Colonization of fouling communities and associated fauna at artificial reefs in Ranong Province, Thailand

by

Niphon Phongsuwan
Hansa Chansang
Ukkrit Satapoomin

Phuket Marine Biological Centre,
Phuket, Thailand

4. *INTRODUCTION*

An artificial reef (AR) is a device installed to provide a habitat for marine life, resulting in new fishing grounds for small-scale fisheries and sport fishing. The sessile benthic organisms colonizing reef structures can be a major source of food supply. High densities of benthic organisms have formed on artificial reefs and have been reported (Woodhead and Jacobson, 1985; Carter *et al.,* 1985). Bohnsack and Sutherland (1985) concluded that artificial reefs either aggregate existing scattered fish or allow secondary biomass production through increased survival and growth of new individuals as a result of the shelter and food resources provided by the AR.

From the time artificial reefs were established in 1978 in Thai waters, most of the studies concerned abundance of fish population relating to fishing effort. Information on benthic organisms on reef modules was presented mainly as general descriptions. The purpose of this paper is to describe the community composition and abundance of benthic organisms on reef modules after their installation three years ago in Ranong Province and to demonstrate the importance of the reef as a source of food for fish and other economic marine fauna.

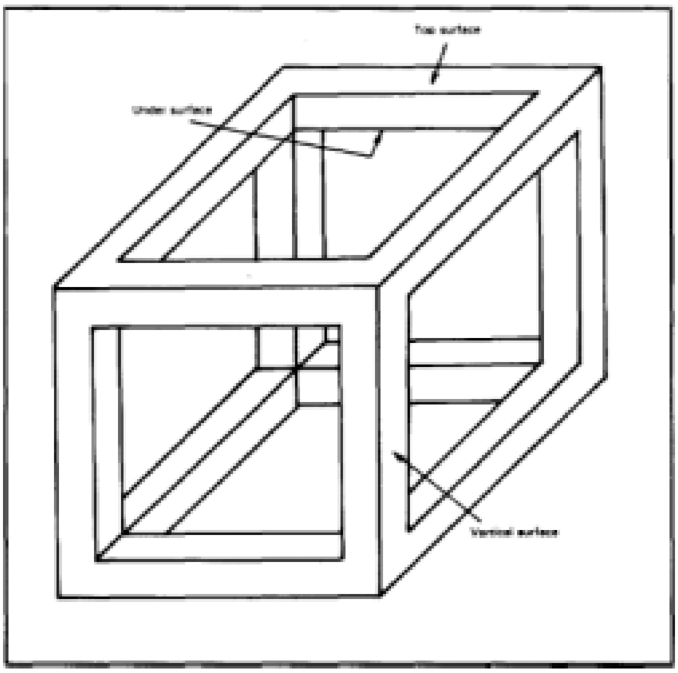
5. *METHODOLOGY*

5.1 *Study site and reef structure*

AR3 was chosen for study, as the other two ARs did not permit underwater investigations because of high turbidity.

5.2 *Sampling methods*

Fig 11. Diagram showing a concrete module with the positions of sampling plots designed into three categories: top surface, under surface and vertical surface



Sessile organisms on the concrete surfaces were collected by scraping the sampling plots (20 cm x 60 cm) with axes or knives. Positions of the sampling plots were categorized as **(1) top surface, (2) under** surface, and (3) vertical surface (Figure 11). Sampling was done in February 1992, December 1992 and April 1993 (hereafter referred to as the first, second and third surveys respectively).

In the first survey, six samples from each were collected from the top and under surfaces and ten samples from the vertical surface; in the second survey, 11 samples each, from the under and vertical surfaces, and ten from the top surface were collected; and in the third survey, ten samples each, from the top and under surfaces, and 11 samples from the vertical surface were collected. Samples were preserved in ten per cent formalin before sorting in the laboratory. Biomass (dry weight) of each taxa was examined. With the exception of tiny organisms, *i.e.* tube polychaete and bryozoa, it was not possible to separate those cemented on substrates, such as on mollusc shells. Thus, their weight was not calculated, but were included as the weight of such faunal substrate instead. The small cryptic fauna, which contributed low weight but were defined here as important food sources of reef fishes, *i.e.* crabs, shrimps, brittle stars and polychaetes, could not be weighed either. However, a number of individuals were analyzed from the samples obtained during the second and third surveys.

In order to observe the initial stage of fouling organism formation, in December 1992, ***155*** plexiglass plates, each of 10 x 10 cm, were tied securely on the concrete surfaces in two sets, *i.e.* horizontal (top) and vertical surface. The plates were collected in April 1993.

Six hundred and eight (608) plexiglass plates had also been placed in February 1992 to study the seasonal differences in settlement rate of sessile organisms. However, it was not possible to retrieve the first batch during the second and third trips. Thus, only the dry season settings (December-April period) were available for evaluation.

In the laboratory, organisms encrusting on the inner side of the plates were removed before examining biomass of organisms on the exposed side. Area cover of the organisms on the plates was also estimated by measurement..

6. *FINDINGS*

6.1 *Physical description of the artificial reef*

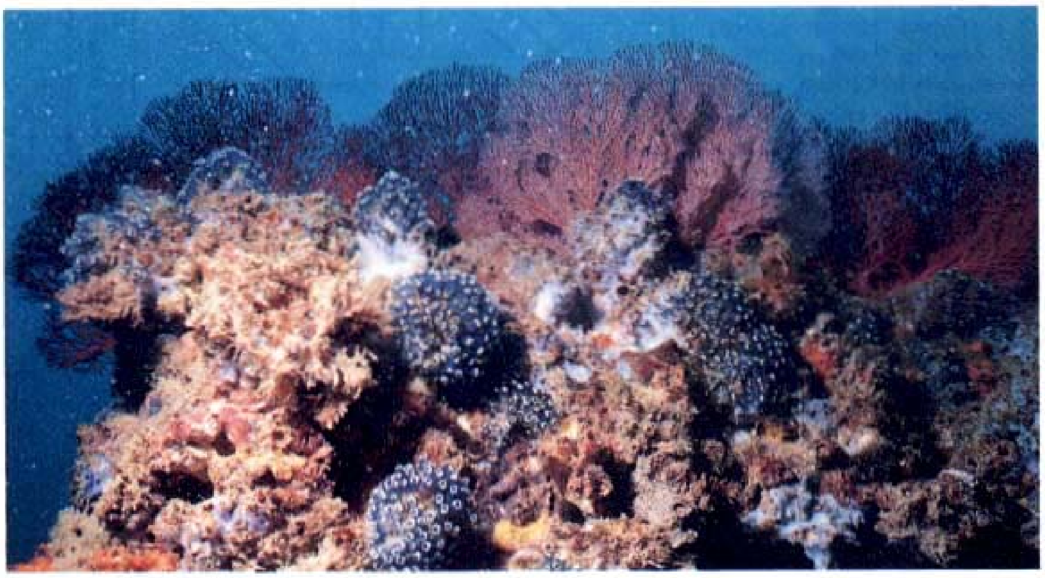
Although the reef was designed to form a belt of 2 x 2 x 2 m cubes spaced im apart, the modules settled on the bottom haphazardly. There were no clearly defined boundaries. At the sample collecting site, the concrete modules of 2 x 2 x 2m size were scattered and distributed in clusters. Generally, they lay ***2-5*** m apart from each other. In certain areas, modules were piled one upon the other. The base of the structure was sometimes buried in the sandy bottom.

Observations in a wider area showed that the concrete modules of 1 x 1 x 1 m size were further apart from each other than planned. The organisms on such modules were generally the same as on the larger modules. The modules of both sizes were generally stable. Only one of them had collapsed.

6.2 *Fouling organisms and associated fauna*

Figure 12 shows the general scenery at the modules with encrusting organisms.

Fig 12. General scenery at a concrete module with fouling organisms (at AR3)



The sessile organisms on the concrete structures included invertebrates of seven phyla, namely Porifera, Coelenterata, Annelida, Mollusca, Echinodermata, Arthopoda and Chordata. Their biomass varied in different positions and in different years (see Figures 13, 14 and 15 on facing page).

Fig 13. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules in February 1992

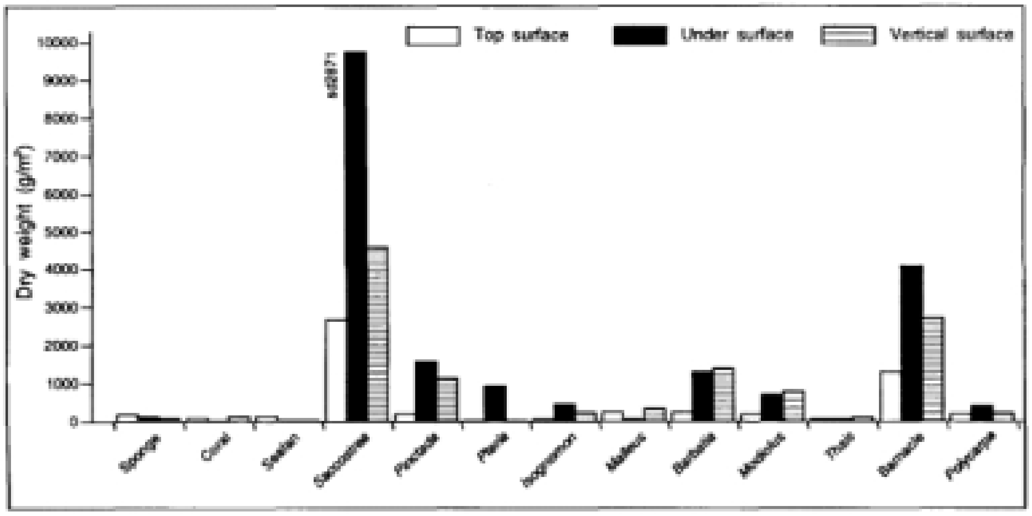


Fig 14. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules in December 1992

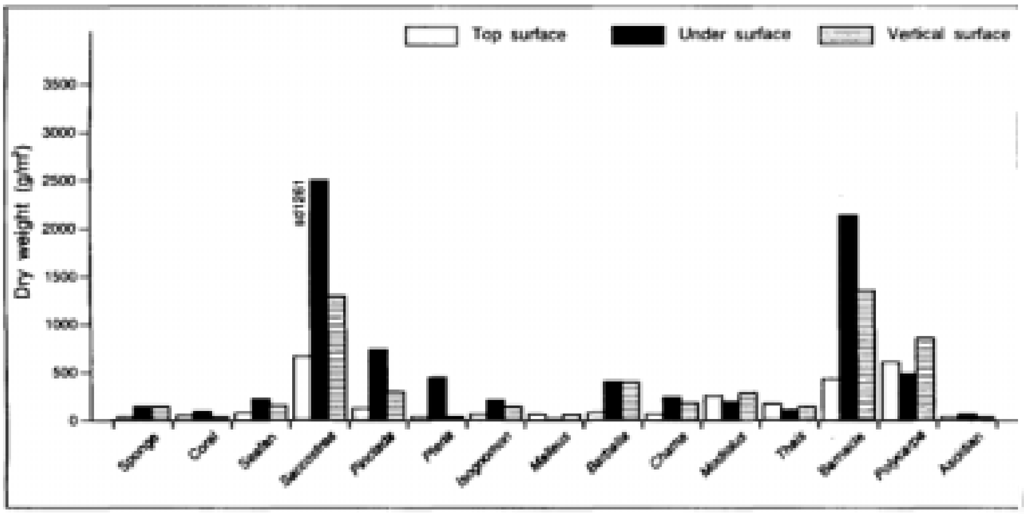
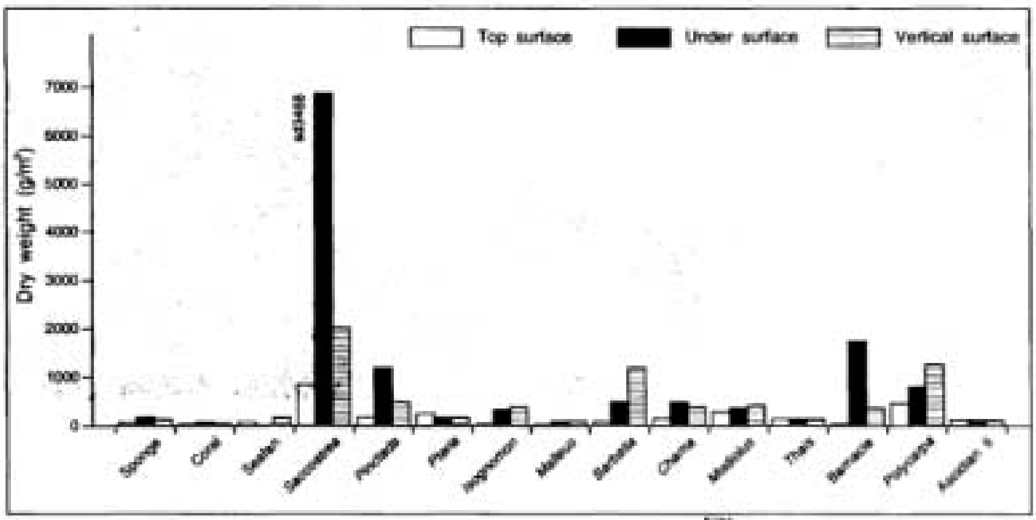


Fig 15. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules in April 1993



This reflects the fluctuation of the average biomass of total organisms (Figure 16). The molluscs of the family Ostreidae, *Saccostrea,* were the most abundant group. They were the major contributors to the reef structure and were mainly responsible for influencing a change of total biomass. The next most abundant groups after *Saccostrea* were barnacle *(Balanus* sp.), molluscs of genera *Pinctada, Barbatia, Modiolus* and *Pteria,* and ascidian *(Polycarpa* sp.). Sponges were sometimes found in abundance. However, their dry weight was negligible.

Among the small cryptic fauna, the most abundant groups included polychaetes *(e.g.,* families Eunicidae, Phyllodocidae, Lumbrineridae, Polyodonidae, Nereididae, Flabelligeridae and Syllidae), crab *(e.g.,* families Portunidae, Xanthidae, Majidae, Porcellanidae and Calappidae), shrimp (Infraorder Caridea), brittle stars (family Ophiotrichidae: *Ophiothrix martensi;* family Ophiactidae: *Ophiactis savignyi)* and isopod (family Cirolanidae: *Cirolana* sp.). Figures 17 and 18 show the number of individuals of the abundant groups found at different positions on the reef modules and in different years. The rare groups recorded were holothurian, sea urchin, limpet, nudibranch, gastropod *(Thais* sp., *Cryprae* spp., *Tridacna,* cerithid), scallop, squid and young fish.

Fig 16. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules during the three surveys

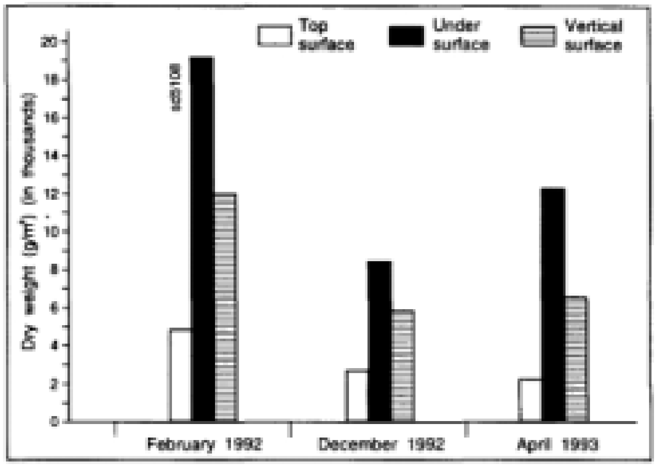


Fig 17. Number of individuals of the cryptic fauna (excluding Brittle star) associated on different surfaces of the concrete modules in December 1992

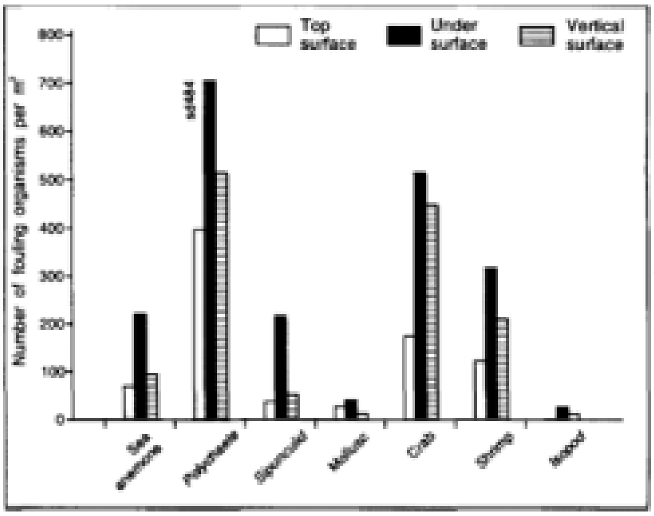
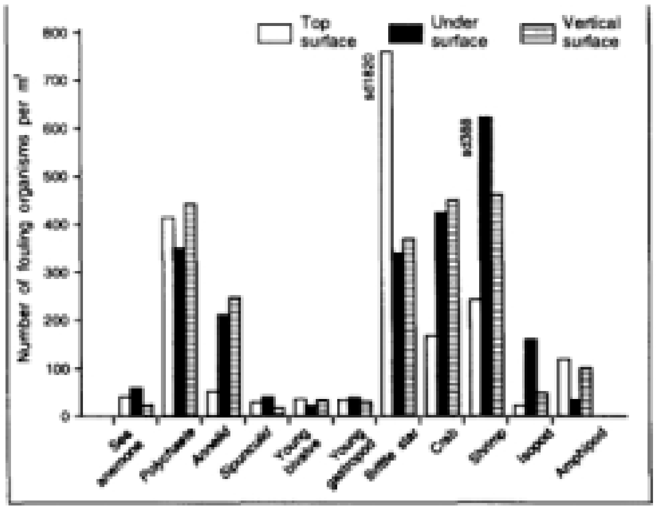
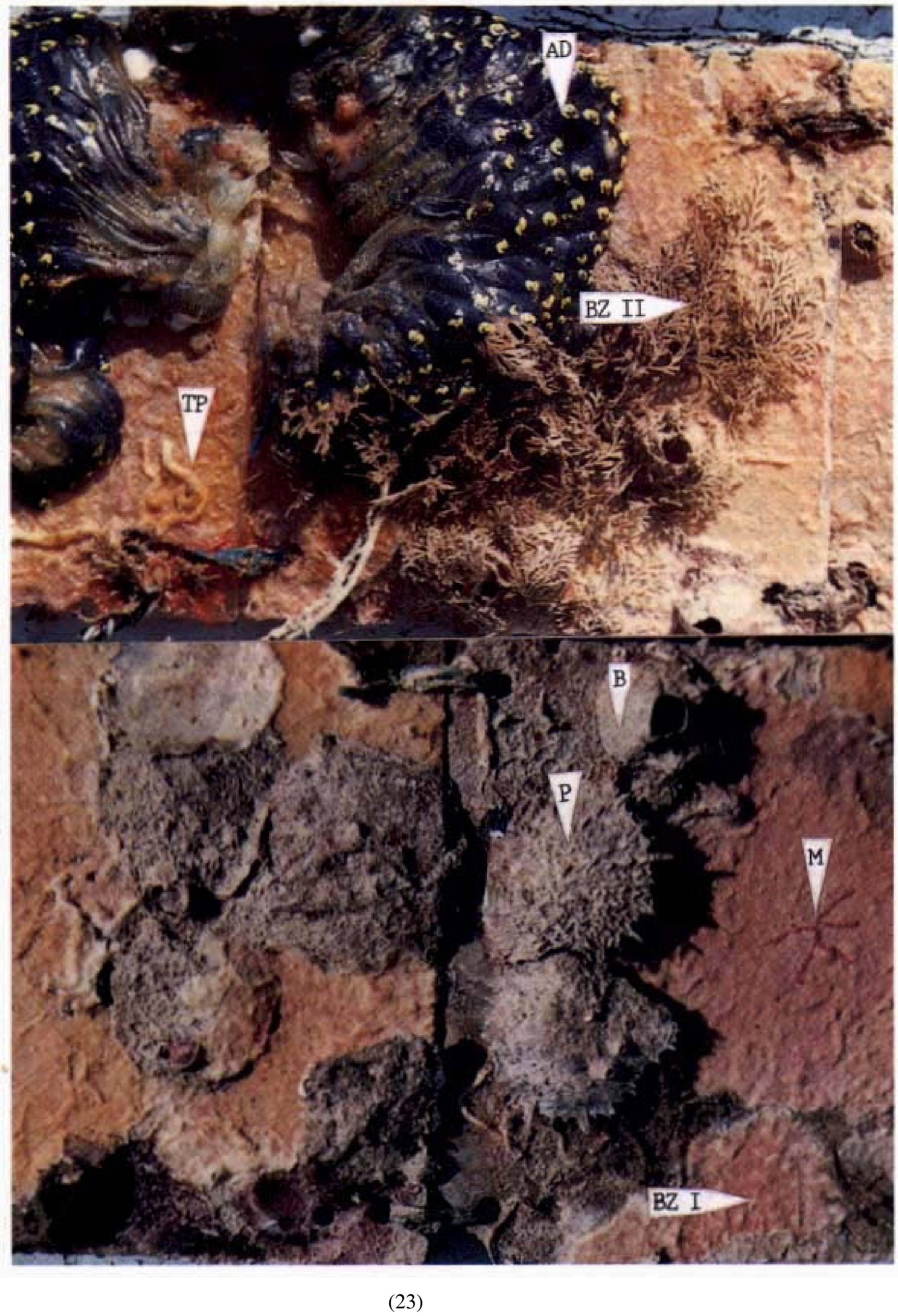


Fig 18. Number of individuals of the cryptic fauna associated on different surfaces of the concrete modules in April 1993



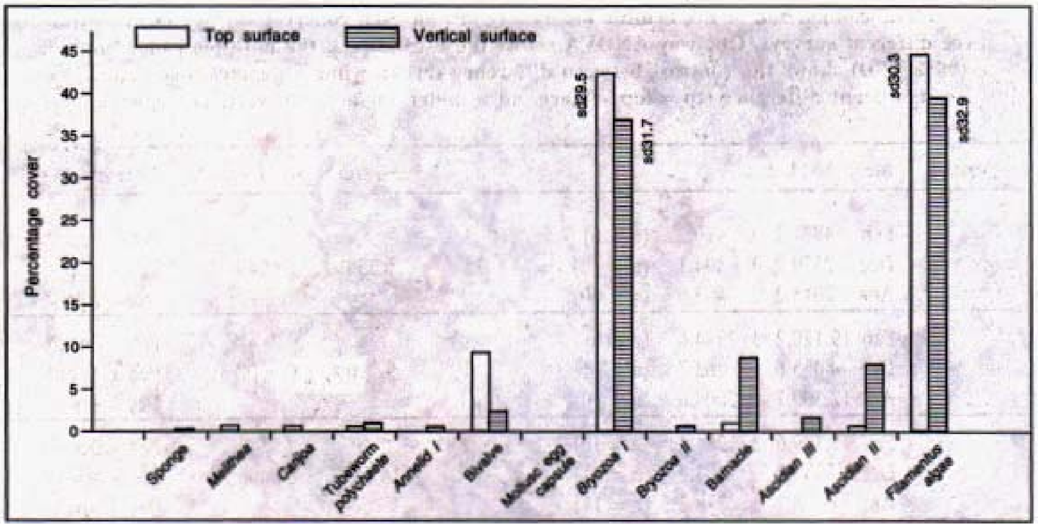
The experiment on the plexiglass plates revealed the early stages of organism-development on the new substrate. Figure 19 shows the general appearance of fouling organisms on the plate.

Fig 19. General appearance of fouling organisms growing on plexiglass plates which had been on the concrete modules for four months. (AD = ascidian type II; B = *Balanus* sp.; BZ I = bryozoa type I; BZ II = bryozoa type II; TP = tube polychaete; M = juvenile *Melithea* sp.; P = *Pinctada sp.)*



The total biomass of the organisms on the horizontal plates was 661 ±sd601 g/m2. There was no significant difference between biomass on horizontal and vertical plates. A thin cover of filamentous algae and encrusting bryozoa (type 1) accounted for the highest average of total cover, *i.e.* 42.1 ±sd31.8% and 40.0 ±sd30.8% respectively (Figure 20).

Fig 20. Percentage cover of the fouling organisms found on the settling plates which were attached on the top and vertical surfaces of the concrete modules for a four-month period



The densities of epifauna on the sandy bottom inside the concrete frames varied among the modules. As shown in Figure 21, they tended to form along the frames. Under modules piling together, the density was greater than in the case of single-layer modules. They were the same groups as found on the concrete surfaces, but with the addition of *Pinna. bicolor,* such predators as gastropods *(Conus* sp., *Murex djariaensis poppei, Trachycardium mode* and *Chichoreus ramosa),* sea star *(Pentaceraster* sp.) and crab *(Charybdis* sp.)

Fig 21. Formation of benthic organisms on sandy bottom inside the module frame

7. CONCLUSIONS

A comparison of the biomass at each collecting position, in different years, with the statistic test (one-way ANOVA) shows a significant difference between the biomass of the organisms of the first and second surveys, but no significant difference between those in the second and third surveys (Table *5).*

Table 5: The comparison of the benthic biomass (g/m^2) on each concrete surface position' during three different surveys. One-way ANOVA shows the F-ratio, and the multiple range analysis (95% LSD) shows the contrast between different surveys, while * denotes a statistically significant difference (tp = top surface, ud = under surface, v = vertical surface).

Position	Mean ± std. error	d.f	F-ratio	Sig. level	Contrast
tp	Feb 4771.2 ±970.2 (n = 6)	25	6.759	0.0049	Feb - Dec *
	Dec 2539.2 ±304.1 (n = 10)				Feb - Apr *
	Apr 2015.2 ±403.0 (n = 10)				Dec - Apr
ud	Feb 19,120.2 ±2284.6 (n = 6)	26	9.790	0.0008	Feb - Dec *
	Dec 8065.6 ±763.7 (n = 11)				Feb - Apr *
	Apr 12,300.7 ±2004.6 (n = 10)				Dec - Apr
v	Feb 11,739.6 ±1284.3 (n = 10)	31	14.587	0.0000	Feb - Dec *
	Dec 5336.0 ±483.0 (n = 11)				Feb - Apr *
	Apr 6438.2 ±778.2 (n = 11)				Dec - Apr

There is no satisfactory explanation, as the site of the first survey could not be subsequently located, even though it was in the same vicinity. The sessile organisms could have reached an equilibrium after three years. The fluctuation, especially on the under and vertical surfaces, may be due to overweight of the aggregated mass, causing it to collapse and drop to the sea floor; a lot of organisms (especially oysters) were observed lying on the bottom, inside the reef modules. Nevertheless, it does not mean that the communities have reached mature stages.

From general visual observation, the population of octocoral *(Carijoa* sp. and *Melithea* sp.) and blue ascidian (Type II: unidentified bouquet-like species) appeared to be much denser in the second and third surveys than in the first survey. Lasker (1988) reported that octocorals exhibit a particularly great range of mechanisms of vegetative propagation. Ascidians also increase their population rapidly, as they have short-lived larvae that often settle immediately after release from the parent (Hurlbut, 1988).

These special biological characteristics caused the explosive growth of octocorals and ascidians. It can be concluded that the octocoral and ascidian population might grow denser in future, as a lot of young individuals were observed on the plexiglass plates and on natural substrates such as mollusc shell fragments at the site.

When comparing biomass on concrete surfaces at different positions in each survey, there were statistical differences (one-way ANOVA) between the positions (Table 6, see page 26). It was obvious that the biomass on the under surface was greater than on the vertical and top surfaces. This indicated a lower chance of survival of the juveniles of the fouling organisms on the top surface, where sedimentation and grazing pressure are higher than on the under or vertical surface.

The experiment on plexiglass plates revealed the initial stage in the formation of this complex system. The common groups found, *i.e.* oysters, barnacles, tube worms and bryozoa, are those that Bailey-Brock (1989) and Ardizzone *et a*l. (1989) reported in temperate and subtropical waters. In general, thin-layered filamentous algae was the first organism occupying the space (Chansang *et al.* 1987). Carlisle *et al.* (1964) and Turner *et al.* (1969) (cited in Carter *et al.,* 1985) described the first-year succession of benthic organisms as being the same group *(i.e.* barnacle, mollusc and ascidian) as in this study. Osman (1982) and Buckley *et al.* (1985) stated that barnacle tests on

Table 6: The comparison of the benthic biomass (g/m^2) found on different positions of the concrete surfaces in each of the three surveys. One-way ANOVA shows the F-ratio, and the multiple range analysis (95% LSD) shows the contrast between biomass at the different times of the survey, while * denotes a statistically significant difference (tp = top surface, ud = under surface, v = vertical surface).

Survey date	*Position*	*Mean ±std. error*	*d.f*	*F-ratio*	*Sig. level*	*Contrast*
	tp	*4771.7 ± 970.1 (n = 6)*				*ud - tp* *
Feb	*ud*	*19,196.6 ±2284.2 (n = 6)*	*21*	*17.586*	*0.0000*	*ud - v* *
	v	11,741.5 ±1283.9 (n = 10)				tp - v *
	tp	2539.2 ± 763.7 (n = 10)				ud - tp *
Dec	ud	8065.6 ± 763.7 (n = 11)	31	23.645	0.0000	ud - v *
	v	5336.0 ± 483.0 (n = 11)				tp - v *
	tp	2015.0 ± 403.0 (n = 10)				ud - tp *
Apr	ud	12,300.0 ±2004.6 (n = 10)	30	16.837	0.0000	ud - v *
	v	6438.2 ± 778.2 (n = 11)				tp - v *

substrate provided microhabitat, then increased the colonization rate of other organisms, such as algae, leading to increased colonization of shrimp and crab.

When considering the biomass at the initial stage and at three years of age, it may be inferred that the biomass increases more or less at a stable rate. If this is true, the biomass in the first six months should be 991 ±sd901/m^2 on the upper horizontal plates or 1167 ±sd870 g/m^2 on the vertical plates. This biomass is much greater than that found in the same season in coral reefs at Phuket Island (Chansang *et al.,* 1987), when biomass ranged between 57 and 165 g/m^2. Nevertheless, the standard deviation of the average biomass in this study was very high due to the occasional settlement of the heavy organisms, such as bivalves and ascidian type II, so the minimum biomass was close to the range reported for the Phuket reefs. In addition, it could be due to variation in water velocity and sedimentation; Baynes and Szmant (1989) observed that, in the same location, the area of high velocity flow and low sedimentation supports high cover and species diversity. The site of AR3 is more exposed, has stronger water circulation and lower sedimentation than other reefs along the west coast of Phuket.

Successful recruitment of scleractinian corals did not occur, although there was evidence that coral larvae were available in the reef area, *i.e.* there appeared to be some colonies of ahermatypic coral *(Astrangia* sp.), whose larvae were possibly from the fringing reefs on nearby islands (for instance, Khang Khow Island) where a record from the 100 m transect line shows a 72 per cent cover of living corals (data from author's unpublished observation). It is likely that the coral reef could not develop in the AR3 area as it is directly exposed to the Southwest Monsoon waves. In contrast, the suspension feeders, especially oysters, could form an oyster reef.

In conclusion, it can be said that AR3 is a productive system that has a high complexity of benthic communities, in contrast to the bare sandy bottom just outside the reef modules. The evidence shows the increasing secondary production of important benthic organisms such as crabs, shrimps, polychaetes etc., which are the major components of a coral reef ecosystem *(e.g.,* Hutchings and Howitt, 1988). These organisms are the food source for the mobile fauna, especially commercial fish. Consequently, it would seem that fish do not aggregate at the AR just to hide or for shade but also to forage.

AR3 is located in a suitable position where the benthic communities can develop considerably, unlike AR2 which, when checked by the authors, had a very poor development of fouling organisms. AR3 is still in the process of undergoing change, with the substrates on the sea bottom having increased by a large number of oyster shells. Consequently, future studies on the development of the benthos communities on the bottom in this area would be of interest.

8. *REFERENCES*

ARDIZZONE, GD., GRAVINA, M.F. and BELLUSCIO, A (1989). Temporal development of epibenthic communities on artificial reefs in the Central Mediterranean Sea. *Bull, of Mar. Sci,* 44 (2) 592-608.

BAILEY-BROCK, J. II. (1989). Fouling community development on an artificial reef in Hawaiian Waters. *Bull of Mar. Sci.* 44 (2) 580-591

BAYNES, T. W. and ZSMANT, A.M. (1989). Effect of current on the sessile benthic communities structure of an artificial reef. *Bull, of Mar.* Sci. *44* (2): 545-566.

BOHNSACK,J.A. and SUTHERLAND, D.L. (1985), Artificial reef research: A view with recommendations for future priorities. *Bull, of Mar. Sci.* 37 (1): 11-39.

CARTER, J.W., CARPENTER, A.L., FOSTER, M.S. and JESSEE, W.N. (1985). Benthic succession on an artificial reef designed to support a kelp-reef community. *Bull, of Mar. Sci.* 37(1):86-1 13.

CHANSANG,H., BOONYANATE, P., PHONGUSUWAN, N. and PANRONG, S. (1987). *Effects of sediment from tin dredging to coral reefs and growth of some coral species.* Technical report presented to the Natural Resource Department 82 p. (in Thai).

HURLBUT, CJ. (1988). Die timing of larval release and settlement of colonial tunicates in Pearl Harbour, Oahu, Hawaii. IN: *Proc. of the Sixth. Intl. Coral Reef Symp.* Australia 2:733 - 737.

HUTCHINGS, P. AND HOWITT, L. (1988). Swarming of polychaetes on the Great Barrier Reef. IN: ***Proc.** of the Sixth intl. Coral Reef Symp.* Australia 2:739-744.

LASKER, HR. (1988). The incidence and rate of vegetative propagation among coral reef alcyonarians. IN: *Proc. of the Sixth Intl. Coral **Reef** Symp.* Australia 2:763-768.

WOODHEAD, P.M.J. and JACOBSON, M.E. (1985). Epifaunaa settlement, the process of community development and succession over two years on an artificial reef in New York Bight. *Bull, of Mar. Sci.* 37 (l):364-376.