Composition, Depth Distribution and Relative Abundance of Corals Colonizing the Artificial Reef Tire Modules in Dalipuga, Iligan City, Mindanao

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Abstract

Assessment of the coral community colonizing the 8 year old- artificial reef tire modules deployed at 8 to 27 m depth at Dalipuga, Iligan City, (Mindanao, Philippines) was done from November 1996 to January 1997 to serve as a baseline information on the colonization of artificial reefs as no previous studies had been done in the area. Twelve (12) coral families and nineteen (19) genera were observed in all the upright modules studied. Family Favidae was represented by the genus Favia, Favites, Montastrea and Goniastrea. More coral genera colonized the modules at 8 m (11) and 24 m depth (14) than at 24 m and 27 m depths. Dendronephthya had more colonies (20) followed by Favites (11), Favia (9) and Porites (9) in all the tire modules at all sampling depths. The hermatypic coral Fungia was observed in all modules at all sampling depths but with relatively few colonies.

Keywords: Antificial tire reef modules, corals, abundance, colonization

Introduction

Artificial reefs are structures installed primarily for the enhancement of benthic habitat for fishes and selected invertebrates and improve production of marine organisms in general thus, the ultimate goal in design is to replicate a coral reef. Ideally, this may only be attained after a period of several years with corals covering the reef (White et al., 1990). Fishes use artificial reefs for shelter, feeding, spawning, and orientation (Gooding et al, 1976; Hunter et al., 1967; Kakimoto et al., 1982; Kojima, 1956; Yoshimuda, 1982; Ogawa, 1982). Artificial reefs function by either aggregating existing scattered individuals, or by allowing secondary biomass production through increased survival and growth of new individuals because of shelter and food resources provided by the reef.

In the Philippines, artificial reefs had been installed since 1977 by various agencies such as the Bureau of Fisheries and Aquatic Resources, National Power Corporation, the academe, NGOs and LGUs that in 1995 about 70 000 modules were reported (Munro and Balgos, 1995) and since then additional modules were planned and installed.

The project on artificial reefs aimed to provide supplementary or alternative fishing

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grounds for small-scale fishermen and focuses on areas where natural coral reefs have been destroyed or do not exist (Miclat & Miclat, 1989).The artificial reef program also serves as a means for disseminating information on coastal resources management and conservation.

The most common materials for artificial reefs used are tires, concrete, old boats, bamboo and occasionally, discarded land vehicles. Old tires are by far the most common material used because of their availability at low cost, physical and chemical stability under water and ease of handling (White et al., 1990, Bohnsack & Sutherland, 1985). A drawback of tires, however, is their buoyancy which makes them vulnerable to wave action in shallow sites (White et al., 1990). Rubber tires gradually lose strength over time in the sea and little would remain after 40 years, especially when subjected to blast fishing and severe storms (Sato & Yoshioko, 1982).

In Iligan City and its vicinity, several artificial reefs were installed using low profile rubber tire modules. One of these areas is in sitio Mapalad, Barangay Dalipuga specifically the area fronting the Refractories Corporation of the Philippines. The ARs were installed on August 16, 1989 as part of the community project of the RCP in the barangay (Allan Badayos, pers. communication) and were deployed near the natural reef. The area is a favorite dive spot due to the luxuriant growth of corals in the natural reef and its accessibility.

As in the other sites in Iligan City, ARs were installed without prior assessment of the suitability of the deployment sites and since the deployment of ARs in the area no documented data on the assessment nor monitoring are available. As part of the Artifiicial Reef Project of MSU- IIT, this study was done to determine the colonization of the corals on rubber tires modules deployed in 1989 in Barangay Dalipuga as a baseline information and for future utilization in evaluating the success rate of ARs installed in the site.

This paper reports on the community structure specifically on the composition, depth distribution and relative abundance of corals on low profile rubber tire modules at depths of 8 to 27 m as determined through SCUBA.

Materials and Methods

Description of the study site

Barangay Dalipuga is situated 12.2 km north of Iligan City, bounded by Lugait, Misamis Oriental to the north, to the south by barangay Kiwalan, and to the west by the Iligan Bay (Fig. 1). The study area is approximately 8°16' North Latitude and 124° 15.2' East Longitude. The landmark of the study area was the circular cottage of the Mapalad Yatch Club beach house fronting the Refractories Corporation of the Philippines situated in sitio Mapalad of barangay Dalipuga, Iligan City. The seaward boundary of the area was about 107 m away from the shoreline. The study area has a total coverage of approximately 7,276 m^2.

Forty (40) tire modules were installed on the continental shelves, however, only fourteen (14) tire modules were found during repeated surveys and these were considered as the sampling units or stations in this study.

Description of the sampling unit

Each low profile tire module represented one sampling unit or a sampling station with each module consisting of pyramid of tires fixed by nylon ropes. The lone, biggest tire with a circumference of 1.28 m, served as the base (level 1) and three tires placed vertically on top of the base was level 2. A single tire placed horizontally represented level 3 and a single vertically-positioned tire served as level 4 (Fig. 2). The estimated total area of the sampling unit was 326.73 m^2.

Sampling methodology and frequency

Preliminary SCUBA dives were done prior to the actual sampling primarily to conduct an ocular inspection of the locations of the tire modules of the same age and to tag all the tire modules with a 12" X 12" white-painted plane GI sheet with number painted black and to connect the modules by a no.12 nylon rope in order to facilitate a more rapid search of all the modules during the actual sampling.

The survey sought to record as many corals as possible growing on tire modules of the same age, and since the tire modules were distantly-located from each other, a quadrat sampling method was not considered appropriate. Instead, each tire module was treated as one sampling unit or sampling station.

Assessment of each tire module was conducted only once and data collection was continuous until all the eleven (11) modules were surveyed. A 6"X6" slateboard printed with sampling date was tagged to the topmost tire of the module after assessment to prevent repeated or duplicated survey.

In each of the tire modules the following data were gathered:

a. Genus composition and depth distribution of corals

All live coral colonies in modules at different depth categories (8, 14, 24 and 27 m) were identified *in situ* and were recorded up to the genus level using the standard text used for the identification of corals by Nemenzo Sr. (1986). The illustrated book on Corals of Australia and the Indo-Pacific by Veron (1986) was used as a supplementary guide. Photographs of corals were prepared using Nikonos V 35 mm underwater camera with Nikonos SB-105 speed-light for further identification in the laboratory and documentation purposes.

b. Quantity of coral genus and relative abundance

The number of live colonies of a particular genus (abundance) was noted and the relative abundance of a coral genus (dominance based on number) was determined by the formula used by Bouchon (1980):

$$\text{Relative abundance of genus A} = \frac{\text{total no. of colonies of A}}{\text{total no. of colonies}} \times 100$$

c. Brillouin's index of total genus diversity

Genus diversity was based on Brillouin's Index of total genus diversity (HSG) (Pielou, 1974).

$$HSG = \frac{1}{N} \ln \frac{N!}{G_1!\,G_2! \ldots G_i!}$$

where:

N - total number of coral colonies
ln - normal logarithm
G - genera observed in module

d. Simpson's index of dominance in number

The Simpson's index of dominance (C) was used to compute for the dominance of coral genus based on number with respect to the sampling unit as:

$$C = \Sigma(n_i/N)^2$$

where:

n_i = total of live coral colonies of one genus

N = total of live coral colonies in one sampling unit

Results

There were forty (40) artificial reef tire modules of low profile deployed by the community in 1989 but only fourteen (14) were observed in the study area during repeated dives and these were either upright or toppled. The geographic locations of both the horizontal and toppled modules at Mapalad, Dalipuga artificial reef as determined using the Global Positioning System (GPS) is shown in Table 1 and its bathymetric map in Fig. 3.

Table 1. The location of the tire modules (upright, up; toppled, tp) at depths of 8-27 m in Mapalad, Dalipuga as determined by a GPS.

Depth (m)	No. of modules		Position			
	up	tp	North		East	
8	3	4	8°	19.310'	124°	14.790'
14	1	2	8°	19.317'	124°	14.788'
16		1	8°	19.307'	124°	14.779'
18		1	8°	19.287'	124°	14.761'
24	1	1	8°	19.340'	124°	14.775'
27	1	1	8°	19.348'	124°	14.740'

Genus composition and depth distribution of corals

For this paper, results are given only for the upright modules observed from 8 m to 27 m -depth. A total of 12 (twelve) coral families and nineteen (19) genera were identified in the six (6) upright tire modules deployed at sitio Mapalad, Dalipuga (Table 2).

Family Favidae was represented by four genera, namely *Favia, Favites, Montastrea* and *Goniastrea* while the other families had one or two representatives. Eleven genera were identified from the tire module at 8 m depth, 14 (fourteen) genera at 14 m depth, 3 (three) genera at 24 m depth and 6 (six) at 27 m depth (Table 3).

The result shows that genus richness was relatively higher (10.66 and 13.71, respectively) at intermediate depths (8 and 14 m) compared to the deeper portions (24 and 27 m), 3.13 and 5.6, respectively (Fig. 3).

The hermatypic coral *Fungia* was common to all tire modules at the four sampling depths while the other genera were found only at some depths. *Goniopora* was observed only at 8 meters, *Millepora, Goniastrea, Merulina* and *Diaseris* only at 14 m, *Leptoseris* only at 24 m while *Turbinaria* was observed only at 27 m. Our results also indicated that *Acropora, Favia, Favites, Montastrea, Pocillopora* and *Porites* were distributed only at intermediate depths (8 and 14 meters).

Quantity and relative abundance of coral colonies

At 8 m depth, *Favites* and *Montastrea* contributed to 5.7 and 5.5 colonies with a relative abundance of 18.08 % and 17.44 %, respectively, in a total of 31.53 colonies (42.31 % relative abundance) for all the tire modules studied (Table 4). In comparison more colonies and higher relative abundance (8 and 26.67 %) of *Dendronephthya* followed by *Favia* (16 %) were observed at 14 m depth. At 24 m depth *Fungia* and *Plerogyra* constituted 40 % of the total population. At 27 m depth *Dendronephthya* was also abundant with 8 colonies and contributing to 40 % of the total population observed at that depth followed by *Favites* and *Porites* each contributing to 15 % of the total population at that depth.

Although *Fungia* was found at all depths studied it contributed to at most two colonies per module or a total of 7 colonies while *Dendronephthya* had the most number of coral colonies (20) followed by *Favites* (11.7), *Favia* (9.5) and *Porites* (9) in all the tire modules at all sampling depths.

In summary, a total of 87.53 colonies were recorded in all the upright AR tire modules at all depths with the tire modules at 8- and 14- m depth showing similar number of coral colonies.

Table 2. Coral composition listed by family and genus as observed on upright tire modules at Mapalad, Dalipuga, Iligan City deployed at 8 to 27 m depth.

Family	Genus	Family	Genus
1. Pocilloporidae	*Pocillopora*	8. Faviidae	*Favia*
			Favites
2. Acroporidae	*Acropora*		*Montastrea*
	Montipora		*Goniastrea*
3. Poritidae	*Porites*	9. Caryophylliidae	*Plerogyra*
	Goniopora		
4. Agaraciidae	*Leptoseris*	10. Dendrophylliidae	*Turbinaria*
5. Oculinidae	*Galaxea*	11. Fungiidae	*Fungia*
			Diaseris
6. Merulinidae	*Merulina*	12. Milleporidae	*Millepora*
7. Pectinidae	*Pectinia*		

Table 3. The distribution of coral genera colonizing the artificial reef tire modules deployed at depths between 8-27 m at Mapalad, Dalipuga, Iligan City.

Genus	Depth (m)			
	8	14	24	27
Acropora	+	+		
Dendronephthya	+	+		+
Diaseris		+		
Favia	+	+		
Favites	+	+		
Fungia	+	+	+	+
Galaxea	+			+
Goniastrea		+		
Goniopora	+			
Leptoseris			+	
Merulina		+		
Millepora		+		
Montastrea	+	+		
Montipora	+			+
Pectinia		+		
Plerogyra		+	+	+
Pocillopora	+	+		
Porites	+	+		
Turbinaria				+
Total	11	14	3	6

+ - presence

Table 4. The average number of colonies and relative abundance (RA, %) of corals colonizing the artificial reef tire modules at Mapalad, Dalipuga deployed at depths between 8 -27 m. Data gathered from November 1996 to January 1997.

Genus	Depth (m)								
	8		14		24		27		
	No.	RA (%)	No.	RA (%)	No.	RA (%)	No.	RA (%)	Total no.
Acropora	1.5	4.76	1	3.33			1	5	3.5
Dendronephthya	4	12.69	8	26.67			8	40	20
Diaseris			1	3.33					1
Favia	4.5	14.27	5	16.67					9.5
Favites	5.7	18.08	3	10			3	15	11.5
Fungia	1	3.17	2	6.67	2	40	2	10	7
Galaxea	2	6.34							2
Goniastrea			1	3.33					1
Goniopora	2	6.34							2
Leptoseris					1	20			1
Merulina			1	3.33					1
Millepora			1	3.33					1
Montastrea	5.5	17.44	1	3.33					6.5
Montipora	1	3.17							1
Pectinia			1	3.33			1	5	2
Plerogyra			1	3.33	2	40			3
Pocillopora	1.33	4.22	2	6.67			2	10	4.5
Porites	3	9.52	3	10			3	15	9
Turbinaria							1	12.5	1
Total	31.53		31		5		20		87.53
Relative	42.31	100	40.25	100	6.71	100	10.73	100	

Based on the number of coral colonies observed, Brillouin's index of total genus diversity (HSG) was high on tire modules deployed at 8, 14 and 27 m depth (1.77, 1.86, and 1.34, respectively) and a low index at 24 m (0.68) (Table 5). With a high genus diversity a reduced dominance by one genus or an increased evenness or redundancy was observed.

Table 5. Indices of coral diversity and dominance in an artificial reef tire modules at Mapalad, Dalipuga

Depth (m)	Brillouin's Index of Diversity (H)	Simpson's Index of Dominance (C)
8	1.77	0.12
14	1.65	0.12
24	0.68	0.36
27	1.15	0.19

The low index of diversity at 24 m (0.68) was indicated by the extremely low number of coral genera (three) where two genera, *Fungia* and *Plerogyra*, constituted 80% of the total population (Table 5).

The degree to which dominance is concentrated in one, several, or many species can be expressed by an appropriate index of dominance (Simpson's) that sum each species' importance in relation to the community as a whole. At 8m, 14m and 27- m depth the tire modules were highly characterized by an incrèased evenness or redundancy of corals (Odum, 1971) and no coral genus based on the number of colonies constituted more than 50% of the total population. Simpson's Index of Dominance was relatively higher on tire modules at 24 m depth (0.36) with *Fungia* and *Plerogyra* compared to those from the other modules.

Discussion

Only very few assessement studies on coral colonization had been done on aritificial reef in the Philippines particularly in Mindanao and comparison could be made only with the early work on artificial reef off Dumaguete, Central Visayas (Gomez et al.,1982). Twenty (20) coral genera colonizing the low profile tire modules were observed by Gomez et al. (1982) at depths between 16-23 m with nine (9) genera as represented by *Acropora*, *Favia*, *Favites*, *Fungia*, *Millepora*, *Pectinia*, *Plerogyra*, *Pocillopora* and *Porites* observed also in our study at Dalipuga.

A very low index of similarity (Si = 0.36) was computed between Dumaguete and Mapalad artificial reefs. The differences in coral genera colonizing the rubber tire modules may be attributed to variations in the environmental and biological factors in the two areas influencing the recruitment of coral polyps on rubber tire substrates.

Adjacent to the artificial reef are coral assemblages growing on the natural reef with thirty - five (35) coral genera observed (Palarca, 1997 unpublished data) both at shallow and deep stations. Of the 19 coral genera identified in this study, 16 (84.21%) were found in the adjacent natural reef which include *Acropora* which is the dominant reef-building genus (Table 6).

The successful recruitment of coral polyps and the subsequent development of reefs depend to some extent on the proximity of source of coral larvae and that the placement of artificial structures near a natural reef is usually recommended to give a high probability of success rate for coral recruitment and colonization.

Table 6. Comparison of coral genera inhabiting the natural reef and colonizing artificial tire reef (AR) modules at Dalipuga, Iligan City and Dumaguete City

Genus	Dumaguete AR *	Dalipuga natural reef ***	Dalipuga AR ***
Acropora	+	+	+
Cyphastrea	+		
Dendrophyllia	+		
Dendronephthya		+	+
Favia	+	+	+
Favites	+	+	+
Fungia	+	+	+
Galarea		+	+
Goniastrea		+	+
Hydnophora	+		
Leptoria	+		
Leptoseris		+	+
Millepora	+	+	+
Merulina		+	+
Montastrea		+	+
Montipora		+	+
Pavona	+		
Pectinia	+	+	+
Platygyra	+		
Plerogyra	+	+	+
Pocillopora	+	+	+
Porites	+	+	+
Psammocora	+		
Seriatopora	+		
Symphyllia	+		
Stylophora	+		
Turbinaria		+	+
Tubipora	+		

* Gomez et al., 1982 ** Palarca, 1997 (unpubl) *** This report

Corals are known to grow favorably at shallower depth than at deeper portion and in our study more coral general were observed at intermediate depths. Similarly a study conducted by Jackson (1991) revealed that the average number of coral species per quadrat or transect is greatest at intermediate depths and the total number of coral species recorded from different reefs decreases with depth. The differences in the composition and distribution of corals colonizing the tire modules may be due to depth as influenced also by light quality and quantity. Genus richness which was relatively higher in shallower portions may be accounted to the positive synergistic effects of light availability, water motion and grazing pressure on coral recruitment and growth.

Decreased light intensity at deeper portions, among other factors, apparently limits coral recruitment and in the study area the Secchi depth was measured at 17 m (Responte & Apao, unpublished data). Studies have shown that calcification rates proceed much faster in light than in darkness affecting the growth rates of corals and a decline in growth rate with increasing depth (e.g. Goreau and Goreau, 1959). All these supported the findings of this present research where corals were least abundant at greater depths (24 and 27 m).

Leptoseris together with *Acropora* and *Favites* are classified as "deep water" genera (Bouchon, 1981) which we observed at intermediate depths (14-24 m). On the other hand, genera not adapted to ecological conditions of the reef like intense illumination are *Turbinaria* and *Leptoseris* which were observed only at 24 and 27 m, respectively. *Favia* and *Goniastrea* are species typical of wave-exposed areas (Bouchon, 1981) and presumably, these coral genera were photophilic corals and were tolerant to wave-exposed areas.

As a conclusion based on these results presented artificial reefs out of discarded rubber tires support coral recruitment similar to those found on natural reefs and colonization are influenced by the same factors affecting the natural assemblages such as depth and light availability. Other factors could have affected the coral colonization but these have to be studied further especially in this area of study.

Acknowledgment

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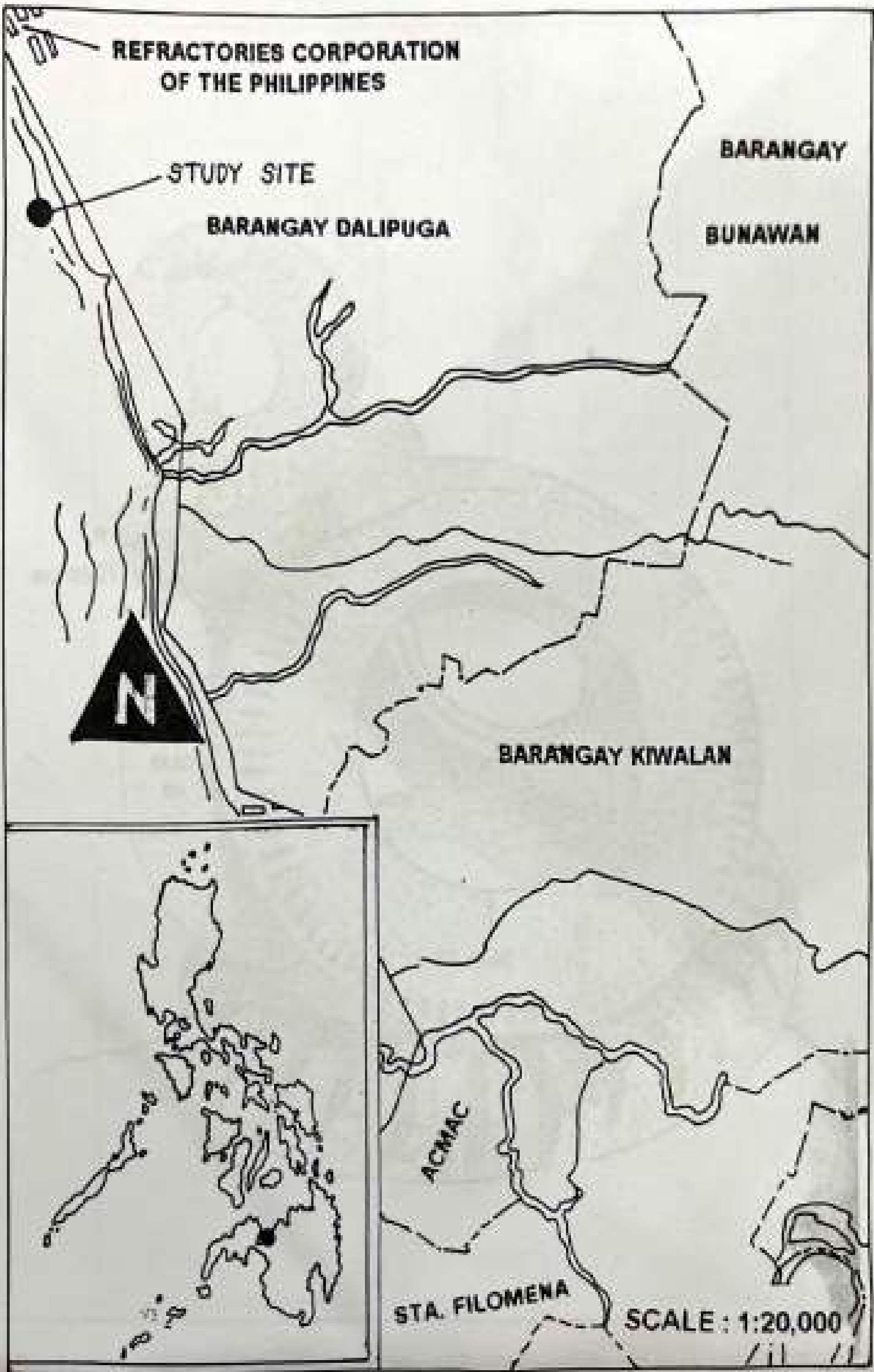


Figure 1. Location of the study site in Mindanao, Philippines.

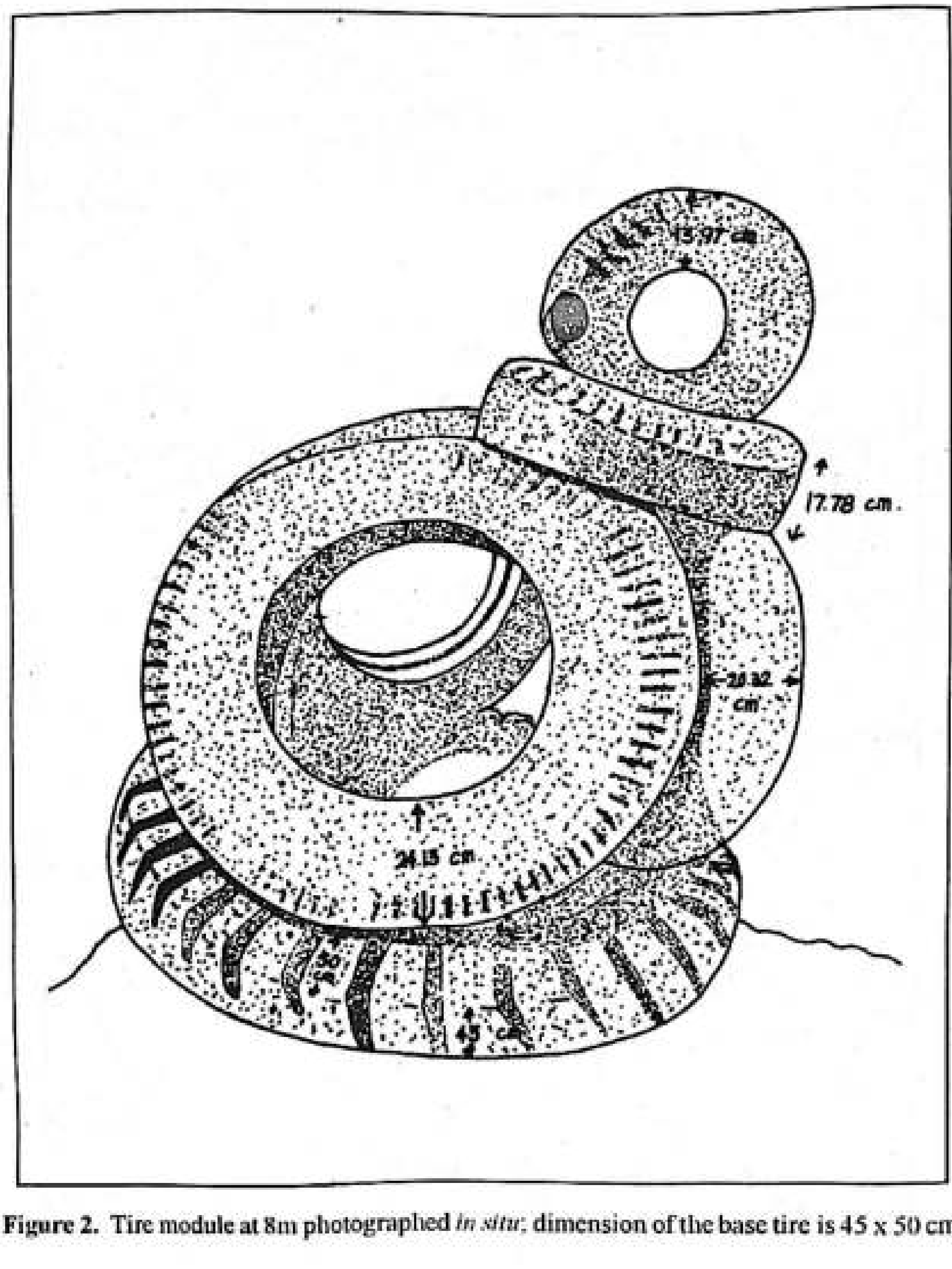


Figure 2. Tire module at 8m photographed *in situ*; dimension of the base tire is 45 x 50 cm.

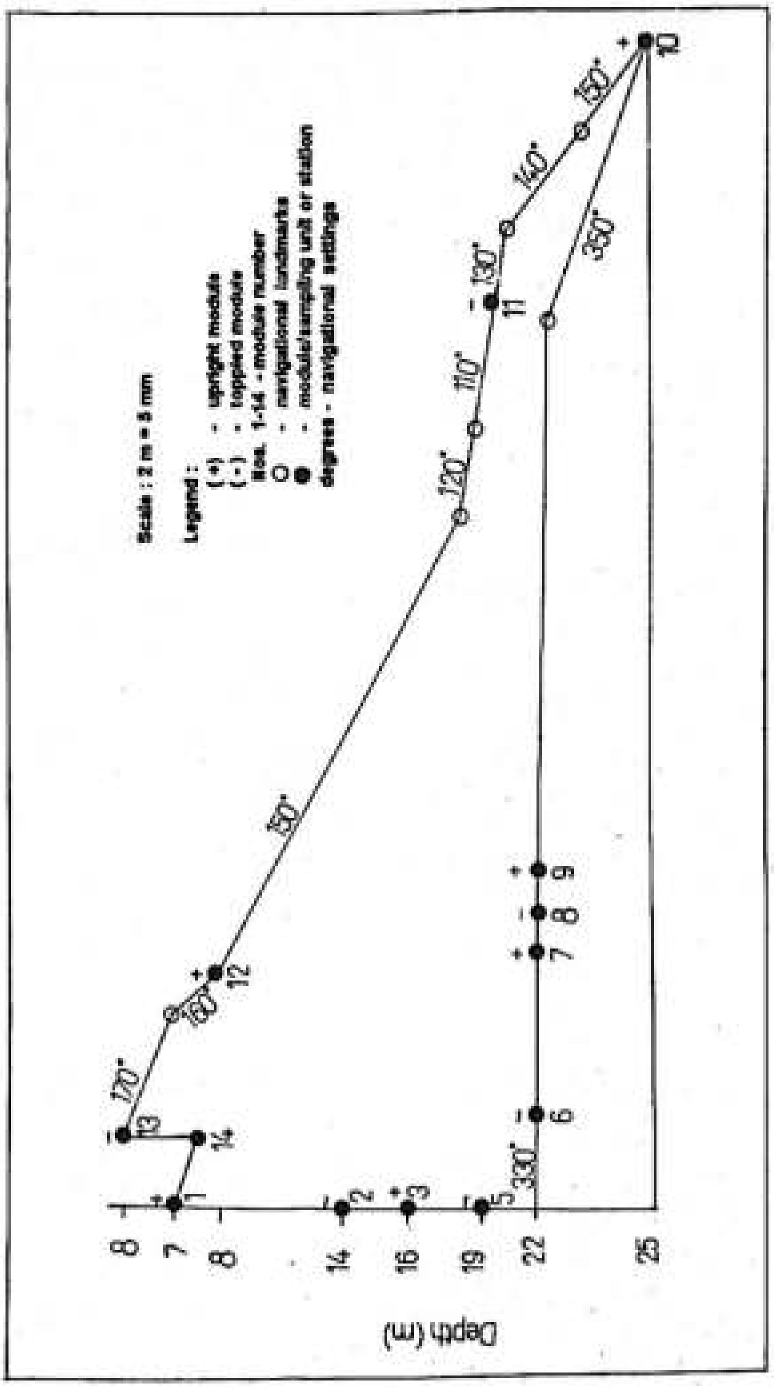


Figure 3. Bathymetric map showing the strategic locations and orientation of the fourteen (14) tire modules deployed between 8-27m depth. The upright (+) and toppled (-) modules are designated.

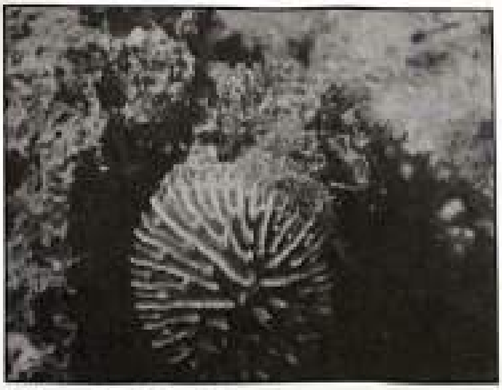


Plate 6A. Fungia sp.

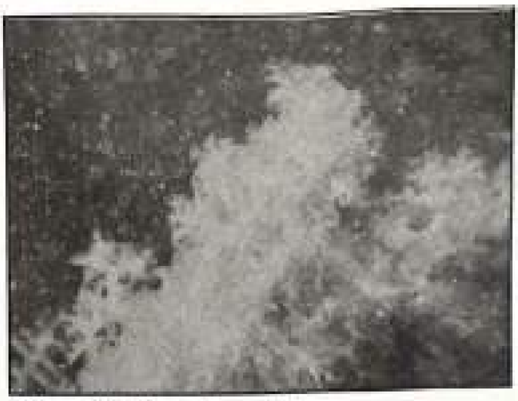


Plate 6B. Dendronephthya sp.

Plate 6C. Porites sp.

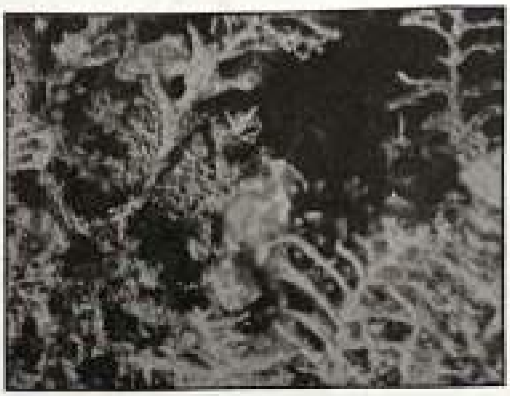
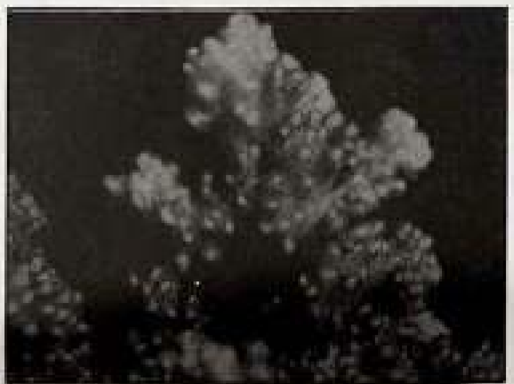


Plate 6D. Pectinia sp.



Place 6E. Pocillopora sp.

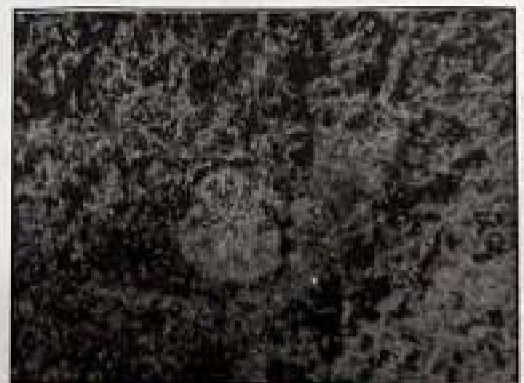


Plate 6F. Diaseris sp.

Plate 6A-F. Corals on artificial tire reef photographed in situ.

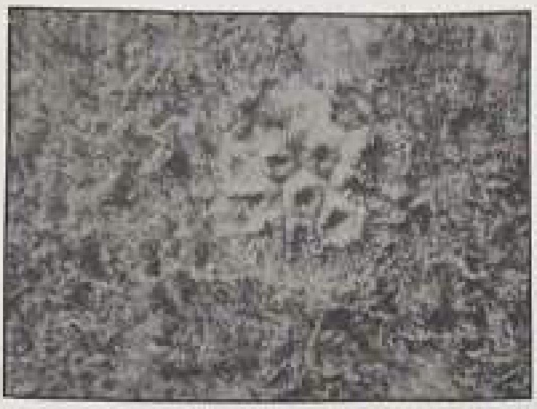


Plate 6G.. Montastrea sp.

Plate 6H. Favia sp

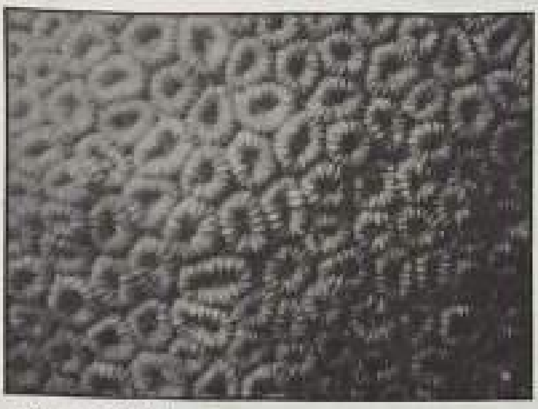


Plate 6I. Favia sp.

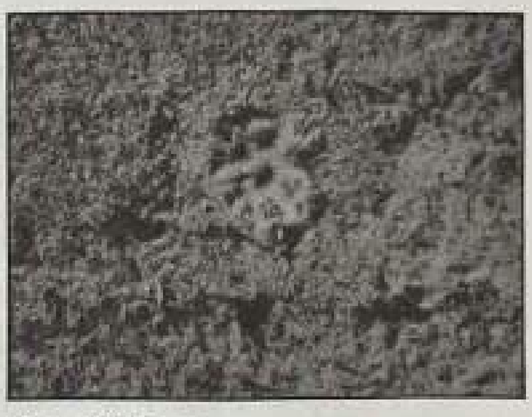


Plate 6J. Favites sp.

Place 6K. Favites sp.

Plate 6L. Favites sp.

Plate 6G-L. Corals on artificial tire reef photographed in situ.

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