RECRUITMENT OF SCLERACTINIAN CORAL JUVENILES AND OTHER SESSILE ORGANISMS ON ARTIFICIAL SUBSTRATA

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The effectiveness of rubber tyres as a substrate for coral colonisation was studied by analysing the succession and percentage cover of coral species. Photographic monitoring was used to determine the species of coral occupying a particular area, and how much of the tyre it colonises. It was found that "Hydroids" were the dominant organism, followed by Sponges and other sessile organisms. There were also observable patterns of succession of each organism, where Sponges and Octocorals seem to thrive in June, while the other organisms seem to prefer cooler waters in December. No scleractinian corals were found and the percentage cover of organisms was lower than that of other substrates like concrete.

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INTRODUCTION

Artificial reefs are gaining in importance as they are seen to be the solution to the need of increasing fish population in the seas for consumption and also to preserve the ecology of marine life. Artificial reefs have been constructed with concrete (Esmero 1978), sunken vessels (Tsuda *et al.* 1975; Fricke *et al.* 1982; Wendt *et al.* 1989), ceramic tiles (Sutherland & Karlson 1977), smooth polyethylene (Goren 1975) and tyres (Alfieri 1975; Alcala *et al.* 1981; Gomez *et al.* 1982). Although many different substrates may support the growth of corals, only a few materials have shown great potential, concrete being one of them. Tyres gave satisfactory results and its feasibility was studied in the offshore islands of Singapore.

Monitoring colonisation patterns of artificial reefs include the extraction of segments of organisms on the tyre surfaces (Alfieri 1975; Esmero 1978; Goren 1975; Fricke *et al.* 1982); measurement by callipers and rulers of coral growth (Alcala *et al.* 1981; Gomez *et al.* 1982); removal of entire substrate to be examined in a laboratory and then replacing it into the sea (Sutherland & Karlson 1977); qualitative identification of colonising species (Tsuda *et al.* 1975); and the photographic sampling in addition to sample scrapes (Wendt *et al.* 1989).

MATERIALS AND METHODS

An artificial reef was constructed off Pulau Hantu, in the southern islands of Singapore on September 1989, consisting of 19 rubber tyre modules, however only modules 1, 4, 7, 8 and 9 were sampled. Each module was made from 12 subunits of three tyres each in a rough pyramidal shape. Close up colour slides, using a Nikonos V underwater camera system with a 28mm lens close-up unit, were taken for each module. The samplings were conducted in September 1991, December 1991, March 1992, June 1992 and December 1992. The slides were projected on a screen of a slide projector. A 23X16 point grid was designed on a transparency to be superimposed on the projected slides to determine the percentage cover of colonising organisms. At each of the 368 intersections of grid lines, the of organism observed at that spot was identified and classified into 5 general categories of Hydroids, Sponges, Ascidians, Algae and Octocorals. The percentage of uncolonised regions were also recorded. The raw counts were then converted to a percentage of the species' area covered on each slide and tabulated (Table 1).

RESULTS AND DISCUSSION

Analysis of the results show that Hydroids (Fig. 1a) were the most abundant colonisers of all the tyre modules (44%-90%), and their percentage cover over the period of observation was relatively consistent. The aggressive colonisation of Hydroids is probably due to the good grip which the tyre provides for the Hydroids the cling on to. The increased surface area provided by the grooves in the tyres gives additional area for colonising. However, there was a drop in percentage cover during the period of June 1992, compared to the high percentage recorded in March 1992 and December 1992. There were variation in the percentage cover in tyre modules 8 and 9 which display a greatly lower cover of Hydroids. This may be due to unsuitable sea conditions of temperature, salinity, siltation and currents. Competition from other organisms and predation are also possible causes.

The second most dominant species were Sponges (Fig. 1b) (7%-37%), suggesting that encrusting organisms tend to be more successful as colonisers, compared to Algae and Octocorals which grow vertically as soon as they achieve a foothold on the tyre. The percentage cover of the Sponges increased steadily over the duration of the sampling period until its peak in June 1992, when it dropped drastically in December 1992, coinciding with the increase in Hydroid cover. Competition from Hydroids may have caused the decline. Sponges may be in the secondary stage of succession of organisms on the tyres. There are also variations among the 5 tyre modules as tyre 7 had consistently low cover of Sponges, probably due to unfavourable conditions specific to that site location.

Ascidians (Fig. 1c) were a minor colonising species (0%-7%), with sporadic and dispersed occurrence, but they grow in clusters, which may in turn explain their low numbers due to the more aggressive colonisation methods of Hydroids and Sponges. Tyre 8 showed an extraordinarily large cover by Ascidians in September 1991, possibly due to the presence of ideal conditions for Ascidian growth or the lack of competition or predators.

Algae (Fig. 1d) were another minor colonising species (0%-3%) which occurred mostly at the start and end of the sample periods (ie. September 1991 and December 1992), and in lesser quantities in the period between. This may be due to the keen competition by succeeding species or predation during that time. There were almost no colonies of Algae in June 1992, indicating the probability of unsuitable conditions experienced then.

Octocorals (Fig. 1e) were also a minor coloniser (0%-16%) occurring in dispersed colonies. They were found in large clusters, sometimes occupying the whole slide, showing that they colonise aggressively after gaining a foothold on the tyre. This is evident in the few, but large records of Octocorals. There was a noticeable low percentage of Octocorals in December 1991, possibly due to competition or poor conditions for survival. Tyre 7 had exceptionally low colonies, most probably due to its location which exposes it to wave attack, which the Octocoral is especially vulnerable to, since they are very long as they grow upwards.

No Scleractinian coral juveniles were found growing on the tyres, suggesting the unsuitability of tyres as a substrate, thus other materials should be considered. However, there were scattered appearances of fishes and slugs which shows the biodiversity of the tyre reef habitat.

CONCLUSION

Rubber tyres are moderately good substrates for artificial reefs as they do encourage the colonisation of sessile organisms. However, they are not as good as other substrates, for example on concrete, where the 100% colonisation of the surface was observed. This was probably due to the toxicity of the processed rubber in tyres which may inhibit some organisms. Scleractinian corals were not observed to recruit successfully on the tyres, so other materials should be used.

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Table 1. Percentage cover of sessile organisms on 5 tyre modules at an artificial reef site.

		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Hydroid	Tyre 1	69	62.1	74.6	51.9	89.8
	Tyre 4	75.1	77.8	78.1	72.9	74.5
	Tyre 7	72.3	60.3	88.7	54.9	68.7
	Tyre 8	68.3	60.6	73.4	45.5	48.6
	Tyre 9	73.5	54.7	44.9	43.8	59.1

		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Sponge	Tyre 1	13.9	24.3	21.5	31.2	6.5
	Tyre 4	23	12.8	19.2	22.2	13.7
	Tyre 7	21.1	25.5	7.3	7	9.8
	Tyre 8	17.2	11.5	19.6	44	29.6
	Tyre 9	17.1	15	24.6	36.7	24.8

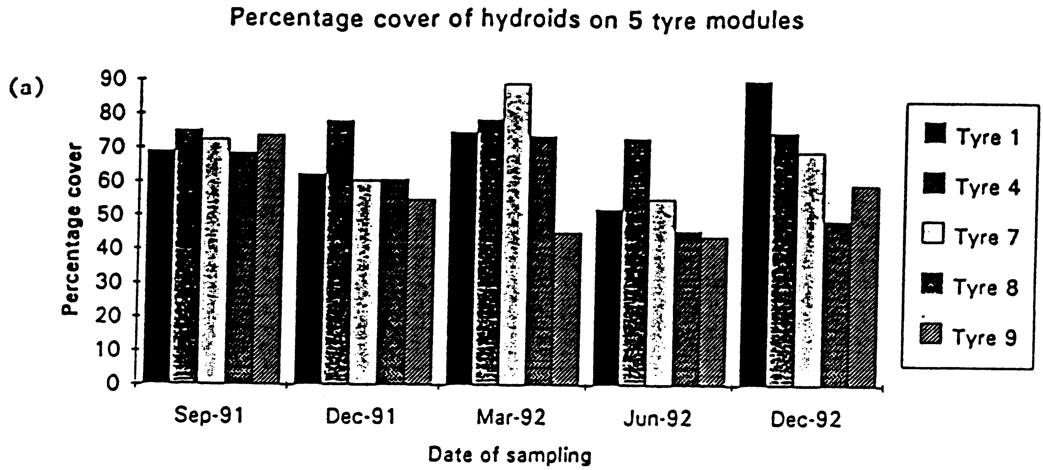
		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Ascidian	Tyre 1	0.2	2.3	1.3	0.3	0.1
	Tyre 4	0.1	0.7	0.3	0	1.4
	Tyre 7	0.1	0.3	0.4	0	0.5
	Tyre 8	6.9	0.1	0.2	0	0
	Tyre 9	0.5	0.3	0.1	0	0.1

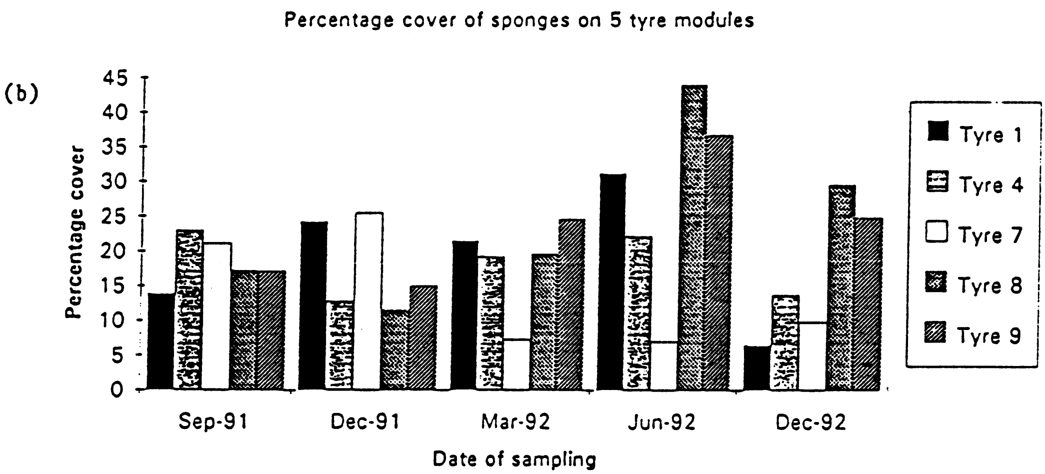
		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Algae	Tyre 1	2.5	0.5	0.1	0	2.5
	Tyre 4	0.1	0.3	0.5	0	1.5
	Tyre 7	0.7	0.9	0	0	0.6
	Tyre 8	0.3	0.1	0.5	0.1	2.3
	Tyre 9	0.2	0.3	0	0	2

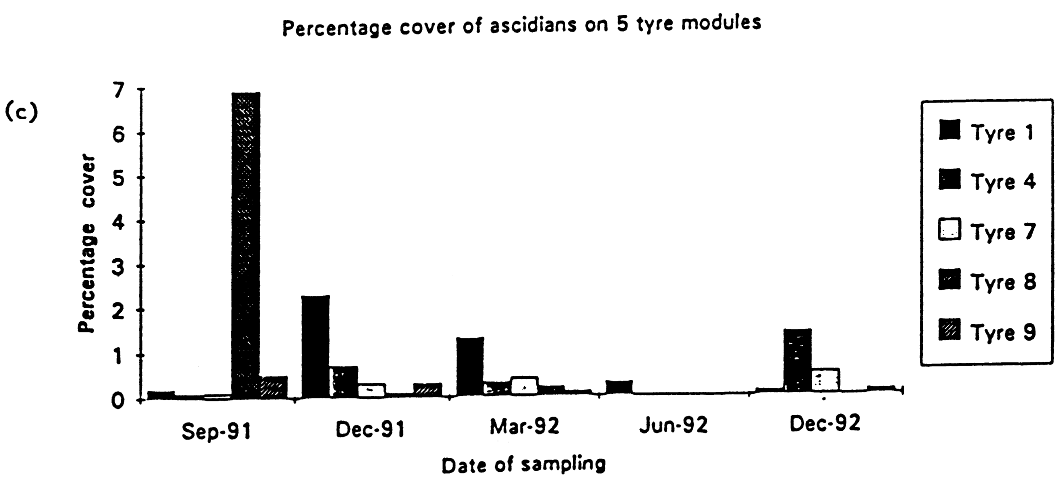
		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Octocoral	Tyre 1	14.2	0.1	1.5	1.6	0
	Tyre 4	0.3	0.1	0	0	2.7
	Tyre 7	0.1	0.4	0.1	0	0.2
	Tyre 8	2	0	0.1	0	12.1
	Tyre 9	0.2	0	8	16	0

		Sep-91	Dec-91	Mar-92	Jun-92	Dec-92
Uncolonise	Tyre 1	0	10.5	1.1	15	1.2
	Tyre 4	1.5	8.5	1.8	4.9	6.2
	Tyre 7	5.7	12.7	3.6	38.1	20.3
	Tyre 8	5.2	27.8	6.2	10.4	7.4
	Tyre 9	8.6	29.7	22.5	3.5	14

Fig.1 Bar charts showing the percentage cover of sessile organisms on 5 tyre modules at the artificial reef site.

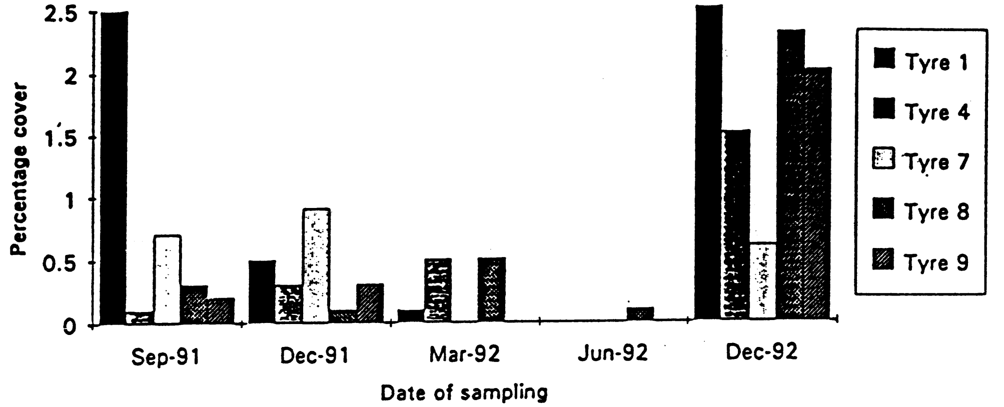






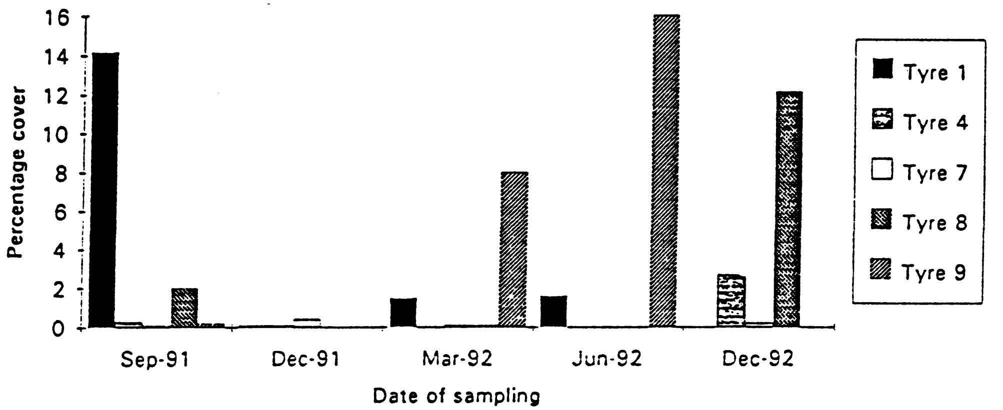
Percentage cover of algae on 5 tyre modules

(d)



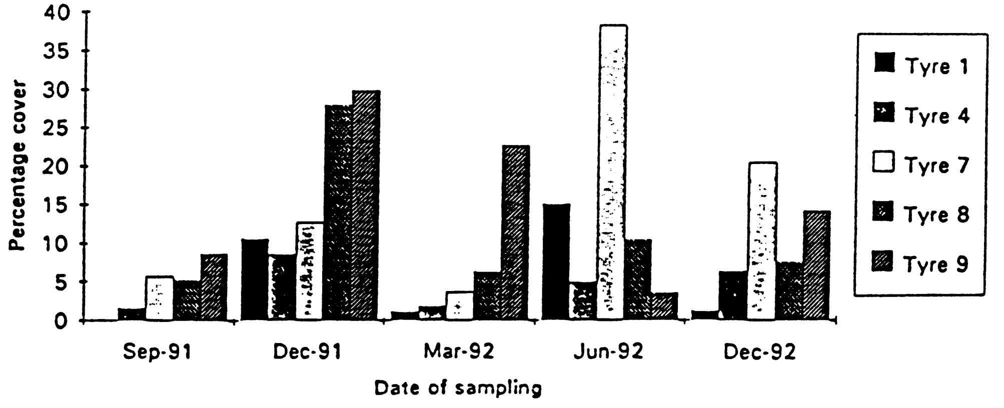
Percentage cover of octocorals on 5 tyre modules

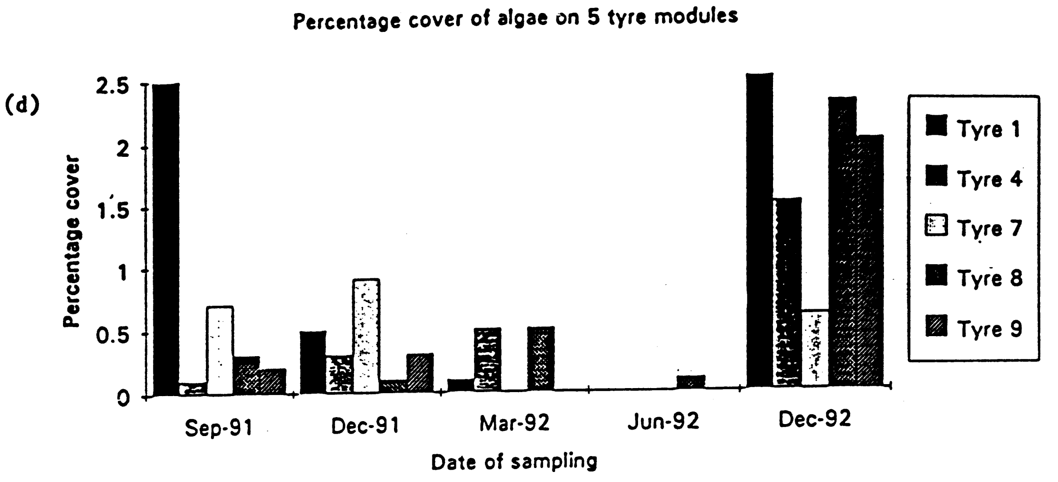
(e)

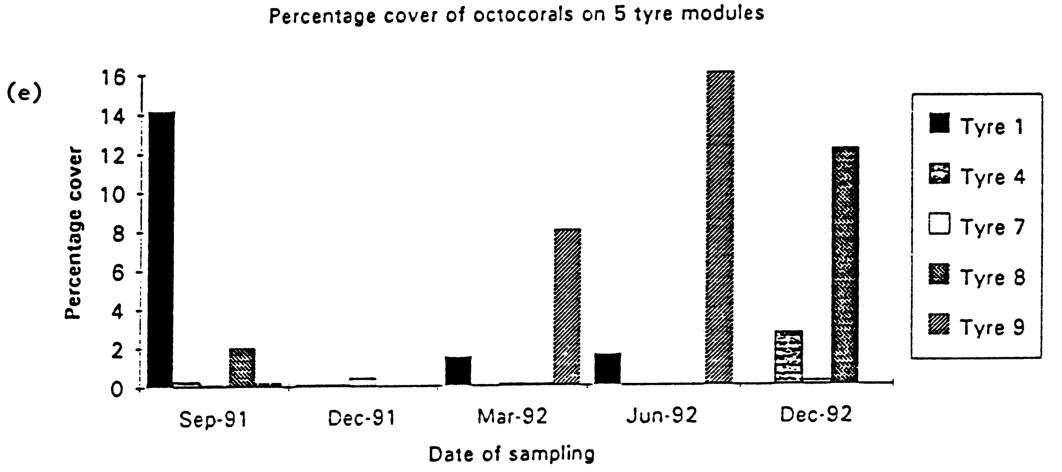


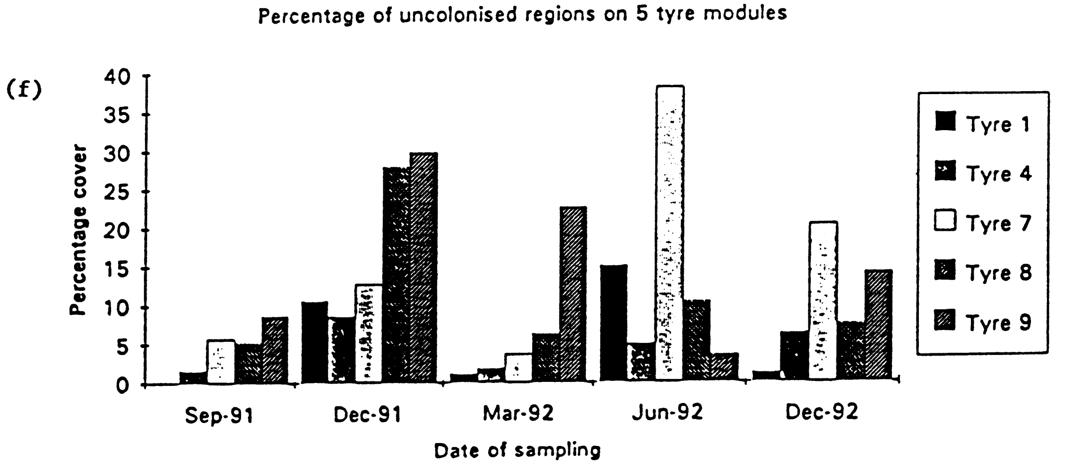
Percentage of uncolonised regions on 5 tyre modules

(f)




Percentage cover of algae on 5 tyre modules
(d)
Percentage cover
2.5
2
1.5
1
0.5
0
Sep-91
Dec-91
Mar-92
Jun-92
Dec-92
Date of sampling
Tyre 1
Tyre 4
Tyre 7
Tyre 8
Tyre 9


Percentage cover of octocorals on 5 tyre modules
(e)
Percentage cover
16
14
12
10
8
6
4
2
0
Sep-91
Dec-91
Mar-92
Jun-92
Dec-92
Date of sampling
Tyre 1
Tyre 4
Tyre 7
Tyre 8
Tyre 9


Percentage of uncolonised regions on 5 tyre modules
(f)
Percentage cover
40
35
30
25
20
15
10
5
0
Sep-91
Dec-91
Mar-92
Jun-92
Dec-92
Date of sampling
Tyre 1
Tyre 4
Tyre 7
Tyre 8
Tyre 9