

## CORAL REEF CONSERVATION IN SINGAPORE - A CASE FOR INTEGRATED COASTAL AREA MANAGEMENT

Christopher Y Y Chua & L M Chou  
Department of Zoology  
National University of Singapore  
Lower Kent Ridge Road  
Singapore 0511

### ABSTRACT

There is a need to conserve some of Singapore's coral reefs and this has to be integrated into a national coastal area management plan initiated by the local government. An extensive survey of these reefs by volunteer sport divers revealed that three-quarters of them support living coral cover of more than 30 %. If successful, this plan will optimize the use of the limited marine resources including the promotion of marine conservation.

### INTRODUCTION

Singapore's limited seaspace continues to be heavily utilised in order to sustain activities which have turned it into the world's busiest port. Since its establishment as an entreport in 1819, urbanisation has proceeded at a rapid rate resulting in massive physical changes to land and sea. These include the large-scale reclamation of coastal areas, offshore islands and patch reefs for expanding industries, residential and recreational demands. It is estimated that by the end of 1992, 6000 ha of land will have been added to the existing total land area.

There is an apparent lack of appreciation of the coral reefs. Many of the southern islands and coral reefs have been reclaimed to form resort islands with sandy beaches, to compensate in part for the loss of other recreational areas through reclamation on the mainland (Yong *et al.* 1991). This current

trend of action does little in preserving what is left of the diminishing number of "untouched" coral reefs. In addition, other human activities have contributed to the degradation of the marine fauna in and around the coral reefs.

As a result of increased sedimentation (Lane 1991) over the last three decades, the deeper zones of the coral reef slopes have become denuded, but the shallower zones continue to support high species diversity and good coral growth (Chua & Chou 1991). All the reefs however, face the threat of total devastation should no concerted action be taken to conserve at least some of them. This may take the form of an integrated coastal area management (CAM) plan which will include coral reef conservation as one of the major components. Properly planned and implemented, it will enable the country to serve as an example of a developing country which is able to conserve some of its limited coral reef resource.

A project undertaken between 1987 and 1991 by three non-governmental organisations (Republic of Singapore Yacht Club, Singapore Institute of Biology and Singapore Underwater Federation) provided information on the condition of most of the coral reefs in the southern waters of Singapore. The aim was to identify the better reefs in terms of biological richness which are worthy of being conserved. This paper provides a summary of the findings of the project and identifies the main issues concerning these reefs and how they can be addressed within a coastal area management plan.

Island/Reef	% cover		Island/Reef	% cover	
	0 m	3 m		0 m	3 m
Raffles Light 1	75.3	28.7	Terumbu Palat	43.2	25.2
T. Pempang Tengah	73.9	22.6	Pulau Jong	43.2	15.3
Raffles Light 2	73.3	45.2	Pulau Sebarok	42.3	0.0
Hantu West 2	70.1	35.0	Pulau Hantu 3	41.3	9.2
The Sisters' 2	70.0	21.3	Lazarus Island	41.9	7.4
Terumbu Raya 1	68.6	60.2	Hantu West 1	41.5	62.0
Selat Sudong 2	66.3	33.7	Pulau Sudong 1	41.0	30.8
Pulau Ular	66.2	32.7	S. Bukom Beacon	39.0	15.2
Terumbu Menalung	66.0	68.3	Kusu Island 2	39.0	0.0
The Sisters' 1	65.7	11.9	Terumbu Raya 2	38.2	35.1
Pulau Sudong 2	63.0	18.4	B. Beting Besar	36.1	35.1
Lazarus Island 2	62.0	2.4	Pulau Seringat 3	35.0	2.1
Terumbu Bemban 1	60.1	23.5	Pulau Busing 2	33.7	18.6
Terumbu Bemban 2	59.2	48.0	Kusu Island 1	33.1	5.1
St John's Island 3	58.1	31.1	Pulau Hantu 1	29.5	27.7
T. Pempang Laut 1	57.7	44.3	Pulau Sudong 3	29.5	14.8
St John's Island 1	57.6	2.2	S. Bukom Beacon2	29.3	10.6
T. Pempang Laut 2	57.0	22.3	Pulau Jong 1	28.6	0.2
Pulau Busing 3	56.5	27.3	Pulau Seringat 2	27.1	0.8
The Sisters' 1	56.4	18.5	Pulau Busing 2	26.0	23.8
Terumbu Semakau 1	54.0	28.1	Pulau Semakau 1	26.0	42.1
The Sisters' 2	53.5	32.9	Terumbu Pandan 2	21.4	0.4
Selat Sudong 1	53.0	17.6	T. Pandan 3	19.3	48.1
Pulau Semakau 2	51.0	59.7	S. Cyrene Beacon	17.8	7.7
Pulau Sudong 4	50.2	27.8	Sebarok Beacon 4	15.5	-
St John's Island 2	49.8	15.0	Kukor Beacon 2	12.1	22.8
Pulau Salu	49.7	37.3	Pulau Semakau 3	12.0	10.3
B. Beting Besar 3	49.3	45.8	Terumbu Pandan 1	11.8	7.1
T. Pempang Darat 2	47.5	49.1	Pandan Beacon 1	6.9	7.9
T. Pempang Darat 1	46.1	31.5	Terumbu Selegi	5.5	0.9
Pulau Sebarok 1	45.7	14.8	Terumbu Pandan	4.4	23.5
Lazarus Island 1	45.3	17.7	Terumbu Pandan	3.6	14.1
Pulau Hantu 2	43.8	46.2			

Table 1. Live coral cover at the reef crest and slope (0 m and 3 m depths respectively) of sites surveyed in the reefs of the southern islands of Singapore. Reef crest percentages in decreasing order.

## THE SINGAPORE REEF SURVEY AND CONSERVATION PROJECT

In order to survey as many reefs in the shortest period of time, a simple survey method was adopted for the training of approximately 150 volunteer SCUBA divers. The 100 m Line Intersect Transect method (Dartnall & Jones 1986) was used in all the surveys because it could be easily taught to non-specialist divers with no background in biology (Chou 1990, 1991). Altogether 65 sites from 41 coral reefs were surveyed and the benthic lifeforms classified into several broad taxonomic categories (eg. live coral

cover; algal cover; dead coral cover) resulting in a total of 13 km of reefs surveyed. At each site, an assessment was made of the reef community at the reef crest (0 m) and the 3 m depth of the reef slope. This survey method has already been proved successful in the ASEAN-Australia Marine Science Project: Living Coastal Resources.

Using percentage live coral cover as an indicator of the condition of the reef, the results showed that the reef crest of the surveyed reefs supported live coral cover ranging from 3.63 to 75.29 % while the 3 m depth supported up to 68.27 % (Table 1). Three-quarters of the reefs surveyed still supported 30 % or more of live coral cover (Fig. 1). Good reefs could be grouped into three distinct areas for possible consideration as zones of conservation and management.

## Management issues

### Land reclamation

Land reclamation has been carried out all along the northeastern but mainly the southern coast since Singapore's founding in 1819 but reached its peak during the last 30 years (Fig. 2). Reclamation is expected to continue until the year 2000 and will make the country 25 % larger than its original size in 1967. These recently-released plans do not augur well for the future of the remaining heavily-sedimented reefs. Natural coastlines, particularly that of the southern islands, will be lost and marine life affected as the coral reefs become buried. Reclamation also alters tidal flow regimes and will, in some places, cause even higher sedimentation rates and reduced light penetration (Yong *et al.* 1991). Visibility of the waters of 10 m in the 1960s has been sharply reduced to 2 m now (Chou 1988), contributed mainly by reclamation, earth spoils dumping and dredging to create deeper port waters.

The effects of land reclamation on water flow (hydraulics) is being modelled and reclamation contractors are now required to ensure minimal siltation or pollution in the adjacent waters and seabed areas (Yong *et al.* 1991).



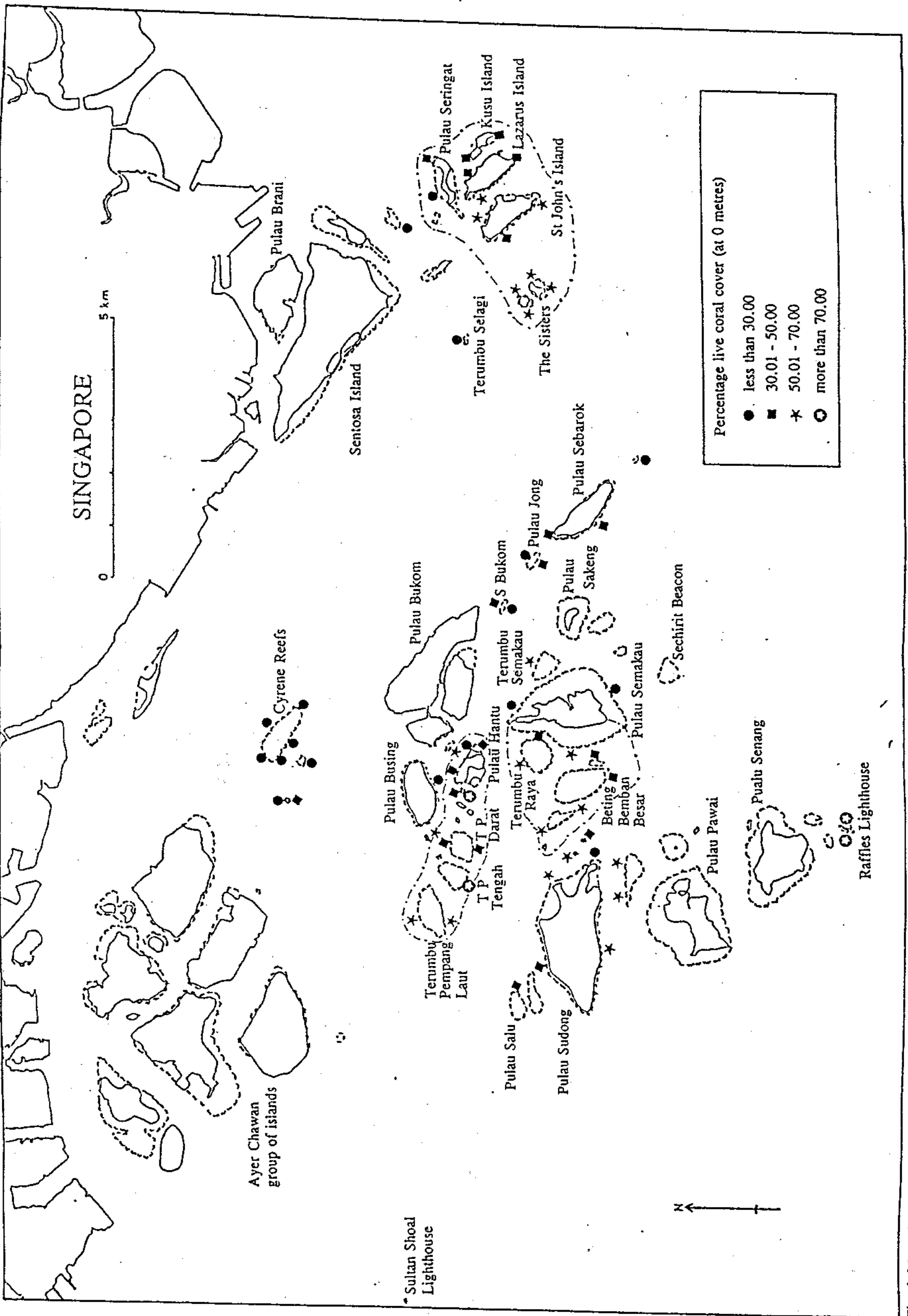


Fig. 1 Map of Singapore's southern islands showing conditions of reefs surveyed (based on live coral cover at the reef crest). Proposed conservation areas enclosed within dotted

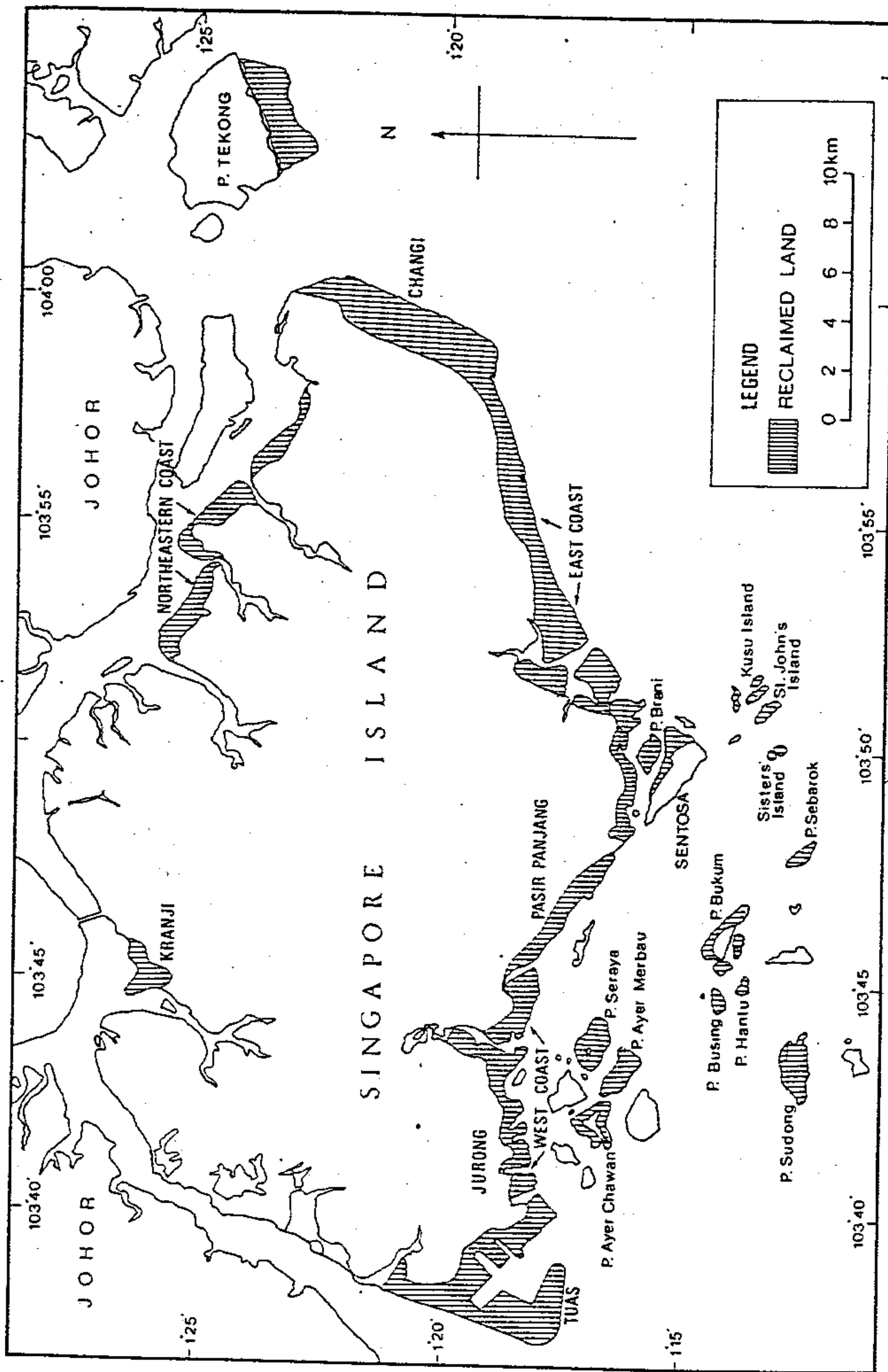


Fig. 2 Reclamation in Singapore (from Chia et al, 1988).

### Fishing and collecting

The removal of fish and other reef-associated fauna has continued without any form of management. Reef fish mainly for the aquarium trade have been steadily removed by barrier nets and fish traps. Commercial operators employ both local and foreign fishermen, many of whom obtain their catches from Singapore reefs. In addition, corals and shells have been collected until very recently when the marine police began to take action against the removal of live corals.

Until such time as effective control and management programmes are implemented for all reef organisms, the rate of removal will definitely exceed the rate of natural replacement and result in further loss of faunal diversity and germplasm. Should a workable management plan be enforced, the removal of reef organisms need not be totally curtailed but instead limited to certain areas of some reefs so that a rotating schedule will allow such areas greater rehabilitation success.

### Earth spoils dumping

Earth spoils have been dumped in the waters near Pulau Semakau, one of the larger offshore southern islands, commencing in December 1988 and reached a peak in June 1989. Much of these materials is soft and soggy marine clay. Approximately one million cubic metres have been deposited into this area by the end of 1991 (Quek 1989). This clay has caused a considerable deterioration of the surrounding coral reefs (Chou 1987, 1988; Lim *et al.* 1990). This dumping project was initiated without considering the possible effects on surrounding waters. An environment impact study was subsequently undertaken by the Ministry of the Environment to determine the effects of the dumping. Future plans for the area include the construction of a rock wall/retaining bund surrounding the present dump site for use as a garbage landfill in the years to come (Liu 1989). The eastern side of the island has also been considered as a possible conservation area for inclusion into a marine reserve.

The present method of dumping uses excavators on barges to toss the earth spoils overboard. This method will have to be reviewed such that the earth spoils are sent directly to the bottom. Environmental impact studies should be implemented before, during and after such activities.

### Commercial and recreational activities

The construction of tourist facilities in some of the southern islands will continue with major projects already planned. Resort hotels are being built on Sentosa, Singapore's major island resort and Lazarus Island will also be developed with a resort hotel. Man-made lagoons are created on these islands and more areas of the sea are being reclaimed. These have immediate physical impacts and will alter water flow around the reefs. They will also act as point sources of pollution, and therefore need to be effectively managed.

Reef visitors can cause damage to the ecosystem in several ways. Firstly, anchor damage by boats can be significant. Without mooring points, anchors and their chains/ropes break up and damage live colonies and reduce already dead ones to rubble, leaving behind a loose and unstable reef slope. Most diving and snorkelling activities cause some damage to corals and other reef biota. At well frequented locations like island resorts and picnic areas, the perturbations can be significant and large coral stands can be rapidly reduced to rubble with local loss of fragile species (Salm & Clark 1984).

The intensity of such activities can be regulated to enable a natural repair of damage. Recreational activities should be confined to less sensitive zones where easy monitoring can be carried out.

### Pollutants

The presence of numerous ships and shipyards along the coastline contributes to the degradation of the reefs. Antifouling paints and agents selectively destroy and damage elements of zooplankton and reef communities



(Salm & Clark 1984). Physiological processes, like reproduction, are affected when larval stages are aborted due to high concentrations of pollutants. Oil spills are a major hazard with the high risks during bunkering and transferring operations at the wharves (Chia *et al.* 1988).

The industries on the islands are also potential sources of pollution. The concentrations of various heavy metals in the coastal waters have been reported to be within international safety guidelines (Chia *et al.* 1988). At present, the Port of Singapore Authority and various government agencies have been monitoring the situation closely and the threat is not considered serious.

## COASTAL AREA MANAGEMENT CONSIDERATIONS

### Lessons learned

The main island of Singapore was developed under a Master Plan since 1958 (Chia & Khan 1987), however, there is no single authority charged with the management of coastal land and waters (Chia 1984). Instead, a total of 14 different agencies are involved in managing various aspects of the coastal zone. The facilities on the southern islands were not developed within a systematic framework, as development was geared towards the specific uses the islands were brought under. Thus far, the utilization patterns of the southern islands have achieved satisfactory results but for the future, a well thought-out comprehensive planning framework may be more useful in reducing user-conflicts on these islands. The use of Singapore's coastal resources has benefitted the country tremendously, giving it economic and social stability. However, the price paid for the rapid changes and intense use of coastal resources and space has been the degradation of the environment. User-conflicts are present today and more will inevitably emerge (Chia 1992).

A local conservation group is attempting to transfer large amounts of live corals and other reef-associated fauna from a coral reef site destined for reclamation to another reef (Gan,

L.W.S. pers. comms.). The intentions and efforts are commendable and the long term results are eagerly awaited. Studies by Yap *et al.* (1990) on coral transplantation in a tropical environment revealed the conditions under which colonies were successfully transplanted: size and shape of the transplant material, biology of the transplant species, site and environmental considerations, transport and handling, and position and orientation of the transplants. With so many variables to consider in such a project, the survival rate of the transplants carried out in the Singapore project and the ultimate success is currently unpredictable. However, the project personnel have made public claims of tremendous success in the project giving the impression to developers, planners and policy makers that transplantation of coral reefs is a workable solution and a convenient alternative to reef conservation.

Different models of coral reef conservation exist throughout the world. In the Philippines, community-based marine reserves have been set up for coastal management (White 1989). In Costa Rica, government intervention has effectively ensured development of tourism without serious negative impacts on the ecosystem. A coastal management plan for Singapore, which incorporates conservation of some marine resources is possible. In fact, Singapore's efforts in rational and effective use of the limited coastal zone has demonstrated a high degree of control and coordination of activities (Chua 1989). All it needs now is the inclusion of some conservation objectives.

### The need for conservation and CAM

While the need to maintain a competitive edge in the development and industrialisation of Singapore is important, there is also a need for a mature and cultured society to live in a satisfying and conducive environment. Coral reefs are already in place to provide that particular environment with a set of conditions that enable unique species of marine animals and plants to thrive. They are worth preserving and this objective should be promoted as a national goal. The idea of a marine reserve differs little from a terrestrial

nature reserve in accomplishing the same goals.

Coral reefs are important enough to be considered for conservation because of the following reasons:

- \* tourism and recreation which generates income; provide outlets for an increasingly leisure-conscious people; reduces the need for the local population to travel abroad to foreign marine attractions while making them readily available here.
- \* reefs, as self-repairing breakwaters along wave-swept shores, prevent coastal erosion and storm damage.
- \* highly active biocompounds with applications in medical and pharmacological research, such as compounds with antimicrobial, antileukemic, anticoagulant, anticoagulant and cardioactive properties (Ruggieri 1976).
- \* science and education in creating public awareness
- \* high diversity of fishes and reef-associated fauna

Coastal area management must include an enhanced awareness of the value of marine space and the need to optimize the use of the limited resources including the promotion of marine conservation. There is a need to extend the planning process to cover the coastal areas and to integrate the marine uses with coastal landuse. Issues arising from conflicts must be resolved through joint consultative committees from all interested parties, informal dialogues and other appropriate channels of communication, which should be established to avoid or minimise future conflicts, and to resolve existing ones. One umbrella agency should coordinate the large number (14) of agencies involved and promote the multiple-use and integrated development of coastal resources. This total approach can result in the formation of management plans on a broad perspective and the prioritization of available

resources for the maximum benefit of the nation. At the same time, non-governmental organisations should also be given opportunities to present their views. In the case of Singapore, a top-down approach with public consultations may be appropriate (Chua 1989).

## SUMMARY

Environmentally detrimental activities like large-scale dumping, over-harvesting and pollution must be curtailed and subsequently monitored. There is a need for more coordination in the area of optimising the use of the coastal and marine resources, thereby resolving user-conflicts. The usage of the limited coastal resources can then be determined by the developers, planners and policy-makers who will make well-informed decisions which are based on scientifically-sound methods of resource assessment.

If a coral reef conservation plan as proposed by the Singapore Reef Survey and Conservation Project is to succeed, its incorporation into a national coastal management plan is important. In addition, an existing organisation with the right infrastructure, like the National Parks Board, can enforce the park regulations and undertake improvement works on the environment and facilities for visitors. Periodic monitoring of the natural resources and levels of use must also be necessary.

## ACKNOWLEDGEMENTS

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