NATURAL COLONIZATION OF MAN-MADE LAGOONS BY REEF COMMUNITIES

- A MODEL FOR THE ASSESSMENT OF REEF RESPONSE TO SEA-LEVEL RISE

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ABSTRACT:

There is growing interest on the response of coral reefs to expected sea level rise accompanying global climate change. One of the questions asked is whether reef communities are able to colonize shore habitats newly submerged by raised sea level. Man-made coastal lagoons created within reefal habitats provide a suitable model for investigations aimed at answering this question. In the southern offshore islands of Singapore, a number of such man-made lagoons constructed at different times in the past enable spatial as well as temporal analysis of their colonization by reef communities. An initial study of one such lagoon constructed in 1975 showed minimal colonization by hard corals (less than 1% areal cover). Although areal extent of algae, sponges and soft corals were greater than that of hard corals, the combined cover did not exceed 20% of the transect considered as supporting the best colonization response. Colonization rate differences were also observed along the different lagoonal zones.

Key words: reef community, colonization, lagoon, sea level rise

INTRODUCTION

Many of Singapore's southern offshore islands with fringing reefs have had their reef flats reclaimed for a variety of reasons. One such island is Pulau Hantu which was reclaimed to enhance its recreational potential. The island, located 8 km south of the main island at position 1^0 13.6'N and 103^0 45.5'E, originally consisted of 2 small adjacent islands, Pulau Hantu Besar (2 ha) and Pulau Hantu Kechil (0.4 ha) surrounded by fringing reefs and sharing a common reef flat in between. Under a massive land reclamation programme between March 1974 and April 1975, 0.4 million m^3 of sand were used to increase the land area of the two islands to 12.2 ha (Fig. 1). 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.

The establishment of some coral colonies and other benthic reef associated organisms have been observed since then. This situation presents a similar scenario to sand beaches that would become inundated by a rising sea level. Colonization by reef communities of coastal man-made lagoons would be a useful model for intepreting reef response in general to newly submerged shore habitats from a raised sea level. A preliminary study was then undertaken in 1992 to assess the reef community colonizing the lagoonal floor, 17 years after the creation of the lagoon.

MATERIALS AND METHOD

A perpendicular transect was deployed at the northern entrance of the lagoon (Fig. 1) moving from the original reef crest into the lagoon. Seven 20m parallel transects at 10m intervals of the perpendicular transect were established. These 7 transects are identified as A to G with A being innermost of the lagoon and G at the entrance. Along each 20m parallel transect, a $1m^2$ quadrat with a grid of a hundred squares of 100 cm^2 each was placed at alternate metre marks, enabling an area of $10m^2$ per parallel transect to be assessed. Within each m^2 quadrat, the areal cover of individual benthic organisms was measured.

RESULTS

The depth profile of the lagoon was constant along the perpendicular transect. There was no exposure even at very low spring tides. The substratum was mostly sandy with the presence of few small rocks. Hard corals were usually found associated with these rocks. The total percent live cover of all organisms across the transects ranged from 5.6 to 19.9 (Table 1). The trend of increasing abundance from the inner to the outer part of the lagoon reversed abruptly at the outermost transect.

Apart from the major life form groups shown in the table, other organisms such as gastropods, bivalves, hydroids, anemones, zoanthids and polychaetes were observed together with more motile forms such as gobies and crustaceans. *Sargassum* was the major macroalgae, and of the two genera of seagrass, *Halophila* was more abundant than the larger *Enhalus*.

TABLE 1. Total live percent live cover of all benthic organisms (including major groups) across the transects.

Transect	A	B	C	D	E	F	G
Hard corals	0.02	0.15	0.34	0.1	1.1	0.7	0.3
Soft corals	0.02	-	0.02	-	-	0.3	-
Sponges	1.2	1.6	2.1	3.5	0.6	0.06	0.07
Seagrass	0.5	2.9	1.4	0.8	0.2	0.04	-
Macroalgae	3.4	5.7	5.2	5.7	18	16	2.1
Others	0.46	1.65	1.44	1.9	-	2.1	4.02
TOTAL	5.6	12	10.5	12	19.9	19.2	6.49

Among the living community itself, the abundance distribution showed macroalgae to be consistently dominant throughout all transects (Table 2). Other well represented groups were seagrass and sponges. Tunicates dominated the innermost transect after macroalgae but tapered off sharply in the remaining transects. Although hard corals were low in abundance, they were spatially distributed throughout all transects together with two other groups, macroalgae and

sponges. Anemones were confined to the 2 outer transects while seagrasses and zoanthids were absent there. In terms of group diversity, the inner transects appear to support a larger variety of life forms.

TABLE 2. Component lifeform percentages based on total living community cover.

Transect	A	B	C	D	E	F	G
Hard corals	0.36	1.16	3.67	0.92	5.8	0.6	11.7
Soft corals	0.36	0.01	0.18	0.04	-	2.7	-
Sponges	21.9	12.9	22.5	32	2.8	5.1	2.5
Tunicates	22	2.19	1.6	6.5	1.4	-	-
Zoanthids	4.5	15	-	0.69	-	1.56	-
Anemones	-	-	-	-	-	0.43	3.9
Seagrass	8.3	22.8	14.9	6.72	0.79	-	-
Macroalgae	61	45.8	57.2	53.1	89.2	89.6	81.9

DISCUSSION

In a previous study of the original reef crest and slope of the island complex (Chou, 1988), live coral cover ranged from 29.5 to 43.8% at 3 survey sites. The site nearest the present transects supported a hard coral cover of 29.5%, dead coral cover of 13.3%, algal cover of 13.5% and other fauna of 10.8%. The original reef community along the reef crest and slope continues to provide the larval source for the colonization of the lagoon. Colonization by macroalgae and seagrass is faster than the faunal groups. Of the faunal groups, sponges formed the fastest and most widespread colonizers. The abundance of macroalgae, seagrass and sponges was equivalent to other reef flats which were unaffected by any form of reclamation (Chou & Wong, 1985).

Colonization response of hard corals was slow, although not absent. Colonies were mainly small and of the massive growth form such as *Goniopora*, *Porites*, *Favites*, *Favia*, *Goniastrea* and *Platygyra*. The observation of hard corals growing in association with rocks indicate that a hard substratum was necessary for their colonization. This same observation has been made in deeper areas beyond the reef slope (Chou, 1986).

The results of this preliminary study give some indication of how reef communities respond to new sandy habitats inundated by a raised sea level. In discussions of sea-level rise, the question is often asked of its effect on coral reefs. Can fringing reefs eventually colonize new habitats submerged by sea level rise? Answers have not been definite, because the problem is complex and compounded by a large number of unknown variables such as erosion and sedimentation through increased storminess, rate of sea level rise, and interaction between newly submerged land and the sea.

Even in a simplistic scenario without these variables, it is not known whether reefs can in fact colonize such areas. Isolated studies on coral colony transplantation and laboratory-based experiments have so far not been conclusive and do not give any indication of how an entire reef community will respond. One way to study this is to look at areas submerged through land subsidence. Another is to examine areas which have been filled by sand but still remain submerged, representing a shallower zone that typifies many such areas when sea level rises. Man-made coastal lagoons are thus ideal for this kind of investigation and the results of such investigations can tell if and how reef communities will colonize such areas, and whether further management strategies are required to enhance colonization.

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