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ENVIRONMENTAL STATUS OF SINGAPORE'S CORAL REEFS

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EXECUTIVE SUMMARY

Singapore's coral reefs have been highly impacted by land reclamation, earth spoils dumping, non-regulated collection of fish and other reef organisms and the intensive coastal development. However, not all its coral reefs are lost. Reef research increased rapidly over the last decade with the inception of the ASEAN-Australia Marine Science Project: Living Coastal Resources. Other studies include community structure of the coral reefs, productivity and growth of corals and extraction of bioactive compounds from corals. These studies showed that coral species diversity remain comparable to that of the region. Management and conservation issues have been proposed resulting in some reefs being designated for conservation in the country's Green Plan.

INTRODUCTION

Singapore's limited sea space 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 change to land and sea. These included large-scale reclamation of coastal areas, offshore islands and patch reefs for expanding industries, residential and recreational needs.

Early surveys and reports dating back to the 1960s' were mainly qualitative in nature (Chuang, 1961 & 1973; Tham, 1973). Further research was restricted to studies of *Amphiprion* spp. (Ting, 1966; Kwok, 1968) and mushroom corals (Goh, 1965). Other detailed work included studies on the biology and taxonomy of certain groups of corals; fungiids, faviids, dendrophylids, pocilloporids and acroporids (Tan, 1970; Tan, 1972; Moll, 1977; Williams, 1977; Yeo, 1977; Krishnaveni, 1986; Koh, 1988; Krishnaveni *et al*, 1989; Chung, 1991; Lane, 1991; Quek, 1991 and Leow, 1993).

The ASEAN-Australia Marine Science Project: Living Coastal Resources (LCR) was the only long-term, systematic quantitative monitoring programme of the reefs and their organisms. The contribution of the LCR project to marine science research in Singapore was discussed by Chou (1991a). Much of the research conducted in the late 1980s stemmed directly or indirectly from this project.

Another project involving three non-governmental organisations (Republic of Singapore Yacht Club, Singapore Institute of Biology and Singapore Underwater Federation) and conducted between 1987 and 1991 provided information on the condition of most of the coral reefs in the southern waters of Singapore. The aim of the Reef Survey and Conservation Project was to identify the better reefs in terms of biological richness, which were worthy of being conserved (Chou, 1990a; 1991b).

RESULTS OF REEF STUDIES

The coral reef community of Singapore has been reported by numerous researchers (Teo, 1982; Chou, 1985, Chou & Teo, 1985; Chou & Wong, 1985; Chou, 1986a; Chou & Koh, 1986; Chou & Wong, 1986; Chong, 1986; Chou & Lim, 1988; Chou, 1988a; Lim *et al.*, 1990; Chua & Chou, 1991; Chua & Chou, 1992).

Data collected over a 10-year period from the ASEAN-Australia Living Coastal Resources Project (LCR), showed that 197 hard coral species belonging to 55 genera occur in Singapore reefs (Appendix 1) (Chou, 1989; 1992b; 1993). Percentage live coral cover ranged from 0% at the 6m and/or 10m depths of the reef slope, to 76% at the 0m (reef crest) and/or 3m depths in the first survey. The upper limit of coral cover subsequently dropped to 72% in survey 2 and 69% in survey 3.

Under the Reef Survey and Conservation Project, 65 sites on 41 reefs were surveyed. The results obtained showed that live coral cover at the reef crest ranged from 3.6% to 75.3% (Fig. 1). Only five sites had live coral cover greater than 70%. Most of the sites had between 30 to 50% cover.

Foliose growth forms were found to be the dominant ecomorph at the reef crest, 3m and 6m depth below the crest (Goh *et al*, in press). This was probably due to their efficient utilisation of available light and aggressive competition for space. The growth rates of the fast-growing *Acropora* were found to be lower than those documented elsewhere (Chung, 1991). Radial growth rates for massive faviids, however, corresponded to documented averages (Lane, 1991).

The biology of certain groups, like the crinoids (Lim, 1987), gorgonians (Goh, 1991; Goh & Chou, 1994), hard coral associates (Goh *et al.*, 1989), the tunicates (Lane, 1987) and sea urchins (Lee, 1968; Hori *et al.*, 1987) have also been studied. The community structure of other reef fauna and flora was studied by Goh & Chou (1991). Another study by Goh & Chou (in press) described the reefs of Singapore as having three distinct zones in non-scleractinian distribution. These were the macroalgae at the crest, a mix of soft corals, sponges and 'others' at the 3m and 6m depth from the crest, and a sponge zone at the 10m depth from the crest. There was also an increase in the cover (relative to live coral cover) of non-scleractinian component with depth, but their absolute cover (relative to the area surveyed) remained fairly constant.

New insights into the physiology of the reef organisms have resulted from recent research into extraction of bioactive compounds from corals (Ding *et al.*, 1994), inter- and intra-specific

interaction between coral colonies (Wong & Chou, 1993) and productivity of coral organisms (Tun *et al.*, in press [a]; [b]). Enhancing degraded reefs through the use of artificial substrata has also been investigated (Chong, 1985; Chou, 1986b; Chou & Hsu, 1988; Chou, 1988b; Chou, 1991b).

Diversity and abundance of reef fish were recorded using the visual census method, and were previously reported by Lim *et al.* (1990), Lim & Chou (1991a) and Low & Chou (1992). Results from the studies showed that the abundance and diversity of fishes decreased with depth but increased with distance from the mainland. More than 198 species of fish have been recorded from Singapore reefs (Appendix 2), which compared favourably with studies done in the Gulf of Thailand (Satumanatpan & Sudara, 1992) and in North Bais Bay in the Philippines (Luchavez & Alcala, 1992). The population dynamics of the pomacentrid community at one reef were also investigated (Leng, 1990), and a pilot study on the recruitment of fish was conducted (Low & Chou, in press [a]). Twenty species from 12 families were observed, dominated by the pomacentrids, especially *Pomacentrus cuneatus*, and they recruited during two periods, one in April and another in October-November.

The threatened plants and animals of Singapore have recently been compiled in "The Singapore Red Data Book" (Ng & Wee, 1994). Twenty-eight species of corals and gorgonians are listed as endangered or very rare.

ENVIRONMENTAL IMPACTS

Pollutants

Singapore's port is one of the busiest in the world. The presence of numerous ships and shipyards along the coastline are a potential threat to the marine ecosystem. Antifouling paints and agents selectively destroy and damage elements of zooplankton and the reef communities. High concentrations of pollutants affect physiological processes like reproduction where larval stages are aborted. Heavy metal concentrations in the waters around Singapore were observed to be correlated to proximity with shipping activities (Goh & Chou, in press). This places the coral reefs around the southern islands at risk, as these islands are surrounded by major shipping lanes. However, the effects of these pollutants have not been studied *in situ*. Oil spills are another major potential hazard, especially, during bunkering and transferring operations at the wharves (Chia *et al.*, 1988).

Riverine discharge

Impacts from riverine discharge is negligible, as most of Singapore's reefs are located at the southern islands, away from the mainland's major river systems. However, regular monitoring of water quality and benthic communities of the major rivers are conducted (see sections on Singapore's watersheds and coastal wetlands).

Sedimentation

The northeastern and southern coasts of Singapore have undergone extensive land reclamation 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. As a result of these plans, 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 has been greatly reduced from 10m in the 1960s to 2m today.

Other activities, such as dredging and earth spoil dumping are also reponsible for the high sediment levels observed. For example, earth spoils have been dumped in the waters near Pulau Semakau, one of the larger southern islands, since December 1988. Approximately one million cubic metres were deposited into this area by the end of 1991 (Quek, 1989). The dumped materials consisted mainly of soft and soggy marine clay. Future plans for the Pulau Semakau area included the construction of a rock wall/retaining bund surrounding the present dump site for use as a garbage landfill for the next 50 years. The present method of dumping uses excavators on barges to drop the earth spoils overboard. This causes many surrounding areas to be affected as the earth spoils are swept about by tidal currents before reaching the bottom.

These activities have resulted in a significant increase in sedimentation, from 3-6 mg $cm^{-2}d^{-1}$ in 1979 (Chan, 1980), to 5-45 mg $cm^{-2}d^{-1}$ (Lane, 1991; Low & Chou, in press [b]). The settlement and accumulation of sediment, and decreased light penetration at the lower slopes contribute to the decline of the reef community in terms of abundance and species richness. The effect of reef flat reclamation on live coral cover at the crest and slope was discussed by Chou (in press), who showed that live coral cover at the crest and slope was depressed on reefs with reclaimed flats compared to reefs with intact flats. In the case of P. Semakau, long-term monitoring of the reefs has shown a drastic decrease of live coral cover (Chou *et al.*, in press).

Fishing and collecting

The removal of fish and other reef-associated fauna has continued in the past without any form of management. Reef fish were collected mainly for the aquarium trade with the use of barrier nets and fish traps. Corals and shells have also been collected until recently when the coast guard began to take action against the removal of corals.

Commercial and recreational activities

Major projects such as the construction of tourist facilities, will continue on some of the southern islands. Hotels were built on Sentosa, the major island resort of Singapore, and man-made lagoons were also created on some of the islands. As such, more areas of the sea were reclaimed resulting in immediate physical impacts like alteration of water flow around the reefs. These areas can also become point sources of pollution with the increased visitor facilities.

Visitors to the reefs can additionally cause several types of damages. For example, without mooring points, anchor damage by boats can be significant. The anchors and their chains/ropes break up and damage live coral colonies and reduce already dead ones to rubble, leaving a loose and unstable reef slope. Even snorkelling and SCUBA diving activities can cause some damage

to corals and other reef organisms. At sites where these activities are popular, such disturbance can be significant with large coral stands being reduced to rubble and fragile species lost (Salm & Clark, 1984). If the intensity of such activities is regulated, there can be natural repair of the damages.

Coral bleaching

This phenomenon, attributed to the El Nino event, did not affect corals in Singapore. While no field studies were conducted on coral bleaching, researchers did not report any occurrences of widespread bleaching during such events when reefs in the neighbouring countries were reportedly affected.

Natural impacts

Singapore reefs are sheltered and no widespread storm-induced damage has been reported. The reefs are also free from *Acanthaster* infestation. Coral damage caused by *Drupella* and other corallovires is not serious although isolated coral colonies have been attcked, but such instances are rare and not known to spread.

MANAGEMENT AND CONSERVATION

A national concept plan "Living the Next Lap" was presented in 1991 (URA, 1991), aimed at developing Singapore into a tropical city of excellence. Commonly referred to as the Green Plan, there will be a network of open spaces and waterways to provide a city with nature. Five percent of total land area has been set aside for nature conservation so as to promote appreciation of nature and interest in the Republic's natural heritage.

The workgroup on nature conservation, established to implement the policy directions in the Plan, identified 18 nature areas for conservation. Four marine areas were also identified (Fig 3). The boundary line demarcating these areas were arbitrarily drawn, but represented the minimum area possible, keeping in view the intense use of the water by various competing sectors. The total extent of the four areas make up 5.9% of the territorial waters (37.25km^2). Within these areas, coral reefs occupied 7km^2 while the islands took up 6.5km^2. These areas also contain a variety of other coastal habitats such as seagrass beds, mangroves and sand flats. The workgroup recommended that the Land Office (Ministry of Law) should continue its present policy of only granting permission to collect corals for scientific, conservation and research purposes.

After further consultation with various agencies and the public, an action programme of the Green Plan was published (MOE, 1993). In the section on nature conservation, the commitment to protect and conserve some of the most important areas of natural beauty and high biodiversity was accompanied by laying out policy directions on nature conservation.

The action programme called for the protection of coral reefs against commercial harvesting within the four identified areas. It called for tighter enforcement by the Coast Guard of the laws for the protection of corals. To further manage these reefs, water quality is to be monitored and

future land reclamation projects will be closely monitored to ensure that they do not cause pollution or excessive siltation of the seas. The action programme also called for widespread education and public awareness activities to promote nature appreciation.

Protection of terrestrial habitats is well taken care of by specialised authorities provided with the appropriate legislative framework but that of marine habitats has yet to be effectively addressed. There is no institutional mechanism for the coordinated protection of coral reefs and marine life. The government is presently reviewing existing laws and regulations to make protection of marine resources more effective and efficient.

Non-governmental organisations involved in marine conservation efforts have also joined forces recently to coordinate their efforts, pool resources and become stronger in making recommendations to the government. With all these initiatives by both non-governmental organisations and the government, the conservation of representative marine and coastal ecosystems in Singapore will be ensured.

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Appendix 1. Hard coral species recorded from Singapore reefs (Chou, 1989; Chou, 1992)

Species	Species
Acanthastrea echinata	*Echinopora gemmacea*
Acanthastrea hillae	*Echinopora hirsutissima*
Acropora acuminata	*Echinopora horrida*
Acropora anthocercis	*Echinopora lamellosa*
Acropora austera	*Echinophyllia aspera*
Acropora brueggemanni	*Echinophyllia echinata*
Acropora chesterfieldensis	*Echinophyllia echinoporoides*
Acropora danai	*Euphyllia ancora*
Acropora elseyi	*Euphyllia divisa*
Acropora formosa	*Euphyllia glabrescens*
Acropora grandis	*Favia amicorum*
Acropora horrida	*Favia favus*
Acropora lutkeni	*Favia laxa*
Acropora microphthalma	*Favia lizardensis*
Acropora nana	*Favia matthai*
Acropora nasuta	*Favia maritima*
Acropora nobilis	*Favia pallida*
Acropora palmerae	*Favia rotundata*
Acropora selago	*Favia speciosa*
Acropora tenuis	*Favia stelligera*
Acropora valida	*Favia veroni*
Acropora verweyi	*Fungia concinna*
Alveopora allingi	*Fungia corona*
Alveopora marionensis	*Fungia danai*
Astreopara cucullata	*Fungia echinata*
Astreopora gracilis	*Fungia fungites*
Astreopora listeri	*Fungia klunzingeri*
Astreopora myriophthalma	*Fungia moluccensis*
Caulastrea echinulata	*Fungia paumotensis*
Coscinaraea columna	*Fungia repanda*
Coscinaraea exesa	*Fungia scabra*
Cycloseris marginata	*Fungia scruposa*
Cycloseris vaughani	*Fungia scutaria*
Cyphastrea chalcidicum	*Fungia simplex*
Cyphastrea microphthalma	*Favites abdita*
Cyphastrea serailia	*Favites chinensis*
Dendrophyllia gracilis	*Favites complanata*
Dendrophyllia micranthus	*Favites flexuosa*
Diploastrea heliopora	*Favites halicora*
Distichopora violacea	*Favites pentagona*
Echinopora aspera	*Favites russelli*

Appendix 1 (cont'd)

Species	Species
Galaxea astreata	*Montipora danae*
Galaxea fascicularis	*Montipora digitata*
Gardineroseris sp.	*Montipora efflorescens*
Goniopora columna	*Montipora foliosa*
Goniopora djiboutiensis	*Montipora grisea*
Goniopora fruticosa	*Montipora hispida*
Goniopora lobata	*Montipora informis*
Goniopora pandorensis	*Montipora monasteriata*
Goniopora somaliensis	*Montipora millepora*
Goniopora stokesi	*Montipora mollis*
Goniopora stutchburyi	*Montipora spongodes*
Goniastrea aspera	*Montipora spumosa*
Goniastrea australiensis	*Montipora stellata*
Goniastrea edwardsi	*Montipora tuberculosa*
Goniastrea favulus	*Montipora undata*
Goniastrea pandoraensis	*Montipora venosa*
Goniastrea pectinata	*Montipora verrucosa*
Goniastrea retiformis	*Montastrea annuligera*
Goniastrea stutchburyi	*Montastrea curta*
Heliofungia actiniformis	*Montastrea magnistellata*
Heliopora coerulea	*Montastrea valenciennesi*
Herpolitha limax	*Mycedium elephantotus*
Herpolitha weberi	*Oulophyllia crispata*
Hydnophora exesa	*Oxypora crassispinosa*
Hydnophora rigida	*Oxypora glabra*
Leptoria phrygia	*Oxypora lacera*
Leptastrea transversa	*Pachyseris rugosa*
Leptoseris explanata	*Pachyseris speciosa*
Leptoseris scabra	*Pavona cactus*
Lithophyllon edwardsi	*Pavona clavus*
Lithophyllon undulatum	*Pavona decussata*
Lobophyllia corymbosa	*Pavona explanulata*
Lobophyllia hataii	*Pavona frondifera*
Lobophyllia hemprichii	*Pavona varians*
Madracis kirbyi	*Pectinia alcicornis*
Merulina ampliata	*Pectinia lactuca*
Merulina scabricula	*Pectinia paeonia*
Millepora exesa	*Physogyra lichtensteini*
Montipora aequituberculata	*Platygyra daedalea*
Montipora angulata	*Platygyra lamellina*
Montipora capricornis	*Platygyra pini*
Montipora corbettensis	*Platygyra sinensis*
Montipora crassituberculata	*Platygyra verweyi*

Appendix 1 (cont'd)

Species	Species
Plerogyra sinuosa	*Psammocora contigua*
Pocillopora damicornis	*Psammocora digitata*
Podabacia crustacea	*Psammocora explanulata*
Polyphyllia talpina	*Psammocora superficialis*
Porites australiensis	*Scapophyllia cylindrica*
Porites cylindrica	*Symphyllia radians*
Porites lichen	*Symphyllia recta*
Porites lobata	*Trachyphyllia geoffroyi*
Porites lutea	*Tubastraea aurea*
Porites murrayensis	*Turbinaria frondens*
Porites nigrescens	*Turbinaria irregularis*
Porites rus	*Turbinaria peltata*
Porites solida	*Turbinaria radicalis*
Porites stephensoni	*Turbinaria reniformis*
Porites vaughani	

Appendix 2. Coral reef fish species observed in Areas 1 to 4, Singapore (from Tay & Khoo, 1984; Chou, 1990; Chou *et al.*, 1991; Lim & Chou, 1991a; Lim & Chou, 1991b; Low & Chou, 1992; Chou, 1992; Chua & Chou, 1994).

Family	Species
Acanthuridae	*Acanthurus* sp.
Apogonidae	*Apogon bandanensis*
	Apogon chrysotaenia
	Apogon compressus
	Apogon cyanosoma
	Apogon sealei (niger?)
	Apogon trimaculatus
	Cheilodipterus macrodon
	Cheilodipterus quinquelineatus
	Sphaeramia nematoptera
Atherinidae	*Atherina* sp.
Batrachoidae	*Halophryne diemensis*
	Halophryne trispinosus
Blennidae	*Entomacrodus stellifer lighti*
	Meicanthus grammistes
	Osmobranchus sp.
	Petroscirtes temmincki
	Blenny sp1 (brown)
	Blenny sp2 (grey and yellow)
Brotulidae	*Dinematichthys iluocoeteoides*
Caesionidae	*Caesio caerulaureus*
	Caesio erythrogaster
	Caesio teres
Carangidae	*Alectis (ciliaris?)*
	Carangoides ferdau
	Selaroides leptolepis
	Carangid sp.
Centrisidae	*Aeoliscus strigatus*
Centropomidae	*Psammoperca waigiensis*

Appendix 2 (cont'd)

Family	Species
Chaetodontidae	*Chaetodon octofasciatus*
	Chelmon rostratus
	Parachaetodon ocellatus
	Coradion chrysozonus
Congogadidae	*Congrogadus subducens*
Dasyatididae	*Taeniura lymna*
Ephippidae	*Platax orbicularis*
	Platax pinnatus
	Platax tiera
Gobiidae	Goby sp1 (big goby)
	Acentrogobius sp.
	Amblygobius sp.
	Amblygobius sphynx
	Smilogobius singapurensis
Grammistidae	*Diploprion bifasciatus*
Haemulidae	*Plectorhynchus pictus*
	Plectorhynchus chaetodontoides
Hemirhamphidae	*Hemirhamphus far*
Holocentridae	*Holcentrum rubrum*
	Myriprisis murdjan
Labridae	*Bodianus mesothorax*
	Cheilinus diagrammus
	Cheilinus fasciatus
	Choerodon anchorago
	Choerodon schoenleinii
	Duymaeria flagellifera
	Halichoeres bicolor
	Halichoeres chloropterus
	Halichoeres dussumeri
	Halichoeres hoeveni
	Halichoeres hartzfeldii
	Halichoeres melanochir
	Halichoeres melanurus
	Halichoeres nigrescens

Appendix 2 (cont'd)

Family	Species
	Halichoeres scapularis
	Halichoeres sp. (green)
	Hemigymnus melapterus
	Labroides dimidiatus
	Pterogogus flagellifera
	Pteragogus sp.
	Thalassoma lunare
	Stethojulis trilineata
	Stethojulis strigiventer
	Unidentified brown labrid
Leiognathidae	*Leiognathus equulus*
	Leiognathus splendens
Lutjanidae	*Lutjanus carponotatus*
	Lutjanus chrysotaenia
	Lutjanus decussatus
	Lutjanus johni
	Lutjanus lutjanus
Lethrinidae	*Lethrinus nebulosus*
Monacanthidae	*Monacanthus chinensis*
	Monacanthus macrurus
	Monacanthus tormentosus
Monodactylidae	*Monodactylus argenteus*
Mugilidae	*Mugil* sp.
Mugiloididae	*Parapercis clathrata*
	Parapercis xanthozona
Mullidae	*Upeneus tragula*
Muraenidae	*Gymnothorax* sp.
	Muraenichthys sp.
Nemipteridae	*Pentapodus caninus*
	Pentapodus setosus
	Pentapodus trivittatus
	Scolopsis affinis
	Scolopsis bilineatus

Appendix 2 (cont'd)

Family	Species
	Scolopsis dubiosus
	Scolopsis leucotaenia
	Scolopsis margaritifer
	Scolopsis phaeops
	Scolopsis trilineatus
	Scolopsis vosmeri
Ostraciidae	*Ostracion* sp.
Pempheridae	*Pempheris* sp. 1
	Pempheris sp. 2
Platycephalidae	*Platycephalus nematophthalmus*
Plotosidae	*Paraplotosus albilabris*
Pomacanthidae	*Chaetodonoplus mesoleucus*
	Pomacanthus annularis
	Pomacanthus sexstriatus
Pomacentridae	*Abudefduf bengalensis*
	Abudefduf sexfasciatus
	Abudefduf notatus
	Abudefduf saxatilis
	Abudefduf septemfasciatus
	Abudefduf vaigensis
	Amblyglyphidodon curacao
	Amblyglyphidodon leucogaster
	Amphiprion clarkii
	Amphiprion frenatus
	Amphiprion melanopus
	Amphiprion ocellaris
	Chromis cinerascens
	Chromis atripectoralis
	Chrysiptera sp.
	Chrysiptera unimaculata
	Dascyllus trimaculatus
	Dischistodus chrysopoecilus
	Dischistodus fasciatus
	Dischistodus prosopotaenia
	Eupomacentrus apicalis
	Hemiglyphidodon plagiometapon
	Neopomocentrus cyanosomos

Appendix 2 (cont'd)

Family	Species
	Neopomacentrus filamentosus
	Neopomacentrus nemurus
	Neopomacentrus taeniurus
Pomacentridae	*Neoglyphidodon melas*
	Neoglyphidodon nigroris
	Pomacentrus albimaculus
	Pomacentrus alexanderae
	Pomacentrus bankanensis
	Pomacentrus brachialis
	Pomacentrus grammorhynchus
	Pomacentrus littoralis
	Pomacentrus moluccensis
	Pomacentrus popei
	Pomacentrus rhondonatus
	Pomacentrus tripuntatus
	Pomachromis richardsoni
Scaridae	*Scarus ghobban*
	Scarus sp.
Scorpaenidae	*Scorpaena picta*
	Scorpaenopsis cirrhosa
	Synanceja horrida
Serranidae	*Cephalopholis argus*
	Cephalopholis boenack
	Cephalopholis miniatus
	Cephalopholis pachycentron
	Cromileptes altivelis
	Epinephalus tauvina
	Plectropomus maculatus
Siganidae	*Siganus guttatus*
	Siganus javus
	Siganus virgatus
Sphyraenidae	*Sphyraena flavicauda*
	Sphyraena sp.
Tetraodontidae	*Arothron mappa* (?)

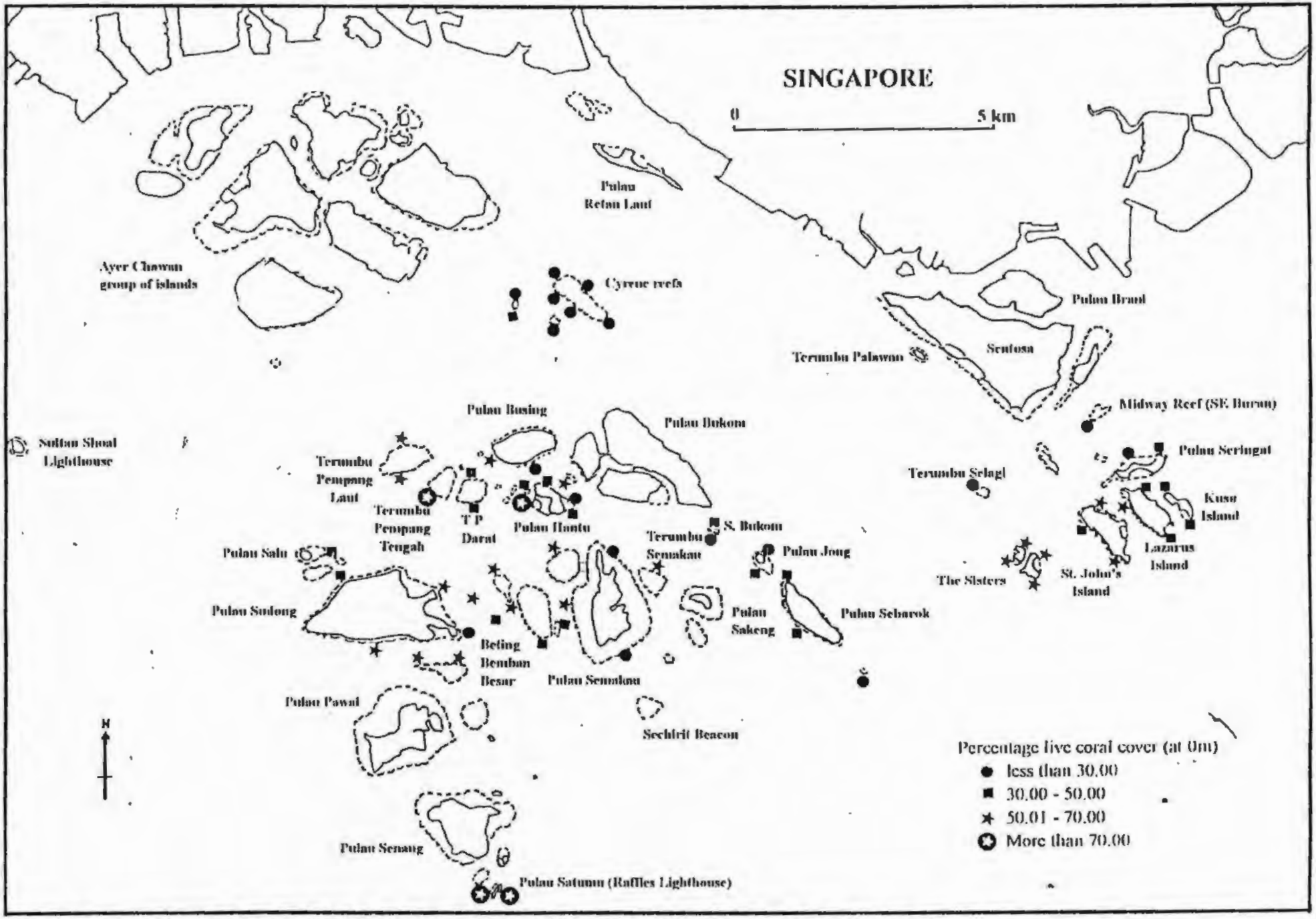

Fig. 1. Map of Singapore's southern islands showing condition of reefs surveyed (based on live coral cover).

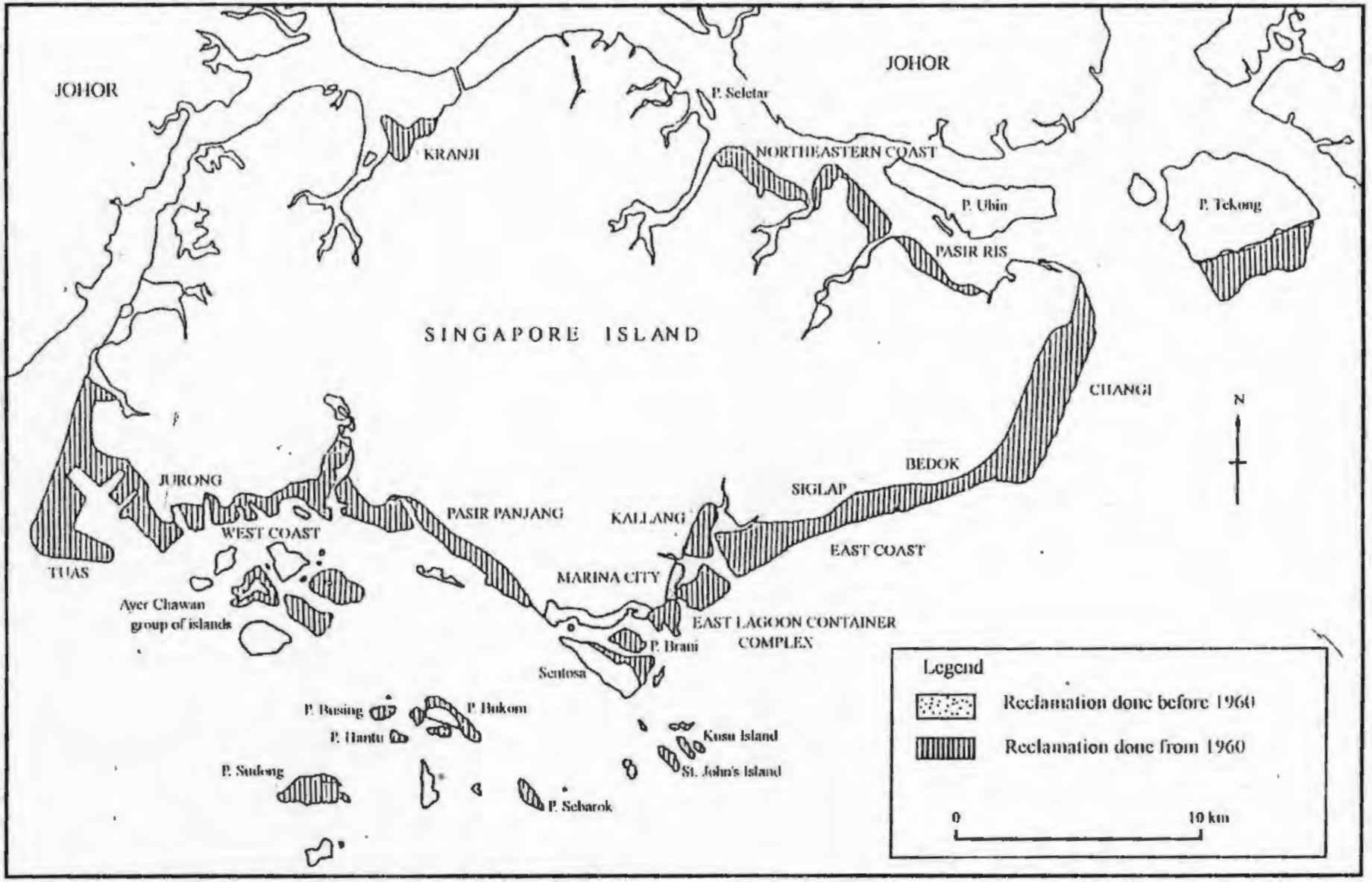

Fig. 2. Map of Singapore showing extent of land reclamation.

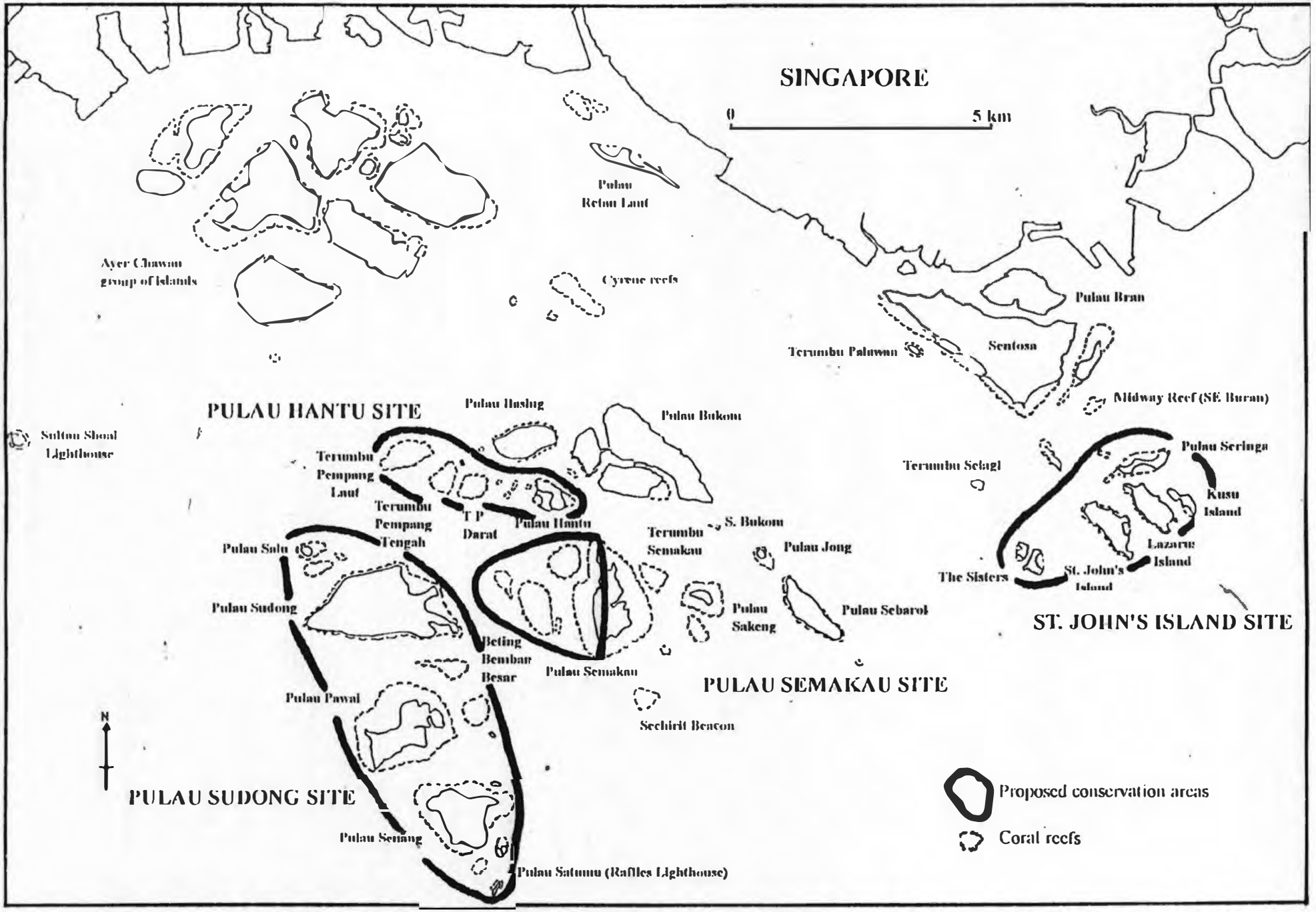

Fig. 3. Map of Singapore's southern islands showing the four marine areas identified for conservation.