CORAL TRANSPLANTATION AS A REEF CONSERVATION TOOL - THE SINGAPORE EXPERIENCE

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ABSTRACT

Corals transplanted to Sentosa, an island south of the main island of Singapore, from a reef due for reclamation, were monitored and assessed one year after completion of a massive two-year transplantation exercise. This transplantation exercise was conducted by the Marine Conservation Group of the Nature Society (Singapore). Assessment of the 3m x 3m permanent quadrat showed that 24.29% of transplants remained healthy, while 57.14% were impacted or dying and the remaining 18.57% completely dead. The broad scale belt transect survey showed that 35.27% of the translocated corals were healthy, while 43.04% were impacted or dying and 21.69% completely dead. The low survival rate could be attributed to 2 main factors : improper securing techniques and unfavourable site conditions. The results also indicated that certain coral growthforms (mushroom, encrusting and massive) and genera (*Fungia*, *Herpolitha, Favia*, *Platygyra*, *Favites*, *Goniopora* and *Turbinaria*) were more suitable transplants than others.

INTRODUCTION

Coral transplantation as a means to aid reef rehabilitation, promote reef development, increase juvenile coral recruitment or save corals threatened by development has been carried out in many parts of the world with varying success (Birkeland *et al.*, 1979; Buchon *et al.*, 1981; Alcala *et al*., 1982; Auberson, 1982; Plucer-Rosario & Randall, 1987; Harriott and Fisk, 1988a, Yap *et al*. 1992; Clark & Edwards, 1995). A brief description of various coral transplantation techniques is discussed in Harriot and Fisk (1988b) while Yap *et al*. (1992) highlights various considerations that should be considered in planning a coral transplantation exercise.

In 1991, the Marine Conservation Group (MCG) of the Nature Society (Singapore), embarked on a coral transplantation exercise dubbed Reef Rescue 1 (RR1). RR1 involved transplantation of 10m^2 to 12m^2 of corals and other reef organisms from Buran Darat to Sentosa (The Straits Times, 1993). The MCG claimed survival rates of between 70% to 90% (Nature News, 1992, 1993; The Straits Times, 1992), and embarked on a second transplantation exercise - Reef Rescue 2 (RR2), which involved transplantation of corals and other reef organisms from another island destined for reclamation to a second site at Sentosa. Undertaken on a larger scale, 450 volunteers spent over 10,000 man-hours to transplant approximately 500m^2 of corals from Pulau Ayer Chawan to Sentosa between July 1993 to June 1995, at a cost of S$50,000 (Nature Watch, 1995). The Reef Ecology Study Team (REST), of the School of Biological Sciences, National University of Singapore, was requested to monitor the health and survival of the transplanted corals.

MATERIALS AND METHODS

Collection and Transplantation

The first trip under RR2 started in July 1993, and continued once every week (Sunday), for two years. As the transplants were not to be anchored to the site by cement, ropes or any other means except to be wedged between existing granite boulders, only large colonies of corals and other reef invertebrates were selected. Once removed, transplants were placed in plastic baskets (some with draining slots), brought to the surface, and transferred onto boats where they were placed in large plastic tubs filled with aerated seawater. Each collection trip averaged between 1hr to 1.5hrs, with an additional 1.5hrs taken to get to Sentosa, the transplantation site. At Sentosa, the transplants were transferred to dry containers, floated by divers or snorkellers to the transplantation sites, and then sunk (Nature News, 1993).

Monitoring

The Reef Ecology Study Team (REST) was not involved in the planning and execution of RR2, and had to design a monitoring programme based on work done by the MCG. The transplantation area outside the lagoon mouth was not specifically defined or mapped out, and thus, there was no defined area to confine the monitoring programme to. In addition, background information on the number of corals, their growthform, genera or species, their sizes, the depths they were collected from, their condition, and the characteristic/s of the substrata at the time of transplantation were not recorded by the MCG.

The establishment of a 3m x 3m permanent quadrat towards the end of RR2 allowed the monitoring and assessment of a definite number of transplanted corals over time. However, a single permanent quadrat to assess the condition of the translocated corals was deemed insufficient to represent the entire population of transplanted corals and a belt transect was included covering a larger area.

The 3m x 3m permanent quadrat was surveyed twice; once in early 1995, soon after corals were transplanted to it, and again in June 1996. Visual mapping was made using 1m x 1m frames. In the first survey, transplants within quadrat were identified, mapped and tagged with waterproof drafting film. In the second survey, transplants were monitored for growth and survival.

Before belt transects were laid out, an initial visual census was conducted to identify the general area of the transplants. It was estimated that the transplants were randomly placed within an area spanning approximately 150m x 30m, or 4500m^2 and that belt transects totalling 500m^2 (or about 10% of the total transplantation area) was a sufficient representation. Within these transects, growthform, genera, size, % colony survival and colony condition were recorded.

Data analysis

The map of the permanent quadrat was redrawn onto a 30cm x 30cm sheet of drafting film and then scanned using a Microtek flatbed scanner. The scanned image was then transferred to an image processing software (SigmaScan/Image 1.20.09), scaled appropriately, before calculating the area of each coral within the permanent quadrat. Field data of the belt transects were keyed into a database (created using Microsoft Access 7.0 for Windows 95) and the area of individual transplants were estimated by taking the product of their length and width measurements.

For both the permanent quadrat and belt transect surveys, the percentage of individual transplant surface that was visibly alive was estimated and recorded as percentage colony survival (ColS). These estimations made it possible to group the corals into three "survival" categories as follows:

Healthy	ColS=100%
Impacted	0%<ColS<100%
Dead	ColS=0%

The size of the transplants (ColSz) were also grouped into three general guilds as follows :

Small	$0m^2 < ColSz < 0.01m^2$ ($100cm^2$)
Medium	$0.01m^2 \leq ColSz < 0.05m^2$ ($500cm^2$)
Large	$ColSz \geq 0.05m^2$

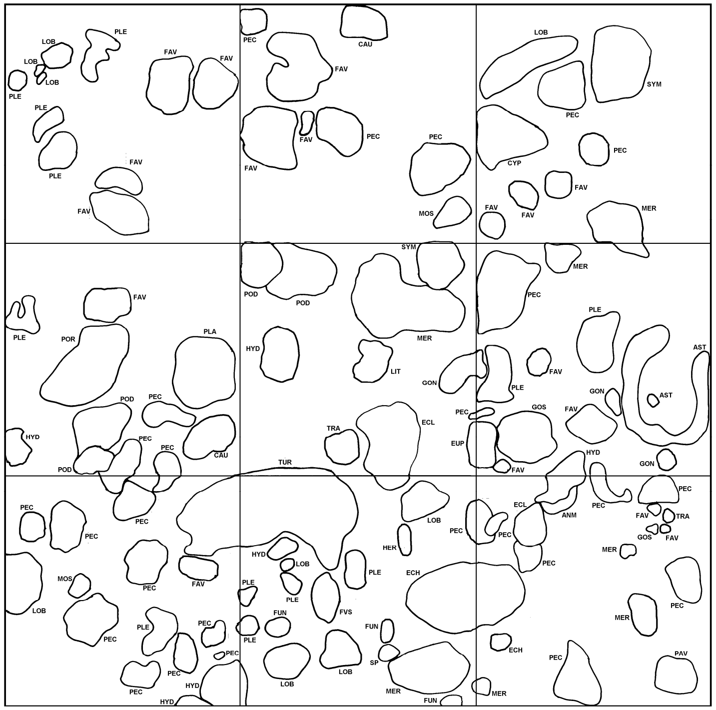
RESULTS

Permanent Quadrat

A total of 114 transplants from 28 genera representing five growthform types were mapped in the 1995 survey (Fig. 1a, Table 1). Of these, 112 were hard corals, with one sea anemone (*Heteractis magnifica*) and one sponge (*Petrosia* sp.) making up the remaining two. All transplants were in the Healthy category. Massive and foliose corals were the dominant growthforms transplanted, accounting for 35.96% (41 corals) and 39.47% (46 corals) of the total number of corals. About 1/3 of the transplanted corals were small colonies (39; 34.21%), while just over 1/2 of them were medium-sized colonies (63; 54.39%) and the remaining 10.53% (12 corals) were large colonies. Some genera were represented by one or two individuals, while others had more than ten. The genus *Pectinia* was most abundant with 26 corals (22.81%) transplanted, followed by *Favia* with 17 corals (14.91%) and *Plerogyra* with 12 (10.53%).

One year after the first survey, the transplants within the permanent quadrat showed varying degrees of impact (Fig. 1b, Table 2). Seventy transplants left, representing 24 genera from 5 growthforms. This translates to a 38.6% decrease in the number of transplants. A total of 13 (18.57% of the total) transplants were dead, with 40 (57.14%) impacted and 17 (24.29%) still healthy. The number of large colonies did not change but the number of small and medium sized colonies decreased by 1/2 and 1/3 respectively. Of the transplants 68 were hard corals and 2 were sponges. The single sea anemone recorded in 1995 was not present.

Both the number of foliose and massive corals decreased by almost 1/2, while mushroom corals decreased by 3/4. Submassive corals showed the lowest decrease in number.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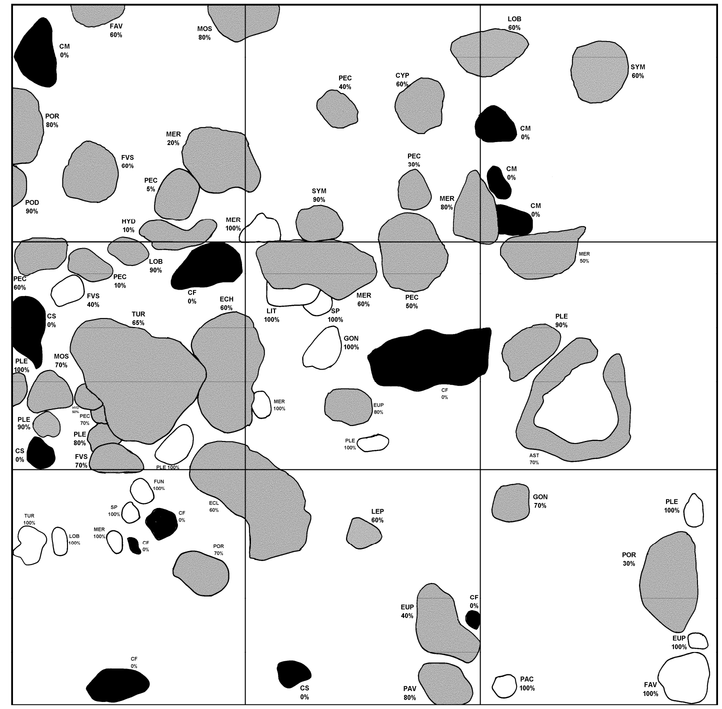
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Figure 1a. Map of permanent quadrat for 1995.

Number of corals within quadrat - 114
Number of healthy corals - 114
Number of corals with partial mortality - 0
Number of corals completely dead - 0

Figure 1b. Map of permanent quadrat for 1996.

Number of corals within quadrat - 70
Number of healthy corals - 17 (white)
Number of corals with partial mortality - 40 (grey)
Number of corals completely dead - 13 (black)

Codes used for coral genera :
AST - *Astreopora*; CYP - *Cyphastrea*; ECH - *Echinopora*; ECL - *Echinophyllia*; EUP - *Euphyllia*; FAV - *Favia*; FUN - *Fungia*; FVS - *Favites*; GON - *Goniopora*; HYD - *Hydnophora*; LEP - *Leptoria*; LIT - *Lithophyllon*; LOB - *Lobophyllia*; MER - *Merulina*; MOS - *Montastrea*; PAC - *Pachyseris*; PAV - *Pavona*; PEC - *Pectinia*; PLE - *Plerogyra*; POD - *Podabacia*; POR - *Porites*; PET - *Petrosia* (sponge); SYM - *Symphyllia*; TUR - *Turbinaria*; XXX - unidentified coral genera.

Table 1. **First survey (1995) of the permanent quadrat; (a) Growthform distribution; (b) Size distribution.**

(a)

GROWTH-FORM (GF)	ColS = 100 (HEALTHY)		% OF TOTAL
	NO OF CORALS	% OF GF	
CF	41	100	35.96
CM	46	100	39.47
CMR	4	100	3.51
CS	21	100	19.30
OT	2	100	1.75
TOTAL	**114**		**100.00**

CF=Foliose coral; CM=Massive coral; CMR=Mushroom coral;
CS=Submassive coral; SC=Soft coral;
OT=Other fauna (e.g., sponge, sea anemone)
ColS = Colony Survival (% of coral colony alive)

(b)

SIZE GUILD (ColSz)	ColSz = 100 (HEALTHY)		% OF TOTAL
	NO OF CORALS	% OF SIZE	
SMALL	39	100	34.21
MEDIUM	63	100	55.26
LARGE	12	100	10.53
	114		**100.00**

Small $0m^2<ColSz<0.01m^2$ ($100cm^2$)
Medium $0.01m^2\leq ColSz<0.05m^2$ ($500cm^2$)
Large $ColSz\geq 0.05m^2$
ColSz = Colony Size

Table 2. **Second survey (1996) of the permanent quadrat; (a) Growthform distribution; (b) Size distribution.**

(a)

GROWTH-FORM (GF)	ColS = 0 (DEAD)		25 < ColS <100 (IMPACTED)		ColS = 100 (HEALTHY)		TOTAL NO OF CORALS	% OF TOTAL
	NO OF CORALS	% OF GF	NO OF CORALS	% OF GF	NO OF CORALS	% OF GF		
CF	6	23.08	14	53.85	6	23.08	26	37.14
CM	4	16.67	18	75.00	2	8.33	24	34.29
CMR					1	100.00	1	1.43
CS	3	17.65	8	47.06	6	35.29	17	24.29
OT					2	100.00	2	2.86
TOTAL	**13**		**40**		**17**		**70**	**100.00**

CF=Foliose coral; CM=Massive coral; CMR=Mushroom coral; CS=Submassive coral; SC=Soft coral; OT=Other fauna (e.g., sponge, sea anemone). ColS = Colony Survival (% of coral colony alive).

(b)

SIZE GUILD (ColSz)	ColS = 0 (DEAD)		25 < ColS <100 (IMPACTED)		ColS = 100 (HEALTHY)		TOTAL NO OF CORALS	% OF TOTAL
	NO OF CORALS	% OF SIZE	NO OF CORALS	% OF SIZE	NO OF CORALS	% OF SIZE		
SMALL	3	16.67	2	27.78	10	55.56	18	25.71
MEDIUM	9	22.50	26	65.00	5	12.50	40	57.12
LARGE	1	8.33	9	75.00	2	16.67	12	17.14
TOTAL	**13**		**40**		**17**		**70**	**100.00**

Small $0m^2<ColSz<0.01m^2$ ($100cm^2$)
Medium $0.01m^2\leq ColSz<0.05m^2$ ($500cm^2$)
Large $ColSz\geq 0.05m^2$

ColSz = Colony Size

Table 3. Results of the belt transect survey conducted in 1996; (a) Growthform distribution; (b) Size distribution.

(a)

GROWTH-FORM (GF)	ColS = 0 (DEAD)		25 < ColS <100 (IMPACTED)		ColS = 100 (HEALTHY)		TOTAL NO OF CORALS	% OF TOTAL
	NO OF CORALS	% OF GF	NO OF CORALS	% OF GF	NO OF CORALS	% OF GF		
ACB			2	100.00			2	0.23
CB	3	30.00	6	60.00	1	10.00	10	1.14
CE	1	5.88	4	23.53	12	70.59	17	1.94
CF	47	20.80	128	56.64	51	22.57	226	25.80
CM	23	10.45	117	53.18	80	36.36	220	15.11
CMR	17	16.50	10	9.71	76	73.79	103	11.76
CS	36	17.48	109	52.91	61	29.61	206	23.52
OT			1	2.56	19	61.29	31	3.54
SC					9	100.00	9	1.03
XXX	63	100.00					63	7.19
TOTAL	**190**		**377**		**309**		**876**	**100.00**

ACB =Branching *Acropora*; CB=Branching coral; CE=Encrusting coral; CF=Foliose coral; CM=Massive coral; CMR=Mushroom coral; CS=Submassive coral; SC=Soft coral; OT=Other fauna (e.g., sponge, sea anemone); XXX=Unidentified dead coral. ColS = Colony Survival (% of coral colony alive).

(b)

SIZE GUILD (ColSz)	ColS = 0 (DEAD)		25 < ColS <100 (IMPACTED)		ColS = 100 (HEALTHY)		TOTAL NO OF CORALS	% OF TOTAL
	NO OF CORALS	% OF SIZE	NO OF CORALS	% OF SIZE	NO OF CORALS	% OF SIZE		
SMALL	8	18.60	5	11.63	30	69.77	43	4.91
MEDIUM	95	20.83	182	39.91	179	39.25	456	52.05
LARGE	87	23.08	190	50.40	100	26.53	377	43.04
TOTAL	**190**		**337**		**309**		**876**	**100.00**

Small $0m^2<ColSz<0.01m^2$ ($100cm^2$)
Medium $0.01m^2\leq ColSz<0.05m^2$ ($500cm^2$)
Large $ColSz\geq 0.05m^2$
ColSz = Colony Size

Majority of corals within the three major growthform guilds were impacted. Although both foliose and submassive corals had the highest number of healthy corals (6 each) in 1996, overall the submassive corals showed better survival rates when compared to the numbers present in 1995. The total number of dead corals were only 13, but this number does not account for the 38.6% missing from the original group of transplants. If the missing transplants are assumed to be dead, then the percent dead corals would increase to 50% of the original 114 transplants. Of the three size guilds, small corals, despite decreasing by almost half the number, showed the greatest survival.

The most abundant genera encountered were *Plerogyra* and *Merulina* with seven colonies each (10% of total), followed by *Pectinia* with six colonies (8.57%). The remaining 21 genera were represented by between one to three colonies only.

The PQ maps of 1995 and 1996 (Figures 1a & 1b) show marked differences in the size, position and to a smaller extent, generic composition of the transplants. A year after the first survey, a large number of small and medium sized transplants were missing from the quadrat. This was due to the transplants being swept out of the quadrat. There also appeared to be a shift in the overall positions of the remaining transplants, suggesting that the area was exposed to strong wave action.

Belt Transect

Tables 3a and 3b list the results of the belt transect survey conducted in 1996. A total of 876 transplants representing 40 genera from eight growthform types were recorded within the $500m^2$ survey area, giving it a density of 1.75 colonies/m^2. The substratum cover consisted of rock boulders (58.17%), sand (19.01%), silt (9.1%), live coral (6.4%), algal assemblage (5.14%) and dead coral (1.83%). Almost all substrata, with the exception of live coral and algal assemblage, was covered with a thin layer of filamentous algae. Of the 876 transplants, 309 (35.26%) were healthy, 377 (43.01%) impacted and 154 (21.69%) dead. Hard corals made up the bulk of transplants with 693 live and 154 dead individuals. A total of 14 anemones (*Heteractis magnifica*), 9 soft corals (*Sinularia* sp.) and 6 sponges (*Petrosia* sp.) were also encountered. Foliose, massive and submassive corals were the most abundant growthforms transplanted, accounting for 25.8% (226 colonies), 25.11% (220 colonies) and 23.52% (206 colonies) of the total number of corals. Mushroom corals accounted for 103 colonies (11.76%) while the remaining growthforms were represented by fewer than 40 colonies each. The 63 dead colonies were not recognisable even to growthform level, and were given a code of XXX.

Only 4.91% of the transplants encountered were small, while medium and large transplants made up 52.05% and 42.04% of the total respectively. The percentage of dead transplants for each size guild was similar (between 18.6% and 23.08%). Small transplants survived well with almost 70% within the size guild healthy, but since the total number of small transplants was low to begin with (43 out of 876), the high percentage of healthy transplants does not necessarily reflect better survivorship over the medium or larger transplants. Visual observations during the survey indicated that many small dead transplants were overlooked as they were either broken into fragments or completely covered with a thick algal mat and were not taken into account. For all growthforms, the percentage of dead colonies did not exceed 30%. Instead, majority of the growthforms had colonies which were impacted. Encrusting and mushroom corals registered the greatest number of colonies in the healthy category.

The genus *Plerogyra* was the most abundant with 91 colonies (10.39% of the total). Other common genera were *Fungia* (84 colonies; 9.59%), *Pectinia* (72 colonies, 8.22%) and *Favia* (51 colonies, 5.82%). Half the number of coral genera (22, 55%) were represented by fewer than 10 colonies each. Based on percentage healthy transplants per genera, several genera showed better survival. Non-hard coral reef invertebrates survived the transplantation better; between 83% and 100% of the sea anemones, sponges and soft corals were healthy. Free living mushroom corals (*Fungia* sp. and *Herpolitha* sp.) survived well with over 75% individuals still healthy. Other genera with good to moderate survival include submassive *Goniopora* sp. (63%), foliose *Turbinaria* sp. (51%), massive *Favia* sp. (51%), *Platygyra* sp. (45%) and *Favites* sp. (40%).

DISCUSSION

Studies on transplantation (almost exclusively on hard coral) have been conducted by various researchers as early as the 1970's, and these studies have shown that even with controlled and carefully planned experiments, survivorship of transplants are not high. Harriott and Fisk (1988b) gave a comprehensive summary of published results of experiments testing coral transplantation by various researchers. Results of both the permanent quadrat and belt transect surveys indicated that generally, the survivorship of transplants one year after transplantation is comparable with other published results (example, see Alcala *et al*., 1982, Plucer-Rosario & Randall, 1987 and Harriott & Fisk, 1988a). The transplants however, did not show potential long term survivorship.

A major reason for the low survivorship of the transplanted corals was the unsuitability of the site. Coral were transplanted beyond the opening of a man-made lagoon, at depths of between 3m to 4m (at mean spring tide). The entire southwestern coastline of Sentosa is subjected to constant surges caused by high speed ferry boats plying daily, and since the transplants were not secured firmly to the substratum, they were subjected to the full force of the surges. During the survey, it was noted that many of the colonies were either overturned or on their sides. The transplantation site was subjected to sediment stress. In addition, reclamation works along the eastern coastline of Sentosa added to the sediment load of the water. Algal growth at the site was also intense such that many transplants were completely overgrown by macroaglae and had little chance of survival.

Clark and Edwards (1995) discussed survivorship of various coral species based on transplant studies conducted by them and others. The fact that a large number of transplants from 40 genera and eight growthform types provided an opportunity to assess the survivorship of a great variety of transplants. Certain coral growthforms and genera fared better than others. Mushroom, massive and encrusting growthforms showed the highest survivorship, as did the genera *Fungia* and *Herpolitha* (mushroom), *Favia*, *Platygyra* and *Favites* (massive), *Goniopora* (submassive) and *Turbinaria* (foliose). In addition, several non-coral reef invertebrates also showed high survivorship. These included the sea anemone *Heteractis magnifica*, the soft coral *Sinularia* sp. and the neptune's cup sponge *Petrosia* sp.

The deployment of proper transplantation techniques such as extraction, handling, positioning and securing of transplants are essential for their long-term survival. Many reef invertebrates, especially corals, are easily stressed and therefore, need to be handled carefully. Yap *et al*. (1990) gave a brief yet detailed summary on proper transplantation techniques.

Although care was taken by the MCG to ensure that proper transplantation techniques were used as much as possible, they did not manage to properly secure transplants onto the substratum. Wedging transplants between granite boulders did not prevent the consistent wave and surge action from tossing them about.

Several general conclusions can be derived from this study:

1) Favourable recipient site conditions are essential for long term survivorship of transplants. Ideally, recipient site should possess similar environmental characteristics as the donor site, and with minimal anthropogenic impacts. In Singapore's coastal waters, the growth and

proliferation of macroalgae is intense along reef-flats and reef-crests, but diminishes rapidly down the reef slope. Thus, securing a recipient site between the depths of 3m to 6m may increase the survivorship of transplants in Singapore waters.

2) Transplants should be properly secured to the substratum to withstand wave action. The use of cement is highly recommenced, and where necessary, masonry nails to secure larger coral colonies.
3) Certain coral growthforms and genera fared better than others. Mushroom, massive and encrusting growthforms showed the highest survivorship, as did the genera *Fungia* and *Herpolitha* (mushroom), *Favia*, *Platygyra* and *Favites* (massive), *Goniopora* (submassive) and *Turbinaria* (foliose).
4) Several non-coral reef invertebrates survival well, such as the sea anemone *Heteractis magnifica*, the soft coral *Sinularia* sp. and the neptune's cup sponge *Petrosia* sp.
5) The number of transplants, the density and position in relation to each other are important considerations. Inter- and intra-specific competition between transplants should be minimised as much as possible, and to achieve this, a good scientific knowledge on the biology and ecology of the transplants is essential.

REFERENCES

Alcala, A. C., E. D. Gomez & L .C. Alcala, 1982. Survival and growth of coral transplants in Central Philippines. Kalikasan, 11(1):136-147.

Auberson, B., 1982. Coral transplantation : an approach to the re-establishment of damaged reefs. Kalikasan, 11(1):158-172.

Birkeland, C., R. H. Randall & G. Grimm, 1979. Three methods of coral transplantation for the purpose of re-establishing a coral community in the thermal effluent area of the Tanguisson Power Plant. Uni. Of Guam Marine Laboratory Technical Report No. 60. 24 pp.

Bouchon, C., J. Jaubert & Y. Buchon-Navaro, 1981. Evolution of a semi-artificial reef built by transplanting coral heads. Tethys, 10(2):173-176.

Clark, S. & A. J. Edwards, 1995. Coral transplantation as an aid to reef rehabilitation : evaluation of a case study in the Maldive Islands. Coral Reefs, 14:201-213.

Harriott, V. J. & D. A. Fisk, 1988a. Accelerated regeneration of hard corals : a manual for coral reef users and managers. G.B.R.M.P.A. Technical Memorandum 15.

Harriott, V. J. & D. A. Fisk, 1988b. Coral transplantation as a reef management option. In : Choat, J. H. *et al*. (eds). Proceedings of the Sixth International Coral Reef Symposium. Volume 2. Townsville, Australia. Pp 375-379.

NatureNews, July/August, 1992. Project reports - Reef Rescue : Project Update.

Nature News, May/June, 1993. Report by marine group - Reef Rescue Project 1 - Buran Darat/Sentosa. Pg 13.

Chua, S. C., 1995. Reef Rescue II. Nature Watch, 3(4):4-9.

Plucer-Rosario, G. P. & R. H. Randall, 1987. Preservation of rare coral species by transplantation : an examination of their recruitment and growth. Bulletin of Marine Science, 41(2):585-593.

The Straits Time, November 13, 1992. Save-the-corals plan a success.

The Straits Times, May, 1993. 400 volunteers in project to save corals.

Yap, H. T., W. Y. Licuanan, E. D. Gomez, 1990. Studies on coral recovery and coral transplantation in the northern Philippines : aspects relevant to manage and conservation. In : Yap, H. T. (ed). Proceedings of the First ASEAMS Symposium of Southeast Asian Marine Science and Environmental Protection. UNEP Regional Seas Reports and Studies 116, United Nations Environmental Programme. Nairobi. Pp 117-127.