UNEP

SCS

GEF

"Rev ... nds
in th ... nd"

Original Official Use
for Meeting

NATIONAL REPORTS
on
Coral Reefs in the Coastal Waters of the South China Sea

First published in Thailand in 2007 by the United Nations Environment Programme.

UNEP/GEF
Project Co-ordinating Unit,
United Nations Environment Programme,
UN Building, 2nd Floor, Block B, Rajdamnern Avenue,
Bangkok 10200, Thailand.
Tel. +66 2 288 1886
Fax. +66 2 288 1094
http://www.unepscs.org

DISCLAIMER:

The contents of this report do not necessarily reflect the views and policies of UNEP or the GEF. The designations employed and the presentations do not imply the expression of any opinion whatsoever on the part of UNEP, of the GEF, or of any cooperating organisation concerning the legal status of any country, territory, city or area, of its authorities, or of the delineation of its territories or boundaries.

Cover Photo: Coral Reefs in Phu Quoc Islands, Viet Nam, by Mr. Nguyen Van Long.

For citation purposes this document may be cited as:

UNEP, 2007. National Reports on Coral Reefs in the Coastal Waters of the South China Sea. UNEP/GEF/SCS Technical Publication No. 11

United Nations
Environment Programme

UNEP/GEF South China Sea
Project

Global Environment
Facility

Reversing Environmental Degradation Trends
in the
South China Sea and Gulf of Thailand

NATIONAL REPORTS
on
Coral Reefs in the Coastal Waters of the South China Sea

Table of Contents

OVERVIEW

Vo Si Tuan
On behalf of the Regional Working Group on Coral Reefs

ABOUT THE SOUTH CHINA SEA

The South China Sea is a semi-enclosed sea bordered by nine nations: Brunei Darussalam, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Viet Nam. The area contains highly diverse tropical ecosystems such as mangroves, coral reefs, and seagrass, and high species richness of marine organisms. A preliminary assessment of the sea's biodiversity indicated more than 8,600 species of plants and animals (Ng and Tan, 2000). Fish alone contribute 3,365 species (Randal and Lim, 2000). The area is a global centre of shallow water marine biodiversity.

Much of the southern half of the South China Sea lies on the Sunda Shelf and waters are shallow (< 200m deep) and influenced by both marine and river/terrestrial inputs. Further north, the South China Sea basin and Palawan Trough are much deeper, at > 1,000m, being bordered by the shallow continental margin and shelves. The coastal and marine waters include several major gulfs and bays, including: the Gulf of Thailand; Gulf of Tonkin; Lingayen Gulf; and Manila Bay. The geomorphological history of the South China Sea has been the main factor influencing the development of coral reefs in the region.

Major oceanographic currents in the South China Sea are generated by the Asian Seasonal Monsoons. Surface currents flow north to south along the Viet Nam coast to the Java Sea during the northeast monsoon, October to February (Wrytki, 1961). The flow reverses south to north along the western margin of the South China Sea during the southwest monsoon beginning in June. The South China Sea interacts with the Indian Ocean via a north flowing current between West Kalimantan and Peninsular Malaysia bifurcating into the Gulf of Thailand and South China Sea. Waters from the South China Sea may also flow seasonally into the Sulu Sea (Bate, 1999) and Java Sea, contributing to the Indonesian through-flow. Within the South China Sea, local current patterns form complex eddies and counter-currents, mainly driven by the monsoon systems. Upwelling occurs in areas north west of the Philippines and coastal Viet Nam, and influences physical conditions in the South China Sea. Current regimes play an important role in determining the distribution and abundance of marine fauna and flora in general, and coral reefs in particular.

Coral reefs do not develop in coastal areas with strong riverine inputs, and land-based activities can affect coral reefs via river discharges. There are many watersheds bordering the South China Sea, with approximately 125 major rivers draining some 2.5 million km^2 of water catchments. The major systems include:

- Kampar, Indragiri and Tembesi-Hari Rivers (Sumatra)
- Pahang, Trengganu and Kelantan Rivers (Peninsular Malaysia)
- Batang Lupar, Sarawak and Seribas Rivers (South Sarawak)
- Kapuas River (West Kalimantan)
- Rajang and Baram Rivers (Sarawak)
- Mae Klong and Chao Phraya Rivers (Thailand)
- Mekong, Red and Dong Nai Rivers (Viet Nam)
- Xun Xi & Bei Rivers (Pearl River estuary – China).

HUMAN POPULATIONS BORDERING THE SOUTH CHINA SEA

The Global International Waters Assessment Project (GIWA) (Winkinson *et al.,* 2005) provided information regarding socio-economic activities in the coastal catchments of the South China Sea. The present human population of the South China Sea's coastal zone is estimated to be 200 million. A mayjority of the population is distributed in some 90 cities with populations > 100,000. Outside the cities, the remaining population is distributed in thousands of villages spread along the coast, across the lowlands and into the highlands. The larger urban centres include Manila (> 10 million, Philippines), Hong Kong – Macao (~ 10 million, China), Hanoi, Haiphong and Ho Chi Minh Cities (> 10 million in total, Viet Nam), Bangkok (> 5 million, Thailand), Kuala Lumpur (> 5 million, Malaysia), Singapore (> 2 million), and Brunei Darussalam (> 2 million). Outside the cities, coastal population densities are highest in Viet Nam (Gulf of Tonkin > 500 persons km^{-2}), China and the Philippines (~ 470 persons km^{-2}).

Populations are increasing at rates between 1-6% annually in the sub-region (e.g., 2.1% for the Philippines, 2.9% for Indonesia, 1.6% for China, 3.3% for Malaysia, 1.3% for Thailand and 5.6% for Cambodia), with an overall average increase of ~ 2.2% per year (Talaue-McManus 2000). Population growth is highest in coastal areas of Cambodia, Indonesia and Malaysia. It is predicted that the population of the sub-region will approach 300 million by 2020 and double by 2035. Parts of the sub-region (e.g., Malaysian Sabah) are also experiencing substantial immigration from Indonesia and the Philippines, up to 4% annually in some areas.

The coastal areas of the South China Sea are the location for a wide range of economic activities, from subsistence agriculture and artisanal fisheries to light and heavy manufacturing and high technology industries. Subsistence farming and fishing are the major activities of large numbers of people outside of the main urban and industrial centres. The major export earners include commercial exploitation of natural resources, particularly fisheries, aquaculture/mariculture, oil palm and other forms of plantation agriculture, and mining. There have been increases in aquaculture (notably *Tilapia* in lakes and inland waters) and mariculture (shrimps) in coastal ponds, and the supply of tropical fish to the live and ornamental fish markets. At present, mariculture is largely dependent on wild stocks, although hatcheries are being developed. Forestry is also a major industry although large areas of loggable forests have already been exploited in many parts of the sub-region, or are now protected (e.g., Palawan, Philippines). Secondary industries including resource processing and manufacturing, and tertiary industries including electronics are of growing importance. Service industries, including tourism, are also expanding, with for example a 5% annual increase in tourism from 1987-1995 in the Philippines.

For most South China Sea nations, fisheries and aquaculture, plantation agriculture, forestry, mining, and manufacturing are important economic activities. The sub-region is a globally important source of minerals, with considerable reserves of oil and gas, which continue to cause international tensions. The South China Sea is the world's second busiest international sea-lane, utilised by more than half of the world's super-tanker traffic.

CORAL REEF DISTRIBUTION AND BIODIVERSITY

Coastal areas of the South China Sea with large riverine inputs are mostly devoid of fringing coral reefs, although small fringing and patch reefs are present in some places. Fringing reefs occur away from the major river estuaries, particularly in the Philippines and the central – southern areas of the South China Sea. All major reef types, including fringing, patch platforms (including 'barrier' reefs) and atolls are observed in the South China Sea, with a total estimated reef area in the order of 10,000km^2 (based on aggregation and de-aggregation of national statistics) (Spalding *et al.*, 2001). Offshore, a series of large platform reefs and atolls have developed, the most famous being the Spratly Islands, Tung-Sha Reefs and Paracel Islands. These reefs are highly biodiverse and are thought to play key roles in the maintenance and replenishment of regional biodiversity, and may be particularly important in replenishment of harvested species.

If coral reefs are the most diverse tropical marine ecosystem on earth, then the Indo-Pacific in general, and the South China Sea in particular, are home to a globally significant coral reef system. The South China Sea is considered part of the "coral triangle" with the highest diversity of hermatypic corals in the world (Veron, 1998). More than 70 hermatypic corals have been recorded in the South China Sea. Hotspots of coral species diversity occur at Nha Trang (Viet Nam) with 351 species and El Nida (Palawan, Philippines) with 305 species. Records of more than 200 species occur for a number of sites in Viet Nam, Indonesia, and the Philippines (UNEP, 2004).

Coral reefs are an important marine ecosystem and habitat. Like mangroves and seagrass beds, coral reefs provide nurseries and breeding grounds for coral reef associated species and other marine life such as pelagic and migratory species. Like an oasis in the ocean, coral reefs are where schools of migrating pelagic fish aggregate. In fact, a quarter of the diet of pelagic and migratory species like the yellow fin tuna (*Thunnus albacares*) includes coral reef-associated organisms (Grandperin, 1978). The high species richness of corals and reef-associated fauna and flora in the South China Sea makes this region a valuable source of genetic and biochemical materials.

THE CORAL REEF SUB-COMPONENT OF THE UNEP/GEF SOUTH CHINA SEA PROJECT

Three priority areas of concern were identified in the Transboundary Diagnostic Analysis (TDA)[1] of the South China Sea, namely the loss and degradation of coastal habitats, over-exploitation of fisheries in the Gulf of Thailand, and land-based pollution. Within the concern about the loss and degradation of coastal habitats, coral reefs were considered as a priority habitat along with mangroves, seagrass, and coastal wetlands (Talaue-McManus, 2000).

The UNEP/GEF Project entitled "*Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand*" (the South China Sea Project) was developed to address the concerns and issues identified by the TDA. The South China Sea Project is funded by the Global Environment Facility (GEF) and is implemented by the United Nations Environment Programme (UNEP) in partnership with seven riparian states bordering the South China Sea[2]. Of the three substantive project components, habitat degradation and loss is the largest, being divided into four sub-components: mangroves, coral reefs, seagrass, and wetlands.

The coral reef sub-component includes 6 participating countries, namely Cambodia, Indonesia, Malaysia, Philippines, Thailand, and Viet Nam. At the regional level, the Regional Working Group on Coral Reefs (RWG-CR) is composed of the national focal points for the sub-component from each of the six countries, together with two internationally recognised experts from the region. The working group has agreed Terms of Reference and a set of Rules of Procedure, which state that each group shall elect its' own Chairperson, Vice-Chairperson and Rapporteur from among the members. The RWG-CR was responsible for developing criteria during the first phase of the project (2002-2004) for use in selecting sites for the various demonstration activities to be executed during the operational phase of the project (2005-2007). In addition, the RWG-CR was responsible for assembling information and data, for inputting these into a regional GIS and meta-database, and for conducting the analyses required to demonstrate the regional and global importance of the demonstration sites proposed to the Project Steering Committee. The RWG-CR was also involved in the process to revised the draft regional Strategic Action Programme (SAP) for the South China Sea. Specific actions of the RWG-CR in this regard included the elaboration of goals and targets for the coral reef component of the SAP, and development of a suite of costed actions for improved coral reef science and management in the South China Sea.

The regional coral reef network of the South China Sea Project extends to the national level. National Coral Reef Committees have been established in all participating countries, and are comprised of representatives from governmental agencies, scientific institutions, and non-governmental organisations. National reports and national action plans have been finalised by the Specialised Executing Agencies (SEAs) for the coral reef sub-component in each country, and included in regional database and utilised for SAP development SEAs are were also responsible for the execution of activities at the coral reef habitat demonstration sites during the operational phase of the Project.

REGIONAL THREATS TO CORAL REEFS

Following Tun *et al.* (2004), coral reefs in South East Asia are the most biologically diverse and productive coral reef systems in the world, but are also the most threatened and damaged reefs, with unprecedented rates of coral reef destruction from the acceleration of anthropogenic pressures over recent decades. The RWG-CR identified the key regional threats to coral reefs in the South China Sea during its sixth meeting from 22nd – 25th August 2005. These threats include over-fishing, destructive fishing, pollution (mainly eutrophication), and sedimentation. Indirect causes of these threats are high demand for food, coastal development, deforestation and unsustainable tourism. Coral bleaching is considered a serious natural threat to coral reefs in the region. Of these threats, some discussions were considered as part of the GIWA project (Winkinson *et al.*, 2005), and are summarised as follows.

---

[1] *All project related documents cited in this paper can be found on the project website at www.unepscs.org.*

[2] *Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam.*

Over-fishing

In total the South China Sea produces ~ 5 million tonnes of fisheries catch each year, some 10% of the total global catch. Five of the bordering nations are among the top eight shrimp (*Penaeus* spp.) producers globally, mostly through aquaculture with large scale attendant impacts to habitats and water quality. Domestic fisheries consumption is highest in the Philippines, with increased production required in Cambodia, Indonesia, and Viet Nam to meet increasing domestic demand. Reef fisheries provide essential sustenance to artisanal fisherman and their families throughout the sub-region, and also play an important role in supplying commercial quantities of high value products for export to expanding international, national, and local markets. Live reef fish export operations to Hong Kong and the Chinese mainland have burgeoned since the 1980s, with removal of large numbers of demersal coral reef fish.

Over-fising is considered to be having severe environmental impact in the South China Sea because most stocks are already exploited beyond maximum sustainable yield (MSY), partly through over-investment and encroachment of large-scale commercial operations into coastal waters, including incursions by foreign vessels using long drift nets into traditional/artisinal fishing areas. Demersal reef fish, holothurian, mollusc and crustacean stocks are heavily over-fished. There is also over-exploitation of sharks, tuna, bill-fish and other pelagic species. Sharks are also caught as 'by-catch' of the trawl fisheries and the tuna long-line fishery. Additionally, the benthic invertebrate fisheries, particularly for sedentary species of holothurian sea-cucumbers, trochus, green snails and clams, are over-fished, particularly around the major coastal population centres. Crayfish ('lobsters') are also targeted in oceanic waters, sandy reef lagoons and flats areas. There are clear indications of over-fishing, with two-thirds of the major fish species and several major fishing grounds already fully or over-exploited.

Overfishing does not only reduce production of living resources but also creates ecological imbalances in coral reef ecosystems. Extensive outbreaks of "Crown of Thorn" starfish, blooms of algae, and coral disease might be evidence of changes to coral reef ecosystem dynamics.

Destructive fishing

Following the "Reefs at Risk" report (Burke *et al.*, 2002), approximately 56% of reefs in South East Asia are under threat from destructive fishing. The use of poisons in fishing for demersal reef fish increased significantly in the 1990s (Cesar *et al.*, 2000) to supply the live fish food trade in Hong Kong and China, and also the aquarium trade, with prices increasing but catch per unit effort (CPUE) declining sharply. The targeting and capture of endangered species (e.g., turtles and dugong) continues within the region, and there have been localised species extinctions. Blast fishing is also widespread within the region.

Benthic trawling also occurs in close proximity to reefs, with adverse direct effects on reef productivity and community structure. Trawl fisheries now target most demersal species, with catches of low-value fish being used for the production of fishmeal and other products. The collection of ornamental reef fishes and other organisms for the global aquarium market is also widespread in the sub-region. This activity has already caused serious damage to reefs in some areas, through use of destructive techniques of poison fishing and/or coral breakage.

Sedimentation

Sedimentation is having severe environmental impact in coastal waters throughout most of the South China Sea. This has resulted from land use practices causing extensive deforestation in many coastal catchments, logging and mining, and urban development. This has been compounded by high rates of erosion and siltation. There have been major changes in turbidity and levels of suspended sediments in Malaysia, Viet Nam, Philippines, Indonesia (Sumatra) and Thailand. These impacts, with extensive dredging and land reclamation, have caused changes in biodiversity of affected benthic communities.

There are trends of increasingly large-scale forestry, by both national and international commercial operators. Large areas of the 'loggable forests' have already been logged and other areas have been assigned for logging, contributing to severe soil erosion in some places. Large-scale sediment mobilisation from unregulated forestry and agriculture has already impacted on the water quality of streams and rivers, and ultimately on estuarine and coastal habitats (e.g., fringing reefs) and processes in parts of the sub-region.

In the Philippines, approximately 1 billion m^3 of sediment is lost to coastal waters annually, carrying high loads of particle-bound nutrients. This is of particular concern given that the timber industry has traditionally suffered from mismanagement and corruption, although there have been some recent improvements. Nonetheless, implementation of 'best-practice' forestry management, such as the retention of buffer zones along watercourses, is rarely enforced and violations are common (Hodgson and Dixon, 1992). One exception to this is in Palawan (Philippines), where logging was halted through effective implementation of legislation in the early 1990s, providing a major reduction in sediment loss from the catchments and much needed protection for the fringing coral reefs and other coastal and marine habitats (A. Alcala pers. comm.).

Pollution

Eutrophication in the South China Sea occurs more frequently in coastal waters with moderate impact in some areas of the Philippines. Impacts are most significant in enclosed bays, harbours and lagoons with limited water circulation (e.g., Manila Bay), and particularly where sewage or industrial discharges are present. The rapid development of aquaculture has caused a high potential of nutrient richness in the coastal waters of Viet Nam and Thailand.

There is also some use of fertilisers in coastal catchments, particularly in plantation agriculture, although by world standards use is low. At present, the effects of the nutrients are uncertain, depending partly on rates of mineralisation and retention of the dissolved nutrients. There is little evidence of the effects of nutrient enrichment on the distribution and abundance of biota, increased frequency of hypoxic conditions, reduced levels of dissolved oxygen, or fish or zoobenthos mortality other than in some enclosed bays and in the immediate vicinity of river mouths. There are no indications that eutrophication from agricultural run-off is a significant problem at the scale of the entire South China Sea basin, although blooms of toxic dinoflagellates have caused paralytic shellfish poisoning in some parts of the region.

Coral bleaching

Coral reefs in the South China Sea suffered the effects of high water temperatures in 1998, causing extensive bleaching in many areas. Moderate to severe damage was reported on Indonesia's coral reefs after the 1998 bleaching event and recovery has been variable. Reefs in the Philipines, Thailand, and Viet Nam suffered widespread bleaching episodes leading to high, variable mortality. Recovery is occurring, yet will take time due to continued anthropogenic threats causing further stress. During 1999-2004, there is evidence of coral recovery in Cambodia, Indonesia, Philippines, Thailand and Viet Nam after extensive coral bleaching mortality, mostly in the northern parts of Southeast Asia. Coral recruitment is low in the Gulf of Thailand indicating that recovery from the 1998 bleaching may be delayed. On a positive note, the coral reefs in the World Heritage Tubbataha reefs south of Palawan are showing rapid recovery after years of blast fishing and the 1998 bleaching event (Goldberg and Wilkinson, 2004).

TOWARD THE SUSTAINABLE MANAGEMENT OF CORAL REEFS

The UNEP/GEF Coral Reef Habitat Demonstration Site Network

Fourty three coral reef sites (Figure 1) were charaterised in the framework of the South China Sea Project using a data compilation form agreed by regional experts during the preparatory phase of the project. Data and information for the characterised sites can be accessed from the GIS database which forms part of the South China Sea Project website <http://www.unepscs.org>. This database contains data about reef locations and type, reef area and structure, biodiversity, and socio-economic information regarding resource use and management at the coral reef sites. Following the process adopted by the Regional Scientific and Technical Committee of the UNEP/GEF South China Sea Project, four coral reef sites were selected as demonstration sites within the framework of the project and receive financial support from the GEF grant. These sites include Masinloc (Philippines), Koh Chang (Thailand), Belitung (Indonesia) and Phu Quoc (joint habitat with Seagrass in Viet Nam and as a transboundary site with Kampot, Cambodia). As coral reef area at Ninh Hai (Viet Nam) was also selected as a demonstration site, and a proposal for activities at this site is currently being prepared for funding as a GEF Medium Sized Project. The network of demonstration sites has been expanded to involve self-funded projects proposed by participating countries, such as the Cu Lao Cham site in Viet Nam. Information regarding the approved demonstration projects has been made available on the South China Sea project website to assist in the sharing of information about activities and examples of best practice at the sites within the project network.

The network of coral reef demonstration sites has been developed in conjunction with a suite of mangrove, seagrass, and coastal wetland sites. It is aimed that this network will act as a basis for regional exchange of information and best practice in coastal habitat management of the South China Sea.

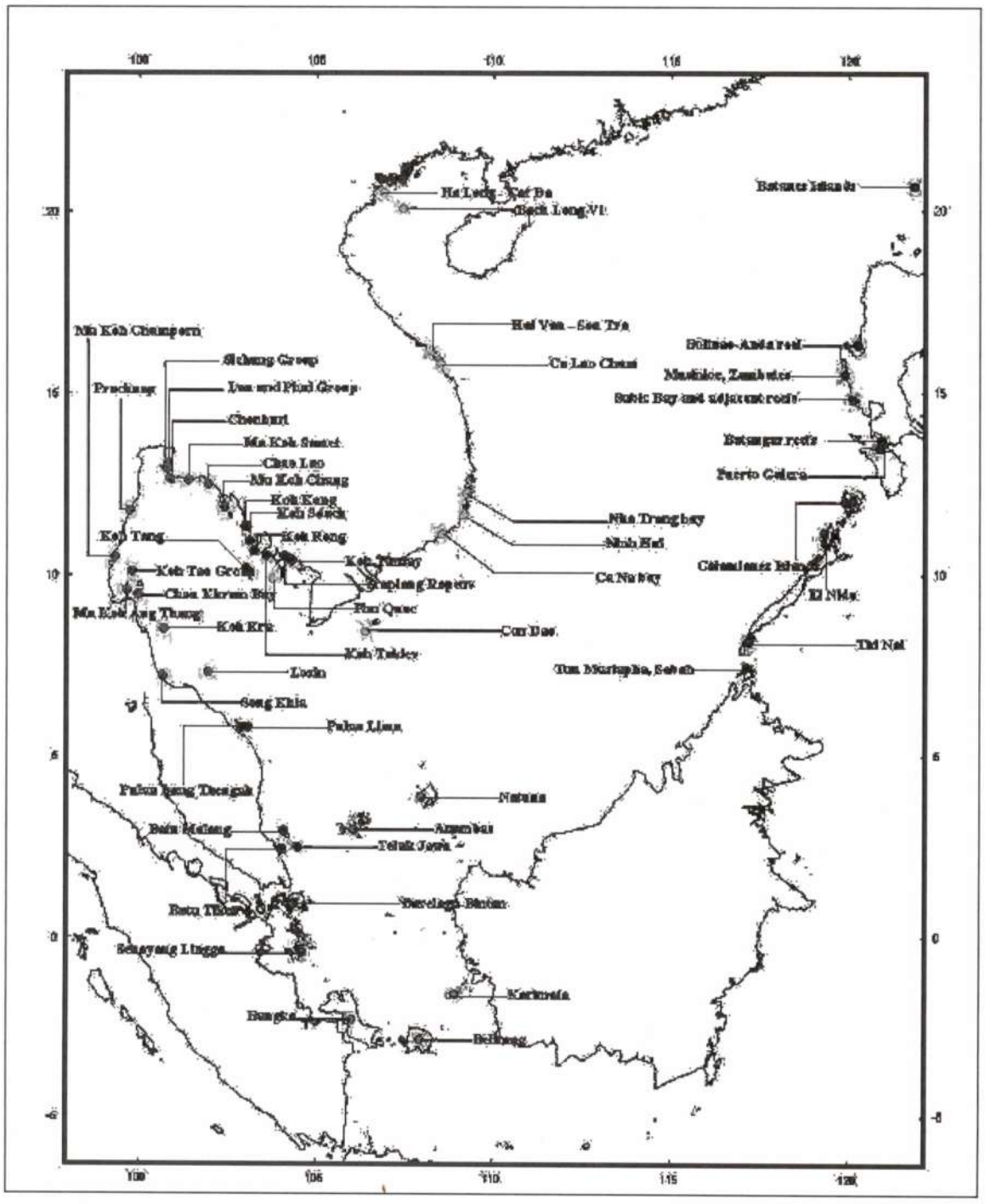

Figure 1 Coral reef sites characterised by the South China Sea Project.

A forum for the exchange of information and experiences between habitat demonstration site managers and local government officials associated with each habitat demonstration site was developed within the framework of the South China Sea Project. This has involved the conduct of two Mayors' Round-Table Meetings, the first in Bangkok, Thailand in November 2005, and the second in Beihai, Guangxi, China in June 2006. These meetings were highly effective in involving local and provincial governments in the implementation of the South China Sea project, and promoting the sharing of information between Mayors and Governors on the integration of environmental

management into local coastal development planning. During the meetings, the provincial Mayors and Governors pledged high-level local government commitment to promote the longer-term sustainability of demonstration site activities, and to integrate environmental considerations into their future development plans.

Participants considered the Round-Table meetings a highly successful and valuable forum for both political and technical people from the local government level to meet at the regional level in order to strengthen political support for the demonstration site network and exchange of experiences. Provincial Mayors and Governors urged UNEP to convene such meetings on an annual basis as far as the project budget allowed. An E-Forum for the exchange of information between meetings was established on the South China Sea Project website, and has been used to facilitate regional level communication between local governments between meetings.

Development of the strategy for sustainable management of coral reefs

During the elaboration of the draft regional Strategic Action Programme for the South China Sea, the RWG-CR analysed the status of coral reef management in the South China Sea geographic region of the six countries based on information assembled for 83 individual coral reef areas. The area of coral reefs in the 83 target coral reef sites is 217,407ha (29% of the total coral reef area of the six countries, of which 100,243ha (13% of the total area) is under management at the present time. In terms of management effectiveness only around 5% of this area is considered as being managed successfully. For 29% of the sites management effectiveness is considered low, whilst around 13% are not under any form of management. The area to be added to the total area managed sustainably by the year 2015 is 53,577ha, thereby increasing the total area under sustainable management to 153,820ha which represents 20% of the total reef area of the six countries berdering the South China Sea or 71% of the total area of the target sites.

Coral reef monitoring has been expanded in most countries bordering the South China Sea over the past decade, and has provided a technical baseline for long-term coral reef management (Tun *et al.*, 2004). The data obtained in the framework of the Global Coral Reef Monitoring Network (GCRMN) indicates that the decadal rate of loss of coral reef cover in the South China Sea is 16%.

The RWG-CR noted that setting a target for the total area under management did not represent a target for the environmental state of the reefs although it could be assumed that those under management would, depending on the management regime, be more likely to sustain their biological diversity than those that were not under management. Therefore, the RWG-CR considered an additional target related to reducing the regional rate of coral reef cover loss. The coral reef focal points of the participating countries agreed that improvements to coral reef management over the next ten years could lead to a reduction in the decadal rate of coral reef cover loss from 16% to 5%. The regional assessment of coral reef status conducted as part of the GCRMN programme will enable an assessment of the effectiveness of coral reef management actions as part of the revised SAP.

In summary, the RWG-CR proposed the following two targets as part of the revised regional Strategic Action Programme:

- *By 2015, at least 70% of the existing area of coral reefs in the 83 target coral reef sites (153,000ha) to be put under an appropriate form of sustainable management.*
- *By 2015, reduce the regional decadal rate of degradation in live coral cover from the present rate of 16% to 5%.*

The concept of sustainable management was also considered the RWG-CR. The group agreed that the sustainable management of coral reef refers to managing the ecosystem in such a way that provides for coral reef resource(s) to be used continuously, and in a cost effective and ecologically friendly manner. Such management typical involves setting targets and objectives, and the establishment of a formal management framework that is clearly understood at all levels and by stakeholders. Indicators are typically used to assess the sustainability of management. The RWG-CR identified three categories of indicators for use in assessing coral reef management, including: management; ecological-environmental; and socio-economic indicators (Table 1).

The purpose of the defining these indicators is to provide a means of assessing whether an area is, or is not, under sustainable management in the framework of targets defined for the coral reef component of the revised Strategic Action Programme. The SAP states that 70% of the existing area of coral reefs in the 83 target coral reef sites in the South China Sea shall be under sustainable management by the year 2015. Depending on objective(s), management input(s) (column 1) are expected to produce measurable output(s) which should be reflected through ecological indicator(s) (column 2) and/or socio-economic indicator(s) (column 3).

Table 1 Sustainable Management Indicator Matrix.

Management Indicators	Ecological/Environmental Indicators	Socio-Economic Indicators
MANAGEMENT CAPACITY • Formal management framework • Trained man-power (nos/levels) • Facilities and equipment • Sustainable financing	• LIVE CORAL COVER • ORGANISM ABUNDANCE • BIODIVERSITY • INDICATOR SPECIES • TARGET SPECIES • WATER QUALITY	FISHERIES • Catch per unit effort • Total landing • Income
MANAGEMENT APPROACH • Sectoral • Integrated • Community-based • Multiple-use		TOURISM • Number of visitors • Number of tourism operators • Income
MANAGEMENT TOOLS • Licensing and permits • Seasonal closure • Zoning		OTHER ALTERNATIVE LIVELIHOODS
		OVERALL LIVING STANDARDS • Level of education • Health of the community

Achieving the targets defined for sustainable coral reef management in the South China Sea requires the implementation of regional and national level actions. The revised Regional Strategic Action Programme contains a set of agreed regional actions aimed at meeting the following objectives:

Objective 1. To promote good environmental governance and sustainable management of coral reef ecosystems

Objective 2. To maintain the regional management framework to ensure the use of sound science in the sustainable management of coral reefs in the South China Sea

Objective 3. To Increase awareness of stakeholders on the ecological roles, economic values, and need for sustainable management of coral reefs

Objective 4. To provide relevant scientific data and information for sustainable management of coral reefs

Objective 5. To improve regional capacity in the management of transboundary issues regarding coral reefs

At the national level, six National Action Plans have been developed with the involvement of related stakeholders. It is aimed that the Governments of the participating countries will adopt and implement these action plans. The scope of national level activities is very diverse in order to cover concerned issues, including policy and legislation, public awareness, capacity building, scientific sound management, and development of models for effective management at the site level. Diverse stakeholders are also involved in implementing the plans in the countries, including central and local governments, non-government organisations, private sector, mass organisations and local communities.

REFERENCES

Bate E. 1999. Biophysical assessment of the Sulu-Sulawesi Large Marine Ecosystem: Geology module. A report prepared for the Sulu-Sulawesi Marine Ecoregion Conservation Program Development, WWF-Philippines.

Burke L., E. Selig and M. Spalding, 2002. Reefs At Risk in Southeast Asia. *World Resources Institute, 72p.*

Cesar, H.S.J., Warren, K.A., Sadovy, Y., Lau, P., Meijer, S., van Ierland, E. 2000. Marine market transformation of the live reef fish food trade in Southeast Asia. In: Cesar, H.S.J. (Ed.). *Collected Essays on the Economics of Coral Reefs.* CORDIO, Dept. Biology and Environmental Sciences, Kalmar University, Sweden.

Goldberg J. and C. Wilkinson , 2004. Global Threats to Coral Reefs: Coral Bleaching, Global Climate Change, Disease, Predator Plagues, and Invasive Species. p: 67-92. *in C. Wilkinson (ed.). Status of coral reefs of the world: 2004. Volume 1. Australian Institute of Marine Science, Townsville, Queensland, Australia. 301p.*

Grandperin R. 1978. Importance of reefs to ocean production. In: Crossland J. and Grandperrin R. South Pacific Commission (Numea, New Caledonia) Fisheries Newletter 15: 125-207.

Hodgson G. and J.A. Dixon. 1992. Sedimentation damage to marine resources: Environmental and economic analysis. In James B. Marsh (ed.) Resources and environment in Asia's marine sector. Taylor and Francis, Washington.

Ng P.K.L. and K.S. Tan, 2000. The status of marine biodiversity in the South China Sea. Raffles Bulletin of Zoology. Supplement N. 8: 3-7.

Randal J.E. and K.K.P. Lim, 2000. A checklist of the fish of the South China Sea. Raffles Bulletin of Zoology. Supplement N. 8: 569-667.

Spalding M., C. Ravilious and E.P. Green, 2001. World Atlas of Coral Reefs. United Nations Environment Programme World Conservation Monitoring Centre, 425p.

Tun, K., L. M. Chou, A. Cabanban, V. S. Tuan, Philreefs, T. Yeemin, Suharsono, K. Sour and D. Lane, 2004. Global Status of Coral Reefs, Coral Reef Monitoring and Management in Southeast Asia, 2004. *p: 235-276. in C. Wilkinson (ed.). Status of coral reefs of the world: 2004. Volume 1. Australian Institute of Marine Science, Townsville, Queensland, Australia. 301p.*

Talaue-McManus, L. 2000. Transboundary Diagnostic Analysis for the South China Sea. EAS/RCU Technical Report Series No. 14, UNEP, Bangkok, Thailand.

UNEP, 2004. Coral Reefs in the South China Sea. UNEP/GEF/SCS Technical Publication No. 2. 11p.

Veron J.E.N., 1998. Corals in space and time. The biogeography and evolution of the Scleractinia. VNSW press. 321pp.

Wilkinson C., L. DeVantier, L. Talaue-McManus, D. Lawrence and D. Souter. 2005 International Waters Assessment South China Sea, GIWA Regional assessment 54. University of Kalmar on behalf of United Nations Environment Programme. 104p.

Wrytki K. 1961. Scientific results of marine investigations of the South China Sea and the Gulf of Thailand 1959-1961. NAGA report, Vol. 2, the University of California, Scripps Institution of Oceanography, 195p.

UNEP
United Nations Environment Programme

UNEP/GEF South China Sea Project

GEF
Global Environment Facility

NATIONAL REPORT
on

Coral Reefs in the Coatal Waters of the South China Sea

CAMBODIA

Mr. Ouk Vibol
Focal Point for Coral Reefs
Fisheries Administration, Ministry of Agriculture, Forestry and Fisheries
186 Narodom Boulevard
P.O. Box 582, Phnom Penh, Cambodia

CAMBODIA

Ouk Vibol
Department of Fisheries, the Kingdom of Cambodia

INTRODUCTION

Marine habitats in Cambodia play a very important role in the national economy and the balance of regional and global environment ecosystems. Marine habitats include coral reefs, inundated forests (mangrove forests), and seagrass. In Cambodia, these habitats primarily fall under the management of the Department of Fisheries with Article 1 of the Fishery Law stating that "*Fishery resources comprise of live animal and vegetable reproduced itself and abided in the fishery domain*", and that the "*Marine fishery domain extends from the coastline to the seaward border of the outer economic zone of the People's Republic of Kampuchea*" (DoF, 1990). This coastal zone is 55,600sq. km and includes 69 islands and 28.065sq. km of coral reefs (DoF, 2004). Administratively, the coastal zone includes the two provinces of Koh Kong and Kampot, and the two municipalities of Sihanoukville and Kep.

From a functional perspective, Cambodia's coastal zone can be conceptualised as being made up of two inter-related systems - ecological and socio-economic systems. The ecological system includes the physical, chemical and biological environmental parameters that provide natural resources, sequesters pollutants, and offers fundamental life-support functions (e.g., clean air and water) for humans and other living organisms. The socio-economic system depends upon many functions and products of complex ecological systems. Cambodia's marine ecosystems are abundant in living resources, but have limited capacity to provide fish, timber, coral reefs, seagrasses, clean water and other goods and services to meet the demands of socio-economic development. Given that the production capacity of the ecological systems is limited, it is not surprising that the final demands by society, and new opportunities for multiple uses, are the source of increasing conflicts arising within Cambodia's coastal zone.

Coral reefs, in particular, are critical habitats for a diverse range of resident and migratory species, especially endangered and vulnerable species. The structure of a reef provides shelter and food for many types of plants, fish and invertebrates (Nelson, 1999). Many Cambodians are also reliant on coral reefs for livelihood and nutrition, with much demand placed on the many commercially valuable species dependent on these habitats. Additionally, these areas provide much potential for the development of eco-tourism in the future. Until recently, little was known about the status of Cambodia's coral reefs due to minimal research and lack of monitoring in this region. However, our knowledge is now increasing with studies carried out by the Danida funded project on Environmental Coastal Zone Management in Cambodia implemented in the Provinces and Municipalities of Kep, Sihanoukville, and Koh Kong Province (Nelson, 1999), the National University of Singapore (Chou *et al.,* 2003), and through the UNEP/GEF South China Sea Project.

PHYSICAL FEATURES

Due to limited research resources, information about the physical characteristics of Cambodia's marine environment is almost completely lacking. However, some general parameters have been recorded such as sea surface and air temperature, depth, turbidity and/or visibility. Usually, visibility is very low near the mainland and high adjacent to offshore islands. Visibility can reach up to 20m in waters surrounding the offshore islands.

CORAL REEF DISTRIBUTION

Coral reefs in Cambodia are mostly distributed as fringing reefs along parts of the mainland, particularly headlands, and around many islands (Figure 1). Corals near to shore are those adapted to living in turbid environments, while further offshore a wider diversity of species is found (Nelson, 1999).

BIODIVERSITY

Coral reefs are some of the most biologically rich ecosystems on earth, however the exact number of species found in Cambodian waters is yet to be determined due to limited research in this region. To

date, at least 70 species of corals in 33 genera and 11 families have been identified during a brief survey at Koh Tang near Sihanoukville (Nelson, 1999). A review conducted by the Fisheries Component of the UNEP/GEF South China Sea Project found 520 marine fish species from 202 genera and 97 families, with an estimated total stock of marine fish of 50,000 metric tonnes (Ing, 2003). The total number of coral reef associated species in Cambodia is largely unknown (Table 1).

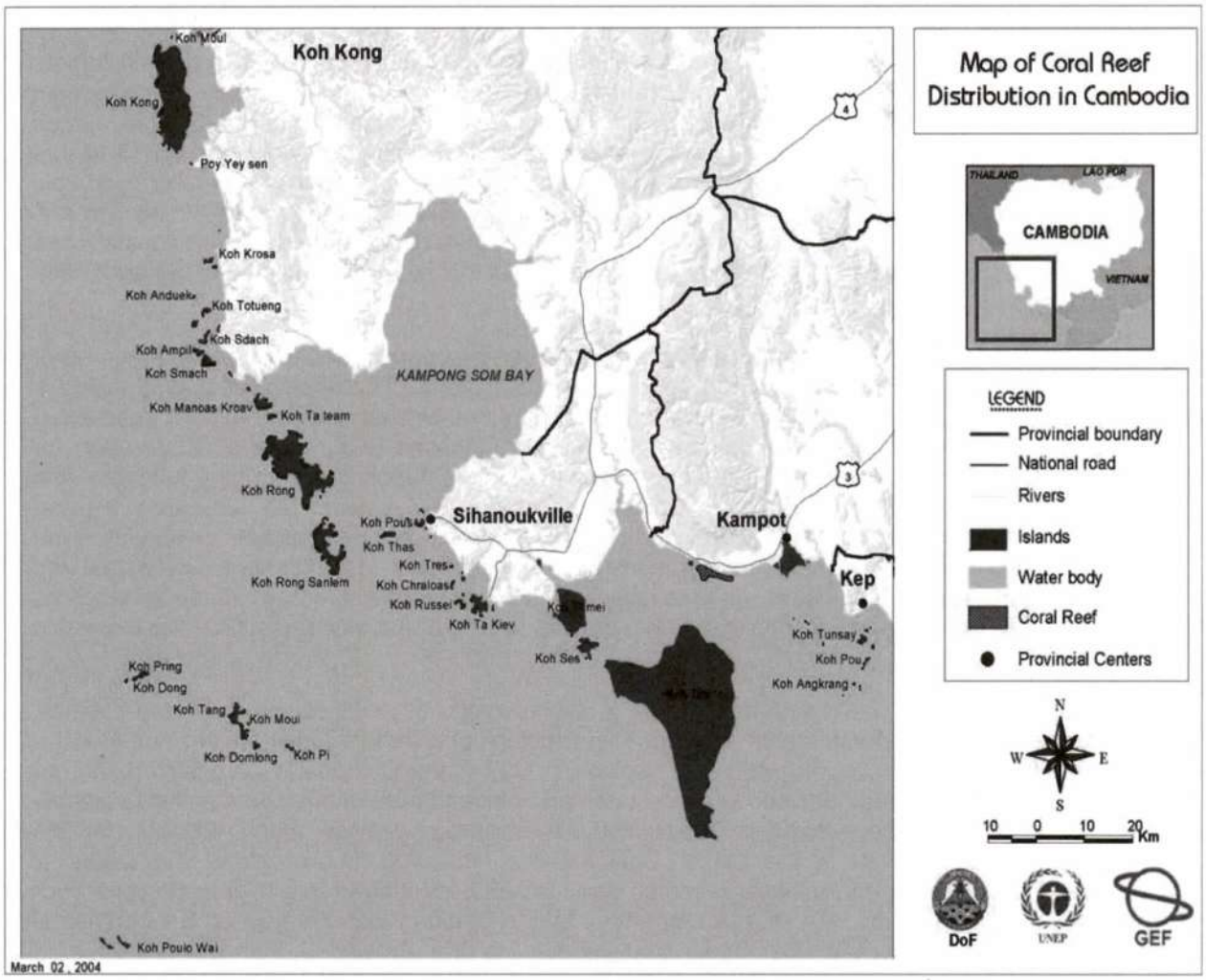

Figure 1 Map of Reef Distribution in Cambodia.

Table 1 Estimated Number of Species for Major Groups of Marine Biota.

Marine Biota	Number of Species	References
Hard Corals	70	Nelson, 1999
Soft Corals	17	Nelson, 1999
Marine Fish	520	Ing, 2003
Echinoderms	21	Ing, 2003
Crustaceans	50	Ing, 2003
Molluscs	250	Ing, 2003
Marine Turtles	5	Ing, 2003
Marine Mammals	12	Ing, 2003
Seaweeds	16	Ing, 2003
Seagrass	9	CZM, 2002

STATUS OF CORAL REEFS

In 2003, the Department of Fisheries conducted a coral reef baseline survey in Cambodia using standard methodologies as outlined by two global coral reef monitoring agencies, the Global Coral Reef Monitoring Network (GCRMN) (http://www.gcrmn.org) and Reef Check (http://www.reefcheck.org.). These methods employ rapid assessment techniques, which enable quick and reliable assessment of coral reef health. Reef Check was used for the survey of reef fish, invertebrates, and general reef condition. The GCRMN Line Intercept Transect Method, which has been widely used within the Asia-Pacific region to survey coral reefs, was used to provide detailed quantitative benthos assessment. Seven sites including the Koh Kong Islands, Koh Sdach Islands (Koh Kong Province); Koh Rong, Koh Rong Sanleom, and Koh Takiev Koh Tang island groups (Sihanoukville); and the Koh Tunsay island group (Kampot Province and Kep Municipality) were selected as monitoring sites. The data collected by monitoring activities provided a figure on coral reef status in the coastal waters of Cambodia.

Status of Reef Benthos (especially corals)

Based on the GCRMN range, Cambodia's coral reefs are in fair to good condition, with coral cover ranging from 23.1% in the Koh Sdach island group of Koh Kong Province to 58.1% at Koh Takiev island group of Sihanoukville. Dead coral was observed to range from 0% in Prek Ampil to 44.9% per square meter at Koh Rong. However, this may not be a reflection of the status of all reefs in Cambodia, as surveys were not carried out in areas of intensive seaweed farming. Reports from the Koh Pouh area indicate that coral reefs have been heavily impacted on by seaweed farming activities in that area, leaving most reefs in very poor condition (Mam 2001). Little other benthos was observed at most of the sites, accounting for only 2.2% of total cover at the Koh Sdach island group. The highest percentage of other benthos was observed in the Prek Ampil area of Kampot Province, accounting for approximately 5.6% of total cover (Table 2).

Algal cover was not very dominant at most sites, and no algae was observed on the reefs of Koh Takiev. The highest percentage cover of algae (17.5%) was observed on the reefs of the Koh Sdach island group of Koh Kong Province. The coverage of sand and rock is considered high, accounting for 15.4% of total cover at the Koh Sdach island group and 40% at Prek Ampil (Table 2).

Table 2 Percentage cover of benthos types on selected coral reefs in Cambodia.

Benthos	Koh Kong	Koh Sdach	Koh Rong	Koh Takiev	Koh Tang	Prek Ampil	Koh Pouh
Live Coral (%)	47.4	29.3	23.1	58.1	38.3	53.8	41.0
Dead Coral (%)	29.6	35.6	44.9	0.6	13.1	0.0	19.2
Other Benthos (%)	4.2	2.2	5.1	3.1	4.2	5.6	2.4
Algae (%)	1.6	17.5	0.6	0.0	0.6	0.6	10.1
Abiotic (%)	17.2	15.4	26.4	38.1	43.8	40.0	27.4

Only Koh Rong and Rong Sanleom of Sihanoukville have been monitored over time. The first survey was conducted in 1998 by the Daninda funded Environmental Coastal Zone Management (CZM) project (Nelson, 1999). In 2001, the site was surveyed by Wetlands International and the CZM project (Mam, 2001). The two final surveys were conducted by the Department of Fisheries with the support of the UNEP EAS/RCU[3] in 2002 and 2003 for trainings on diving, reef check, and the GCRMN Line Intercept Transect (LIT).). Although no exact positions of the transects were plotted by GPS for the last two monitoring programmes, it is believed that all surveys, including the last two, were conducted at very similar locations, although at different times of the year.

The percentage of live coral cover did not change significantly from 1998 to 2003 (Figure 2). The initial survey in 1998 found that live coral accounted for 20% of the total reef cover at this site. The percentage cover was observed to increase slightly to 26.25% in 2002, before dropping to 23.12% in 2003. However, regular annual monitoring is needed in order to detect any trends over a larger temporal scale.

[3] *East Asian Sea Regional Coordinating Unit.*

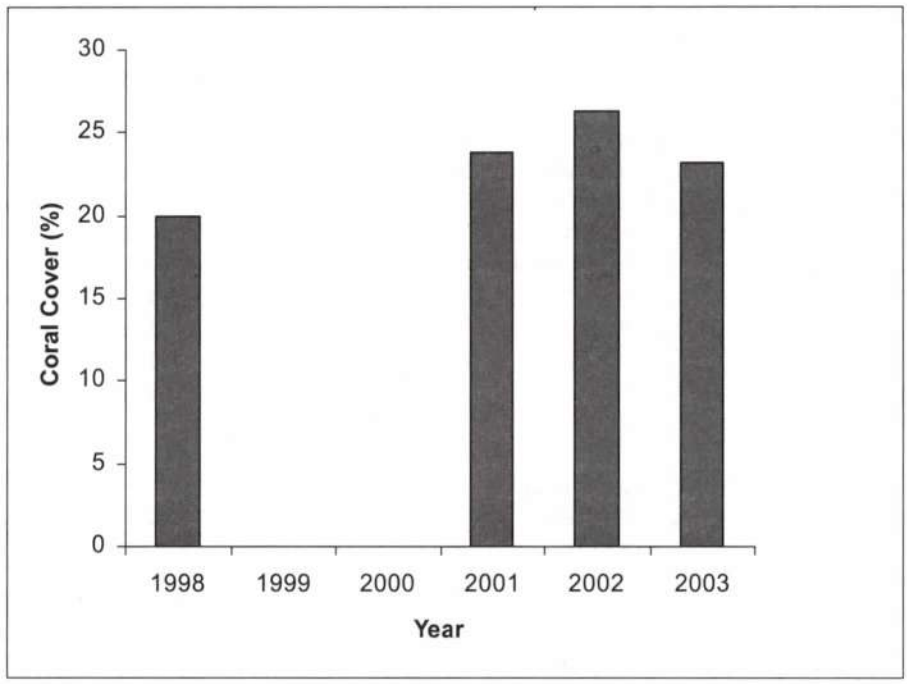

Figure 2 Trend of Live Coral Cover in Koh Kok (Koh Rong and Rong Sanleom) of Sihanoukville.

Status of Reef Fish

Based on the ReefCheck method, about 17 groups of reef fishes and invertebrates have been recorded at seven locations. They include butterfly fish, sweetlip, snapper, barramundi cod, grouper, humphead wrasse, bumphead parrotfish, other parrotfish, moray eel, banded coral shrimp, pencil urchin, sea urchin, sea cucumber, crown-of-thorn star fish, giant clam, triton shell, and lobster. The following table shows the number of each animal group per 100 square metres. Reef fish indocators are found at nearly all sites except Koh Pouh of Kep Municipality. Sweetlip, barramundi cod, moray eels, lobster, triton shell, and banded coral shrimp were rarely present at any of the sites. The lack of banded coral shrimp may not be a true reflection of their actual numbers, but a consequence of their small body not seen by researchers (Table 3).

Table 3 Site Summaries of Major Fish Groups per $100m^2$.

Major Fish Group	Koh Kong	Koh Sdach	Koh Rong	Koh Takiev	Koh Tang	Prek Ampil	Koh Pouh
Butterflyfish	1.63	0.47	1.75	0.75	1.25	7.00	0
Sweetlips (Haemulidae)	0	0.33	0	0	0	0	0
Snapper (Lutjanidae)	0.13	0.10	6.50	1.75	0.42	0	0
Barramundi Cod (*Cromileptes*)	0	0.07	0	0	0	0	0
Grouper	2.63	0.23	2.25	0.25	1.67	0	0
Humphead Wrasse		0.47			0.33	0	0
Bumphead Parrotfish	0.13	0.07		1.25		0	0
Other Parrotfish	4.38	2.37	0.75	2.00	15.33	0	0
Moray Eel					0.08	0	0
Banded coral shrimp (*Stenopus hispidus*)	0	0	0	0	0	0	0
Diadema urchins	*5.0*	17.0	213.0	17.0	129.8	7.0	4.3
Pencil urchin (*Heterocentrotus mammilatus*)	0	0.4	0	0	0.1	0	0
Sea cucumber (edible only)	0	0.1	0	0	0	0	0
Crown-of-thorns star (*Acanthaster*)		0.1	0.8				
Giant clam (*Tridacna*)	2.0	1.2	0.3		0.3		
Triton shell (*Charonia tritonis*)		0.2					
Lobster							

THREATS

There are many anthropogenic impacts causing damage to the coral reefs of Cambodia. These include destruction of coral from anchors, dynamite fishing, discarded fishing gear, and seaweed farming. Monitoring data indicates the status of damage to coral reefs at the site level (Table 4).

Table 4 Anthropogenic damages to the coral reefs in Cambodia.
(General reef condition: None=0, Low=1, Medium=2, High=3)

Location	Koh Kong	Koh Sdach	Koh Rong	Koh Takiev	Koh Tang	Prek Ampil	Koh Pouh
Coral damage: Anchor	0.9	0.2	0.0	0.0	1.4	0.0	0.3
Coral damage: Dynamite	1.8	0.7	0.0	0.0	2.4	0.0	1.3
Coral damage: Others	0.5	0.7	0.0	0.3	1.2	0.0	0.3
Trash: Fishing gear	0.4	0.3	0.0	0.0	0.7	0.0	0.8
Trash: Others	0.0	0.3	0.0	0.0	0.2	0.0	0.3

Destructive Fishing Methods

There is little data on over-fishing and destructive fishing practices. Data from ReefCheck surveys and other studies indicate however, that dynamite fishing is a major threat to coral reefs in Cambodia (CZM 1999). Only one interviewee admitted to using dynamite, and claimed that a profit of up to 14.7 million riel per day was possible (CZM 1999). Information about cyanide fishing is equally lacking but thought to be practiced using cheap chemicals from Viet Nam (US$36/kg). It has been reported that groupers and cod are caught using this method for grow-out in cages at Tumnup Rolork and Stoeng Hav (CZM, 1999).

Coral collection, an important threat from 1995 to 1997, is declining because the Fisheries Department has tightened controls and confiscated coral from vendors. More recently, there has been a reduction in the collection of coral due to the prohibition of this activity by the Provincial Government and the declining value of coral for use in the curio trade.

Anchor and Trawler Damage, Others Kind of Damage (divers, trampling, etc.)

Anchor damage is apparent on most reefs in Cambodia, largely as a consequence of a lack of mooring buoys and low-level awareness amongst fishermen of the damage boat anchors do to reefs. Tourism based on Cambodia's coral reefs is limited, such that the impacts from tourist boats, divers and trampling are limited. However, this could be a potential threat in the future with the development of the tourism industry.

The introduction of seaweed cultivation to Cambodia in 1999 is also contributing to the destruction of once healthy corals. Seaweed cultivation is a lucrative business attracting significant foreign investment in Cambodia. This activity is particularly prevalent in Kampot Province. The destruction of corals associated with seaweed culture is a consequence of local people cultivating seaweed directly on reefs, with damage caused by trampling or discarded trash. In some areas, corals are now under severe threat from seaweed farming and are disappearing from many sites. The majority of coral communities on Koh Pouh where intensive seaweed farming takes place have been converted to rubble due to unsustainable farming practices (Mam, 2001).

Development Impacts (ports, airports, dredging, etc.)

There are many construction activities taking place in the coastal areas of Cambodia, but their impacts on coral reefs are largely unknown. Construction activities, including commercial port expansion, five-star hotel construction, and golf course development are particularly prevalent in Sihanoukville municipality. Even with the Government's policy of conducting Environmental Impact Assessments (EIAs), no EIAs were conducted prior to recent development activities in this important coastal municipality.

Coastal agriculture and development have contributed to the damage of coral reefs in Cambodia as a result of increased sedimentation and land-based pollution. Without any prompt mitigation, large quantities of agricultural run-off and soil will continue to be discharged from coastal rivers to areas of Cambodia's coral reefs each year. The sediment and nutrient loads of Cambodia's coastal rivers are largely unknown, but increased turbidity has been reported for most coastal water areas.

Coral Bleaching

There is little data available on coral bleaching in Cambodian waters. However, similar to other places in the region, coral bleaching did occur in 1998. Bleaching from the 1997-1998 event affected Cambodian reefs, with one survey indicating that 80% of corals in Sihanoukville bleached during 1998 (Burke *et al.* 2002). Nelson (1999) also noted that bleaching occurred elsewhere in Cambodia, including other sites on Koh Rong Sanleom, Koh Rong, Koh Tang, Koh Damlong, and Koh Thas.

Outbreaking or Invasive Organisms

Crown-of-thorns starfish were abundant in 1998. At one site on Koh Tang, crown-of-thorns starfish were abundant, with more than 20 large starfish observed per $100m^2$ (CZM, 1999). However, recent surveys have reported low densities, with only one animal observed at some sites and none found in others. Of more concern are the numbers of *Diadema setosum*, with 218 observed per $100m^2$ in Koh Rong and Rong Sanleom.

Potential threats to coral reefs

There are many potential threats to coral reefs in Cambodia. *Reefs at Risk in Southeast Asia* indicated that the main threats are from coastal development, marine-based pollution, sedimentation, over-fishing, and destructive fishing (Burke *et al.*, 2002). Over-fishing is major threat to all reefs in Cambodia, and while destructive fishing is also a potential threat, it is unknown how many reefs are at risk.

Coastal Development

At present, coastal development is only a high threat to a relatively small percentage of reefs in Cambodia. However, in the future, as the amount of development along the coastline increases, the percentage of reefs at risk from this potential threat will also increase if strict environmental impact assessments and mitigation are not carried out.

Marine-Based Pollution

The majority of reefs are considered to be only at medium to low threat from marine-based pollution. However, many reefs would be at high risk in the case of a catastrophic event such as an oil spill, as the government is insufficiently prepared for such events.

Sedimentation and Nutrient Inputs

Burke *et al.* (2002) considered the threat to coral reefs from sedimentation to be low. However, much land clearing, for both timber and agricultural purposes, occurs upstream of rivers and estuaries, and as this continues in the future, the threat of sedimentation to coral reefs may increase.

Over-fishing

Over-fishing is considered one of the greatest threats to coral reefs in Cambodia, with all reefs at high risk. It is thought some reef fish and invertebrates are now locally extinct, while populations of others have been reduced significantly. While exact figures are unavailable, it is certain that increasing populations in coastal areas are placing increasing demand on fisheries resources, due to a high level dependence on them for food and income.

SOCIO-ECONOMY AND RESOURCE USES

Socio-economic status

Population

A population census conducted in March 1998 showed a population of 11.4 million, with approximately 85% living in rural areas. In coastal areas, populations ranged from 28,677 in Kep to 527,904 in Kampot Province (Table 5). The average household size ranged from 5.0 people in Kampot province to 5.5 people in Sihanoukville, with females heading 24.8% of households in coastal areas (Ministry of Planning 1999).

Table 5 Population size and density of Cambodia and its coastal areas.

Location	Areas (km^2)	Population	Women (% total)	Density ($/km^2$)
Cambodia	181,035	11,426,223	51.8	64
Kampot	4873	527,904	52.1	108
Koh Kong	11160	131,912	48.7	12
Sihanoukville	868	155,376	50.5	179
Kep	336	28,677	51.0	85

Source: *Ministry of Planning – General Population Census of Cambodia, 1999.*

Cambodia's population is growing at an estimated annual rate of 2.4% (Ministry of Planning, 1999). The population is mostly comprised of people of Khmer decent (90%). The main ethnic groups are the Cham, Vietnamese, Chinese (also sometimes called Khmer-Chinese), and others from different hill tribe groups. It is estimated that 95% of the population speak the Khmer language. The main religion in Cambodia is Theravada Buddhism, while the Cham are Muslims. There are no estimates of the distribution of ethnic groups in coastal areas, however, the proportion of Cham people on at least part of the coastline is relatively high (Ministry of Planning, 1999).

Occupations

There is a scarcity of clear information about the occupations of Cambodia's coastal people. However, studies suggest that while most households depend on several occupations and sources of income, fishing is dominant, being the main occupation in six villages of Sihanoukville, six villages of Kampot, five villages of Koh Kong, and three villages of Kep. (Carl Bro International a/s 1999).

Migration

There was considerable rural to urban migration in the years immediately following the 1993 elections, as villagers searched for better employment opportunities in the largely urban private sector generated by the influx of international development assistance (UNICEF, 1996). Coastal migration is still occurring with 29.6% of men and 15.6% of women relocating in search of employment (Table 6). There has been substantial migration into the coastal areas, particularly Koh Kong province, over the last 20 years. Table 6 highlights the percentage of distribution of migrants by reason for migration and gender.

Table 6 Migration into Cambodia's coastal zone by reason and gender.

Reason for migration	Both Sex (%)	Males (%)	Females (%)
Total	100	100	100
Transfer work	11.0	15.2	3.2
To search for employment	31.0	29.6	15.6
Education	2.5	2.8	1.6
Married	11.4	12.2	9.3
Family moved	53.9	28.9	56.2
Natural calamities	2.7	2.6	3.0
Return after replacement	6.0	5.3	6.1
Other reasons	5.2	3.6	5.1

Source: *Ministry of Planning (1999)*.

Education

According to the 1998 Census, 61.2% of Cambodia's literate population had not completed the primary level of education. In Kampot, Koh Kong, Sihanoukville, and Kep, the percentage of the population yet to have completed education at a primary level was 65.9%, 58%, 56% and 68%, respectively. A small percentage (1.45%) of Cambodia's literate coastal population had acquired literacy without passing any grade or class (Ministry of Planning, 1999).

Gender disparity is greatest among the poor, but it is also significant among the richest 20% of the population. Boys and girls have fairly similar school enrolment rates until the age of 10. By 15 years of age, male enrolment is 50% greater than that of girls, and by 18 years of age, male enrolment rates are nearly three times as large as female enrolment rates. This means that initially, parents send both their sons and daughters to school, but take the girls out of school after a couple of years. Household survey data suggest that more than 60% of children drop out of school because they have to help the family with household and market work. Furthermore, parents are often reluctant to send their girls to secondary school as they would be required to travel long distances or stay away from home (Ministry of Planning, 1999).

Income level

The average per capita income of Cambodia in 1998 was 79,355 Riels or US$20.80 per month. In coastal zones it is slightly less, with the average income per person per month reported at US$19.50. This level was higher than that in the Tonle Sap zone (US$17.80) and mountain zone (US$18.21), but

lower than in the plain (US$23.09) (Ministry of Planning, 1999). General problems faced by some local communities include lack of rice and food, lack of water during dry season, lack of schools and health facilities, lack of capital for productive use, and decline in fish catch.

Fishing conflicts

Small-scale, trawl, and motorised push-net fishers are in conflict over access to inshore areas and fish resources. Trawls often destroy small-scale fishing gear and large commercial operators typically do not pay compensation to local fishers. Small-scale fishers cannot claim compensation as trawling is banned in most inshore areas and the crews of such vessels are usually under the protection of high-ranking military, police, or government officials. There have also been reports of significant variations in the types and levels of taxes and other fees paid by local fishermen. In Koh Kong it has been reported that many fishermen had to pay a monthly fee ranging from R50,000 – 80,000 to the police, army, fisheries officers and village guard, in addition to the annual tax to the Fisheries Office. There are also reports of fishing equipment being confiscated if fishermen did not pay around R50,000 per month to people whose task it was to prevent violation of fishing regulations (Carl Bro International a/s 1999).

Resource uses

The development of Cambodia's coastal zone continues to occur at a rapid pace. While the coastal areas of Cambodia are a prime location for foreign and domestic tourism investment, due to pristine beaches along the coastline and the offshore islands, the primary economic benefit comes from extractive use of its resources. As a consequence, the coastal area is experiencing high immigration rates, second only to Phnom Penh. Concern exists about the unsustainable use of natural resources, particularly those located near the coastline, and the detrimental effect that loss of value would have on many local communities.

Marine resources are vital to the livelihood of many inhabitants of coastal villages, with many people reliant on fishing for their primary source of income. Most fishermen catch fish, shrimp, crab and squid around different islands and headlands, some fishing up to 15km from the village. Much shrimp, crab, crab meat and expensive fish is sold to traders both locally and internationally, with villagers in Koh Kong selling most of the sea products in Thailand. There is seasonal variation in prices which traders are willing to pay for the products, with villagers having no other option but to sell their products to the traders (Carl Bro International a/s 1999).

Many people feel there has been a decline in their standard of living over recent years, with loss of value of marine resources due to significant reduction in fish stocks and declines in fish catch. Many fishermen are dissatisfied or angry about the use of trawling and pushing nets and boats using lights in shallow water because it can damage local fishermen's equipment and also takes away all the small fish and other marine resources (Carl Bro International a/s 1999).

Reef Fish and Fisheries

The most direct use of the coral reef ecosystem is marine fisheries with the Department of Fisheries reporting 42,000 to 45,000 metric tons of non-reef fish and reef fish collected every year (Ing, 2003). However, these figures are unreliable and it has been estimated that it could be much larger than the official figure. It is also hard to determine how much of these resources have come from coral reefs. With increasing population growth in coastal areas, increasing demands are being placed on this resource with more people dependent on fish for their livelihoods and nutrition. Reef fish are the most valuable species in both domestic and international markets, and therefore the most targeted species by both legal and illegal fishers.

Reef fish, such as Sweetlips (Haemulidae), Snapper (Lutjanidae), Barramundi Cod (*Cromileptes*), Grouper, Humphead Wrasse and Parrotfish, are the most valuable and targeted marine species. Though, at present, there are no statistical records of these fish. Traditionally fishers catch these species by using trap, gillnet, and hook and lines. These species are collected in all sizes including juveniles. The juveniles and pre-adult fish are collected and ranched in cages along the coast, to be then sold alive to both local restaurants and international markets in Hong Kong, China and Taiwan when they reached commercial sizes.

Tourism

Tourism related to coral reefs seems is limited in terms of infrastructure and activities. Cambodia has very limited resources to develop the marine tourism sector. However, compared to the last few years, more and more tourists are coming to Sihanoukville to see the coral reefs of Koh Thas, Koh Rong and Rong Salem, and even Koh Tang. Diving and snorkelling by foreign tourists in Sihanoukville is also becoming more popular and expected to increase in the future with much potential for further development of eco-tourism in the region. Currently there are three private SCUBA diving centers in Sihanoukville, namely, ECO-SEA, Chez Claude, and SCUBA NATION. Each centre brings about 30-40 divers per month. It is anticipated that the number of divers will increase in the near future when infrastructure and equipment are put in place.

Other Uses

Apart from fisheries and tourism, coral reef resources may play another very important role in scientific research for medical purposes and socio-economic use. However, in Cambodia very limited scientific research has been carried out for medicines or other purposes. In terms of socio-economic use however, most local people who live nearby the reef areas are making their living from the reefs. Most of them are fishers, but some are gaining indirect benefits from the reefs by selling fishing gear and fishing boats.

Collection of corals for souvenirs has also been popular for many years, and even now, though illegal, is still continuing. The main types of corals collected include table corals (*Acropora* spp.), elephant ear corals (*Turbinaria* spp.), deer horn corals (*Porites* spp.). Previously, large amounts of dead corals were collected by high rank military officers for use in the construction of their homes.

MANAGEMENT

Legislations

Existing laws and regulations for coral reef management in Cambodia are insufficient, especially considering the increasing threats to coral reefs in the country. There is no law that explicitly relates to coral reef management, although Cambodia's fisheries law notes the requirement to protect Cambodia's rich marine living resources. Most laws relate to the protection of fisheries rather than coral reefs and there is still a lack of clear policies and regulations for the management of these important resources. The weaknesses in the current system need to be identified and laws amended to provide a sound legislative basis for the protection of coral reefs, while facilitating the development of a transparent legal framework and procedures. Transparency is imperative to reducing the current levels of misuse of authority within the system and ensuring the protection of coral reefs.

Currently, two new legislative tools are being proposed by the Department of Fisheries. These are:

- Royal Decree on the establishment of protected aresa and the conservation of coral reefs and seagrass in Koh Rong and Koh Sdach Group of Islands.
- Sub-Decree on the management of Marine Protected Areas covering coral reefs and seagrass areas.

At the time of writing, the Royal Decree had been submitted to the Consul Minister and was awaiting approval, while the Sub-Decree submitted to the Ministry of Agriculture, Forestry and Fisheries is still in draft form. It is uncertain as to when these legislative tools will be implemented.

It must be recognised that these amendments will remain ineffective unless qualified law enforcement officials, at the local and national level, ensure compliance. Ultimate success is dependent on the awareness of local communities and resource users of laws and regulations and their compliance to the system. Only then will coral reefs be effectively protected by law.

Institutional framework

The institutional framework for the conservation of coral reefs in Cambodia is still rudimentary, possibly as a consequence of little understanding and awareness of the significance and benefits of this habitat amongst stakeholders. Day-to-day management of natural resources and resource use on the coast is primarily the responsibility of the Ministry of Agriculture, Forestry and Fisheries (MAFF), particularly the Department of Fisheries. There are fisheries staff at district and provincial levels responsible for the patrolling and management of commercial and medium-scale marine fisheries, and the protections of critical fisheries habitats such as mangroves, seagrass and coral reefs.

However, there are overlaps of responsibilities among concerned government agencies, particularly Ministry of Environment and Department of Fisheries of the Ministry of Agriculture, Forestry and Fisheries, and between the national and provincial level agencies and departments. The Ministry of Environment is responsible for the management of protected areas and for overseeing environmental protection. This includes the protection of coral reefs, seagrass and mangroves, particularly when they are in a protected area. This overlap does not seem to be problematic for managers on the ground, but needs to be clarified legally. As coral reef management is a shared responsibility between many departments, including the Department of Fisheries, the Provincial Government, and District Government, there are many potential sources of institutional conflict (Chou *et al.*, 2002).

Existing institutional frameworks for coral reef management in Cambodia should be reformed to ensure the protection of coral reefs from the national down to the local level. In compliance with the *Fisheries Master Plan*, empowerment of local communities is required to enable community participation in management. Providing resource users with an opportunity to contribute to management decisions, gives the community greater ownership over, and responsibility for, marine areas and resources. With the rapid development of most coastal areas, it is important that local communities have a sound knowledge of the importance of coral reef areas and the potential impacts of economic activities, particularly tourism.

Marine Protected Areas (MPAs)

Legally, only one marine protected area has been established, namely the Ream National Park. Originally, it was designed to protect mangrove forests, with no consideration of adjacent coral reef areas. However, the park was later extended to include some coral reef area. The first project was community-based fisheries management at Ream National Park, which was a demonstration project funded by ADB in 1999. This project involved the development of community participation in fisheries resources management at the site. Regulations at the community level were developed, and participatory enforcement was initiated.

Currently, the Department of Fisheries is proposing to establish another MPA around two groups of islands, specifically the Koh Kong island group and Koh Sdach. The area of this proposed MPA is 712 km^2. The Department of Fisheries realises the importance of establishing these areas and their significance to the sustainable management of marine fisheries in Cambodia.

Monitoring

The Government of Cambodia is committed to ensuring the effective management and conservation of the countries marine resources. Therefore, information on the extent and present health of coastal and marine ecosystems, including coral reefs, is needed to provide the basis for a long-term management strategy. Monitoring and assessment is a critical element of marine resource management aimed at achieving the sustainable use of Cambodia's coral reefs and associated resources. In the past there has been no coral reef monitoring programmes in Cambodia due to a lack of funding and resources. However, several organisations/programmes have supported coral reef survey activities in Cambodia since 1998. These include:

- *Environmental Coastal Zone of Cambodia (CZM)*
  This programme, financially supported by DANIDA, focused on coastal zone and resource management and conservation. The project started in November 1998, undertaking the first coral reef baseline surveys in some areas, particularly around Sihanoukville.

- *Wetland International Asia-Pacific and Lower Mekong Basin Programme*
  In 2001, a team from the Ministry of Environment, Wetlands International Asia-Pacific, and Lower Mekong Basin Programme conducted field surveys of Cambodia's coral reefs and seagrass areas.

- *National University of Singapore (NUS) Project*
  In 2002, The National University of Singapore, with support from the Singapore International Foundation (SIF) and Youth Expeditions Projects (YEP), organised three expeditions to assess the marine biodiversity of the reefs off Koh Kong Province, Cambodia. Data was collected from the Koh Sdach group of islands, using the methods of Reef Check and Line Intercept Transect (LIT).

- *United Nations Environment Programme (UNEP)/International Coral Reef Action Network (ICRAN)*
  In 2002, UNEP/ICRAN supported staff from the Department of Fisheries in SCUBA diving, Reefcheck and LIT Training courses through the implementation of the project entitled "Proposed Marine Protected Areas in Koh Rong and Rong Sanleom".

- *United Nations Environment Programme/Global Environment Facility/South China Sea Project (UNEP/GEF/SCS)*
  The Department of Fisheries is currently implementing the coral reef and seagrass component of the UNEP/GEF project entitled "*Reversing Environmental Degradation Trends in the Gulf of Thailand and South China Sea*". This project determined the general distribution of coral reefs within Cambodia's marine waters, and conducted baseline surveys to determine the abundance and distribution of coral reef benthos, reef fish, and invertebrates. The general condition of coral reefs was investigated by identifying visible impacts. The project also supports the development of the National Action Plan for Coral Reef and Seagrass Management in Cambodia.

CONCLUSIONS AND RECOMMENDATIONS

Due to the fact that Cambodia had a very long period of civil war, limited research has been carried out on coral reefs and the marine environment. As a result, information regarding the status of coral reefs is scarce. Recent surveys indicate that coral reefs cover a total area of 28.065km^2, including 70 species of coral in 33 genera and 11 families. Live coral cover at coral reef sites in Cambodia has been observed to range mainly from 23%-58%. However, there have been reports of much damage and destruction of reefs as a result of destructive fishing methods and seaweed farming. In general, near shore reefs are in poor condition with turbid conditions, while healthy reefs are found further offshore, away from human impacts.

Policies and plans for the long-term management of coral reefs in Cambodia are not yet in place. Existing laws focus on fisheries only. This situation, in conjunction with ineffective law enforcement, is not conducive for the effective management of coral reefs and their resources. There are also overlaps in responsibilities among concerned government agencies, which have the potential for conflict in the future. In addition, the Cambodian government has limited capacity, infrastructure, and finances to conduct regular scientific research and monitoring. Greater awareness of the ecological and economical value of coral reefs is needed from all stakeholders at all levels to promote the protection of these areas. With the increase in demand for these resources, increasing populations in coastal areas, as well as the potential for development in the future, there is a need to establish effective management strategies for the long-term sustainable use of coral reefs in Cambodia.

Therefore the development of a National Action Plan for coral reef management in Cambodia, coupled with: improvements to legislation, administrative frameworks and enforcement; establishment of management models; research and regular monitoring; capacity building and maintenance; increasing public awareness and participation; and financial sustainability, is urgently needed to ensure sustainable use and reduce the degradation of this important resource.

Recommendations:

- Implement a National Action Plan for coral reef management to ensure conservation and sustainable use of coral reef ecosystems.
- Implement a national policy, legal and administrative framework applicable to coral reef management and conservation with the aim of reducing the degradation of coral reefs and maintaining their multiple benefits and uses.
- Establish management models to ensure sustainable use of coral reefs according to their different ecological and economic values in order to maintain a balance of uses.
- Establish research and monitoring facilities to monitor the status of coral reefs and to support conservation and management.
- Build cross-sectorial capacity for sustainable coral reef management at national and local levels.

- Increase awareness of managers and communities on the ecological roles and economic values of coral reefs to promote the balance between utilisation and conservation of these resources.
- Create financial sustainability and improve economic status of coastal communities.

REFERENCES

Burke, L., Selig, E., Spalding, M. (2002). *Reefs at Risk in South East Asia.* World Resource Institute. 10 Street, NE Washington, DC 2002, USA.

Carl Bro International a/s (1999*). Cambodian Socio-economist and International Sociologist: Socio-economic and Natural resources studies in three villages in Koh Kong Province.* DANIDA Ref. No.104. Camb.1.MIKA.3. Cambodia.

Chou, L.M., Loh, T.L., Tun, K.P.P., (2003). *Status of Coral Reef of the Koh Sdach Group of Islands, Koh Kong Province, Cambodia, Part II.* Marine Biology Laboratory, Department of Biological Sciences. National University of Singapore. Blk S1, 14 Science Drive 4. Singapore 1175 43.

Chou, L.M., Tun, K.P.P., Chan, T.C., (2002). *Status of Coral Reef and Socio-economic Evaluation of the Koh Sdach Group of Islands, Koh Kong Province, Cambodia.* Marine Biology Laboratory, Department of Biological Sciences. National University of Singapore. Blk S1, 14 Science Drive 4. Singapore 1175 43.

CZM (2002). *National Report of Coastal Resources in Cambodia.* Environmental Coastal Zone Management in Cambodia. Danida/Ministry of Environment. Phnom Penh, Cambodia.

CZM, (1999). *Case Study: Coral Reefs of Sihanoukville, Destruction by Dynamite and Coral Collection.* Environmental Coastal Zone in Cambodia. Danida/Ministry of Environment. Phnom Penh, Cambodia.

DoF (1990). *Compiled Theme of Fishery Laws.* Department of Fisheries. Phnom Penh.

DoF (2004). *Map of Seagrass Distribution in Cambodia.* Department of Fisheries, Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia.

Ing, T. (2003). *National Report on Fish Stocks and Habitats of Regional, Global and Transboundary Significance in the South China Sea, Cambodia. The Cambodian Fishery Component of* Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Department of Fisheries. Phnom Penh, Cambodia.

Mam, K. (2001). *Coral Reef and Seagrass Survey in Cambodia.* Lower Mekong Basin Program of Wetlands International Asia Pacific. Ministry of Environment. Phnom Penh.

Ministry of Planning (1999) *General Population Census of Cambodia 1998. Final Census Results. National Institutes of Statistics.* Ministry of Planning, Phnom Penh.

Nelson, V. (1999). *State of Coral Reefs Cambodia.* Environment Coastal Zone Project, MoE/Danida, Phnom Penh, Cambodia.

UNEP, (2003). Report of the Training Programme in SCUBA Diving and ReefCheck Technique in Cambodia (30 pages), and Report of the Training Programme in Coral Reef Survey Using Line Intercept Transect (LIT) Method (24 pages). United Nations Environmental Programme, UN Building, 9th Floor, Block A, Rajdamnern Nok Avenue, Bangkok 10200, Thailand.

UNICEF (1996). *Towards a Better Future: An Analysis of Situation of Children and Women in Cambodia.* UNICEF, Phnom Penh, Cambodia.

UNEP
United Nations Environment Programme

UNEP/GEF South China Sea Project

GEF
Global Environment Facility

NATIONAL REPORT
on

Coral Reefs in the Coastal Waters of the South China Sea

INDONESIA

Dr. Suharsono
Focal Point for Coral Reefs
Puslit OSEANOGRAFI – LIPI
Research Center for Oceanography – LIPI
Pasir Putih 1 Ancol Timur, Jakarta UTARA, Indonesia

INDONESIA

Suharsono
Research Centre for Oceanography – LIPI

INTRODUCTION

The South China Sea coast of Indonesia is comprised of four provinces, namely Riau, Jambi, West Kalimantan and Bangka-Belitung, stretching roughly from the Malaka Strait to the Natuna and Java Seas. The Natuna Sea is the northern boundary while the Java Sea is the southern limit. This region belongs to the shallow Sunda shelf and consists of more than 3,500 islands surrounded by well-developed fringing reefs. This vast area offers a variety of environments for reef development and therefore the diversity of fringing reef types are high. The northern coastline of Natuna and Anambas Islands faces the winter swell of the South China Sea, while fringing reefs along the east coast of Sumatra, the west coast of Kalimantan, and the northwest coast of Java enjoy in the relatively calm intra-archipelagic seas.

Riau Province has the largest bordering the South China Sea, with 3,214 islands and 235,306 square km of territorial waters or almost 71.3% of Riau as a whole. In addition, Riau's coastal zone is the centre of various economic sectors including the shipping industry, agribusiness, tourism, residential development, and waste disposal. The dominant economic activity in the area is the development of industrial areas on the Batam, Rempang and Galang Islands, and the development of tourism and industry on Bintan Island.

PHYSICAL FEATURES

Tide and current

The tide along the South China Sea coast of Indonesia is diurnal with a range of 1.2-2.3m. The amplitude of the tide varies depending on the location of the islands and the weather. Current patterns in the area are very complex due to the physiography of the group of islands and due to its position at the equatorial zone. Reversal of monsoon seasons has significant effects on currents. The group of islands stretches mainly in southeast-northwest direction. This controls the current in the straits. The tide and the physical change of seawater mass with the South China Sea also affects the current pattern in this area. In general, the North monsoon causes the current to flow in a southeast direction. During the East monsoon, currents generally flow from the northeast to the southwest. The tidal current in the inner side of the islands is characterised by an alternating current, parallel with the islands axis running in southeast-northwest direction. The speed of surface currents ranges from 5 to 30m/second. Tidal currents reach peak velocity at times of spring tides during the North monsoon. The dominant physical factor influencing the development of coral reefs along the South China Sea coast of Indonesia are the monsoon seasons and the and reversal of currents associated with shifting monsoons.

The physical properties of coastal waters in the area are influenced significantly by the South China Sea. During the easterly monsoon, coastal waters are influenced by the movements of three water masses, i.e., water of low temperature and high salinity from the north and south; water of high temperature and low salinity from the Malaka Strait; and fresh river water from Sumatra (Musi River) and Kalimantan (Kapuas River). Results of research activities indicate that the influence of rivers from West Kalimantan is stronger than that of rivers from Sumatra.

Surface water temperature of the easterly monsoon ranges between 28.87° – 30.86°C, with an average of 30.78°C. In general, coastal water temperatures are higher than those offshore, and water temperature in the deeper layer is lower than that of the surface. Salinity in the surface layer varies significantly, and is typically lower than those at greater depths. Low salinity conditions are commonly found close to the land and reflect the occurrence of big rivers, such as the Kapuas and Musi Rivers, which have greatest impact in the Natuna Sea.

The impact of the Kapuas River extends some 30 miles offshore and affects the entire coastal water body. In September-October 2001, the impact was noted to reach 120 miles from the coast. During the beginning of the easterly season of 2002, the flow pattern of the water mass in the Natuna Sea showed water movement toward the southeast and southwest at times of high tide, and to the north and northeast during low tide. Based on water mass circulation, it is concluded that this forms the

entry point of the water mass from the South China Sea to the Java Sea. Coral reefs are found in the western and southern parts of the Natuna Sea where the seawater is relatively clear, i.e., in the waters of Belitung Island, east of Bangka Island, and the Karimata Islands.

Rainfall

The most important climate factor affecting natural resources management is rainfall. The average yearly rainfall is 2,214mm with an average of 110 rainy days between the period of October to February.

CORAL REEF DISTRIBUTION AND BIODIVERSITY

In the framework of the UNEP/GEF South China Sea Project, a coral reef base map was developed based on the interpretation of Landsat 7 data. This map was not groundtruthed. The accuracy of the map depends on the skills of the interpreter and the cloud cover on the image. Assuming that the interpreter is an expert, it can be said that the map accuracy is only related to the percentage of cloud cover on the source image. Therefore, since the average cloud cover on the images used to derive the maps is around 20%, the reef base map accuracy is more or less 80%. Consequently, all information derived from the map such as perimeter and area only has a maximum validity of 80%.

Initially the coral reef base map represents five classes of substrate (i.e., coral reef, sand flat, mud flat, land, and other). These were subsequently reclassified into three classes, namely coral reefs, land, and other areas including sand and mud flats. Figure 1 and Table 1 highlight coral reefs sites of interest in Indonesian waters of the South China Sea.

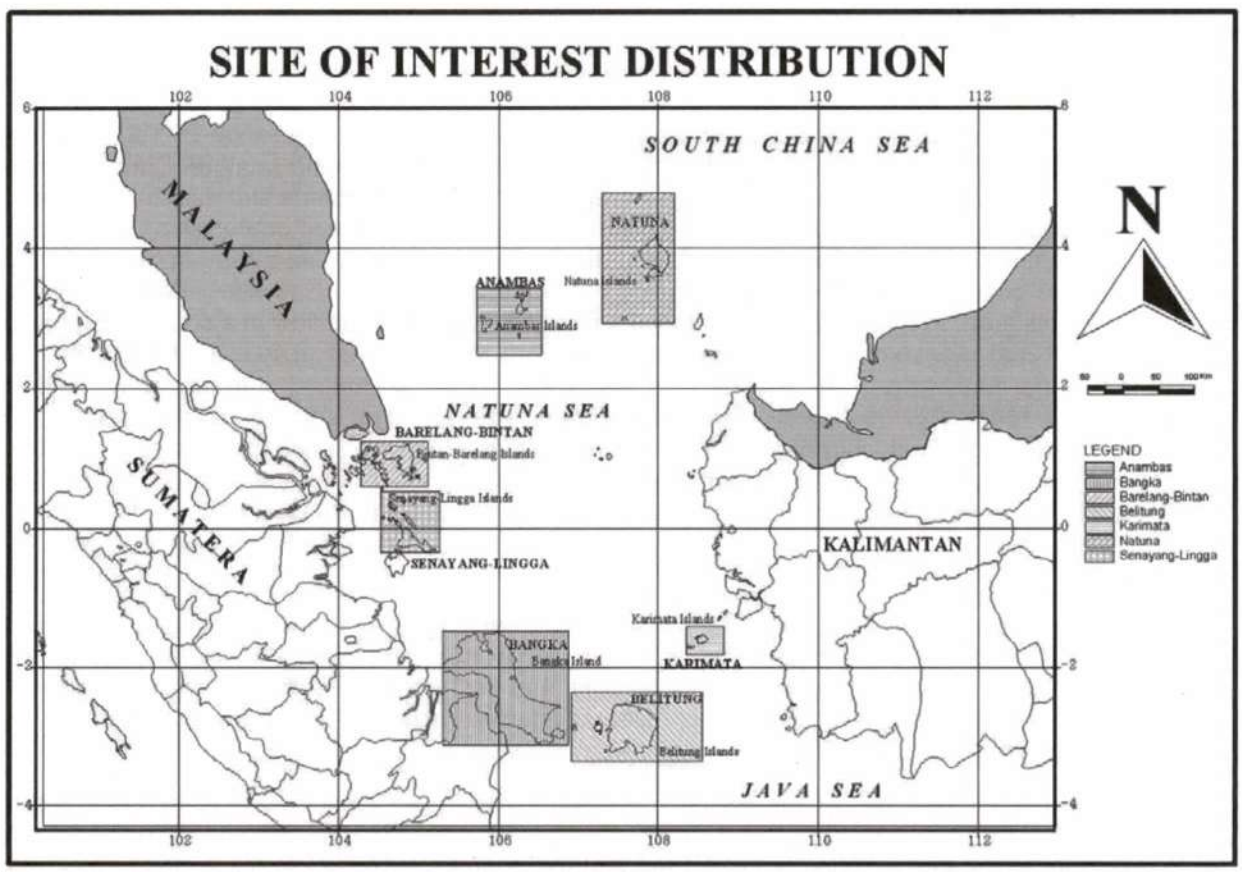

Figure 1 Distribution of coral reef sites of interest in Indonesian waters of the South China Sea.

Natuna Islands

The Natuna Islands, Tambelan Islands, and Anambas Islands are island groups situated in the Natuna Sea (southwestern waters of the South China Sea). The island groups have several types of fringing reefs and they are affected less by terrestrial processes. Natuna District covers an area of 2,776km, with a total coastline of 2,109km. The total area of coral reef in the district is estimated to be 159km^2. The development of fringing reefs in the area is largely influenced by the reversing wind and current regimes associated with the monsoon seasons.

Table 1 Approximate area of main coral reef sites located in Indonesian waters of the South China Sea based on Landsat 7 data. (approximate 20% error)

No	Site	Area (km^2)
1.	Natuna Islands	159.05
2.	Anambas Islands	62.55
3.	Batam, Rempang, Galang and Bintan	61.45
4.	Senayang and Lingga	47.32
5.	Karimata Island and Surroundings	10.41
6.	Bangka Island and Surroundings	29.34
7.	Belitung Island and Surroundings	11.61
	Total	381.73

The reef flats of the Natuna Islands are mostly narrow with steep reef slopes along the western and eastern parts of the island. The inner reef flat is dominated by seagrass, particularly *Thallassia* sp. and *Enhalus* sp., and the seaweeds *Sargassum* sp. *and Padina* sp.. The outer reef flat is dominated by *Montipora digitata, Seriatopora hystrix*, and *Favia chinensis*, while the upper reef slopes are typically dominated by *Acropora humilis* and *A. hyacinthus.* In general, the percentage coral cover on the reef slope increases with depth and attains its maximum at 5 to 10 meters. At depths of more than 10 metres, coral cover is observed to decline rapidly and corals are scarce at depths of 25 metres.

Live coral cover varies between sites, and is largely dependent upon the degree of exposure. Reef slopes are dominated by foliose corals such as *Pachyseris speciosa and Echinophora sp.* The degree of exposure also influences the dominant coral species on reef slopes, with the massive corals such as *Porites lutea* and *Porites lobata* more typically observed on sheltered reefs to the west of the islands.

A total of 182 species from 63 genera of hard corals have been recorded in the area of the Natuna Islands. A total of 190 species of coral reef fish from 30 families, and 71 pelagic fish species from 16 families, were during surveys using visual census techniques at the island group. These surveys identified that fish diversity and abundance at the Natuna Island group remains high, with a diversity of size ranges of fish present on the reefs.

Barelang (Batam-Rempang-Galang) – Bintan

The reef flat in this area varies, but is mostly wide and covered by seagrass. The coral species observed on the reef flats and upper reef slopes include massive corals such as *Goniastrea retiformis and Porites lutea* and branching coral such as *Porites cylindrica and Porites nigrescens.* Coral reefs are not observed at depths greater than 7 metres in this area. The reef slopes in the area are gently sloping and dominated by massive corals and encrusting coral species. Branching coral species are observed on the upper reef slopes. Percentage coral cover ranges between 20-69% at different sites. The exposed reefs to the east of the island group exhibit great percentage coral cover than the reefs on the sheltered western coasts of the islands. Percentage coral cover exhibited distinct trends of greater percentage coral cover occurring at the exposed eastern reef and lower percentage coral cover on the sheltered western reefs. A total of 169 species of stony corals belonging to 62 genera have been observed on reefs of this group of islands.

Senayang – Lingga

The Senayang-Lingga Island area is located approximately 130km southeast of Singapore, consisting of 453 islands and covering an area of 129.411km^2. Lingga Island is the largest island, with a land area of 81,669km^2. The coastal waters of the area are comprised of patch reefs, fringing reef, and extensive mangrove forests (9.158km^2). The bathymetry of coastal waters at the Senayang – Lingga Islands is very complex, with most corals occurring at depths of less than 10m. The physical environment of Senayang – Lingga consists of a high level of suspended sediments in the water column. Strong water currents and shallow waters in the area strongly influence the composition of the reef edge benthos.

The reefs in the area are dominated by mushroom corals *Fungia spp, Polyphyllia talpina, Ctenactis crassa*, and non-*Acropora* species adapted to living in the turbid environment. Reef flats are typically wide and dominated by seagrass species such as *Thallasia* sp. and *Enhalus* sp.. The reef slopes in the area are gently sloping, and there is an abundance of corals on the upper reef slopes (<7m) of most sites. The dominant species are the foliose corals including *Pectinia lactuca, Pachyseris speciosa and Turbinaria* sp. Areas of soft sediments are dominated by species adapted to turbid water conditions, including *Trachyphyllia geoforyi and Goniopora* sp. Percentage live coral cover

ranges between 19 and 67% at individual sites, and *Acropora* contributes to less than 7% of coral cover at most sites.

A total of 217 species of stony corals belonging to 64 genera have been observed at coral reef sites in this area. An underwater visual census conducted at 102 stations within 12 locations in the area identified 117 species of coral reef fish belonging to 31 families. The dominant species were fusiler fish (Caesionids), followed by Pomacentrids, Chaetodontidae, Lutjannidae, Serranidae, Labridae, Pomacanthidae, and Scaridae.

Belitung

Coral reef ecosystems observed in the western waters of Belitung Island are categorised as being in good condition (Wouthuyzen, personal communication). Reefs have significant potential for supporting a variety of uses, both direct and indirect, that benefit the coastal community. The coral reef fishery in the area is highly productive, supporting yields of 5 tonnes/km^2.

The reefs adjacent to the small islands west of Belitung Island, such as Mendanau Island and Batu Dinding Island, are characterised by extensive gentling sloping reefs on sandy substrate. Coral communities develop near the reef slope down to a depth of 7 m, and are dominated by sub-massive types such as *Porites rus, Galaxea fascicularis* and *Acropora palifera.* Altogether 30 coral reef sites in the area have been surveyed, with an average coral cover of less than 25% observed in the area. This value indicates that the coral colonies of the Belitung area are in poor condition. Of the 30 sites surveyed, 20 sites were characterised by a percentage cover of less than 25%. Five sites had a percentage live coral cover between 25-50%, whilst 3 sites had a percentage cover greater than 50% (excellent condition). Two sites had zero percentage cover, since the sites were dominated by dead corals covered with algae.

Research conducyed by the Research Centre for Oceanography in 2002 (P2O-LIPI, 2002a) identified 187 species of corals belonging to 74 genera and 14 families at Belitung Islands. Observations of coral fish identified 218 species belonging to 85 genera and 36 families, 105 species of molluscs, 35 species of crustaceans, 36 species of echinoderms, 20 species of mangroves, 8 species of seagrass, and 3 endangered species. Fisheries resources in this region are still productive, although action is required to ensure the prevention of over-fishing. Fishermen report a gradual decline in the size of economically important species harvested from Belitung's coral reefs, suggesting that stocks of these species may be over-fished.

Anambas

The Anambas Island group, including several small islands, is located in the south westernmost part of Natuna islands. The typical reef flats in these islands are narrow and steeply sloping. The depth contours of the fringing reef range between 1-30m with an average cross sectional slope of 30°. A survey conducted in several small islands indicates that the reef flat is covered by seagrass and algae, as well as some corals including *Montipora digitata* and *Serriatopora hystrix*. The percentage live coral cover ranges between 21.72-82.72% at different sites. A total of 206 species of hard corals from 62 genera have been recorded in the area (P2O-LIPI, 2002b). Surveys in the area have also identified 26 species of algae from 17 genera. With regard to macro-benthic fauna at the sites, 85 species of 53 genera of molluscs, 24 species of 14 genera of crustacean, and 25 species of 18 genera of echinoderm have been recorded. Visual census surveys conducted at six islands of the island group identified a total of 128 species of fish from 54 genera. Fish diversity and abundance is relatively high at this group.

Karimata

The Karimata Islands are located in the southeasternmost part of the Natuna Sea, adjacent to West Kalimantan Province. A Marine Nature Reserve (209.635ha) has been established for the conservation of corals and associated organisms at the islands. The two main islands in the area are Karimata and Serutu Island, as well as a number of smaller islands. The reef flats of the small islands are considerably wider than those of the two large islands. The clear water in the area is favourable for coral development. Large colonies of *Acropora* spp. dominate the reef flats in the area. The gently sloping reef of Busung Island is covered with large colonies of *Acropora hyacinthus* down to depths of 20m (P2O-LIPI, 2002a). In comparison, no *Acropora* was observed during surveys conducted at Tanjung Barat Island. Reefs at this island are dominated by non-*Acropora* coral species, including *Diploastrea heliopora* (with diameters up to 380cm) and the soft coral *Sarcophyton* spp. The percentage live coral cover ranges from 31.28-76.2%. The total number of hard coral species observed at the group is 192 species from 42 genera.

Alga is dominated by *Sargassum* sp. with a total percentage cover of algae ranging betwen 30.38-44%. Macro-benthic fauna at the group is comprised of 60 species of 42 genera of molluscs, 15 species of 11 genera of crustacean, and 15 species of 12 genera of echinoderm. A total of 200 species belonging to 75 genera of reef fishes were recorded during fish visual census surveys conducted on reefs in the area.

Bangka

Bangka Island is located in Klabat Bay and faces the Natuna Sea, and the area is characterised by moderately turbid waters. Coral reefs observed on outer parts of the island are generally in good condition, whilst those inshore are deteriorating rapidly due to highly turbid water conditions. A total of 126 species of hard coral from 37 genera have been recorded in the survey area. Tabulate *Acropora* dominates reef flats down to the slope. Other dominant species include *Porites lutea*, *Diploastrea heliopora*, and *Gonipora columna*. The percentage cover of hard coral ranges from 28 to 52% between different coral reef sites in the area.

The percent cover of alga ranges between 6.67-52.57% and is dominated by *Laurencia* sp. Surveys of macro-benthic fauna in the area have identified 60 species of molluscs from 43 genera, 25 species of crustaceans from 19 genera, and 23 species of echinoderm from 19 genera. A total of 169 species of coral reef fish from 67 genera have been observed to utilise the coral reefs of the area.

THREATS

Destructive fishing methods

A large number of the practices used by Indonesian fishers may be regarded as destructive either through the damage they do to the environment, particularly corals, or through indiscriminate targeting and over-fishing. The practices and their effects have been widely described (e.g., Cesar, 1996; Pet-Soede *et al.*, 1999). Many of the methods have been used for at least 50 years and are firmly entrenched in the practices of the region. Some are are regarded locally as 'traditional' fishing methods. Destructive fishing methods are more commonly employed in remote areas of Indonesia's EEZ, and have been observed in protected areas such as the Komodo Islands (Pet and Djohani, 1999). Fishing methods regarded as destructive include blast fishing, poison fishing, muroami, fish trap, gill net, weir, beam trawl, gleaning and collecting.

Blast Fishing

Bombs, originally made from World War II explosives, are now made with artificial fertiliser (ammonium or potassium nitrate). This fertiliser is typically used by palm plantations. Schooling reef fish (fusilers, surgeon fish, rabbit fish and snappers) are targeted. Divers often use "hookah" equipment for collecting dead and stunned fishes after blasts. Given that blast fishing is illegal, fishermen often bribe officials or detonate bombs when aircraft are landing or taking off to avoid detection (Cesar, 1996). Blast fishing is popular amongst fishers from Bugis, Bajau, Makassarese, and Maduran. Fish landings per blast fishing event is estimated to be 30kg from productive, previously "unbombed" reefs, and 7.5kg on regularly bombed areas (Cesar, 1996).

Fish harvested by blast fishing method are often damaged, with average per kilogram prices for fish caught by this methods being one third lower than fish caught by other methods. As such, fish caught by this method are almost all sold only on the local market. In East Nusa Tenggara, and probably elsewhere, the practice is most common during the inter-monsoon seasons (April-May, and October-November) with records of 20 to 30 explosions heard daily in this area. Individual boats may explode 1 to 3 bombs a day, but larger vessels may stay at sea for up to 10 days and return with two tonnes of fish caught by the blast fishing method (Pet-Soede *et al.*, 2000). Damage to coral reefs by this fishing method is catastrophic. A single beer bottle bomb can destroy an area of $5m^2$, a larger 'gallon' container up to $20m^2$. Coral mortality may be 50% to 80% on regularly bombed reefs.

Poison Fishing

The use of poisons to stun or kill fish is common in Indonesia. The early Dutch Naturalist, Rumphius, commented on this practice in the seventeenth century when crushed roots and stems containing rotenone were used (Cesar, 1996). However, since the 1960s the use of sodium or potassium cyanide has become very common, as it has throughout the ASEAN region (Johannes and Riepen, 1995). This technique is used on coral reefs for the:

- Live fish food industry, almost entirely developed since 1990;
- Ornamental aquarium fish industry; and
- Collection of rock lobsters (*Panulirus* sp.).

The effects of cyanide fishing are multiple. Corals are broken during retrieving fish, and the poisons contribute to significant mortalities of larvae and juvenile fish. Corals are also bleached by the use of cyanide, at concentrations far below those used. *Pocillopora damicornis* exposed to 4% of cyanide for only 10 minutes bleached within four hours and nine out of 10 specimens died within four days (Johannes and Riepen, 1995).

The economic loss to Indonesia of this damage is high, quantified at US$46 million with the industry collapsing within 4 years by the maintenance of current catch levels. Conversely a sustainable hook and line fisheries option could create net benefits of US$321.8 million (Llewellyn, unpublished). However, with prices in Hong Kong for live Napolean wrasse reaching US$60 to US$80 per kg, the incentives are high to maintain this destructive fishing practice. Demand from Hong Kong, mainland China, Taiwan and Singapore continues to control supply, even as catches decline in size and quality.

Muroami

Muroami is a fishing technique involving teams of people using scarelines, palm fronds, sticks, hollow metal pipes, or compressed air to drive small reef fish into traps in shallow reef flats. It is generally regarded as damaging to coral reefs because of the mechanical damage to corals by the implements and by trampling, and because there is a large discarded by-catch. This fishing method is practiced by fishers in Bugis, Bajau and Makassarese, but is much more common in waters of Riau Province and the Seribu Islands.

Fish trap (bubu)

Fish traps are a static fishing gear. They are typically constructed with a wire net fixed on a rattan frame and furnished with inward-turned spikes which allow entrance but make egress impossible. Traps are set on the seafloor and on coral reefs, and are usually ballasted with blocks of corals. Fishers occasionally use live corals for trap ballast, and both dead and live corals are attached to traps as "camouflage". The use of bamboo mesh traps known as 'bubu' is widespread and increasing, largely due to their effectiveness in catching large live reef fish. These traps are also often used in conjunction with cyanide tainted baits.

Trap fishing can cause physical damage to corals, particularly branching and folioise corals. The intensive deployment of heavily ballasted traps onto coral reefs from fishing vessels can lead to significant coral mortalities. Traps set by 'hookah' divers are less damaging that those lowered on buoyed ropes. Heavy wooden runners also cause considerable damage of reefs.

Gillnet

This gear is commonly operated on and adjacent to coral reefs. The collection of live coral for use as gillnet ballast causes direct damage to reefs, and lost or discarded nets may cause large mortalities and waste of fish as a result of "ghost fishing".

Weir (Kelong)

The setting up weirs in the vicinity of coral reefs degrade nearby coral communities.

Beam trawl

The use of demersal trawl gear in coral reef areas is particularly destructive of coral reef habitat. Research indicates that one tow of a beam trawl over a coral reef destroyed 66.67% of the coral community. As fishing nets are typically damaged by reefs, fishermen avoid using this fishing gear in coral reef areas where possible.

Gleaning and Collecting

The gleaning and collection of marine organisms from reef flats and shallow reef fronts accessible by free diving also has a significant impact on reef communities, as many of the target species are easily collected and vulnerable to local extinction. Traditional management in the past has helped to protect such species but this is now breaking down in many areas as the result of economic and population pressures (Nikijuluw, 1998). For example, Thorburn (1998) describes the traditional management of the trochus fishery (lola or *Trochus niloticus*) in the Kei Islands of Maluku. This included three-year

closures of areas to coincide with the time required for the growth of commercially mature shells, and restrictions on the types of gear used. In many islands such traditional management or *sasi* has broken down because of the pressures from outside fishers, such as the Bugis and Bajau, which are organised on a commercial rather than artisinal basis (Nikijuluw, 1998). Short-lived high profit in these situations may be followed by a complete collapse of the fishery as in the example of the tripang fishery in West Nusa Tenggara. Most of reef species which have are collected by gleaning are protected by law but may now be locally extinct including:

- All giant clams (*Tridacna* spp. and *Hippopus* spp.)
- Black lip and gold lip pearl oysters (*Pinctada margaritifera* and *P. maxima*)
- Triton (*Charonis tritonis*)
- Green snail (*Turbo marmoratus*)
- Giant helmet shell (*Cassis cornuta*).

Sedimentation

The rivers of Indonesia have always carried freshwater and sediments to the sea and have been at least in part responsible for the distribution of inshore coral reefs. However, human interference to the hydrological cycle, producing more rapid run-off and increased sediment yield has pushed many coastal reefs beyond thresholds at which they can survive. Deforestation, inappropriate agricultural practices, urbanisation, and construction processes along the coastline can all have serious effects on sedimentation rates. These practices may be long standing. For example, Pollnac *et al.,* (1997) describes the many uses for which timber cut from steep hill slopes is used as part of the local subsistence economy in Banten (boat construction, firewood, fish smoking). However, with increasing population the clearing is becoming more widespread in many areas (e.g., Riau Islands), and has led to an increase in both freshwater run-off and sediment yield to the coast. Forest fires in dry *El Nino* years also contribute to the removal of the protective vegetation cover.

Sewage and other land-based pollutants

Severe water pollution, sufficient to cause massive fish kills, harvest failure in aquaculture ponds and threats to human health is found in virtually all populated or highly industrialised areas of Indonesia (Dahuri, 1998). Point sources include rivers and discharge pipes but more widespread pollution also comes from groundwater. No sewage treatment plant is available for any major coastal city in Indonesia (Edinger *et al.*, 1999). The problem is aggravated by recent increased intensity of rice cultivation and application of chemical fertilisers.

The effects on coral reefs are highly detrimental and include:

- The rapid growth of industries in some Indonesian territory has brought about not only positive impact on the economic development but also a negative impact in the form of increased pollution of the surrounding sea. Take for example Pancur Bay (Senayang Lingga, Riau) where there are a number of companies engaging in logging activities. Sawdust resulting from the sawing activities that entered the nearby sea caused the seawaters in the vicinity to become reddish, turbid and anoxic. Industrial growth in Batam (Riau Province) has also contributed indirectly to marine pollution in the area. Batam with an area of 1,647.83km^2 (1,035.30km^2 of sea and 612.53km^2 of dry land) has enjoyed a vast and high investment growth. The investment that in the early years amounted to approximately US$201,350,307 has grown up to US$8,010,000,000. Even when the national economic growth was 4.8%, the economic growth of Batam was 7.6%, or an increase from the previous year of 6.38%.

- The rapid growth of industries was followed by increasing population. The rapidly increasing human population and the high rate of urbanization in Riau Province have an inevitable impact on the environment, namely in the form of increasing accumulation of domestic waste. This domestic waste, which consists of a variety of materials contribute to pollution of the marine environment. This is mainly due to the lack of awareness of the population in managing domestic waste properly.

- The clearing of forests for factory/industrial developments, human settlement and agriculture, has reduced the capability of the soil to absorb and maintain ground water. This has led to increased run-off to coastal water bodies during high rainfall events. This has led to increasingly turbid coastal waters, which are not conducive for the growth of corals and seagrass.

Oil Production and shipping

Coral reefs are highly sensitive to oil spill damage. In Indonesian waters oil pollution comes from two sources: spills at the well head and from shipping. Indonesia is one of the world's major oil producers, producing 1.36 million barrels per day in 1997 from 8535 wells (Edinger and Browne, in press). The major oil producing area is along the coast of East Sumatra. Natuna Islands is a major producer of liquid natural gas and oil.

There is chronic pollution from production facilities and oil refineries in Indonesia. Hot water discharges from the plant have killed corals adjacent to fringing reefs. The Natuna Sea and Karimata Strait are a major shipping line from Singapore, Batam and Jakarta and the area is at high risk of oil spill.

Most production is exported and tanker traffic is concentrated in the Malacca and Sundra Straits. Large volumes of domestic oil are shipped through the Sunda Strait to refineries in Java. Between 1974 and 1994, 36 major tanker spills were reported in Indonesian waters, 66% of which were in the Malacca Strait.

Sand mining

Sand mining in the coastal waters of the Natuna Sea and its surroundings (especially Riau Province) is taking a heavy toll on the marine environment and the people who depend on it. The majority of the demand for sand comes from Singapore. Companies, backed by Singaporean buyers, use dredges to excavate sand at a rate of 6,000 cubic meters a day. The sand is then transported to Singapore to be used in the construction industry and coastal reclamation projects. Singapore is said to require a further 1.8 billion cubic meters of sand over the next 7-8 years for these projects, which are aimed at expanding the country's land area and providing living space for its growing population.

According to the Indonesian Center for Forestry Studies, some 400,000 hectares of seabed and an extensive area of coral reefs have been damaged by mining at Riau Islands. The dredging, sometimes conducted within meters of the shore, has caused coastline erosion, destruction of fishing grounds and important fisheries habitats.

Illegal sand mining takes place and is allegedly controlled by a cartel of three Singaporean-backed companies. Around 400 million cubic meters of sand are illegally exported per year, with losses to the state amounting to millions of dollars in the form of uncollected taxes and royalties. Data from the Department of Industry and Trade indicates that 60% of all sea sand exported to Singapore and other countries has been dredged illegally. The economic losses associated with these illegal activities are simply calculated, but the costs to the environment are largely unknown.

Regional and central government have initiated efforts to prevent the illegal dredging of sea sands, including the issuance of a decree that prohibits the activity. Efforts to stop illegal sand mining have been supported by many groups including NGO's and environmentalists. A Joint Ministerial Decree regarding the prevention of illegal sea sand mining was signed on 14th February 2002 and has been in effect since 18th February 2002. Based on this Decree, the President instructed all Governors and city Mayors to stop the mining and export of sea sand. The President also urged provincial authorities not to issue any additional permits.

Mining of material rocks for construction

The mining of coral reefs presents a significant threat to the sustainability of these ecosystems in Indonesia. In many areas, dead corals are collected for use in the manufacture of concrete for houses and roads. The removal of dead corals can increase turbidity and decrease the resilience of reefs and live corals to the effects of waves during storm events. Often live corals are removed in order to provide access to dead corals. A large number of new house constructions in the area of Senayang have used corals as raw materials. The healthy-housing campaign, which promotes the construction of houses on a soil base, has been undermined by the large-scale use of corals for several building constructions in the area.

The excavation of soil and rock from coastal catchments is also increasing in support of the rapid industrial development observed on many of the islands. This has led to an increase in the quantity of sediments entering coastal water bodies via coastal streams and rivers, and contributes to the increasingly turbid conditions of waters nearby most islands. This presents a significant risk to both coral reef and seagrass communities in Indonesian waters of the South China Sea.

Metal mineral mining

The mining of minerals from the Senayang-Lingga and Singkep areas has been conducted for many years. Mining of bauxite ore is common on the islands of Batam and Bintan. Mining takes place at some islands and around Bintan. The key threat to coral reefs from mining activities is increased sedimentation of coastal water bodies.

Tourism

In some coral reef areas of the world where management plans are in place and reasonable protection is given, tourism is seen as potentially a major impact on the reefs. In Indonesia, the attraction of high species diversity of both corals and fish, easy accessibility and low prices contribute to making the archipelago an attractive destination for marine tourism. Undoubtedly, the industry is having some impact on the coral reefs. But in comparison to some of the stresses described above, the detrimental effects are minimal. Indeed, dive operators and others in the tourist industry have vested interests in monitoring reef quality and have instigated preliminary measures to minimise impacts. Further, local people may be employed and diverted from other damaging practices, such as destructive fishing.

The impacts come at two stages in the development of the industry. The early construction phase may employ damaging techniques of land clearing and even quarrying of reefs for resort construction. Following the establishment of resorts, damage may result from sewage disposal, anchor damage at dive sites (mooring facilities are not normally installed) and breakage of corals by inexperienced divers and snorkellers (but operators are not trained to give environmental advice to the tourists). There are several tourist resorts in Tanjung Pinang such as Trikora Beach, Mapor Islands, and in Batam Islands.

ECONOMIC VALUATION AND USES

Coral reefs play an important role in the ecology, economy and aesthetics of Indonesia. Ecologically this system protects the beach, and supports significant marine communities. From an economic view, coral reefs serve as a source of food and income for coastal communities. They are also an important source of foreign exchange via the international trade in live coral reef fish and tourism.

Regrettably, fishers continue to employ destructive fishing gear and practices to catch fish and other coral reef associated species. Fishing techniques including fish traps (bubu), beam trawls, weirs, gillnets, poisons, and explosives are still common in coral reef areas. The result is a continuous degradation of coral reefs. According to research conducted by the Research Center for Oceanography (LIPI), only 6.69% of Indonesian reefs were in excellent condition in 2003.

McAllister (1988, in Cesar 1996) stated that the sustainable potency of coral reefs in excellent condition is 18 tonnes/km^2/year, those in good condition 13 tonnes/km^2/year, and those of fair condition 8 tonnes/km^2/year. Multiplying the foregoing values with the area of the Indonesian coral reefs, the total coral fish production was estimated as shown in Table 2.

Table 2 Coral reef fish production estimated for Indonesia.

Category	Coral Reef Area (km^2)	Production m.tonnes/km^2/year	Total Production (m.tonnes/year)
Excellent	6.69 % x 50,000	18	60,210
Good	26,59 %x 50,000	13	172,835
Fair	37,56 % x 50,000	8	150,240

However, it should be noted that the values stated above are to be treated with caution, considering that excluded the depth factor. Cesar (1996) pointed out that at the depth of 30m the sustainable potency of coral reefs varies between 10-20m.tonnes/km^2/year or an average of 15m.tonnes/km^2/year. He further stated that finfish make up two-thirds of the sustainable potency, while various invertebrates make up the rest (1/3). It should be noted, however, that the above values are used only when the area is composed of 50% reef edge and 50% reef flat. If the finding of Cesar (1996) is incorporated with that of the sustainable potency of Indonesian coral reefs, values as in Table 3 will be obtained.

Table 3 Fisheries production estimation including depth factor. (Cesar, 1996)

Excellent Category	Area of Coral Reef (km^2)	Production m.tonnes/km^2/year	Total production m.tonnes/year
Total Potency	6.69% x 50,000	15	50,175
Finfish	6.69% x 50,000	10	33,450
Invertebrates	6.69% x 50,000	5	16,725

Assumption: *All areas consists 50% of reef edge and 50% of reef flat.*

Basically, the calculation of the Total Economic Value (TEV) of a given coral reef site can be approached by determining the economic value of goods and services on per hectare value. There are some techniques used in Indonesia to evaluate the economic value of coral reef ecosystems. The most common techniques used for valuing the goods and services of coral reef ecosystems are derived from three different ways:

- Directly to obtain information about the value of the given goods and services or of direct expenditures.
- Potentially applicable techniques, which use the market indirectly to obtain information about values and expenditures.
- Survey based methods, which use hypothetical market and situation through, for instance, questionnaire surveys such as the contingent valuation method (CVM).

An application of this approach provided a figure of economic valuation of coral reef in Barelang (Batam, Rempang, Galang) and Bintan Islands (Table 4).

Meanwhile, Cesar (1996) attempted to analyse the economic value of Indonesian coral reefs on the basis of their utilisation, which was differentiated in three aspects, i.e. fisheries, tourism and coastal protection. Information relating to fisheries aspect was further split up into 8 variables, including: Type of fish or other resources, productivity, fishing effort, fish price, cost, reef reduction, condition of reefs and recovery.

Table 4 The result of economic value calculation of coral reefs in Barelang (Batam, Rempang, Galang) and Bintan Islands.

Category		Value USD/ha/Year	Assumption	Reference
Use	Coral Fishery	4,464.44		
	Preventing erosion	34,871.75	Constant/year	Hiew and Lim in Kusumastanto *et al.*, 1998
	Researches	91.08	Constant/ha	Kusumastanto *et al.*, 1998
	Carbon stock	240.00	Constant/year	Kusumastanto *et al.*, 1998
	Biodiversity	15.00	Constant/year	Ruitenbeek, 1991
	Total Uses	39,682.27		
Budget	Investment	8,320.00	Constant/10 year	Saragih, 1993
	Operational	1,019.04	Constant/year	Saragih 1993
	Constant yearly	3,352.52	Constant/year	Saragih 1993
	Rehabilitation	5.75	Constant	PKSPL-IPB, 1999
	Total Budget	12,697.31		
TEV Coral Reef Ecosystem:		52,379.58		

Source: *Dahuri, 1998.*

From a tourism stand point, location, accessibility, and prospect of future development are of primary importance. For that reasoning, three *types of areas* are distinguished:

(1) Remote and sparsely populated areas with no current tourism nor future potential
(2) Less remote areas with some present tourism and /or future tourism potential
(3) Areas with major tourism activities/potential

On the basis of the valuation of the three types of areas, two scenarios are envisaged: LOW and HIGH scenarios. The LOW scenario reflects a situation representing condition between *area type* 1 and *area type* 2; while HIGH scenario represents a situation between *area type* 2 and *area type* 3. Results of calculation indicated that area type 1 has no economic value, area type 2 has a net present value of US$6,000 per km^2 of coastline, area type 3 has a net present value of US$1 million per km^2 of coastline.

Generally, tourism areas commonly suffer various degradation due to haphazard anchoring, waste disposal, and the breaking of corals. After all these degradation factors are taken into account, a net present value of US$3,000 per km^2 for the low scenario and US$503,000 per km^2 of coastline for the high scenario are obtained.

Similar to the case for tourism, coastal protection can likewise be distinguished by three area types and two scenarios. Calculation gives the following results:

- US$820/$km^2$ coastline for remote area
- US$50,000/$km^2$ coastline for less remote area
- US$1,000,000/$km^2$ coastline for area with major infrastructure
- US$25,410/$km^2$ coastline for low scenario
- US$550,000/$km^2$ coastline for high scenario

MANAGEMENT

The Indonesian Constitution contains regulations with regard to the natural wealth of the people of Indonesia. Decisions of the House of the People's Consultative Assembly and Law provide detailed guidance with regard to the use and management of Indonesia's natural resources. This guidance is incorporated into detailed regulations that are part of Laws and Acts pertaining to natural resource management.

In maintaining the system of laws and regulation it is important for each institutions to follow Presidential Decree No. 188 of 1998 (former Presidential Instruction No. 15 of 1970) containing disciplines or procedures for the establishment of Laws and other lower regulations. Each type of regulation appears in each chapter explaining the function and relevant rights and duties within the scope of that regulation. Lower regulations that are derived from higher legal instruments should reflect the substance or scope of the given instrument. Provisions beyond the scope of higher regulations may cause overlapping rights and management responsibilities.

Hierarchical legal system in Indonesia consists of:

1. The basic constitution
2. General assembly decrees
3. Laws and act
4. Government regulations
5. Presidential decrees
6. Ministerial decrees
7. Provincial government regulations
8. District or city regulations

Indonesia has also recognised its obligations under several international environment instruments. The purpose of this section of the report is to review the basis for environmental and natural resource law in Indonesia. The main laws, Government Regulations, Presidential Decrees, Ministerial Regulations, Regional Government Decrees, City and District Decrees, and traditional fishing rights and mutual agreements relating to coral reef management along Indonesia's South China Sea Coast will also be reviewed.

Substantive instruments for marine environment

Laws related to fisheries and coral reefs conservation

(1) Law No. 31 of 2004 is related to the management and use of fish resources (Art.1 part 1). There is no regulation explicitly mentioning about coral reefs management in the provision of the Fishery Law, even with certain fish, which depend on coral reefs. With the wording "Coral Reef implant" of the authentic clarification of Art.7 part 1 it is recognised that coral reef related fishery was included in the law. This authentic clarification would be a basis for the management of related coral reefs fish.

(2) Law No.5 of 1990 concerning Conservation of Living Resources and their Ecosystem consist of three main issues:

- Protection of living buffer system within protected zones (Art.6 to Art.10)
- Preservation of plants and animals diversity and their ecosystems contained in Art.20 to Art.25 concerning prohibitions of protected plants and animals
- Zoning system of exploitation (Art.26 to Art.28).

(3) Law No. 23 of 1997 concerning Management of Living Environment does not directly link with operational activities on coral reefs. However, this law has an important function related with the procedure of management of living environment.

(4) Law No. 32 of 2004 concerning Regional Government concerns right of Regional Government, containing also conservation and preservation. Art. 18 of the Regional Government stipulates that regional Government has the right to manage natural resources in their own territory and is responsible for the maintaining preservation of the marine environment according to laws and regulations.

Rights of Regional Government are in relation with the sea stipulated in article 3 consist of: exploration, exploitation, conservation, and sea resources management over relevant sea zones; establishment of administration; establishment of space settlements; law enforcement related to regional and central regulations; and security and defence support.

Ministerial regulations related to coral reefs conservation

Several kinds of Ministerial regulations considering directly with coral reefs related fisheries are listed below:

1. Minister of Agriculture Decree (MAD), No.923/Kpts/Um/12/82 concerning Sea Park of island Weh.
2. Minister of Forestry Decree (MFD), No.328/Kpts-II/1986 concerning Sea Protection Park of Bunaken.
3. Minister of Forestry Decree (MFD, No.12/Kpts-II/1987 concerning the Protection of certain Coral Reefs Bio-organisms (*Antiphates* spp., *Tridacna gigas* etc).
4. Minister of Agriculture Decree (MAD), No. 700/Kpts/IK.120/10/1898, 6 October 1989 concerning export of Penaeidae shrimp from Indonesia.
5. Minister of Agriculture Decree (MAD), No.375/Kpts/IK.250/5/95, 16 July 1995 concerning prohibition to catch Napoleon Wrasse (*Cheilinus undulatus*).
6. Minister of Forestry Decree, No. 280/Kpts-II/92, 26 February 1992 concerning National Park Taka Bone Rate (Include sea area and coral reefs).

The above-mentioned Ministerial Decrees show that regulations concerning fisheries, coral reefs organisms, or marine parks may be born by Minister of Forestry Decrees. This causes overlapping rights with fishery sector under Ministry of Agriculture. A memorandum of understanding should be made between two ministries to overcome this problem.

Analysis and discussion

There are many agencies governing the use and management of marine and coastal areas in Indonesia. Their actions are typically not well co-ordinated. Many resource management issues have been addressed via ministerial decrees, which cover only part of the solution because the Ministry concerned had limited jurisdiction. Often these ministerial decrees concerning marine resources were inconsistent with one another, and as such, were difficult to implement. Institutional weaknesses and lack of political will have also failed to institutionalise the spatial planning concept in managing marine and terrestrial resources. Law enforcement and regulations is weak largely because of lack of transparency and weak institutional capability. Many resources allocation and resource use decisions were taken at high level of government without considering resource sustainability and adherence to legal provisions. Such decisions were frequently made without adequate consultation with local governments and the affected communities. Some problems exist with the legal instruments concerned with the utilisation and management of marine resources in many parts of Indonesia.

Law Effectiveness/coverage

Not all districts and towns in Indonesia are currently equipped with local regulations regarding the utilisation and management of marine resources. Law enforcement in many districts and towns has not been very effective on account that so far all local regulations still refer to the one issued by the central government. Enactment of the Act on Regional Autonomy (Act No. 32 of 2004) gives the local governments (districts and towns) the opportunity to develop regulations relating to the utilisation and management of marine resources that are in line with the existing problems faced by each local government. The Act aims to decentralise most government services and devolve the planning and management functions and responsibilities of marine and coastal resources within Indonesia's territorial waters to the provincial and district governments. The Act provides incentives to local government for sustainable management of natural resources within their respective jurisdictions and requires a revision of some existing laws and regulations. Implementation of local regulations in combination with national regulations will therefore be more effective since they have been so designed as to match the problems faced at the provincial level.

Socialisation of some other laws and regulations relevant to the utilisation and sustainability of the marine resources has not been optimally done. In some areas, there is the tendency that communities, legal officers and decision makers have limited understanding and knowledge on the regulations relevant to the utilisation and management of marine resources. Several cases of violations occur due to the fact that most coastal communities are unaware of the various prohibitions that are stipulated in the existing legal instruments.

Another aspect that impedes the effectiveness of some regulations concerning the utilisation and management of marine resources is the vast expanse of the Indonesian territorial waters to be supervised. The manpower available for surveillance is far from adequate as compared to the area to be monitored. This situation leaves some violations unnoticed and unattended. Beside the limited human resources available, supporting equipment like patrol boats are also limited in terms of quantity and technology. The existing patrol boats are mostly of low capacity, hence are no match to those of the law breakers.

Conflicts – Harmonisation

Implementation of regulations in the field quite often brings about some conflict. It can happen internally between various legal authorities, as well as between legal authorities and communities. Internal conflicts have most commonly been due to struggles for power or authority. For example in one district in Southeast Sulawesi, conflicts regarding authority occurred between Marine Police and Air Police, as well as between Sectoral Police and Gurads of the National Park. In this case, the conflict was in part due to an inadequate understanding on behalf of each legal authority regarding their primary task and function. Conflicts between legal authorities and local communities are usually triggered by inconsistent use of legal authority in the field. Resolving problems with corruption and bribery of surveillance officers and law enforcement officials is critical towards resolving such conflicts.

Compliance and enforcement

To enhance law enforcement, some communication strategies that have been and will be implemented, include the socialisation and dissemination of information concerning a variety of regulations relevant to the utilisation and management of marine resources to stakeholders, namely legal authorities, decision makers, and the general public (including fishermen). The method of dissemination has depended on the stakeholders. For example, for legal authorities and policy makers, the socialisation process has been done through workshops, seminars, lobbying, advocacy, dialogues, and other informal meetings (morning tea). For the general public and fishermen, socialisation of information has been done not only using multi-media materials (film, radio, VCD, brochures, leaflets, posters, and billboards) but also by way of direct contact, e.g., through village meetings, fisherman associations, and various religious activities.

With regard to the enhancement of law enforcement, various programmes and activities have been conducted. For instance, surveillance and law enforcement has been carried out in some localities, namely Taka Bonerate (Selayar District, South Sulawesi Province) and in Biak Islands (Papua Province) through COREMAP (Coral Reef Rehabilitation and Management Programme). A moderate patrol boat has been granted to each of these provinces. Financial support for staff and the operation of the patrol boats comes from COREMAP. They are assigned to carry out surveillance activities in the Taka Bonerate and Biak waters to prevent violation against existing regulations, such as fishing with explosives or poison. In carrying out the task, the security force is supported by a number of reef

watchers, including some local villagers and fishermen. The basic idea is to promote the participation of the local community in implementing surveillance and law enforcement.

Strength and weaknesses of present enforcement mechanisms

Surveillance and law enforcement mechanisms involving local communities have some advantages. One among them is the efficiency in terms of budget and time frame. In general, illegal fishing activities are often conducted in waters that are difficult for patrol boats to reach. In such cases, involvement of local communities and reef watchers will be of great advantage. Local villagers and reef watchers should report any violation to patrolling force or may take action themselves directly. Community participation over this matter is urgently needed, taking into account the limited manpower and infrastructure currently available for carrying out the task, coupled with the great extent of the area to be monitored.

On the other hand, surveillance mechanism involving the local community is very much dependent on the level of community participation as well as on the consistency of law enforcement. In some rare cases, the local community protects the violators instead of assisting monitoring activities. Apart from that, the inconsistency in law enforcement coupled with the implementation weakness give result to apathetic attitude in the part of the community to participate in the monitoring activities. Very often the community has done their job by reporting some violations, or they may even have arrested the violators, yet no follow up action is taken by the law enforcers. The cases were not brought to justice, rather the violators were in the end freed in a trade off deal.

REFERENCES

Cesar, H. 1996. The Economic Value of Indonesian Coral reefs. Agriculture Operations Division. CDIII, East Asia and Pacific Region. Environment Department. The World Bank, 9p.

Dahuri, R. 1998. The Application of Carrying Capacity Concept for Sustainable Coastal Resources Development in Indonesia. *Pesisir and Lautan 1(2): 53-65*

Edinger, E.N., J. Jompa, G.V. Limmon, and W. Widjatmoko. 1999. Reef degradation, coral biodiversity, and reef management in Indonesia. *Pesisir and Lautan 2(2): 1-16*

Johannes, R.E. and M. Riepen. 1995. Environmental, Economic and Social Implications of live Reef Fish Trade in Asia and the Western Pacific, TNC, Hawaii

Nikijuluw, V.P.H. 1998. Identification of Indigenous Coastal Fisheries Management (IFCM) System in Sulawesi, Maluku and Irian Jaya. *Pesisir and Lautan 1(2): 1-17.*

Ohman, M. C. and Herman S.J. Cesar 2000. Cost and Benefit of Coral Mining. *In* : The economics of Coral Reefs (Cesar, HSJ. Ed). CORDIO, Sweden : 85-93.

Pet-Soede, L.; H.SJ. Cesar and J.S. Pet-Soede, 2000. Blasting away : The economics of blast fishing on Indonesia Coral Reefs. *In* : The economics of coral reefs (Cesar, HSJ. Ed.) CORDIO, Sweden : 77-84.

Pet-Soedo, J.S. and R.H. Djohani. 1999. Combatting destructive fishing practices in Komodo National Park: Ban the hookah compressor. *Pesisir and Lautan 2(1): 21-34.*

Pet-Soede, L.; H.S.J. Cesar and J.S. Pet. 1999. An Economic Analysis of Blast Fishery on Indonesian Coral Reefs. *Environmental Conservation 26(2): 83-93.*

Pollnac, R.B., F. Sondita, B. Crowford, E. Mantjoro, C. Rotinsulu, A. Siahaenenia 1997. Baseline assessment of socioeconomic aspects of resource use in the coastal zone of Bentenan and Tumbak. Coastal resources Center, Univ. of Rhode Island, Narragansett, RI, USA, 79p.

P2O (Pusat Penelitian Oseanografi) – LIPI, 2002a. Report on Management and Development on Marine Ecosystem Area of Bangka- Belitung and Karimata Islands), 87p. (in Indonesia).

P2O (Pusat Penelitian Oseanografi) – LIPI, 2002b. Report on Biological Feature of Anambas Waters. 56p. (in Indonesia).

Thornburn, C.C. 1998. Sasi 'Lola' (Trochus niloticus) in the Kei Island, Moluccas: An Endangered Coastal Resource Management Tradition. *Pesisir and Lautan 1(2): 15-29.*