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THE IMPACT OF HUMAN INFLUENCE ON THE FRINGING REEF OF PULAU HANTU, SINGAPORE

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ABSTRACT

Pulau Hantu (1° 13.6'N, 103° 45'E), located 8 km south of Singapore mainland was transformed by a massive land reclamation programme into a recreational island. The major part of the reef flat was buried but the reef slope remained untouched. Line transect surveys at depths of 0, 3, 6, 10 m along the reef slope at 3 stations around the island in 1986-88 showed that the upper part of the slope supported better coral growth in terms of cover and generic richness. A total of 41 scleractinium genera was recorded with Pachyseris, Fungia, Porites and Pectinia widely distributed. Average dead coral colony size was larger than for live coral. Laminate, foliose and submassive growth forms of hard corals were favoured.

INTRODUCTION

Pulau Hantu, situated 8 km south of mainland Singapore (Fig. 1), at position 1° 13.6'N and 103° 45.5'E, originally consisted of 2 small nearby islands, Pulau Hantu Besar (2 ha) and Pulau Hantu Kechil (0.4 ha) surrounded by fringing reefs with a common reef flat in between. Under a massive land reclamation programme between March 1974 and April 1975, 400,000 m^3 of sand was used to increase the land area of the two islands to 12.2 ha (Fig. 2). The reclamation covered most of the reef flat up to an average distance of 15 m from the reef edge with a rock bund holding back the sand. The common reef flat between the two islands was buried under sand and transformed into a swimming lagoon.

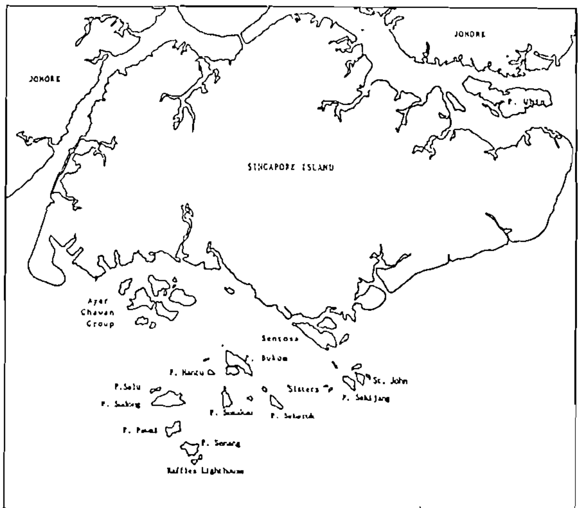

Figure 1. Map of southern islands in relations to mainland Singapore.

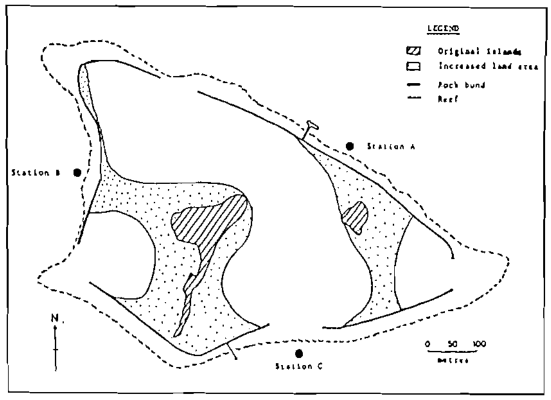

Figure 2. Map of Pulau Hantu showing the extent of land reclamation and the survey sites.

Other facilities were added to the islands to increase their recreational potential and to date, the islands are extremely popular with picnickers, especially on weekends.

No quantitative studies have been made on the reef life of Pulau Hantu prior to its physical transformation and comparisons cannot be made to assess the direct impact of the man-made changes. The results of this study however, will establish the basic reference for the reef at this stage, and enable monitoring of future changes that may arise from strong recreational pressures. The results can also be compared with similar surveys conducted recently on other non-reclaimed reefs within the surrounding area.

MATERIALS AND METHODS

Surveys were carried out using parallel-to-shore 100m line transects set at the reef edge and at depths of 3m, 6m and 10m of the reef slope at 3 stations located around the islands (Fig. 2). The method used is fully described in Dartnall & Jones (1986) consisting essentially of laying a graduated 100m line along a fixed depth following closely the contours of the slope. All lifeforms as well as abiotic characteristics transected by the line were recorded in pre-determined codes together with the absolute amount of transection. The hard corals were identified to the generic level while all other lifeforms were not classified beyond broad taxonomic categories.

Station A is situated just south of the only concrete jetty which serves the island complex. There is frequent movement of propellar-driven vessels around this area which also has limited mooring facilities. Station B is separated from a nearby patch reef by a narrow channel of 50m width and 18m depth. Strong tidal streams occur here during tidal changes. The location of station C is directly at the southern entrance to the main lagoon. The semi-diurnal tidal flushing exchanges water between the lagoon and the sea over this site.

All surveys were carried out using SCUBA between April 1986 and April 1988.

RESULTS

The lifeform cover values as well as the hard coral generic richness and colony number are shown in Table 1. Live coral cover is greatest on the reef edge and 3m depth of the reef slope at stations A and B. At station C, live coral cover was substantially reduced at the 3m depth. All stations showed low live coral cover at the 6m and 10m depths. Station B registered the highest live coral cover at all depths as compared with those of station A and C. Dead coral cover was comparatively higher at all depths of station C than the other two stations. The majority of dead corals was coated with algae. Recently dead corals were few in numbers. The upper levels of the reef slope supported a greater diversity of hard corals and higher colony numbers.

Algal cover at all depths of the three stations was dominated by macroalgae except at the 10m depth transect of station A which was mainly coralline algae and the 3m depth transect of station B which was mainly mixed algal assemblages. Coralline algae were not abundant and even at the 10m depth transect of station A where they were dominant, they occupied only 1.89% of the total length of the transect. Algal cover also decreased with increasing depth.

The other reef fauna apart from the hard corals, did not show the same trend of decreasing value with increasing depth, as was shown by the hard corals. The reef edge at station A registered the highest amount of other fauna, most of which was soft coral. The areal cover of other fauna was generally low. The abiotic component of mainly sand and rubble showed a clear increase from the shallower to the deeper parts of the reef slope at all sites. A total of 41 genera of hard corals was obtained from all the survey locations and their distribution shown in Table 2. Pachyseris, the most widespread genus, was present on 11 of the 12 survey locations. Fungia occurred in 10 of the locations while Porites and Pectinia were present in 9 locations. In general, the shallower transects supported a higher diversity of hard corals. Station B supported the highest total number of coral genera (35), and all depths of this station with the exception of the 6m depth were generically richer compared with the other two stations. Limited in distribution to one survey location only were Pocillopora, Acropora, Leptoseris, Polyphyllia, Oulastrea, Trachyphyllia, Tubastraea and Turbinaria.

Generic dominance in terms of percentage cover as shown in Table 3, indicates Merulina as the widespread dominant genus at the reef edge, Pavona at the 3m depth and Fungia at the 10m depth. The 6m depth was dominated by a different genus at each site.

The average colony sizes of both live and dead corals are compared in Table 4. Dead coral colony sizes were generally larger than those of live coral. Live coral colony size showed a decrease at the deeper parts of the reef slope. Dead coral colony size at station B increased with depth but for stations A and C, larger colonies were present on the upper transects. Size variation however was wide, resulting in large standard deviations.

DISCUSSION

The reef community at Pulau Hantu has been subjected to human influence of various sorts, the most serious of which was land reclamation which

Table 1. Lifeform cover, hard coral generic richness and colony number at all survey locations of Pulau Hantu reef

Station	Depth (m)	Hard coral generic richness per 100m line	Live coral colony no. per 100m line	Lifeforms cover (%)				
				Live coral	Dead coral	Algae	Other fauna	Abiotic component
A	0	15	89	29.54	13.27	13.45	10.76	32.98
	3	23	89	27.66	11.69	0.17	1.33	59.15
	6	11	26	3.68	18.97	1.08	3.37	72.90
	10	2	3	0.35	1.09	2.03	2.73	93.80
B	0	26	139	43.76	13.73	6.48	1.34	34.69
	3	27	130	46.23	4.13	11.28	5.99	32.37
	6	7	27	3.71	14.38	0.62	1.09	80.20
	10	10	20	5.49	5.75	0.70	1.34	86.72
C	0	25	154	41.92	35.04	4.55	4.40	14.09
	3	19	49	9.23	56.27	0.40	0.45	33.65
	6	3	4	0.82	46.15	0.00	2.53	50.50
	10	1	2	0.24	13.74	0.70	3.91	81.41

Table 2. Distribution of hard coral genera among the transect depths of all stations surveyed (+ = present, - = absent)

FAMILY	GENERA	STATION DEPTH (m)	A 0	A 3	A 6	A 10	B 0	B 3	B 6	B 10	C 0	C 3	C 6	C 10
POCILLOPORIIDAE	Pocillopora		-	-	-	-	+	-	-	-	-	-	-	-
ACROPORIDAE	Acropora		+	-	-	-	-	-	-	-	-	-	-	-
	Astreopora		-	+	-	-	+	-	-	-	-	-	-	-
	Montipora		+	+	+	-	+	+	-	-	+	+	-	-
AGARICIIDAE	Leptoseris		-	-	-	-	-	-	+	-	-	-	-	-
	Pachyseris		+	+	+	+	+	+	+	+	+	+	+	-
	Pavona		-	+	-	-	+	+	+	-	+	-	-	-
FUNGIIDAE	Fungia		+	+	-	-	+	+	+	+	+	+	+	+
	Herpolitha		-	+	-	-	+	+	+	+	-	-	-	-
	Heliofungia		-	+	-	-	-	+	-	+	-	-	-	-
	Podabacia		-	+	-	-	-	+	-	-	+	-	-	-
	Polyphyllia		-	-	-	-	-	+	-	-	-	-	-	-
	Cycloseris		-	-	-	-	-	-	-	+	-	-	-	-
PORITIDAE	Goniopora		-	-	-	-	+	-	-	+	+	+	-	-
	Porites		+	+	+	-	+	+	+	+	+	+	-	-
FAVIIDAE	Cyphastrea		-	-	+	-	+	+	-	-	+	+	-	-
	Diploastrea		-	-	+	-	+	+	-	-	+	-	-	-
	Echinopora		+	+	+	-	+	+	-	-	+	-	-	-
	Favia		+	+	+	-	+	+	-	-	+	+	-	-
	Favites		-	+	+	-	+	+	-	-	+	+	-	-
	Goniastrea		-	+	-	-	+	+	-	+	+	+	-	-
	Hydnophora		+	+	-	-	+	+	-	-	+	+	-	-
	Montastrea		-	+	-	-	-	+	-	-	+	+	-	-
	Platygyra		+	+	-	-	+	+	-	-	+	-	-	-
	Leptastrea		-	-	-	-	+	-	-	-	-	-	-	-
	Oulastrea		-	-	+	-	-	-	-	-	-	-	-	-
TRACHYPHYLLIIDAE	Trachyphyllia		-	-	-	-	-	-	-	-	+	-	-	-
OCULINIDAE	Galaxea		+	-	-	-	+	+	-	-	-	-	-	-
MERULINIDAE	Merulina		+	+	-	-	+	+	+	-	+	+	-	-
MUSSIDAE	Lobophyllia		-	+	-	-	-	+	-	-	+	-	-	-
	Symphyllia		-	-	-	-	+	-	-	-	+	+	-	-
PECTINIIDAE	Echinophyllia		-	+	+	-	+	+	-	-	+	-	-	-
	Mycedium		-	-	-	-	-	+	-	-	-	+	-	-
	Oxypora		+	+	-	-	+	+	-	-	+	-	-	-
	Pectinia		+	+	-	+	+	+	-	+	+	+	+	-
CARYOPHYLLIIDAE	Euphyllia		+	+	-	-	+	+	-	+	+	+	-	-
	Physogyra		-	+	-	-	-	+	-	-	-	-	-	-
	Plerogyra		-	-	-	-	+	-	-	-	-	+	-	-
SIDERASTEREIDAE	Psammocora		+	-	-	-	-	-	-	-	+	-	-	-
DENDROPHYLLIIDAE	Tubastraea		-	-	+	-	-	-	-	-	-	-	-	-
	Turbinaria		-	-	-	-	-	-	-	-	-	+	-	-

Table 3. Dominant hard coral genera of locations surveyed (values in brackets indicate the cover of that genus against total live coral cover for that particular location)

DEPTH (m)	STATION A		STATION B		STATION C	
0	Montipora	(55.86)	Merulina	(17.07)	Merulina	(18.13)
3	Pavona	(20.97)	Pavona	(19.01)	Pectinia	(27.84)
6	Porites	(25.00)	Fungia	(51.48)	Pachyseris	(70.73)
10	Pectinia	(62.86)	Fungia	(42.81)	Fungia	(100.00)

Table 4. Average colony sizes of live and dead corals

Station	Depth(m)	Colony size + SD (sample number) in cm: Live coral	Dead coral
A	0	32.93 ± 26.95 (90)	44.23 ± 36.13 (30)
	3	31.07 ± 25.40 (89)	116.90 ± 81.26 (10)
	6	14.19 ± 16.66 (26)	65.41 ± 66.45 (29)
	10	11.66 ± 9.29 (3)	13.62 ± 8.07 (8)
B	0	31.48 ± 38.18 (139)	31.20 ± 29.80 (44)
	3	35.56 ± 30.85 (130)	41.30 ± 42.74 (10)
	6	13.74 ± 9.36 (27)	53.26 ± 43.76 (27)
	10	27.45 ± 46.27 (20)	63.88 ± 57.06 (9)
C	0	27.22 ± 22.71 (154)	0.00
	3	18.83 ± 10.43 (49)	148.07 ± 226.56 (38)
	6	20.50 ± 9.95 (4)	90.49 ± 81.49 (51)
	10	12.00 ± 0.00 (2)	59.74 ± 68.10 (23)

permanently smothered the major portion of the reef flat. In addition, the activities of visitors especially on weekends provide a continued pressure on the reef slope and what remains of the reef flat. A study on the reef community prior to the land reclamation programme was restricted to a listing of species (Chuang, 1961) but it is suspected that the list of 19 genera of stony corals was not exhaustive as it is unlikely that the coral community could have increased substantially after the reclamation.

Although it is not possible to assess the actual impact of the reclamation on the coral community, it can be inferred from the results that the deeper zones of the reef slope have become unfavorable to coral growth judging from the frequency and size of live and dead corals at these areas.

Station B appeared to support the best live coral cover and diversity throughout the various depths of the reef slope. The strong tidal currents here make this area less popular with swimmers and divers and this may be the reason for the better coral growth here.

The conditions at Pulau Hantu seem to support laminate and foliose growth forms at all levels of the reef slope as well as submassive forms (Fungia) at the deeper zones. Branching forms appeared to be rare. Tilmant and Schmahl (1983) in their 3-year study of coral damage on recreationally used reefs within Biscayne National Park, Florida, found that damage was greatest in branching species of Acropora and Porites. In their review on the effects of stress on reef corals, Brown and Howard (1985) pointed out that a number of case studies such as those by Sheppard (1980), Dollar and Grigg (1981), Hudson et al (1982) revealed an apparent lack of serious damage arising from man's influence and that there existed a variability in the response of different corals to the stresses even at the same site.

The Pulau Hantu reef slope is subject to different types of disturbances such as sedimentation and recreational activities, and the reef community that is present now indicates the community structure which is able to withstand such influences. It would appear that the laminate, foliose and submassive growth forms are tolerant of these conditions.

Based on generic diversity and live coral cover, the upper parts of the reef slope remain comparable to that of reefs in relatively clearer waters such as in Sichang Island, Gulf of Thailand (Sakai et al, 1986) and Cape Rachado, Malaysia (Goh & Sasekumar, 1980). The reef life of Pulau Hantu is also comparable to the other reefs within the vicinity where sedimentation load is high but recreational pressure low (Chou, 1988).

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