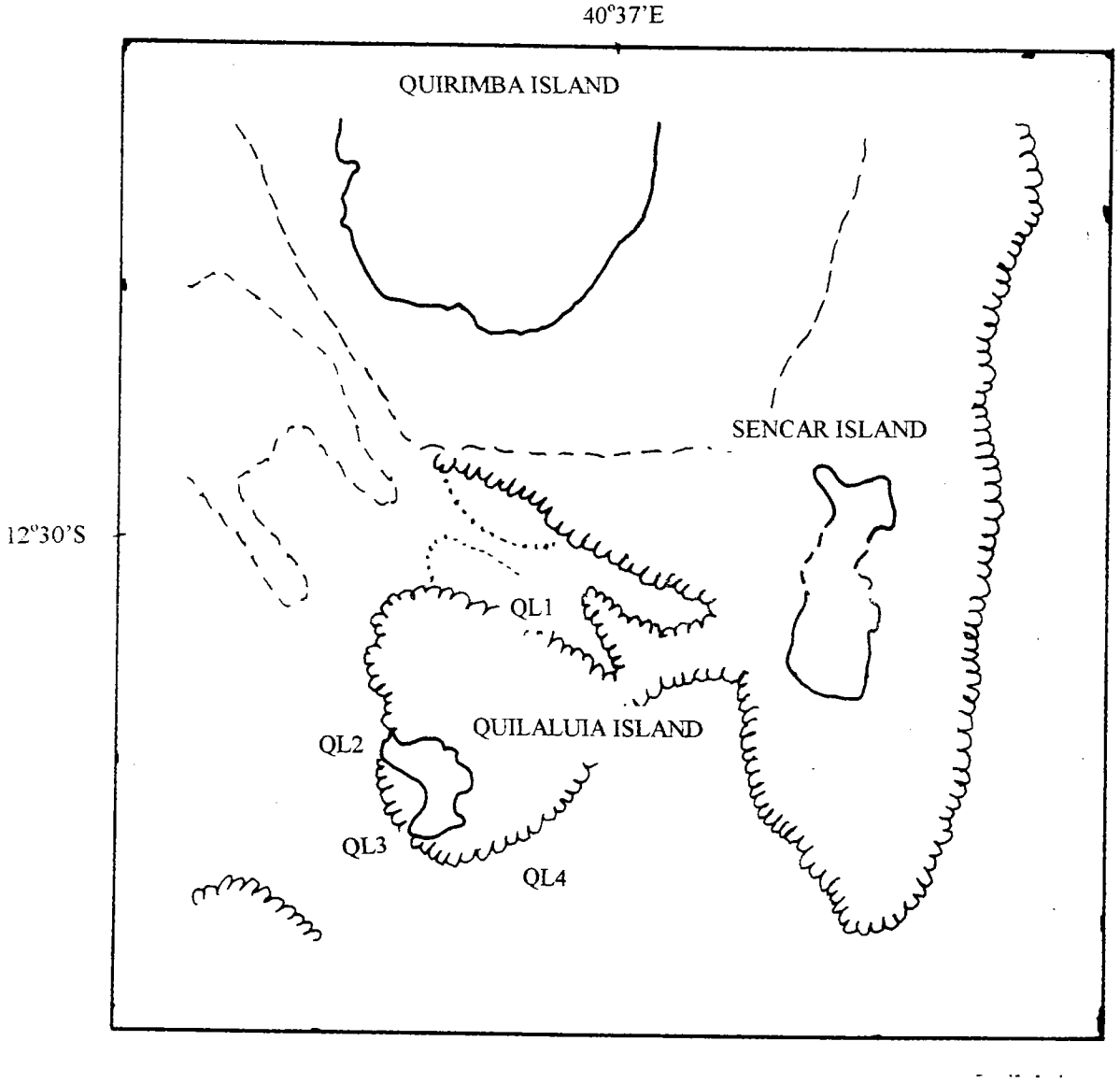


Figure 80: A map indicating the position of the subtidal survey sites around Quilaluia island.

were diverse at all sites, but the areas of surface cover varied considerably. *Acropora* tended to be well developed at sites along the fringing reef, especially in depths shallower than 8 m. 'Encrusting' and 'Foliose' forms were taxonomically diverse with surface cover highly variable and ranging from less than 1 % cover at QL1 to 10-20 % cover at QL2. 'Large polyp' corals were present in low densities (<1 % cover) at all the sites. 'Solitary' Fungiid corals were common at all sites and covered up to 10 % of the reef. *Tubastrea* was only observed on the rock wall at QL3.

Soft corals cover was highly variable between sites, with cover ranging from 10-15 % at QL4 to 0-5 % at QL2. The diversity was highest at QL4 where 5 genera were found. The other sites each supported 3 genera.

6.4.2 Site Reports

Site QL1:

The reef structure and community composition are summarised in Table 73 and Figure 81 and are described below.

Reef Structure
The reef was limited in its extent and patchy, with areas of abundant coral growth interspersed with sand and rubble, and seagrass beds. The gradient of the reef slope was variable and dropped down to a sand/rubble channel bed with occasional coral bommies. In places there were no reef features present.

Substrate Composition
The substrate was generally a mixture of sand, rock and rubble.

Biotic Cover
Biotic cover was highly variable, with hard and soft corals dominant on the hard substrates together with small amounts of macroalgae and *Halimeda* spp. On the soft substrate areas seagrasses were abundant, with occasional isolated colonies of hard and soft corals, macroalgae and *Halimeda* spp. Of the hard corals, staghorn, table and branching forms were dominant in the deeper areas and encrusting and massive forms in the shallower areas.

Coral Composition
Although the reef was very patchy coral growth had led to up to 75% surface cover in some areas.

Massive Forms: 'Large massives' were limited in abundance with a typical surface cover of 0-1 %. However, diversity was high with the following 4 genera identified; *Porites*, *Goniastrea*, *Favia* and *Galaxea*. 'Small massive' forms were also limited in abundance (typically <1 % cover), although the genus *Porites* commonly covered 5 % of the reef.

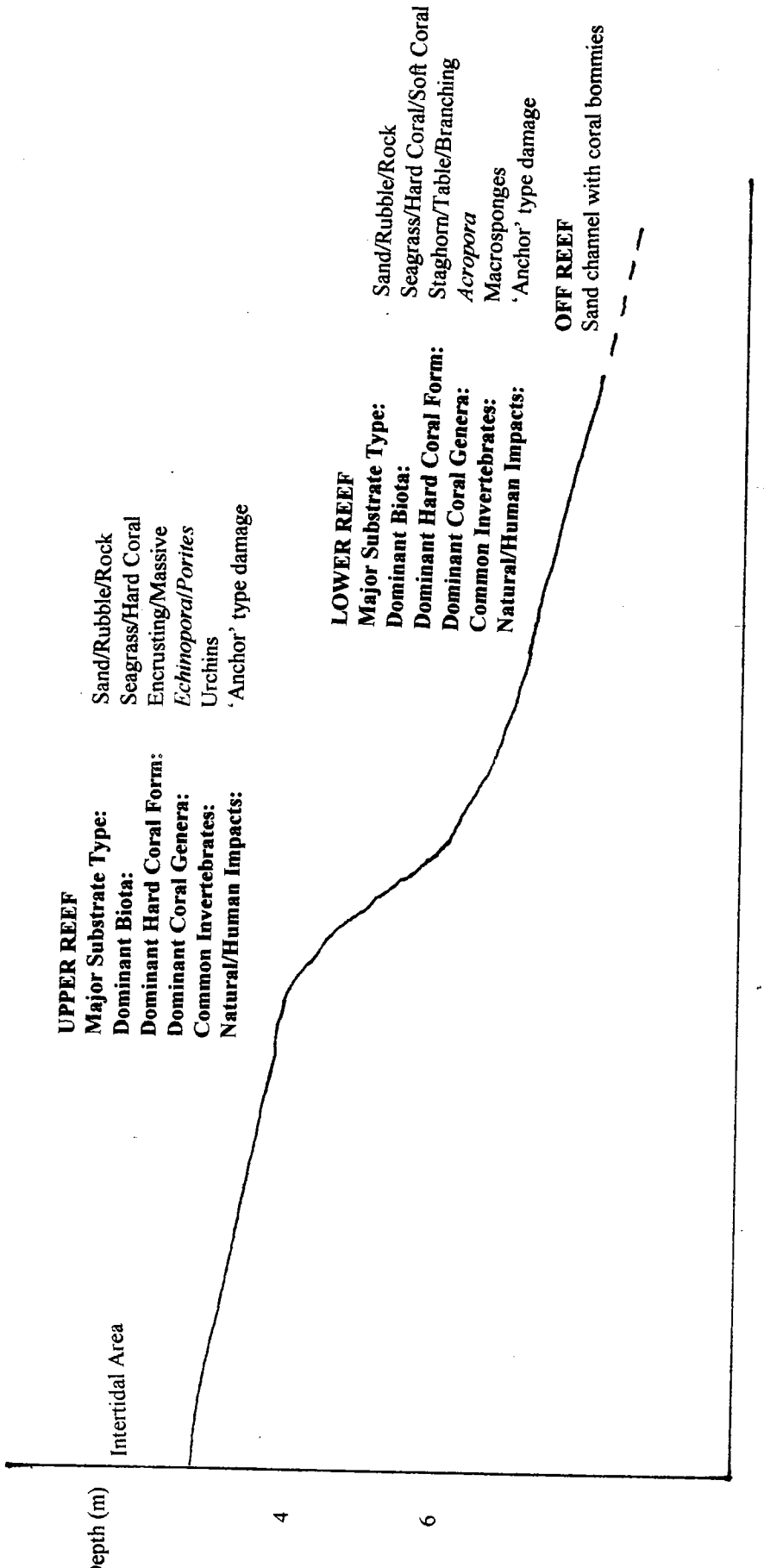


Figure 81: A diagrammatic representation of the "Reef Profile" at site QL1. A summary of the major features of the site is presented.

Branching/Table Forms: *Acropora* was often dominant with 'Staghorn', 'Small table' and 'Large table' forms all common. Surface cover ranged from 1-55 %. *Pocillopora* was also present (0-5 % cover).

Encrusting/Plate Forms: 'Plate' and 'Encrusting' forms were limited to *Echinopora* which typically covered 0-1 % of the reef.

Other Forms: The 'Large polyp' corals *Lobophyllia* and *Plerogyra* were absent from most of the reef, except for a few small, isolated colonies. 'Solitary' fungiids were observed between *Acropora* colonies and constituted <10 % of the corals present. *Millepora* was abundant over small areas (0-10 %).

Soft Corals: Soft coral composition was similar over much of the site. *Lithophyton* was the most abundant genus (5-15 % cover), with *Heteroxenia* (0-10 %) and *Sarcophyton* (approximately 1 %) also present.

Table 73. A summary of the structure, composition and biotic cover at QL1 (P=<1 % cover; Ma-Massive form; En-Encrusting form; Br-Branching form; St-Staghorn form; Ta-Table form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	0	0-5	30	20-50
	Rugosity	1	0-1	3	0-4
Substrate	Rock	2	1-3	3	1-3
	Rubble	3	1-4	3	1-4
	Sand	3	2-3	3	2-3
	Mud	-	-	-	-
Biota	Hard Coral	2	P-2	2	P-2
	Soft Coral	1	P-2	2	P-2
	Seagrass	2	0-5	3	0-5
	Macroalgae	P	0-P	P	0-P
	Halimeda spp.	P	0-P	P	0-P
Coral state	Heterogeneity	0	0	0	0
	Dominant forms	En, Ma	-	St, Ta, Br	-

Site QL2:

The reef structure and community composition are summarised in Table 74 and Figure 82 and are described below.

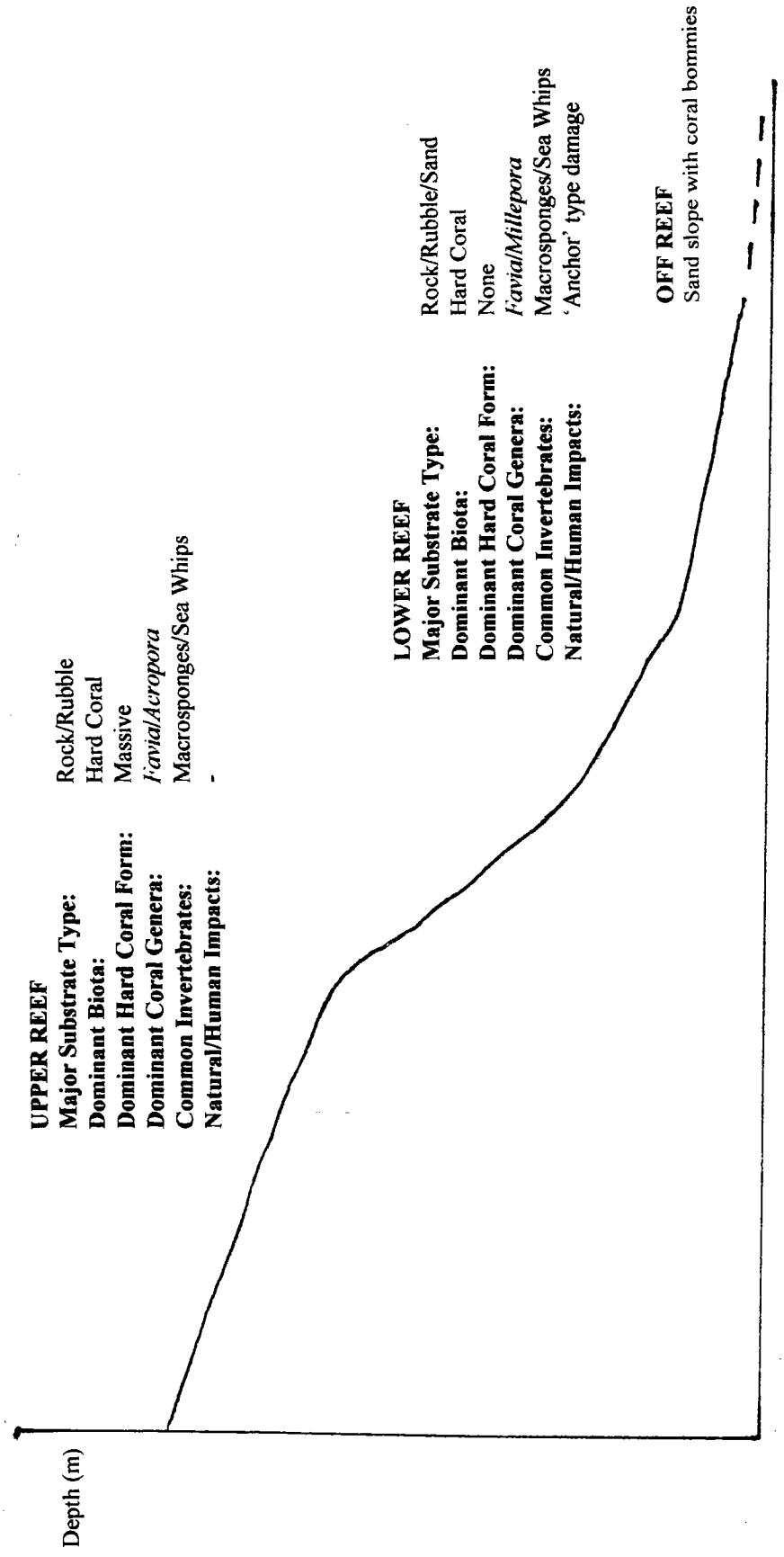


Figure 82: A diagrammatic representation of the "Reef Profile" at site QL2. A summary of the major features of the site is presented.

Reef Structure

The reef at this site comes close to the shore dropping off directly from the beach on a shallow, gradual slope (20°) to a depth of 6-8 m. Coral growth started at 1 m depth. At about 8 m the reef slope increased to 30-70° and descended to the reef base at 16 m. A gently sloping sandy seabed with occasional coral bommies stretched beyond the reef base. Rugosity was highest at the top of the reef slope where coral growth was most developed.

Substrate Composition

Rock and rubble were dominant substrata. Sand was relatively abundant at the base of the reef.

Biotic Cover

The shallower parts of the reef supported a diverse biota, with hard corals dominant, soft corals common and macroalgae and *Halimeda* spp. present. Towards the base of the reef hard coral was more abundant with a typical surface cover of 50 %, whilst only small quantities of soft coral and *Halimeda* spp. were present. Hard corals were heterogeneous in form.

Table 74. A summary of the structure, composition and biotic cover at QL2 (P=<1 % cover; Ma-Massive form).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	40	20-50	60	50-80
	Rugosity	3	3-4	2	2-3
Substrate	Rock	3	2-3	2	2-4
	Rubble	4	3-4	3	2-4
	Sand	3	0-1	2	1-3
	Mud	-	-	-	-
Biota	Hard Coral	2	2	4	2-4
	Soft Coral	P	0-P	1	P-1
	Seagrass	-	-	-	-
	Macroalgae	P	0-P	-	-
	Halimeda spp.	-	-	P	P
Coral state	Heterogeneity	0	0	0	0
	Dominant forms	Ma	-	-	-

Coral Composition

Massive Forms: 'Large massive' forms were dominant with 15-20 % surface cover. *Favia* was the dominant genus, which was abundant from the reef base at 16 m to the crest of the reef slope. Other 'Large massive' genera were absent with the exception of a few isolated colonies of *Diploastrea*. 'Small massive' forms were more diverse, with 4-5 genera recorded. *Porites* was the most abundant (10-15 % cover) and was most prevalent between 6 and 12 m.

Branching Forms: *Acropora* was commonly found in its 'Small table' form, particularly on the upper slope (2-8 m), with a surface cover of up to 10 %. Occasional 'Large tables' were also found on the upper slope and slope crest (4-8 m). 'Staghorn' forms were patchy and most common between 3 and 5 m. *Pocillopora* colonies were small and isolated.

Other Forms: *Millepora* was abundant with up to 20% cover on the mid-lower slope (11-15 m) where *Echinopora* was also common (10-15 % cover). *Montipora* was common only on the lower reef. *Pachyseris* was the dominant genus (15-20 % cover) between 7 and 15 m. *Turbinaria* was absent. The 'Large polyp' corals, *Plerogyra* and *Lobophylla*, were found in isolated colonies along the lower reef slope. There were numerous solitary fungiids at all depths of the reef, (<10 %).

Soft Corals: Soft corals were observed at low abundances throughout.

Site QL3:

The reef structure and community composition are summarised in Table 75 and Figure 83 and are described below.

Reef Structure
The reef was relatively steep (30-60°) with a vertical wall from 11 to 14m. Rugosity was low throughout, a reflection of the relatively poor development of hard coral growth.

Substrate Composition
Rubble was the overwhelmingly dominant substrate, with the rock and sand present towards the base of the reef.

Biotic Cover
Soft corals were the dominant biota, being able to colonise the relatively loose rubble substrate. Hard corals, macroalgae and *Halimeda* spp. were also present, but in low abundances. The hard coral present was heterogeneous in form.

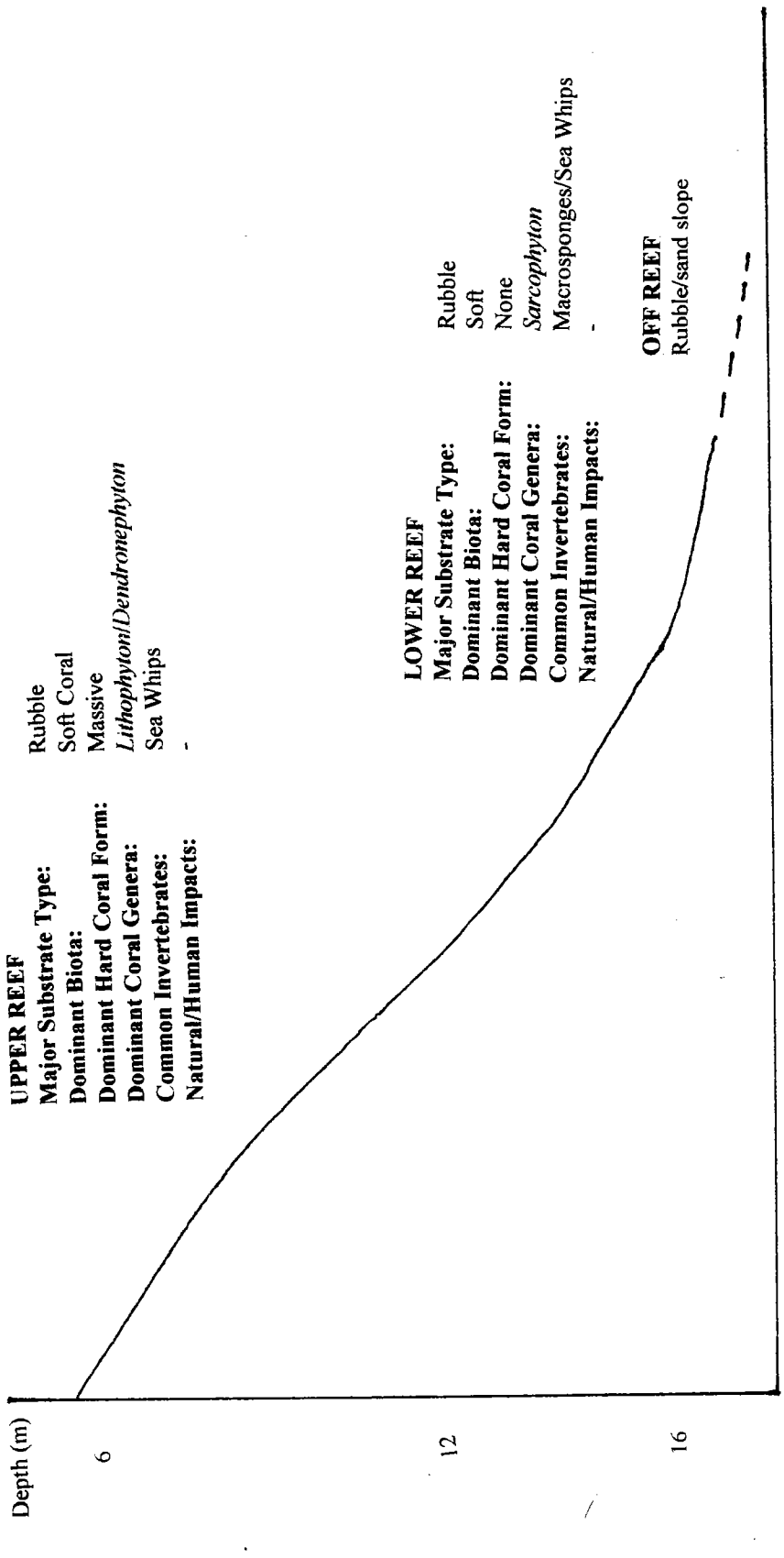


Figure 83: A diagrammatic representation of the "Reef Profile" at site QL3. A summary of the major features of the site is presented.

Table 75. A summary of the structure, composition and biotic cover at QL3 (P=<1 % cover; Ma-Massive).

Reef Features		Upper Reef Mode (0-6)	Range (0-6)	Lower Reef Mode (0-6)	Range (0-6)
Morphology	Slope (°)	30	30-40	60	30-80
	Rugosity	3	2-3	1	1
Substrate	Rock	1	1-2	2	1-6
	Rubble	5	5-6	4	0-5
	Sand	1	1-2	2	0-2
	Mud	-	-	-	-
Biota	Hard Coral	P	P	1	P-2
	Soft Coral	2	P-3	2	P-6
	Seagrass	-	-	-	-
	Macroalgae	P	P	P	0-P
	Halimeda spp.	P	0-P	-	-
Coral state	Heterogeneity	0	0	0	0
	Dominant forms	Ma	-	-	-

Coral Composition

Massive Forms: 'Large massive' forms were poorly developed, with a scattered distribution and a low abundance. A single large *Porites* colony was noted at 7-9 m, *Goniastrea* was present at 13-15 m and *Platygyra* at 9-11 m. *Diploastrea* was the only genus commonly observed. In contrast, 'Small massive' forms had an more extensive and abundant distribution. The 6 genera identified covered 15-40 % of the shallower reef (7-13 m) and 1-12 % of the deeper reef (13-19 m), although was variable.

Branching Forms: *Acropora* spp. were common on the shallower reef (7-11 m) with 'Small table' forms dominating. *Pocillopora* spp. were also present.

Encrusting Forms: *Montipora*, *Echinopora* and *Pachyseris* genera were most abundant on the mid reef (11-13 m), covering up to 10 % of the vertical rock wall.

Other Forms: 'Large polyp' corals were rare and 'Solitary' fungiids covered up to 10 % of the reef in the relatively level sections below and above the vertical wall. Occasional individuals were found in steeper sections, behind rocks. A single *Tubastrea* colony was found at the base of the reef. *Millepora* was the most abundant genus in the shallower parts of the reef, (typically 5-15 % between 6-11 m).

Soft Corals: 'Soft' corals were limited to the genera *Lithophyton*, *Dendronephthya* and *Sarcophyton*, with each inhabiting different areas of the reef. The former covered 15 % of the upper (7-11 m) reef, occasional large *Dendronephthya* individuals were observed on both the deep slope beneath the vertical wall and at the top of the wall and *Sarcophyton* was most abundant on the vertical wall itself.

Site QL4:

The reef structure and community composition are summarised in Table 76 and Figure 84 and are described below.

Reef Structure

The reef was best developed over a short, steep slope from 6-8 m. Shallower, there was a gently sloping rock and low-lying coral zone. Beyond the reef base at 12 m was an area of flat sand with small coral bommies (<2 m diameter and 1 m high). Below this was a steep (30-45^0) slope. Rugosity was highest and most variable on the upper slope.

Substrate Composition

The upper reef was composed of an equal mix of rock and rubble, with limited amounts of sand. Rock was dominant on the lower reef, with rubble and sand found in equal, but lower concentrations.

Biotic Cover

Hard and soft corals were dominant, with equal representation over much of the reef. Macroalgae and *Halimeda* spp. were present in smaller concentrations, with the former relatively abundant at shallow depths. Massive form hard corals formed a substantial homogenous stand over an area of mid reef. Otherwise, the hard corals were heterogeneous in form.

Table 76. A summary of the structure, composition and biotic cover at QL4 (P=<1 % cover; Ma-Massive).

Reef Features		**Upper Reef Mode (0-6)**	**Range (0-6)**	**Lower Reef Mode (0-6)**	**Range (0-6)**
Morphology	Slope (^{0})	20	0-30	10	0-20
	Rugosity	2	2	3	2-3
Substrate	Rock	3	1-4	3	2-5
	Rubble	3	1-4	2	0-4
	Sand	2	1-3	2	1-2
	Mud	-	-	-	-
Biota	Hard Coral	2	2-4	3	2-4
	Soft Coral	2	2-4	3	2-4
	Seagrass	-	-	-	-
	Macroalgae	2	1-2	1	P-1
	Halimeda spp.	P	-	P	0-P
Coral state	Heterogeneity	0	0	0	0-1
	Dominant forms	-	-	Ma	-

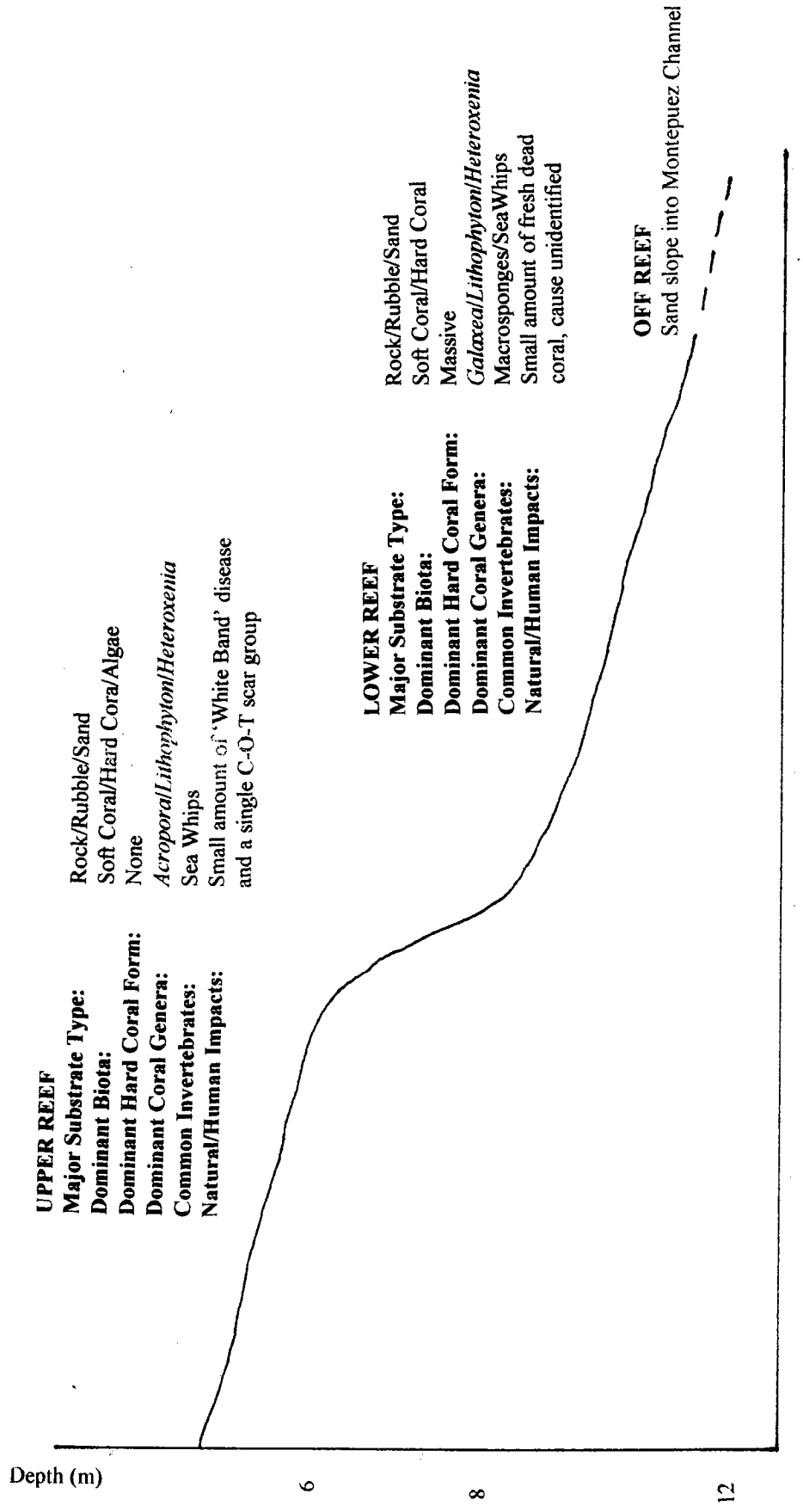


Figure 84: A diagrammatic representation of the "Reef Profile" at site QL4. A summary of the major features of the site is presented (C-O-T: Crown of thorns starfish).

Coral Composition

Massive Forms: 'Large massive' corals were not found below 10 m, being restricted to the bommies and reef slope areas. *Porites* and *Platygyra* were the dominant genera on the coral bommies. On the reef slope 'Large massive' forms were abundant and often produced impressive homogenous stands. *Galaxea* covered, on average, 20 % of the slope, however, on occasion it was found in patches (typically 5 m x 20 m) covering up to 90 % of the surface. *Porites* and *Goniastrea* were also common on the reef slope. 'Small massives' were also limited to the bommies and reef slope areas. Although not as abundant as the 'Large massive' forms, they were generally more widespread and diverse. In the bommies area (8-12 m), 5 genera were identified, but each covered less than 1 % of the total area. On the reef slope their surface cover was typically 5-10 %.

Branching/Table Forms: *Acropora* spp. were also restricted to the bommie and reef slope areas. In the bommie area only 'Small table' forms were common, whilst on the reef slope 'Small table', 'Large table' and 'Staghorn' forms were abundant (10-15 %). Isolated *Pocillopora* colonies were also noted.

Encrusting/Plate Forms: 'Plate' and 'Encrusting' forms were limited in extent and abundance. Only *Millepora* and *Echinopora* were recorded, both on the reef slope. The latter reached 15 % cover in places (usually 0-5 %). *Montipora* and *Turbinaria* were absent and *Pachyseris* was only observed in very small colonies.

Other Forms: The 'Large polyp' coral *Lobophyllia*, unlike other colonial hard corals, was recorded on the bare sand slope, where isolated colonies were observed attached to small rocks. They were also occasionally noted on the reef slope where a single small *Plerogyra* colony was also recorded. 'Solitary' fungiids also inhabited the sand slope, covering approximately 15 % of the area.

Soft Corals: The 'soft' corals *Lithophyton*, *Sarcophyton* and *Heteroxenia* were abundant in all areas, together forming a cover of approximately 35 % of the sand slope, 20 % of the bommie area and 30 % of the reef slope. On the sand slope they were the most dominant coral form, as 'hard' corals were not well developed here. *Sinularia* and *Dendronephthya* were poorly represented in all areas.

6.5 Subtidal Invertebrate and Impact Surveys

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 80).

6.5.1 Overview

Macrosponges and Sea whips were the dominant invertebrates at the deeper sites (QL2, QL3 and QL4). At QL1, a shallow water site sea, urchins occurred in large numbers. Crown of Thorns starfish feeding scars and White band disease were seen at most sites. Evidence of human impacts on the reef were uncommon and were limited to a few areas of broken coral attributed to anchor damage and a few lost or discarded fishing lines.

6.5.2 Site Reports

Site QL1:

The distribution and density of invertebrates, and the incidences of reef damage are summarised in Table 77 and are described below.

Urchins were observed in huge numbers (<100 individuals/5 mins.) at the top of the reef in 2-3 m of water but were absent in deeper water. Other invertebrates were far less common (typically <2 individuals/5 mins.). Both natural coral damage (cause unknown) and anchor damage were noted.

Table 77. Invertebrate and Natural/Human Impacts at Site QL1 (numbers given are for individuals recorded during 5 mins. of survey. A++ = 100+).

		Shallow Reef		Deep Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		4.7	1-9	5.5	2-13
Bivalves	Giant Clams			0.2	0-1
Urchins		60.3	26-A++		
Sea Cucumbers	Holothuria			0.2	0-1
	Others			0.2	0-1
Impacts	**Causes**				
Dead Corals	Unknown	0.5	0-1	0.2	0-1
Human Effects	Anchor damage	0.8	0-2	0.5	0-2

Site QL2:

The distribution and density of invertebrates, and the incidences of reef damage are summarised in Table 78 and are described below.

Macrosponges and Sea whips were the most abundant invertebrates recorded and, although found over the full reef profile, they occurred in greater numbers towards the bottom of the reef. Sedimented 'Massive' form corals were found on the shallower reef close to the sand beach. Occasional patches of freshly dead coral (cause unknown) were noted at all depths. Human impacts on the reef were limited to small areas of anchor damage and pieces of tangled fishing line.

Table 78. Invertebrate and Natural/Human Impacts at Site QL2 (values given are for individuals recorded during 5 mins. of survey. A = 20-50 individuals).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		6.8	2-15	11	8-15
Sea Whips		11.8	8-16	18.5	5-A
Sea Fans		0.2	0-1	1.5	0-4
Bivalves	Giant Clams	0.7	0-1	0.3	0-1
Lobsters		0.3	0-1		
Sea cucumbers	Holothuria			0.2	0-1
	Others			0.7	0-2
Impacts	**Causes**				
Dead Corals	Sedimented	0.3	0-1		
	Unknown	0.5	0-1	0.3	0-2
Human Effects	Anchor damage	0.3	0-2	0.7	0-3
	Fishing lines	0.2	0-1		

Site QL3:

The distribution and density of invertebrates, and the incidences of reef damage are both summarised in Table 79 and described below.

In a similar pattern to Site QL2, Macrosponges and Sea whips were the most abundant (<50-100 individuals/5 mins.) invertebrates recorded. Macrosponges were restricted to the deeper parts of the reef whereas Sea whips were found throughout, but occurring in greater numbers towards the bottom of the reef. Crown of Thorns starfish were observed at the bottom of the reef whilst their feeding scar groups were found on the upper reef. Few other invertebrates were observed. White Band disease and other dead coral (cause unknown) were also observed. No evidence of human impacts were found.

Table 79. Invertebrate and Natural/Human Impacts at Site QL3 (numbers are for individuals recorded during 5 minutes of survey. A+ = 50-100 individuals).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges				30.5	2-A+
Sea Whips		1.5	0-5	25.8	5-A+
Sea Fans		0.2	0-1		
Urchins	Others	1.7	0-7		
Sea Cucumber	Holothuria	0.2	0-1		
	Synapta spp.	1.3	0-5		
C-O-T	Individuals			0.3	0-1
	Scars	0.7	0-2		
Impacts	**Causes**				
Fresh Dead	White band	2.2	0-4		
Corals	Unknown	2.2	0-4		

Site QL4:

The distribution and density of invertebrates, and the incidences of reef damage are both summarised in Table 80 and described below.

Invertebrate abundance was relatively low. Macrosponges were the most abundant, but were very much concentrated on the bottom half of the reef (<20-50 individuals/5 mins.). On the upper reef Sea whips were the most common invertebrate. Several sites of Crown of Thorns starfish feeding scars and White Dand disease were recorded towards the top of the reef. No evidence of human impact was found.

Table 80. Invertebrate and Natural/Human Impacts at Site QL4 (numbers are for individuals recorded during 5 mins. of survey. A = 20-50).

		Upper Reef		Lower Reef	
Invertebrates	**Types**	**Mean**	**Range**	**Mean**	**Range**
Macrosponges		0.2	0-1	15.7	6-A
Sea Whips		3.5	1-7	3.2	1-7
Bivalves	Giant Clams	0.2	0-1		
Gastropods	Murex	0.2	0-1		
Urchins		0.2	0-1		
Sea Cucumbers	Holothuria	0.3	0-1		
	Synapta spp.	0.3	0-1		
	Others			0.7	0-2
Impacts	**Causes**				
Feeding Scars	C-O-T	1.2	0-3		
Freshly Dead Corals	White Band	1.5	0-4		
	Unknown			0.7	0-2

6.6 Reef Fish Census

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 80).

6.6.1 Overview

Quilaluia possesses some of the most sheltered but also most poorly developed reefs in the C.I.G.. However, the diversity of reef fish observed at most of the sites was comparable with the high diversity found on the well developed, exposed outer reef sites of the other C.I.G. islands. In contrast, the abundance of reef fish was generally low, with none of the large shoals of fish recorded along the outer reef. The diversity of reef fish recorded on each site is given in Table 80.

Table 81. Relative Diversity Indices (R.D.I.) and total number of reef fish species observed. Numbers are for those fish observed from the 72 species being censused.

Site	R.D.I.	Total No. Species
QL1	0.15	11
QL2: Shallow	0.28	20
QL2: Deep	0.34	24
QL3: Shallow	0.17	12
QL3: Deep	0.37	26
QL4	0.24	17

For a complete list of censuses species recorded at each site refer to Appendix 7. A comprehensive list of all fish species recorded during the surveys of the C.I.G. is presented in Appendix 8.

6.6.2 Site Reports:

Site QL1:
Site diversity and abundance was low with only 11 species of reef fish recorded. This was thought to be a reflection of the limited surface cover of coral at this site. Dusky surgeonfish (*Acanthurus nigrofuscus*, <20-50 fish/5 mins.), Yellow-striped goatfish (*Mulloidichthys flavolineatus*, <10 fish/5 mins.) and Spotted butterflyfish (*Chaetodon guttatissimus*, <6 fish/5 mins.) were the most abundant species observed. The relative abundance and diversity of reef fish recorded are shown in Figure 85.

Site QL2:
Diversity was relatively high with 24 species recorded. Abundance and diversity were similar at all depths although there was a small increase in diversity at the deeper sections of the reef, due to an increase in the numbers of triggerfish (Balistids), goatfish (Mullids) and angelfish (Pomacanthids) species. Thompson's surgeonfish (*Acanthurus thompsoni*, <14 fish/5 mins.) and the Dash-Dot goatfish (*Parapeneus barberinus*, <10 fish/5 mins.) were the most abundant species. None of the large shoals of reef fish observed on the exposed outer reef were observed at this more sheltered site. The relative abundance and diversity of reef fish recorded on the upper and lower reef are shown in Figures 86 and 87 respectively.

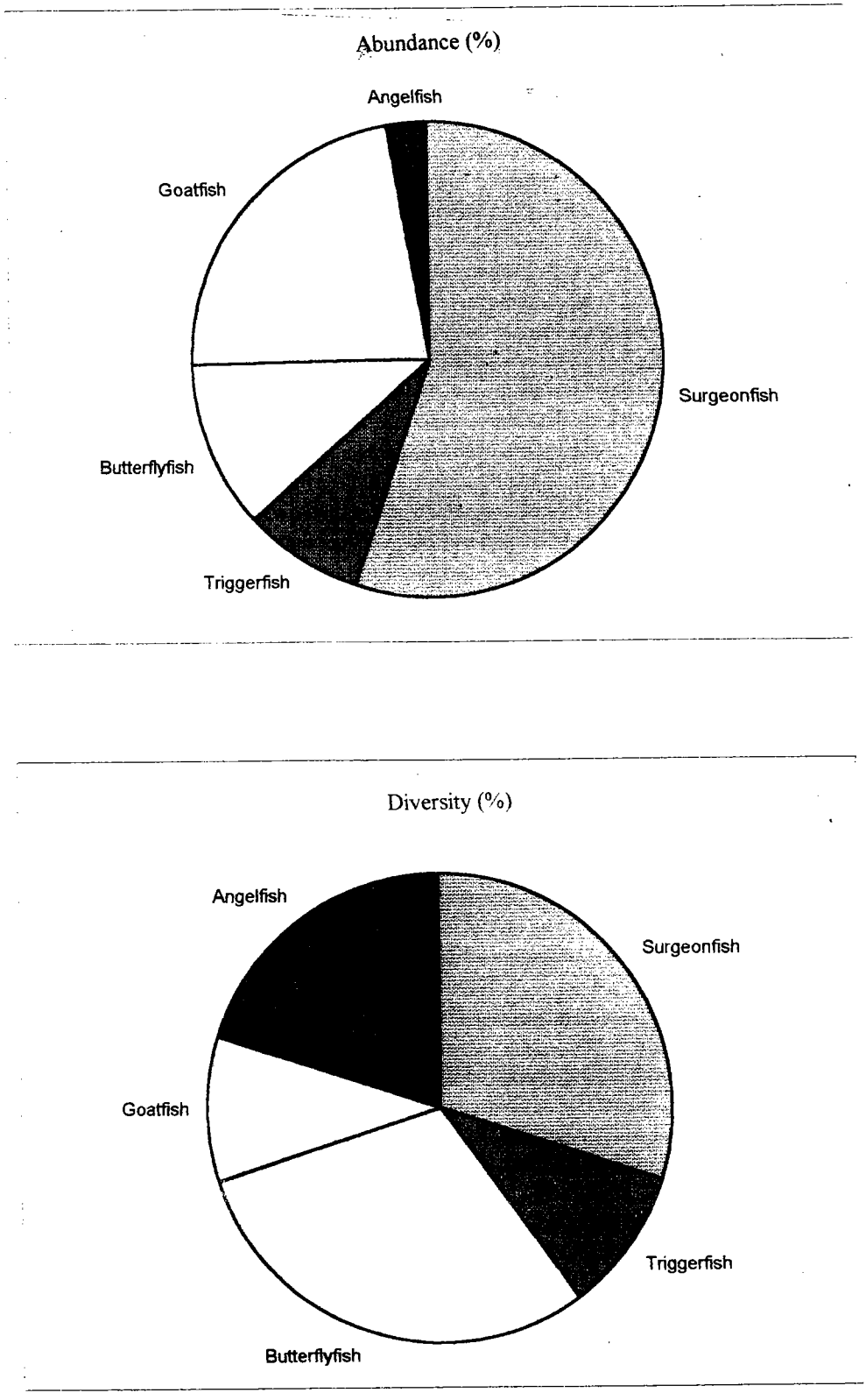
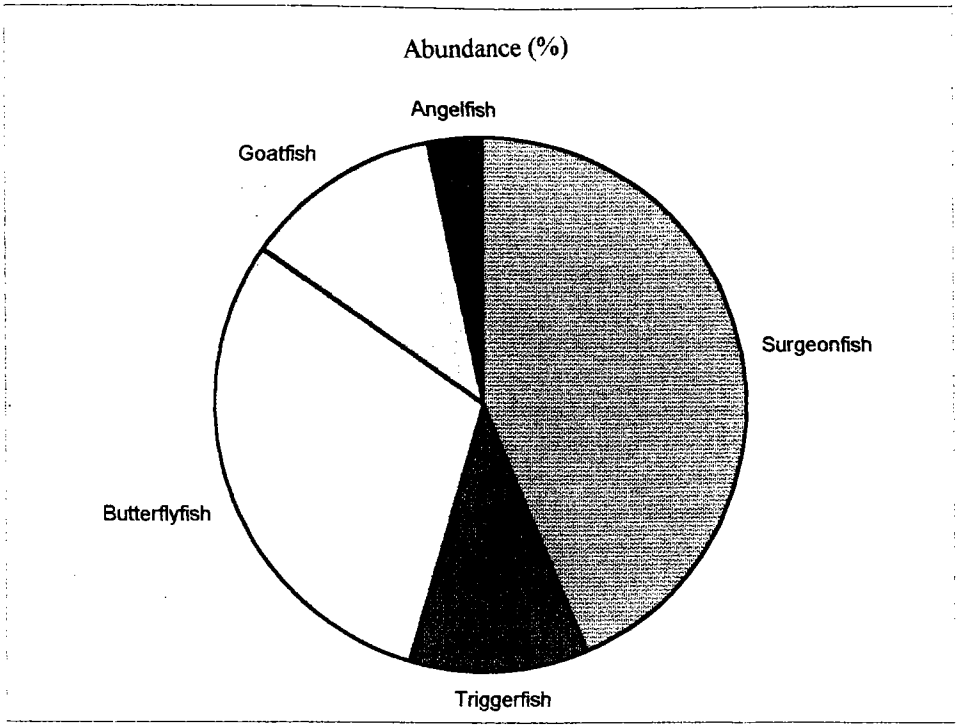


Figure 85: The relative diversity and abundance of reef fish families at site QL1.



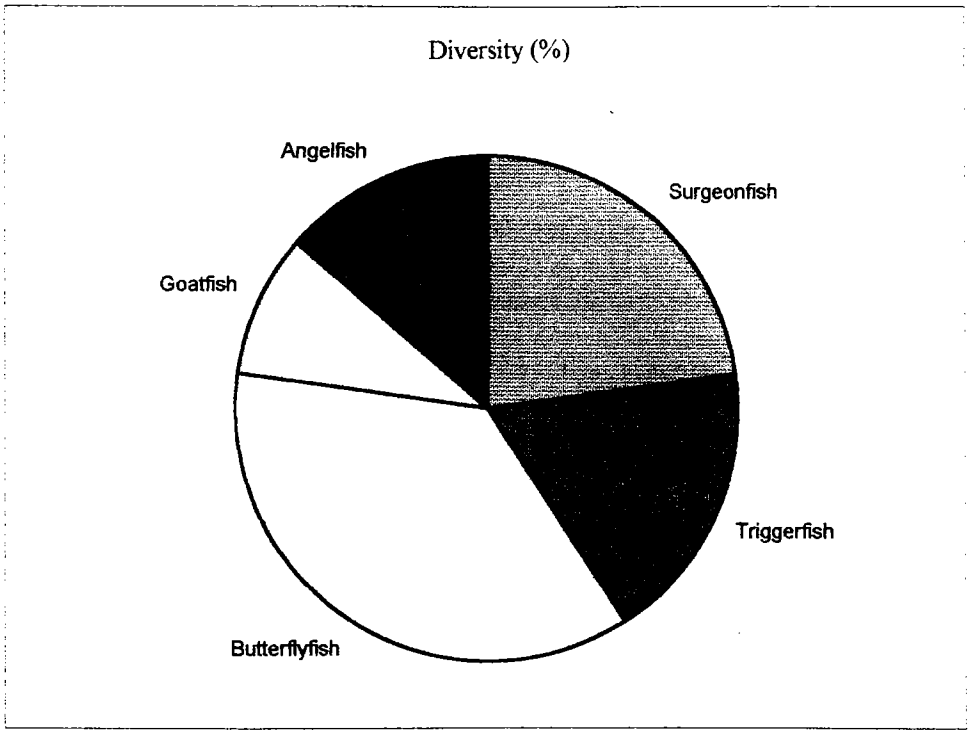
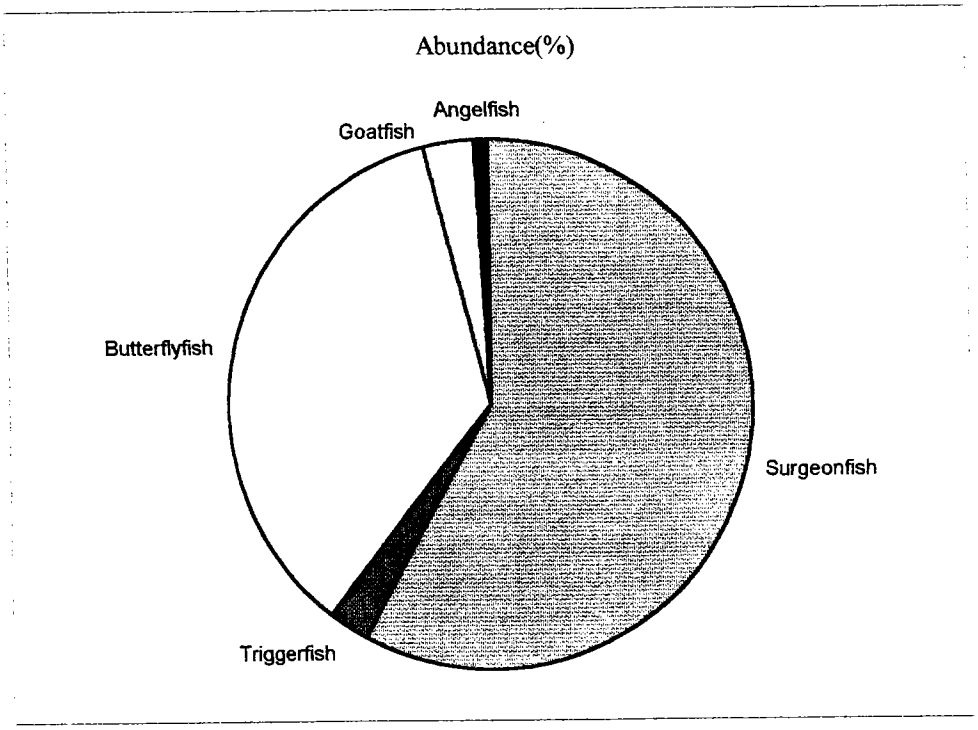


Figure 86: The relative diversity and abundance of reef fish families at site QL2, Upper reef.



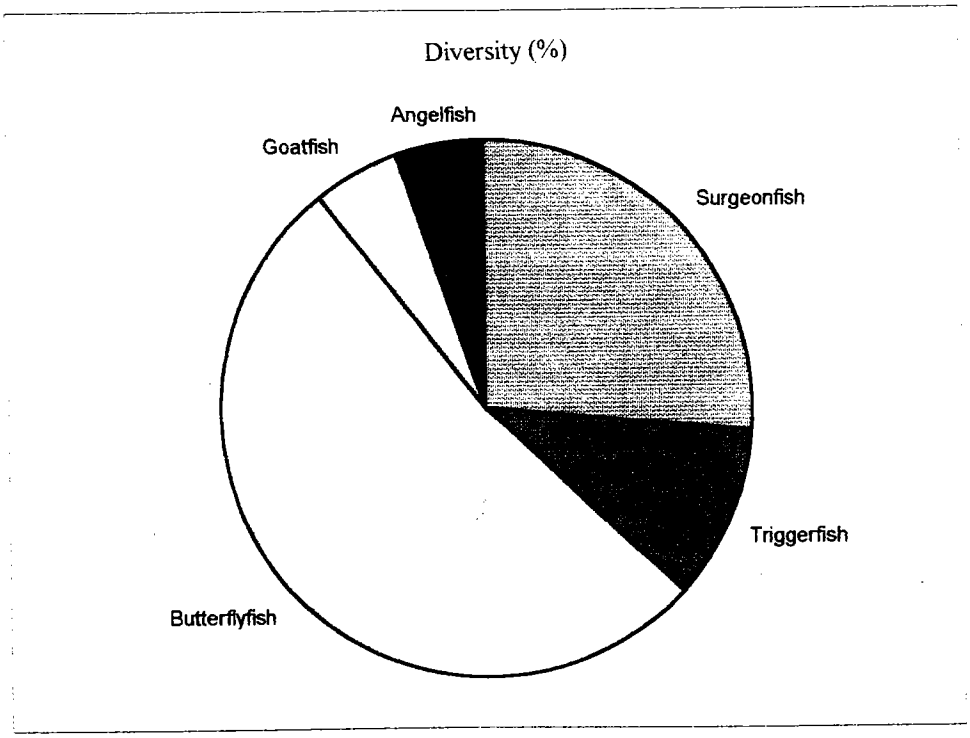
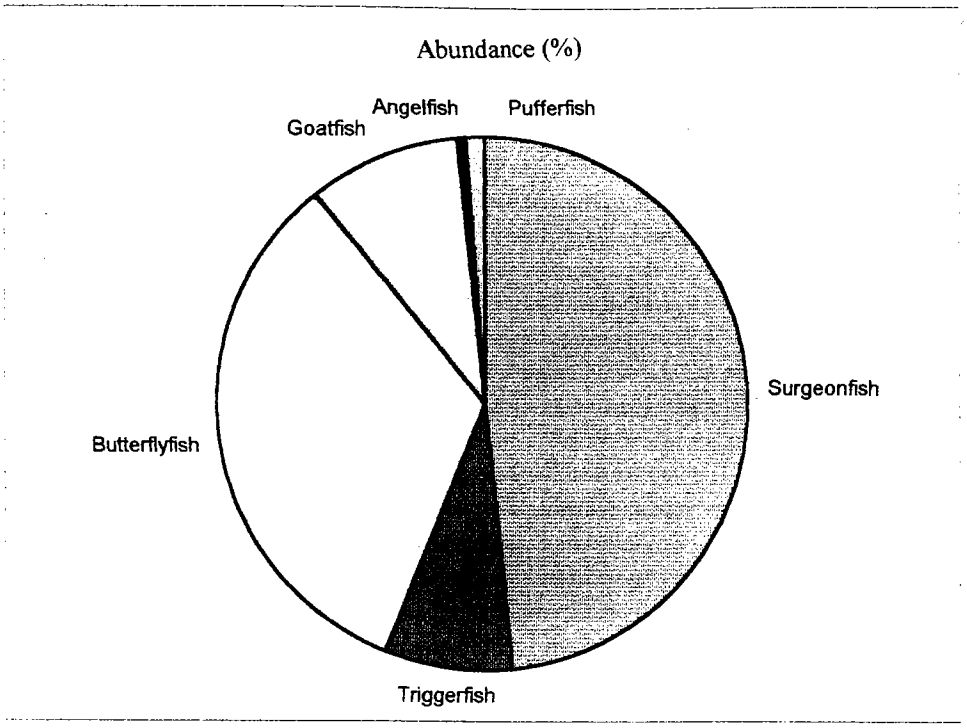


Figure 87: The relative diversity and abundance of reef fish families at site QL2, Lower reef.



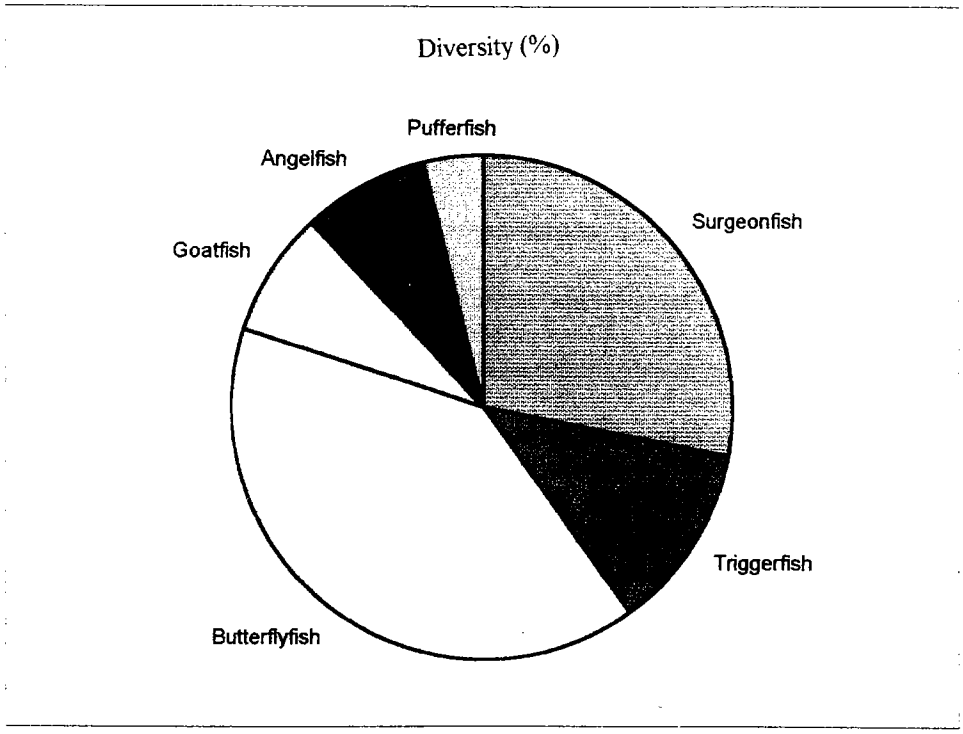


Figure 88: The relative diversity and abundance of reef fish families at site QL3, Upper reef.

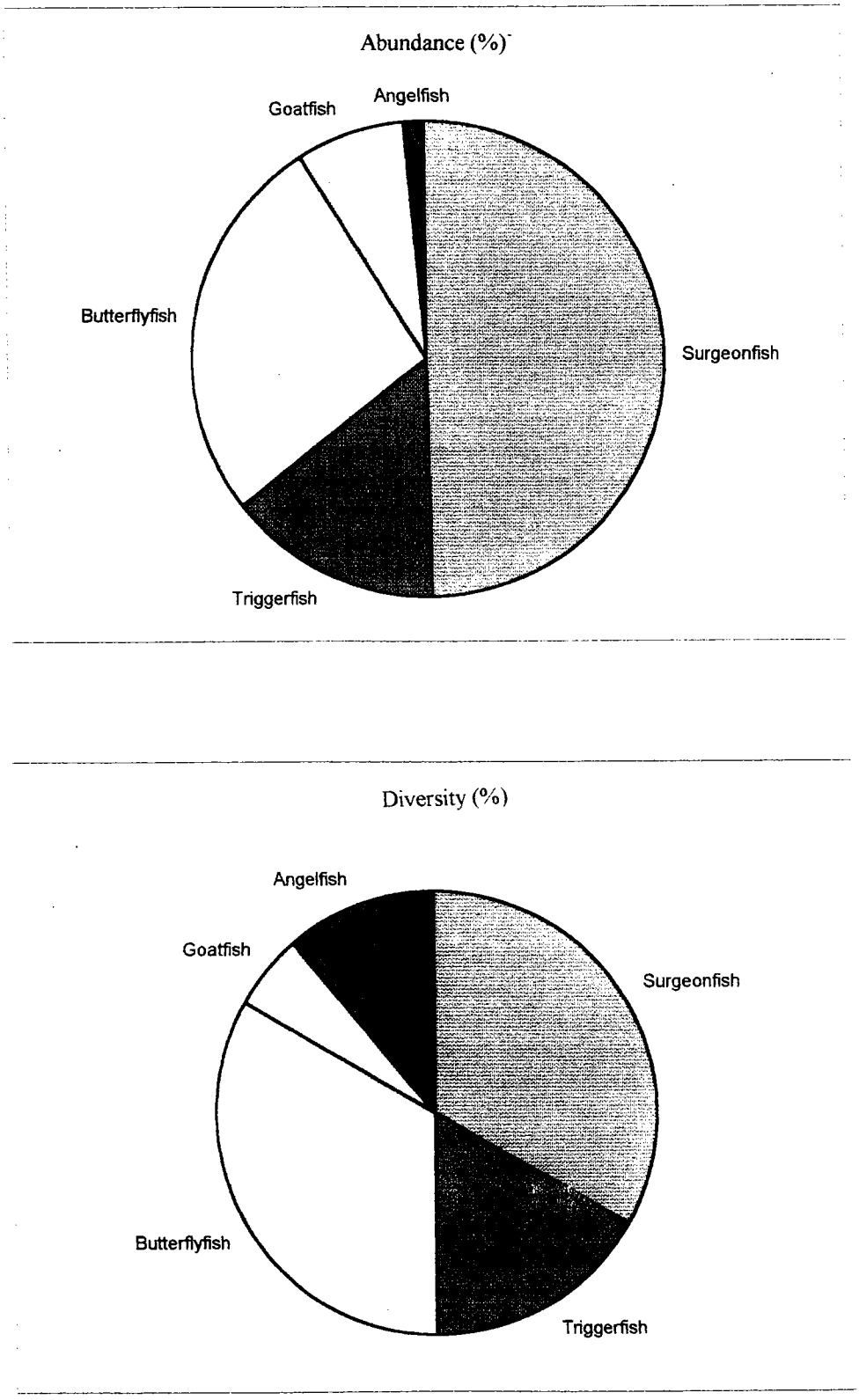


Figure 89: The relative diversity and abundance of reef fish families at site QL3, Lower reef.

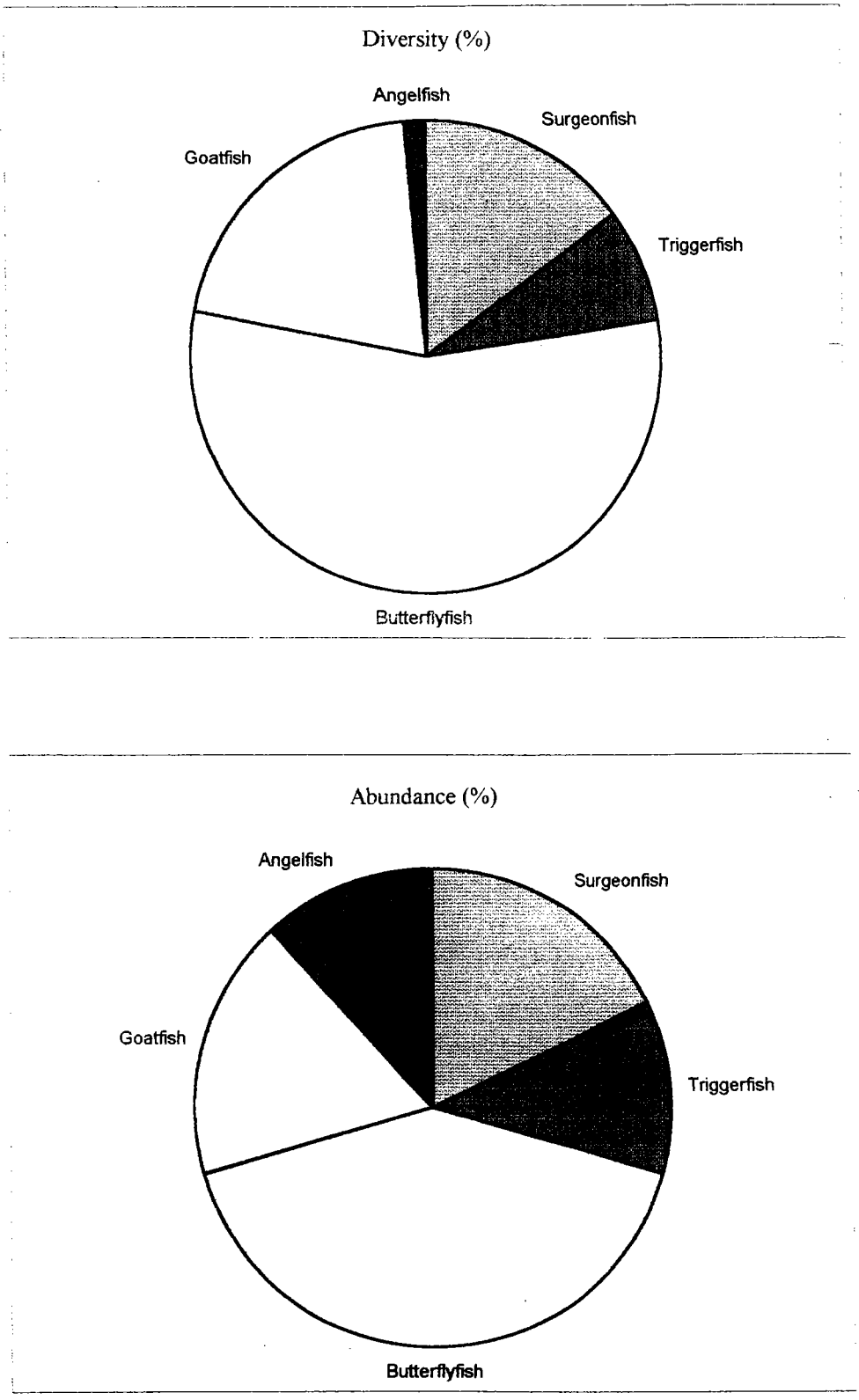


Figure 90: The relative diversity and abundance of reef fish families at site QL4.

Site QL3:
Overall diversity was high with 26 species recorded but, in contrast to the adjacent site, QL2, there was a marked increase in diversity with depth. Differences in abundance were far less marked, with only a small increase at the deeper reef sections. Abundant species included; the Dusky surgeonfish (*Acanthurus nigrofuscus*, <20-50 fish/5 mins.), Thompson's surgeonfish (*Acanthurus thompsoni*, <15 fish/5 mins.) and the Brown Tang (*Zebrasoma scopas*, <10 fish/5 mins.). The relative abundance and diversity of reef fish recorded on the upper and lower reef are shown in Figures 88 and 89 respectively.

Site QL4:
Diversity was moderate with 17 species recorded. No single species was present in large numbers. The most abundant species were the Dot-Dash butterflyfish (*Chaetodon kleinii*) and the Moorish Idol (*Zanclus cornuta*), both <10 fish/5 mins.). The relative abundance and diversity of reef fish recorded are shown in Figure 90.

6.7 Commercial Fish Census

Survey site locations are as for the subtidal habitat surveys reported above (Fig. 80).

6.7.1 Overview

The abundance of commercial fish species around Quilauia's reefs was relatively low and this is thought to be a reflection of the more sheltered nature of the reefs in comparison to the other islands of the C.I.G.. Notably absent were the large shoals of snappers (Lutjanids) and emperors (Lethrinids) often seen on the exposed outer reef sites of the other islands. Additionally, the relatively sheltered nature of these reefs has allowed a greater intensity of fishing in this area than at any other in the C.I.G.. However, the diversity of commercial reef fish species was relatively high in places and the presence of large grunts (Haemulidae) and parrotfish (Scarids) suggests that fishing pressure has not been too excessive.

6.7.2 Site Reports

Site: QL1
The sparse patches of coral at this site supported few commercial fish, with only a limited number of small parrotfish (Scarids: *Scarus sordidus* and *S. ghobban*) recorded. Large numbers of Seagrass parrotfish (Scarid: *Leptoscarus vaigiensis*), which form a significant part of the nearby seine net fishery were, however, observed in the extensive patches of seagrass. The family composition and encounter rates are given in Figure 91.

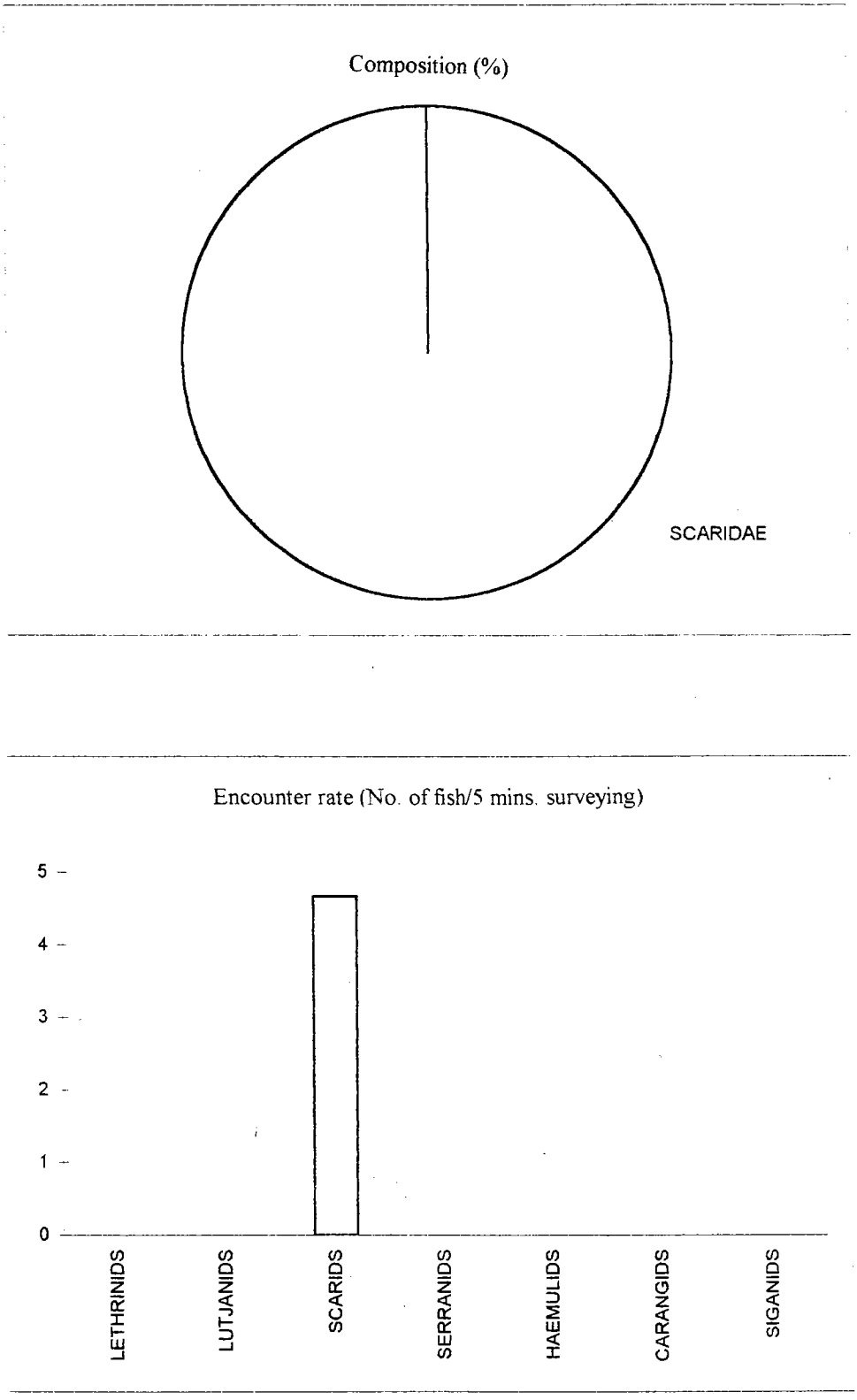


Figure 91: The composition and encounter rates of commercial fish recorded at site QL1.

Site: QL2

The diversity of commercial fish species was relatively high (16 species recorded) but abundance was low with no large shoals observed during the surveys. Large shoals of fusiliers (Caesionids) and jacks (Carangids) were however observed on other occasions close to the shore. Numerous species of parrotfish (Scaridae: estimated average length 20 cm; *Scarus ghobban* < 60 cm), a few large grunts (Haemulidae) including, *Plectorhincus gibbosus* and *P. plagiodesmus* (estimated length <60 cm) and two pairs of rabbitfish, *Siganus stellatus* (estimated length 40 cm) were recorded. Although not recorded in the surveys, large specimens of *Diagramma pictum* (Haemulid) and *Lethrinus nebulosus* (Lethrinid) were regularly observed. The family composition and encounter rates are given in Figure 92.

Site: QL4

Very few commercial fish were recorded at this site with an average encounter rate of only six commercial fish in a 30 minute survey. Species identified included the parrotfish (Scaridae), *Scarus ghobban* and *S. frenatus* and the grouper (Serranidae), *Cephalopholis miniatus.* The family composition and encounter rates are given in Figure 93.

6.7.3 Size Distributions

The size distributions of the commercial fish recorded are summarised for all the sites surveyed around Quilaluia island in Table 82 below. The range of fish lengths was generally smaller than that recorded for islands with fringing 'outer reef', although the estimated median length was greater. This could be an artefact of the smaller number of fish sampled rather than a reflection of a genuinely larger fish around the island.

Table 82. Size distribution summary for the commercial fish of Quilaluia island

'Commercial' Fish Family	Estimated Median Length (cm)	Estimated Length Range (cm)
Lethrinidae*	20	20-30
Lutjanidae*	30	30
Scaridae	20	20-60
Serranidae	20	20-50
Siganids*	40	40
Haemulidae	50	50-60
Carangidae	-	-

* based on less than 4 specimens

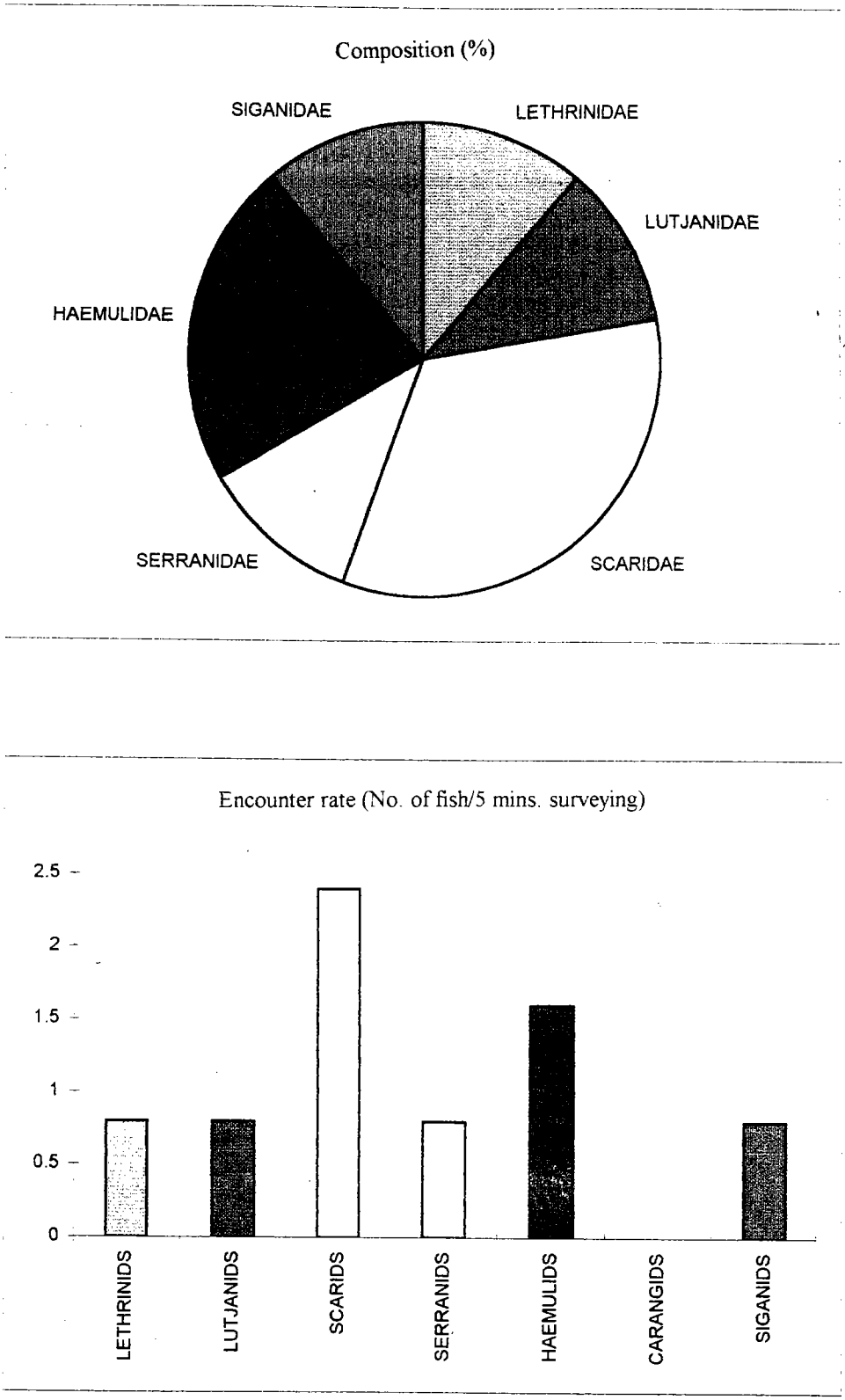


Figure 92: The composition and encounter rates of commercial fish recorded at site QL2.

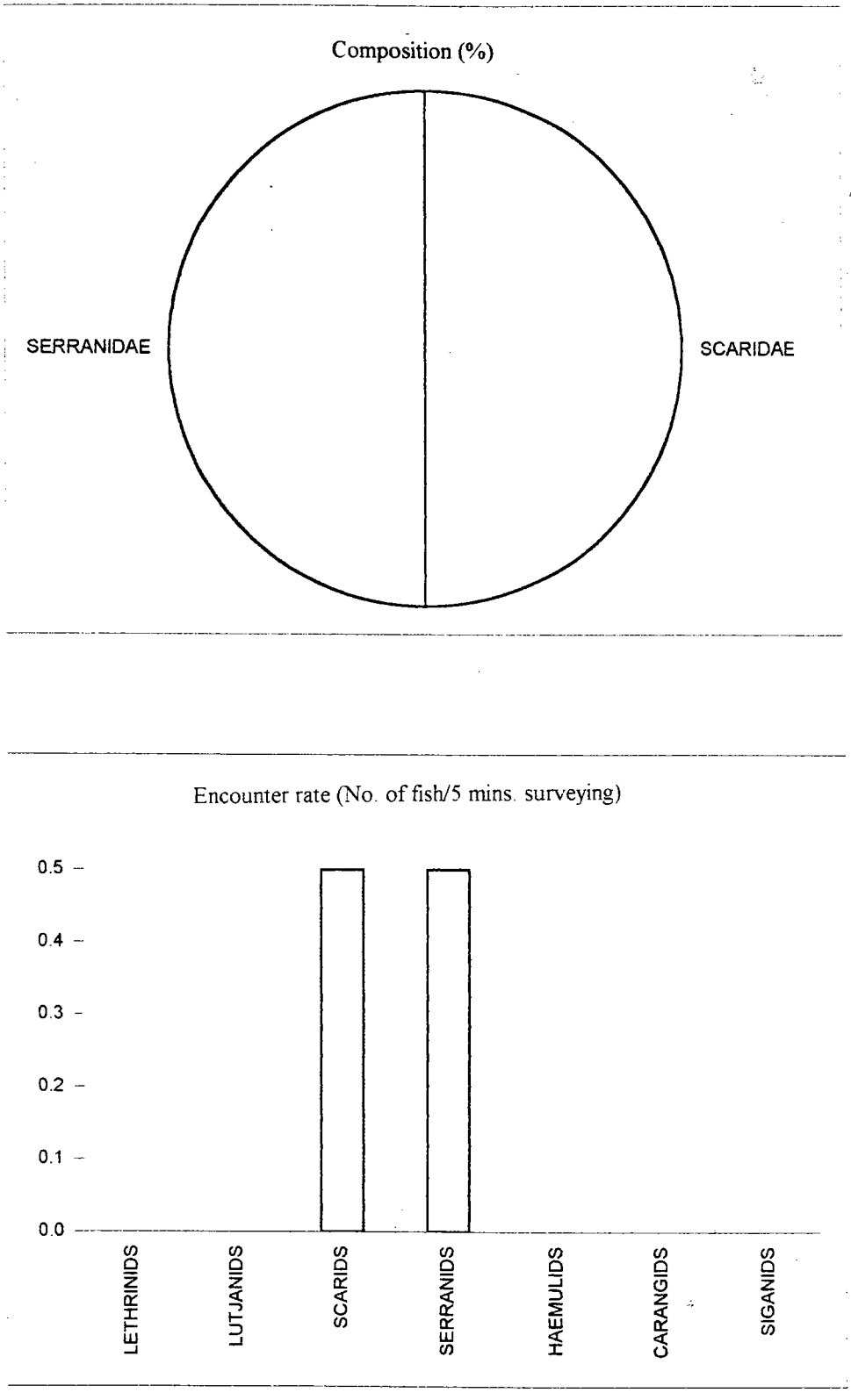


Figure 93: The composition and encounter rates of commercial fish recorded at site QL4.

6.8 Finfish Fisheries

Quilaluia is the only island of the C.I.G. that has been settled within the last fifteen years. Although some inhabitants have lived on the island semi-permanently for up to ten years, the lack of fresh water necessitates frequent trips to the neighbouring island, Quirimba or to the mainland, and so discourages further population growth. Additionally, agriculture has been limited by the rocky terrain and there was little evidence of any produce being grown for consumption. At the time of this study there were 11 houses or small compounds on the island. A few of them were inhabited by families but most housed visiting fishermen from the mainland who had left their families behind. The permanent population of the island was estimated at 30 people. The distribution of fishing gears used is summarised in Table 83.

Table 83. A summary of the population involvement with different fishing techniques.

Quilaluia Island		**Number**
Permanent population		30
Fishermen:	resident	16
	itinerant	40
Fishing Method		
Line		4
Seine net		28
Surround net		6
Trap: Marema		0
Trap: Suri		13
Trap: Large Marema		2
Luwando		0
Spear		1
Intertidal		2
Sailing Boats		4
Canoes		20
Rowing Boats		3

Quilaluia was one of the most popular bases for visiting fishermen from Nampula Province and Tanzania. Although the numbers of fishermen visiting the island fluctuated greatly there was usually a large encampment of visiting fishermen who stayed for from between a few days to three or more months. The visiting groups of fishermen encountered included approximately 50 net fishermen from Nampula province, 30 Nampula fishermen who were employed by a marine curio company to collect shells, and a group of 16 seacucumber fishermen from Tanzania equipped with full SCUBA diving equipment and a motorised fishing boat.

Fishermen also visited from the nearby mainland on a regular basis, and have been doing so for some time. These included a small number of fishermen from Quissanga, one of the nearest mainland villages, who come to Quilaluia for three months to fish and then return to the mainland and work on their 'mashambas' (cultivated plots) for three months. A Quissanga fisherman interviewed said that he had been coming to Quilaluia island for five years. Most itinerant fishermen operate some sort of pattern so that they are at home during the wet season.

The visiting fishermen favoured the use of gillnets and seine nets and targeted large reef fish which were dried on huge drying racks for later sale on the mainland. Very large unicornfishes (Acanthuridae) of at least three species (*Naso brachycentron, N. tuberosus and N. brevirostris*) were caught by the net fishermen and were said to be one of the best fish to dry. Local fishermen usually used the suri traps which targeted the small emperor *Lethrinus variegatus* almost exclusively. These fish were also dried but were only for the consumption of the fisherman and his family and for limited local sale or barter. The traps were set in sand and seagrass areas of the channel to the north of the island.

Quilaluia was unusual within the C.I.G. for having excellent access for boats on the western side where there was a steep beach with deep water and a very limited intertidal area. This may account for the large proportion of boat-based fishing activity. Directly in front of the village area is a deep drop-off and well developed coral reef but the strong currents in this area appear to have restricted fishing activities in this area. Much of the net fishing takes place in the shallow coral channel between Sencar and Quilaluia.

6.9 Intertidal Resource Collection

6.9.1 Overview

The intertidal of Quilaluia was almost equally divided between the north-western sand and seagrass beds, and the eastern reef intertidal. The distribution of intertidal habitats is given in Figure 94. The scale and patterns of collection were surveyed over a two day period and the results are summarised below.

Scale and Intensity of Collection
Thirty nine people were observed collection on the intertidal during the two day survey, giving an exploitation density of 9 people/ km^2 for the entire intertidal area. This collection intensity is the highest recorded for all the C.I.G. intertidal areas studied. This high density of collectors was principally due to the large numbers of visiting collectors. Of the 39 collectors interviewed, 25 had come by boat from Navinje (a journey of several hours), and another two were from Pemba. Whilst the total number of people on Quilaluia at this time was estimated at 60 people, it was ascertained that on other days during the period July-October, the island supported up to 120 people.

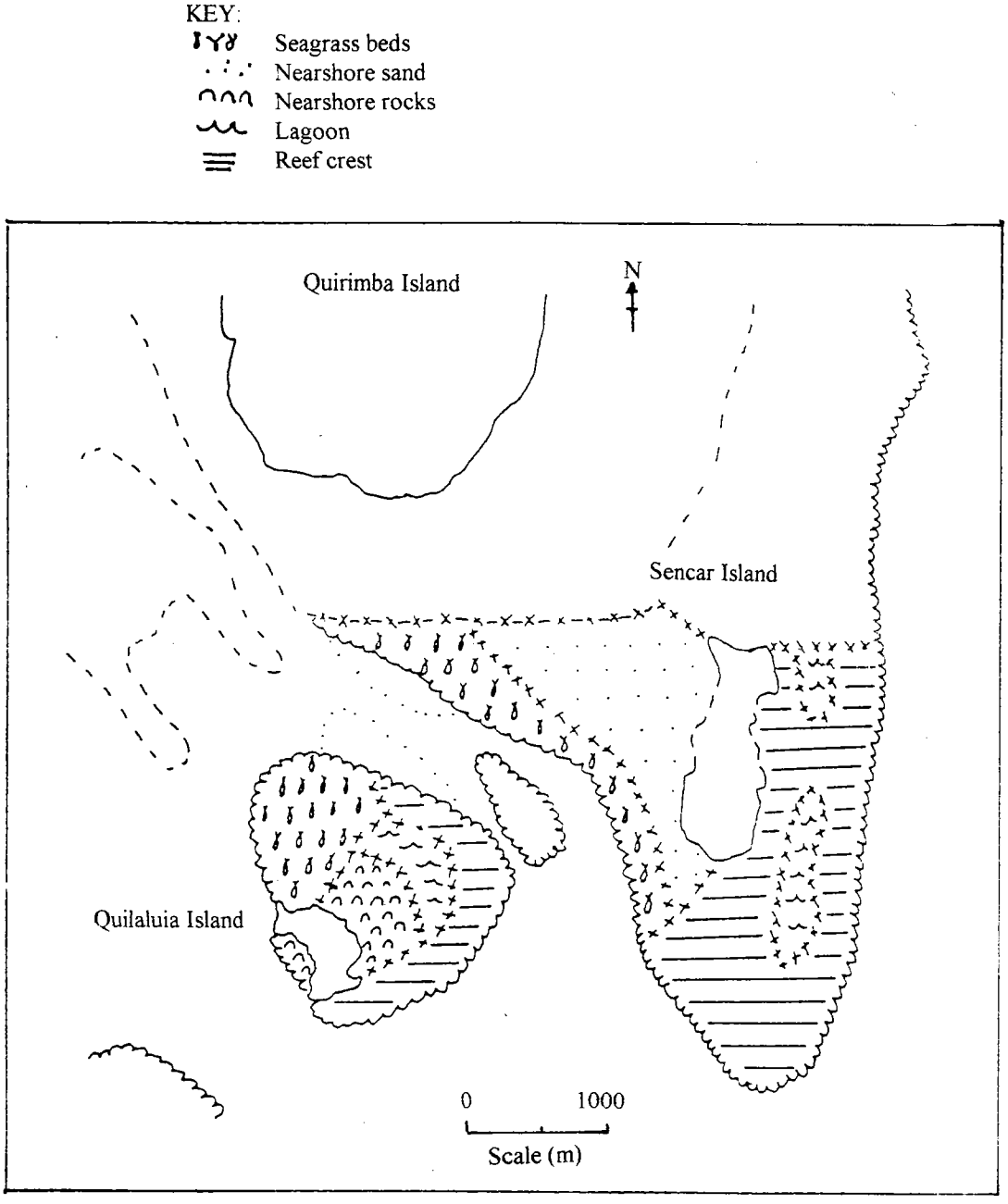


Figure 94: The intertidal zones distinguished on Quilaluia island in relation to the resource use surveys.

Gender of Collectors
Adult women accounted for 85% of the people observed collecting and there was a marked absence of young men and women.

Group Structure
A high proportion (77%) of the collectors worked in groups. Most were included in a single group of 25 women who collected Ark shells (Barbatia sp.) from the sand and seagrass beds. Two other smaller groups were composed of two men and two women each. Of the remaining 14 collectors nine operated as individuals.

Origin of Collectors
The majority of the adult women were part of a group of 25 women who arrived by boat from Navinje. Only eight women were from Quilaluia itself. Two men had come from Pemba for a few weeks of collecting.

Collection Methods
Most collected by hand (30/39) whilst the remainder used iron rods, with two of these also using marema traps. Collection by hand was the preferred technique as most were collecting bivalves from the sand/seagrass zone. Iron rods were used to catch octopii and fish in the lagoon, around the nearshore rocks and at the waters edge close to the seagrass beds.

Catch Composition
Most people (82%) were involved in the collection of bivalves, notably *Barbatia* sp. (estimated 12,800 shells collected in two days), but also *Pinna* sp. shells. A large proportion (74%) of people also collected 'FO' gastropods, but their catches were small (45 specimens of *Fasciolaria trapezium* and 23 specimens of *Chicoreus ramosus*). Other resources collected were relatively few and involved only a small number of people, with only two species of 'CT' gastropods (*Conus* sp. and *Cypraecassis rufa*), five species of holothuria, and four species of fish taken.

6.9.2 Distribution of Effort across Intertidal Zones

Most (87%) collectors were in the sand and seagrass beds where their density reached 18/km^2. Small numbers of people collected in the lagoon (4/39) and nearshore rocks (1/39), with respective densities of 8/km2 and 2/km^2. There were no collectors on either the reef crest or the nearshore rocks of the southern and western sides of the island. In the sand and seagrass beds 94% of collectors were adult women, most of whom (25/32) were part of the group from Navinje. All four collectors in the lagoon were adult men.

Collection Methods
The collection of bivalves in the sand and seagrass beds was by hand, although four individuals also possessed iron rods. In both the lagoon and nearshore rocks, the most commonly employed technique was the use of iron rods, with two men also supplementing this with the use of 'marema' traps.

KEY:

Oct	Octopii
Biv	Bivalves
FO	Food/Operculae Gastropods
CT	Curio Trade Gastropods

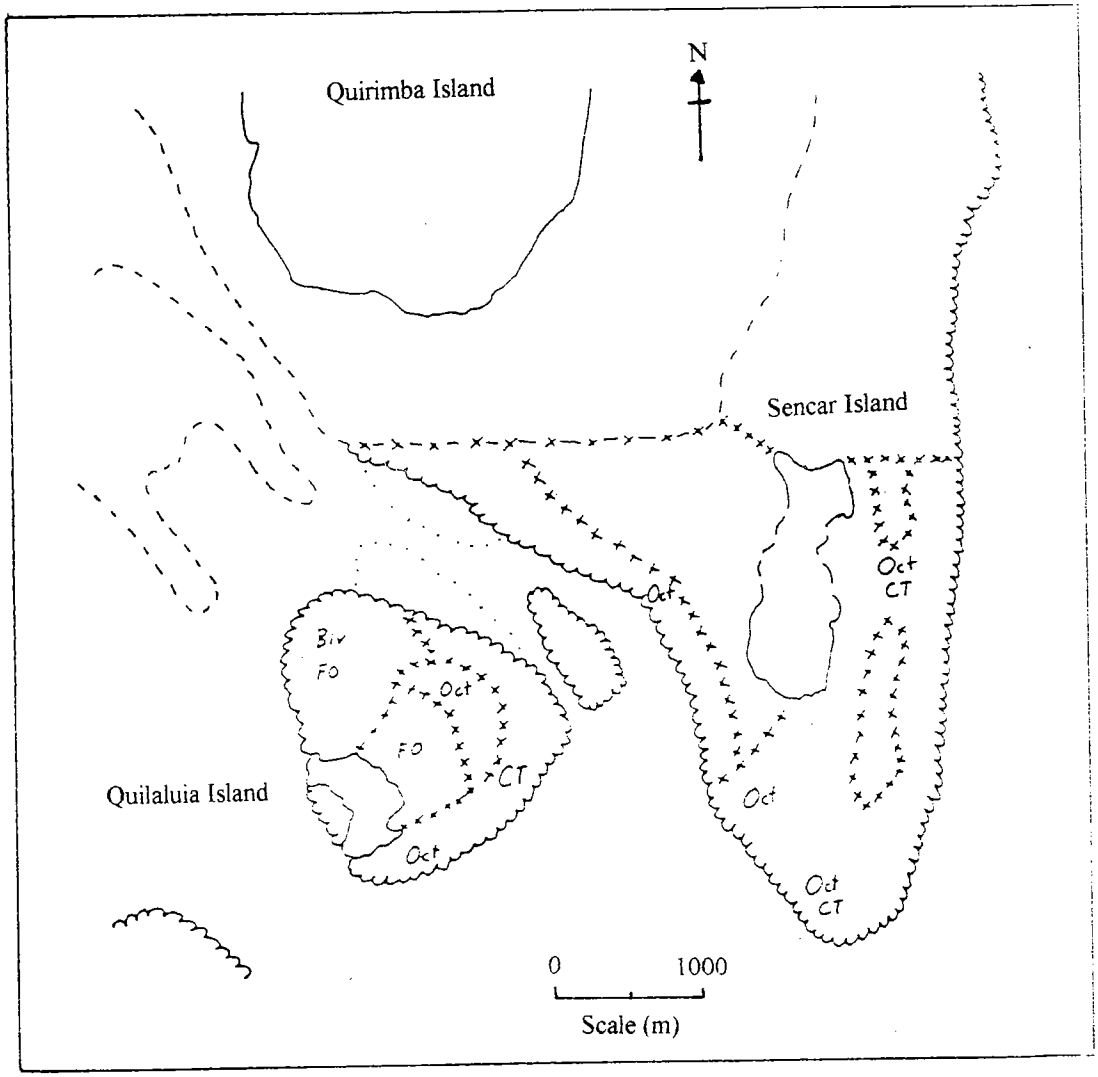


Figure 95: The main areas for the collection of intertidal vertebrates on Quilaluia island.

Catch Composition

The distribution of resources across intertidal habitats is summarised in Figure 95. The main catch, from the sand and seagrass zone, comprised huge quantities of *Barbatia* sp. bivalves (12,800 shells), and a number of octopii and 'FO' gastropods. The two 'marema' trappers caught an estimated 20 fish and a few 'FO'/'CT' gastropods. A single woman concentrated her efforts on the near shore rocks where she collected *Fasciolaria trapezium,* 'FO' gastropods, and a couple of octopii.

6.9.3 Subtidal Collection

A few of the visiting fishermen collected molluscs and holothuria when snorkelling. Two groups of three men, from Nacala, in two days of work had collected, 200 *Cypraea tigris*, 80 *Lambis lambis*, 20 *Conus litteratus*, 2 *Conus textilis*, 5 *Cypraecassis rufa*, 1 *Cassis cornuta* and 1 *Mitra mitra.* This group spent the rest of their 40 days on the island line fishing. The 'CT' gastropods were to be sold to 'LusoAfrica' in Nacala. Another group of three men from Pangane had collected 90 kg of semi-dried holothuria by snorkelling over a week-long period. Another group of four men, also from Nacala, showed the results of 11 days work which included 150 kg of fish), 250 *Cypraea tigris* (50 kg), 200 *Lambis lambis* and 5 *Cypraecassis rufa* also for later sale to 'LusoAfrica'. A joint Tanzanian and Mozambican operation of nine men was using SCUBA to collect seacucumbers.

6.9.4 Discussion

Quilaluia island, like Sencar has been, until relatively recently, and open to settlers from neighbouring coastal areas, such as Ibo, Pangane and Pemba. The island still attracts itinerant fishermen who set up camp for several weeks in the dry season (May-November) and at times number up to 120. The 25 women who arrived from Navinje were not regular visitors and had come to collect *Barbatia* sp. shells as elephants had destroyed their fields of cassava and they needed some form of resource to exchange for more cassava from neighbouring villages.

Quilaluia was an important centre for the subtidal collection of molluscs and holothuria for later sale in Nacala and Pemba to exporters such as 'LusoAfrica' in Nacala ('CT' gastropods) and 'Willaw' in Pemba (holothuria). These resources appear to have been relatively unexploited by local fishermen and are open to future collection by itinerants. The problem with this arrangement is that outsiders are rarely observed to respect the traditional management of local resources preferring to collect heavily until the resource is depleted and then moving on to new areas.

6.10 Mollusc Biodiversity Study

6.10.1 Overview

Eleven species of bivalves and 38 species of gastropods (from 15 Families) were recorded. The most diverse of these Families were the Cypraeidae and Strombidae, each containing 7-8 species. A full list of species recorded is given in Appendix 16.

6.10.2 Habitat Distributions

The sand/seagrass zone
Five bivalve species and 14 species (from 10 Families) of gastropods were identified. Within the gastropods the most diverse Family were Whelks (4 species).

The reef zone
Three bivalve species and 22 species (from 9 Families) of gastropods were identified. Within the gastropods the most diverse Family were Cypraeidae (7 species).

The subtidal zone
Four bivalve species (including; *Chlamys* sp., *Pecten* sp. and *Pitar abbreviatus*) and 8 species (from 5 Families) of gastropods were identified. Within the gastropods the most diverse Family were Cassidae (3 species).

6.10.3 Discussion

Overall Diversity
Despite the relatively small intertidal area of Quilaluia island (2.25 km^2), the diversity of bivalves and gastropods was high. The high bivalve diversity may be a consequence of the relatively high diversity of available habitats which included well-developed reef and sand/seagrass zones. The gastropod diversity was also high and this can also be credited to the high variety of suitable habitats.

Diversity within Habitats
The greatest diversity of bivalves was found within the sand/seagrass zone, where 5 sand-dwelling species were recorded. Additionally, the subtidal zone was important with the 3 species found there not recorded elsewhere in the intertidal habitats. The intertidal reef bivalves identified were specialists for rock/reef habitats. These factors combined to produce a marked zonation of bivalves, each species (except *Tridacna squamosa*) being restricted to a single zone. The distribution of gastropods also showed marked zonation. Of the 38 species identified, 25 were restricted to a single habitat, whilst only 1 species (*Cypraea tigris*) was found in all 3 habitats. Correspondingly, 9 of the 15 Families were also restricted to a single habitats. The distinct nature of each of the habitats was probably the causative factor for this zonation. The species diversity of gastropods was greater in the reef habitat than in the sand/seagrass but, in contrast, the diversity of families was greater in the sand/seagrass habitat. Within the subtidal zone, all 8 of the gastropod species recorded off Quilaluia were also found in the subtidal zone of Quirimba island.

7.0 DISCUSSION

The findings reported above support the conclusions of Tinley (1970) in that the areas so far surveyed contained a rich diversity of both habitat types and flora and fauna within these habitats. 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 create and preserve the Quirimba Archipelago, including the C.I.G., as an area of regional importance in terms of its high biodiversity and extensive marine resources.

Individual habitats and the use of marine resources within them are discussed below in terms of their biodiversity, threats to their continuity, and requirements for management and further study.

The Mangrove Habitat

The C.I.G. supports the largest mangrove stand in the Quirimba Archipelago, at approximately 1,900 hectares. The large mangrove stand to the south and west of Ibo island (termed the 'Ibo Stand' in this report) and the 'Quiwandala Stand' on the north-west side of Quirimba island are closely linked with the mangrove of the adjacent coastline. If both the coastal and island mangroves are combined then the total area of mangrove associated with the C.I.G. is over 3,000 hectares. The majority of mangrove surveyed was undisturbed, the effects of mangrove cutting being mainly limited to the more accessible areas. This stand represents an extensive and important example of this habitat type for the region.

A total of eight species of mangrove tree have been recorded to date. With only 11 species known from the East African Region this represents a significant centre for regional diversity. The limited freshwater input has limited the structural development of the stands in comparison to the mangrove of the Rufiji or Ruvuma river deltas, but areas of mature trees were recorded with trees up to 15 m high supporting a dense canopy.

Current threats to the mangroves were low with the scale of cutting relatively limited and localised. However, many of the more accessible areas have had the majority of the more prized species selectively removed. Examples of this selective cutting were observed along the main channels and close to Quirimba island in the 'Ibo Stand' and in large areas of the 'Quiwandala Stand' on Quirimba island.

'Quiwandala Stand', close to the main village on Quirimba island, has been used as the primary source of firewood and building materials for the islands population. This has placed the stand under considerable pressure and has resulted in the clear felling of significant tracts of mangrove of up to several hundred square metres. This localised clear felling has led to an erosion problem along the adjacent shoreline, which has increased markedly in recent years (Quirimba island administration, pers. comms.). Although there has been an apparent change in the hydrography of the island over the last 15 years (J. Gessner, pers. comms.) which has also given rise to increased

erosion in a number of places, it was thought that mangrove cutting has played a significant role in shoreline erosion, particularly close to the village.

The administration on Quirimba tried to introduce a voluntary ban on the cutting of mangrove on the island, particularly of the smaller trees which were popular for fence building. However, the ban was generally ignored by the islanders, probably due to the greater effort and logistics required to exploit the alternative 'Ibo Stand'.

Future management of the mangroves will be important not only in terms of the value of the mangrove resource itself and the shoreline erosion problems on the island, but in terms of their value in helping to support the associated seagrass fishery in the Montepuez Bay. The role of mangroves in the tropical marine systems has been the subject of many studies and it is now recognised that they play an important role as a nursery site for many species of fish and crustaceans which may later migrate to the seagrass beds or coral reefs.

The Intertidal Flats

Macroalgae

The diversity of macroalgae was high, with a total of 195 taxa (182 species and 13 specimens identified to genus level) recorded to date and a number more specimens yet to be identified. This level of diversity compares favourably with those areas studied further south in Mozambique (M. Carvalho, pers. comm.) and for areas of the Tanzanian and Kenyan coasts to the north.

The highest levels of diversity were recorded on the two largest islands, Ibo and Quirimba (141 and 126 taxa respectively), and appeared to be linked to the greater variety of available habitats. The species composition varied between islands, with approximately 40% of the taxa distributed widely while the majority tended to show a more restricted distribution.

No species were observed to be utilised by the island's population and any obvious impacts were limited to reef trampling by collectors on the intertidal area and dragging fishing nets through the shallow subtidal areas. Consequently, the perceived threats to biodiversity were low. However, as many macroalgae species are susceptible to changes in a variety of environmental factors, such as increased nutrient levels and increased turbidity, any future coastal development occurring within the islands should be managed with consideration for such factors.

The correct identification of certain algal specimens, particularly the Rhodophyta (Red algae), relies field observations being supplemented with cytological, reproductive and biochemical data which is beyond of scope of the current Programme's field work. It is therefore recommended that future macroalgae studies in the area should plan to incorporate these more advanced identification techniques.

Invertebrates

Assessment of the intertidal invertebrate populations resulted from a combination of findings from biological surveys of the intertidal zones and investigations into the activities of collectors targeting intertidal invertebrates. The shear variety of invertebrate fauna, combined with the limited taxonomic skills available, meant that it was not possible to study the fauna in detail. The Programme's studies therefore concentrated their efforts on the phylum Mollusca, particularly gastropods and bivalves, as they represented the dominant fauna in most intertidal areas and were subject to a relatively high level of exploitation.

The 140 taxa of intertidal Molluscs recorded, combined with the high diversity of recorded flora, suggests the intertidal habitat as a whole to be a site of high biodiversity.

The majority of invertebrates were collected on a subsistence basis for consumption at home or barter on the islands for other staple food items. In general, it was the adult women that collected and the gathering of intertidal resources was one of the most important work components for the women on the islands. In some households, particularly when the adult males were absent or not fishing, invertebrates, particularly bivalves (*Pinctada* spp. and *Barbatia* spp.), became more of a staple food than fish.

The scale and nature of the exploitation of intertidal invertebrates varied considerably between the islands and was the product of the following factors: the size of the intertidal area; the distribution of intertidal sub-habitats (e.g. sand/seagrass zone, lagoon zone, reef crest zone); the size and demographics of the island's population, and; the scale of other resource use activities based on the island. Consequently, Quirimba island, supporting a large population and having a large and varied intertidal area had the greatest number of collectors, with over 200 observed on some spring tides. If the intertidal collection of invertebrates was assessed for the C.I.G. as a whole it could be considered a relatively intensive resource use activity and one which poses a threat to the biodiversity of the intertidal habitat. During the period of the survey work, the threat was increasing with the arrival of greater numbers of invertebrate collectors from the mainland, especially to the less populated islands such as Quilaluia.

As for all other resource use within the C.I.G., there is currently no management of the collection of intertidal invertebrates. Given the relatively large-scale of collection, it's importance as a source of protein, and the arrival of increasing numbers of migrant collectors, there is a real need for management of the intertidal collection of invertebrates to both safeguard the sustainability of the resource as a source of food, and to maintain the biodiversity of the habitat. However, given the heavy reliance on these resources by the more vulnerable members of the islands' communities, the lack of specialised equipment required for the gathering of these resources, and the open access to the intertidal areas, it is difficult to envisage a simple solution to the management of intertidal invertebrates. It may be possible to spread collection pressure to include a wider range of species. For example, a small group was recorded collecting sea urchins on Ibo island, an activity they had learnt in Pemba and had continued to practise when they moved to Ibo. However, they reported a lack of

willingness in other islanders to collect this resource, possibly because of underlying traditional beliefs.

Further studies are required to understand: (1) the socio-economic importance of invertebrate collection to the island communities; (2) the impacts of collection on the abundance and diversity of both the target and non-target species, and; (3) possible strategies for managing these important resources.

Seagrass Beds

Seagrasses

Nine seagrass species (from seven genera) were identified representing 90 % of the species known to occur in northern Mozambique. *Zostera capensis* (Zosteraceae) was the only species known to occur but was not recorded during the surveys. The records for *Enhalus coroides* and *Halophila stipulacea* represented a new southern limit for each species in East Africa.

The level of diversity varied considerably between the islands, with Ibo and Quirimba islands supporting the most species. Additionally, the pattern of distribution of seagrass diversity provided evidence to suggest that Ibo and Quirimba islands may be the centre of distribution for seagrass within a whole group of islands. Seagrasses constituted the dominant vegetation in the shallow water ecosystems in areas unsuitable for coral reef growth and development.

In relation to their conservation status, the seagrass beds of the C.I.G. can be classified as 'disturbed', since they were damaged by seine nets and reef trampling during invertebrate collection.

Since the largest artisanal fishery of the C.I.G. is based in the seagrass beds of the Montepuez Bay, and provides the major source of protein for a large proportion of the Quirimba island population, there is an obvious need to conduct more detailed studies on the biological and ecological factors related to these beds.

Fish Populations

The fish populations of the seagrass beds were assessed through the analysis of fishery catches of the seine net and trap fisheries, in particular the fishery based in the seagrass beds of the Montepuez Bay, to the west of Quirimba island (a full discussion of the results of the Programme's detailed study of this seagrass fishery are presented in "Marine Biological and Resource Use Surveys of the Quirimba Archipelago, Mozambique. Technical Report 5: The Quirimba Island Seagrass Seine Net Fishery"). This fishery was highly diverse with 192 species in 52 families being identified. The seagrass fisheries were vital to a large proportion of the community, providing the main source of protein for the majority of islands' residents. The fishermen of the islands were poor and had only limited access to refrigeration facilities or transportation to sell fish outside the local area. This heavy reliance and consequent exploitation of the fish populations of the seagrass bed habitats presents a definite threat to their biodiversity. Additionally, there is evidence, from discussion with local

communities, that the high level of fishing intensity now seen is a relatively recent development. The majority of fishermen have moved to the islands in the past decade to either escape the fighting during the civil war, or, in more recent years, to find an area of productive fishing following the depletion of their own local fisheries. The fishing pressure to which the fish populations of the seagrass beds are currently subjected may therefore be already unsustainable and having a detrimental effect on the habitats biodiversity.

The seagrass fisheries must be considered a priority area for protection and management to ensure their future sustainability. In order to facilitate these processes information is required on the following:

i) The population structure of the ten dominant species within the catch (70% of the total catch). This information is essential to the formulation of a management strategy for the fishery. The Programme has already collected extensive data on the length-frequency of these species and ageing studies are also underway;

ii) The effects of imposing a mesh size limit for the fishery require investigation, both in terms of ensuring a sufficient catch for the subsistence fisherman and for the long-term sustainability of the fishery;

iii) In order to fully understand the fishery and be in a position to make informed management decisions as to its future, detailed information on the ecological processes which determine its productivity are needed, and;

iv) The effects of the seagrass fishery on the biodiversity and abundance of fish populations in adjacent habitats needs to established.

Reef Habitat

The reefs of the C.I.G. were primarily exposed, fringing reefs, with a well-developed hard coral cover. The sites surveyed that were exceptions to this, were: to the north of Ibo (site I1), where the reef was short (<2 m tall) and broken and coral development was poor; in the shallow and turbid Quirimba Channel (site QR1) where the coral was present only as bommies; on the sheltered, western side of Sencar island (sites SC1 and SC2) where the reef was relatively short (<5 m tall), but the coral development was similar to that of the more exposed sites, and; around the sheltered reefs of Quilaluia island (sites QL1-QL4) where coral development was variable.

The exposed, fringing reef sites (sites I3-I5; QR2-QR4 and SC3-SC4) were similar in structure, biotic cover, and fish abundance and diversity. Consequently, in terms of the biodiversity of the reef habitats of the C.I.G, potential threats to the status of the habitat and its management requirements, these sites can be considered together.

Corals

The diversity of the corals of the C.I.G. were assessed to the level of the major genera present (18 'hard' (scleractinian) coral genera and 5 'soft' coral genera were included

in the surveys of the reef habitats) and for the 'hard' corals, to their respective growth forms (a more detailed taxonomic list of corals for the Quirimbas is currently being compiled by the Programme). The majority of shallower reef areas surveyed were dominated by *Acropora* spp. (particularly 'Branching' and 'Table' forms) whilst the lower reef areas were commonly dominated by *Montipora* spp. and *Echinopora* spp. ('Foliose' form) corals. *Sarcophyton* spp. and *Lithophyton* spp. were the commonest 'soft' corals recorded.

The exposure of the fringing, outer reef to a high degree of wave action had resulted in a considerable amount of coral damage on the upper sections of the reef and was the likely cause of the domination of the faster growing genera in these areas. However, this cannot be regarded as a threat to the reef habitat, being a long-term, naturally occurring process, and it is probable that the large waves found close to the reef have prevented the establishment of a large-scale reef fishery and the associated impacts on the coral of anchor and fishing gear damage (anchor damage was noted at site QL2 which was adjacent to the main landing beach on Quilaluia island, but was not extensive). Natural threats to the coral, e.g. coral predators and disease, were rarely recorded during the Programme's surveys. The Crown of Thorns starfish was present at most sites surveyed, but at relatively low densities only and as such, cannot be considered a cause for concern.

The corals of the C.I.G. can consequently be considered to be, at almost all sites, in a 'natural state', with little or no human caused impacts. The need for management controls to protect the reefs are therefore not an urgent requirement. However, few reefs in the East African Region are in such a good condition, having often been severely damaged by fishing activity and thus the reefs of the C.I.G. can be regarded as of both national and regional importance. It is therefore recommended that the required information is collected for the formulation of a management plan for the protection of the current status of the reefs, and so ensure their long-term conservation.

Other Reef Invertebrates

The limitations of the Programme in terms of work capacity and available taxonomic expertise, limited the extent to which detailed assessments of the biodiversity of reef invertebrates could be made. The invertebrate 'data elements' surveyed on a regular basis were those that were: indicators of environmental conditions (e.g. large numbers of seawhips, *Leptogorgonia* sp., can indicate elevated nutrient levels); were a potential resource (e.g. Giant clams, *Tridacna* spp.), or; were of influence to the reef habitat (e.g. the coral eating Crown of Thorns starfish, *Acanthagaster plancii*). Therefore, no direct measure of the biodiversity of any group of reef invertebrates was made. However, observations made during the reef surveys suggests that in many areas, the level of diversity of reef invertebrates was high, and comparable with those fauna and flora of the C.I.G. examined by the Programme.

Two resource use activities were observed to directly affect the diversity and abundance of populations of selected groups of reef invertebrates; the collection of gastropod molluscs for the curio trade and the collection of seacucumbers (holothuria)

(the latter were normally collected on the sandy substrate areas close to the base of the reefs).

As previously discussed (see discussion on intertidal invertebrates) the diversity of gastropods within the C.I.G. was very high and this had attracted commercial collectors and traders to the islands and encouraged the islands' community to regard gastropods as a profitable resource to exploit. With the increased exploitation of the more accessible intertidal areas, more of the collection was observed to be being carried out in the shallow, subtidal reef areas by migrant collectors.

Quilaluia island, with its relatively sheltered reef areas, attracted large numbers of itinerant fishermen (up to 120 at any one time had been observed) from the mainland during the dry season. Many of these came for the subtidal collection gastropods for the curio trade (also collected seacucumbers and catch finfish) which were then taken and sold to traders in Ibo and Pemba. These towns were amongst the most important regional places for the sale of gastropod shells for the tourist and export industry with large exporters such as 'LusoAfrica' based in Nacala.

The move of emphasis for the collection of gastropods from the intertidal to the subtidal areas suggest that populations of the target species have already been diminished considerably in the former habitat. Additionally, given the large concentration of collectors that are targeting relatively small reef areas, e.g. the reefs of Quilaluia island, it is probable that over-exploitation of target species is already occurring in localised areas of the subtidal habitats as well. There is therefore an urgent need for some management controls over the scale of collection.

Few residents of the C.I.G. were involved with the subtidal collection and trade of curio shells, possibly due to a variety of factors including: a lack of personal trade connections with mainland towns; a lack of expertise in the methods of snorkelling and collecting of the gastropods; non-ownership of boats to reach collection sites; a lack of tradition in this occupation, and; a preference for catching finfish. A management strategy that includes a restriction of access to the exploitation of curio shells to the C.I.G. residents, may reduce the pressure on this resource significantly and also provide a potential valuable source of income for the limited numbers of islanders that wish to collect curio shells.

Holothuria collection occurred on a large scale throughout the Quirimba Archipelago and was almost certainly, in terms of the commercial value of the collected animals, the most valuable resource use activity. The C.I.G. islanders, particularly groups of adult women and children purposefully exploited the lagoon areas of the intertidal areas, targeting this catch; and many other exploiters collected a few holothuria as incidental to their main catch. However, the greatest numbers of holothuria were taken subtidally, from near-reef areas, by teams of adult males operating from boats using SCUBA and snorkelling equipment.
The majority of these teams of collectors were comprised of Tanzanian fishermen operating illegally within Mozambique waters. Due to this situation it was not possible for the Programme to study their activities in detail, however, from the limited observations made it was clear that large numbers of holothuria were collected from the C.I.G. area. The effects of this activity cannot be assessed given the lack of

data on the exact scale and nature of the exploitation, but given the history of over-exploitation of holothuria populations in Tanzanian waters it would appear likely that a similar situation could develop within the Quirimbas. There also appears to have been a negligence on behalf of the administration of the C.I.G. in not discouraging or preventing these illegal operators from basing there camps on the islands and this can only encourage the further exploitation of the resource.

The management requirements of the exploitation of holothuria are similar to those of the curio shells discussed above. Both are almost certainly subjected to a degree of over-exploitation and in need of timely management controls and accurate assessments of their current status.

Reef Associated Fish

The diversity of fish at almost all the reef sites surveyed within the C.I.G. was high (most of the over 300 species of fish recorded by the Programme within the C.I.G., were observed within the reef habitat), reflecting the developed nature of the reefs and a minimal fishing pressure. Only at sites where the development of the reef was poor, e.g. site I1 on the north of Ibo island, site QR1 in Quirimba Channel and site QL1 in the shallow channel to the north-east of Quilaluia island was the level of fish relatively poor. 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, particularly those along the exposed, fringing reef on the eastern sides of Ibo, Quirimba and Sencar island.

The reef based fishery within the C.I.G. was mainly limited to areas of the intertidal lagoon and those upper portions of the reef accessible by shore-based beach seining from the reef crest. Handlining and spearing were both employed along all areas of the reef but were severely limited by the exposed nature of much of the reef area within the C.I.G. which prevented the safe use of canoes and traditional sailing vessels close to reef edge. The more sheltered reef areas (western side of Sencar island and around Quilaluia island) were observed to support a lower abundance of 'commercial fish', particularly snappers (Lutjanidae). However, this appeared to be linked mainly to the relatively shallow water at these sites and the development of the reef rather than an indication of increased fishing pressure.

The exposed nature of, and the corresponding rough conditions on the fringing outer reef appears to protect the resident fish populations from being targeted as a resource and consequently, the fish biodiversity is currently under little threat. Additionally, the reef habitat maybe acting as a *refugia* for those adult fish that spend part of their lifecycle within the seagrass habitat of the C.I.G. where they are subjected to relatively intense fishing pressure.
Given the current situation there appears to be no urgent need for controls or limitations on the reef fishery. The abundance of 'commercial fish' suggest that there is potential for further development of a reef fishery within the C.I.G., perhaps as part of a management strategy to reduce the fishing pressure on other habitats, e.g. the seagrass beds. Future commercial development, particularly tourism, within the C.I.G. will probably create a demand for fish species found within the reef habitat. In order

to ensure the sustainable exploitation of these fish populations at that time, investigations into effects of possible management strategies and the ecological processes which influence the fish populations of the reefs in the near future are advisable.

Oceanic Waters

Although not specifically studied by the Programme, the oceanic waters close to the C.I.G. were noted to support a high diversity and abundance of pelagic fish, particularly the families Scombridae (Tunas and Mackerels) and Carangidae (Jacks and Trevallys). There is currently no developed fishery, commercial or artisanal, which exploits these fish populations. Some of the fishermen based on Ibo island who have access to the freezing facility were observed to occasionally catch 'Billfish' species which were subsequently transported to Pemba and Nampula for sale in restaurants. However, due to the exposed nature of the coastline and the low technology of the fishing boats and gear of the island's fishermen, access to these fish populations is limited.

As a result of the current, limited exploitation of the fish populations of the oceanic waters there is most likely, little immediate threat to their abundance or biodiversity and should be regarded as a potential fishery to be developed. The expansion of coastal development, in particular tourism, in the north of the country could lead to an increasing demand for these fish species, that are too large and expensive for sale within the Quirimbas. An up-scaling in the development of the fishery, primarily in the boats and gear of the fishermen would be necessary for the establishment of a permanent pelagic fishery based in the C.I.G. In addition, an assessment of the pelagic fish stocks would be needed and a management plan for the fishery formulated to ensure the its long-term sustainability.

7.1 Key Sites for Biodiversity Within The Central Islands Group

1) The Montepuez Bay:
The extensive seagrass beds of this area are home to a large and diverse population of fish, and play an important role in the lifecycles of many fish species associated with the adjacent reef habitats.

2) 'Ibo Stand' Mangrove:
The largest single stand of mangrove within the Quirimba Archipelago, supporting a rich variety of flora and fauna. Although not as yet established, this area of mangrove is highly likely to exert a large influence on the marine ecosystem of the C.I.G. as a whole and therefore important in maintaining the overall levels of biodiversity within the islands.

3) Central Islands Group, fringing outer reef:
Although not a specific site, the exposed fringing reef to the east of the C.I.G. supports high levels of marine biodiversity. Additionally, the minimal human impact on the reefs has preserved their natural state and as such, are some of only a few reef

in the East African Region in this condition. The reefs of the C.I.G. can therefore be regarded as a habitat of both national and regional importance for biodiversity.

7.2 Key Sites Under Threat Within The Central Islands Group

1) 'Quiwandala Stand', Quirimba Island:
The unmanaged and relatively large-scale cutting of trees in this stand poses a threat to the integrity of the mangrove habitat in this area and is already the contributing to the significant coastal erosion problem along the shoreline at the north of the island.

2) Montepuez Bay:
The seine net fishery based in the seagrass beds of the Bay are placing the fish stocks under relatively intense fishing pressure. Although the exact effects of this on the fish populations are not fully understood, it is likely that the current levels of exploitation are too high to be sustainable. Given the importance of the area as a source of vital protein for a large number of islanders and as a nursery ground for many fish species, management controls on the fishery are urgently required to safeguard its long-term sustainability.

3) Central Islands Group: Curio Shells and Holothuria Populations
The status of the populations of the molluscs collected for the curio trade and the holothuria of the islands is unknown. However, the intensity of collection and the witnessed decline in the abundance and diversity of these resources in the more accessible areas, indicates that a degree of over-exploitation already exists. Urgent management controls are required to safeguard the conservation of these resources.

7.3 Recommendations for Future Studies Within the Central Islands Group

1) An assessment of the effects of the various management strategies that could be employed to safeguard the resources and biodiversity of the islands. For some of the resources e.g. curio shells, seagrass bed fish populations, the need for management controls to ensure their sustainability are urgently required. However, the formulation and implementation of an integrated management plan for the Central Islands Group, and 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. Would be envisaged to contain work on the hydrography of the islands, the relative productivity of each of the habitat types and the detailed effects of human impacts on the functioning of the each of the habitats.

3) The communities of the C.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 to the islands. Further to this, environmental education initiatives are required to create a better understanding by the islands' community of the processes that affect the resources they exploit and the marine environment in general.

4) The administration and policing of the islands require a better understanding of the importance of proper management of the islands' resources to the future prosperity of the islanders. The necessary legal structure must be established so that proper control of the exploitation of the resources can be made.

8.0 BIBLIOGRAPHY

Tinley, K.L. 1970. Proposed maritime national parks and a dugong and marine turtle sanctuary in the Paradise Island region of the Mozambique coast. Internal report, Mozambique Veterinary Department.

APPENDICES

Appendix 1
The geographic data for the Central Islands Group (C.I.G.)

Grid References for the islands.

Island	Latitude	Longitude
Ibo	12°20.5'S	40°35.0'E
Quirimba	12°25.0'S	40°37.0'E
Sencar	12°28.7'S	40°39.0'E
Quilaluia	12°29.6'S	40°36.2'E

Island Dimensions (Units are metres and are based on the maximum dimensions)

Island	North-South	East-West
Ibo	3650	4550
Quirimba	6200	2900
Sencar	1650	600
Quilaluia	650	350

All the above grid references and dimensions 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.

Appendix 2

Seagrass and Macroalgae taxa recorded during the intertidal surveys of the Central Island Group

Checklist of Cyanophyta (Blue-green algae), Chlorophyta (Green algae), Phaeophyta (Brown algae) and Rhodophyta (Red algae) taxa and their distribution within the C.I.G.. (+) = 'present' and (-) = 'not recorded'. QR = Quirimba, I = Ibo, SC = Sencar, QL = Quilaluia.

Division/Species	Island			
	QR	I	QL	SC
Cyanophycea (Blue-green algae)				
Lyngbya majuscula	+	+	+	+
Chlorophyta-Green algae				
Acetabularia sp.	+	+	-	-
Anadyomene wrigthii	+	+	+	+
Avrainvillea erecta	+	+	+	+
A. obscura	+	+	-	-
Boergesenia forbesii	+	+	+	+
Boodlea composita	+	-	-	-
Bornetella oligospora	-	-	+	-
Bryopsis spp.	+	-	+	-
Caulerpa cupressoides var. *flabellata*-		+	-	-
*C.*cf. *fastigiata*	+	+	+	+
C. lentillifera	-	-	+	+
C.occidentalis	+	+	-	-
C. peltata	-	+	-	-
C. racemosa var. *clavifera*	+	+	-	+
C. racemosa var. *turbinata*	+	+	-	-
C. racemosa var. *uvifera*	+	+	-	-
C. scapelliformis	-	+	-	-
C. selago	+	-	+	+
C.sertularioides	+	+	-	-
C. spp.	-	+	-	-
C.taxifolia	+	+	-	-
*C.*cf. *zeyheri*	+	-	-	-
Chaetomorpha aerea	+	-	-	-
C. crassa	+	+	+	+
Chaetomorpha?	+	-	-	-
Chamaedoris delphinii	+	+	-	-
Chlorodesmis hildebrandtii	+	+	+	+
Chlorodesmis sp.	+	+	+	+
Cladophora mauritiana	+	+	+	+
C. cf. *saviniana*	+	-	-	-
C. sibogae	-	+	+	-
Cladophora sp.	+	-	-	-
Codium arabicum?	+	-	-	-

Appendix 2. Continued

Division/Species	Island			
	QR	I	QL	SC
C. dwarkense	+	-	-	-
C. geppi	+	-	-	-
Dictyosphaeria cavernosa	+	+	+	+
D. verluysii	+	+	+	-
E. clathrata?	+	+	-	-
E. flexuosa?	+	+	-	-
E. kylini	+	-	+	+
E. ramulosa	+	-	-	+
Enteromorpha sp.	-	+	+	-
Halimeda cilindracea	+	+	-	+
H. discoidea	+	-	+	+
H. gigas	-	+	-	+
H. macroloba	+	+	-	-
H. micronesica?	+	+	-	+
H. milanesica	-	+	-	-
H. opuntia	+	+	+	+
H. renschii	+	+	+	+
Halimeda sp.	-	+	-	-
Microdictyon montagnei	+	+	+	-
Neomeris van bosseae	+	+	+	-
Rhizoclinium grande?	+	-	-	+
Spongocladia vaucheriaerformis	+	+	+	-
Udotea indica	+	+	+	+
U. orientalis	+	+	-	+
U. palmetta	+	+	-	-
U. flabellum f. *longifolia*	-	+	-	-
U. flabellum f. *flabellum*	-	+	-	-
U. glauscens	-	+	-	-
Ulva fasciata	+	-	-	+
U. lactuca	-	+	-	-
U. pertusa	+	+	-	+
U. pulchra	-	+	-	-
U. reticulata	+	+	-	+
U. rigida	+	+	-	-
Valonia aegagrophila	+	+	-	-
V. fastigiata	+	+	-	-
V. macrophysa	+	+	-	-
Valoniopsis pachynema	+	+	-	-
Ventricaria ventricosa	+	+	-	-

Appendix 2. Continued

Division/Species	Island			
	QR	I	QL	SC
Phaeophycea-Brown algae				
Chonospora implexa	+	+	+	-
Cistoseira myrica	+	+	+	+
C. trinodis	+	+	+	+
Colpomenia sinuosa	-	+	-	-
Dictyopteris sp.	-	-	+	-
Dictyota adnata	-	+	-	-
D. bartayresii	+	-	-	-
D. cervicornis	+	-	-	+
D. ceylanica	-	-	+	+
D. divaricata	-	-	+	-
D. friabilis	+	-	-	-
D. pardalis	+	+	-	+
Hormophysa triquetra	+	+	+	+
Hydroclathrus clatrathus	+	+	+	+
Hydroclathrus sp.	+	-	-	-
Padina boryana	+	+	+	+
Padina gymnospora	+	+	+	+
Rosenvingea intricata	+	+	-	-
Rosenvingea orientalis	+	+	-	+
Sargassum asperifolium	+	+	-	+
S. aquifolium	+	+	-	+
S. binderi	+	+	-	+
S. duplicatum	+	+	+	+
S. ilicifolium	+	+	-	+
S. *swartz*	+	+	-	+
Sargassum spp.	+	+	-	-
Turbinaria conoides	+	+	+	+
T. decurrens	+	-	-	+
T.ornata var. *ornata*	+	+	+	-
T. ornara var. *serrata*	+	+	-	+
Rhodophyta-Red algae				
Acanthophora dendroides	-	-	+	-
A. muscoides	+	+	+	+
A. specifera	+	-	-	-
Acrocistis nana	-	-	+	-
Actinotrichia fragilis	+	-	+	-
Amansia dietrichiana	+	-	-	-
A. glomerata	+	-	+	-
Amphiroa anceps	-	-	+	-
A. beauvoise	+	+	-	-
A. fragilissima	-	-	+	+
A. cf. *tribulus*	+	-	-	-
Bostrychia binderi	+	+	+	-
B. radicans?	+	-	-	+

Appendix 2. Continued

Division/Species	Island			
	QR	I	QL	SC
B. tenella	+	+	+	-
Caloglossa cf. *leprieuri*	+	-	-	-
Caulacanthus ustulatus	+	-	+	-
Catanella opuntia	+	+	+	-
Centroceras clavulatum	+	+	+	+
Ceramium sp.	+	-	+	+
C. compressa	+	-	-	-
C. cf. *globulifera*	+	+	+	-
Champia spp.	+	+	+	+
Chondria cf. *armata*	-	-	+	+
C. dasyphylla	+	+	-	+
C. sedifolia	+	-	-	-
Chondrococcus harvey	+	-	-	+
Dasya sp.	+	+	+	-
Dasyopsis cf. *pilosa*	+	+	+	-
Dictyurus purpurascens	-	+	-	-
Digenia simplex	+	+	+	-
Endosiphonia clavigera	+	-	+	+
Eucheuma dendiculatum	+	-	+	+
Galaxaura breviarticulata	+	+	+	-
G. fasciculata	+	-	+	-
G. oblongata	+	-	+	-
G. tenera	+	+	+	-
Gelidiopsis?	+	+	-	+
Gelidiella acerosa	+	+	+	+
G. myrioclada	+	+	-	-
Gelidium micropterum	+	+	+	-
Gracilaria arcuata	+	-	-	-
G. cf. *corticata*	-	+	+	-
G. crassa	+	+	-	-
G. edulis	+	+	+	-
G. fergusoni	+	+	+	+
G. folifera	-	+	+	-
G. millardetii	-	-	+	-
G.salicornia	+	+	-	-
G. spp.	-	-	+	-
G. verrucosa	+	+	-	-
Griffthisia rhizophora	-	+	-	-
Kappaphycus striatum	+	-	-	-
K. spp.	+	-	+	-
Halymenia sp.	+	+	-	-
Halymenia venusta	-	-	+	+
Hypnea cornuta	+	-	-	-
H. hamulosa	+	-	+	+
H. musciformis	+	+	-	+
H. cf. *nidifica*	+	+	-	+
H. cf. *nidulans*	+	+	+	-

Appendix 2. Continued

Division/Species	Island			
	QR	I	QL	SC
H. pannosa	+	+	+	+
Jania adhaerens	+	+	+	+
Laurencia collumelaris	-	+	-	-
L. complanata	+	+	-	-
L. distichophyla	-	-	+	+
L. cf. *divaricata*	-	-	+	-
L. elata	+	-	-	+
L. obtusa	+	+	-	+
L. papillosa	+	+	+	+
L. cf. *perforata*	+	-	-	+
Liagora ceranoides	+	+	+	+
L. cf. *divaricata*	-	-	+	-
Liagora sp.	+	+	-	-
Muryaella periclados	+	-	-	-
Neurymenia fraxinifolia	-	+	-	-
Poritiera harvey	+	+	+	-
P. pulvinata	+	+	+	-
Pterocladia parva	+	-	-	-
Rabdonia cf. *africana*	-	+	-	-
Sarcodia monatagnea?	+	+	-	-
Sarconema filiformis	+	+	+	-
Soliera robusta	+	+	-	-
Spyridia filamentosa	+	-	-	-
S. fusiformis	+	-	+	-
Trichogloea sp.	+	+	+	-
Vanvoorstia spectabilis	+	+	+	-
Vidalia fimbriata	-	-	+	-
Wurdemannia miniata	+	-	+	+
Zellera turvallina	-	+	-	-

Appendix 3
The invertebrate fauna recorded during the intertidal surveys of the Central Island Group

Full checklist of invertebrates found within 24 transects surveyed.

Taxa	Islands			
	QR	I	QL	SC
Gastropods				
Cypraea annulus	+	+	+	+
C. tigris	+	-	-	-
C. moneta	+	+	-	-
C. felina	-	-	-	-
Conus ebraeus	+	-	-	+
C. tessalatus	+	-	-	-
Conus spp.	+	+	-	+
Gibbula multicolor	+	-	-	-
Gibbula beckeri	+	-	-	-
Strombus sp.	-	-	-	+
Strombus mutabilis	+	+	-	-
Rhinoclavis sinensis	+	+	-	-
Nerita textilis	+	-	-	-
Nerita albicilla	+	-	-	-
Nerita sp.	-	+	-	-
Marginella sp.	+	-	-	-
Gafrarium pectinatum alfredense	-	+	-	-
Peristernia forskallii	-	-	-	-
Polinices sp.	+	-	-	-
Calliostoma sp.	-	-	-	-
Oliva sp.	+	-	-	-
Turritela sp.	+	+	-	-
Mitra sp.	+	+	-	-
Lambis lambis	+	-	-	-
Terebralia palustris	+	-	-	-
Morula granulata	+	+	-	-
Littoraria glabrata	-	+	-	-
Trochus sp.	-	+	-	-
Patella sp.	-	-	-	-
Turbo coronatus	+	-	-	+
Thais sp.	+	+	-	+
Thais savignyi	+	-	-	-
Bivalve				
Pinna sp.	+	+	-	-
Pinctada sp.	+	-	-	-
Perna perna	+	-	-	+
Choromytilus sp.	+	-	-	-
Trachycardium flavum	+	-	-	-
Tridacna squamosa	+	-	-	-

Appendix 3. Continued

Taxa	Islands			
	QR	I	QL	SC
Echinoderms				
Echinometra muthaei	+	+	-	+
Tripneustes gratilla	+	-	-	-
Stomopneustes variolaris	+	+	-	+
Holothuria sp.	-	+	-	-
Synapta cf. *maculata*	-	+	-	-
Fromia sp.?	-	+	+	-
Crabs				
Calcinus laevimanus	+	-	-	-
Clibanarius longitarsus	+	-	-	-
Chiton				
Chiton spp.	-	-	-	+
Octopus				
Octopus sp.	+	-	-	-
Cnidarian				
Cassiopia	+	+	-	-
Total	**36**	**19**	**2**	**9**

Appendix 4. Reef fish species presence/absence for Ibo Island. Presence indicated by '+'.

	Site				
Fish Species	**I1**	**I2**	**I3**	**I4**	**I5**
Acanthuridae					
Acanthurus auranticavus		+	+		+
Acanthurus dussumieri					
Acanthurus leucosternon		+			+
Acanthurus lineatus		+			
Acanthurus nigricauda					
Acanthurus nigrofuscus	+	+	+	+	
Acanthurus tennenti	+	+	+	+	+
Acanthurus thompsoni			+		+
Acanthurus triostegus					
Ctenochaetus strigosus		+	+	+	+
Naso brevirostris				+	
Naso hexacanthus					+
Naso literatus					
Paracanthus hepatus					
Zebrasoma desjardinii					
Zebrasoma scopas		+	+	+	+
Balistidae					
Balistapus undulatus			+	+	+
Balistiodes conspicillum				+	
Balistiodes viridescens					
Melichthys niger					
Odonus niger			+		+
Pseudobaliste fuscus			+		
Rhinecanthus aculeatus					
Rhinecanthus rectangulus				+	
Sufflamen bursa		+			+
Sufflamen chrysopterus		+	+	+	
Chaetodontidae					
Chaetodon auriga	+	+	+	+	+
Chaetodon blackburnii					
Chaetodon bennetti			+		
Chaetodon dolosus					
Chaetodon falcula			+	+	+
Chaetodon guttatissimus				+	+
Chaetodon kleinii	+		+	+	+
Chaetodon leucopleura					+
Chaetodon lineatus			+		
Chaetodon lunula			+	+	+
Chaetodon madagascarensis			+	+	
Chaetodon melannotus			+	+	+

Appendix 4. Continued

Chaetodontidae Cont.	**I1**	**I2**	**I3**	**I4**	**I5**
Chaetodon meyeri				+	+
Chaetodon trifascialis			+	+	+
Chaetodon trifasciatus	+	+		+	+
Chaetodon unimaculatus	+				
Chaetodon vagabundus		+			
Chaetodon xanthocephalus				+	+
Chaetodon zanzibarensis					+
Forcipiger flavissimus				+	+
Hemitaurichthys zoster			+	+	+
Heniochus acuminatus			+	+	+
Heniochus monoceros				+	+
Mullidae					
Mulloidichthys flavolineatus					+
Parupeneus barberinus		+	+	+	+
Parupeneus bifasciatus		+		+	
Parupeneus cyclostomus				+	
Parupeneus macronema	+		+	+	+
Parupeneus pleurostigma			+		+
Upeneus tragula					
Pomacanthidae					
Apolemichthys trimaculatus			+		+
Centropyge acanthops					
Centropyge flavicauda					
Centropyge multispinis	+	+		+	+
Pomacanthus chrysurus					+
Pomocanthus imperator			+		+
Pomacanthus maculosus					
Pomacanthus rhomboides					
Pomocanthus semicirculatus				+	+
Pygoplites diacanthus			+	+	+
Tetradontidae					
Arothron hispidus		+			
Arothron immaculatus					
Arothron meleagris					
Arothron nigropunctatus					
Arothron stellatus					
Zanclidae					
Zanclus cornutus	+	+	+		+

Appendix 5. Reef fish species presence/absence for Quirimba Island. Presence indicated by '+'.

	Site			
Fish Species	**QR1**	**QR2**	**QR3**	**QR4**
Acanthuridae				
Acanthurus auranticavus				
Acanthurus dussumieri				+
Acanthurus leucosternon			+	+
Acanthurus lineatus		+		
Acanthurus nigricauda				
Acanthurus nigrofuscus	+	+	+	+
Acanthurus tennenti				
Acanthurus thompsoni		+	+	+
Acanthurus triostegus			+	
Ctenochaetus strigosus			+	+
Naso brevirostris				+
Naso hexacanthus				
Naso literatus				
Paracanthus hepatus				
Zebrasoma desjardinii				
Zebrasoma scopas			+	+
Balistidae				
Balistapus undulatus			+	+
Balistiodes conspicillum				
Balistiodes viridescens				
Melichthys niger				
Odonus niger				
Pseudobaliste fuscus				
Rhinecanthus aculeatus				
Rhinecanthus rectangulus				
Sufflamen bursa			+	+
Sufflamen chrysopterus				+
Chaetodontidae				
Chaetodon auriga	+	+	+	+
Chaetodon blackburnii		+		
Chaetodon bennetti				+
Chaetodon dolosus				+
Chaetodon falcula			+	+
Chaetodon guttatissimus				+
Chaetodon kleinii	+		+	+
Chaetodon leucopleura				
Chaetodon lineatus				
Chaetodon lunula		+	+	+
Chaetodon madagascarensis	+		+	+
Chaetodon melannotus			+	+

Appendix 5. Continued

Chaetodontidae Cont.	**QR1**	**QR2**	**QR3**	**QR4**
Chaetodon meyeri		+	+	+
Chaetodon trifascialis		+		+
Chaetodon trifasciatus			+	+
Chaetodon unimaculatus			+	+
Chaetodon vagabundus				+
Chaetodon xanthocephalus			+	+
Chaetodon zanzibarensis		+		+
Forcipiger flavissimus		+	+	+
Hemitaurichthys zoster			+	+
Heniochus acuminatus		+	+	+
Heniochus monoceros		+		+
Mullidae				
Mulloidichthys flavolineatus				
Parupeneus barberinus	+	+	+	+
Parupeneus bifasciatus				+
Parupeneus cyclostomus			+	+
Parupeneus macronema				
Parupeneus pleurostigma				
Upeneus tragula				
Pomacanthidae				
Apolemichthys trimaculatus				+
Centropyge acanthops				
Centropyge flavicauda				
Centropyge multispinis				
Pomacanthus chrysurus				+
Pomocanthus imperator			+	+
Pomacanthus maculosus				
Pomacanthus rhomboides				
Pomocanthus semicirculatus				+
Pygoplites diacanthus		+	+	+
Tetradontidae				
Arothron hispidus				+
Arothron immaculatus				
Arothron meleagris		+		
Arothron nigropunctatus				
Arothron stellatus				
Zanclidae				
Zanclus cornutus	+	+	+	+

Appendix 6. Reef fish species presence/absence for Sencar Island. Presence indicated by '+'.

Site

Fish Species	SC1	SC2	SC3	SC5
Acanthuridae				
Acanthurus auranticavus				
Acanthurus dussumieri				
Acanthurus leucosternon			+	+
Acanthurus lineatus				
Acanthurus nigricauda				
Acanthurus nigrofuscus				
Acanthurus tennenti				
Acanthurus thompsoni		+	+	
Acanthurus triostegus				
Ctenochaetus strigosus	+	+	+	
Naso brevirostris				+
Naso hexacanthus				
Naso literatus	+			+
Paracanthus hepatus			+	
Zebrasoma desjardinii				+
Zebrasoma scopas	+		+	+
Balistidae				
Balistapus undulatus		+	+	+
Balistiodes conspicillum				+
Balistiodes viridescens				
Melichthys niger				
Odonus niger		+	+	
Pseudobaliste fuscus				
Rhinecanthus aculeatus				
Rhinecanthus rectangulus				
Sufflamen bursa				
Sufflamen chrysopterus		+	+	+
Chaetodontidae				
Chaetodon auriga	+	+	+	+
Chaetodon blackburnii				
Chaetodon bennetti			+	+
Chaetodon dolosus				
Chaetodon falcula	+	+	+	
Chaetodon guttatissimus		+	+	
Chaetodon kleinii		+	+	+
Chaetodon leucopleura				
Chaetodon lineatus				+
Chaetodon lunula	+			+
Chaetodon madagascarensis				+
Chaetodon melannotus		+	+	+

Appendix 6. Continued.

Chaetodontidae Cont.	SC1	SC2	SC3	SC5

Chaetodon meyeri			+	+
Chaetodon trifascialis	+	+	+	+
Chaetodon trifasciatus	+	+	+	+
Chaetodon unimaculatus				+
Chaetodon vagabundus			+	+
Chaetodon xanthocephalus	+		+	+
Chaetodon zanzibarensis				
Forcipiger flavissimus				+
Hemitaurichthys zoster		+		
Heniochus acuminatus				+
Heniochus monoceros				+
Mullidae				
Mulloidichthys flavolineatus				
Parupeneus barberinus	+	+		
Parupeneus bifasciatus				
Parupeneus cyclostomus				
Parupeneus macronema	+	+		+
Parupeneus pleurostigma				
Upeneus tragula				
Pomacanthidae				
Apolemichthys trimaculatus				+
Centropyge acanthops				
Centropyge flavicauda				
Centropyge multispinis				+
Pomacanthus chrysurus				+
Pomocanthus imperator				+
Pomacanthus maculosus				
Pomacanthus rhomboides				
Pomocanthus semicirculatus				
Pygoplites diacanthus		+		
Tetradontidae				
Arothron hispidus		+	+	
Arothron immaculatus				
Arothron meleagris				
Arothron nigropunctatus				
Arothron stellatus				
Zanclidae				
Zanclus cornutus		+	+	+

Appendix 7. Reef fish species presence/absence for Quilaluia Island. Presence indicated by '+'.

Site

Fish Species	QL1	QL2	QL3	QL4
Acanthuridae				
Acanthurus auranticavus				
Acanthurus dussumieri			+	
Acanthurus leucosternon				
Acanthurus lineatus				
Acanthurus nigricauda				
Acanthurus nigrofuscus	+	+	+	
Acanthurus tennenti	+			
Acanthurus thompsoni		+	+	
Acanthurus triostegus			+	+
Ctenochaetus strigosus		+		
Naso brevirostris				
Naso hexacanthus				
Naso literatus				
Paracanthus hepatus				
Zebrasoma desjardinii	+			
Zebrasoma scopas		+	+	+
Balistidae				
Balistapus undulatus			+	
Balistiodes conspicillum				
Balistiodes viridescens				
Melichthys niger				
Odonus niger		+	+	+
Pseudobaliste fuscus				
Rhinecanthus aculeatus				
Rhinecanthus rectangulus				
Sufflamen bursa				
Sufflamen chrysopterus	+	+	+	+
Chaetodontidae				
Chaetodon auriga		+	+	+
Chaetodon blackburnii				
Chaetodon bennetti				
Chaetodon dolosus				
Chaetodon falcula		+	+	+
Chaetodon guttatissimus		+	+	
Chaetodon kleinii	+	+	+	+
Chaetodon leucopleura				
Chaetodon lineatus				
Chaetodon lunula		+	+	
Chaetodon madagascarensis		+		
Chaetodon melannotus				+

Appendix 7. Continued.

Chaetodontidae Cont.	QL1	QL2	QL3	QL4

Chaetodon meyeri				
Chaetodon trifascialis	+		+	
Chaetodon trifasciatus	+	+	+	+
Chaetodon unimaculatus				
Chaetodon vagabundus				
Chaetodon xanthocephalus		+		
Chaetodon zanzibarensis				
Forcipiger flavissimus		+	+	+
Hemitaurichthys zoster				+
Heniochus acuminatus		+	+	
Heniochus monoceros			+	
Mullidae				
Mulloidichthys flavolineatus				
Parupeneus barberinus	+	+	+	+
Parupeneus bifasciatus				
Parupeneus cyclostomus				
Parupeneus macronema		+	+	+
Parupeneus pleurostigma				
Upeneus tragula		+		+
Pomacanthidae				
Apolemichthys trimaculatus				+
Centropyge acanthops				
Centropyge flavicauda				
Centropyge multispinis	+	+		+
Pomacanthus chrysurus				
Pomocanthus imperator		+	+	
Pomacanthus maculosus				
Pomacanthus rhomboides				
Pomocanthus semicirculatus		+	+	
Pygoplites diacanthus	+	+	+	
Tetradontidae				
Arothron hispidus				
Arothron immaculatus				
Arothron meleagris				
Arothron nigropunctatus				
Arothron stellatus				
Zanclidae				
Zanclus cornutus		+	+	+

Appendix 8.
Fish species recorded during the surveys within the Central Islands Group.

Acanthuridae
Acanthurus auranticavus
Acanthurus dussmieri
Acanthurus hepatus
Acanthurus leucosternon
Acanthurus lineatus
Acanthurus mata
Acanthurus nigricauda
Acanthurus nigrofuscus
Acanthurus nigroris
Acanthurus tennenti
Acanthurus thompsoni
Acanthurus triostegus
Ctenochaetus striatus
Naso brevirostris
Naso hexacanthus
Naso literatus
Naso unicornis
Zebrasoma desjardini
Zebrasoma scopas

Antennariidae
Antennarius spp.

Anthiinae
Nemanthias carberryi
Pseudanthias evansi
Pseudanthias sqamipinis

Apogonidae
Apogon aureus
Apogon cookii
Apogon cyanosoma
Apogon nigripinnis
Cheilodipterus macrodon
Cheilodipterus quinqueleatus
Foa brachygramma
Fowleria variagata

Balistidae
Balistipus undulatus
Balistoides conspicillum
Balistoides viridescens
Melichthys niger
Odonus niger
Pseudobalistes flavimarginatus
Pseudobalistes fuscus
Rhinecanthus aculeatus
Rhinecanthus rectangulatus
Sufflamen bursa
Sufflamen chrysopterus

Belonidae
Tylosurus crocodilus

Blenniidae
Ecsemius midas
Exalias brevis
Petroscirtes variablis
Plagiotremus tapeinosoma

Appendix 8 Continued.

Bothidae
Bothus mancus
Bothus pantherinus

Caesionidae
Caesio caerularea
Caesio lunaris
Caesio teres
Caesio xanthonota
Pterocaesio chrysozona
Pterocaesio marri
Pterocaesio pisang
Pterocaesio tile

Callionymidae
Synchiropus sp.

Carangidae
Alectis indicus
Carangoides fulvoguttatus
Carangoides orthogrammus
Caranx ignobilis
Caranx melampygus
Gnathanodon speciosus
Scoberoides tol
Selar crumenopthalmus
Selaroides leptolopis
Trachinotus blochii

Chirocentridae
Chirocentrus dorab

Chaetodontidae
Chaetodon auriga
Chaetodon blackburni
Chaetodon bennetti
Chaetodon falcula
Chaetodon guttatissimus
Chaetodon kleinii
Chaetodon lineatus
Chaetodon lunula
Chaetodon madagascariensis
Chaetodon melannotus
Chaetodon meyeri
Chaetodon trifacialis
Chaetodon trifasciatus
Chaetodon unimaculatus
Chaetodon vagabundus
Chaetodon xanthocephalus
Chaetodon zanzibariensis
Forcipiger flavissimus
Forcipiger longirostris
Heniochus acuminatus
Heniochus monoceros

Cirrhitidae
Cirrhitichthys oxycephalus
Oxycirrhites typus
Paracirrhites arcatus
Paracirrhites forsteri

Appendix 8 Continued.

Clupeidae
Herklotsichthys quadrimaculatus

Cynglossidae
Cynnoglossus spp.

Dactylidae
Dactyloptena orientalis

Dasyatidae
Taeniura lymna

Echeneidae
Echeneis naucrates
Remora remora

Engraulidae
Stolephorus heterolobus

Entriscidae
Aeoliscus punctulatus

Fistularidae
Fistularia commersoni

Gerreidae
Gerres acinaces
Gerres oyena

Gobiidae
Amblygobius albimaculatus
Amblygobius semicinctus

Grammistidae
Grammistes sexlineatus

Haemulidae
Diagramma pictum
Plectorhinchus gaterinus
Plectorhinchus orientalis
Plectorhinchus plagiodesmus
Plectorhinchus playfairi
Plectorhinchus schotaf
Plectorhinchus sordidus

Appendix 8. Continued.

Hemiramphidae

Hemiramphus far
Hemiramphus lutkei
Hyporhamphus affinis

Holocentridae
Neoniphon sammara
Sargocentrum caudimaculatum
Sargocentrum diadema
Sargocentrum melanospilos
Sargocentron praslin

Labridae
Anampses caeruleopunctatus
Anampses twisti
Bodianus anthiodes
Bodianus axillaris
Bodianus bilinulatus
Bodianus diana
Cheilinus arenatus
Cheilinus bimaculatus
Cheilinus chlorosus
Cheilinus diagrammus
Cheilinus oxycephalus
Cheilinus trilobatus
Cheilinus undulatus
Cheilio inermis
Coris africana
Coris aygula
Coris frerei
Cymolutes praetextatus
Cymolutes torquatus
Epibulus insidiator
Gophosus caeruleus
Halichoeres hortulanus
Haliochoeres iridis
Halichoeres scapularis
Hemigymnus fasciatus
Labroides bicolor
Labroides dimidiatus
Novaculichthys macrolepidotus
Novaculichthys taeniourus
Oxycheilinus mentalis
Oxymolutes marea
Pseudocheilinus hexataenia
Pteragogus flagellifera
Stethojulis albovittata
Stethojulis bandenensis
Stethojulis interrupta
Stethojulis strigiventer
Thalassoma fuscum
Thalassoma hardwicke
Thalassoma hebraicum
Thalassoma lunare
Thalassoma purpureum
Xyrichthys pavo
Xyrichthys pentadactylus

Lethrinidae
Gnathodentex aurolineatus
Lethrinus conchyliatus
Lethrinus harak
Lethrinus lentjan
Lethrinus mahsena
Lethrinus mahsenoides
Lethrinus microdon
Lethrinus nebulosus
Lethrinus obsoletus
Lethrinus olivaceous
Lethrinus rubrioperculatus
Lethrinus variegatus
Lethrinus xanthochilus
Monotaxis grandoculis

Appendix 8. Continued.

Lutjanidae
Aphareus furcatus
Lutjanus gibbus

Appendix 8 Continued.

Clupeidae
Herklotsichthys quadrimaculatus

Cynglossidae
Cynnoglossus spp.

Dactylidae
Dactyloptena orientalis

Dasyatidae
Taeniura lymna

Echeneidae
Echeneis naucrates
Remora remora

Engraulidae
Stolephorus heterolobus

Entriscidae
Aeoliscus punctulatus

Fistularidae
Fistularia commersoni

Gerreidae
Gerres acinaces
Gerres oyena

Gobiidae
Amblygobius albimaculatus
Amblygobius semicinctus

Grammistidae
Grammistes sexlineatus

Haemulidae
Diagramma pictum
Plectorhinchus gaterinus
Plectorhinchus orientalis
Plectorhinchus plagiodesmus
Plectorhinchus playfairi
Plectorhinchus schotaf
Plectorhinchus sordidus

Appendix 8. Continued.

Hemiramphidae

Hemiramphus far
Hemiramphus lutkei
Hyporhamphus affinis

Holocentridae
Neoniphon sammara
Sargocentrum caudimaculatum
Sargocentrum diadema
Sargocentrum melanospilos
Sargocentron praslin

Labridae
Anampses caeruleopunctatus
Anampses twisti
Bodianus anthiodes
Bodianus axillaris
Bodianus bilinulatus
Bodianus diana
Cheilinus arenatus
Cheilinus bimaculatus
Cheilinus chlorosus
Cheilinus diagrammus
Cheilinus oxycephalus
Cheilinus trilobatus
Cheilinus undulatus
Cheilio inermis
Coris africana
Coris aygula
Coris frerei
Cymolutes praetextatus
Cymolutes torquatus
Epibulus insidiator
Gophosus caeruleus
Halichoeres hortulanus
Haliochoeres iridis
Halichoeres scapularis
Hemigymnus fasciatus
Labroides bicolor
Labroides dimidiatus
Novaculichthys macrolepidotus
Novaculichthys taeniourus
Oxycheilinus mentalis
Oxymolutes marea
Pseudocheilinus hexataenia
Pteragogus flagellifera
Stethojulis albovittata
Stethojulis bandenensis
Stethojulis interrupta
Stethojulis strigiventer
Thalassoma fuscum
Thalassoma hardwicke
Thalassoma hebraicum
Thalassoma lunare
Thalassoma purpureum
Xyrichthys pavo
Xyrichthys pentadactylus

Lethrinidae
Gnathodentex aurolineatus
Lethrinus conchyliatus
Lethrinus harak
Lethrinus lentjan
Lethrinus mahsena
Lethrinus mahsenoides
Lethrinus microdon
Lethrinus nebulosus
Lethrinus obsoletus
Lethrinus olivaceous
Lethrinus rubrioperculatus
Lethrinus variegatus
Lethrinus xanthochilus
Monotaxis grandoculis

Appendix 8. Continued.

Lutjanidae
Aphareus furcatus
Lutjanus gibbus

Aprion virescens
Lutjanus argentimaculatus
Lutjanus bohar
Lutjanus ehrenbergi
Lutjanus fulviflamma
Lutjanus fulvus
Lutjanus kasmiri
Lutjanus monostigma
Lutjanus sebae
Macolor niger
Pristopomides multidens

Microdesmidae
Ptereleotris evides

Monacanthidae
Aluterus scriptus
Amanses scopas
Paluteres prionurus
Pseudalutarius nasicornis

Mullidae
Mulloides flavolineatus
Mulloides vanicolensis
Parupeneus barberinus
Parupeneus bifasciatus
Parupeneus cinnabarensis
Parupeneus cyclostomus
Parupeneus heptacanthus
Parupeneus indicus
Parupeneus macronema
Parupeneus pleurostigma
Parupeneus rubescens
Parupeneus indicus
Upeneus moluccensis
Upeneus taeniopterus
Upeneus tragula
Upeneus vittatus

Muraenidae
Rhinomuraena quaesita
Siderea picta

Nemipteridae
Scolopsis bimaculatus
Scolopsis ghanam

Ostracidae
Lactoria cornuta
Ostracion cubicus

Pegasidae
Eurypegasus sp.

Pinguipedidae
Parapercis hexophtalma
Parapercis punctulata
Appendix 8. Continued.

Platacidae
Platax orbicularis
Platax teira

Platycephalidae
Papilloculiceps longiceps
Thysanophrys arenicola
Thysanophrys chiltonae

Plotosidae
Plotosus lineatus

Pomacanthidae
Apolemichthys trimaculatus
Centropyge acanthops
Centropyge bispinosus
Centropyge flavicauda
Centropyge multispinus
Pomacanthus chrysurus
Pomacanthus imperatos
Pomacanthus maculosus
Pomacanthus rhomboides
Pomacanthus semicirculatus
Pygoplites diacanthus

Pomacentridae
Abudefduf sparoides
Abudefduf sexfasciatus
Abudefduf vaigiensis
Amphiprion akallopisos
Amphiprion allardi
Chromis agilis
Chromis annulata
Chromis dimidiata
Chromis opercularis
Chromis viridis
Chromis weberi
Chrysiptera annulata
Dascyllus aruanus
Dascyllus carneus
Dascyllus trimaculatus
Neoglyphidodon melas
Neopomacentus fulginosus
Plectroglyphidodon lacrymatus
Pomacentrus caeruleus
Pomacentrus sulphureus

Priacanthidae
Priacanthus cruentatus
Priacanthus hamrur

Rhynchobatidae
Rhynchobatus djeddensis

Appendix 8 Continued.

Scaridae
Calotomus carolinus
Calotomus spinidens
Cetoscarus bicolor
Scarus japanensis
Scarus psitticas
Scarus ruroviolaceus

Hipposcarus harid
Leptoscarus vaigiensis
Scarus frenatus
Scarus ghobban
Scarus globiceps
Scarus niger
Scarus scaber
Scarus sordidus
Scarus strongylocephalus
Scarus tricolor
Scarus viridifucatus

Scorpaenidae
Pterois antennata
Pterois miles
Pterois radiata
Scorpaenopsis spp.
Synanceia verrucosa

Serranidae
Aethaloperca rogaa
Cephalopholis argus
Cephalopholis aurantia
Cephalopholis miniata
Cephalopholis nigripinnis
Cephalopholis sexmaculata
Cephalopholis sonnerati
Cephalopholis spiloparaea
Epinephelus fasciatus
Epinephelus flavocaeruleus
Epinephelus fuscoguttatus
Epinephelus hexagonatus
Epinephelus longispinnis
Epinephelus malabricus
Epinephelus rivulatus
Epinephelus tauvina
Epinephelus tukula
Plectropomus laevis
Plectropomus punctatus
Variola albimarginata
Variola louti

Siganidae
Siganus argenteus
Siganus rivulatus
Siganus stellatus
Siganus sutor

Sphyraenidae
Sphyraena barracuda
Sphyraena flavicauda
Sphyraena forsteri
Sphyraena jello
Sphyraena putnamie

Appendix 8. Continued

Syngnathidae
Corythoichthys haemopterus
Corythoichthys schultzi
Hippocampus spp.

Synodontidae
Saurida gracilis
Synodus variegatus

Teraponidae
Pelates quadrilineatus

Tetraodontidae
Arothron hispidus
Arothron immaculatus
Arothron mappa
Arothron meleagris
Arothron nigropunctatus
Arothron stellatus
Canthigaster bennetti
Canthigaster solandri
Canthigaster valentini
Diodon liturosus

Zanclidae
Zanclus cornutus

Appendix 9
Commercial Fish Census: Species identified during the course of the commercial fish surveys (all islands):

LETHRINIDAE	**SERRANIDAE**
Lethrinus harak	*Aethaloperca rogaa*
Lethrinus mahsenoides	*Cephalophilis argus*
Lethrinus obsoletus	*Cephalophilis miniata*
Lethrinus xanthochilus	*Cephalophilis nigripinnis*
Monotaxis grandoculis	*Cephalophilis sexmaculata*
Gnathodentex aurolineatus	*Cephalophilis sonnerati*
Other emperors	*Cephalophilis spiloparea*
	Epinephelus caeruleopunctatus
LUTJANIDAE	*Epinephelus fasciatus*
Aprion virescens	*Epinephelus hexagonatus*
Macolor niger	*Epinephelus malabricus*
Lutjanus bohar	*Epinephelus ongus*
Lutjanus ehrenbergii	*Epinephelus polyphekadion*
Lutjanus fulviflamma	*Epinephelus tukula*
Lutjanus fulvus	*Plectropomus laevis*
Lutjanus gibbus	*Plectropomus punctatus*
Lutjanus kasmiri	*Variola louti*
Lutjanus monostigma	*Variola albimarginata*
Other snappers	**Other groupers**
SCARIDAE	**HAEMULIDAE**
Cetoscarus bicolor	*Diagramma pictum*
Hipposcarus harid	*Plectorhinchus flavomaculatus*
Leptoscarus vaigiensis	*Plectorhinchus gaterinus*
Scarus capistratoides	*Plectorhinchus gibbosus*
Scarus caudofasciatus	*Plectorhinchus orientalis*
Scarus frenatus	*Plectorhinchus plagiodesmus*
Scarus ghobban	*Plectorhinchus playfairi*
Scarus japanensis	**Other grunts**
Scarus niger	
Scarus psittacus	**CARANGIDAE**
Scarus rubroviolaceus	*Carangoides ferdau*
Scarus scaber	*Caranx ignobilis*
Scarus sordidus	*Caranx melampygus*
Scarus strongylocephalus	**Other jacks**
Scarus tricolor	
Scarus viridifucatus	**SIGANIDAE**
Other parrotfishes	*Siganus stellatus*

Appendix 10.
The Diversity of the Resource Catch. Central Islands Group.

Species	Quirimba	Sencar	Quilaluia	Ibo
Bivalves				
Barbatia sp.	x		x	x
Pinctada sp.	x	x		
Pinna sp.	x		x	
Tridacna sp.	x	x		
FO Gastropods				
Chicoreus ramosus	x	x	x	x
Cymatium pileare		x		
Fasciolaria trapezium	x	x	x	x
Marginella sp.	x			x
Mancinella alouina	x			
Polinices mammila				x
Strombus mutabilis	x			x
Turbo coronatus	x			x
CT Gastropods				
Charonia tritonis		x		
Conidae sp.	x		x	
Cypraea carneola	x			x
Cypraea tigris	x	x		x
Cypraea vitellus				x
Cypraecassis rufa	x	x	x	x
Lambis chiragra				x
Lambis lambis	x	x		x
Mitra sp.	x			
Monodonta australis	x			
Murex pecten	x			
Ovula ovum		x		
Chitons				x
Chiton spp.				
Octopii				
Octopus vulgaris	x	x	x	
Holothuria				
Bosi	x	x		x
Espinho	x			x
Grife	x			x
Kufulie	x			
Laupwela	x			
Lusi				x
Momade				x
Mwelupa	x			
Mwerufi	x			

Appendix 10. Continued.

Species	Quirimba	Sencar	Quilaluia	Ibo
Nankoko	x			
Namunya	x	x		x
Namwali	x	x		x
Ningi	x			x
Primeira	x			
Pula	x			
Pwali	x			
Safiya	x			x
Supedi	x			
Tendeko	x			
Umvua		x		
Kojojo (Others)	x			
Crustaceans				
Panilurus ornatus	x			
Phallium labiatum	x			
Portunus sp.	x			
Fish	x	x	x	x
Urchins				x

Appendix 11
Local and Regional Use and Cost (meticais) of Island Biological Resources.

Latin name	Use	Quirimba Cost/unit	Quirimba Cost/kilo	Pemba Cost/unit	Pemba Cost/kilo
Bivalvia	**Food/ Curio trade**				
Arcinella sp.	Food			1,000 (Nacala)	
Barbatia sp.	Food		1,000/ handfull		
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	**Food/ Operculae**				
Chicoreus ramosus	Operculum	250			75,000 (Tz.)
	Food				
Fasciolaria trapezium	Food				75,000 (Tz.)
	Operculum	250			
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*1	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	Not sold	Not sold	Not sold

Appendix 11. Continued.

Latin name	Use	Quirimba Cost/unit	Quirimba Cost/kilo	Pemba Cost/unit	Pemba Cost/kilo
Gastropoda	**Curio trade**				
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	15,000 1st class ; 7,000 2nd; 3750 3rd	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 5,000 (N) *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	1,000			
Murex pecten	Curio trade	1,000			
Nassarius coronatus	Curio trade			250/10	
Patella spp.	Curio trade(mobiles) 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
Turbo coronatus			1000		

Appendix 11. Continued.

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

NOTES:

Prices were given by Saidi Kashim, a shell collector and vendor in the Quirimbas and Pemba (9/96). Prices of holothuria were given by various collectors. 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 Quilalia.
* 9 given by intertidal exploiter on 15/8/96.
* 10 given by ITRUser on 15/8/96.

Appendix 12
Local, English and Latin names of the biological resources utilised by the people of the Central Island Group.

LATIN	ENGLISH	KIMWANI	MAKUA
Bivalvia	**Bivalvia**		
Atrina vexillum	Giant Pen	Nyeta	Nyeta
Barbatia fusca	Almond Ark	Ombe	Ikope
Gafrarium spp.	Venus clam	Namesa/Kauri	Kamesa
Lepas spp.	Barnacle	Ulumbe/Umkoe	Uwala
Malleidae spp.	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 spp.	Natal rock oyster	Ulombe/ Enlumbe	Uwala
Striostrea sp.	Cape rock oyster	Kipambama maulu	
Telina spp.	Tellin	Kauri lume	Komrobwe
Trachycardium spp.	Cockle	Ombe lume	Ikope
Tridacna squamosa	Fluted giant clam	Nyeta	Nyeta
Gastropoda	**Gastropod**		
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	-	-

Appendix 12. Continued.

LATIN	ENGLISH	KIMWANI	MAKUA
Terebra spp.	Auger	-	-
Terebralia palustris	Mangrove whelk	Nonde	Kolote
Tonna spp.	Ton		
Trochus spp.	Top	Ukindo	Irauwe
Turbo coronatus	Turban	Opolo	Singine
Chiton	**Chiton**		
Polyplacophora spp.	Chiton	Nyamata	
Cephalopoda	**Octopus**		
Octopus vulgaris	Common Octopus	Pweza	Pweza
Holothuria	**Sea cucumber**	**Kojojo**	**Nikojojo**
Actinopyga mauritiana		Mingui	
Actinopyga miliaris		Namwali	
Bohadschia marmorata		Namunya	
Holothuria nobilis		Grife	
Holothuria fuscogilia		Umvua	
Holothuria scabra		Namwali	
Stichopus chloronotus		Espinho	
Stichopus variegatus		Bosi	
Thelenota ananas		Espinho	
No identification		Kufulie	
No identification		Mwelupa	
No identification		Ningi	
No identification		Pula	
No identification		Pwazi	
No identification		Safiya	
No identification		Supedi	
Echinomata	**Sea Urchins**		
Tripneutes gratilla	Short-spined urchin	Unsunkuru	
Crustacea	**Crustacean**		
Panulirus ornatus	Ornate spiny lobster	Mwambamba	
Portunus pelagicus	Pelagic swimcrab		
Scylla serrata	Green mangrove crab		

Notes:
Names were provided by Saidi Kashim, a shell collector and vendor in the Quirimbas and Pemba, and other collectors.

Appendix 13. Species list for Mollusca recorded from Ibo island

Species	Sand/ Seagrass	Nearshore Rocks	Lagoon	Crest	Subtidal
BIVALVIA					
Atrina vexillum	+				
Barbatia fusca	+				
Brachidontes spp.			+	+	
Gafrarium pectinatum alfredense	+				
Loripes clausus	+				
Pinna muricata	+				
Striostrea spp.				+	
Tellina spp.	+				
Tridacna squamosa			+	+	+
GASTROPODA					
Cypraeidae					
C. annulus	+		+		
C. caputserpentis				+	
C. carneola			+	+	
C. erosa				+	
C. helvola				+	
C. moneta	+		+		
C. tigris	+		+		+
Conidae					
C. chaldeus		+			
C. ebraeus		+			
C. litteratus			+		
C. textilis			+	+	
Cassidae					
Cassis cornuta					+
Cypraecassis rufa			+		
Phalium labiatum				+	
Haliotidae					
Haliotis sp.				+	
Littoraria					
Littoraria glabrata	+				
Harpidae					
H. major	+				
Marginellidae					
Marginella sp.1	+				
Marginella sp.2	+				
Mitra spp.					
Mitra mitra	+				
Muricidae					
Chicoreus ramosus	+		+		

Appendix 13. Continued.

Species	Sand/ Seagrass	Nearshore Rocks	Lagoon	Crest	Subtidal
Nassarius spp.					
N. albescens gemmuliferus	+				
Naticidae					
Polinices tumidus	+				
Neritidae					
N. polita		+			
N. plicata		+			
N. textilis	+	+			
Ranellidae					
Cymatium pileare	+				
Strombidae					
Lambis chiragra			+		
Lambis lambis			+		
Strombus mutabilis	+		+		
Turritella					
Rhinoclavis sp.	+				
Whelks					
Bursa granularis				+	
Burnupena sp. 1				+	
Fasciolaria lugubris heynemanni			+		
Fasciolaria trapezium	+		+		+
Mancinella alouina	+				
Morulla granulata	+	+			
Thais savignyi	+	+			
Winkles					
Clanculus puniceus				+	
Trochus sp. 2			+	+	
ACANTHOPLEURA		+	+	+	
OCTOPUS VULGARIS			+	+	
SCAPHOPODA					
Dentalium sp.	+				

Appendix 14. Species list of Mollusca recorded from Quirimba island.

Species	Reef	Sand/ Seagrass	QR/SC Sand/ Seagrass	Village	Transect Panlanzi	Subtidal
BIVALVIA						
Atrina vexillum			+			
Barbatia fusca		+	+		+	
Brachidontes spp.	+	+			+	
Cardita variegata		+				
Dosinia spp.		+				
Gafrarium spp.		+	+			
Gafrarium pectinatum alfredense		+			+	
Loripes clausus		+			+	
Malleidae spp.				+		
Mytilidae spp.			+			
Pinctada nigra		+	+			
Pinna muricata		+	+	+	+	
Saccostrea spp.		+			+	
Solen capensis					+	
Striostrea spp.			+			
Tellina spp.		+	+		+	
Trachycardium spp.			+		+	
Tridacna squamosa	+					+
GASTROPODA						
Cypraeidae						
C. annulus	+	+	+	+	+	
C. arabica	+					
C. caputserpentis	+					
C. carneola		+	+			
C. felina		+				
C. isabella	+					
C. moneta					+	
C. tigris	+		+			+
C. vitellus	+					
C. ziczac	+					
Conidae						
C. chaldeus		+				
C. ebraeus	+	+			+	
C. sponsalis	+		+			
C. textilis	+					
Conus sp. 2	+					
Conus sp. 3	+					
Conus sp. 4	+					

Appendix 14. Continued.

Species	Reef	Sand/ Seagrass	QR/SC Sand/ Seagrass	Village	Transect Panlanzi	Subtidal
Cassidae						
Cassis cornuta						+
Cypraecassis rufa						+
Phalium labiatum						+
Haliotidae						
Haliotis sp. 1	+					
Harpidae						
H. major		+				
Littorinidae						
Planaxis sulcatus					+	
Littoriana glabrata		+				
Littorinid sp. 3			+			
Littorinid sp. 5		+				
Littorinid sp. 6			+			
Littorinid sp. 7				+		
Marginellidae						
Marginella sp.1					+	
Mitra spp.						
Mitra mitra	+					
Mitra sp. 2		+				
Mitra sp. 3					+	
Mitra sp. 4				+		
Muricidae						
Chicoreus chicoreus			+			
Chicoreus ramosus		+	+		+	
Murex pecten		+				
Nassarius spp.						
N.albescens		+		+	+	
gemmuliferus						
N. arcularius plicatus		+	+		+	
N. capensis.				+	+	
N. coronatus	+	+	+		+	
Naticidae						
N. gualteriana		+	+			
Polinices tumidus		+			+	
Neritidae						
N. polita		+				
N. plicata		+			+	
N. textilis	+	+	+		+	
Olividae						
Oliva caroliana						+
Oliva spp.	+	+			+	

Appendix 14. Continued.

Species	Reef	Sand/ Seagrass	QR/SC Sand/ Seagrass	Village	Transect Panlanzi	Subtidal
Patellidae						
P. miniata	+	+				
Patella sp. 2	+					
Patella sp. 3	+					
Potamididae						
Cerithidea decollata		+				
Cerithium nodulosum		+	+		+	
Terebralia palustris		+	+	+	+	
Ranellidae						
Charonia tritonis tritonis						+
Cymatium pileare	+	+		+	+	
Strombidae						
Lambis chiragra						+
Lambis lambis	+		+			+
Strombus gibberulus		+		+		
Strombus mutabilis	+	+	+	+	+	
Terebridae						
Terebra sp.2			+			
Terebra sp.3		+				
Terebra sp.4	+			+		
Terebra sp.5			+			
Terebra sp.6			+			
Tonnidae						
Tonna canaliculata					+	
Turbinidae						
Turbo coronatus	+	+	+		+	
Turbo sp. 2		+				
Turbo sp. 3			+			
Turrets						
Epitonidae sp.		+			+	
Rhinoclavis sinensis		+	+		+	
Turritella sp. 1		+			+	
Turritella sp. 3						
Violet shells						
Janthina janthina		+			+	+
Whelks						
Fasciolaria trapezium	+	+			+	+
Mancinella alouina	+	+	+		+	
Mancinella spp.	+				+	
Morulla granulata		+	+	+	+	
Peristernia forskalii	+					
Thais savignyi		+	+	+	+	

Appendix 14. Continued

Species	Reef	Sand/ Seagrass	QR/SC Sand/ Seagrass	Village	Transect Panlanzi	Subtidal
Winkles						
Caliostoma sp. 1	+				+	
Clanculus puniceus	+					
Heliacus variegatus					+	
Gibbula beckeri		+				
Gibbula multicolor					+	
Monodonta australis	+					
Tectus conus	+					
Trochus sp. 2	+					
Trochus sp. 3	+					
Worm						
Serpulorbis sp. 1	+					
ACANTHOPLEURA		+			+	
Octopus vulgaris	+					
SCAPHOPODA						
Dentalium sp.			+	+		

Appendix 15. Species list of Mollusca recorded from Sencar Island.

Species	Transect 5 N. Sencar	Transect 6. S. Sencar Reef	Central Crest-Sencar
BIVALVIA			
Brachidontes spp.	+	+	+
Tridacna squamosa	+		+
GASTROPODA			
Bullia spp.			
Bullia sp. 1		+	
Cypraeidae			
C. annulus	+	+	
C. arabica			+
C. caputserpentis	+		+
C. carneola	+	+	+
C. felina	+		
C. helvola	+		
C. tigris	+	+	+
Conidae			
C. ebraeus	+		+
C. litteratus	+		+
C. sponsalis			+
C. textilis			+
Conus sp. 2	+	+	+
Conus sp. 3	+	+	+
Cypraecassis rufa		+	+
Haliotidae			
Haliotis sp. 1	+		+
Mitra spp.			
Mitra mitra	+		
N. polita			+
N. plicata			+
N. textilis		+	+
Ovulidae			
Ovula ovum			+
Patellidae			
Patella sp. 2		+	
Ranellidae			
Charonia tritonis tritonis		+	
Strombidae			
Lambis lambis		+	
Strombus mutabilis	+		+
Terebridae			
Terebra sp.2			+
Terebra sp.5			+
Tonnidae			
Tonna canaliculata			+

Appendix 15. Continued.

Species	Transect 5 N. Sencar	Transect 6. S. Sencar Reef	Central Crest-Sencar
Turbinidae			
Turbo sp. 2	+		
Whelks			
Fasciolaria trapezium		+	+
Mancinella alouina			+
Mancinella spp.	+		
Morulla granulata	+		+
Thais savignyi			+
Winkles			
Clanculus puniceus	+		
Gibbula beckeri		+	
Tectus conus		+	+
Trochus sp. 2		+	
Trochus sp. 3			+
ACANTHOPLEURA			+
Octopus vulgaris	+	+	+

Appendix 16. Species list of Mollusca recorded from Quilaluia island.

Species	Sand/Seagrass	Reef	Subtidal
BIVALVIA			
Atrina vexillum	+		
Barbatia fusca	+		
Brachidontes spp.		+	
Cardita variegata	+		
Chlamys spp.			+
Pecten spp.			+
Pinctada nigra		+	
Pinna muricata	+		
Pitar abbreviatus			+
Trachycardium spp.	+		
Tridacna squamosa		+	+
GASTROPODA			
Cypraeidae			
C. annulus	+	+	
C. caputserpentis		+	
C. carneola		+	
C. helvola		+	
C. isabella		+	
C. moneta			
C. oryx		+	
C. tigris	+	+	+
Conidae			
C. chaldeus		+	
C. ebraeus		+	
C. litteratus		+	
Conus sp. 3		+	
Cassidae			
Cassis cornuta			+
Cypraecassis rufa		+	+
Phalium labiatum			+
Littorinidae			
Littorinid sp. 3	+		
Marginellidae			
Marginella sp.1	+		
Marginella sp.2		+	
Mitra spp.			
Mitra mitra	+		
Muricidae			
Chicoreus ramosus	+	+	
Nassaridae spp.			
N. albescens gemmuliferus	+		
Neritidae			
N. plicata		+	
N. textilis		+	

Appendix 16. Continued

Species	Sand/Seagrass	Reef	Subtidal
Potamididae			
Terebralia palustris	+		
Ranellidae			
Charonia tritonis tritonis			+
Strombidae			
Lambis chiragra			+
Lambis lambis			+
Strombus mutabilis	+		
Strombus tricornis		+	
Strombus sp 3		+	
Strombus sp. 4		+	
Strombus sp. 5		+	
Turrets			
Rhinoclavis sinensis	+		
Whelks			
Fasciolaria trapezium	+		+
Mancinella alouina	+		
Morulla granulata	+	+	
Thais savignyi	+		
Winkles			
Clanculus puniceus		+	
ACANTHOPLEURA		+	
Octopus vulgaris		+	

Appendix 17.
Scientific and local names for the mangrove trees of the "Central Islands Group" *(*X. moluccensis* identification is still to be confirmed).

SPECIES	FAMILY	LOCAL NAME
Rhizophora mucronata	Rhizophoraceae	Mtanganda / Akalva
Brugiera gymnorrhiza	Rhizophoraceae	Nkandala / Mpiria
Ceriops tagal	Rhizophoraceae	Nsangi / Nkandala
Avicennia marina	Avicenniaceae	Musso
Sonneratia alba	Sonneratiaceae	Mpiria
Lumnitzera racemosa	Combretaceae	Not known
Xylocarpus granatum	Meliaceae	Nseti
*Xylocarpus moluccensis**	Meliaceae	Ngoma-manyani

Appendix 18.
Coral Genera Assessed in the Surveys of the Central Islands Group

Scleractinian ('hard') Corals

Porites
Platygyra
Galaxea
Diplostrea
Favia
Favites
Goniastrea
Tubastrea
Plerogyra
Acropora
Pocillopora
Pachyseris
Montipora
Echinopora
Turbinaria
Millepora
Fungia
Lobophyllia

'Soft' Corals

Lithophyton
Sarcophyton
Sinularia
Heteroxenia
Dendronephyta