

## THE STATUS OF SOUTHEAST ASIAN CORAL REEFS

L.M. Chou

School of Biological Sciences, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119261

## ABSTRACT

Southeast Asia is known for its rich marine life and abundant coral reefs of all types. It is the center of species diversity for hard corals and many groups of reef-associated flora and fauna. The region is also experiencing rapid population increase and dynamic economic growth, concentrated mainly in coastal areas. Heavy reliance on the marine environment and its resources has resulted in non-sustainable use and degradation of resources. Reef systems close to major population centre have in many cases collapsed or deteriorated drastically. The remoter reefs remain in pristine condition but will come under threat as accessibility improves and the demand for untouched reefs from marine tourism and the fishing industry increases further. Of 49 reefs monitored in 5 ASEAN countries, less than 20% had live coral cover in excess of 75%. Many of the reefs also showed a steady decline in live coral cover with time. In response, increasing numbers of marine protected areas are being gazetted throughout the region, but less than 10% maintain a high level of management.

## INTRODUCTION

Southeast Asian seas occupy 2.5% of earth's ocean surface but contain 30% of the world's coral reefs. Two of the world's largest archipelagoes, Indonesia with more than 17,000 islands and Philippines with over 7,000 islands are located within a region that is noted as the center of reef diversity (Kelleher et al. 1995). All reef types including oceanic atolls and barrier reefs are represented although fringing reefs are the most common throughout. Oceanographic features, climate and geological development have combined to present factors favouring rich reef growth (Chou in press). Coral species richness here is highest worldwide (Veron 1995). These reefs also support high diversity of marine life such as fish, molluscs, crustaceans and echinoderms (UNEP/IUCN 1988).

Economic growth and coastal population expansion have been increasing rapidly and anthropogenic threats to the reef ecosystem have resulted in serious degradation of many reefs (McManus 1988). Wilkinson (1992) showed that the high biodiversity reefs of Southeast Asia will succumb to these pressures unless sustainable management practices are effected. Various reef management models exist throughout the region, ranging from national government initiatives to local community involvement (Chou and Wilkinson 1994). Community-based management of reefs has been successful particularly in the Philippine (Alcala 1988; White et al. 1994). Of the growing number of nationally legislated marine parks, less than 10% are adequately managed to meet protection objectives (Kelleher et al. 1995).

## THE REEFS AND NATURAL CONDITIONS

The reefs of Southeast Asia stretch across longitudes 93° to 141°E and latitudes 21°N to 11°S. Over 25,000 islands of varying sizes dot the seas which separate the continents of Asia and Australia and link the Pacific and Indian Oceans. Two extensive continental shelves, the Sahul and the Sunda, are separated by oceanic depths. Most are coastal reefs fringing small islands and larger land masses, while barrier reefs and atolls are present in the deeper seas. The distribution and diversity of coral reefs in Brunei Darussalam, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam have been described (e.g.

UNEP/IUCN 1988). Reef resources of Cambodia remains little known to date. The strongest natural influence are the annual monsoons which reverse current flow and introduce freshwater into coastal areas, lowering salinity and increasing sedimentation. Typhoons affect the Philippines, Vietnam, and Thailand while volcanic and tectonic activity occurs in Indonesia and the Philippines. Isolated instances of *Acanthaster* infestations have been noted. Numerous reports of natural disturbances and community structure of the region's reefs are available, particularly in the proceedings of regional conferences such as Alcala (1991), Chou and Wilkinson (1992), Sudaral et al. (1994), Wilkinson et al. (1994).

Brunei Darussalam is not well-endowed with coral reefs. Known reef areas are located offshore from nearby Pelong Rocks, Two Fathom Rock, and Brunei Patches, to Louisa Reef (230 km off the coast). An initial study revealed 88 species of hard corals belonging to 52 genera (Chua et al. 1987). Cambodia's reefs are present around the offshore islands near Sihanoukville. The reefs of Myanmar are associated with the numerous islands of the Mergui Archipelago. Hard coral diversity is recorded at 65 species from 31 genera although further investigations are expected to increase these values considerably. These reefs are not known to be stressed by natural causes. All of Singapore's reefs are found in the southern offshore islands from which more than 197 species of hard corals belonging to 55 genera are known. Being relatively sheltered, storm damage is negligible and no *Acanthaster* occurrence has been recorded.

Fringing and patch reefs have developed widely throughout the Indonesian Archipelago with increased reef diversity such as atolls and barrier reefs present in the deeper seas of the eastern region. Barrier reefs are well developed along the edge of the Sunda shelf, east of Kalimantan and around the Togian Islands of central Sulawesi. Among the few atolls, Taka Bone Rata, in the Flores Sea is the world's third largest. The 1983 El Niño which raised seawater temperature in the Java Sea caused up to 90% coral mortality on the reef flats of Pulau Pari in the Seribu Islands (Brown and Suharsono 1990). The major casualties were branching species of *Acropora* and *Pocillopora*. Five years after the event, coral cover reached 50% of the former level. *Acanthaster* damage is known particularly on the Seribu Islands, but no serious population outbreaks are known. Up to 359 species of hard corals have been recorded from eastern Indonesian seas (Soekarno 1994) with additional new species reported in recent times (Wallace 1994).

The only Malaysian atoll is at Layang-Layang in the Spratlys. Along the Malaysia Peninsula, reef development is more vigorous on the east coast than the west coast. These are mostly fringing reefs along the coast or around the offshore islands. Fringing reefs are also found in the East Malaysian state of Sabah, more at the offshore islands than the mainland coast. Extensive fringing and patch reefs and a small barrier reef are associated with the offshore islands away from the southeast coast. The reefs of Sarawak are confined mainly to coral communities with poor reef development. Low tides have caused damage to the reefs on east coast of the Peninsula while sporadic *Acanthaster* outbreaks have been observed on most reefs except those on the west coast of the Peninsula. On these west coast reefs, seasonal blooms of maroon algae were noted during inter-monsoon months. Ridzwan (1994) reported a total of 346

scleractinian species from Malaysian reefs, adding that *Acropora* was the dominant genus.

Most of the Philippine reefs which cover an estimated 25,000 km<sup>2</sup> are fringing varying in length from tens of metres to 5 km (Gomez et al. 1994a). The largest concentration is in the southwest of the country. Two atoll systems are found on the submarine Cagayan Ridge in the Sulu Sea; Cagayancillo and Tubbataha. Atoll-like formations such as Apo Reef near Mindoro Island and Scarborough reefs west of Luzon are present. The banks west of Palawan may constitute a barrier reef which could be one of the largest in the world. A double-barrier reef is represented by the Danajon Bank off Bohol and a few more small barrier reefs may be present. Fringing reefs and atolls in the Sulu Sea, and the reefs of the Palawan islands are known to be among the best of Philippine reefs. Typhoons cause extensive damage to some reefs such as at Mactan, while *Drupella* outbreaks (Moyer et al. 1982) and *Acanthaster* infestations (Alifio et al. 1981) have been reported. The eruption of Mt. Pinatubo caused a 23 to 69% decline in fish biomass from the reefs along the coast of Zambales. This was correlated with the drop in live coral cover due to ashfall deposits (Ochavillo et al. 1992). Nemenzo (1986) reported 499 species of hard corals from the Philippines.

Thailand has over 300 major reef groups covering an estimated 12,000 km<sup>2</sup> which can be divided into 4 distinct areas: inner part of the Gulf of Thailand (Chonburi), east side of the Gulf (Rayong and Trad), west side of the Gulf (Prachuap Kirikhan, Chumporn and Surathani), and along the Andaman Sea coastline (Ranong, Phuket, Phang-Nga, Krabi, Trang and Satun). About 55% of Thailand's reefs occur in the Andaman Sea. The majority of Thailand's reefs are fringing with widespread occurrence of developing coral communities (Sudara and Yeemin 1994). Storms and monsoons are the major natural causes of coral reef damage in Thai waters, turning over coral heads and breaking coral branches. Typhoon Gay which hit southern Thailand in November 1989 caused significant damage to some reefs. Localised outbreaks of *Acanthaster* have been reported in the Gulf of Thailand and a significant increase in infestations has occurred in the Andaman Sea since 1982. Extreme low tides and coral bleaching are other natural phenomena reported to cause severe damage to Thailand's reefs.

The reefs of Vietnam, estimated to cover 400 km<sup>2</sup> can be found along its 3200 km coastline from north to south except around the deltas of the Red and Mekong Rivers, but mostly around the 3000 islands on the shelf and offshore Lang et al. (1995). Five sub-regions may be defined: west of Tongkin Bay, central Vietnam, east of south Vietnam, west of south Vietnam, and offshore islands. Fringing reefs are common with atolls located far offshore in the Spratlys. Coral assemblages rather than reefs characterise west of Tongkin Bay so that coral diversity here is less than in the other sub-regions. The reefs around Con Son Islands off the southern tip of the country are known to be particularly rich. More than 300 hard coral species have been recorded.

The highest coral diversity (188 species) was recorded from the Spratly Islands belonging to Vietnam. Lower diversity occurred in northwest Tonkin Gulf (165 species), southeast of Vietnam (176 species) and southwest of Vietnam (138 species). Storms and typhoons, and low winter temperature have been implicated as natural stresses.

#### STATUS OF CORAL COVER

The five ASEAN countries which participated in the ASEAN-Australia Living Coastal Resources Project from 1986 to 1994 have carried out extensive line-intercept surveys totalling 942 100-metre transects at 42 reef locations

throughout the region (Chou et al. 1994a). From data archived at the project's data centre in Chulalongkorn University (Bangkok), less than 3% of the reefs surveyed in Indonesia, Malaysia and Singapore could be considered to be in excellent condition (i.e. supporting more than 75% live coral cover) (Table 1). Recent assessments by experienced scientists placed degraded reefs at up to 70% more than 50 years ago (Chou et al. 1994b) and productivity loss of up to 80% during the same time frame.

**Table 1:** Status of ASEAN coral reefs based on data from the ASEAN-Australia Living Coastal Resources project (Chou et al. 1994a). Live coral cover determined on transects placed usually at depths of 3 and 10m on reef slope. Condition values refer to percentage of transects with cover >75% (excellent); <75% and >50% (good); <50% and >25% (fair); <25% and 0% (poor)

Country	No. of transects	Excellent %	Good %	Fair %	Poor %
Indonesia	190	2.6	24.2	31.6	41.6
Malaysia	193	11.4	52.8	27.5	8.3
Philippines	238	1.3	7.5	49.2	42.0
Singapore	142	2.8	9.2	20.4	67.6
Thailand	178	16.9	42.1	34.8	6.2

The reefs of Brunei Darussalam had low live coral cover of less than 40% at Pelong Rocks and 27% at Two Fathom Rock. This is due to the turbid water conditions and proximity to the mainland coast. Data are not available for the reefs of Cambodia and Myanmar. In Vietnam, coral cover ranged from 30 to 50% in northwest Tonkin Gulf, and 30 to 40% southwest of Vietnam (Gulf of Thailand). No mention is made of coral cover in the Spratly Islands claimed by Vietnam.

Reefs in the western Indonesian archipelago are subjected to greater human pressures than those in the east. For example, almost 40% of the reefs in the Seribu islands (north of Jakarta) are in the poor category (live coral cover > 25%) with 5% maintaining coral cover in excess of 75%. In the eastern archipelago, 22% of the reefs surveyed were in the poor category while 7% were in excellent condition (Soekarno 1994).

Reefs at the offshore islands of Peninsula Malaysia's east coast support an average range of 56 to 69% live coral cover. Those along the west coast have lower live coral cover between 25 and 46% due to the higher sediment load discharged by runoff. The reefs of Sabah (East Malaysia) support between 43 and 52% live coral cover with reportedly higher dead coral cover and coral rubble than at Peninsula Malaysia, attributed mainly to human disturbance (Ridzwan 1994). The clear waters of the Layang-Layang atoll permit corals to develop at depths of more than 40m but live coral cover on the upper slope of the oceanic reef face was naturally low at 29%. Recent development into a resort with an airstrip caused a massive 75% drop in live coral cover. The reefs of Sarawak on the north-western face of Borneo exhibit an average of 60% live coral cover, which is surprisingly high for the turbid waters. The reef community was also reported to be vigorous and diverse.

In their review of Philippine reef condition (Gomez et al. 1994a) surveyed over the last 7 years and the use of a "coral mortality index" (ratio of dead coral cover to the sum of dead and live coral cover), 84% of the reefs had at least half of their corals still alive compared to the 16% in the earlier surveys. They however cautioned that this may be attributed to the differences in sampling protocol between the earlier and later surveys. The report by Gomez et al. (1994b), showed that in Luzon, 3.6% of reefs were in

excellent condition (> 75% live coral cover) while 27% had less than 25% coral cover; in Visayas, 6.6% in excellent condition while 31% were poor; and in Mindanao 5.3% in excellent condition and 49% poor.

An estimated 70% of Singapore reefs are now degraded compared to the pristine condition 50 years ago. Recent temporal data indicated further decline in live coral cover on the upper slope of the better reefs (76% in 1989 to 69% in 1993). Over 60% of all major reef groups of Thailand have below 50% live coral cover and increased algal growth is evident due to increased nutrients from coastal tourism. Reefs in good condition are located in the provinces of Trad, Phang-Nga and Trang.

#### STATUS OF FISH AND OTHER REEF ORGANISMS

Southeast Asian reefs are known for the rich diversity of reef fish and other related organisms. A number of species of reef-associated invertebrates and vertebrates are endemic to the region. Surveys of the ASEAN-Australia Living Coastal Resources project revealed a total of 783 reef fish species from 59 locations in Indonesia, Malaysia, Philippines, Singapore and Thailand (Alfio 1994). As of March 1995, the generic diversity of reef-associated fish in FishBase was highest in the region particularly in the Philippines (307), East Indonesia (268) and West Indonesia (179). Lower generic diversity occurred in East Malaysia (144), West Malaysia (118), Myanmar (86), Vietnam (83), Singapore (77), East Thailand (77), West Thailand (70) and Brunei Darussalam (38). The region's reefs have also been described as an important source of larval recruits to reefs in adjacent regions.

Fish forms the main source of animal protein throughout the region. While reef fisheries contribute 12% of the world's fish catch, higher values up to 30% have been reported for Southeast Asia (DeSilva and Ridzwan 1982). This reflects the extent of coral reefs and fish exploitation opportunity offered by the system. Major target reef fish for food include grouper (serranids), snapper (lutjanids and lethrinids), rabbitfish (siganids), fusiliers (caesionids), and mackerel, tuna and carangids. Squid and cuttlefish are also caught from reefs. The decline in fisheries catch indicates that many stocks have been depleted beyond sustainable levels. Subsistence fishery at the Seribu Islands in Indonesia decreased from 1350 tonnes in 1973 to 100 tonnes in 1990 accompanied by a distinct correlation with decreased coral cover (Wilkinson 1994). Reef fisheries in the Philippines provided up to 36 tonnes per square kilometre with degraded reefs offering only 10 to 15% of this amount.

Apart from fish, other major groups of reef organisms such as molluscs, crustaceans, echinoderms and seaweed are commonly exploited for food (McManus 1988). Reef resources are also exploited for uses other than food. The marine curio trade removes shells and corals resulting in devastating impacts on the ecosystem, while the aquarium trade demands fish and other invertebrates. Most are exported to countries beyond the region. Giant clams, once abundant have become endangered and virtually wiped out from many reefs through overfishing (Gomez 1988). Coming close to extinction in the Philippines, brood stocks had to be imported for the clam hatcheries set up in Bolinao and Dumaguete to restock the reefs. High demand for anemones by the aquarium trade in the late 1980s caused a serious decline from many reefs.

Both, human and natural impacts have influenced changes in community structure leading to population explosions of *Diadema*, or algal takeover. Corals with higher tolerance to sediment, such as *Porites* and *Pectinia*, survive better in sedimented reefs and become the dominant genera of a less diverse community.

#### MAJOR ANTHROPOGENIC DISTURBANCES

Anthropogenic impacts, direct and indirect, have been recognised as the greatest threat to Southeast Asian reefs (Wells 1993; Wilkinson and Ridzwan 1994). The growing population of 440 million today is expected to almost double to 716 million by 2025. With the majority of the population concentrated along the coast, enormous pressures have caused the decline of many reefs, in particular those closer to major population centres (Wilkinson 1992; Wilkinson et al. 1993).

The region's scientists have assessed that sediment loading (due to dredging, coastal engineering and coral sand mining) is the most serious threat, followed by population pressure which causes nutrient pollution through sewage and agriculture, oil pollution and industrial pollution (Wilkinson and Ridzwan 1994). Other identified human disturbances are tourism and fishing. All human impacts were ranked higher than natural impacts. In addition, coral mining and nearshore trawling have caused considerable damage to the region's reef system.

Rapid economic development has resulted in large-scale land clearing, coastal modification, reclamation, and the need to continually dredge silted coastal areas. Sediment loading of the waters is high around many coastal settlements. Agricultural fertilisers, sewage and industrial pollution are often discharged without treatment, introducing large amounts of organic matter and nutrients which favour algae and coral competitors. Fishing pressures coupled with destructive fishing methods (such as the muro-ami or the use of dynamite or cyanide) have caused irreversible damage many reefs. A recent widespread threat cyanide fishing targetting high quality reef fish so that they can be captured and exported live to countries where demand has risen dramatically over the past few years. Increasing numbers of less accessible reefs are now more frequently being exploited to meet overwhelming demand. High levels of poverty make it difficult to manage over-exploitation and destructive fishing, but education and awareness programmes at local community levels have convinced some communities that their future depends on long-term sustainable management rather than short-term and often destructive gain.

#### CORAL REEF MANAGEMENT

A variety of reef management systems exists in the region. An increasing number of Marine Protected Areas (MPAs) have been established throughout Southeast Asia, but many occur only on paper without any commitment to staffing and operational funding. Few MPAs are effectively managed. Of the 106 MPAs established in the ASEAN countries (excluding Vietnam) by 1994, 65% contain coral reef resources. Existing staff in MPAs that have a management team often are not adequately trained in park management and lack the necessary skills for the task. Apart from the need to enhance capacity and to train staff, other problems are encountered and they usually originate from the traditional sectorally based management systems in the region. Agencies managing different aspects of the coastal area do not have much communication between them, resulting in uncoordinated and sometimes conflicting efforts which undermine conservation and protection of reef resources. Increased political commitment is necessary to address the deficiency seen in the region's MPAs (Chou and Wilkinson 1994).

Community-based management systems appear to have more widespread success and different models have been applied in different situations. Successes in the Philippines and Thailand showed that it is effective for small areas where local communities are directly involved. Community-based management gives the users a better sense of propriety and greater motivation to manage the very resource that they

are dependent on. Such communities are effective in controlling destructive activities caused by other users as well as themselves. For larger areas, the co-management system approach is more effective where management is shared between government agencies, local communities and non-governmental organisations.

Many Southeast Asian countries are signatories to international conventions and agreements to maintain natural ecosystems. Of relevance to coral reefs is the Convention on International Trade in Endangered Species (CITES), which has been effective in slowing the export of in live and dead corals and other reef organisms from the region. Another international convention addressing the global loss of plant and animal species is the Convention on Biological Diversity which the majority of the region's states have signed and ratified. Informal regional agreements such as the 1989 Langkawi Declaration on the Environment, the 1990 Baguio Resolution on Coastal Resource Management, the 1990 Kuala Lumpur Accord on Environment and Development, and the 1994 Bangkok Resolutions on Living Coastal Resources, all attest to increased regional awareness of the need to manage coastal resources including coral reefs for sustainable use.

Southeast Asian reefs have been heavily exploited particularly within the last 3 decades. Economic growth and population increase have caused the collapse of many reefs within easy reach. Driven by development pressures, destruction of reefs was carried out without much concern. Wilkinson et al. (1993) estimated that 11% of Southeast Asia's reefs have collapsed and a further 48% are in the critical category, with collapse likely within the next 20 years, if management commitments are not met. Another 36% of reef area is threatened and could collapse in 20 to 40 years without effective management. Only 5% of the reefs (Spratlys and remote reefs of eastern Indonesia) are considered to be under little threat.

The benefits and significance of reef systems are now better known and there is greater awareness of the importance of managing and protecting the resource. Indonesia will soon launch a massive Coral Reef Rehabilitation and Management Project (COREMAP) aimed at safeguarding the country's dwindling coral reefs, and arresting degradation of reef habitats. Vietnam commenced its Marine Conservation Project in 1992 aimed at managing marine resources including coral reefs. The growing number of marine protected areas in the region indicates the attention currently given to reef management.

While policy makers now know that a managed reef can provide sustained use, government bureaucracy and inter-agency conflicts prevent effective management beyond the initial step of declaring marine protected areas. Coral reef management is best facilitated as part of an overall integrated coastal management strategy. For this, administrative and legislative mechanisms have to be instituted. Experience shows that Southeast Asian countries are still a long way from adopting national policies on integrated coastal management and that development considerations often override sustainable development policies and adherence to international agreements and protocols. This has resulted in the continued decline of the region's reefs and increasing exploitation of the more remote reefs. There are examples of effective community-based management of reef systems, but these are few and localised. Wider application of these models are necessary.

An action agenda for ASEAN coral reefs calls for responsibility for action by and full support from all sectors of government, users and the public, to manage reef resources (Wilkinson 1994). It spells out a strategy for

coral reef conservation, adding that reef management will fail unless local users and officials are informed and involved in sustainable resource management. Excellent legislation and planning, backed by the current structures for enforcement will remain ineffective unless users agree with the process and are convinced of the benefits of compliance. The rate of reef degradation has eased but only a little with a better understanding of its functions and the establishment of marine protected areas. To ensure maintenance of Southeast Asian reefs, stronger and more concerted efforts are still needed.

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