CONTRIBUTIONS OF THE ASEAN-AUSTRALIA COASTAL LIVING RESOURCES PROJECT TO COASTAL LIVING RESOURCE ASSESSMENTS IN SINGAPORE

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Within three years of the project's implementation, much information has been gathered on the state of coastal living resources in Singapore. This is particularly useful for a country whose coastal environment has been subjected to intense human influence. Surveys of coral reefs, soft-bottom benthic communities and mangroves are being carried out, in a systematic manner, for the first time on such a large scale. The studies have already yielded some interesting information and have resulted in a better understanding of the country's coastal living resources.

INTRODUCTION

Development along most of Singapore's 193 km of coastline has resulted in major changes to the geomorphology of the affected areas. Such development has totally changed the original coastal environment and conditions of nearshore areas, and has affected the living resources found in these areas. Both qualitative and quantitative surveys on these living resources, in the time before development was carried out, were few and completely at random.

The ASEAN-Australia Coastal Living Resources Project represented for the first time in this country the implementation of a broad-scale, systematic survey programme that would determine the state and condition of its coastal ecosystems, in particular, coral reefs, mangroves and soft-bottom benthic communities. Survey methods employed in the project were those agreed to by the participating ASEAN countries which would yield quantitative results that are comparable *inter alia* throughout the region.

STUDY SITES

The distribution of the study sites is shown in Figure 1. Surveys were carried out on ten coral reef sites, five mangrove sites and eight benthic sites. The coral reef sites were selected to represent a transect stretching from 3.75 km (Cyrene reef) to 15.00 km (Raffles Lighthouse) from the mainland.

The mangroves of Singapore are now restricted to small scattered remnants, mostly along the north coast and on the islands of Ubin, Tekong, Semakau and Pawai. The current percentage of land area occupied by mangroves is estimated to be 0.5% amounting to about 600 x 10^4 m^2. Of these 600 x 10^4 m^2, the mangroves at Mandai constitute a small fraction. The Mandai mangrove is one of the best documented areas for vegetation. Current data sets will add to the historical records already existing and will provide a basis for more detailed studies on the benthic fauna, and on organisms directly affecting the survival and population structure of higher plants.

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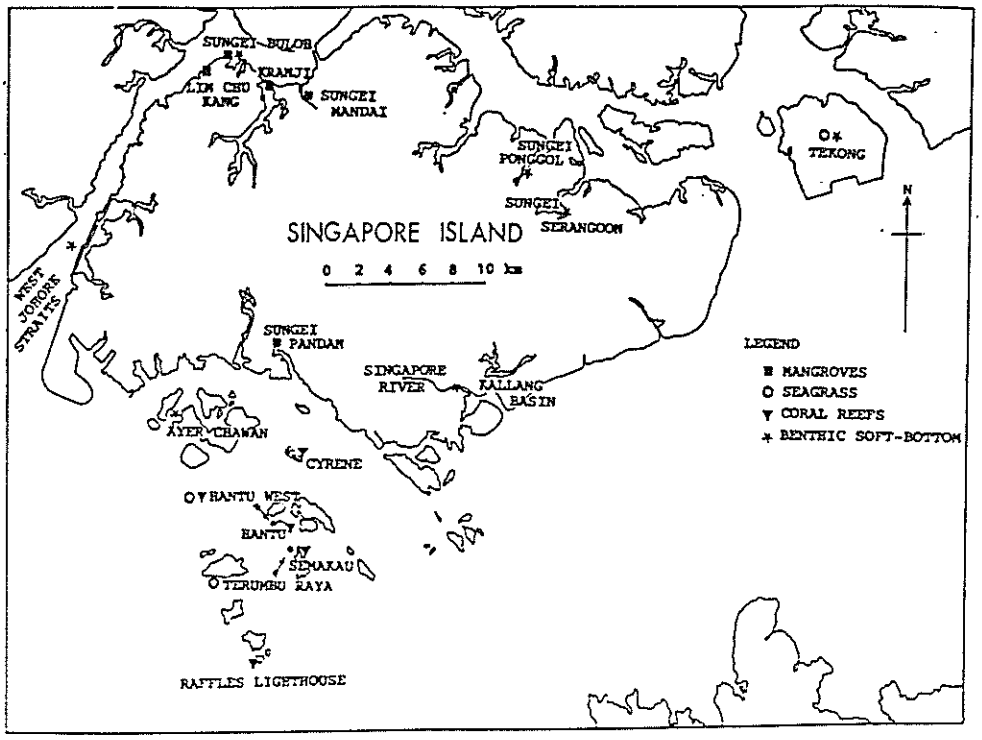

Figure 1. Location of all survey sites.

The soft-bottom benthic survey sites were chosen to represent two habitats, namely, nearshore and riverine. The riverine habitats are of interest because of the recent (1977 to 1987) drive by government authorities to clean up the rivers. The riverine surveys also included the pelagic fauna. Since little is known of our nearshore benthic soft-bottom communities, three sites around the main island were selected for survey. Additional sites were selected for seagrass surveys.

RESULTS

CORAL REEFS

Results of the reef surveys showed live coral cover to range from 23.5% to 62.0% at the 3 m depth on the reef slope and 0% to 14.0% at the 10 m depth. Scleractinian generic diversity is also greater on the shallow transects (40 genera per 100 m line transect) than on the deeper ones (22 genera per 100 m line transect). The studies have revealed the existence of 51 hard coral genera in Singapore waters. Variation in growth forms was also evident, with massive species common on the upper slope, while encrusting and free-living species occurred more frequently on the lower slope. Foliose forms were present throughout the slope. Notwithstanding the high sedimentation rate of more than 20 mg/cm^2/d, coral growth on the upper slope remains rapid with annual colony linear extensions of 5.1-8.7 cm for table *Acropora*, 2.9 cm for *Merulina ampliata*, and 3.2 cm for *Pachyseris speciosa*.

For reef-associated organisms, algae formed the main proportion with mean values of 16.9% on the upper slope and 22.0% on the lower. These were mainly algae which encrusted the dead coral, and the higher percentage of dead coral at the deeper zones served as suitable sub-

stratum for their establishment. Macroalgae appeared greater at the shallower depths. The associated fauna are represented by a variety of soft corals, sponges, Zoanthidae, tunicates, echinoderms, and gorgonians. They occupied 3.8% of space on the upper slope and 7.2% on the lower slope.

A total of 51 species of reef fishes were recorded, with the families Pomacentridae and Labridae dominating in both species diversity and abundance. Four species of Chaetodontidae were recorded while target species, such as serranid and lutjanid fishes, etc., were generally few in number. The fish fauna was richer at the 3 m depth than at the 10 m depth and positive correlations were obtained between fish abundance and live coral cover.

MANGROVES

Basal area values obtained from the relascope method ranged from 49 $m^2/10^4$ m^2 in Kranji to as low as 16 $m^2/10^4$ m^2 in Mandai. Energy-flux readings posed a problem because weather conditions did not usually conform to the requirements of no cloud cover within two hours of noon. However, based on one set of light readings, results gave a very low primary productivity estimate of 2.21 $kgC/10^4$ m^2/d in Mandai Kechil site 2, an area containing old *Avicennia* trees with thin canopy.

Extensive mapping was carried out in Mandai to show the general topography of the Mandai mangroves. A total of 23 transects, comprising 181 10 m x 10 m quadrats, were established across this mangrove belt. A count of 39 ground rooting species of woody trees and climbers was obtained. Typically *Sonneratia alba* and *Avicennia alba* were dominant at the water's edge, where the forest structure data indicated a preponderance of large trees with little undergrowth. In contrast, the more landward mangroves, where accelerated drainage due to riverine erosion had led to extensive loss of old trees, are now dominated by high densities of much smaller trees.

Soil core samples taken at Mandai showed that highly organic peat, which included timber, extended down to two metres before resting on white plastic marine clay. Soil types ranged from sandy loams to loams.

SOFT BOTTOM BENTHIC AND PELAGIC COMMUNITIES

A total of 190 families belonging to seven phyla were found. More families (126) were found in the nearshore habitats than in the riverine habitats (119). The macrofauna were mostly molluscs, echinoderms, polychaetes and crustaceans. The family diversity ranged from 36 at Ayer Chawan to 94 at Pulau Tekong for the nearshore habitats, and, from eight at Sungei Serangoon to 51 at Kallang Basin for the riverine habitats.

Physico-chemical parameters taken at the riverine habitats show a strong correlation between the level of dissolved oxygen and the number of families found. The rivers that were 'cleaned up' had a higher family diversity than those that were not.

As a result of the surveys, sea cucumbers of the genus *Pseudocolochirus* were found, which may be a new record to Singapore. Many other species are also believed to be new records and their identification is in progress.

The seagrass communities consisted of four species namely *Enbalus acoroides, Halophila ovalis, Halophila ovata,* and *Halophila spinulosa.* These were patchy in distribution and did not occur in great quantities.

EXTENT OF COASTAL LIVING RESOURCES

The microBRIAN remote sensing system is now being used to map the extent of these resources in Singapore. Analysis of satellite or aerial images when completed will give accurate areal cover of the various ecosystems and can be used to determine temporal changes. Up till now, mangrove extent has been estimated only from maps while coral reef extent remains unknown. This technique is of particular use in monitoring the effect of development on coastal living resources.

CONTRIBUTIONS OF AND BENEFITS FROM THE PROJECT

The project has made a significant contribution to the knowledge of coastal living resources in Singapore. Analysis of the numerous data sets has revealed some interesting trends in these

ecosystems, such as the high coral diversity of the upper reef slopes, the improving coral cover with increasing distance from the mainland, rapid growth rates of corals, and location-dependent diversity variation in soft-bottom benthic communities.

It has also resulted in the development of manpower resources with approximately 20 graduates and undergraduates trained in coastal living resources survey techniques and data analysis/management. Training in the use of remote-sensing techniques forms an important technology transfer component of the project. All the research personnel involved have also benefited from participation in workshops, symposia and meetings and gained a better insight into coastal ecosystems. The project has substantially enhanced the participating organization's capability in marine science research in terms of equipment and trained personnel. Results arising from the project have been published in various journals and conference proceedings (Chou and Koh 1986, Chou 1987, Chou and Boto 1988, Chou 1988a, Lim and Chou 1988, Chou, in press), and will continue to be submitted for publication. Educational materials have been published (Chou and Lim 1988) or are being prepared for publication and will be distributed to schools and organizations.

Some other benefits are beginning to emerge. The earlier results of reef surveys drew attention to the fact that a surprisingly high diversity of hard corals exists on the upper reef slope zones in spite of the long-term high sedimentation levels, and provided the basis for three non-governmental organizations to join force to undertake a comprehensive reef survey and conservation project.

It is anticipated that a greater awareness of the roles of and benefits derived from coastal living resources will be created and will consequently lead to a better appreciation of them.

REFERENCES

Chou, L.M. 1987. Community structure of sediment-stressed reefs in Singapore. Proc. Int. Symp. on the Conserv. and Manage. of Coral Reef and Mangrove Ecosystems, Okinawa, Japan, October 2-3, 1987.

Chou, L.M. 1988. Long term effects of sedimentation on the reefs of Singapore. Environmental Management and Research Association of Malaysia (ENSEARCH) Annual Seminar, Kuala Lumpur, Malaysia, March 31-April 2, 1988.

Chou, L.M. The impact of human influence on the fringing reef of Pulau Hantu, Singapore. Proc. 6th Int. Coral Reef Symp., Townsville, Australia, August 8-12, 1988. (In press)

Chou, L.M. and K. Boto (eds.). 1988. Living coastal resources data management and analysis. Singapore: National University of Singapore. 76 pp.

Chou, L.M. and G.L.E. Koh. 1986. Initial characterisation of upper reef slope communities in Singapore waters. J. Singapore Natl. Acad. Sci. 15:5-8.

Chou, L.M. and G.S.Y. Lim. 1988. Coral reef life. Flora and Fauna Series No. 1, Singapore Institute of Biology.

Lim, G.S.Y. and L.M. Chou. The echinoderm fauna of sediment-stressed reefs in Singapore. Proc. 6th Int. Coral Reef Symp., Townsville, Australia, August 8-12, 1988. (In press)