Scleractinian Coral Communities of Two Inshore High Island Fringing Reefs at Magnetic Island, North Queensland

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ABSTRACT: The characteristics of the scleractinian coral communities on 2 fringing reefs of an inshore high island were compared, using data from surveys by the line transect method. The communities are divided into zones on the basis of numbers of species per transect, species diversity indices, percentage coral cover and numerical classification of transects. The Geoffrey Bay community is divided into a Reef Flat Zone dominated by *Goniastrea aspera*, *Platygyra sinensis* and *Montipora ramosa* and a Reef Slope Zone dominated by arborescent and tabulate *Acropora* species. The Cockle Bay community is divided into an Inner Reef Flat Zone dominated by *Montipora ramosa*, an Outer Reef Flat Zone dominated by *Platygyra sinensis* and *Symphyllia recta*, and a Reef Slope Zone dominated by *Goniopora tenuidens*. Differences in community structure, species composition and distributions of abundant species of the zones of the 2 reefs, can be attributed to prevailing environmental conditions. In particular, differences in exposure to wave action and sedimentation between the reefs are reflected in smaller numbers of species, lower coral cover, lower values of the Shannon Diversity Index and selection of silt resistant species on the less exposed reef in Cockle Bay.

INTRODUCTION

This paper presents the first quantitatively based ecological study of coral assemblages on inshore fringing reefs in the Great Barrier Reef region. By virtue of their sheltered position and geomorphology these reefs are quite different from others described in the current literature.

Several quantitative coral community descriptions based on surveys by the line transect (or similar) method have been published. Most such descriptions of fringing reefs in the Indo-Pacific, e.g. Eilat (Loya and Slobodkin, 1971; Loya, 1972), Seychelles (Braithwaite, 1971), L'Ile Rodrigues (Faure and Montiaggioni, 1967), Réunion and Mauritius (Pichon, 1971) and Mahé, Sechelles (Rosen, 1971) show features determined by far greater exposure than is found at inshore areas such as Magnetic Island. Lovell (1975) has described shallow, sheltered coral assemblages in Moreton Bay (Southern Queensland), but recent coral growth there has not led to development of fringing reefs morphologically comparable with those described in the present study.

THE STUDY AREA

Magnetic Island is a high mainland island situated in Cleveland Bay approximately 8 km north of the City of Townsville (Fig. 1). Several of the island's bays have fringing coral reefs. The reefs chosen for this study are 2 of the most conspicuous: Cockle Bay Reef on the mainland (southwest) side of the Island and Geoffrey Bay Reef on the south east side. The reefs are formed by a thin (mostly 6 m or less), recently formed (since 6000 y B.P.) crust of reefal growth over large sand and mud banks (Hopley, 1982). The gradients of the outer reef slopes are extremely gentle; the reef front in Geoffrey Bay extends over a horizontal distance of 150 m with a maximum depth of 9 m (taken from 0 m tidal datum). In Cockle Bay the depth range is 4 m over a distance of 100 m. The reef flat extends 150 m landward of the crest in Geoffrey Bay and 200 m in Cockle Bay. Both have extensive backreef sand/mud flats.

The island is well inshore in a relatively shallow, sheltered situation and comes under the freshwater and siltation influence of the mainland Ross and Burdekin Rivers. Rainfall in the area is seasonal with
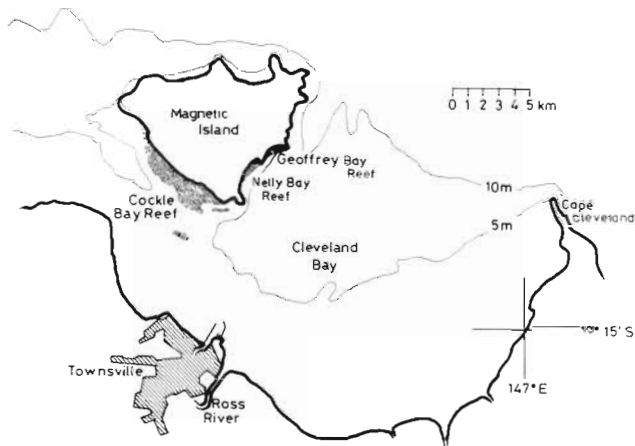
Fig. 1. Cleveland Bay area with Geoffrey Bay and Cockle Bay Reefs

approximately 70 % of the annual fall on the Burdekin catchment occurring in the summer period, January to March (Pickard, 1977). Surface salinity and temperature measurements over 3 y at an open water station in Cleveland Bay, between Magnetic Island and Cape Cleveland, showed a salinity range from 24.3 ‰ to 36.3 ‰ S and a temperature range from 19.3 ° to 30.9 °C (Walker, 1981a, 1981b). However, there may be greater local variations in reef areas due to solar heating of shallow water and the influence of local island freshwater runoff. Collins (1978) recorded an extreme low salinity of 17.0 ‰ S after cyclonic rain, at a station on the reef flat in Nelly Bay (adjacent to Geoffrey Bay).

The prevailing winds entering Cleveland Bay are easterly or south easterly for most of the year and a west going swell is usually present. The Bay has a sandy-mud bottom composed of sand material eroded around headlands, silt and clay brought down by coastal rivers and locally some large particle size carbonate deposits from reef areas (Belperio, 1980). The wind and swell regime and the consequent distribution of terrigenous silt result in the Geoffrey Bay Reef, which is more exposed to swell, being less heavily silted than the Cockle Bay Reef. The tidal regime in the area is semi-diurnal with diurnal inequality. The mean tidal range during spring tide periods is 2.5 m, and 0.8 m during neap tide periods (Dept. Harbours and Marine, 1976). As a consequence of the tidal range, the reef flat areas in Geoffrey and Cockle Bays are air-exposed for a few hours daily during spring tide periods, but not during neaps. The lowest daytime spring tides occur during winter (coolest and driest months).

METHODS

The procedures used for the line transect surveys were as described in detail by Loya (1972). The advan-

tages of the line transect method for this kind of work are discussed by Loya (1978). A line length of 30 m was chosen by the species-number/transect-length method (Loya, 1972). The lines were positioned at right angles to a chosen line running from the beach edge to the reef front. Each transect was positioned so as to fall within one visually homogeneous area such that each major section of the reef (reef flat, reef crest and seaward slope) is represented by at least five transects (Fig. 2). By visually positioning transects in this way, the communities could be surveyed using fewer transect lines than would have been required if transects had been positioned at fixed intervals as has been the practice (Loya, 1972, etc.). Surveys of emersed reef flat areas were done during low spring tide, the remaining areas were surveyed using SCUBA.

Three samples of reef sediment were taken from each reef (Fig. 2) for analysis of grain size distribution using methods reviewed in Carver (1971).

Data were analysed using the James Cook University's PDP 10 computer. Formulae and notation for the Shannon diversity indices (Shannon and Weaver, 1948) are as used by Loya (1972). For cluster analysis of transects using the absolute cover values of all species present, the CLUSTAN 1C software package (Wishart, 1975) was employed with the Bray-Curtis Dissimilarity Index (as modified by Stephenson et al., 1970) and the Lance-Williams flexible fusion strategy (Lance and Williams, 1967) using the now standard value of $beta = -0.25$.
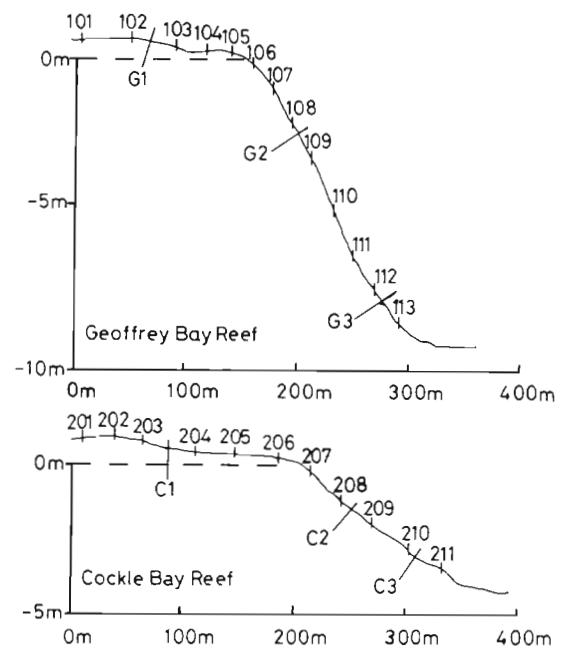

Fig. 2. Diagrammatic profiles of the 2 reefs showing positions of transect lines (101 to 113 and 201 to 211) and sediment sampling sites (Gl to G3 and Cl to C3)

RESULTS

Sediment Grain Size Analysis

The 2 reef flat samples are similar, except that the Cockle Bay reef flat sample (mean *phi* = 1.54) has slightly smaller mean grain size than the Geoffrey Bay reef flat sample (mean *phi* = 1.23) which has an excess of coarse particles (-ve skewness). However, the subtidal samples from each reef differ greatly. The Cockle Bay slope samples have a much smaller mean grain size (mean *phi* = 3.34 and 1.58), greater excess of fine particles and higher clay content (7.8 % and 4.1 %) than the Geoffrey Bay slope samples (mean *phi* = 0.75 and 0.33; clay content 2.3 % and 1.2 %). This reflects the reduced wave action and turbulence in Cockle Bay as compared with Geoffrey Bay.

Species Composition and Distributions

A total of 78 species belonging to 33 genera and 14 families were recorded during the line transect survey: 69 species in Geoffrey Bay and 42 species in Cockle Bay. Of these, 33 species were found on both reefs, 36 species were recorded only in Geoffrey Bay and 9 species were recorded only in Cockle Bay.

Abundant species on both reefs include *Favia favus*, *Goniastrea aspera*, *Turbinaria mesenterina* and *Montipora ramosa*. The number of species common to both reefs indicates some similarity between the communities. However, the following major differences in species composition and abundances between the reefs are apparent:

(1) A generally reduced complement of species is present in Cockle Bay as compared with Geoffrey Bay.

(2) *Acropora* species which are abundant on the Geoffrey Bay reef slope are almost totally absent from Cockle Bay.

(3) Other small polyped species – unlikely to be resistant to siltation – are present in Geoffrey Bay, but are rare in Cockle Bay, including *Pachyseris speciosa*, *Oxypora lacera* and various encrusting and foliose *Montipora* species.

(4) The reef slope in Cockle Bay is dominated by *Goniopora tenuidens*, a species able to resist siltation by having long, continually distended polyps. Another reason for the dominance of this species on the slope in Cockle Bay may be its ability to act as a primary coloniser of the soft substrate at the reef base by production of asexually reproduced 'polyp-balls' (Scheer, 1959, 1960; Rosen and Taylor, 1969). Other abundant species on the Cockle Bay reef slope include *Symphyllia recta* and *Fungia fungites* which, by their functional morphology, are likely to be active sediment rejectors (Hubbard and Pockock, 1972).

Table 1. Statistics for each transect line

	Cockle Bay Transects													Geoffrey Bay Transects										
Transect line number	101	102	103	104	105	106	107	108	109	110	111	112	113	201	202	203	204	205	206	207	208	209	210	211
Number of species	3	5	7	9	5	7	8	10	20	24	30	20	19	2	3	2	3	11	8	19	15	8	11	13
Percentage coral cover	5.73	4.80	5.80	5.93	6.27	4.00	3.93	5.23	20.56	35.23	24.07	24.03	26.13	21.63	43.17	32.90	2.50	8.70	14.23	16.83	14.17	23.80	5.73	8.50
Number of colonies	20	15	20	25	20	14	14	26	32	46	46	40	35	35	73	26	5	19	33	50	41	29	18	25
Mean colony size (line intercept, cm)	8.60	9.60	8.70	7.12	9.40	8.57	8.43	6.04	20.56	22.98	15.69	18.03	22.40	18.54	17.74	37.96	15.00	13.74	12.94	10.10	10.37	24.62	9.56	9.45
Standard deviation from mean colony size	4.59	5.03	3.94	3.77	5.40	4.20	4.61	4.25	17.86	20.15	12.30	14.15	22.40	28.72	19.08	115.04	10.04	11.44	12.22	10.01	10.00	27.35	9.88	7.34
Minimum line intercept (cm)	1	2	2	2	2	3	4	2	6	2	1	2	2	2	1	3	6	3	3	1	2	3	2	2
Maximum line intercept (cm)	19	19	15	14	22	17	21	18	83	115	65	65	107	163	90	606	33	47	65	50	46	114	44	29
Shannon, Diversity Index H'c	0.773	1.287	1.001	1.669	1.360	1.440	1.812	1.879	2.609	2.823	2.950	2.531	2.373	0.121	0.053	0.087	0.942	2.079	1.799	2.349	2.193	2.182	2.064	2.156
Shannon, Diversity Index H'n	0.886	1.287	1.400	1.504	1.400	1.451	1.909	1.977	2.853	2.981	3.202	2.442	2.773	0.293	0.145	0.271	1.055	2.132	1.670	2.634	2.197	1.597	2.293	2.191

Zonation

Both reefs, from the lower limits of coral growth (the bases of the reef slopes) to the landward reef limits, can be regarded as single coral 'communities'. These can be divided into 'zones'. For the purpose of this study, zones are described as subdivisions of the coral communities which can be defined on the basis of percentage coral cover, colony size, number of species per

transect and species diversity indices. Each zone has its own characteristic species composition, spatial distribution of species and dominant species.

The statistics calculated for each transect line (Table 1) and the results of cluster analysis (Fig. 3) indicate division of the Geoffrey Bay community into 2 zones: A, the Reef Flat and Crest Zone and B, the Reef Slope Zone. By contrast the Cockle Bay community is divided into: C, the Inner Reef Flat Zone; D, the Outer Reef Flat

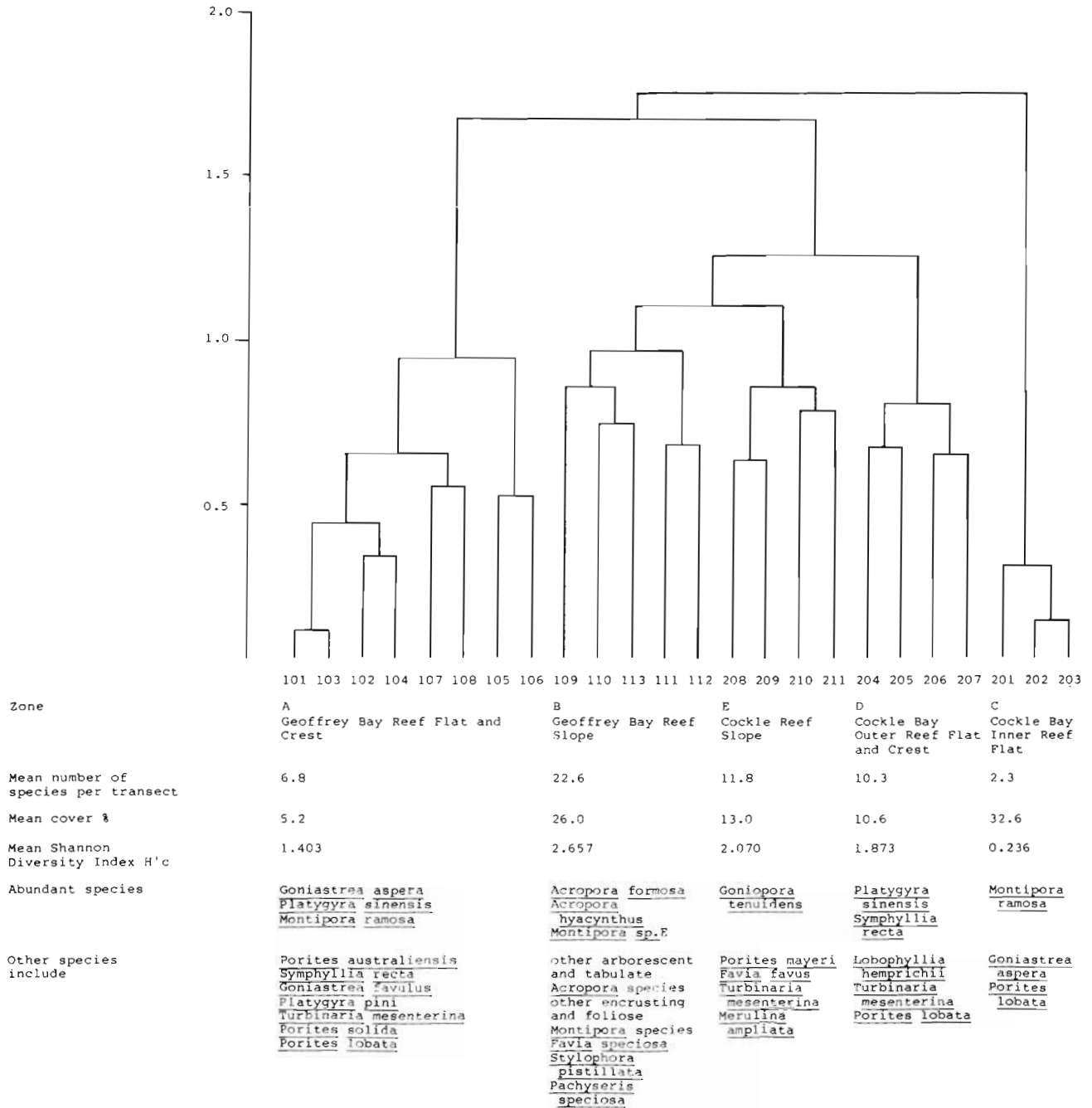|	A	B	E	D	C
Zone	Geoffrey Bay Reef Flat and Crest	Geoffrey Bay Reef Slope	Cockle Reef Slope	Cockle Bay Outer Reef Flat and Crest	Cockle Bay Inner Reef Flat
Mean number of species per transect	6.8	22.6	11.8	10.3	2.3
Mean cover %	5.2	26.0	13.0	10.6	32.6
Mean Shannon Diversity Index H'c	1.403	2.657	2.070	1.873	0.236
Abundant species	Goniastrea aspera Platygyra sinensis Montipora ramosa	Acropora formosa Acropora hyacynthus Montipora sp.F	Goniopora tenuidens	Platygyra sinensis Symphyllia recta	Montipora ramosa
Other species include	Porites australiensis Symphyllia recta Goniastrea favulus Platygyra pini Turbinaria mesenterina Porites solida Porites lobata	other arborescent and tabulate Acropora species other encrusting and foliose Montipora species Favia speciosa Stylophora pistillata Pachyseris speciosa	Porites mayeri Favia favus Turbinaria mesenterina Merulina ampliata	Lobophyllia hemprichii Turbinaria mesenterina Porites lobata	Goniastrea aspera Porites lobata

Fig. 3. Dendrogram from classification of transects with summarised characteristics of each zone

and Crest Zone; and E, the Reef Slope Zone. The community structure parameters and species of each zone are summarised in Fig. 3.

DISCUSSION

There is an overall similartiy of species composition on the 2 reefs, shown in particular by the closeness of clustering of the 2 reef slope zones (B and E in Fig. 3). However, there are differences in dominant species and community structure parameters between the reefs.

The species complement is reduced in Cockle Bay, with associated lower numbers of species per transect and lower values of the Shannon Diversity Indices. There is also lower cover on the outer reef flat and slope of Cockle Bay and selection for siltation resistant species is apparent. This can be attributed to the higher sedimentation and finer sediment in Cockle Bay. These results are comparable with those of Loya (1976). Loya attributed similar differences in community structure between 2 sites at Puerto Rico to higher sedimentation and turbidity at one site.

In spite of the relatively sheltered position of Magnetic Island it is possible to compare the growth forms of the dominant coral species on the slope and outer reef flat zones with the synthetic models of Rosen (1971, 1975) and Pichon (1973). These models relate dominant coral growth forms to strength of water movement. In particular, the reef slope in Geoffrey Bay (Zone B) is dominated by arborescent and tabulate *Acropora* species. According to Rosen's and Pichon's models this is a reflection of moderate water movement. Conversely, the slope in Cockle Bay (Zone E) is dominated by the massive species *Goniopora tenuidens*. Similarly the outer flat and crest in Cockle Bay (Zone D) and the reef flat in Geoffrey Bay (Zone A) are dominated by massive species. These correspond to Rosen's *Porites* assemblage and Pichon's zone-type dominated by species with massive growth form, which is a reflection of reduced water movement.

The most abundant species on both reef flats is *Montipora ramosa*, which appears to be the only species able to maintain high cover on the reef flat areas with a shifting rubble substrate, probably because of a fast growth rate and ability to regenerate from fragments. The rubble substrate itself is largely composed of dead *Montipora ramosa* fragments. Other reef flat species only reach significant levels of cover and colony size where there is a firm substrate for attachment. Because Cockle Bay is very sheltered, the rubble is likely to be shifted rarely – only in severe storm or cyclonic surge conditions. This permits the development on the Cockle Bay inner reef flat of a

zone totally dominated by *Montipora ramosa*, with high cover of that species. In Geoffrey Bay the rubble areas are much less extensive and less stable.

There are some similarities in zonation and species composition between this study and the descriptions of fringing reef flats at NW side of Maer Island, Murray Is. (Mayer, 1918), Gaua, New Hebrides (Baker, 1925), Bay of Batavia (Umbgrove, 1940) and Iwayama Bay, Palao (Abe, 1937). In particular, each of these studies includes a description of a *Montipora ramosa* zone comparable with the Inner Reef Flat Zone in Cockle Bay.

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