INTERNATIONAL CORAL REEF INITIATIVE (ICRI)
REGIONAL WORKSHOP FOR THE EAST ASIAN SEAS

(Indonesia, Bali, 18 -22 March 1996)

SINGAPORE
NATIONAL REPORT

NB: **This report was received on 26 February 1996 from Ministry of Environment, as Singaporean National Report for the ICRI Regional Workshop for the East Asian Seas.**

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MARCH 1996

ISSUES AND COUNTRY PRIORITIES RELEVANT TO CONSERVATION OF CORAL REEFS AND RELATED ECOSYSTEMS IN SINGAPORE

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1. *Key country issues relevant to the conservation and sustainable use of the coral reefs and related ecosystems (including mangroves and seagrass areas):*

1.1 Management, including relevant legislation and funding

Pollution

There is an ever present risk of pollution from the heavy shipping activity and shipyards along the coastline. Pollutants include antifouling paints and agents, heavy metals and oil spills. The Port of Singapore Authority (PSA) monitors for hydrocarbons. In general, pollutant levels have remained within acceptable limits.

Impact of riverine discharge on the coral reefs is negligible in Singapore's case. The Ministry of the Environment monitors pollutant levels in the rivers and along shores and has a concerted programme since the early 1980s to clean up the rivers. Pollutant levels monitored since then have shown marked improvement in water quality and within acceptable limits since the late 1980s.

All sewage is treated before discharge. Industrial waste has to be treated on-site before discharge into the sewage system. The Ministry of the Environment, in conjunction with the National University of Singapore has a current five-year programme to monitor the water quality and biotic diversity of the major river systems.

The threat of oil pollution to the mangroves was discussed in Chou *et al.* (1980) and several oil spills have been reported along Singapore's coast (Prema & Chua, 1987). Recent studies on heavy metal concentrations in marine sediment (Goh & Chou, in press) showed a correlation with proximity to shipping activities.

Reclamation and Development

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 much of the southern islands will be developed and marine life affected as the coral reefs and seagrass beds become buried. High sedimentation levels from these activities have been recorded. Dredging and earth spoil dumping are also partly responsible.

Other impacts from the development of the islands include alteration of water flow around the reefs, point sources of pollution from visitor facilities, anchor damage from pleasure craft, disturbances caused by snorkellers and SCUBA divers.

Certain mangrove areas (eg. Sungei Buloh) were developed for prawn and poultry farming in the past. However, such activities on the mainland have ceased, and are now confined to the island of Pulau Ubin in the northeast.

Unmanaged activities
Fishing and collecting, either for the aquarium trade or for subsistence, is on the decline.

Natural impacts
Coral bleaching, attributed to the El Nino event, did not affect corals in Singapore. Storm-induced damage and *Drupella* infestations are negligible. *Acanthaster* infestations have not been recorded before.

1.2 Capacity building, including public awareness at every level

Several organisations are involved in the dissemination of information on conservation issues to the public:

The Nature Society (Singapore) is made up of conservation-minded individuals, and is educating the public through talks and books, such as the "The Singapore Red Data Book" (Ng & Wee, 1994). Twenty-eight species of corals and gorgonians are listed as threatened or very rare. However, the emphasis of the Society is terrestrial.

The Reef Survey and Conservation Project involving three non-governmental organisations (Republic of Singapore Yacht Club, Singapore Institute of Biology and Singapore Underwater Federation) conducted surveys between 1987 and 1991, providing information on the condition of most of the coral reefs in the southern waters of Singapore. They identified four areas of coral reefs worthy of being conserved (Chou, 1990; 1991a). One hundred and forty volunteer divers were trained for these surveys.

The Singapore Environmental Council (previously called the National Council on the Environment), has initiated many projects aimed at increasing the awareness of school students on conservation issues, including the Reefs Insights programme.

The National University of Singapore, comprising academic staff, research assistants and post-graduate students, supply scientific and technical support to many of the projects and publications on conservation.

1.3 Research and monitoring

Coral reefs
The Reef Survey and Conservation Project surveyed 65 sites on 41 reefs between 1987 and 1990. Results showed that live coral cover at the reef crest ranged from 3.6% to 75.3%. Only five sites had live coral cover greater than 70%. Most of the sites had between 30 to 50% cover.

The ASEAN-Australia Living Coastal Resources Project (LCR) recorded 197 hard coral species belonging to 55 genera (Chou, 1989; 1991b; 1992; 1993). Live coral cover was found to range 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 (in 1987). This upper limit of coral cover subsequently dropped to 72% in survey 2 (in 1991) and 69% in survey 3 (completed in 1994). Foliose growth forms were found to be the dominant ecomorph at the reef crest, 3m and 6m depth below the crest (Goh *et al.*, 1994).

Other studies on coral reefs included:

- Community structure (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; Goh & Chou, 1991; Chua & Chou, 1992; Goh & Chou, 1994a);
- Distribution and systematics of the crinoids (Lim, 1987) and hard coral associates (Goh *et al.*, 1989);
- Biology of the gorgonians (Goh, 1991; Goh & Chou, 1994b), tunicates (Lane, 1987) and sea urchins (Lee, 1968; Hori *et al.*, 1987);
- Bioactive compounds from corals (Ding *et al.*, 1994);
- Inter- and intra-specific interaction between coral colonies (Wong & Chou, 1993)
- Productivity of coral organisms (Tun *et al.*, 1994 [a]; [b]);
- The enhancement of degraded reefs through the use of artificial substrata (Chou, 1986b; Chou & Hsu, 1988; Chou, 1988b; Chou, 1991c; Chua & Chou, 1994).
- Community structure of reef fish (Lim *et al.*, 1990; Lim & Chou, 1991; Low & Chou, 1992).
- Population dynamics of the pomacentrid community (Leng, 1990);
- A pilot study on the recruitment of fish was conducted (Low & Chou, 1994a).
- Sedimentation rates (Chan, 1980; Lane, 1991; Low & Chou, 1994b).

These studies indicate that coral species diversity remain comparable to that of the region, despite the high and increasing sedimentation rates recorded, from 3-6 mg $cm^{-2}d^{-1}$ in 1979 (Chan, 1980), to 5-45 mg $cm^{-2}d^{-1}$ (Lane, 1991; Low & Chou, 1994b).

Seagrass

Earlier work on seagrass communities include research on the associate shrimp, *Periclimenes indicus* of *Enhalus* beds at Pulau Hantu (Itoggi, 1971), while Low (1973) recorded 22 species of molluscs at the same seagrass area.

Much of the work on seagrass was conducted during the ASEAN-Australia Marine Science Project, Living Coastal Resources, including :

- Quantitative and qualitative assessment of seagrass distribution

and associated fauna. A total of seven seagrass species have been observed in Singapore's coastal waters, including *Enhalus acoroides*, *Cymodocea rotundata* and *Halophila ovalis*, *Halophila minor* (*H. ovata*) and *Halophila spinulosa*, *Halodule uninervis* and *Cymodocea serrulata* (Hsu & Chou, 1989a & b).

- Loo *et al.* (1990) conducted a qualitative study on the seagrass-associated fish community (15 years after the island was developed) using a visual census method. Despite the patchy distribution of *Enhalus*, a total 13 species of fish from nine families were recorded, most of which were juveniles, reflecting the importance of seagrass communities as nursery grounds for juveniles.
- Preliminary *in situ* primary productivity work has been conducted on *Enhalus acoroides* using an automated respirometer (Tun *et al.*, 1994a). Maximum instantaneous gross production ($Pm_{(gross)}$) and respiration (Rd) were measured at 30.98 and 2.57 mol O_2 cm^{-1} min^{-1} while gross 24 hour production ($P24_{(gross)}$) and respiration (Rd24) were 6.03 and 3.01 $mMolO_2cm^{-2}day^{-1}$ respectively. These gave ratios for instantaneous $Pm_{(gross)}$/Red and $P_{(gross)}$/Red of 11.1 and 2.6 respectively. This suggests that *E. acoroides* contributes positively to the total carbon pool of the reef-flat ecosystem, thus supporting a wide spectrum of organisms, either directly or indirectly.

Mangroves

The diversity of flora and fauna in Singapore's degraded mangrove areas is indicative of the richness that can be found in a mature system.

- A summary of the state of Singapore mangroves compiled by Chou *et al.* (1980) provided an inventory of 1200 taxa.
- An updated list of brachyuran crabs was reported by Tan & Ng (1994).
- Fish fauna in some mangrove areas were reported at Low & Chou (1993; 1994c) and Lim & Larson (1994).
- Murphy (1992) on the natural history of insect herbivory on mangrove trees.
- The benthic soft-bottom community of mangrove habitats has also been examined by Goh & Chou (1993) at Sungei Buloh and Chung & Goh (1990) at Pulau Tekong.
- Faunal zonation at Pandan mangroves (in the south of Singapore) was studied by Berry (1963).
- Murphy & Lee (1991) attempted to elucidate zonal patterns of mangrove trees from stem count data and measurement of tidal ranges in the Mandai mangroves (in the north of Singapore).

1.4 Others

The Department of Zoology, National University of Singapore, has been involved in many regional initiatives, such as the ASEAN-Australia Marine Science Project: Living Coastal Resources (1985 to 1995), the ASEAN-

US Coastal Resources Management Project (1987 - 1992), the ASEAN-Canada (since 1987) and the United Nations Environment Programme-East Asian Seas Action Plan, and the UNDP/IMO Regional Programme on the Prevention and Management of Marine Pollution in the East Asian Seas.

2. *Existing programmes relevant to coral reefs and related ecosystems and existing funding levels:*

2.1 Management, including the institutional and legal mechanisms and measures in relation to the development of the coastal and marine areas

National

Under the nation's "Green Plan", 5% 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. A workgroup on nature conservation was established to implement the policy directions in the Plan. Eighteen nature and 4 marine areas were identified for conservation. The marine areas have a total extent of 37.25km^2 (5.9% of the territorial waters). 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.

The laws governing environmental pollution were discussed by Lim *et al.* (1987) and Lye (1991). Steps are being taken to integrate and update existing laws, including the formulation of an "umbrella" law (Anon., 1994), and a review of current industrial site laws (Nathan, 1996).

Coral reefs

Stricter action against unlicensed collection on the reefs have been taken by the Coast Guard. In Oct 1991, five men were arrested by the Coast Guard and their cargo of corals confiscated. This arrest was the first of its kind in Singapore (Anon., 1991a).

Seagrass

The loss of seagrass beds has had little observable impact, despite its importance to fisheries as nursery grounds (Wood *et al.*, 1969). This is due to the near non-existence of commercial fisheries in Singapore waters. There was a reduction in subsistence fishing (Tham, 1973), but evidence to link this with the degradation of seagrass beds.

Mangroves

Trees were in the past harvested for firewood, charcoal and poles,

including "Nibong" trunks for fishing traps ("kelongs") and *Nypa* palm for sugar and seeds. A large variety of seafood was also harvested from mangrove areas.

Artisanal fisheries is on the decline, due to changes in the socio-economic profile of the community. Gear still in use include gill and trammel nets, fish traps, crab nets, long lines and kelongs. Much of the catch consists of groupers and snappers (*Epinephalus*, *Cephalopholis* and *Lutjanus* spp.), shrimps (*Penaeus* and *Metapenaeus* spp.) and crabs (*Scylla serrata* and *Portunus pelagicus*). Various kinds of molluscs (*Glauconome*, *Cerithidea*, *Telescopium*, *Geloina* spp.) are also collected in small numbers by hand for local consumption. Green mussel (*Perna viridis*) culture is practiced on a small scale. Small numbers of the horseshoe crab (*Carcinoscorpius rotundicauda*) are also occasionally collected for their eggs.

The only mangrove area that has been designated as a nature reserve is at Sungei Buloh. The situation with the Sungei Buloh Nature Park was comprehensively discussed by Murphy & Sigurdsson (1990), who also provided an historical account of previous studies on Singapore mangroves.

2.2 *Capacity building, including public awareness*

Coral reefs

The Coral Reef Naturalist course for scuba divers was developed by the Singapore Institute of Biology and the Singapore Underwater Federation. This course trains divers to identify and appreciate the underwater environment.

A programme targeting secondary and junior college students has also developed. The Reef Insights course, jointly organised by the Singapore Environmental Council and the Singapore Science Center reaches out to high school students, giving the an awareness of the coral reef environment, its inhabitants, and the threats faced.

Courtesy mooring buoys were deployed by the Singapore Environment Council and Raffles Marina in 1994 (sponsored by Shell Pte Ltd.) around a reef popular with boats and divers in an effort to reduce anchor damage.

Posters and publications from the Dept of Zoology, National University of Singapore and the Singapore Science Centre provided an educational value to the public. The Department has enhanced its capacity for marine science monitoring since 1984 with better equipment and facilities. Staff of the Department are also represented in regional initiatives in marine biology.

2.3 Research and monitoring

Coastal areas
The major rivers of Singapore are the subject of a 5-year biological monitoring programme. This project is a joint project involving the Department of Zoology, National University of Singapore and the Ministry of the Environment, and began in 1993.

Coral reefs
Monitoring of artificial reefs as an enhancement tool in the rehabilitation of degraded reefs. This project was initiated in 1989 and is on-going.

Monitoring the impact of Pulau Semakau landfill on the ecosystem; undertaken by the Dept of Zoology, National University of Singapore.

Seagrass
Broad scale studies have yet to be initiated, since the conclusion of the ASEAN-Australia LCR Project.

Mangroves
Certain areas where reforestation is taking place are being monitored. In addition, studies on the biodiversity of the fauna is continuing.

2.4 Others

The University is involved in the establishment of a Tropical Marine Science Institute on one of the offshore islands to enhance research in marine science.

3. *Country priorities for action for the conservation and sustainable use of the coral reefs and related ecosystems:*

3.1 Management, including relevant legislation and funding

General
Protection of terrestrial habitats is well established with specialised agencies having 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.

Coral reefs
The "green plan" action programme calls for the protection of coral reefs against commercial harvesting within the four identified areas, with the Coast Guard enforcing the laws for the protection of corals.

While it is not mandatory, many companies are now conducting baseline

studies and environmental impact assessments of the proposed major projects. Monitoring of these sites to ensure that they do not cause pollution or excessive siltation of the seas is also called for.

Seagrass

The importance of seagrass ecosystems as a sustainable resource has not been fully realised. As a result, no management plans for the conservation of existing seagrass stands or the restoration of denuded beds have been initiated. There was, however, a pilot study initiated by the Primary Production Department in 1989, to assess the use of artificial seagrass as a tool for enhancing fish communities in the Singapore River (Lee & Low, 1989). It was found that the use artificial seagrass was effective in enhancing the fauna of the river within three months of its implantation. An almost 100% increase in the number of families (from 12 to 24) and species (from 16 to 30) was recorded during the study period. The artificial seagrass also made a good ecological niche for stocked seabass which was found to remain and grow at the habitat one or two months after stocking. Unfortunately, the study was discontinued due to multisectoral conflicts on the use of the site.

Mangroves

Specific laws for the protection of the mangrove forests do not exist. However, all wild animals are protected under the Wild Animals and Birds (WAB) Act of 1974. In addition, the Parks and Trees Act of 1975 includes the protection of the natural habitat. A National Parks (NP) Act was introduced in 1990 for specific protection of animals in the parks and catchment areas. These Acts are administered by the Parks and Recreation Department and National Parks Board, respectively. A good account of wildlife legislation was given by Lye (1991), who pointed out certain loopholes in the structure of the laws. A major step towards the reconciliation of conservation laws in Singapore, is the present drafting of an "umbrella" environment law. This law will encompass four separate Acts that cover the environment in Singapore: the Water Pollution Act, the Clean Air Act, the Environment Public Health Act and the Poisons Act (Anon., 1994). A summary of the organisations involved in the maintenance of the environment was discussed by Lim *et al.* (1987).

Historically, concern over the destruction of the mangrove forests dates back to 1884, when mangrove areas were included in 5000 hectares of forest reserves (Wee & Corlett, 1986). The largest reserve was at Pandan. This reserve however, has been degazetted and has dwindled drastically over the years. The remnants of the original 1000 hectares of forest will be soon be cleared for development. Kranji mangroves, adjacent to the Mandai system, originally 300 hectares, were mostly destroyed when the Kranji Reservoir was developed. The Mandai mangroves have also been subjected to development. Expansion of the Singapore-Malaysia causeway has resulted in the loss of the Sungei Mandai Kechil mangrove forests. However, the development has spared mangroves in the adjacent Sungei Mandai Besar.

An inter-ministerial Steering Committee was formed to work out action plans to implement policy directions contained in the Green Plan. Six workgroups were established by the committee, of which one focused on nature conservation. Chaired by the Ministry of National Development, it comprised representatives from various government agencies, as well as the NSS. Eighteen areas, encompassing primary rainforests and secondary forests to mangroves and marshlands were identified for conservation. These areas are to be either managed by the State or Statutory Boards, or left "wild". The government has indicated its commitment to set aside no less than 5% of the land area of Singapore for conservation purposes (Anon.,1991b; 1993). These areas include the remaining mangrove forests at Sungei Buloh and the Mandai-Sungei Khatib Bongsu-Loyang network of mangroves. In addition, there are park areas which include mangroves, eg. Pasir Ris Park (northeastern Singapore).

3.2 *Capacity building, including public awareness at every level*

Non-governmental organisations involved in marine conservation efforts have joined forces, through the formation of the Singapore Reef Conservation Committee, to coordinate their efforts, pool resources and become stronger in making recommendations to the government.

Education and public awareness activities to promote nature appreciation have been implemented and will be continued.

3.3 *Research and monitoring*

In addition to monitoring programmes to detect temporal change in the coral reef community, seagrass beds and mangrove forests, emphasis on *in situ* studies on the effects of pollutants on the coral reefs and *in situ* coral reef productivity studies to further our understanding of coral biology must be initiated.

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THE INTERNATIONAL CORAL REEF INITIATIVE (ICRI) EAST ASIAN SEAS FOR THE REGIONAL WORKSHOP

BALI, INDONESIA

18-22 MARCH 1996

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REGIONAL REPORT - SINGAPORE

General characteristics

Coral reefs are located mainly around the islands south of Singapore. The reefs on the southern islands are mostly fringing reefs.

Major Issues Affecting Coral Reefs and Associated Environments

* Sedimentation from terrestrial run-off and development of coastal areas through land reclamation since the 1960s has seriously reduced the water quality of reef areas around Singapore (Chou, 1994). Hydrocarbon, chemical and organic pollutants are however, effectively controlled and managed.
* Coral communities in the northern waters of the Johore Strait, and reefs in the southwestern coast of the main island and the southern offshore islands have been affected by development
* An integrated management strategy for coastal waters does not exist, despite the increasing pressure of multiple use on coastal waters (Chou, 1995).

Relevant Activities for Conservation and Management

In 1991, three NGOs recommended to the Government that some coral reefs in the southern islands be conserved. Four reef areas were selected for conservation after a survey was conducted (using the transect method adapted from the ASEAN-Australia Marine Science Project: Living Coastal Resources) by over 150 volunteer sport divers. Results of this survey indicated the occurrence in these four areas of 197 species of scleractinian corals from 55 genera (Chou, 1993). Despite the diversity of corals observed in the survey, the abundance and diversity of the reef organisms such as fish, spiny lobsters, and molluscs has declined from dumping of spoils and removal by collectors.

In 1992, the Government, through the National Parks Board, carried out a detailed study on the feasibility of protecting and managing proposed areas. In 1993, the Working Group on Nature Conservation formed by the Government recommended making the proposed areas protected areas and imposing the following restrictions (Chou, 1995):

* restrict the issue of permits for coral collection to research, conservation, and educational purposes only
* enforce legislation to prevent illegal harvesting of corals
* prevent illegal dumping of materials within and around identified coral areas and also prevent pollution from land reclamation activities
* cultivate appreciation for nature among young Singaporeans
* raise general public awareness of nature conservation and improve resources to provide its appreciation
* avoid indiscriminate promotion of ecotourism

Priorities for Conservation and Sustainable Use

Because existing legislation and institutional arrangements are insufficient for protection and management of the reefs, a single agency that has full jurisdiction of both land and sea, including the proposed areas, is needed. The National Parks Board is seen as the most appropriate agency for these responsibilities (Chou, 1995).