



# REGIONAL SEAS

## Overview on Land-based Sources and Activities Affecting the Marine Environment in the East Asian Seas

*UNEP Regional Seas Reports and Studies No. 173*

*Chia Lin Sien and Hugh Kirkman*

**Note:** The preparation of this Report was prepared for the United Nations Environment Programme (UNEP) by Chia Lin Sien (Visiting Professor, Institute of Asia-Pacific Studies, Graduate School of Asia-Pacific Studies, Waseda University, 1-21-1 Nishiwaseda, Shinjuku-ku, Tokyo, 169-0051, Japan) and Hugh Kirkman (UNEP East Asian Seas Regional Coordinating Unit, Rajdamnern Avenue, Bangkok, 10200, Thailand). This Report was prepared under Project FP/GN/GP/1100-98-11.

The designations employed and the presentation of the materials in this document do not imply the expressions of any opinion whatsoever on the part of UNEP concerning the legal status of any State, Territory, city or area, or its authorities, or concerning the delimitation of their frontiers or boundaries. The document contains the views expressed by the author(s) acting in their individual capacity and may not necessarily reflect the views of UNEP.



©2000 UNEP - United Nations Environment Programme

The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities

GPA Co-ordination Office

P.O. Box 16227

2500 BE The Hague

Visiting address: Vuurtorenweg 35-37, The Hague, The Netherlands

East Asian Seas Regional Coordinating Unit (EAS/RCU)

Rajdamnern Avenue,

Bangkok, 10200, Thailand

This publication may be reproduced in whole or in part and in any form for educational and non-profit purposes without special permission from the copyright holder, provided that acknowledgement of the source is made. UNEP would appreciate receiving a copy of any publication that uses this material as a source.

No use of this publication may be made for the resale or for any other commercial purposes whatsoever without the prior permission in writing of UNEP.

For bibliography purposes this document may be cited as:

UNEP: Chia, L.S. and H. Kirkman. Overview of Land-Based Sources and Activities Affecting the Marine Environment in the East Asian Seas. UNEP/GPA Coordination Office & EAS/RCU (2000 Regional Seas Report and Studies Series. 74 pp.

ISBN: 92-807-1931-9

Cover Picture: Hugh Kirkman; UNEP/Vichannuvat Yongyooth (Topham Picturepoint)

# Contents

|  |    |
|--|----|
| Preface .....                                      | 1  |
| Acknowledgements .....                             | 2  |
| 1. Introduction .....                              | 3  |
| 2. Aim of the Study .....                          | 4  |
| 3. Scope of the Study .....                        | 4  |
| 4. Approach of the Study .....                     | 5  |
| 5. Socio-Economic Status .....                     | 8  |
| 5.1 Demographic Features .....                     | 8  |
| 5.2 Economic Status .....                          | 9  |
| 6. Characteristics of the East Asian Seas .....    | 12 |
| 6.1 Southeast Asia .....                           | 12 |
| 6.1.1 Physical Characteristics .....               | 13 |
| 6.1.2 Biological Characteristics .....             | 20 |
| 6.2 Northern East Asia Sub-Region .....            | 29 |
| 6.2.1 Physical Characteristics .....               | 29 |
| 6.2.2 Biological Characteristics .....             | 30 |
| 6.3 Australia Sub-region .....                     | 31 |
| 6.3.1 Coral reefs .....                            | 31 |
| 6.3.2 Mangroves .....                              | 31 |
| 6.3.3 Seagrass .....                               | 32 |
| 7. Status of Land-based Sources of Pollution ..... | 32 |
| 7.1 Issues and Problems .....                      | 33 |
| 7.2 Domestic Wastewater .....                      | 35 |
| 7.3 Agricultural Waste .....                       | 37 |
| 7.4 Industrial Waste .....                         | 39 |
| 7.5 Sedimentation .....                            | 40 |
| 7.6 Solid Waste .....                              | 42 |
| 7.7 Oil and Other Hydrocarbons .....               | 44 |
| 7.8 Atmospheric Sources .....                      | 45 |
| 7.9 Coastal Tourism .....                          | 46 |
| 8. Hot Spots, High-Risk and Sensitive Areas .....  | 49 |

## Preface

The Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-Based Activities was adopted by 108 governments and the European Commission on 3 November 1995 in Washington, USA. These governments also designated the United Nations Environment Programme (UNEP) as Secretariat of the GPA, with the task of promoting and facilitating its implementation at the national, regional and global level.

The GPA aims at preventing the degradation of the marine environment from land-based activities by facilitating the realisation of the duty of States to preserve and protect the marine environment. It is designed to assist States to take actions individually or jointly within their respective policies, priorities and resources, which lead to the prevention, reduction and control and/or elimination of the degradation of the marine environment, as well as to its recovery from the impacts of land-based activities. Achievement of the GPA will contribute to maintaining and, where appropriate, restoring the productive capacity and biodiversity of the marine environment, ensuring the protection of human health, as well as promoting the conservation and sustainable use of aquatic living resources.

In the Washington Declaration, governments expressed their commitment to protect and preserve the marine environment from the impacts of land-based activities by, among others, "cooperating on a regional basis to coordinate efforts for maximum efficiency and to facilitate action at the national level, including, where necessary, becoming parties to and strengthening regional cooperative arrangements and creating new arrangements when necessary".

To facilitate implementation of the GPA, UNEP, as Secretariat, organised in cooperation with relevant regional organisations, a series of regional technical workshops as a means of strengthening national capabilities for protection of the aquatic environment from land-based activities, and to promote regional and sub-regional cooperation.

For the East Asian Seas Region, UNEP convened a Workshop on Implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities in Cairns, Australia (30 April-3 May 1996). This workshop, hosted by Australia, was the third of a series of similarly planned regional workshops that UNEP organised between 1996 - 1997 in the framework of the Regional Seas Programme.

This report comprises recommendations of the Cairns workshop, country reports with respect to the implementation of the GPA at national level prepared by member states of the Coordinating Body on the Seas of East Asia (COBSEA). Existing relevant information, published articles, reports, books, and consultations with regional and national authorities/ experts were used by Hugh Kirkman of the EAS/RCU in Bangkok, as a first draft for the consideration of the governments of member states of COBSEA. This report incorporates and addresses comments provided by member states.

This report contains gaps, in which additional information is required for a complete analysis of land-based sources of pollution in the region, in particular the linkages between land-based activities and their impacts on marine and coastal areas. Nevertheless, the report is a significant contribution that will facilitate the GPA and the achievement of all its goals at the regional and national levels.

# Acknowledgements

The authors wish to thank Dr. Anond Snidvongs, Southeast Asia START Global Change Regional Center and Environmental Research Institute, Chulalongkorn University, for the preparation of maps in this report. The support of Dr. Jiang Yihang and the able and willing assistance of the office staff of the East Asian Seas Regional Coordinating Unit, UNEP in Bangkok was unfailing and crucial to the work undertaken for the project. Grateful thanks are also due to the Global Programme of Action (UNEP GPA Coordination Office in The Hague) for providing support to the preparation of the analyses. Technical Assistance in preparing this report was also given by Maria Bella Aguilos, George Samson Akpan, Wilma A. Cristobal, Lloyd Chidiebere Onyirimba and Yap Lian Ho, Adriel without whose diligence and perseverance it would never have been done.

U  
N  
E  
P  
G  
P  
A  
C  
O  
O  
R  
D  
I  
N  
A  
T  
I  
O  
N  
A  
L  
P  
R  
O  
G  
R  
A  
M  
M  
E  
O  
F  
A  
C  
T  
I  
O  
N

# 1. Introduction

The East Asian Sea is bordered by some of the most populous nations in the world and has been undergoing, over the last four decades, rapid industrialisation and economic and social development. The eight Southeast Asian countries around the South China Sea are the People's Republic of China to the north, the Republic of the Philippines to the east; Malaysia, the Republic of Singapore, the Republic of Indonesia; the Kingdom of Thailand, the Kingdom of Cambodia and the Socialist Republic of Viet Nam to the west. In addition, the study covers South Korea to the north and northern coastal Australia in the south. At the core of the area under study are the Southeast Asian regional waters. Within these waters, the South China Sea is strategically positioned and has always been central to issues of economic and political stability in Southeast Asia and adjacent regions. The heavy reliance on marine resources for these countries demand continued vigilance on ensuring environmental sustainability for the littoral States and for the welfare of future generations.

The Action Plan for the Protection and Sustainable Development of the Coastal and Marine Areas of the East Asian Seas Region, covers the coastal and marine areas of Australia, Cambodia, China, Indonesia, Malaysia, Philippines, Republic of Korea, Singapore, Thailand and Viet Nam. The region has shown an unprecedented rapid industrial development and population growth over the last decade, with little regard for the environment. Over-exploitation of resources in major areas of the region has rendered the marine and coastal ecosystems to be heavily impacted that they have lost a large part of their productive capacity.

It is generally stated that our scientific knowledge of pollution of the marine environment is poorly understood. In fact, the magnitude and main causes of degradation are well known, although specific areas of pollution activity and effects may not be well researched nor documented. Managerial, technological and technical solutions to reduce or eliminate

pollution are also well known. Problems relate more to poor management, inadequate monitoring and lack of information and resources, poor communication between scientists and managers, a sectoral approach to terrestrial and marine management, lack of co-operation between the public and private sectors, ignorance of the costs and economic and social practicalities of implementing solutions, and the lack of will on the part of policy makers in the most countries within the region.

Land-based sources account for 77 per cent of marine pollution with marine transport and dumping at sea constituting the remainder (Chamber of Shipping, n.d).<sup>1</sup> Most land-based sources are small point sources that pass without attracting public attention or area simply accepted as the normal state of affairs. Land-based sources of marine pollution, as an issue, rarely captures the public imagination. It is the classic example of a 'wicked problem'; one that is interconnected between problem and issue; complicated with social, organisational, administrative, economic and legal dimensions; exists in a dynamic and uncertain environment; is the result of several competing claims and interests, and contains social constraints that require social, political and organisational solutions, not just technological ones.

Exploitation of the watersheds and forest cover and unsustainable agriculture and use of pesticides and fertilisers caused most of the rivers to be heavily silted and polluted. A combination of factors including population growth, saturation of cultivable land for agriculture, migration of population into marginal and vulnerable upland areas, and the high demand for timber for both domestic and foreign markets has resulted in massive loss of forest cover in many part of the Southeast Asian region. There have also been many State-supported programmes to settle people in sparsely populated areas leading to an acceleration of resource use and degradation in many cases. Examples of these are the resettlement of people from the densely populated Red River Delta area to the

<sup>1</sup> See Chia (1995) for a study on ship-source pollution in the Southeast Asian sub-region.

upland provinces in Viet Nam.<sup>2</sup> Such encroachment into forested upland areas invariably involves land clearance and deforestation often in an uncontrolled manner that leads to soil erosion and silting of river channels. Coastal development, including land reclamation, dredging and conversion of coastal land for industrial and housing estates, aquaculture and agriculture activities, tourist resorts and sand mining, are major problems. These activities result in severe coastal erosion and loss of clean beaches, clear water, and increased nutrient and pollution loads that pollute coastal and marine habitats such as mangroves, coral reefs, seagrass beds and other benthic communities.

Within the East Asian Sea countries under review, there are marine ecosystems that range from Arctic to sub-tropical to Equatorial types. These marine waters are some of the most productive in the world and are heavily exploited for fishing and other resources. A significant percentage of the world's fisheries production comes from the waters of this region and provides protein for a large percentage of the population. The East Asian region supports an unparalleled diversity of marine fauna and flora. It contains one-fourth of the world's most productive mangrove forests (World Resources Index, 1996) and nearly one-third of the world's coral reefs (Smith, 1978).

More than 70 per cent of the population in the countries in the region lives in coastal areas, and depend in some way on marine and coastal resources for its main source of food, employment and income. Activities within the coastal and marine areas include manufacturing industries, coastal and marine tourism and recreation, fisheries, aquaculture, harvesting of medicinal and industrial products, and marine and riverine transportation. These activities may be large-scale commercial operations or small-scale land and traditional actions involving local communities. For a region that depends so heavily on marine and

coastal resources, it is of the utmost urgency for the countries in the region to undertake sustainable development of these resources through the prevention of pollution and degradation of the coastal and marine ecosystems.

## 2. Aim of the Study

This overview report as well as the country case studies have the following objectives:

- Present a broad view of the region's marine environment and the major resources contained in it,
- present a comprehensive overview on land-based sources and activities that pollute the seas,
- present the status of activities dealing with the protection of the marine, coastal and associated freshwater environments,
- review relevant information provided by the individual countries of the region,
- identify and assess the problems and establish priorities,
- set management objectives for these priority problems,
- identify, evaluate and select strategies and measures for management,
- establish criteria for evaluating the effectiveness of these strategies, and
- determine the elements required to support the management strategies.

## 3. Scope of the Study

The terms of reference specified ten countries to be covered and they are: Australia, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand and Viet Nam (Figure 1). For the purposes of this report, the East Asian Seas is divided into three sub-regions: Southeast Asia, northern East Asia, and Australia. While the report covers these countries in their entirety, some areas are

<sup>2</sup> Bernard and De Koninck (1996) reported intensive deforestation in the Central Highlands of Viet Nam resulting from massive commercial logging and agricultural expansion. In 1970, forest cover in Southeast Asia was two-thirds of total area. By 1990, the proportion had fallen to below 50 per cent.

treated in more detail because of the available details in the TDA report which covers the South China Sea. Due to the large size of the country, in the case of China, only the southern provinces of Guangdong, Guangxi, and Hainan with the addition of the Special Administrative regions of Hong Kong and Macau are included. Also, only the Tropical areas of northern Australia is considered.

Figure 2 shows only Southeast Asia plus the southern provinces of China. The areas shaded indicate the portion of the countries that come under the TDA study. Together with Korea, these two regions represent the only Northern East Asian seas sub-region in this overview. In the case of Australia, the area of consideration is the tropical portion from Exmouth Gulf in Western Australia (Lat. 22° S Long. 114° E) to Cairns (Lat. 16° S Long. 146° E) in north Queensland.

Much attention has been directed at ship-source pollution because of the dramatic nature of oil spills arising from shipping incidents and the severity of the aftermath of the spills in relatively small affected areas. The present excludes marine pollution of oil derived from activities that occur in the sea and only deals with oil and a wide range of other pollutants that enter the marine environment derived from land-based sources. These are derived from various land-based sources from a wide variety of anthropogenic activities including those derived from inland locations that result in inputs that are carried by water courses to the sea. Often the level of pollution is exacerbated by natural causes such as flooding and forest fires. This report covers the pollution of the sea and coastal areas but also related freshwater environments.

## 4. Approach of the Study

This report is based on earlier work undertaken for the regional Transboundary Diagnostic Analysis (TDA) for the South China that involved the partici-

pation of seven national bodies, namely, Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam. Each national committee prepared a country report intended to provide a country-based analysis of water-related problems and concerns. The reports were completed in the second half of 1998. The present terms of reference (TOR) include three other East Asian Seas countries/regions, namely Australia, Singapore, and South Korea. The study here is based only on secondary sources of information and does not involve any field visits.

The task of the present overview is to draw out only land-based sources of pollution. Inevitably, the coverage and degree of detail of the national TDA reports vary considerably in terms of their quality and completeness. In any case, for the three additional sub-regions — northern Australia, Singapore and South Korea — where national reports were not undertaken, it was necessary to develop the components covering these three sub-regions, based on the preliminary work done by the UNEP Regional Office for Asia Pacific in Bangkok, and the rest from whatever information that could be gathered quickly from other sources.

The present report draws information from a number of earlier reports undertaken by the EAS/RCU and on reports prepared by the member countries. These include an early draft of the state of the marine environment undertaken by Kirkman (unpublished and a set of reports from a project on *Transboundary Diagnostic Analysis of the South China Sea* (Talaue-McManus, 1999), referred to as the TDA report in this study. The TDA report was extensively revised by Kirkman and this study draws from the revised version. Valuable information is obtained from the UNEP EAS/RCU study on land-based pollution on a number of Southeast Asian countries by Koe and Aziz (1995). Information is also derived from a number of compilations on the state of the environment undertaken by the UNEP Regional Office in Bangkok (n.d.), ASEAN Secretariat (1996)<sup>3</sup>, and a major report by ESCAP and ADB (1995).

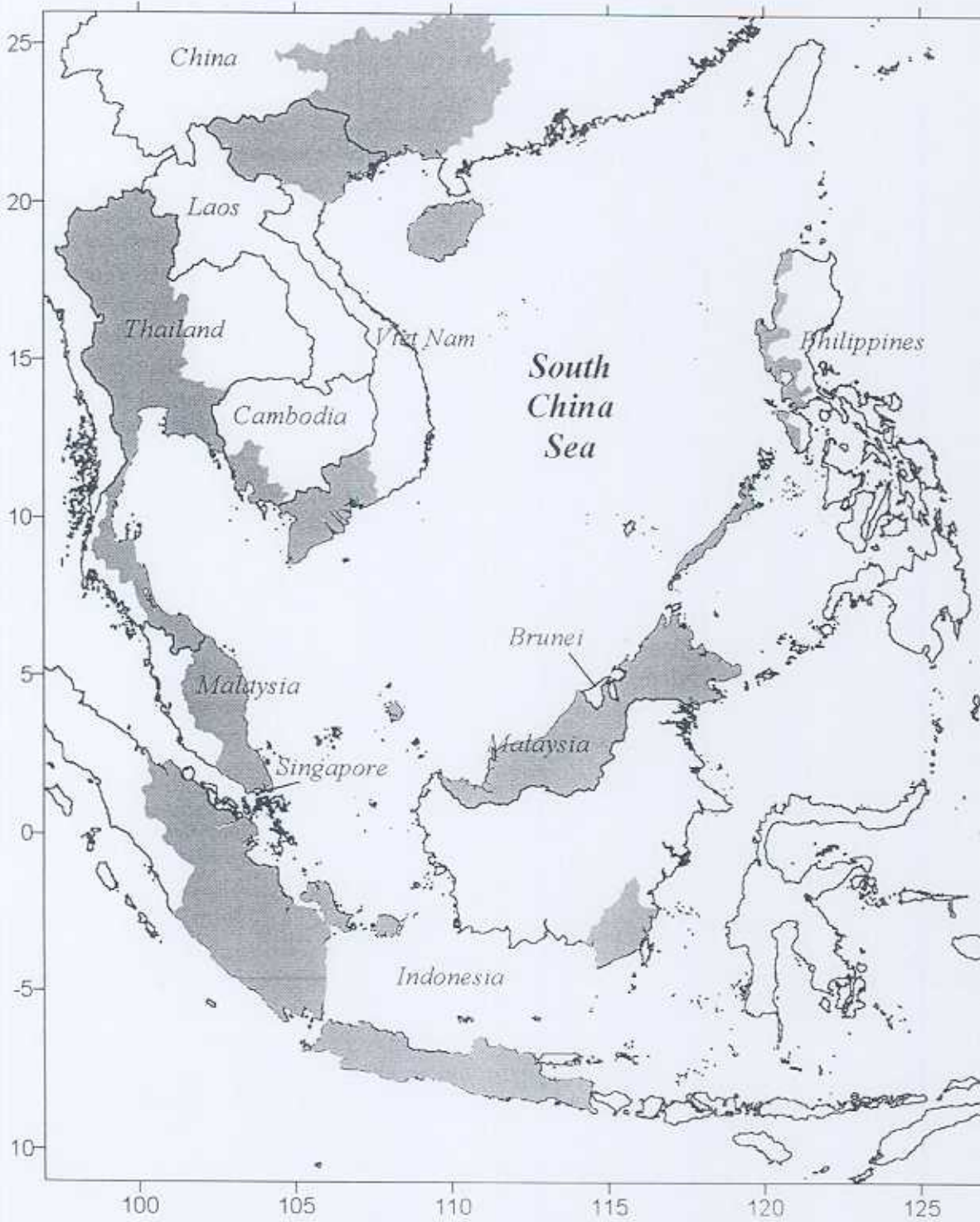
<sup>3</sup> With assistance from UNEP.



Figure 1: Map of the East Asian Countries Covered in this Report



Figure 2. Map Showing South East Asia Countries and Southern China Covered in this Report



Note: Shaded areas are provinces/areas where data were analysed in the SCS/TDA study.

## 5. Socio-Economic Status

### 5.1 DEMOGRAPHIC FEATURES

While the very high population growth rates of 3%/yr in the post-war years no longer apply, several of the countries are experiencing growth rates of over 2%/yr, e.g. Cambodia (2.7%/yr), Malaysia and Philippines (2.3%/yr), and Viet Nam (2.1%/yr). The return to peace and a more stable economic condition in Cambodia and Viet Nam in the last two decades have encouraged high birth rates. High growth rates are also related to a high proportion of rural population, and, in the case of Malaysia, a result of official encouragement for increased birth rates. Low population growth rates are indicative of a high level of urbanisation (e.g. Australia and Singapore) but they are also the result of successful population control as are the cases of China, Thailand, and Indonesia. For the seven SCS States, the weighted mean growth rate is 2.17 per cent. At this rate, the population would double in 32 years. In Cambodia, Indonesia and Malaysia, growth rates in the coastal provinces bordering the South China Sea are 1.5 to 2.0 times the

national growth rates (Talaue-McManus, 1999). In the case of China, coastal cities have been experiencing very high rates of population growth as a result of the opening up of coastal areas for foreign investments that began in the early 1980s. Cities such as Guangzhou and Shenzhen have attracted large flows of rural-to-urban migrants. This also affected the Special Administrative Region of Hong Kong, which shows a 1.9% growth rate.

Table 1 shows that several of the countries were, by 1997, already highly urbanised: Singapore (100%), Australia (85%), while South Korea's urbanised population rose from 57% in 1980 to 83% in 1997. As with Korea, all other countries experienced rapid urbanisation over the 18-year period with Thailand experiencing the slowest urbanisation trend increasing from 17% to 21% over the interval. Several of the countries: Viet Nam (20%), Thailand (21%), Cambodia (22%), China (32%) and Indonesia (37%) have remained largely rural. Generally, the trend toward urbanisation for the East Asian Seas countries is unmistakable. Available data drawn from the TDA national reports for the seven South China Sea (SCS) countries reveal that a large proportion of these generally coastal communities are concentrated in some

Table 1. Population Characteristics of Selected East Asian Countries

| Country         | Population (million) | Av. annual growth rate (%) | Density (persons/km <sup>2</sup> ) | Urban (% of total) |      |
|-----------------|----------------------|----------------------------|------------------------------------|--------------------|------|
|                 | 1997                 | 1990-1997                  | 1997                               | 1980               | 1997 |
| Australia       | 19                   | 1.2                        | 2                                  | 86                 | 85   |
| Cambodia        | 11                   | 2.7                        | 57                                 | 12                 | 22   |
| China           | 1,227                | 1.1                        | 129                                | 20                 | 32   |
| Hong Kong       | 7                    | 1.9                        | 6,218                              | 92                 | 95   |
| Indonesia       | 200                  | 1.7                        | 107                                | 22                 | 37   |
| Korea, Republic | 46                   | 1.0                        | 456                                | 57                 | 83   |
| Malaysia        | 21                   | 2.3                        | 61                                 | 42                 | 55   |
| Philippines     | 73                   | 2.3                        | 236                                | 38                 | 56   |
| Singapore       | 3                    | 1.9                        | 4,896                              | 100                | 100  |
| Thailand        | 61                   | 1.2                        | 116                                | 17                 | 21   |
| Viet Nam        | 77                   | 2.1                        | 227                                | 19                 | 20   |

Source: World Bank (1999), *World Development Report 1998/99*, Oxford: New York

93 cities, each with over 100,000 inhabitants (Table 3)(Talaue-McManus, 1999).

There is great variation of population densities among the ten East Asian countries with highly urbanised Hong Kong and the city-state of Singapore leading the way. Australia, a continental state, represents the other extreme. Several countries—Cambodia (57 persons/km<sup>2</sup>), Malaysia (61), China (107), and Thailand (116)—may be considered to be relatively lightly populated (Table 1). However, coastal areas present quite a different picture. Tables 2a and 2b show that population densities are highest for the coastal sub-regions of China and the Philippines at 471 and 472 persons/km<sup>2</sup>, respectively. Malaysia and Cambodia are least dense at 31 and 49 persons/km<sup>2</sup>. Hinrichsen (1998) notes that in Viet Nam, people live at even higher densities of 500-1,000 persons/km<sup>2</sup> along the northern part of the Gulf of Tonkin. In some parts of Hanoi, densities can reach 35,000 persons/km<sup>2</sup>. He cites tourism, increasing fisheries efforts and oil exploitation as among the major economic driving forces behind this dramatic increase in coastal populations. Elsewhere, in many heavily populated areas such as the Mekong delta, Java and Luzon, over the last several decades, there has been very large migration gains in coastal areas and especially in coastal cities.

The implications arising from higher population growth rates and level of urbanisation especially for coastal and riverine cities are that pressure on coastal resources is greatly raised. There is also more intense pressure on the part of governments and city administration to provide basic facilities such as sanitation and wastewater treatment plants to cope with more people and water and other forms of pollution generated by more industrial and commercial activities.

## 5.2 ECONOMIC STATUS

There are giants and minnows in terms of the size of the economies measured by GNP figures for countries in the region, with China exceeding US\$1 trillion and Cambodia with a mere US\$3 billion at two ends of the scale. Until the start of the financial crisis in Asia in mid 1997, the East Asian region was

the fastest growing region in the world. There are several of the so-called Newly Industrialising Economies (NIEs) or 'Asian Tigers', namely, Hong Kong, South Korea, and Singapore, among the countries under review. The NIEs and the less developed countries in the region are described as making a flying-geese formation following the lead of Japan that first experienced rapid economic growth from the 1960s. In time the NIEs and later the rest of the region would close the technological gap and level of development with Japan. GDP growth rates for these three NIEs were 6.3, 5.1 and 6.2, respectively, in 1992. Other rapidly developing countries in the region were China 14.2% GDP growth, Indonesia (7.2%), Malaysia (7.8%), Thailand (8.2%), and Viet Nam (8.5%) (1992 figures). Growth rates for per capita GDP mirrored similar levels of development (Table 2).

Rapid economic growth was fuelled by large flows of foreign direct investments (FDI) into the region. A number of the Association of South East Asian Nations (ASEAN) followed Japan and the NIEs in experiencing high economic growth. This was followed by China from the start of the 1980s decade, later by Viet Nam and Cambodia when they too opened up their economies and reaped the benefits of large influx of FDI. Encouraged by attractive government packages, foreign investments poured into manufacturing industries, construction, tourism and other sectors. In several of the resource-rich countries such as Indonesia, Malaysia, Thailand, and Viet Nam both domestic and foreign companies were engaged in large-scale timber extraction, mining, petroleum, and fisheries activities. Exploitation of natural resources often far exceeded the carrying capacity. It is clear that such rapid and massive development has to be accompanied by substantial provision of sanitation and wastewater treatment facilities to keep up with greatly augmented levels of pollution loads into the marine and related freshwater environments. It is clear also that it is necessary to institute strong control to protect natural resources and to prevent environmental degradation to ensure sustainable development.

Table 2. Economic Indicators of Selected East Asian Countries

| Country/<br>Region | Gross GNP<br>(billions \$S)<br>1997 | Growth Rate of GDP<br>(%/yr) <sup>a</sup> |      |                   | Growth Rate of<br>per capita GDP<br>(%/yr) <sup>a</sup> |      | Share of GDP<br>Agric. &<br>Mining (%)<br>1996 (1986) | Share of GDP<br>Manufacturing<br>(%) 1996 (1986) | Share of<br>GDP<br>Services(%)<br>1996 (1986) |
|--------------------|-------------------------------------|---|------|-------------------|---|------|---|--|---|
|                    |                                     | 1992                                      | 1997 | 1998 <sup>b</sup> | 1992  | 1997 |   |  |   |
| Australia          | 380.0                               |   |      |                   |   |      |   |  |   |
| Cambodia           | 3.2                                 | 7.0                                       | 2.0  | n.d.              | 1.6   | -1.7 | 47.5 (46.2) <sup>c</sup>                              | 13.5 (18.8) <sup>c</sup>                         | 39.0 (35.0) <sup>c</sup>                      |
| China              | 1,055.4                             | 14.2                                      | 8.8  | 7.2               | 12.9  | 7.7  |   |  |   |
| Hong Kong          | 164.4                               | 6.3                                       | 5.2  | 3.0               | 5.4   | 2.1  |   |  |   |
| Indonesia          | 221.9                               | 7.2                                       | 4.6  | -3.0              | 5.4   | 2.9  | 24.6 (35.4)   | 34.4 (22.5)                                      | 41.0 (42.1)                                   |
| Korea, S.          | 485.2                               | 5.1                                       | 5.5  | -1.0              | 4.0   | 4.5  |   |  |   |
| Malaysia           | 98.2                                | 7.8                                       | 7.5  | 3.5               | 3.3   | 5.1  | 19.8 (32.5)   | 41.4 (26.8)                                      | 38.8 (40.7)                                   |
| Philippines        | 89.3                                | 0.3                                       | 5.1  | 2.4               | -2.1  | 2.8  | 22.3 (26.3)   | 31.0 (32.3)                                      | 47.0 (41.5)                                   |
| Singapore          | 101.8                               | 6.2                                       | 7.8  | 3.0               | 4.1   | 5.7  | 0.2 (0.8)   | 35.5 (37.4)                                      | 64.3 (61.8)                                   |
| Thailand           | 169.6                               | 8.1                                       | -0.4 | -3.0              | 6.8   | -2.8 | 11.7 (17.4)   | 25.4 (31.3)                                      | 63.0 (51.3)                                   |
| Viet Nam           | 24.5                                | 8.6                                       | 9.2  | 5.0               | 6.1   | 7.0  | 27.2 (50.7)   | 30.7 (31.5)                                      | 42.1 (17.3)                                   |

a. Asian Development Bank (1998), *Asian Development Outlook, 1998, Special Chapter: Population and Human Resources*, Oxford Univ. Press, New York, Table A1 and A2, p. 234 & 235.

b. GDP growth rates 1998/1999 estimated (*Asiaweek*, December 17, 1999 issue)

c. Cambodia, 1987 figures.

Source: Institute of Southeast Asian Studies, *Regional Outlook: Southeast Asia 1998/1999*, Appendices

Table 2. Continued

| Country/<br>Sub-region | GNP<br>US\$ bil. | GDP <sup>a</sup><br>Growth rate<br>(%/yr) |                   | Growth rate of<br>Per cap. GDP <sup>a</sup><br>(%/yr) |      | Mining &<br>Agriculture<br>Share of GDP<br>(%) |      | Manufacturing<br>Share of GDP<br>(%) |      | Services<br>Share of GDP<br>(%) |      |
|------------------------|------------------|---|-------------------|---|------|--|------|--------------------------------------|------|---------------------------------|------|
|                        |                  | 1992                                      | 1998 <sup>b</sup> | 1992  | 1998 | 1986   | 1996 | 1986                                 | 1996 | 1986                            | 1996 |
| Year                   | 1997             |   |                   |   |      |  |      |                                      |      |                                 |      |
| Australia              | 380.0            |   |                   |   |      |  |      |                                      |      |                                 |      |
| Cambodia               | 3.2              | 7.0                                       | n.d.              | 1.6   | -1.7 | 46.2 <sup>c</sup>                              | 47.5 | 18.8 <sup>c</sup>                    | 13.5 | 35.0 <sup>c</sup>               | 39.0 |
| China                  | 1,055.4          | 14.2                                      | 7.2               | 12.9  | 7.7  |  |      |                                      |      |                                 |      |
| HongKong               | 164.4            | 6.3                                       | 3.0               | 5.4   | 2.1  |  |      |                                      |      |                                 |      |
| Indonesia              | 221.9            | 7.2                                       | -3.0              | 5.4   | 2.9  | 35.4   | 24.6 | 22.5                                 | 34.4 | 42.1                            | 41.0 |
| Korea, S.              | 485.2            | 5.1                                       | -1.0              | 4.0   | 4.5  |  |      |                                      |      |                                 |      |
| Malaysia               | 98.2             | 7.8                                       | 3.5               | 3.3   | 5.1  | 32.5   | 19.8 | 26.8                                 | 41.4 | 40.7                            | 38.8 |
| Philippines            | 89.3             | 0.3                                       | 2.4               | -2.1  | 2.8  | 26.3   | 22.3 | 32.3                                 | 31.0 | 41.5                            | 47.0 |
| Singapore              | 101.8            | 6.2                                       | 3.0               | 4.1   | 5.7  | 0.8  | 0.2  | 37.4                                 | 35.5 | 61.8                            | 64.3 |
| Thailand               | 169.6            | 8.1                                       | -3.0              | 6.8   | -2.8 | 17.4   | 11.7 | 31.3                                 | 25.4 | 51.3                            | 63.0 |
| Viet Nam               | 24.5             | 8.6                                       | 5.0               | 6.1   | 7.0  | 50.7   | 27.2 | 31.5                                 | 30.7 | 17.3                            | 42.1 |

d. Asian Development Bank (1998), *Asian Development Outlook, 1998, Special Chapter: Population and Human Resources*, Oxford Univ. Press, New York, Table A1 and A2, p. 234 & 235.

e. GDP growth rates 1998/1999 estimated (*Asiaweek*, December 17, 1999 issue)

f. Cambodia, 1987 figures.

Source: Institute of Southeast Asian Studies, *Regional Outlook: Southeast Asia 1998/1999*, Appendices

For the period 1986-1996, only Cambodia showed an unaltered share of GDP of the mining and agriculture sector while most other countries witnessed a substantial decline of the sector in favour of the manufacturing sector. Indonesia and Malaysia underwent rapid industrialisation during the period while the Philippines, Singapore, Thailand, and Viet Nam showed little change over the interval. By 1996, the manufacturing sector for all countries under review with the exception of Thailand account for over 30 per cent of the GDP with Malaysia showing the highest proportion, at 41 per cent. The concern has been that manufacturing plants set up by foreign firms do not practise as stringent environmental controls as in the originating countries. However, there is evidence to show that large multi-national corporations (MNCs) have been more responsible for keeping up high environmental standards in operating their industrial plants than domestic industries. The worst offenders are likely to be small and medium-sized firms whether local or foreign-owned (in the case of Singapore, see Loh *et al.*, 1995).

## 6. Characteristics of the East Asian Seas

The division into three sub-regions — Southeast Asia, Northern East Asia, and Australia — is necessary because of their vastly different environmental condition. The Southeast Asian sub-regional marine areas include the South China Sea (SCS), Indonesian archipelagic waters, Andaman Sea, and the Philippines seas while the southern coasts of China abut the SCS and share the SCS with a number of Southeast Asian States. The remaining waters of China and those of South Korea constitute a part of the Northern East Asia sub-regional marine area. The Australian sub-region covers the northern portion of Australia from Cape York in Queensland to Exmouth Gulf in Western Australia.

### 6.1 SOUTHEAST ASIA

The basic physical attributes of the countries of South-

east Asia are shown in Table 3. The total coastline of the Southeast Asian countries is more than 100,000 km. For the South China Sea, 125 major rivers drain  $2.5 \times 10^6$  sq km of catchment area and deliver materials, nutrients and pollutants into it. The population of Southeast Asian nations is about 500 million and account for some 8 per cent of the world's population. Total population for the seven Southeast Asian States is 446 million (1997 figures)(Table 1). Over 70 per cent of the region's population live in coastal areas. With the exception of Singapore, the Southeast Asian region is experiencing rapid population growth although the rates have been moderated over recent decades. The region's total population is estimated to increase from 475 million in 1993 to 726 million by the year 2025 (World Resources Institute, 1992), representing an increase of over 50 per cent over the 32-year period. Most countries are also highly urbanised.

The sub-region was experiencing the highest rates of economic growth in the world until 1997 when the financial crisis drastically set back its development. However, some countries, notably Singapore, in the sub-region have already turned around as the social and economic fundamentals of most countries are sound. Once the economic growth trends resume, the already visible adverse impacts on the marine environment including such ecosystems as coral reefs, mangroves and seagrass beds will be exacerbated by urban growth and new investments in industrial and commercial activities. The economic recession and the associated social instability in most Southeast Asian countries bring about their own adverse consequences. The coastal and marine environment are being adversely impacted due to curtailed essential infrastructure development and stalled operation of existing waste treatment facilities as a result of lack of funds and other resources. The impacts on the marine environment and resources has yet to be assessed.

The richness and productivity of the East Asian Seas and associated environments are seriously threatened by high population growth, pollution from both land and sea-based sources, over-exploitation and habitat

modification, resulting in high rates of habitat loss and impairment of the regenerative capacities of living resources. The socio-economic impacts of environmental deterioration are significant for the newly developed economies of this region. This is due to the heavy dependence on utilisation of coastal resources for the generally poor coastal communities. The governments in the region are well aware of the seriousness of the depleted and degraded marine and related freshwater environment and have formulated policies to deal with management the pollution at source and to ameliorate the impacts on the environment. Implementation of environmental policies are constrained by many factors but the task is urgent and immediate.

### 6.1.1 Physical Characteristics

The waters of the Southeast Asian sub-region under review comprise the centrally located South China Sea with the adjoining waters of the Gulf of Tonkin (Bei Bac) and Gulf of Thailand, the Straits of Singapore, Java Sea, the waters surrounding the Riau Archipelago and Bangka and Bilitung, and the Makassar Strait.<sup>4</sup> The oceanographic features that influence

<sup>4</sup> The total seaspaces of Southeast Asia covers an area of 8.94 mil. sq km representing 2.5 per cent of the World's ocean surface (Soegiarto, 1981, p. 23).

the severity and movement of pollution in the sea are: climate and meteorology, the bathymetry of the ocean floor, the depth of the mixed water layer, surface waves, tidal currents and surface wind drift.

#### 6.1.1.1 CLIMATE

The waters of the Southeast Asian sub-region are strongly influenced by the Asian monsoon regime: the Northeast monsoon blows between October/November and March, bringing in a cold and dry season to the mainland portion of the region. However, during the initial period of the monsoon and especially where the winds are directed onshore and are orographically lifted, very heavy rainfall that may persist for over a week, occurs over the Central Viet Nameese coast and along east coast of southern Thailand and Peninsular Malaysia. Towards the Equator, the winds turn northerly than westerly further south and bring a period of rainy conditions in most of Indonesia.

From May to September, the Southwest monsoon prevails throughout the entire region. Over the southern portion of the region covering Indonesia, the winds are from the east and southeast and come from the dry interior of Australia bringing a period of dry conditions to the area. North of the Equator, the winds turn southerly (from the south) and join with the Indian monsoon from the Bay of Bengal and sweep

**Table 3. Major Cities and Large River Basins in Selected South China Sea Countries and Coastal Provinces<sup>1</sup>**

|                 | City <sup>2</sup> | River              | Watershed Size ('000 km <sup>2</sup> ) | Population <sup>3</sup> ('000) |
|-----------------|-------------------|--------------------|--|--------------------------------|
| <i>Cambodia</i> |                   |                    |  |                                |
| Koh Kong        | Koh Kong          | Stung Metoek       | 1.14                                   | 105                            |
|                 |                   | Stung Russei Chrum | 2.73                                   |                                |
|                 |                   | Stung Sala Munthun | 1.57                                   |                                |
|                 |                   | Stung Chhay Areng  | 2.11                                   |                                |
| Sihanouk Ville  | Sihanouk Ville    | Prek Piphot        | 1.16                                   | 132                            |
|                 |                   | Prek Kompong Som   | 2.64                                   |                                |
| Kompot          | Kompot            | Prek Toeuk Chhou   | 2.06                                   | 603                            |
| Subtotal        | 3                 | 7                  | 13.41                                  | 840                            |



Table 3. Continued

|                                    | City <sup>2</sup>   | River            | Watershed Size ('000 km <sup>2</sup> ) | Population <sup>3</sup> ('000) |
|------------------------------------|---|------------------|--|--------------------------------|
| <i>China</i>                       |   |                  |  |                                |
| Guangdong                          | Chaozhou, Shantou, Jieyang, Shanwei, Huizhou, Shenzhen, Dongguan, Guangzhou, Zhongshan, Zhuhai, Jiangmen, Yangjiang, Maoming, Zhanjiang | Han              | 30.11                                  | 47,919                         |
|                                    |   | Rong             | 4.41                                   |                                |
|                                    |   | Pearl            | 442.10                                 |                                |
|                                    |   | Moyang           | 6.09                                   |                                |
|                                    |   | Jian             | 6.09                                   |                                |
| Guangxi                            | Beihai, Qingzhou, Fangcheng Port  | Nanliu           | 8.64                                   | 5,088                          |
|                                    |   | Qing             | 2.46                                   |                                |
|                                    |   | Maoling          | 2.96                                   |                                |
| Hainan                             | Haikou, Sanya   | Nandu            | 7.02                                   | 5,733                          |
|                                    |   | Changhua         | 5.15                                   |                                |
|                                    |   | Wanquanhe        | 3.69                                   |                                |
| Hong Kong                          | Hong Kong   | None             | None                                   | 6,190                          |
| Macau                              | Macau   | None             | None                                   | 424                            |
| Subtotal                           | 21  | 11               | 518.72                                 | 65,354                         |
| <i>Indonesia</i>                   |   |                  |  |                                |
| Riau-Batam                         | Tanjung Pinang  | None             | None                                   | 3,648                          |
| Bangka-Belitung and South Sumatera | Pangkal Pinang, Palembang   | Musi             | 9.13                                   | 6,997                          |
| Jakarta and West Java              | Jakarta   | Ciliwung-Cisadne | 2.24                                   | 47,547                         |
| East Java                          | Surabaya  | Brantas          | 12.00                                  | 34,758                         |
| South Kalimantan                   | Banjarmasin   | Barito River     | 32.00                                  | 2,804                          |
| West Kalimantan                    | Pontianak   | Kapuas River     | 5.00                                   | 3,616                          |
| Subtotal                           | 7   | 5                | 60.37                                  | 99,370                         |
| <i>Malaysia</i>                    |   |                  |  |                                |
| Kelantan                           | Kota Bharu  | 3                | 15.02                                  | 1,208                          |
| Terengganu                         | Kuala Terengganu  | 9                | 12.97                                  | 809                            |
| Pahang                             | Kuantan   | 5                | 42.24                                  | 1,081                          |
| Johor                              | Johor Baru  | 4                | 7.44                                   | 2,162                          |
| Sabah                              | Kota Kinabalu   | 11               | 31.31                                  | 1,809                          |
| Sarawak                            | Kuching   | 19               | 122.45                                 | 1,718                          |
| Subtotal                           | 6 cities  | 51               | 231.42                                 | 8,787                          |

Table 3. Continued

|                    | City <sup>2</sup>  | River                        | Watershed Size ('000 km <sup>2</sup> ) | Population <sup>3</sup> ('000) |
|--------------------|--|------------------------------|--|--------------------------------|
| <i>Philippines</i> |  |                              |  |                                |
| Western Luzon      | Laoag, Dagupan, Olongapo, Metro Manila (7 cities), San Pablo, Cavite, Batangas | Laoag                        | 1.32                                   | 22,653                         |
|                    |  | Abra                         | 5.12                                   |                                |
|                    |  | Agno                         | 5.95                                   |                                |
|                    |  | Pampanga                     | 9.76                                   |                                |
|                    |  | Pasig-Marikina-Laguna de Bay | 5.28                                   |                                |
| Mindoro Occidental |  | None                         | None                                   | 339                            |
| Palawan            | Puerto Princesa  | None                         | None                                   | 640                            |
| Subtotal           | 16   | 5                            | 27.43                                  | 23,632                         |
| <i>Singapore</i>   |  |                              |  |                                |
|                    | Singapore  | Singapore-Kallang            | 0.03                                   | 3.4                            |
| Subtotal           | 1  |                              | 0.03                                   | 3.4                            |
| <i>Thailand</i>    |  |                              |  |                                |
| Northern           | Chuang Mai, Nakorn Sawan   | Salawin                      | 17.90                                  | 12,091                         |
|                    |  | Ping                         | 33.90                                  |                                |
|                    |  | Kok                          | 7.89                                   |                                |
|                    |  | Wang                         | 10.79                                  |                                |
|                    |  | Yom                          | 23.62                                  |                                |
|                    |  | Nan                          | 34.33                                  |                                |
|                    |  | Khong                        | 57.42                                  |                                |
| Central            | Bangkok, Nonthaburi, Patumthani, Samut Prakan, Samut Sakorn, Saraburi          | Chao Phraya                  | 20.12                                  | 14,350                         |
|                    |  | Sakakrang                    | 5.19                                   |                                |
|                    |  | Pasak                        | 16.29                                  |                                |
|                    |  | Ta Chine                     | 13.68                                  |                                |
| Eastern            | Chonburi, Rayong   | Prachine buri                | 10.48                                  | 4,065                          |
|                    |  | Tonlasap                     | 4.15                                   |                                |
|                    |  | Eastern coastal              | 13.83                                  |                                |
| Southern           | Surathani, Nakorn Sri-Thammarat, Songkhla, Hatyai                              | Eastern coastal of South     | 26.35                                  | 6,636                          |
|                    |  | Tapee                        | 12.22                                  |                                |
|                    |  | Songkhla Reservoir           | 8.49                                   |                                |
|                    |  | Pattanee                     | 3.86                                   |                                |
| Subtotal           | 14   | 18                           | 320.55                                 | 37,142                         |

Table 3. Continued

|                              | City <sup>2</sup>  | River           | Watershed Size ('000 km <sup>2</sup> ) | Population <sup>3</sup> ('000) |
|------------------------------|--|-----------------|--|--------------------------------|
| <i>Viet Nam</i>              |  |                 |  |                                |
| Northern Mountains           | Quang Ninh   | Bang Giang      | 4.56                                   | 813                            |
|                              |  | Kycung          | 6.66                                   |                                |
| Red River Delta and Midlands | Hai Phong<br>Thai Binh<br>Nam Ha<br>Ninh Binh  | Thao            | 51.75                                  | 6,354                          |
|                              |  | Da              | 52.61                                  |                                |
|                              |  | Lo              | 38.97                                  |                                |
|                              |  | Red             | 154.72                                 |                                |
|                              |  | Cau             | 6.06                                   |                                |
|                              |  | Thuong          | 3.58                                   |                                |
|                              |  | Luc Nam         | 3.07                                   |                                |
|                              |  | Thai Binh       | 15.52                                  |                                |
| Central Coastal Region       | Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue, Quang Nam-Da Nang, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan | Ma              | 28.37                                  | 8,500                          |
|                              |  | Chu             | 7.55                                   |                                |
|                              |  | Ngan Sau        | 3.81                                   |                                |
|                              |  | Hieu            | 5.33                                   |                                |
|                              |  | Ca              | 27.22                                  |                                |
|                              |  | Tra Khuc        | 3.18                                   |                                |
|                              |  | Ve              | 1.26                                   |                                |
|                              |  | Ba              | 13.81                                  |                                |
| South Central                | Ho Chi Minh, Ba Ria-Vung Tau   | Dong Nai        | 29.52                                  | 11,314                         |
|                              |  | La Nga          | 4.00                                   |                                |
|                              |  | Be              | 8.20                                   |                                |
|                              |  | Sai Gon         | 5.56                                   |                                |
| Mekong Delta                 | Tien Giang, Ben Tre, Tra Vinh, Soc Trang, Kien Giang, Minh Hai   | Se San          | 17.50                                  | 6,076                          |
|                              |  | Sre Pock        | 18.28                                  |                                |
|                              |  | Cuu Long Mekong | 65.00<br>777.00                        |                                |
| Subtotal                     | 26   | 25              |  | 32,564                         |

1. Information in this table relate to coastal and watershed areas defined in the TDA reports.

2. Cities of over 100,000 or most significant urban centres in the region.

3. Population estimates are for different years: China (1995), Indonesia (1994), Malaysia(1991), Philippines (1995), Singapore (1998), Thailand (1997), and Viet Nam (1996).

Source: Modified from Talaue-McManus (1999).

across the region in a south-westerly direction. This is associated with heavy rainfall in the windward areas and all of mainland Southeast Asia. In between the two monsoons are two transitional periods occurring during October/November and March/April in the northern hemisphere. During these two periods, the Intertropical Convergence Zone ITCZ that separates the northern and southern hemispheric trades migrate overhead and bring along heavy thunder showers and periods of heavy intense precipitation.

The Southwest monsoon is also the season when tropical storms and typhoons occur. These tropical cyclones affecting only areas north of about 6° latitude, originate from the Pacific Ocean and cross the northern island of Luzon in the Philippines before reaching the Viet Namese coasts. Within the vicinity of the Philippines, typhoons can occur any time of the year. The highest incidents (4.4 per year on the average) are in the months of August and September and the lowest in the first three months of the year (Table 4). Typhoons are less frequent, but no less destructive, in the Bay of Bengal than in the western Pacific. The period, August, September and October, have the highest frequency of 2.1, 2.2, 2.0, respectively. These systems also occur south of Indonesia and affect Java and the northern Australian coastal areas. These systems bring windspeeds exceeding 100 km/hr and approaching 200 km/hr, and extremely heavy and widespread rainfall causing severe floods. Rainfall amounts are considerable augmented by upward air motion along mountain ranges as in Viet Nam and Peninsular Malaysia dur-

ing the north-east monsoon. A contributing factor to widespread flooding is that they are accompanied by raised sea-levels due to the shoring up of the water by winds directed landwards and an upward bulge of the seawater at the centre of the low-pressure systems (Chia, 1979). Severe storms and swell erode coastal areas and redistributes beach materials and may cause floods in low-lying areas. Flood water can result in severe shortage of drinking water and mix sewage with surface water in areas where there are no sewerage systems.

The monsoon causes changes in circulation pattern of surface ocean waters, the seasonal distribution of its physical, chemical and biological properties (Soegiarto, 1981:30). It also initiates upwellings in some areas and create vertical mixing of water layers over many areas of the shelf, increasing the amount of nutrients. Upwelling of deeper waters influences the biology and productivity of the marine living resources in the area. Nutrient from the discharge of major rivers in the sub-region, such as the Chao Praya, the Mekong and the Red River adds to this enrichment. This phenomenon combined with the generally shallow waters in the region account for the high diversity and productivity of the region. Marr (1976; 1981) estimated more than 2,500 fish species in the Southeast Asian sub-region.

#### 6.1.1.2 BATHYMETRY

The South China Sea, which has a total area of about 3.5 mil. sq km comprises the Mainland Shelf in the north and north-east, and the Sunda Shelf including

Table 4. Typhoon Frequencies in the Western Pacific

|      | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| No.  | 18  | 10  | 10  | 22  | 69  | 108 | 263 | 305 | 310 | 213 | 148 | 65  | 1531 |
| Avg. | 0.3 | 0.1 | 0.1 | .3  | 1.0 | 1.5 | 3.8 | 4.4 | 4.4 | 3.0 | 2.1 | 0.9 | 22.0 |

Note: The region bounded by Lat. 5-30°N and 105-150°E

Source: Meteorology for Mariners, H.M.S.O (1967) quoted in Chia (1979:22)

the Gulf of Thailand, in the south and south-west. The seabed is highly variable and there are shallow continental shelves, deep-sea basins, troughs, trenches, continental slopes and volcanic and coral islands. The large number of islands divides the waters into several seas, which are connected by many channels and straits. The portion of the South China Sea underlain by the Sunda Shelf to the south-west and the Java Sea is less than 200 m in depth while the north-eastern portion between the China-Viet Nam coast and the Philippines are deeper and forms a basin interrupted only by coral atolls rising from the deep seabed. The average depth of the South China Sea basin is about 4,000 m and reaches a maximum depth of 5,000 m. Around the deep basin, the central coast of Viet Nam and especially the Philippines coast in the South China Sea have a narrow shelf and slopes steeply into the basin floor (Soegiarto, 1981:26-30).

Elsewhere in the sub-region, several ocean basins – the Sulu Sea, Celebes Basin, Banda Basin, the smaller Flores Basin are as deep as the deeper portions of the SCS. The Celebes Basin with an extension in the northern part of the Makassar Strait, the water reaches a depth of over 4,000 m and the deepest portion exceeds 5,000 m near Mindanao. Similarly, the Banda Sea is highly irregular in seabed topography with a number of troughs and ridges and several distinct basin formations. The deepest, Weber Basin to the east, has depths reaching to below 8,000 m.

Around the outer edges of the sub-region, there are two very deep and long trenches. Off the Philippines coast, the Mindanao Trench reaches depths of over 9,000 m. The second, Java Trench, runs along the southern edge of South Sumatra, Java, to as far as the island of Samba. Parts of this trench is deeper than 7,000 m. The eastern extension of the Java Trench is the Timor Trough, which is shallower and separates the Indonesian island of Timor from the Sahul Shelf and the Arafura Shelf that slope away from the northern Australian coast. The shallow Arafura Shelf with depths of less than 200 m in most parts joins the Australian continent to New Guinea. To the west of the sub-region, the Mentawai Ridge

that runs along the Sumatra coast forms a string of islands (including the island of Nias) and the group of islands is separated from the Sumatra island by the Mentawai Trough. To the east of the Ridge, the ocean floor slopes away to the deep (average 5,000 m) Indian Ocean. Finally, north of Sumatra lies the Andaman Basin and its deepest portions are over 3,000 m. The Basin is enclosed by the southern Myanmar extension and Peninsular Thailand to the east and, to the west, by the string of Nicobar Islands. The shelf area along the mainland is broader compared with that along the western and southern Indonesia islands (see Morgan and Valencia, 1983: 6-8 and bathymetry map on page 7).

### 6.1.1.3 WATER TEMPERATURE AND SALINITY

The water mass of the Southeast Asian sub-region has its origin in the Pacific Ocean, though currents from both the Indian and Pacific oceans influence its tides. High temperatures, and low salinity and density prevail in the surface waters, with temperature ranging from 26°C to 30°C throughout the year and across the entire sub-regional seas area. The exception is during the northern Winter months when sea-surface temperatures fall below 26°C in the northern portion of the SCS and declines to below 16°C in the Taiwan (Formosa) Strait. Thus, over the broad Equatorial belt that cover most of the archipelagic Southeast Asian waters, temperatures do not vary by more than 2 degrees Centigrade around 28°C. The salinity varies greatly due to the influence of the monsoons, high rainfall, run-off from many large rivers and poor circulation prevailing in bays and semi-enclosed sea areas. High rainfall compensates for the high evaporation rate, and results in an average salinity of less than 34 parts per thousand in most parts of the sub-regional seas. Salinity varies during the two monsoons: the north-east monsoon draws in highly saline oceanic waters from the Pacific that increasing the maximum salinity values saturating the whole continental shelf. During the southeast monsoon, the conditions are reversed, with decreasing salinity due to an increasing intrusion of fresh water from the surrounding land masses (Soegiarto,

1981; Morgan and Valencia, 1983: 8-14).<sup>5</sup>

#### 6.1.1.4 WATER TRANSPARENCY

Factors such as silt, plankton and other particulate matter influences the degree of water transparency. Generally, water transparency is low in depths of less than 10 m, especially around river mouths and in the coastal seas around Sumatra, Borneo and the Gulf of Thailand, while transparency is high in the deep and open waters. Locally, land reclamation and dredging of seabed as well as offshore mining activities will increase turbidity and reduce water transparency.

#### 6.1.1.5 TIDES AND CURRENTS

Tides in the Southeast Asian sub-region are part of the oscillatory tides between the Pacific and the Indian Oceans: with different oscillation in each of the several sub-basins. Diurnal tides predominate in the South China Sea and Java Sea area. Mixed tides are found in Philippine waters, while in waters around Singapore and the Riau archipelago area, semi-diurnal tides prevail.

In the open sea, the monsoon wind drifts dominate the scene, except in channels, inlets and along the shoreline where the current is constrained and attain higher velocity. In February, surface currents in the SCS is strongest and has a maximum off the central Viet Nameese coast. A broad current flows along the western fringes of the SCS from southern China down to Viet Nam and Peninsular Malaysia. Further south, the current flows into the Java Sea where it turns eastward and across to the Banda Sea. Currents in the eastern portion of the SCS are weak and their direction variable. They are likewise weak and variable in direction in the semi-enclosed seas of the Gulf of Thailand and the Gulf of Tonkin. East of the Philippines, the Pacific Equatorial current is directed westward onshore toward the Philippines where the current is split into a northern branch and moves

northward along the northern half of the Philippines. The southern branch is swift (maximum around 75 cm/sec) but quickly reverses in direction to flow in an easterly direction between latitudes 3-7°N.

In August, the general pattern of the prevailing winds of the south-west monsoon is reversed from that in February. In response, the surface currents generally flow in a reverse direction from the February (northern Winter) pattern. There is a distinct fast stream of currents that emanate from the western Banda Sea flowing westward along the Flores and Java seas, then turn northward to flow along the western SCS along the Peninsular Malaysia and southern Viet Nameese coast before broadening (and weakening in velocity) north-eastwards within the northern parts of the SCS. Currents are weaker off the Borneo coast in the SCS but one of two clockwise gyres are evident during this season. As in the February situation, currents in the Indonesian ocean basins are determined by narrow channels such as the Makassar Strait where they are stronger, but become weaker in more enclosed and sheltered bodies of water. East of the Philippines, currents flow toward the land masses and turn northward off the Luzon coast. The pattern becomes highly complex off the southern Philippines where the Equatorial Counter Current is found. To the south of the Indonesian islands, a stream of strong currents flow just off the coast toward the direction of the Indian Ocean. (Wyrki, 1976; Soegiarto, 1981:34-35; Morgan and Valencia, 1983: 8-14).

With such a complex seasonal patterns of winds and currents, there will be areas of upwelling where biological productivity is raised. It is important to note that the sub-region suffers from two major natural hazards – severe tropical storms (typhoons) and earthquakes and the associated volcanic eruptions. As a result of these irregular events, coastal areas affected can become devastated by the storm surges, general rise of the sea-level, and tidal waves (tsunamis) (Morgan and Valencia, 1983: 14-17). Severe coastal erosion can be inflicted in sections of the affected coast by high waves and unusually high tides. Whole villages along the coast can be wiped out by

<sup>5</sup> See also earlier work by Wyrki (1961), and more recently, Soegiarto and Birowo (1976), quoted in Soegiarto (1981). Details of the coastal environment of Viet Nam are given in Roop *et al.* (1994).

tidal waves. These powerful phenomena with potential disastrous consequences impose very great on the part of governments to find solutions to reduce their effects in order to prevent environmental degradation and water pollution.

## 6.1.2 Biological Characteristics

The Southeast Asian marine environment supports an unparalleled diversity of corals and associated fauna and flora (Veron, 1986; Leis, 1991). The region has 40 per cent of the World's mangrove area and is one of two centres of biodiversity for mangroves (Spalding *et al.*, 1997)(see section 6.1.2.2 below). The great diversity is due to the high biological productivity in a warm, nutrient-rich and shallow-water environment further enriched by a highly varied coastal environment. Various landmasses and seas of the region exert their influence on the Southeast Asian marine environment. Currents from the Pacific and Indian oceans bring in oceanic waters reducing the impacts of the land masses and provide optimum conditions for coral growth (Wilkinson and Buddemeier, 1994) and seagrass ecosystems.

### 6.1.2.1 CORAL REEFS

One-fourth of the world's charted reefs are located in this region. The Southeast Asian region is recognised to be the global centre of biodiversity for coral reefs (Kelleher, *et al.*, 1995; Bryant *et al.* 1998). More than 30 per cent of the world's coral reefs are found in the region (Smith, 1978). Species diversity is highest, at around 450 species in the equatorial central Indo-Pacific defined by Sumatra and Java in the south-west, by Sabah and the Philippines in the north-west, and by the Philippines, eastern Indonesia and Papua New Guinea in the southeast. Over 70 hard coral genera are recorded in the waters around eastern Indonesia, the Philippines and the Spratley islands, while 50 are recorded for the other parts of Southeast Asia (Veron, 1986; 1992). Details of status of coral reefs in Viet Nam are given in Tuan and Ho (1994), Tuan (1992), and Tuan and Yet (1995). A recent survey by Bryant *et al.* (1998: 9) reports that there are more than 700 species of corals in the

region extending through Southeast Asia to the Great Barrier Reef off north-eastern Australia. However, they are of the opinion that most coral reefs of the Philippines, Sabah, Eastern Sumatra, Java and Sulawesi are at high potential threat from disturbances.

The reefs are mainly fringing types found around small to medium-size islands. The most extensive, diversified and spectacular reefs are found within the waters stretching from western Indonesia to the Philippines. Well-developed reefs are also found along the southern coasts of Myanmar and Thailand, the offshore islands of Viet Nam, the eastern coasts of Peninsular Malaysia, and the coasts of East Malaysia (Sabah) (UNEP/IUCN, 1988). The distribution of coral reefs in the South China Sea area is shown in Figure 3.

The reefs of Southeast Asia provide nursery and breeding grounds for many important commercial species of marine life, such as sea cucumbers, reef fish, giant clams, sea anemones, etc. Reef fisheries form an important part of the region's catches and, in some areas such as East Malaysia, the percentage of reef fishes in the total catch is about 30 per cent and can rise to as high as 40 per cent in seasons when fishermen cannot go far out to sea. In the Philippines reef fish catch is estimated to be about 25 per cent of the local catch (Gomez, 1988). The reefs are also an increasingly popular tourist attraction. Coral reefs in the region, therefore, directly and indirectly provide the basis for a significant social, economic and ecological life-support system. One of the most spectacular diving sites in the world is found near the oceanic atoll of Pulau Sipadan off the coast of Sabah, where a rich array of coral and marine life abounds. The atoll and the surrounding waters are major breeding and mating grounds for marine turtles.

Table 5 shows the main land-based activities that adversely impacts on the coral reef ecosystems in Southeast Asia. It is predicted that 48 per cent of the existing Southeast Asian reefs will be depleted in the next 10 to 20 years and the rest in 20 to 40 years if

**Table 5. Major Land-Based Activities and their Impacts on Coral Reef Ecosystems in Southeast Asia**

| Activity  | Impact                               |
|---|--------------------------------------|
| Coastal urban development   | sedimentation due to run-off         |
| Land reclamation, dredging of waterways and estuaries, and construction | sedimentation due to run-off         |
| Removal of mangrove belts   | sedimentation and freshwater run-off |
| Uncontrolled aquaculture practices                                      | eutrophication and sedimentation     |
| Untreated domestic sewage run-offs                                      | eutrophication                       |
| Industrial wastes run-off   | eutrophication, poisoning            |
| Watershed/ catchment areas modification                                 | sedimentation, eutrophication        |
| Agriculture development   | sedimentation, eutrophication        |
| Tourist resort development  | sedimentation, eutrophication        |

Source: Talaue-McManus, 1999.

nations of the sub-region do not take effective measures to ensure sustainable use of coral reef resources and their associated ecosystems (Wilkinson *et al.*, 1994). Bryant *et al.* (1998: 20) report that, of the four major threat factors on coral reef areas, inland pollution emerges as the second most important factor after over-exploitation followed by coastal development as far as posing high threat is concerned. However, in terms of posing medium threat, the latter poses a more serious threat than inland pollution. Both these factors can be considered as land-based pollution.

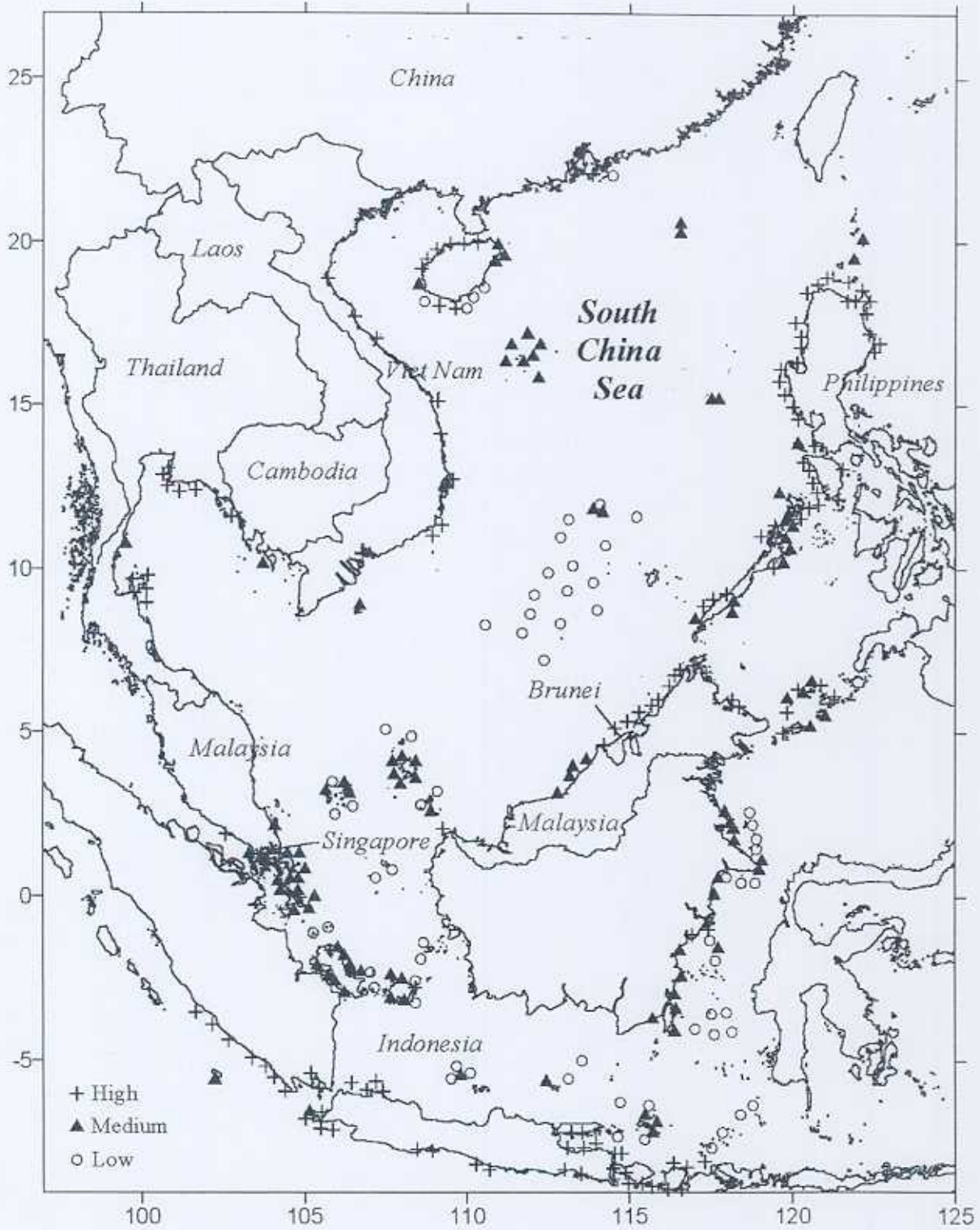
The quality, extent and variety of the reefs, together with the degree of their exploitation vary greatly within the waters of each country of the sub-region. Eighty per cent of the reefs of Southeast Asia are exposed to medium and high potential threat and over half are at high risk imposed by coastal development, marine pollution, over-exploitation and destructive fishing, and land-based pollution and erosion (Bryant *et al.*, 1998). Generally, it can be said that the majority of these reefs are degraded to various extents and, in the absence of concerted sustainable management efforts, most are threatened by further degradation. Table 6 provides some details of the extent of reef areas at risk for the whole of the Southeast Asian region, Australia and for the World. The proportion of reef areas considered to be in the high

risk category is 56% compared with 27% for the World and only 1% for Australia. Figures for Indonesia and Philippines are even worse with all of the reef areas in the Philippines classified as being under medium and high risk. The table also shows that marine areas designated for protection in the Philippines at 458 sq km is minuscule and patently inadequate. As an indication of commitment to protecting coral reefs, Indonesia's over 30,000 sq km of protected reef areas is commendable, at least on paper. This is almost as much as for the whole of the rest of Southeast Asia.

Coral reefs are subjected to degradation from a variety of factors. These include siltation and turbidity, freshwater run-off, domestic sewage, agricultural chemicals, industrial wastes, oil pollution, thermal pollution, over-fishing and destructive methods of fishing, dredging, land reclamation, shipping and recreational activities, commercial collection of reef fish and corals, and natural events such as storms (see Burbridge and Koesoebiono, 1981; Johannes, 1975). Bryant *et al.* (1998: 12-13) consider land-based pollution as important, these being sedimentation, inputs of pesticides, and pollution from human activities transported by rivers into coastal waters. They result in smothering of corals, reduced light levels (affecting growth), and over-nitrification of reef communities.



Figure 3. Known Distribution of Coral Reefs in the East Asian Seas Categorized by the Degree of Human Treats



Ir  
si  
Pe  
M  
of  
w  
re  
be  
lal  
co  
de  
er  
in  
(U

Na  
ma  
the  
cy  
qu  
ev  
Vic  
ied  
als  
fro  
pri  
as

Tal

|    |
|----|
| Re |
| W  |
| SI |
| In |
| Ph |
| At |

a. Pe  
Sou

In certain areas where freshwater runoff is excessive such as the Gulf of Thailand, the west coast of Peninsular Malaysia and the coast of Sarawak, East Malaysia, reef growth is limited. Excessive discharge of nutrient and sediment-rich run-off decreases the water clarity by increasing phytoplankton growth thus reducing the amount of sunlight necessary for coral health and growth. In addition, eutrophication stimulates macro-algal growth often results in changes of community species toward a predominance of less desirable benthic communities that in turn can accelerate the bioerosion of the reef system, leading to an imbalance or the collapse of the reef structure (UNEP/EAS, 1995).

Natural causes of reef damage are generally minimal. Apart from the central and northern Philippines, the region's reefs do not suffer from the effects of cyclones. Storm waves, therefore, appear to have quite limited impact on the reefs of the region. However, storm-induced damage to coral reefs on the Viet Nameese and Chinese coasts has yet to be studied and assessed. The reefs of Southeast Asia are also vulnerable to organic and non-organic pollution from land-based sources. Organic pollution stems primarily from untreated urban sewage discharges, as well as runoff from agriculture and aquaculture.

Tourism development in the coastal areas and on the islands of the region has increased over the past two decade. These resorts are usually located in the near vicinity of reefs as an added attraction. Paradoxically, there are very few examples of proper management and safeguards to protect the reefs. The impacts occur from untreated sewage discharges and physical damage. Destructive activities associated with recreation and tourism include coral trade, excessive reef visits and damage by trampling, souvenir collecting, fishing (including spear fishing), anchor damage by boats and dredging of reefs to create channels and marinas. This is very evident in Peninsular Malaysia, where tourism development on the nearshore islands of Johore and Terengganu, have adversely affected the islands' fringing reefs. An example is the island of Pulau Langkawi, off the north-west coast of Peninsular Malaysia, where heavy sedimentation in the adjacent waters and lowered salinity due to excessive runoff reduced coral reef cover from 46% in 1988 to 30% in 1995 (EAS/RCU, 1997). Unchecked mining activities in coastal areas can also lead to major damage to coral reefs and associated ecosystems. On Phuket Island, Thailand, past tin mining activities in coastal areas destroyed a significant part of the adjacent reef ecosystems.

**Table 6. Reefs at Risk Indicators, World and Selected Regions and Countries in Southeast Asia**

| Region           | Reef Area (sq km) by threat category |         |        |        | Percentage (%) |        |      | Coastal Pop'n Density <sup>a</sup> (pp/km <sup>2</sup> ) | Marine Protected Areas |         |
|------------------|--------------------------------------|---------|--------|--------|----------------|--------|------|--|------------------------|---------|
|                  | Total                                | Low     | Medium | High   | Low            | Medium | High |  | No.                    | (sq km) |
| <b>World</b>     | 255,300                              | 108,400 | 79,000 | 67,900 | 42             | 31     | 27   | 101  | 367                    | 475,298 |
| <b>SE Asia</b>   | 68,100                               | 12,300  | 18,000 | 37,800 | 18             | 26     | 56   | 128  | 57                     | 36,263  |
| Indonesia        | 42,000                               | 7,000   | 14,000 | 21,000 | 17             | 33     | 50   | 93   | 26                     | 30,405  |
| Philippines      | 13,000                               | 50      | 1,900  | 11,050 | 0              | 15     | 85   | 74   | 12                     | 458     |
| <b>Australia</b> | 48,000                               | 33,700  | 13,700 | 600    | 70             | 29     | 1    | 12   | 12                     | 374,967 |

a. Population within 60 km of the coast.

Source: Bryant *et al.* (1998: 21)

In Jakarta Bay, chronological data show a significant increase in the extent of sedimentation, pollution, and eutrophication between 1929 and 1993. As a result, the average coral cover diminished from 30% in 1985 to 5% in 1995. A concomitant decrease in the number of species of corals from 96 to 16 for the period between 1929 and 1993 was also observed at this site (UNEP EAS/RCU, 1997). Benthic communities, which have now become predominant, are rapidly destroying the limestone reef matrix. A similar reduction in the numbers of fish species in the area was also observed (Kelleher *et al.*, 1995).

Most of the Philippines reefs are similarly afflicted. Studies showed that only about 5% of the reefs are in good condition, with about 70% being seriously degraded (ASEAN-Australian Marine Science Project, 1992; Yap and Gomez, 1985). The situation is comparable in Indonesia where 5% of the reefs are considered to be in good condition and about 60% degraded (Sukarno *et al.*, 1986).

The Spratley Islands are situated in the South China Sea far from any land mass and, therefore, from the major land-based sources of pollution. Compared with the condition of reefs located close to land masses, those of the Spratleys are relatively pristine. They have some 600 coral reefs which support around 70 species of scleractinian coral genera. They extend for more than 480 km (300 miles) north of Sabah (East Malaysia) and southern Palawan (the Philippines). Knowledge of the marine and coastal living resources of the Spratley islands is relatively poor.

Malaysia established a tourist resort on one of the islands (Pulau Layang Layang) and has undertaken a systematic survey of the adjacent reefs. The objective is to develop a management plan for the protection of the marine resources as a marine park. However, some damage to the reefs has already been caused by the development of the facilities on this island.

#### 6.1.2.2 MANGROVES

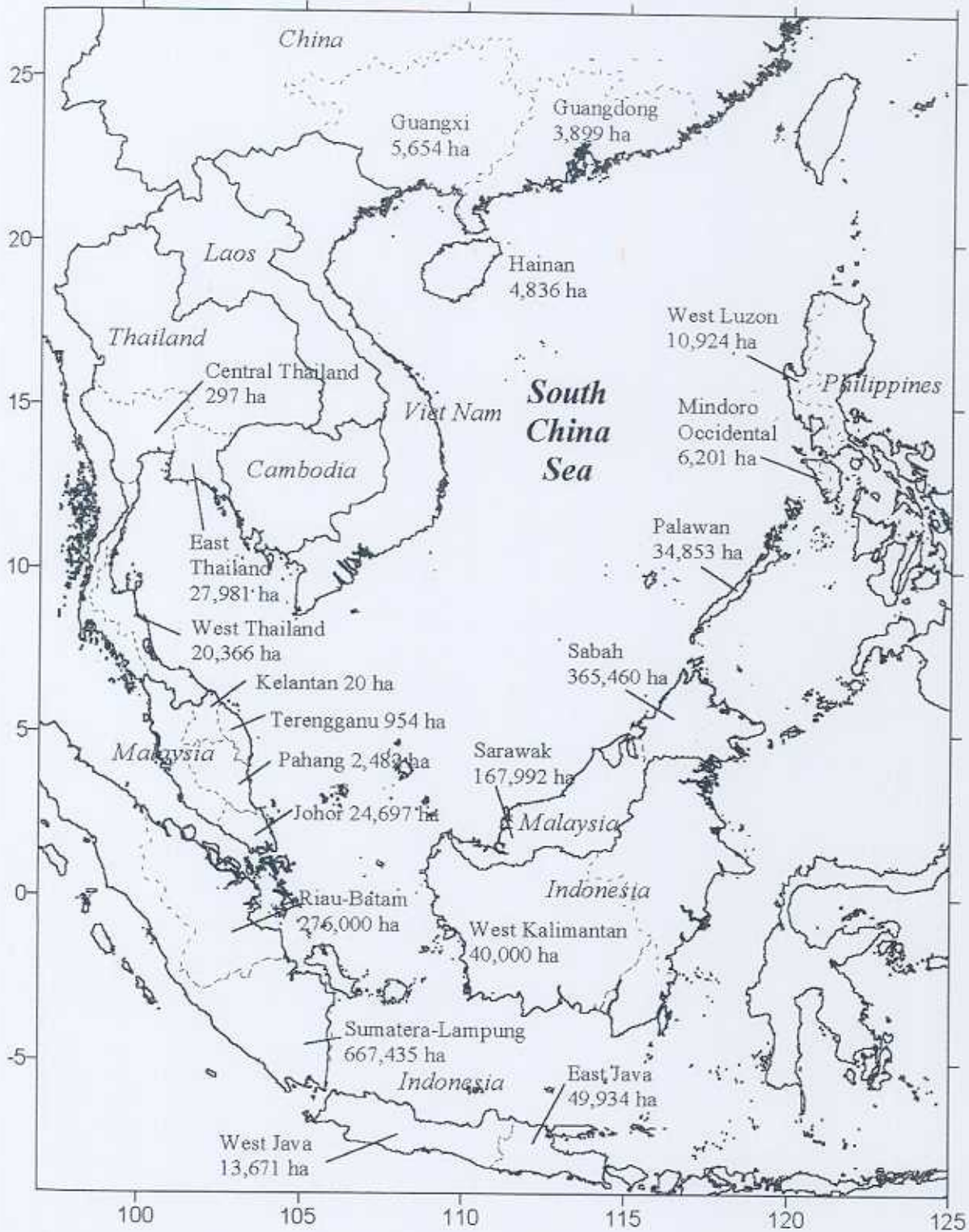
Mangroves support a rich ecosystem that is crucial

to the health of commercial marine species by providing important breeding, feeding, and nursery grounds for valuable types of shrimps and other commercially and environmentally significant organisms. Mangrove forests also support numerous seabirds and are roosting and feeding grounds for migratory birds. Mangroves also provide many products that are commercially harvested and are used for many uses by local communities. In addition, mangroves play a major role in the coastal ecosystem as a stabiliser. They also function as a buffer to the effects of storm waves and their removal often results in coastal erosion, which can be severe and expensive to repair if at all possible. They assist in reducing the effects of land-based discharges on associated ecosystems such as reefs and seagrass due to their capacity to function as filters. Mangroves probably act as a "sink" for industrial chemicals, although the long-term effects are poorly known and not understood.

Mangroves are found in the humid tropical belt between 30° north and south of the Equator. They are thus found in great abundance throughout the region and represent the dominant coastal vegetation of Southeast Asia (Figure 4). About 35 per cent of the world's mangroves occur in Malaysia, Thailand, Indonesia, Singapore, Cambodia and Viet Nam. The sub-region has 40 per cent of the global mangrove areas and represents an area with the highest diversity of mangroves in the world. There are 39 mangrove species (belonging to 21 genera and 19 families). Southeast Asia is at the core of one of two centres of biodiversity (Spalding *et al.*, 1997). However, there is a lack of management and conservation measures, it is estimated that approximately 30-40 per cent of the region's mangroves have now been lost (EAS/RCU, 1997).

Indonesia's mangroves cover an area of 4.25 million ha, which is the largest area of mangroves of any country in the world. In Irian Jaya alone, there are 2.9 million ha of mangroves. Much of the mangroves in the densely settled islands such as Java has been removed or heavily degraded. The mangroves in the western part of Indonesia have suffered a great deal of disturbance by human activities such as illegal

Figure 4. Mangroves in East Asian Seas Countries



cutting, pollution and conversion to other uses such as mariculture (ASEAN-Australian Marine Science Project, 1992). There are also indications of degradation in other eastern parts of the country, for example on the islands of Ambon and Halmahera (Kelleher *et al.*, 1995).

About 642,000 ha of mangroves are found in Malaysia. Mangroves and peat swamps cover 81% of the coastal areas in Peninsular Malaysia. Thailand and Viet Nam each have about 200,000 ha. The mangrove cover in Thailand decreased by 25% from 1979 to 1987, and 46% of the remaining stands have since been converted to other uses. The 100,000 ha in the Philippines are estimated to be only about 20% of that of the 1920s, and about half of this remaining forest is composed of secondary forest. About 7,000 hectares are found in Brunei Darussalam and 10,000 hectares in Cambodia (ASEAN-Australian Marine Science Project, 1992). In Viet Nam and Cambodia, there are reports of extensive cutting of mangroves for aquaculture and development projects. According to Viet Nam's National TDA Report, mangrove forests in the country provide food and associated products for about 30 million people. This report also describes rapid reduction of mangrove areas in the Mekong Delta from 154,000 ha in 1980 to 15,000 ha in 1995 due to reclamation for aquaculture. Defoliants used during the 1962-1975 war may have halved the area of mangrove (see Ross, 1974).

The main land-based causes of mangrove depletion and degradation in the Southeast Asian sub-region are the following:

- Discharge of untreated wastewater from industrial plants and commercial establishments such as restaurants and itinerant food hawkers;
- untreated sewage from residential and commercial areas;
- uncollected garbage and seepage of contaminated water from rubbish;
- silt, nutrients and other contaminants arising from upstream watershed development such as removal of forest cover; agriculture; industrial, commercial and housing

- expansion; mining; construction of roads and other infrastructure, etc;
- of the above, especially runoff of pesticides and herbicides associated with intensive agricultural activities;
- reduction of water volume available to mangroves due to upstream damming, irrigation activities, and diversion of water to other watersheds.

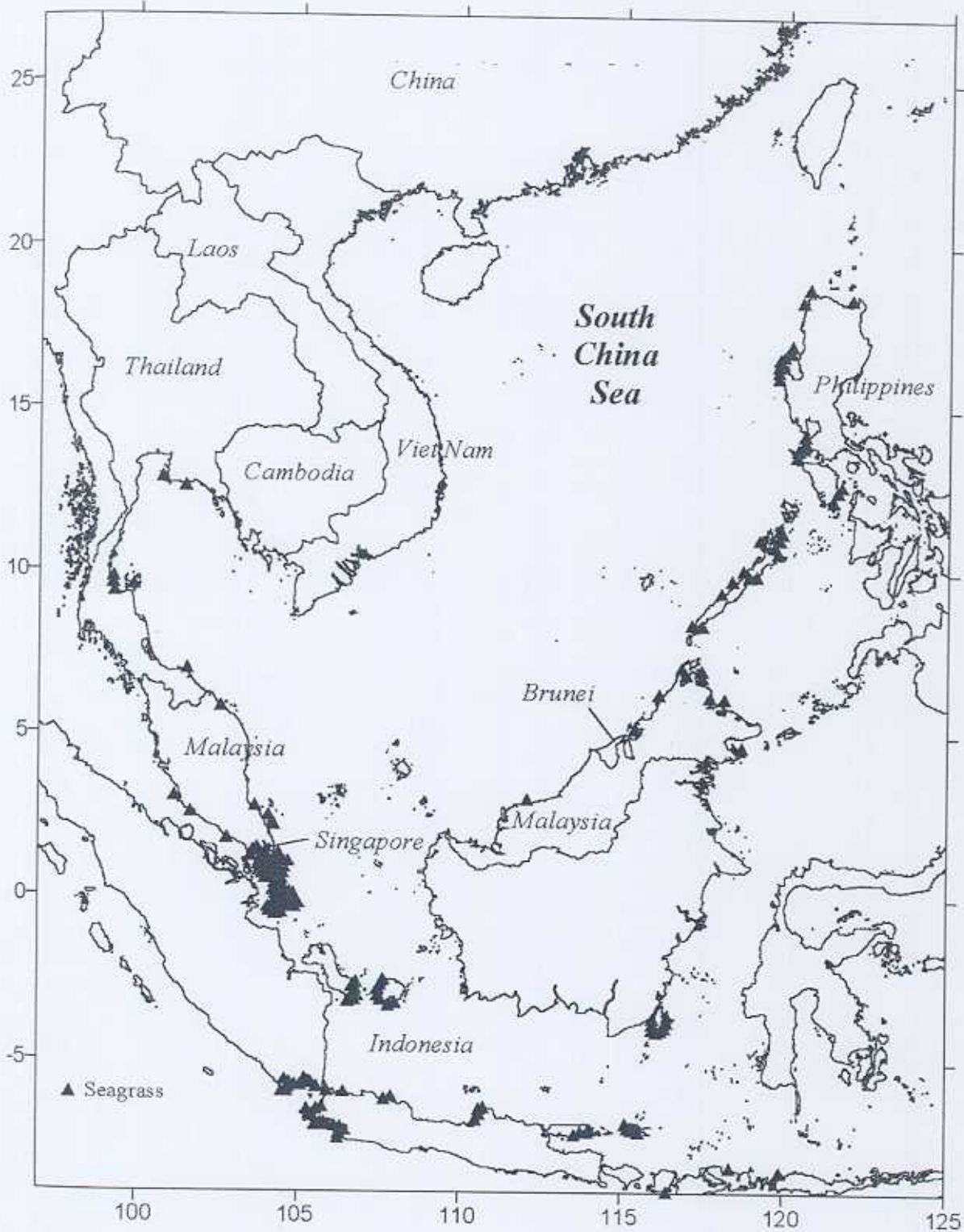
Mature mangrove stands are resilient to increased sediment, nutrient and pollution loads, but only for short periods. The recruitment rate of mangroves is probably negatively affected by heavy sediment loads (UNEP/EAS, 1997).

### 6.1.2.3 SEAGRASS

Generic richness of seagrass is also centred in the Indo-West Pacific region (Heck and McCoy, 1978). Species diversity is highest in Malesia, a region defined by Indonesia, Borneo, Papua New Guinea and northern Australia. East Asia harbours the second highest number of seagrass species at 20 of 50 recorded species world-wide (Fortes, 1989, 1995; Sudara *et al.* 1994). Of the twenty species and seven genera of seagrass in Southeast Asia: 12 species are found in the waters of Indonesia (den Hartog, 1970; Soegiarto and Polunin, 1982), 16 in the Philippines (Fortes, 1989), 10 in Malaysia (Japar, 1994), and 12 in Thailand (Lewmanomont and Ogawa, 1995) (see Table 8). The known distribution of seagrass meadows are shown in Figure 5.

The ecological and economic importance of seagrass to commercial and recreational fisheries is well documented. Fortes (1989) listed 16 traditional and contemporary uses of seagrass. Seagrass beds enhance substrate stabilisation and are important in detrital food chains nutrient cycling and the supply and fixation of biogenic calcium carbonate. They serve as substrate for epibiota and are critical habitats for many species of marine animals. Seagrass meadows serve as feeding areas, nursery grounds (Hutomo and Peristiwady, 1996) and habitats for fish, many invertebrates, turtles and dugong. They also act as

Figure 5. Known Distribution of Seagrass in the East Asian Seas



S  
E  
A  
S  
I  
N  
D  
O  
N  
E  
S

Table 7. Number of Seagrass Species in Selected East Asian Countries

| Sub-region/Country | No. of Species | Country           | No. of Species |
|--------------------|----------------|-------------------|----------------|
| Southeast Asia:    |                | Western Pacific   |                |
| Cambodia           | 1              | Hong Kong         | 4              |
| Indonesia          | 12             | Korea             | 1              |
| Malaysia           | 9              |                   |                |
| Philippines        | 16             | Australia         |                |
| Singapore          | 11             |                   |                |
| Thailand           | 10             | Western Australia | 17             |
| Viet Nam           | 8              | Queensland        | 12             |

Source: Fortes (1989), Table 1, pp. 4-7.

filters and help stabilise sediments. Seagrass meadows are the sole habitat of the sea cow, *Dugong dugon*. The dugong is the only remaining representative of the mammalian family, *Dugongidae*, and is an endangered species throughout its distribution. Similarly, endangered sea turtles are found in seagrass areas and the green sea turtle (*Chelonia mydas*) feeds on seagrass.

In Southeast Asia, it is only over the past two decades that seagrass beds have been recognised as a significant ecosystem of economic and ecological importance. Seagrass can grow as fast as cultivate corn, padi, hayfields, or tall grass prairies (Philipps, 1978 quoted in Fortes, 1989, p. 10). The production rate of tropical eelgrass in the Philippines, for example, is 1.08 g C/m<sup>2</sup>/day. Seagrass beds in Bolinao Bay, in the Philippines, produce at least 18,900 kg C/day. One square metre of the bed produces 8,635 C/day or about 20 per cent of the daily caloric requirement of an average individual. A 70-kg individual can be supported by 350 sq m of seagrass bed. Ignorance of its potential has caused neglect in instituting protective measures for these valuable resources. Indonesia and the Philippines, among other Southeast Asian countries, have a relatively good knowledge of their seagrass habitats and associated resources. Information is needed especially on the impacts of sedimentation, eutrophication and other types of pollution, in order to enable the formulation and adoption

of appropriate management measures to ensure sustainable use of this resource.

Natural threats to seagrass meadows include cyclones, volcanic dust, floods, sedimentation, storm waves, freshwater run-off and exposure at low tide. These threats are responsible for seagrass loss over a wider area than are anthropogenic impacts but recovery is quicker. The most common anthropogenic impacts in the region are sedimentation, nutrient-loading, and other types of pollution. Excess sediments damaging seagrass in the sub-region have their origin in river-runoff, resulting from extensive shrimp pond development, logging of forests, diminished mangrove cover, land reclamation, dredging and coastal development in general. There is increasing evidence that extensive land reclamation, agricultural development and mining activities have led to high water turbidity and the burying of seagrass beds (Fortes, 1988).

Land-based activities lead to industrial and domestic sources of pollution such as chemical wastes (particularly heavy metals), pesticides, various other toxic substances, and hydrocarbons. Fertilisers, stemming from intensive agriculture and aquaculture practices, domestic sewage, and storm-drain run-off carrying organic wastes add nutrients to runoff waters. The most notable effect of nutrients is to increase algal growth and hence reduce light penetration to

**Table 8. Extent of Damage and Causes of Degradation of Seagrass Meadows in the East Asian Region**

| Country     | Extent of damage  | Immediate causes of degradation  |
|-------------|---|--|
| Cambodia    | n.d.  | Fishing by pushnets, trawling, transport and navigation  |
| China       | 4,200 ha remaining in Guangxi region                              | Land reclamation   |
| Indonesia   | 30-40%  | Sedimentation  |
| Malaysia    | Adverse impacts of coastal reclamation in South China Sea regions | Coastal reclamation, oil spills, land-based pollution  |
| Philippines | 30-50%  | Industrial development, ports and recreation   |
| Singapore   | n.d.  | Land reclamation, dredging, shipping   |
| Thailand    | 20-30%  | Waste disposal from domestic use and aquaculture, fisheries, collection for traditional medicine, land reclamation and development |
| Viet Nam    | Heavily exploited   | Fertiliser production, animal feed production, land reclamation for agriculture and aquaculture, mats and handicrafts              |

Sources: Fortes (1995), national TDA reports.

seagrass. Eutrophication poses one of the major threats to seagrass beds in the region. It is especially prevalent in enclosed bays with insufficient tidal flushing. Table 8 below summarises the extent of damage and causes of degradation of seagrass meadows in the East Asian region though not restricted to land-based activities.

## 6.2 NORTHERN EAST ASIA SUB-REGION

The waters of the northern East Asia sub-region include the Sea of Japan (also referred to as East Sea), the Yellow Sea with the adjoining Bohai and East China Sea. The two countries of special concern, China and Korea, were experiencing very rapid economic growth, especially in the Chinese coastal cities that have been opened for foreign investments over the last two decades. The Asian financial crisis that began in mid 1997 affected Korea badly while China remained relatively unaffected. However, Korea's economy has recovered strongly from 1999. Rapid economic growth also attracts a huge flow of migrants from inland regions in China to coastal cit-

ies. The combined effects of rapid industrial development and urbanisation will bring about a higher demand for food and other resources that can generate detrimental effects on the marine environment and related freshwater bodies due to land-based activities and increased pollution loads.

### 6.2.1 Physical Characteristics

#### 6.2.1.1 BATHYMETRY

Maximum depths are 5,000 m in the South China Sea area and 2,700 m in the East China Sea. Despite these significant depths, the seas are separated from the open ocean by quite shallow passes and straits (a few hundred metres). The arch formed by the islands and archipelagos is one of the most active volcanic regions in the world. Off the western edge of the arch, the seabed reaches great depths. These are the deep trenches to the west of the Marianas, the Philippines and South Honshu. The continental shelf is wide in some areas of the Northern East Asian sub-regional seas, but there is almost no shelf on the deep oceanic side facing the Pacific Ocean.



### 6.2.1.2 WATER TEMPERATURE AND SALINITY

In the sea areas in the South China Sea around Hainan, sea surface temperatures vary between 20°C in winter and 29°C in summer. Further north, temperatures range from 8°C and 26°C in the East China Sea. Salinity is usually between 32 and 34 ppt, except in areas where it is influenced by river runoff, in which case it can be as low as 28 ppt.

### 6.2.1.3 TIDES AND CURRENTS

The major current systems influencing the region are the Kuroshio (warm) and the Oyashio (cold). The fronts of these two currents converge north of Japan, inducing highly productive conditions. The local currents in these seas are influenced by the Kuroshio-Oyashio system, the large rivers that flow into them and the reversals of the monsoons.

## 6.2.2 Biological Characteristics

The sub-region is rich in biodiversity, with China having more than 20,000 marine species. Southern China and the Ryukyu are characterised by a great diversity of coral reefs, marine fish and invertebrates.

### 6.2.2.1 CORAL REEFS

In the province of Taiwan, there are coral reefs at the southern point of the island, around Kenting and in the Penghu Archipelago. The northernmost reefs in China are found in Fujian province, around Pingtan Island. Small reefs also follow the coast and off Hong Kong. Large coral reefs grow south of Hainan and in the archipelagos of the South China Sea (Kelleher *et al.*, 1995; Anon, 1995). According to Liang (1995), the sub-region has a high diversity of corals: about 325 species in China. About 300 species are reported along the coast of the province of Taiwan.

The reefs in the Northern East Asia sub-region show the same pattern of degradation and depletion from land-based sources of pollution as observed in the Southeast Asian sub-region. In China, many of the reefs have been significantly depleted (UNEP/IUCN,

1988). On the southern coast around Hainan, pressures from the large human population resulted in extensive degradation of the reefs (Wilkinson and Buddemeier, 1994). The threats to coral reefs from land-based sources of pollution are essentially the same as in the Southeast Asian sub-region, with a possibly different emphasis on the severity of certain causes. These threats can be summarised as:

- sediments, pesticides and nutrient-rich runoff from agricultural and aquacultural development,
- discharge of untreated urban sewage and industrial wastewater,
- reclamation of nearshore areas for development,
- dredging and construction along the coast, and
- increased tourism development.

### 6.2.2.2 MANGROVES

There are no mangroves in Korea. Most of the mangroves in the sub-region are found in the coastal areas of southern China and cover approximately 67,000 ha (WCMC, 1992). The northernmost mangroves in the country are near Fuding in Fujian province. Significant areas of mangroves grow around Hainan and in the Beibu Gulf near Quinzhou and Beihai. China has a total of 36 mangrove species, which is about 43 per cent of the total number of mangrove species in the world.

The mangroves in the Northern East Asia sub-region, like those in the Southeast Asian sub-region, are facing continued threat from land-based sources of pollution from agriculture, aquaculture, domestic sewage, and industrial discharge. Integrated coastal zone management, combined with conservation and rehabilitation measures, are essential to counteract the ever-increasing pressures from a growing population and its concomitant impacts on the coastal areas and mangroves of China.

6.2.

Sea  
Eas  
in t  
Har  
Eas  
as t  
fron  
aqu  
fres  
acti  
luti  
buti  
sult,  
ecos  
imp  
tems  
adop

6.3

For t  
coas  
disc  
temp  
water  
cal w  
expe  
ing 2  
do no  
anic  
nutrie  
fisher

The g  
envir  
cal w  
speci  
cies a  
cific.

6.3.1

Austr  
count

### 6.2.2.3 SEAGRASS

Seagrass beds are found throughout the Northern East Asia sub-region. Of the 12 genera of seagrass in the world, three are located in the sub-region (den Hartog, 1970). The seagrass beds in the Northern East Asia sub-region suffer from the same problems as those of Southeast Asia: excessive nutrient loads from domestic sewage discharge, agriculture and aquaculture development, heavy sedimentation and freshwater run-off due to inappropriate development activities in the watersheds and hinterlands and pollution from industrial development. The spatial distribution of seagrass meadows is not known. As a result, little is known about human impacts on these ecosystems. This lack of baseline knowledge is an impediment to our understanding of marine ecosystems and will prevent the formulation of policies and adoption of appropriate measures to conserve them.

## 6.3 AUSTRALIA SUB-REGION

For the purposes of this report, only the waters and coastal areas of northern Australian continent are discussed here. The northern tropical waters have temperatures reaching a high of 32°C in shallow waters in the summer months. Generally, the tropical waters of the Indian and eastern Pacific Oceans experience surface temperatures sometimes exceeding 28°C. Surface temperatures in the deep oceans do not exhibit marked seasonal changes. The oceanic waters around Australia are generally low in nutrients and consequently possess low biological and fisheries productivity.

The greatest species diversity in Australia's marine environment occurs in the country's northern tropical waters. However, there are very few endemic species, and most of Australia's tropical marine species are widely distributed in the tropical Indo-Pacific.

### 6.3.1 Coral reefs

Australia has the largest area of coral reefs of any country. The Great Barrier Reef forms the largest

reef complex in the world extending for 2,000 km from the low-latitude tropics to temperate zones. The Great Barrier Reef is most diverse in reef types (fringing, platform, barriers and atolls), habitats and environmental regimes. Other major reef areas occur in the Torres Strait and the Coral Sea territories (Bleakley and Lawrence, 1997). The Ningaloo Reef on the central Western Australian coast is the world's largest fringing reef. The reef in this area stretches for 150 km from Lat. 21° 55'S to Lat. 23° 30'S. A wide variety of coral types are found here; oceanic atolls, fringing and veneer reefs and platform reefs of varying degrees of development. Further north the tides are extreme in amplitude and the sediment stirred up by tidal currents precludes large reef formations. Offshore islands and atolls, e.g., Ashmore, Montebellos and Rowley Shoals, have a wide range of species diversity.

Australia's coral reefs are relatively unaffected by human activities due to their remoteness from large urban settlements and because of low to moderate levels of use. However, increasing levels of nutrients and sediments from inland soil erosion pose a threat in the non-arid areas. A great deal of effort has also been made to control the adverse effects of recreational activities and tourism.

Australia's reefs grow within the area of the world's highest coral diversity, namely the central Indo-Pacific region. The Australian reefs are, therefore, critical to coral reef conservation as few other countries in the region have such low coastal population pressure or the capacity to control the anthropogenic impacts on their reefs. Australian reefs, besides being an ecological asset, support very rich fisheries and a thriving tourist industry. The annual revenue from fisheries and tourism in the Great Barrier Reef alone is over A\$1 billion. The reefs are also valuable for scientific research on natural products with biopharmaceutical properties.

### 6.3.2 Mangroves

Mangroves extend throughout the tropical coastal areas of Australia. There are 39 mangrove species

(belonging to 21 genera and 19 families), of which only the *Avicennia integra* is endemic, whilst the rest are also found in Southeast Asia, Papua New Guinea and Irian Jaya. The most diverse communities are found in the tropical areas (35 species in the estuaries of Cape York) reducing with increasing latitude.

As in Southeast and East Asia, mangroves are ecologically and economically important to Australia. Mangroves provide important habitats for fish and crustaceans and some of Australia's valuable commercial fisheries of single species are either directly or indirectly linked to mangroves. Approximately 200 species of fish have been documented from northern Australian mangroves. The Australian mangroves provide bird sanctuaries and play important roles in stabilising the coastline by mitigating the effects of cyclones and storm waves. Mangroves also have a crucial function in trapping and stabilising sediments from river systems, and act as an effective barrier to nutrients carried by run-off from land to sea thereby protecting the coral reef and seagrass communities from excessive sedimentation and nutrient loading.

### 6.3.3 Seagrass

Australia has the most extensive area of seagrass and the highest number of seagrass species (over 30 species) in the world. Knowledge and a comprehensive data base on seagrass habitats are available in Australia but much has still to be learned about the response of seagrass habitats to environmental changes so that mitigating measures of adverse impacts can be put in place. This is particularly true of the impacts of sedimentation, nutrient-loading and other types of pollution. Australia's seagrass face such threats as sedimentation from large river run-offs, floods, mining and chemical discharges from industrial and domestic sources.

## 7. Status of Land-based Sources of Pollution

Reference must be made of global reviews of the marine environment undertaken by GESAMP (1982; 1990). The latter reports that (1) marine habitats are irretrievably being lost to the construction of harbours and industrial installations, to the development of tourist facilities and mariculture, and to the growth of settlements and cities; and (2) destruction of beaches, coral reefs and wetlands including mangrove forests, as well as increasing erosion of the shore, are evident all over the world (quoted in Chua, 1995, p. 148). UNEP also commissioned a study on the state of the marine environment in the East Asian seas sub-region (Gomez *et al.*, 1990). In 1993, GESAMP examined the impacts of oil and related chemicals and wastes on the marine environment (GESAMP, 1993). The UN Economic and Social Commission for Asia and the Pacific (ESCAP) also undertook two reviews of the state of the environment in the Asia and the Pacific region (ESCAP, n.d.; ESCAP and ADB, 1995), the latter massive review was undertaken jointly with the Asian Development Bank (ADB). In addition, UNEP recently undertook a similar review of the state of the environment on behalf of the Association of South East Asian Nations (ASEAN Secretariat, 1997). The GEF/UNDP/IMO Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas published the proceedings of a conference on the theme of managing pollution in the East Asian seas (Chua and Bermas, 1999) that come close to a review of the state of the environment of the regional sea. Finally, the Japan Environmental Council (Awaji and Teranishi, 2000) is the latest attempt at reviewing the state of the environment in Asia. All of the above reviews cover the marine environment and deal with problems arising from land-based sources of pollution.

More directly concerned with the marine environment in the East Asian region is the report commissioned by ESCAP giving a review of the marine environmental problems and issues for the region

(ESCAP, 1985). The UNEP study undertaken by Koe and Aziz (1995) is focused directly on land-based sources of pollution affecting coastal and marine areas in the East Asian Seas. Mention too must be made of an early attempt at a review of marine coastal environment pollution in the ASEAN region undertaken by Ruddle (1981) while, more recently, Chua (1995) concisely reviewed the problem of marine pollution in the Southeast Asian sub-region. The present review is linked to the latest study commissioned by UNEP - the Transboundary Diagnostic Analysis covering seven countries in the South China Sea area (Talaue-McManus, 1999). There is thus an accumulation of considerable information on the pollution of the marine environment of the East Asian region. Albeit, there remain many information gaps that require additional monitoring and assessment.

The evidence gathered shows that, thus far, there has been serious degradation of the environment including the marine and related freshwater environment and points to an urgent need to strengthen environmental management. The national reports of seven participating countries in the TDA of the South China Sea area together with the additional three countries reviewed in this study give ample detail of the various sources of land-based pollution and the level of pollution in various parts of the countries concerned. The reports also indicate hot spots, high risk and sensitive areas for most of the ten countries covered.

It can be stated here that there are examples of successes in the East Asian region as in the cases of South Korea and Singapore. The World Bank selected several East Asian countries including Korea and Singapore for a study on management of industrial pollution of the Newly Industrialising Economies to draw lessons from their experience (see Loh *et al.* (1995) on Singapore). The country's experience in evolving a package of sound environmental management policies and management practices are reported by Chia (1979b), and Chia and Chionh (1989). In the case of Malaysia, Ong (1987) and Hamzah (1989) provide useful reviews of the country's marine environment. Malaysia has paid special atten-

tion to prevent marine pollution of the Malacca Straits aimed primarily at ship-source pollution (see, for example, Dow, 1997) but is also concerned with the problem of land-based sources of pollution. Indeed, there were early efforts made on the part of the Philippines to manage the country's already deteriorating environment in the 1970s (Lesaca, 1979).

## 7.1 ISSUES AND PROBLEMS

The identification of regional concerns and principal issues formed part of the preparation of the regional transboundary diagnostic analysis. The issues and concerns were deliberated upon and accepted by the national research teams before proceeding with the preparation of the national reports and overview TDA. The degradation of marine habitat emerged as an area of major concern within the South China Sea area (Table 9). Mangroves and coral reef degradation ranks as 1 and 2 among principal issues while pollution by sewage of the marine environment ranks as number 3 among principal issues.

Table 10 summarises the sources of pollution among the participating countries in the South China Sea, the quality of the data base, and the perceived contribution of these sources to the state of aquatic environments in each country. Wastes from domestic, agricultural, and industrial sources, along with sediments and solid wastes are the major sources of pollutants that impinge on both freshwater and coastal systems in the seven countries. Land-based sources play a major role in both inland and coastal pollution. Ship-based sources contribute relatively small amounts, but may have severe local impacts when large amounts of oil is released in oil spill accidents. Atmospheric inputs, that can be considered a source of land-based pollution, feature lowly in the ranking of issues. However, this may be due to a very poor data base and because their impacts are harder to establish given the nature of atmospheric chemistry and the larger scales needed to carry out appropriate studies of air sheds. Atmospheric pollutants are well capable of being transported across national boundaries while transboundary movements of marine pollution can also occur in certain circumstances.

Table 9. Ranking of Major Concerns and Principal Issues for the South China Sea Countries

| Major Concerns      | Score | Rank | Principal Issues         | Score | Rank |
|---------------------|-------|------|--------------------------|-------|------|
| Habitat             | 18.5  | 1    | Mangroves                | 21    | 1    |
|                     |       |      | Coral reef               | 20    | 2    |
|                     |       |      | Seagrass                 | 17    | 6    |
|                     |       |      | Estuaries                | 16    | 7    |
| Over-exploitation   | 17.5  | 2    | Marine                   | 19    | 3    |
|                     |       |      | Freshwater               | 16    | 7    |
| Pollution           | 14    | 3    | Sewage                   | 19    | 3    |
|                     |       |      | Freshwater Contamination | 17.5  | 5    |
|                     |       |      | Agricultural loading     | 15    | 9    |
|                     |       |      | Industrial waste         | 15    | 9    |
|                     |       |      | Sedimentation            | 14    | 11   |
|                     |       |      | Solid waste              | 13    | 12   |
|                     |       |      | Hydrocarbon              | 12    | 13   |
|                     |       |      | Ship-based sources       | 12    | 13   |
| Atmospheric         | 8.5   | 16   |                          |       |      |
| Freshwater concerns | 9     | 15   |                          |       |      |

Source: Annex V, Second Coordinators Meeting, June 1998, quoted in Talaue-McManus (1999)

Table 10. Ranked Sources of Pollution in South China Sea Countries<sup>1</sup>

| Source             | Rank & Data base | Contribution to pollution of national aquatic environments (L=Low, M= Moderate, H= High) |       |       |     |      |      |      |
|--------------------|------------------|--|-------|-------|-----|------|------|------|
|                    |                  | Cam  | China | Indon | Mal | Phil | Thai | Viet |
| Domestic waste     | 1-Fair           | H  | H     | H     | M   | H    | H    | H    |
| Agricultural waste | 2-Poor           | M  | H     | H     | M   | H    | H    | H    |
| Industrial waste   | 2-Poor           | M  | H     | H     | H   | H    | H    | H    |
| Sediments          | 3-Poor           | M  | H     | H     | M   | H    | H    | H    |
| Solid waste        | 4-Fair           | H  | H     | H     | M   | H    | H    | H    |
| Ship-based sources | 6-Poor           | M  | M     | M     | M   | M    | M    | M    |
| Atmospheric        | 7-Poor           | M  | M     | M     | M   | M    | M    | M    |

<sup>1</sup> Ranking of pollution sources was done during the Second Meeting of National Co-ordinators (June 1998) quoted in Talaue-McManus (1999).

7.

Bi  
se  
Ta  
da  
ble  
tur  
Se  
tor  
tio  
Ch  
ge

Tal  
Co

C

Ci

In

M

Ph

Th

Vi

TC

\* Onl  
using  
\* Tote  
\* Ave  
meth  
\* Esti  
\* Koe

## 7.2 DOMESTIC WASTEWATER

Biological Oxygen Demand (BOD) levels of the seven South China Sea countries are shown in the Table 11 and its distribution in Figure 6. Based on the data provided in the national TDA reports, it is possible to generate a set of data to give a regional picture for watersheds that interact with the South China Sea basin. The table shows that an estimated 6 mil. tonnes of BOD are generated by the coastal population of the seven participating countries of the South China Sea alone. Only about 11 per cent of the BOD generated is removed by sewage treatment in four

countries. Assuming the same population growth rates prevail up to 2005, the generated BOD will increase to 6.6 mil. tonnes. There is clearly a need to raise the volume removed by sewage treatment especially in coastal waters that receive the pollutants from large urban centres.

Reduced assimilative capacity of the marine environment is indicated by the incidence of both toxic and non-toxic algal blooms that are being reported more frequently in the region. This has caused serious public concern, especially the dinoflagellate *Pyrodinium* as there have been reports of cases of

Table 11. Population and Estimated BOD Generation and Removal in Selected South China Sea Countries

| Country <sup>a</sup> | Population <sup>b</sup><br>( <sup>000 persons)</sup> | Proportion<br>of<br>population<br>in cities (%) | Population<br>growth rate<br>(%) <sup>c</sup> | BOD<br>generated<br>(10 <sup>3</sup> t/yr) <sup>d</sup> | BOD<br>removed by<br>sewage<br>treatment <sup>e</sup><br>(10 <sup>3</sup> t/yr) |
|----------------------|--|---|---|---|---|
| Cambodia             | 1,985  | 89  | 2.7   | 36.2  | No treatment  |
| China                | 59,694   | 35  | 1.6   | 1,089.4   | <109  |
| Indonesia            | 105,217  | 48  | 2.9   | 1,920.2   | 364   |
| Malaysia             | 10,336   | 15  | 3.3   | 188.6   | 53  |
| Philippines          | 23,633   | 27  | 2.1   | 431.3   | 149   |
| Thailand             | 37,142   | 0   | 1.4   | 677.8   | 89  |
| Viet Nam             | 75,124   | 3   | 1.6   | 1,371.0   | No treatment  |
| <b>TOTAL</b>         | <b>313,131</b>                                       | <b>&gt;27</b>                                   | <b>1.4</b>                                    | <b>5,714.5</b>  | <b>655</b>  |

<sup>a</sup> Only populations of subdivisions interacting with the South China Sea were included, and were recalculated to 1996 using growth rates in column 3.

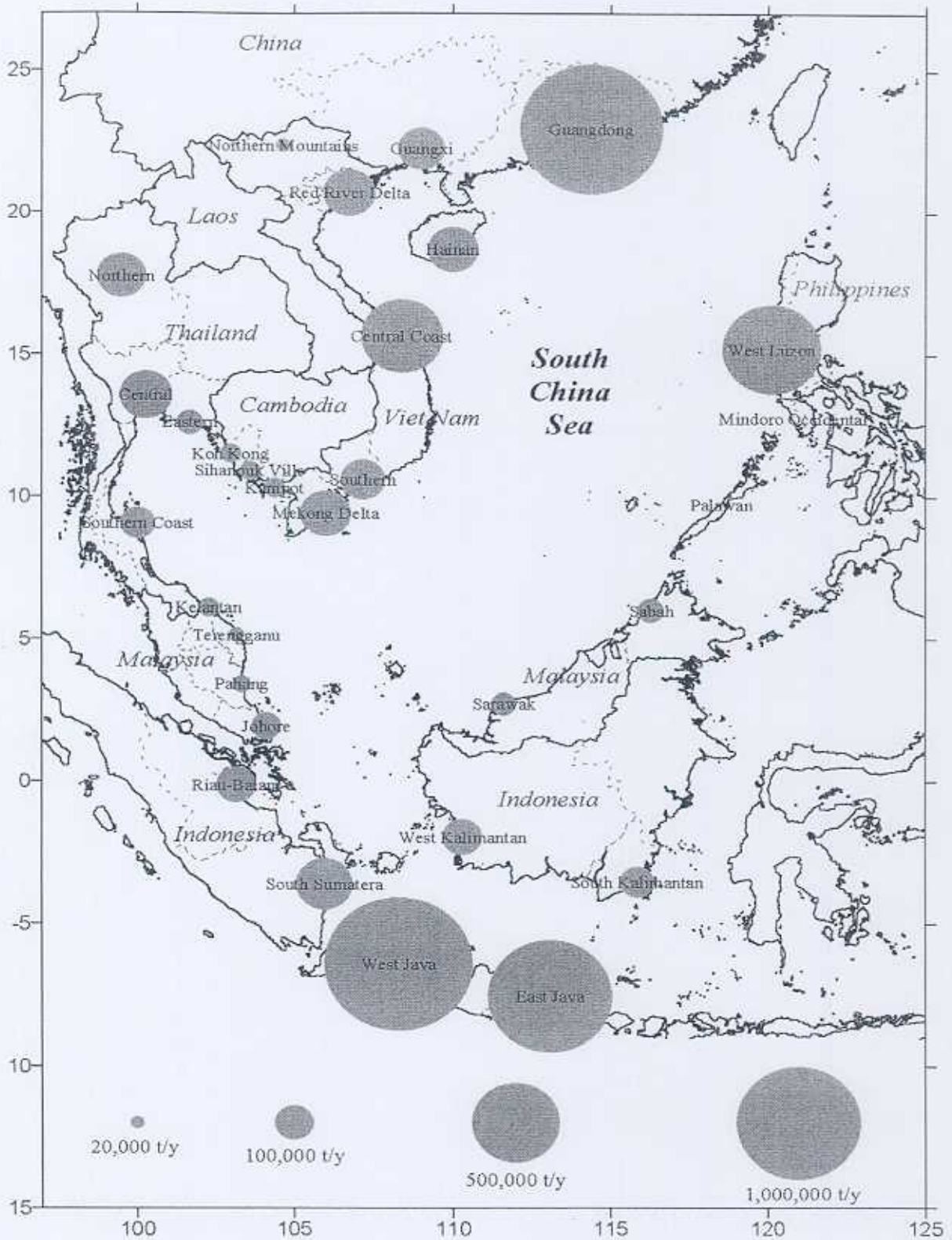
<sup>b</sup> Total population for all South China Sea subdivisions in a country was obtained.

<sup>c</sup> Average population growth rate for all South China Sea subdivisions in a country was obtained using a weighted mean method.

<sup>d</sup> Estimated BOD production using 0.05 kg/person/day (WHO, 1993).

<sup>e</sup> Koe and Aziz (1995).

Figure 6. Biochemical Oxygen Demand (BOD) Loading from Domestic Sources in East Asian Seas



death by paralytic shellfish poisoning following consumption of contaminated mussels in the Philippines, Sarawak and Sabah (Gomez, 1990 quoted in Chua, 1995; see also Guerrero, et al. 1995). In Jakarta Bay, phytoplankton biomass distribution has undergone significant shifts; plankton blooms are now spreading further offshore. In 1988 blooms spread 5 km offshore from Tanjung Priok, the main harbour, by 1990 they had spread 12 km offshore. In Korea, nine red tide incidents have been reported in bays used for aquaculture (see Maclean, 1989).

In view of the large concentration of population in cities, it will be most strategic to focus attention on the establishment of sewage treatment, and more generally on sanitation facilities, in the megacities of the littoral states within the region. Within the seven South China Sea countries, there are 46 cities with populations over 100,000 with two (Bangkok and Chiang Mai) in Thailand. At least 30 per cent of the total population live in these crowded areas, so that waters receiving domestic waste from these cities are themselves pollution hot spots.

### 7.3 AGRICULTURAL WASTE

Wastes generated by agriculture and aquaculture enter water bodies in a diffuse mode. They make up the second most important group of pollutants in the marine environment (Koe and Aziz, 1995). The pollutants contained in agricultural waste are primarily fertilisers and pesticides (fungicides, herbicides and insecticides). Land clearance for agriculture, whether large-scale commercial plantations, or small-scale subsistence farmers, can lead to large quantities of silt entering stream channels and contribute to sediments in river discharge into the marine environment. Data on pesticide use are scarce, and detecting its presence in aquatic environments and removing it require expensive methods that most governments can ill afford. Over time, high nutrient contents in the marine and related freshwater environments can result in the loss of biodiversity and productivity in these systems.

The total loading of nitrogen in the South China Sea area is shown in Figure 7. Over the seven South China Sea countries, China uses the most fertiliser at 1,000 kg/ha/yr and Cambodia, the least at 22 kg/ha/yr (Table 12). China reports more than 89,000 tonnes used

Table 12. Use of Fertilisers and Pesticides in South China Sea Countries

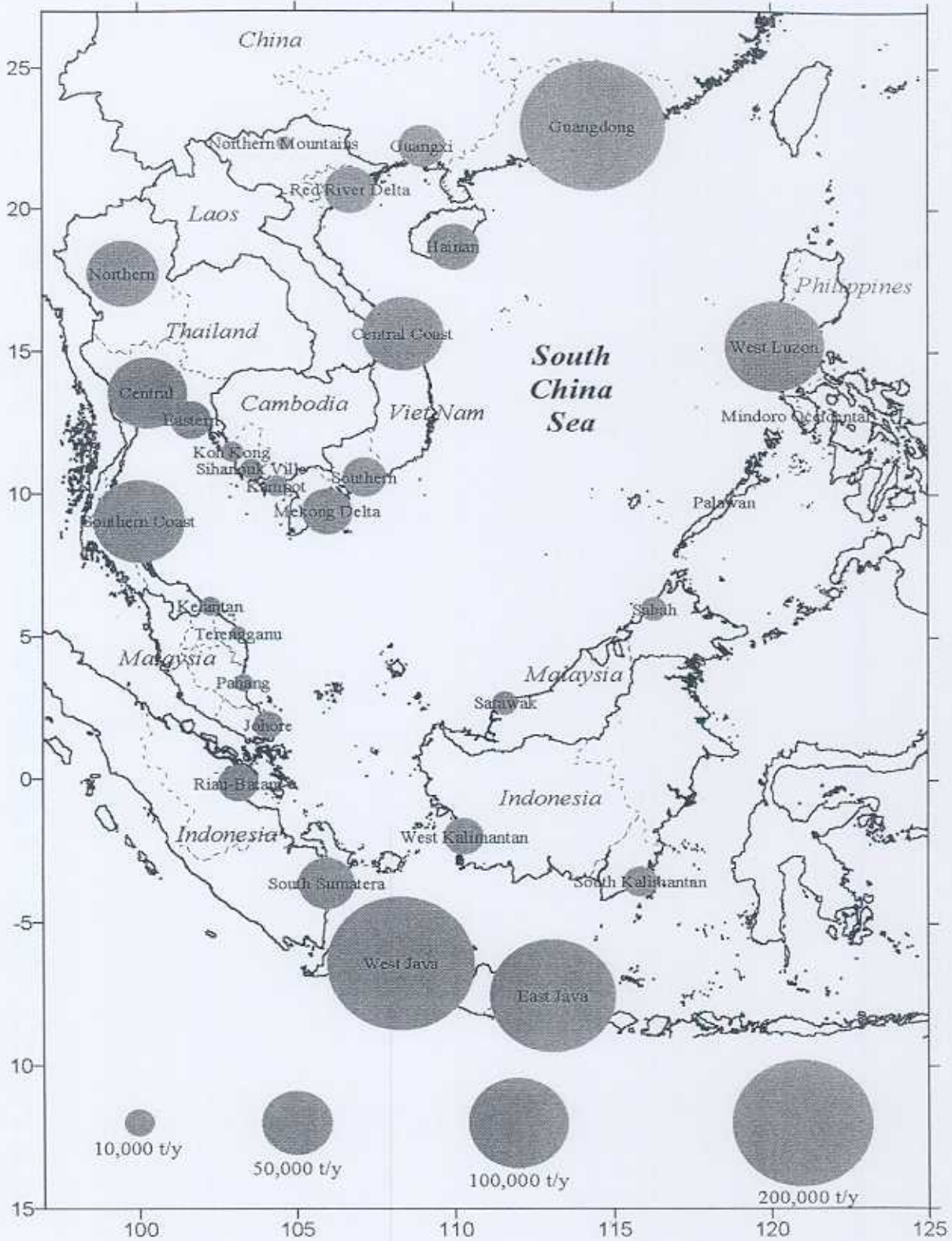
| Country <sup>a</sup> | Padi field area<br>(10 <sup>3</sup> ha) | Aquaculture<br>area (10 <sup>3</sup> ha) | Fertiliser use<br>(t/yr) | Pesticide use<br>(t/yr) |
|----------------------|---|--|--------------------------|-------------------------|
| Cambodia             | 1,800                                   | n.d.                                     | >40,000                  | n.d.                    |
| China                | 3,400                                   | 2,500                                    | 3,640,000                | >89,000                 |
| Indonesia            | 5,000                                   | 200                                      | >5,600,000               | 29,000                  |
| Malaysia             | n.d.                                    | <100                                     | n.d.                     | n.d.                    |
| Philippines          | 1,200                                   | <100                                     | 181,000                  | n.d.                    |
| Thailand             | 8,600                                   | n.d.                                     | n.d.                     | n.d.                    |
| Viet Nam             | 1,500                                   | n.d.                                     | 110,000                  | n.d.                    |

<sup>a</sup> Coastal areas as defined in the TDA study.

Source: National reports of TDA summarised by Talaue-McManus (1999).



Figure 7. Total Nitrogen Loading in East Asian Seas Countries



in its South China Sea areas in 1995. Indonesia used about 29,000 tonnes annually during the period 1992-1996. Fertilisers when leached to aquatic environments contribute to nutrient loading in addition to that generated by domestic sources. In the past, the sale of pesticides was motivated by the desire to enhance crop production by eliminating undesirable organisms in the culture system. There is a need to encourage farmers to employ environmentally friendly farm practices that minimise the use of fertilisers and biocides, and to enhance soil retention of fertilisers.

#### 7.4 INDUSTRIAL WASTE

Considering the incomplete data base, industries release a minimum of about 430,000 tonnes of BOD into aquatic systems interacting with the South China Sea (Table 13). Eighty per cent of the reported value comes from Thailand, of which half of the total is conveyed by the river systems of Chao Phraya, Ta Chin, Mae Klong, and Bang Pakong.

Data provided in the national reports on heavy metals are incomplete. Viet Nam, whose major rivers are all transboundary, reports an annual load of at least 96,560 t/yr, 96 times more than Japan disposed of in 1988 (Table 14). Around 80 per cent of this load

come from the Dong Nai-Saigon River. In contrast, China reports the release of only 25 t/yr. Metal specific data should bear out whether limits have already been exceeded. Viet Nam indicates in its national report that in the Northern Economic Zone, the amounts of Pb, Zn, and Cu are 7-10 times the allowable limits.

Aside from pesticides and heavy metals, hazardous and toxic pollutants include paint and colour agents, organic solvents, and other by-products of industrial manufacturing or processing. Hazardous wastes are products having one or more of the following features: explosive, inflammable, reactive, disease-causing, corrosive, and/or toxic (Hernandez (1993) estimated production rates of hazardous waste for a number of South China Sea countries (Table 14). The data in this table are estimates derived from various sources, with some for 1992 and others pertaining to the late 1980s. As the same definition of hazardous waste has not been used in all cases, the information is not comparable between countries and should be used only as a crude estimate. There is a need to monitor the production and disposal of hazardous waste and strategically to control these wastes at the source by advocating the use of clean technology.

Table 13. Estimated Industrial Waste Discharge from Coastal and Non-coastal Installation

| Country     | BOD<br>(t/y) | N<br>(t/y) | P<br>(t/y) | Heavy Metals<br>(t/y) | Suspended solids<br>(t/y) |
|-------------|--------------|------------|------------|-----------------------|---------------------------|
| Cambodia    | n.d.         | n.d.       | n.d.       | n.d.                  | n.d.                      |
| China       | 10,300       | 370        | 17         | 25.4                  | 17,300                    |
| Indonesia   | 26,000       | n.d.       | n.d.       | n.d.                  | n.d.                      |
| Malaysia    | 430          | >1,000     | n.d.       | n.d.                  | 1,400                     |
| Philippines | >49,000      | n.d.       | n.d.       | n.d.                  | n.d.                      |
| Thailand    | >340,000     | >400       | n.d.       | n.d.                  | n.d.                      |
| Viet Nam    | >4,500       | n.d.       | 96,560     | >13,000               |                           |

Table 14. Estimated Disposal of Toxic Substances in Selected East Asian Countries

| Country            | Estimated production of hazardous waste (10 <sup>6</sup> t/yr) | Toxic to humans (10 <sup>6</sup> t/yr) | Toxic to aquatic organisms (10 <sup>6</sup> t/yr) | Toxic levels of heavy metals (10 <sup>6</sup> t/yr) |
|--------------------|--|--|---|---|
| Japan (1988)       | 0.82   | 13,715                                 | 15,877  | 1,034   |
| China (1987)       | 50   | 3,226                                  | 4,098   | 155   |
| Indonesia (1986)   | 5  | 195                                    | 247   | 7   |
| Malaysia (1987)    | 0.4  | 181                                    | 217   | 9   |
| Philippines (1987) | 0.08-0.15  | 118                                    | 143   | 7   |
| Thailand (1986)    | 0.88   | 137                                    | 167   | 6   |

Source: ESCAP/ADB (1995) and Hernandez (1993).

## 7.5 SEDIMENTATION

Sediments are a major pollutant in rivers and coastal waters. In aquatic systems, total suspended solids include sediments brought about by soil erosion as a result of mining; removal of forest to open up land for agriculture, road construction, and urban expansion; coastal development that involves land reclamation; and natural processes. Removal of forest cover in tropical areas exposes the soil surface to intense rainfall and causes rapid soil erosion. In marine environments, they have immediate observable impacts including the smothering of coral reefs, and burial of macrophytes such as seagrass. However, very little quantitative data is available in terms of actual sediment loads in the region's aquatic systems, and little information is given in the national reports.

Data from Table 15 can be used as a basis for estimating the extent of sedimentation as a function of land clearance. Indonesia topped the list at a clearance rate of over 32,000 sq km of forest per year in order to produce 158 million cu m of roundwood. Thailand came second in the region with a rate of almost 12,000 sq km/yr from 1981 to 1989 to produce 37 million cu m of roundwood. If the slope of the cleared area is given, an index of erosion can be

made to estimate the amount of sediments that are moved. Given the data above, sediment loads from cleared land in Indonesia would have contributed the most sediment, followed by Thailand, Malaysia and the Philippines.

For most Southeast Asian countries under consideration, the extraction of timber has become a major economic activity. This leads to rapidly disappearing forest cover. Over the last several decades many countries in the region have granted major logging concessions. This was the case for the Philippines in the 1950s, Peninsular Malaysia and Sabah in the 1960s, Indonesia in the 1970s, followed by Sarawak and Papua New Guinea in the late 1970s (Collins *et al.* 1991, quoted in Greer and Perry, forthcoming). In the 1990s decade, timber extraction has moved on to newer, non-traditional areas. For example, in Cambodia, log production increased from 600,000 m<sup>3</sup> in 1991 to around 4 million m<sup>3</sup> in 1997 (ITTO, 1998 quoted in Greer and Perry, forthcoming). Some countries have run out of commercially exploitable forests and in the case of Thailand and the Philippines, they have become net importers of timber. Loss of forest cover due to logging, which even if properly managed, will mean increased soil erosion and heavier discharge of silt into river channels and eventually

Table 15. Forested Area, Land Clearance and Reforestation in Selected Countries

| Country     | Land area<br>(10 <sup>3</sup> km <sup>2</sup> ) | Forest area<br>(% of land area) |      |      | Clearance rate with<br>reforestation<br>(km <sup>2</sup> /y) | Annual<br>roundwood<br>production<br>(10 <sup>3</sup> m <sup>3</sup> ) | Annual<br>average<br>reforestation<br>(km <sup>2</sup> ) |
|-------------|---|---------------------------------|------|------|--|--|--|
|             |   | 1981                            | 1986 | 1989 |  |  |  |
|             | 1989  |                                 |      |      |  | 1985-87  | 1980's   |
| US          | 9,167   | 31.0                            | 28.9 | 28.3 | 13,189   | 485,760  | 17,750   |
| Germany     | 244   | 30.0                            | 30.0 | 29.5 | No clearance   | 31,583   | 620  |
| Australia   | 7,618   | 13.9                            | 13.9 | 13.5 | 3,189  | 19,907   | 620  |
| UK          | 242   | n.d.                            | 9.0  | 5.7  | 2,181  | 5,082  | 400  |
| France      | 550   | n.d.                            | 26.6 | 26.6 | No clearance   | 39,890   | 510  |
| Malaysia    | 329   | 66.0                            | 60.0 | 57.8 | 3,122  | 32,000   | 250  |
| Indonesia   | 1,812   | 75.0                            | 72.5 | 60.0 | 32,335   | 158,075  | 1,640  |
| Philippines | 298   | 31.0                            | 24.5 | 21.5 | 2,516  | 35,822   | 630  |
| Thailand    | 511   | 47.0                            | 35.0 | 28.0 | 11,826   | 36,900   | 310  |

Source: Indonesia national TDA Report (1999).

into the marine environment. There have been reports of widespread illegal logging that inevitably mean total disregard to minimisation of soil loss and damage to the remaining smaller trees. This applies in the cases of Cambodia and Thailand.

Mining activities and coastal reclamation projects both lead to serious sedimentation of the receiving waters and seabed. Both activities produce a large amount of sediment that is transported by rivers. In the case of mining, large quantities of silt are discharged directly into coastal waters. The Baguio Mining district, during its peak operations in the 1980's, produced at least 11 mil. tonnes of tailings each year that were conveyed by two river systems draining into the Lingayen Gulf (Maaliw, 1990).

Within the East Asian region, sand mining is an activity that has been carried out traditionally in many locations where there are coastal sand deposits. Sharifah (1995) reports that there is an estimated 100 mil. cu. m of sand deposits in the southern and eastern coast of Johor State in Peninsular Malaysia. An addition 9 mil. cu m is available in river mouths in

the State. Revenue collected by the State government from royalties range from RM 0.70/cu m for marine sand to RM1.20/cu m for river sand. Annual production is 3-4 mil. cu m yielding royalties totalling RM 5-6 mil. annually in recent years. The material is used for construction purposes and as landfill for coastal reclamation. A considerable amount of sand and aggregates is traded within the region. Singapore, for example, imports both sand and fill material from neighbouring countries. The latter is dredged from the shallow waters in the Riau area. The activity is therefore an important economic activity but entails considerable damage to the coastal environment and the seabed.

Dredging to deepen navigation channels can also result in massive amounts of sediments released into the surrounding aquatic environments. In the Mahakam River Delta, around 2 million cu m of sediments were dredged to maintain navigation channels, which presumably were silted by erosion caused by massive logging in the interior of Kalimantan (Hinrichsen, 1998). Dredging is practised regularly

as part of seaport operations. Ports located at or near river mouths are subjected to heavy silting and require constant dredging to keep channels open to large cargo ships.

In the case of land-scarce Singapore, land reclamation provides much needed additional space for commercial, industrial, residential, and recreational uses. Reclamation has been carried out on a large-scale basis from 1962. By 1991, Singapore had reclaimed 5,400 ha or about one-tenth of its original land area (affecting most of the offshore islands and coastal areas of the Republic). It is envisaged that eventually a total of about 25 per cent of reclaimed land would be added to the island country (Tan, 1999, see also Chia, 1992: 31-35). The experience of Singapore is not exceptional as major land reclamation schemes have also been carried out in other coastal cities in the East Asian countries. Malaysia has plans to reclaim a large portion of the West Coast of Peninsular Malaysia. Major cities of Hong Kong, Manila, Jakarta, Surabaya, and smaller ones such as Johor Bahru in Malaysia, Batangas in the Philippines, Kota Kinabalu in Sabah, Batam island in the Riau Province of Indonesia, Vung Tau near Ho Chi Minh City in Viet Nam, and others have undertaken large-scale land reclamation to make available land for seaport development, industrial parks, commercial and residential development.

The responses of marine life to reduced light intensities in turbid coastal waters are variable. Under natural processes of erosion, silt load is trapped by mangrove roots in estuarine waters, and then bound by the rhizomes of seagrass, as they approach the coral reefs. During massive sediment loads, these natural sediment filters break down. For filter feeders such as coral polyps, suffocation leads to death as particle removal through tentacular movement is greatly restrained under high silt load. For seagrass, a reduction in light regimes leads to their demise, and reduced productivity of plants that can normally deal with relatively higher concentrations of silt and high nutrient regimes of coastal waters. Thus, there is a loss both of biodiversity and productivity of benthic macroflora. The high amount of nutrients associated

sometimes with high sediment loads sustains high production. Thus, algal blooms very often are initiated in coastal areas, specifically in bays and sheltered water bodies.

Many of the anthropogenic factors that result in siltation and sedimentation are unavoidable and are carried out for essential purposes. However, there should be strong efforts made to reduce the impacts of these anthropogenic activities that increase soil loss and erosion. The measures that can be adopted to minimise sediment loads into coastal waters are simple and not unduly expensive. Greater efforts to closely monitor mining and agricultural activities and to enforce regulations are needed. With population growth and industrialisation, there will inevitably be increased pressure to provide cleared land for wide ranges of construction and infrastructure development in support of industries, as well as for agriculture to increase food production. These are clearly political decisions but must be made with minimal negative consequences to the natural resources based on land and in the sea.

## 7.6 SOLID WASTE

Solid waste is generated by domestic and industrial activities. The national TDA reports do not give data on solid waste production coming from industries. Table 16 compares estimates of reported solid waste generated by domestic activities and those estimated using a value of 0.6 kg/person/day. The discrepancies could be in the conversion factor used, as well as in the population estimates. Koe and Aziz (1995: 15-16) give estimates of daily per capita generation of solid waste to range from 0.4 kg in Indonesia to 2.0 kg in Singapore, the amount increasing with the level of income (Table 17). Using the proportion of solid waste disposal at authorised sites in 1989, the amount disposed in non-authorised locations including rivers and coastal waters would be at least 68 per cent of domestic solid waste production for the entire region.

When solid waste reaches aquatic systems, it reduces the aesthetic value of beach and underwater scen-

**Table 16. Solid Waste from Domestic Sources in Selected South China Sea Countries and Sub-regional Areas**

| Country <sup>a</sup> | Solid waste production (10 <sup>3</sup> t/yr) <sup>b</sup> | Reported volume ('000 t/yr) | Percent disposal at authorised disposal sites (1989) <sup>1</sup> |
|----------------------|--|-----------------------------|---|
| Cambodia             | 435  | 560                         | n.d.  |
| China                | 13,073   | n.d.                        | n.d.  |
| Indonesia            | 23,042   | 22,899                      | 60  |
| Malaysia             | 2,264  | 1,924                       | 65  |
| Philippines          | 5,176  | 1,330                       | 70  |
| Thailand             | 6,134  | 482                         | 40  |
| Viet Nam             | 16,452   | n.d.                        | n.d.  |
| <b>Total</b>         | <b>66,576</b>  | <b>--</b>                   | <b>--</b>   |

<sup>a</sup>Coastal areas as defined in TDA report (Talaue-McManus, 1999).

<sup>b</sup> Estimated on the basis of 0.6 kg of sold waste per person per day.

Source: Koe and Aziz (1995).

**Table 17. Components of Solid Waste in Selected East Asian Countries (in percent)**

| Country     | Paper | Glass | Metals | Plastics | Organics | Others |
|-------------|-------|-------|--------|----------|----------|--------|
| Indonesia   | 2     | 1     | 4      | 3        | 87       | 3      |
| Malaysia    | 25    | 3     | 6      | 8        | 56       | 2      |
| Philippines | 10    | 2     | 3      | 9        | 70       | 6      |
| Singapore   | 28    | 4     | 5      | 12       | 44       | 7      |
| Thailand    | 19    | 6     | 4      | 10       | 55       | 6      |

Source: Koe and Aziz (1995).

ery for coastal tourism. Although the largest proportion of solid waste from domestic sources comprises organics (putrescible), decomposition rates of solid waste are low. A significant proportion of the material, such as plastics, metals and glass, is not readily biodegradable. Solid waste collection and appropriate disposal pose a major problem in cities and densely populated coastal and riverine areas. Landfills, when not properly maintained, can produce toxic leachates that can seep into groundwater, or aggregate haz-

ardous materials that can impair public safety. In Metro Manila, some landfills have become methanogenic (hence the name Smoky Mountain for a landfill located in a suburb of Metro Manila in Navotas) causing severe respiratory illnesses among residents in surrounding areas.

## 7.7 OIL AND OTHER HYDROCARBONS

There is scant information on land-based sources of oil released into the marine environment from the national TDA reports. China and Malaysia gave 187 t/yr and 0.52 t/yr of oil released from industrial sources into the marine environment, respectively, while Viet Nam reported 2,132 t/yr of oil released from domestic sources (Talaue-McManus 1999)<sup>6</sup>. The values given for China and Malaysia are far too low to be credible and probably reflect land-based oil-spills. Most oil entering the marine environment comes from urban runoff and disposal of used oil into drains. Table 18 gives world-wide estimates (GESAMP, 1993) for the ocean. The figures show far higher values for municipal and industrial sources and account for

50 per cent of the total amount of oil released into the marine environment globally.

The contribution of various land-based sources of oil released into the marine environment depends on factors such as population density, level of industrialisation, vehicular population, production of energy generated by oil-fired plants of littoral countries. Among the East Asian Sea countries, for the period 1993 to 2005, the demand for oil is predicted to increase at between 4.8 and 6.5 per cent average annually and by 3.6 per cent for the Asia-Pacific region as a whole (Table 19). Actual growth rates for the years 2000 and 2005 would be lower than estimated values due to the financial crisis that has badly affected countries in the East Asian region.

**Table 18. World-wide Inputs of Oil into the Marine Environment from Various Sources**

| Source                           | Inputs ('000 t/yr) | Percent Contribution (%) |
|----------------------------------|--------------------|--------------------------|
| Municipal and industrial sources | 1,175              | 50                       |
| Marine transportation            | 564                | 24                       |
| Atmosphere                       | 305                | 13                       |
| Natural sources                  | 258                | 11                       |
| Offshore production              | 47                 | 2                        |

Source: GESAMP (1993).

**Table 19. Oil Demand by Selected Countries in the East Asia Region (in 10<sup>3</sup> barrels/day)**

| Country      | 1993   | 2000   | 2005   | Av. annual growth 1993-2005 (%) |
|--------------|--------|--------|--------|---------------------------------|
| China        | 2,743  | 4,031  | 5,001  | 5.1                             |
| Indonesia    | 756    | 1,170  | 1,556  | 6.2                             |
| Malaysia     | 290    | 414    | 522    | 5.0                             |
| Thailand     | 517    | 839    | 1,096  | 6.5                             |
| Philippines  | 253    | 367    | 466    | 5.2                             |
| South Korea  | 1,552  | 2,217  | 2,740  | 4.8                             |
| Asia-Pacific | 14,197 | 18,469 | 21,630 | 3.6                             |

Source: GEF/UNDP/IMO (1997).

GESAMP (1993) summarises the effects of oil on a number of marine organisms. High concentrations of oil in critical areas, including spawning and recruitment grounds, have an impact on the viability of populations including reducing the number of potentially reproducing adults. Mangroves found in sheltered waters when affected by oil spills become very susceptible to stress. They are inevitably badly degraded in areas close to urban areas and around sea-ports. They suffer from clogging of their aerial roots or pneumatophores. As a consequence, they become partially or fully defoliated, and may take as long as 20 years to recover.

In the case of corals, species accommodate oil contamination along a gradient of tolerance and the associated biota of coral reefs is impacted adversely, especially the young life stages of crustaceans and echinoderms. The water-soluble fractions of oil are the most lethal components. Tainting of food species has yet to be established. It is evident that oil interferes with lipid metabolism but the components of oil residuals and the substances that bind on organisms are unknown, much less their potential impacts on man. While healthy reefs will recover with time, it is found that multiple stressors, both natural and human induced, can have a cumulative effect on reef ecosystems. Human-damaged reefs appear to be more vulnerable to some types of natural disturbances and take longer to recover (Brown, 1997 quoted in Bryant *et al.* 1998: 15).

## 7.8 ATMOSPHERIC SOURCES

Emissions from power generation, industries and transportation contribute greatly to the release of airborne pollution; a significant proportion of it will enter the marine environment. A major contributor is the power sector. Fuel used for power generation includes fuel and diesel oil, coal and natural gas. Oil and coal are the most common fuels used in East Asian Seas countries. The most pollutive of all fuels is coal in increasing intensity as its quality decreases. Most countries opt to use low-grade coal to produce cheaper energy, but the environmental impacts and effects on human health are more severe. Table 20 gives the amount of oil and coal consumed, number of motor vehicles, and areas affected by forest fires for several East Asian countries.

In urban areas, transportation is responsible for the release of most air pollutants. The number of vehicles will most likely increase to meet the transportation demands of a growing population. Considering only South China Sea-related sub-regions, Thailand has the most number of vehicles, followed by Indonesia, Malaysia and the Philippines (Table 20). China and Viet Nam, with their increasing involvement in free trade, are likely to experience fast growth of the motor vehicular population. In Jakarta, transportation accounts for 100% of lead, 42% of suspended particulate matter, 89% of hydrocarbons, 64% of nitrous oxides and 100% of carbon monoxide. The pro-

Table 20. Atmospheric Pollution Sources in Selected East Asian Countries

| Country                 | Oil consumption<br>(10 <sup>3</sup> t/y) | Coal consumption<br>(10 <sup>3</sup> t/y) | No. of vehicles<br>(thousands) | Forest fire<br>damaged area<br>(ha) |
|-------------------------|--|---|--------------------------------|-------------------------------------|
| China                   | 13,094                                   | 62,641                                    | 2,260                          | n.d.                                |
| Indonesia<br>(National) | n.d.<br>33,580                           | n.d.<br>n.d.                              | 8,951<br>14,886                | 263,992 (1997)                      |
| Malaysia                | n.d.                                     | n.d.                                      | 2,725                          | n.d.                                |
| Philippines             | 10.25x10 <sup>6</sup><br>barrels         | 118.05x10 <sup>6</sup><br>barrels         | 2,062                          | 2,851 ha (1997)                     |
| Thailand                | --                                       | --  | 11,050                         | --                                  |

Source: National TDA reports (Talaue-McManus, 1999).



**Table 21. Composition of Precipitation in Indonesia and Thailand**

|                                      | Rainfall<br>(mm) | Area (km <sup>2</sup> ) | SO <sub>4</sub><br>(t/y) | H <sup>+</sup><br>(moles/yr) | NH <sub>4</sub> |
|--------------------------------------|------------------|-------------------------|--------------------------|------------------------------|-----------------|
| Riau-Batam                           | 1,719            | 94,561                  | 185,729                  | 307,022                      | 172,493         |
| Bangka-Belitung<br>and South Sumatra | 1,868            | 103,688                 | 132,322                  | 313,350                      | 141,605         |
| West Java                            | 858              | 46,890                  | 155,195                  | 139,489                      | 6,486           |
| East Java                            | 941              | 47,921                  | 251,294                  | 165,861                      | 25,096          |
| S. Kalimantan                        | 1,644            | 37,660                  | 196,096                  | 313,823                      | 41,256          |
| W. Kalimantan                        | 2,550            | 146,760                 | 278,103                  | 437,593                      | 91,303          |
| Indonesia                            |                  |                         | 1,198,739                | 1,677,138                    | 478,239         |
| Central                              | 1,304            | 64,044                  | 67,802                   | 42,919                       | 4,927           |
| Eastern                              | 2,142            | 36,502                  | 286,681                  | 146,781                      | 21,740          |
| Thailand                             | -                | -                       | 354,483                  | 189,700                      | 26,667          |

Source: National TDA reports of Indonesia and Thailand (Talaue-McManus, 1999).

file may not be very different for other cities in East Asian countries.

Sulphur and nitrous oxides have serious impacts on the human respiratory system. When hydrated by precipitation, these ions form acid rain, a phenomenon that has been shown to considerably alter aquatic and terrestrial systems in the Northern Hemisphere. The long-range transport of atmospheric pollutants is of transboundary and global concern. Indonesian coastal provinces interacting with the South China Sea are rained on with 1.2 million t/yr of sulphate. In Thailand, about 350,000 tonnes of sulphate goes back to the watershed annually (Table 21). Globally, it is estimated that 13 per cent of the atmospheric pollution enters the marine environment (Table 21).

One other major source of airborne pollution that enters the marine environment are forest fires that are deliberately or inadvertently set off by human activities to clear land for agriculture. It appears that individual or slash and burn cultivators are not the main culprits. Large commercial enterprises clearing land for plantations are responsible for the worst fires in Indonesian Kalimantan and southern Sumatra

in 1997 that lasted several months. The air pollution levels were much higher than previous episodes of forest fires and, in this case, destroyed an estimated 20,000 sq. km of forested land. Clearing land by fire is undertaken during the dry season and during El Niño episodes conditions are favourable for uncontrollable spread of fires over large areas (see WWF-EEPSEA, 1999). Unfortunately, there are no estimates of the amount of pollution that are deposited onto the sea and no evaluation has been made of their impacts on the marine environment. In June 1995, an ASEAN Cooperation Plan on Transboundary Pollution was adopted two years before the fires (Atkinson 1999).

## 7.9 COASTAL TOURISM

Tourism in the East Asian Seas region has been expanding very quickly. In 1991, the region attracted about 51 million international tourists. Tourist arrivals in East Asia and the Pacific has been growing at a 15 per cent average annual rate between 1950 and 1991, the highest among world regions. In terms of foreign currency earnings from tourism, Hong Kong, Singapore, Thailand, Australia, China and Indonesia are among the top 25 earners in the world (Sharifah,

Table 22. Domestic and Foreign Tourists (in thousands)

| Country                                     | Domestic Tourists | From SCS countries (% of foreign tourists) | From non-SCS countries (% of foreign tourists) | Foreign tourists Total | Total          |
|---|-------------------|--|--|------------------------|----------------|
| Cambodia, 1995                              | n.a.              | n.a.                                       | n.a.   | n.a.                   | 110            |
| China (southern Provinces) 1996             | 34,062            | 4,786 (81%)                                | 1,106 (19%)                                    | 5,892                  | 39,954         |
| Indonesia (National), 1996                  | n.a.              | 2,628 (52%)                                | 2,406 (48%)                                    | 5,035                  | At least 5,034 |
| Malaysia (SCS Coast) (1993)                 | 1,194             |  |  | 637                    |                |
| Philippines (SCS coast) 1993                | 253               | 516 (33%)                                  | 1,058 (67%)                                    | 1,574                  | 1,827          |
| Thailand (coast and Chao Phraya basin) 1997 | 70,096            | 4,741 (39%)                                | 7,387 (61%)                                    | 12,129                 | 82,225         |

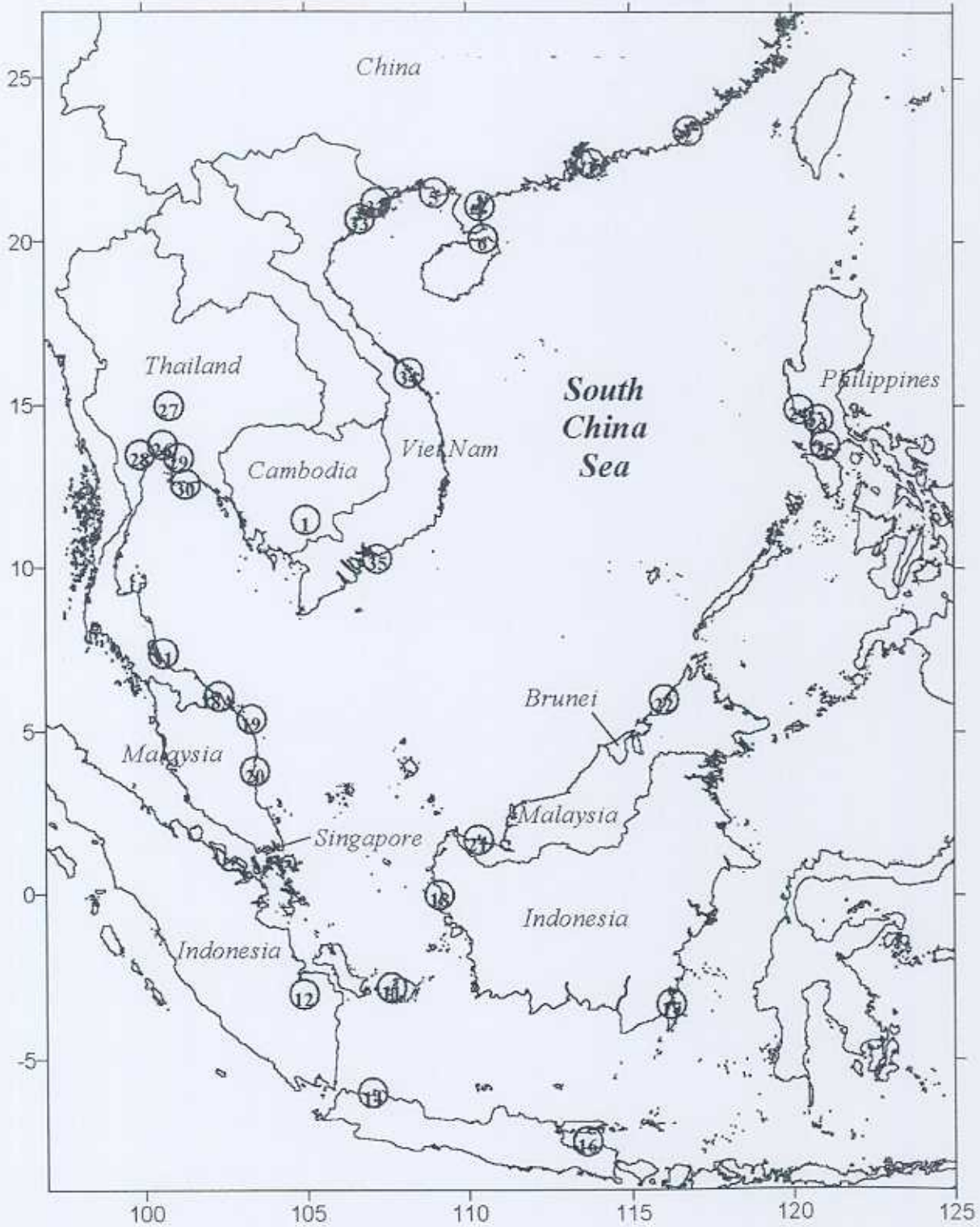
Source: National TDA reports (Talaue-McManus, 1999).

1995). Table 22 provides estimates of tourist arrivals for the SCS countries and coastal provinces. Figures given for domestic, South China Sea countries and non-SCS countries are for the varying years from 1993 to 1997. The total number of foreign tourists is of the order of tens of millions per year. Domestic tourist numbers are very high especially for the southern China and Thailand sub-regions amounting to 34 mil. and 70 mil., respectively.

Coastal tourism areas of the East Asian region is dependent on scenic coastlines, clean beaches and coral reefs as well as undisturbed mangroves, coastal forests, and islands. Marine nature reserves are gaining popularity among foreign tourists. However, coastal tourism contributes significantly to marine pollution and caused degradation of corals, mangroves, beaches and seagrass. Wastes generated by tourist facilities built on prime beach areas are traditionally taken as necessary evils that countries must

accept in generating tourism-based revenues. If uncontrolled, coastal tourism development can lead to soil and beach erosion, water quality degradation, and water pollution arising from generation of solid waste and sewage from tourist facilities. It is well known that a number of beach resorts including Pattaya, Thailand, have become polluted and coastal environment degraded and have lost the attraction as prime tourist destinations as a result. There should be proper planning of the resorts in the region and to ensure that proper waste collection, treatment and disposal are carried out. Care should also be exercised in avoiding shore erosion through proper design and construction of the facilities, roads and other infrastructure (see Wong, 1998).

Figure 8. Pollution Hot Spots Identified in the East Asian Seas Countries



## 8. Hot Spots, High-Risk and Sensitive Areas

Countries participating in the Transboundary Diagnostic Analysis for the South China Sea each identified hot spots and high-risk areas (Figure 8). Such areas are associated with major cities that are heavily industrialised and in enclosed or restricted waters such as in river mouths or estuaries and in bays. These pollution hot spots are areas where the pollution load is high and poses the serious impacts on marine and coastal ecosystems and threat to public health. Sensitive areas are locations that are subjected to high levels of pollution loads, have limited assimilative capacity, and have high biodiversity and key ecological support function. High-risk areas are sensitive locations that may be easily damaged or threatened by pollution or intensive human activities. They thus represent priority areas for monitoring and mitigation measures.

A total of 35 pollution hot spots and 26 sensitive and high-risk areas in the countries and sub-regions were identified (Figure 8). A good number of these hot spots is located in inland locations and were included because they are in watersheds draining into the sea. In northern Australia where low population densities and economic activities coupled with well-established legal and institutional arrangements help to keep a relatively pollution-free marine and coastal environment. However, the abundant marine resources and pristine natural environment of the coast in the northern portion of Australia under consideration do mean that they can be regarded as sensitive areas should anthropogenic activities increase. Natural hazards such as tropical storms and flooding of low-lying inhabited areas can pose a threat, albeit short-lived, to the marine environment.

In Cambodia, the two hot spots are Phnom Penh City and Sihanouk Ville. The former is more significant as the city has a population of over one million, collection of solid waste is poor, and there is barely any treatment for sewage. Construction of industrial plants across the city and vicinity is uncontrolled and there

is little done to minimise the disposal of wastewater and solid waste. Wastewater is discharged directly into the Bassac River and the Tonle Sap. Sihanouk Ville poses a far smaller threat as the population size is still low but pollution of the coastal waters is already on the rise, especially when new industrial plants without pollution control facilities are set up in and around the city.

China identified five hot spots all worthy of serious attention. They are the Han River (Shantou city), Pearl River (Hong Kong, Shenzhen, Dongguan, Guangzhou, Zhuhai, and Macau), Zhanjiang Bay (Zhanjiang city), and Behai and Haikou coastal waters. Other rivers not in the southern provinces are no better and can equally be regarded as hot spots. Water pollution levels for all of these heavily populated locations are already high and there is serious silting in the rivers on which major cities are located or where there are adjoining large seaports in operation in the vicinity. Southern China's coastal waters are also rich in biodiversity and there is a number of endangered species under threat from land-based pollution. A total of 15 sensitive areas in southern China were also identified.

For Indonesia, the national reports indicated a total of ten hot spots. Five of these are directly associated with rivers: Dumai, Siburik, Lahat, Japat, and Kali Mas, where pollution levels in the water are already high. Pulau Nipah (Batam Island), Tanjung Pandan (Belitung), Palembang Harbour, Jakarta Bay, Strait of Madura, Pulau Laut, and Pontianak are areas of sea pollution and degradation of the marine environment. The most serious Indonesian example of large-scale pollution is Jakarta Bay where the inshore demersal fishing industry disappeared and the coral reefs are completely destroyed. Several river systems drain into Jakarta Bay and they flow through heavily populated and industrialised areas. Pollution levels are excessively high and pose serious health threat to humans. The nutrient concentrations in the Bay are extremely high. This leads to increased primary productivity of the surface waters as measured in terms of chlorophyll-a concentrations. Phytoplankton biomass distribution underwent signifi-

cant shifts; plankton blooms are now spreading further offshore. In 1988, blooms spread five km offshore from Tanjung Priok, the main seaport in Jakarta. By 1990, they had spread 12 km offshore. Other large coastal cities with heavily polluted rivers that drain through the urban areas are also identified as hot spots in the country. These river banks are often inhabited by slum dwellers that consider the water courses as open sewers and garbage is thrown freely into them.

Korea went through a long period of rapid industrial development from the 1960s and is regarded as one of four Asian tigers that experienced fast economic growth. There are six cities in the country exceeding a population of one million: Seoul (10.0 mil.), Pusan (3.8 mil.), Incheon (2.8 mil.), Taegu (2.6 mil.), Taejon (1.5 mil.), Kwangju (1.4 mil.) and Syngnam (1.0 mil.).<sup>7</sup> There is only large coastal city, Pusan, the second largest city in the country, located on the southeast coast. The large Han River runs through the environs of the capital city, Seoul. Until the start of the 1990s decade, little attention was paid to environmental protection and the city, the Han River and coastal waters suffered from severe pollution from industry and untreated wastewater.

A serious water pollution incident in the inland city of Taegu, Korea's third largest city located in a heavily industrial region, serves to illustrate the situation in the country (Hattori, 1995). The deterioration of the river water had been identified since the latter half of the 1970s. The incident involved the release of phenol into the Nagdong River from a major industrial plant. The contaminated water was then drawn into the city's water supply pipe system. The incident deprived 80 per cent of the city's 2.2 million inhabitants of drinking water for several days. The firm causing the pollution paid out a total of 2.14 billion Won to 10,500 individuals and households as well as 3.0 billion Won to 1,400 corporations and organisations (see Korea case study).

Philippines' four pollution hot spots are areas considered as regional growth centres and where there have been incidents of red tides. These are: (1) Manila Bay and the Calabarzon area, (2) the Zambales area where the Subic Bay Freeport is located, (3) Mindoro Strait where Batangas Bay and Puerto Galera Bay interact, and (4) the Lingayen Gulf that receives pollutants from mining activities in the Agno and Veritas river basins. In Manila Bay, nutrient levels during the wet and dry seasons are reported by Valesquez and Hacinto (1995). Elsewhere in the Philippines, major port cities such as Cebu, Tacloban, Davao, with large populations are certainly to be marine environmental hot spots.

Manila Bay is the equivalent of Jakarta Bay in terms of the serious degradation of its marine and coastal environment. The bay receives wastewater from Metro Manila and about 17,000 sq km of watershed drained by 26 sizeable rivers. Metro Manila alone is host to about 13 per cent of the country's population and more than half of the country's manufacturing establishments generating very large quantities of wastewater and solid waste. Toxic algal blooms in Manila Bay occur during the onset of the rainy season in May and June when large quantities of runoff containing nutrients and microorganisms are discharged into the bay. There are also large amounts of litter, high concentrations of faecal coliforms and a high incidence of mass fish kills. The last may be related to toxic chemical discharge, overload of chemicals and feeds in aquaculture ponds, oil/chemical spillage, and sewage pollution.

Singapore does not have hot spots, as the waters around Singapore are virtually free from pollution generated by domestic and industrial sources. There is also favourable water movements in the southern waters, where the city core and harbour are located, to carry pollutants away from the island country. This is due to the availability of a comprehensive wastewater collection system and modern sewage treatment plants so that all sewage is treated. Conservation of water for human consumption and other uses is at a premium and great effort is expended to ensure that water resources are protected. However,

<sup>7</sup> Recent (1999) figures from Global Population Project, website.

massive land reclamation activities sustained over nearly four decades have almost completely modified the coastal environment and the country's major concern is silting of the seabed.

Singapore is the world's largest shipping port. In 1998, there were 141,000 vessel arrivals and a throughput of 312 mil. tonnes of cargo at the port. The country is also the world's third largest oil refining centre for petroleum (and petrochemicals). It is also a major trader of liquid cargo and has a large shipbuilding and repairing industry. Apart from the need to maintain high alertness to see to safe navigation within its port waters and the very heavily trafficked Singapore Strait, it is necessary to control the safe operation of the processing and handling of hazardous materials from the large number of industrial plants. The potential for damage to the marine environment and the country's economy is high and, in this regard, Singapore can regard all its waters as being a high risk and sensitive area. The Johor Strait, shared with the Malaysian State of Johor, is a relatively stagnant and shallow waterway and is used for navigation for an increasing number of ships that call on ports on both sides of the strait. There are plans on the part of Singapore to discharge treated wastewater away from the strait into the more open southern waters to reduce pollution levels in the Johor Strait.

Thailand has included the watershed of the Chao Phraya and other major river systems that drain into the Gulf of Thailand as part of the national sub-region for study. The National TDA report considers as under threat six freshwater systems — the lower Chao Phraya, Pasak River, Petchburi River, Bangpakong River, Rayong River and Songkhla Lagoon. The estuaries and marine areas around the river mouths of these rivers are subjected to pollution especially during May-July when the runoff is small. Although, at the start of the rainy Southwest monsoon in June the heavy rainfall can flush out pollutants and for a time raise the level of water pollution. Low oxygen, high BOD and high coliform counts result from the discharge of both domestic and industrial organic wastes. Trace and/or heavy metals have been found in high concentration in some rivers. Eutrophication is evident everywhere in the upper

Gulf of Thailand, especially during the high river runoff period. Eutrophication resulting in algal blooms is also found near other river mouths such as Ban Don Bay and off Songkla Lagoon because of nutrient inputs from the land.

Most of the nearshore areas of Thailand are considered sensitive because they are spawning grounds for several marine and brackish-water species. There are also important small-scale local subsistence fisheries and numerous aquaculture farms in the Gulf area. Many of the areas of the Gulf are also prime tourist spots that generate large revenues for local communities. The Thailand national TDA report identified the head of the Inner Gulf of Thailand, the Ban Don Bay, the marine area around Rayong on the eastern seaboard and Songkhla Lagoon as being hot spots.

The Viet Nam national TDA report identified four marine pollution hot spots and two sensitive and high-risk marine areas. Ha Long Bay is badly polluted by the silt and pollutants discharged by the Red River and other water courses. Open pit coal mining, oil depots and port operations further add to the level of pollution. Three other hot spots — Hai Phong, Da Nang, and Vung Tau-Ganh Rai — are associated with river discharge and seaport activities and high levels of various pollution indicators. The two high-risk and sensitive areas are the deltas of the Red River and the Mekong where there are rich marine and coastal resources. Also identified are four river systems that are severely polluted by nutrients, sediments and heavy metals. Since opening up the country's economy to foreign investments and adopting an open market system at the start of the 1980s, there has been intensification of all facets of economic activities with commensurate high rates of economic growth. Unless efforts are made early to control land clearance, changes in landuse, industrial, commercial, and infrastructure development, port and shipping operations, pollution in these areas and others will increase.

## 9. Policies, Law and Remedial Measures

The ten countries reviewed in this report range widely in terms of level of social and demographic background, economic and technological development, forms of government and political persuasion, legal and institutional framework, and capacity to deal with land-based pollution. However, all are clearly aware of the urgent need to manage land-based pollution in order to safeguard natural resources and prevent environmental degradation as well as minimise risk to human health and loss of economic opportunities. Countries/national sub-regions such as southern China, Indonesia, Viet Nam, and the Philippines with densely populated coastal areas and intensively used marine resources clearly suffer from greater pressure on coastal and marine resources and encounter considerable difficulties in managing land-based and other forms of marine pollution. Likewise, heavily industrialised areas, usually associated with large urban settlements, are faced with greater challenges to manage their marine environment on a sustainable basis. The challenge is heightened in sensitive areas where there are valuable natural resources, endangered animal and plant species, and valuable coastal assets including tourist resort facilities that are dependent on clean beaches and water, unspoilt scenery, and undamaged natural habitats.

From the national TDA reports, it is clear that world environmental bodies including UNEP have applied much impetus to encourage countries to give higher priority to protect coastal and marine resources. The obligation to protect the marine environment is implicit in the UN Law of the Sea Convention and most countries in the region are signatories to the international convention. Clear policies, targets and plans have been spelt out in submissions made by governments to the UN Conference on Environment and Development (UNCED) and have been translated into national action plans as are the cases of Singapore, Indonesia and others among the East Asian countries under review. The efforts of regional organisations such as UNEP, ESCAP, IMO and IUCN

to help raise awareness, promote research, implement international environmental conventions, build capacity to formulate, design and implement management programmes have also helped to put environmental conservation on a higher priority. Sustainable environment, conservation of biodiversity, and protected natural habitats have become a matter of national pride as much as essential conditions for economic and social development.

There are often difficult policy decisions relating to reconciling conflicting objectives among environmental conservation, economic development, and social values associated with traditional users. The national TDA reports have not highlighted this particular aspect sufficiently, but the case of the Taegu water pollution in Korea illustrates the dilemma confronting decision makers on how much priority should be given to environmental protection against the operation of industrial plants controlled by powerful *chaebols* that generate much needed revenues and employment. The outcome of the Taegu case was in favour of giving greater attention to environmental protection. There continues to be many other cases of discharge of untreated sewage, large amounts of nutrients and toxic substances into rivers and coastal waters in the region. Uncontrolled and unplanned industrial, commercial and residential development without due consideration given to adequate provision for potable water, management of solid waste, and collection and treatment of wastewater continue to plague urban managers.

The case studies given of the East Asian countries have shown the urgent need to adopt a set of integrated environmental policies rather than treat land, water and atmospheric pollution as distinct areas of management. There is a clear need to integrate also land and marine environmental management and to give greater attention towards the latter. Countries such as Cambodia, Korea, Singapore, and Viet Nam that have established a ministry of environment is clearly better able to formulate comprehensive environmental programmes that can deal with land-based sources of pollution of the marine environment. As against this, countries that have fragmented environ-

mental responsibilities under many agencies are likely to encounter great difficulties in controlling land-based pollution. It is important to note that, whether or not there is an environment ministry, it is necessary to empower key environmental agencies with strong mandates and endow them with adequate financial, human and technical resources for effective management. The Singapore case is noteworthy in this regard, while Malaysia, Korea and China have, in recent decades, significantly raised the priority given to environmental management and given due emphasis on water pollution control.

Integration of environmental management also suggests that watershed management for river basins is very much an essential part of coastal management. Destabilisation of upland areas through land clearance, deforestation, soil erosion and silting of river courses lead to degradation of the coastal and marine environment. Discharge of mine tailings, untreated wastewater, nutrients and toxic chemicals into rivers will pose serious threats further downstream and in the receiving coastal waters.

The financial crisis from mid-1997 that devastated the economies of most East Asian countries has highlighted the problem of poverty and serious lack of resources. Most countries including Indonesia, the Philippines and Thailand have yet to recover from it. Most countries have still to allocate scarce resources to other than environmental tasks. Coastal areas are commonly characterised by low economic and social development, lack of infrastructure, poor sanitation and a high incidence of diseases. Over-exploitation of natural resources, unrestricted clearance of forests and mangrove areas for cultivation are the consequences of low income levels of the community. These problems are augmented by higher than national average population increase mainly through migration from inland areas. The economic downturn has deprived city managers of essential funds to pay for the operation and maintenance of water supply, sewerage, and wastewater treatment facilities. It has also resulted in the curtailment of much needed facilities and infrastructure and set back the programme for controlling land-

based and other forms of pollution. Protection of resources such as coral reefs, mangrove forests and upland forests has been abandoned or curtailed in deference to still heavier exploitation to meet domestic and export markets.

A comprehensive set of legislation and well-endowed environmental institutions empowered by law are two pillars on which a country must stand in order to effectively manage the country's environment. Unfortunately, until countries in the region regain social stability and economic growth, there is little hope of significant improvements in marine and coastal environmental management.

## 9.1 ENVIRONMENTAL LEGISLATION

All the countries covered in this study have one law or another dealing with the protection of the marine environment. However, from available information, there appears to be no specific legislation dealing with land-based marine pollution in all the countries covered. The basic approach is to adopt one legislation covering environmental protection generally. These laws also make provisions for land-based marine pollution. On the whole, there are a variety of laws dealing with environmental protection in various sectors that supplement the general environmental legislation. However, there are a few countries that have laws and regulations that deal specifically with pollution or marine environment. Such laws also cover land-based marine pollution. Some of the countries dealt with have also entered into one international convention or the other that has a bearing on the protection of the marine environment.

**Table 23** gives a list of laws adopted by each of the countries bearing on land-based marine pollution. Most of the information in the table is drawn from the National TDA reports and additional information gathered for the country reports in the current study. It is likely not to be complete or up-to-date. It can be seen that, generally, there is basic environmental legislation covering different aspects of pollution, and it also relates to land-based marine pollution. The provisions on marine-based pollution are not contained



Table 23. Environmental Legislation that Deals with Land-based Pollution in East Asian Countries

| Country   | Environmental Legislation  | Environmental Regulation   | International Convention  |
|-----------|--|--|---|
| Australia | <ul style="list-style-type: none"> <li><input type="checkbox"/> The Ozone Protection Act (as amended in 1992);</li> <li><input type="checkbox"/> The Hazardous Wastes (Regulation of Exports and Imports) Act, 1989;</li> <li><input type="checkbox"/> The Resource Assessment Commission Act 1989;</li> <li><input type="checkbox"/> The World Heritage Properties Conservation Act, 1983;</li> <li><input type="checkbox"/> The Environment Protection (Sea Dumping) Act, 1981;</li> </ul> <p>There are various legislation at the state level dealing with the subject. For instance in New South Wales, The following legislation exist:</p> <ul style="list-style-type: none"> <li>◆ Waste Disposal Act, 1970;</li> <li>◆ Dangerous Goods Act, 1975;</li> <li>◆ Environmental Planning and Assessment Act, 1979;</li> <li>◆ Environmentally Hazardous Chemicals Act, 1985;</li> <li>◆ Marine Pollution Act, 1987;</li> <li>◆ Water Board Act, 1987;</li> <li>◆ Ozone Protection Act, 1989;</li> <li>◆ Environmental Offences and Penalties Act, 1989;</li> <li>◆ Protection of Environment Administration Act, 1991.</li> </ul> <p>This law, passed in 1991 allows for the reorganization of the State Pollution Control Commission and other environment related bodies into a single agency now known as Environment Protection Commission.</p> | <p>Various environmental regulations exist at both the Federal and State levels.</p>   | <p>The State has also Entered into many International Environmental Treaties.</p> |
| Caribbean | <ul style="list-style-type: none"> <li><input type="checkbox"/> Law On Environment Protection Natural Resource Management, 1996</li> <li><input type="checkbox"/> Decree Law on Forestry Administration, 1988</li> <li><input type="checkbox"/> Decree Law on Fishery Administration and Management 1987</li> <li><input type="checkbox"/> Land Law</li> <li><input type="checkbox"/> Law of land Management of Urbanisation and Construction 1994</li> </ul> <p>The following Laws are at Draft stage</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Forestry Law</li> <li><input type="checkbox"/> Mining Law</li> <li><input type="checkbox"/> Petroleum Exploration and Development</li> <li><input type="checkbox"/> Poisons Act, Chapter 234</li> <li><input type="checkbox"/> Fisheries Act, Chapter 111</li> <li><input type="checkbox"/> Planning Act, Chapter 232</li> <li><input type="checkbox"/> Building Control Act, Chap. 29</li> <li><input type="checkbox"/> Prevention of Pollution of the</li> <li><input type="checkbox"/> Sea Act, Chap. 111</li> </ul>   | <ul style="list-style-type: none"> <li><input type="checkbox"/> MOE Praka No. 992</li> <li><input type="checkbox"/> On the Regulation of the industrial Solid and Liquid Waste Management</li> <li><input type="checkbox"/> Petroleum Regulation, 1991</li> <li><input type="checkbox"/> Sub Decree on Harbour Rules for Foreign Ships, 1983</li> </ul> <p>The following are at the draft stage:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Sub-Decree on Environmental Impact Assessment</li> <li><input type="checkbox"/> Sub Decree on Water Quality</li> <li><input type="checkbox"/> Sub Decree on Waste Management</li> <li><input type="checkbox"/> Sub Decree on Hazardous Substances</li> <li><input type="checkbox"/> Sub Decree on Construction Permits</li> <li><input type="checkbox"/> Sub Decree on National Committee on Land Use, Urbanisation and Construction</li> </ul> | <p>The State has also Entered into many International Environmental Treaties.</p> |

Table 23. Continued

| Country   | Environmental Legislation   | Environmental Regulation  | International Convention   |
|-----------|---|---|--|
| China     | <ul style="list-style-type: none"> <li><input type="checkbox"/> The Environmental Protection Law (EPL)</li> <li><input type="checkbox"/> The "Marine Environmental Protection Law of the People's Republic of China, 1982"</li> <li><input type="checkbox"/> The Law of the PRC on the Prevention and Treatment of Water Pollution, 1984.</li> <li><input type="checkbox"/> Forest Law of People's Republic of China (1984).</li> <li><input type="checkbox"/> Mineral Resources Law of People's Republic of China (1984).</li> <li><input type="checkbox"/> Land Management Law of People's Republic of China (1984).</li> <li><input type="checkbox"/> Law on Water and Soil Conservation of People's Republic of China (1991)</li> </ul> | <ul style="list-style-type: none"> <li>• Regulation on Preventing Seawater Pollution from Boats and Ships</li> <li>• Regulation on Marine Environment Protection from Oil Exploration and Exploitation</li> <li>• Regulation on Marine Dumping</li> <li>• Regulation on Preventing Environmental Pollution from Ship Dismantling</li> <li>• Regulation on Preventing and Controlling the Pollution and Damage of Marine Environment from Land-based pollutants</li> <li>• Regulation on Preventing and Controlling the Pollution and Damage of Marine Environment from Coastal Construction Activity</li> <li>• Regulation on Co-operative Exploitation of Marine Oil with Foreign Partners</li> <li>• Regulation on Nature Reserves</li> <li>• Regulation on the Protection of Reproduction of Aquatic Resources</li> <li>• Regulation on Abroad Boats and Ships</li> <li>• Regulation on Drinking Water Source Protection</li> <li>• Seawater Quality Standard</li> </ul>       | <p>The State has also Entered into many International Environmental Treaties.</p>  |
| Indonesia | <ul style="list-style-type: none"> <li><input type="checkbox"/> Act No. 23 of 1997 concerning The Management of the Living Environment</li> <li><input type="checkbox"/> Act No. 12 of 1992 on the Plant Cultivation System</li> <li><input type="checkbox"/> Act No. 5, 1990 on the Conservation of Natural Resources And Ecosystems</li> <li><input type="checkbox"/> Water Resources Development Act, 1974</li> <li><input type="checkbox"/> Basic Mining Act, 1967</li> <li><input type="checkbox"/> Basic Agrarian Law Act, 1960</li> <li><input type="checkbox"/> Basic Provisions for Forestry Act, 1967</li> <li><input type="checkbox"/> Indonesian Waters Act, 1960</li> </ul>  | <ul style="list-style-type: none"> <li>• Water Control Regulation, 1990</li> <li>• Government Regulation No. 29, 1986: Analysis of Impacts to the Environment (AMDAL)</li> <li>• Presidential Decree No. 26, 1986: Ratification of ASEAN Agreement on the conservation of Nature and Natural Resources</li> <li>• Ministerial Decree Population and Environment No. 2, 1988: Guidelines for Environmental Quality Standards for Water, Waste water, Air and Sea Water</li> <li>• Ministerial Decree Mines and Energy No. 18SK, 1988: Technical Guidelines on Environmental Information and Environmental Impact Analysis for General Mining, Oil and Gas Mining and Geothermal (Offshore tin mining)</li> <li>• Ministerial Decree Agriculture No. 417, 1988: Utilization of the fishery Resources in the Indonesian Exclusive Economic Zone</li> <li>• Ministerial Decree forestry No. 687, 1989: Utilization of Recreation Forests, Tourism Forests, National Parks,</li> </ul> | <p>Act No. 17, 1985: Ratification of Principles of the Archipelagic Concept and United Nations Convention on the Law of the Sea (UNCLOS)</p> |

Table 23. Continued

| Country  | Environmental Legislation  | Environmental Regulation   | International Convention   |
|----------|--|--|--|
| Malaysia | <ul style="list-style-type: none"> <li><input type="checkbox"/> Environmental Quality Act, 1974 (EQA).</li> <li><input type="checkbox"/> National Forestry Act, 1984.</li> <li><input type="checkbox"/> Forestry regulations in Sabah and Sarawak.</li> <li><input type="checkbox"/> National Land Code, 1965.</li> <li><input type="checkbox"/> Land Conservation Act, 1960.</li> <li><input type="checkbox"/> The Sarawak Land Ordinance, 1948.</li> <li><input type="checkbox"/> The Sabah Land Ordinance 1930</li> <li><input type="checkbox"/> The National Forestry Act, 1984.</li> <li><input type="checkbox"/> The Street, Drainage and Building Act, 1976.</li> </ul> | <p>Grand Forest Parks and Marine Tourism Parks Act No. 5<br/>1990 Conservation of Living, natural Resources and their Ecosystems</p> <ul style="list-style-type: none"> <li>• Government Regulation No. 20 1990 Water Pollution Control</li> <li>• Presidential Decree No. 23 1990 Establishment of Agency for Environmental Impact Management (BAPEDAL)</li> <li>• Presidential Decree No. 32 1990 Management of Protected Areas</li> <li>• Ministerial Decree Population and Environment No. 3 1991 Water Quality Standards for Activities Already in Operation</li> <li>• Ministerial Decree Population and Environment No. 103, 1992 Quality Standards of Liquid Waste (waste discharges from coastal developments)</li> <li>• Government Regulation No. 51 1993 Revision of Environmental Impact Analysis (AMDAL)</li> <li>• Government Regulation No. 19 1994 Dangerous and Toxic Waste Management</li> </ul>  | <p>Exclusive Economic Zone Act, (1984) (EEZ Act)<br/>It mirrors Part V of the United Nations Convention on the Law of the Sea. (LOS)</p> |
|          |  | <ul style="list-style-type: none"> <li><input type="checkbox"/> Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977.</li> <li><input type="checkbox"/> Environmental Quality Licensing Regulations, 1977;</li> <li><input type="checkbox"/> Environmental Quality (Premises) Raw Natural Rubber) Regulations, 1978;</li> <li><input type="checkbox"/> Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979;</li> <li><input type="checkbox"/> Environmental Impact Assessment (EIA) Order, 1987;</li> <li><input type="checkbox"/> Environmental Quality (Scheduled Wastes) Regulations, 1989;</li> <li><input type="checkbox"/> Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Order, 1989;</li> <li><input type="checkbox"/> Environmental Quality (Prescribed Premises) (Scheduled Wastes Treatment and Disposal Facilities) Regulations 1989 etc.</li> </ul> |  |

Table 23. Continued

| Country     | Environmental Legislation   | Environmental Regulation   | International Convention  |
|-------------|---|--|---|
| Philippines | <ul style="list-style-type: none"> <li><input type="checkbox"/> PD1152, Philippine Environmental Code</li> <li><input type="checkbox"/> Republic Act 6969: The Toxic Substances and Hazardous Wastes Control Act of 1990</li> <li><input type="checkbox"/> Marine Pollution Decree of 1976 oil spills</li> <li><input type="checkbox"/> Toxic Substance and Hazardous and Nuclear Wastes Control Act of 1990</li> <li><input type="checkbox"/> Presidential Decree 1586</li> <li><input type="checkbox"/> Environmental Impact Statement System (1978) DAO 96-37, revised EIA system.</li> </ul>  | <p>Administrative Order 34: Revised Water Usage and Classification/ Water Quality Criteria.7</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> DENR Administrative Order 35. Revised Effluent Regulations of 1990.</li> </ul> <p>DENR Administrative Order 29. This provides for the implementing Rules and Regulations of RA 6969.</p>  | <p>The State has also Entered into many International Environmental Treaties.</p>   |
| Singapore   | <ul style="list-style-type: none"> <li><input type="checkbox"/> Environmental Act, 1998</li> <li><input type="checkbox"/> Environmental (Public Health) Act, Chapter 95</li> <li><input type="checkbox"/> Water Pollution Control and Drainage Act, Chap. 348</li> <li><input type="checkbox"/> Petroleum Act, Chapter 229</li> <li><input type="checkbox"/> Hazardous Waste (Control of Export, Import and Transit) Act Chapter 122A</li> <li><input type="checkbox"/> Fisheries Act, Chap. 111</li> <li><input type="checkbox"/> Poisons Act, Chap. 234</li> <li><input type="checkbox"/> Public Utilities act, Chap. 261</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea Act, Chap. 180</li> <li><input type="checkbox"/> Merchant Shipping (Oil Pollution) Act, 236</li> <li><input type="checkbox"/> Port Of Singapore Authority</li> <li><input type="checkbox"/> Act, Chap. 236 Prevention of Pollution of the Sea (Oil) Regulations</li> </ul> | <ul style="list-style-type: none"> <li><input type="checkbox"/> Environmental Public Health (Toxic Industrial Waste) Regulations, 1988</li> <li><input type="checkbox"/> Environmental Public Health (General Waste Collection) Regulations,</li> <li><input type="checkbox"/> Environmental Public Health (Public Cleansing ) Regulations 1970</li> <li><input type="checkbox"/> Sanitary Plumbing and Drainage Systems Regulations, 1976</li> <li><input type="checkbox"/> Surface Water Drainage Regulations</li> <li><input type="checkbox"/> Trade Effluent Regulations, 1976</li> <li><input type="checkbox"/> Sewage Treatment Plants Regulations, 1976</li> <li><input type="checkbox"/> Hazardous waste Regulations, 1998</li> <li><input type="checkbox"/> Poison Rules</li> <li><input type="checkbox"/> Poison (Hazardous Substances) Rules, 1986</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea (Oil) Regulations, 1991</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea (Noxious Liquid Substance in Bulk) Regulations</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea ( Reporting of Pollution Incidents) Regulations</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea (Reception Facilities) Regulations</li> <li><input type="checkbox"/> Prevention of Pollution of the Sea (Detergent and equipment Regulations</li> </ul> | <ul style="list-style-type: none"> <li><input type="checkbox"/> Control of Imports and Exports (Montreal Protocol) Order, 1989</li> <li><input type="checkbox"/> Hazardous Waste Act, Chapter 122A (Implementation of the Basel Convention on the Transboundary Movement of Hazardous Wastes</li> </ul> |
| Korea       | <ul style="list-style-type: none"> <li><input type="checkbox"/> The Basic Environmental Policy Act;</li> <li><input type="checkbox"/> The Water Environment Preservation Act;</li> <li><input type="checkbox"/> The Hazardous Chemical Substance Control Act;</li> <li><input type="checkbox"/> The Environmental Pollution Damage Dispute Coordination Act;</li> <li><input type="checkbox"/> The Act to Protect the Ozone Layer by Controlling Manufacture of Special Materials, 1990;</li> <li><input type="checkbox"/> The Solid Waste Management Act, and the Marine Pollution Prevention Act, were amended in 1991;</li> <li><input type="checkbox"/> The Environment Enhancement Act was passed in 1991;</li> <li><input type="checkbox"/> The Natural Environment Act also came force in 1991.</li> </ul>   | <p>Various environmental regulations exist</p>   | <p>The State has also Entered into many International Environmental Treaties.</p>   |

Table 23. Continued

| Country  | Environmental Legislation  | Environmental Regulation  | International Convention   |
|----------|--|---|--|
| Thailand | <ul style="list-style-type: none"> <li><input type="checkbox"/> Enhancement and Conservation of National Environmental Quality Act B.E. 2535</li> <li><input type="checkbox"/> Factory Act B.E. 2535 (1992)</li> <li><input type="checkbox"/> Public Health Act B.E. 2535</li> <li><input type="checkbox"/> Cleanliness and Tidiness of the Country Act B.E. 2503 (1960)</li> <li><input type="checkbox"/> Ordinance of Land Allocation B.E. 2535</li> <li><input type="checkbox"/> Poisonous Substance Act B.E. 2510 (Amended B.E. 2516)</li> <li><input type="checkbox"/> The Minerals Act B.E. 2510</li> <li><input type="checkbox"/> Private Irrigation Act B.E. 2482 (Amended B.E. 2521)</li> <li><input type="checkbox"/> Royal Irrigation Act B.E. 2485 (Amended B.E. 2518)</li> <li><input type="checkbox"/> The Public Irrigation Act, B.E. 2485</li> <li><input type="checkbox"/> The Navigation in Thai Waterways (Vol.14) Act B. E. 2535</li> <li><input type="checkbox"/> Fisheries Act B.E. 2490</li> <li><input type="checkbox"/> The Public Irrigation Act, B.E. 2485</li> <li><input type="checkbox"/> Maintenance of Canal Act B.E. 2446</li> <li><input type="checkbox"/> The Penal Code B.E. 2499</li> <li><input type="checkbox"/> The Municipal Cleanliness and Orderliness Act B.E.2535</li> <li><input type="checkbox"/> The Provincial Authority Act, Municipal Government Act, Sanitary District Act, City of Pattaya Act and Bangkok Metropolitan Act Petroleum Act B.E. 2514</li> <li><input type="checkbox"/> The Municipal Cleanliness and Orderliness Act B.E.2535</li> </ul> | <ul style="list-style-type: none"> <li>• Announcement No. 286 of the Revolutionary Council B.E. 2515</li> <li>• Mischief and Penalty in Accordance with the BMA Ordinance for Sanitation and Orderliness in the Bangkok Metropolis B.E. 2523</li> </ul>   | The State has also Entered into many International Environmental Treaties. |
| Viet Nam | <ul style="list-style-type: none"> <li><input type="checkbox"/> Law on Environmental Protection (LEP), 1993</li> <li><input type="checkbox"/> Law on Forest protection, and Development, 1991</li> <li><input type="checkbox"/> Law on Minerals, 1996</li> <li><input type="checkbox"/> Law on Petroleum, 1993</li> <li><input type="checkbox"/> Law on Protection of people's Health, 1989</li> <li><input type="checkbox"/> Law on Land, 1993</li> <li><input type="checkbox"/> Law on Water Resources, (Draft)</li> <li><input type="checkbox"/> Law on Fisheries (Draft)</li> </ul>  | <ul style="list-style-type: none"> <li><input type="checkbox"/> Decree 175/CP on Guidance for the Implementation of the Law on environmental protection, 1996</li> <li><input type="checkbox"/> Instruction No. 490/1998 On Environmental Impact Assessments, 1998</li> <li><input type="checkbox"/> Decree No. 26/CP on Sanctions against Administrative violations in Environmental protection, 1996</li> <li><input type="checkbox"/> Viet Nam Standards, Soil Quality, Maximum Allowable Limits of Pesticides Residues in Soil, 1995</li> <li><input type="checkbox"/> Viet Nam Standards, Water Quality, Coastal Water Quality Standard, 1995</li> <li><input type="checkbox"/> Viet Nam Standards, Water Quality, Surface Water Quality Standard 1995</li> <li><input type="checkbox"/> Viet Nam Standards, Water Quality, Ground   Water Quality Standard 1995</li> <li><input type="checkbox"/> Viet Nam Standards, Industrial Waste Water Discharge Standards, 1995</li> </ul> | The State has also Entered into many International Environmental Treaties. |

in a single legislation but in many laws that represent the different sources through which the marine environment can be polluted. In the case of Australia, a federal state, the component states have separate legislative powers on the environment. Legislation covering the control of land-based pollution is very comprehensive in some countries as it covers most, if not all the possible sources of land-based marine pollution. However, from data available to us, not many countries have legislation specifically for sewage. A few countries, such as Malaysia, have regulations on different types of sewage. An innovation has been introduced by some of the countries with respect to management of environmental problems. This is clearly noticeable in the Philippines and Indonesia, where local communities are given the opportunity to participate in the management of environmental issues. In Indonesia, this is contained in the 1997 Environmental Management Act, while in the Philippines, power is contained in the Local Government Act. Apart from the national laws, most of the countries have entered into international conventions that have a direct effect on the management of the marine environment.

## 9.2 INSTITUTIONAL FRAMEWORK

With respect to institutional framework, different countries adopt different strategies on the institution charged with the enforcement and regulatory functions of protection of the environment. This review shows that there is no specialised organisation dealing specifically with land-based marine pollution. The organisation dealing with general environmental matters also has the function of regulating land-based marine pollution. In general, there are specialised organisations dealing with regulatory matters on the protection of the environment. Most countries covered in the study have fully-fledged ministries dealing with environmental matters. Several of these ministries have responsibilities covering the environment and, where there exists no full ministry, there are specialised agencies dealing with enforcement and regulatory functions. **Table 24** below shows the strategies adopted on organisational framework by the countries.

In some states there are many agencies/bodies that deal with environment issues related to land-based marine pollution (Table 24). The resultant effect of this arrangement is that most of the time, there is little or no co-ordination between the activities of the various bodies and agencies responsible for management of environmental issues. For instance, in the case of Indonesia, Alan Tan (1998) argues that at the central level, there is uncertainty in the respective jurisdiction of the State Minister and BAPEDAL (the national environmental agency), and that there are other significant jurisdictional issues, *vis-à-vis* the other sectoral ministries, which traditionally had jurisdiction that are now being governed by the Office of the State Minister in charge of BAPEDAL. He noted that the Office of the State Minister and BAPEDAL are not powerful departmental agencies with full-fledged provincial competence like most sectoral ministries are. Consequently, there is much legislation adopted by national and provincial agencies that seems to conflict in different spheres of environmental protection.

Malaysia and Australia both face the problem of dichotomy between Federal and State like most other countries with a federal system of government. The result is that, except where the Constitution specifically gives jurisdiction to the Federal government, the state may have its agencies and bodies dealing with environmental issues leading to serious problems of co-ordination. With the exception of Singapore, the problems of co-ordination and overlapping jurisdiction exist in almost all the countries covered in this study.

Table 24. Organisational Framework of Selected East Asian Countries

| Country     | National Environmental Agencies   | Local/ State Agencies   |
|-------------|---|---|
| Australia   | <ul style="list-style-type: none"> <li>◆ Department of Arts, Sports and Environment Territories (DASET). This was later Replaced by The Commonwealth Environment Protection Agency.</li> </ul>  | <ul style="list-style-type: none"> <li>• In Queensland, there is the Department of Environment and Heritage.</li> <li>• In Western Australia, there exists the Environment Protection Authority.</li> <li>• There are other agencies that have responsibilities covering the environment including pollution issues.</li> </ul> |
| Cambodia    | <ul style="list-style-type: none"> <li>◆ Ministry of Environment (MOE).</li> <li>◆ Ministries of Agriculture, Forestry and Fisheries, Public Works and Transportation; Industry, Mines And Energy; Council for the development of Cambodia; National Committee for Land Use and Urbanisation all have departments dealing with Environmental issues including land based marine Pollution.</li> </ul>   | <ul style="list-style-type: none"> <li>• At the provincial and City levels there are Corresponding Provincial / city environment departments.</li> </ul>  |
| China       | <ul style="list-style-type: none"> <li>◆ The Environmental Protection Commission takes responsibility over China's environmental institutional framework. This apart, there are Ministries with departments that deal with environmental matters including land-based pollution matters. They include:               <ul style="list-style-type: none"> <li>• Agriculture Ministry.</li> <li>• Energy Ministry etc.</li> </ul> </li> </ul>  | <ul style="list-style-type: none"> <li>• Local environment Protection bureaux take care of law enforcement</li> </ul>   |
| Indonesia   | <ul style="list-style-type: none"> <li>◆ Ministry of Population and Environment (MPE).</li> </ul> <p>The operational department for pollution is Bapedal (Environmental Impact Assessment Commission or the Environmental Protection Agency).</p>   | <ul style="list-style-type: none"> <li>• Bipedal has offices in many priority cities and many priority provinces.</li> </ul>  |
| South Korea | <ul style="list-style-type: none"> <li>◆ The Ministry of Environment was established in early 1990. Some bureau and offices exist under it. e.g. International Affairs Office set up to deal with the issue of multilateral negotiations on Ozone layer and global warming issues.</li> </ul>   | <ul style="list-style-type: none"> <li>• There are also six Regional enforcement offices that has existed since the middle of the 1980s.</li> </ul>   |
| Malaysia    | <ul style="list-style-type: none"> <li>◆ Department of Environment (DOE). The Department reports to the Ministry of Science, Technology and Industry.</li> <li>◆ The EQA established the Environmental Quality Control Council to advise the Minister of Science, Technology and Environment.</li> </ul>  | <ul style="list-style-type: none"> <li>• DOE has regional offices.</li> </ul>   |
| Philippines | <ul style="list-style-type: none"> <li>◆ The Department of Environment and Natural Resources (DENR) is the principal agency of government that deals with environmental matters, including pollution. Several agencies and other specialised bodies are attached to the DENR.</li> </ul> <p>The main ones related to our subject of study are:</p> <ul style="list-style-type: none"> <li>• Pollution Adjudication Board: This is made up of top officials of the department. Its responsibility is to adjudicate on pollution cases.</li> </ul> <p>Environmental Management Bureau: This was created in 1987 with the mandate of advising the Secretary of DENR on environmental management, conservation and pollution control.</p> |   |

Table 24. Continued

| Country   | National Environmental Agencies  | Local/ State Agencies   |
|-----------|--|---|
| Singapore | <ul style="list-style-type: none"> <li>◆ Ministry of the Environment (ENV).</li> <li>• The Ministry's functions are divided into four divisions: Public Health, Environmental Policy &amp; Management, Corporate Services, and Environmental Engineering</li> <li>• The Pollution Control Department comes under the Division of Environmental Policy &amp; Management.</li> <li>• The Environmental Engineering Division has under it departments of Engineering Services, Sewerage, and Drainage.</li> <li>◆ Ministries of National Development, Trade and Industry, Health, Labour, Communications and IT as well as Land Transport Authority all have departments that deal with environmental matters.</li> </ul> | <ul style="list-style-type: none"> <li>• Under the Environmental Health Department (under Public Health Div.) there are six Environmental Health district offices.</li> </ul>   |
| Thailand  | <ul style="list-style-type: none"> <li>◆ Ministry of Science Technology and Environment (MOSTE). It has many departments:               <ul style="list-style-type: none"> <li>• Office of Environmental Policy and Planning (OEPP);</li> <li>• Dept. of Environmental Quality Promotion;</li> <li>• Pollution Control Department;</li> <li>• The Ministries of Agriculture and Co-operatives, Interior, Industry and Communications have various departments dealing environmental matters.</li> </ul> </li> </ul>  | <ul style="list-style-type: none"> <li>• The Departments have several divisions and regional offices that take charge of specific environmental concerns at national and provincial levels.</li> </ul>                      |
| Viet Nam  | <ul style="list-style-type: none"> <li>◆ Ministry of Science, Technology and Environment (MOSTE)               <ul style="list-style-type: none"> <li>• Environmental arm of MOSTE is the National Environment Agency (NEA);</li> <li>• Several ministries also have environmental divisions within them.</li> </ul> </li> </ul>   | <ul style="list-style-type: none"> <li>• At the provincial level, there are departments of Science, Technology and Environment (DOSTE). They operate under the People's Committees of the provincial governments</li> </ul> |

Sources: Compiled from national reports in the present study.



## 9.3 IMPLEMENTATION OF REGULATIONS

Many countries considered in this study have adopted a combination of strategies in the implementation of environmental laws and regulations relating to land-based marine pollution. A few of these are considered below.

### 9.3.1 Environmental impact assessment (EIA) requirements

Almost all the countries considered have one kind of law or regulation requirement for environmental impact assessment. Thus, in Indonesia, Government Regulation no. 51 of 1993 instituted the EIA system in that country. Malaysia, through the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order, 1987 also has this requirement in place. So also are the following countries: Philippine, Environmental Impact System (PD 1586) and Presidential Proclamation No. 2146 of 1981, and 803 of 1996; Thailand, Notification of MOSTE on the Types and Sizes of Projects or Activities of Government Agencies etc. are required to Prepare an EIA Report, dated 24/8/1992; Viet Nam, Decree 175/CP and Decree 26/CP and the various regulations require EIAs for certain projects; Cambodia has prepared a draft Law on EIA. Nevertheless, EIA is required on an *ad hoc* basis for projects funded by international organisations. Singapore has no specific legislation for compulsory EIA for major developmental projects, but nonetheless, the Ministry of the Environment, whenever it deems that a particular project may have potential for pollution that may affect public health does require an EIA to be conducted. (Alan Tan, 1998). The basic requirements of the EIA is that projects that are considered capable of having significant effects on the environment are required to conduct studies on the effects, and plan a programme to mitigate the adverse effects. Until this is satisfactorily done, such projects would be denied government authorisation to commence operation.

### 9.3.2 Application of the polluter-pays principle

The requirement that the person, company, or agency responsible for environmental damage or for causing pollution to the marine environment should bear the cost for remedying the situation is known as the "polluter pays principle". It is not contained in legislation in all cases, but has been adopted as a matter of policy by countries covered in this study. In Thailand, for instance, if leakage or contamination caused by or originating from any point source of pollution is the cause of death, bodily harm or health injury of any person or has caused damage in any manner to the property of any private person or of the State, the owner or possessor of such point source shall be liable to pay compensation or damages. This occurs, regardless of whether such leakage or contamination is the result of a wilful or negligent act of the owner or possessor. Exceptions are made when it can be proved that such pollution leakage or contamination is the result of *force majeure* or war, an act done in compliance with the order of the Government or State authorities. The compensation or damages to which the owner or possessor of the point source of pollution shall be liable includes all the expenses actually incurred by the government service for the clean-up of pollution arising from such leakage or contamination. In China, the principle is statutorily provided. Article 24 of the 1989 EPL stipulates the principle that the one who pollutes is responsible for its control. Lai *et al.* (1992) argue that the practical utility of this provision in China is that it impels the leaders of enterprises to take seriously the protection of the environment and to include pollution control in the enterprise planning.

### 9.3.3 Penalties

Countries have traditionally imposed fines and various terms of imprisonment as a tool of environmental management. This is usually known as the command and control approach. This requires the company, person, etc. responsible for environmental damage or in breach of any law relating to environmental protection to pay penalties or undergo a specified

term of imprisonment or both. A good example of this approach could be found in Thailand where Public Health Act B.E. 2535 empowers local authorities that are permitted to issue by-laws that cover areas, ranging from disposal of rubbish and dirt to the control of operations by a commercial entity that affects an individual's health. Violation of this Act can result in fines not exceeding Baht 100,000. Also, the ECNEQ Act B.E.2535 and the Factory Act B.E.2535 impose terms of imprisonment and fines for the offence of unauthorised use of water from a prohibited area. Six years' imprisonment and Baht 600,000 or both are imposed upon an offender. In Malaysia, fines are imposed for failure to obtain a license for prescribed premises under the EQA. Under Section 18 (3) of the EQA, the penalty is a fine not exceeding Ringgit 50,000 or imprisonment not exceeding two years or both, and a further fine of Ringgit 1,000 for every day that the offense is continued after a notice has been served on the offender (Tan, 1998). In Indonesia, the basis upon which the Environmental Law of Indonesia rests is Act No. 4, of 1982 amended in 1997. The law lays down the basic principles for environmental management and heavy penalties of up to Rupiah 1,000 million fine and a term of imprisonment of 10 years for a breach of the law. In addition, the law gives members of the public the right to institute action in court for damages suffered through pollution. Invariably, all the countries combine both fine and imprisonment as regulatory tools for environmental management.

#### 9.4 ADMINISTRATIVE MEASURES

The countries reviewed in this study to manage environmental issues including land-based marine pollution also adopt various administrative measures. First, the law may stipulate the level of pollution that a company or person may be allowed to generate without being liable for any of the penalties discussed above. Thus, in Malaysia, Section 30B of the EQA inserted in 1996, prescribes minimum percentages of recycled substances for specified products etc. A similar system of permits that must be obtained before a certain polluting activity is carried out is in place in Singapore and other countries.

Second, many countries also use financial inducement to encourage companies to adopt environmentally sound technologies in order to reduce pollution. For instance, in Thailand, in 1983, the Finance Ministry announced a duty reduction on imported machinery, materials and equipment for the purposes of energy saving and environmental conservation (TDA, National Report). Another measure used is the establishment of an environmental fund to be used for the purposes of compensating victims of pollution damages or redressing pollution. Such measures exist in Thailand and Malaysia and other countries. In Thailand, the Environmental Fund is one of the new supportive resources, established by the new Environmental Act. Initially the funding came from the government budget and Fuel Fund. However, other sources such, as grants and soft loans should be added. The policy of this fund emphasises water pollution and solid waste management projects both for the private sector and local governments. In Malaysia, Section 36E of the EQA also inserted in 1996 established an environmental fund that is to be operated as a trust account within the Federal Consolidated Fund, for the purposes of financing research and pollution control generally, preventing and combating spillage etc.

## 10. Problems and issues

Many problems militate against the effective management of land-based pollution and environmental issues generally in the countries covered by the study. Although the degree and severity of the problems are not the same in all countries, the problems are identified as follows: ineffective laws, insufficient financial resources, need for capacity building, conflict among agencies/different levels of government, and lack of political will and desire to implement strong enforcement of regulations. The following comments address the problems in the countries covered generally and specifically.

## 10.1 INEFFECTIVE LAWS

Most of the laws dealing with land-based environmental problems are very broad and do not specifically address specific problems including those relating to land-based pollution. Some countries in the region need to strengthen legislation adequately address environmental problems. For instance, Cambodia is still to adopt important laws dealing with environmental protection generally, and land-based marine pollution in particular. Many laws, however, exist that address various aspects of the problem. But these are not necessarily effective, especially in the less developed of the countries covered in this study. In Thailand, for instance, The Factory Act (B.E. 2535) and the ECNEQ Act (B.E. 2535) focus only on the control of pollution discharges to meet effluent standards. These statutes fail to examine the possible carrying capacity of water sources at a particular point in time in absorbing pollution discharges, which are not harmful to the public (Thailand National TDA Report). Thus, some of the provisions in the environmental laws of some of the countries covered are not sophisticated enough to address the problems. In addition, different regulations administered by different bodies are sometimes in conflict and render them even less effective from the perspective of enforcement.

## 10.2 INSUFFICIENT RESOURCES

The desire to address land-based marine pollution and other environmental problems generally is often hampered by the lack of sufficient financial resources in many of these countries. The problem is particularly acute in the less developed countries where insufficient budgetary allocations are made to control environmental pollution. At present, constraints to the management of mangroves in Indonesia are caused, among other reasons by insufficient resources (equipment, personnel, training) and inadequate allocation of financial resources for their protection. The problem of lack of resources have been made worse for countries adversely affected by the still ongoing financial crisis. Funds for garbage collection, illegal logging and dumping of wastes, operation of existing

sewerage and sewage treatment facilities and the like are simply unavailable. However, from information available from the country reports, some countries such as China, Korea and Singapore show a high level of commitment to environmental protection by allocating huge amounts of financial resources for the construction of environmental infrastructures.

## 10.3 NEED FOR CAPACITY BUILDING

A major problem confronting most of the countries covered in the study is the lack of skilled, highly trained and sufficiently motivated staff to undertake monitoring, surveillance and enforcement of environmental regulation. In Korea, the government's problem in maintaining consistency in enforcement has been attributed to the fact that the environmental bureaus are chronically understaffed and open to corruption. Allegations abound for instances, in the past, where firms have found ways to bypass regulations to avoid prosecution for violations of pollution regulations and to obtain permission to build factories outside of permitted zones. Effective enforcement of law is essential to the protection and control of water pollution. In Thailand, although the law requires the installation of wastewater treatment systems in factories, owners do not provide or operate such systems to save production costs. As a result, improper discharge of waste and wastewater is common. This is a common problem in other countries in the region where planning and environmental regulations are not strictly enforced. This is exacerbated by the shortages of manpower on the part of responsible government bodies to cope with the rapid increase in the number of factories. With the current depressed economic condition, illegally constructed factories are few but enforcement remains a major problem (Thailand National TDA Report). The same observations may also be made for Cambodia, Indonesia, the Philippines, and Viet Nam.

## 10.4 CONFLICT AMONG AGENCIES/ DIFFERENT LEVELS OF GOVERNMENT

The conflict between agencies and different levels of government is a very serious problem in most of

the countries covered in the study. This arises from the fact that legislation covering environmental issues gives power to different organisations to enforce and most of the countries have different levels of governments that have power over implementation of environmental regulations. This necessarily gives room for conflict and lack of co-ordination in the application of environmental policies and regulations, including land-based marine pollution. In Indonesia, it has been observed that lack of co-ordination and co-operation (egoism) among sectoral agencies or between central and regional governments has led to duplication of efforts in such areas as data gathering, project implementation and the enforcement of regulations. In addition, this lack of institutional co-ordination and co-operation has created resource use (development) duplication and conflicts. For example, the conflict between mangrove area conservation versus golf course and real estate development at Pantai Indah Kapuk near the Jakarta International Airport, conflict between traditional fishermen versus trawlers prior to 1980, and between conservation versus tourism in Seribu Island Marine Park. All of this in turn results in a lack of policy implementation (Indonesia National TDA Report). In Malaysia, there is the conflict between the federal government and the states. Some legal instruments provide authorities with adequate tools for controlling land development activities. However, most of these instruments are national laws and, because the powers to regulate land use are vested in state authorities and local governments, the implementation of this body of legislation has not always been satisfactory (Tan, 1998). The problem of the "federal-state dichotomy" is a widely discussed issue in Malaysia, and was the subject of a recent study commissioned by the Ministry of Science, Technology and Environment. Similar statements can also be made of other countries in the region.

### **10.5 LACK OF POLITICAL WILL**

Most of the countries covered in this study are developing countries. They share in the general problem confronting environmental protection in developing countries, namely lack of political will. These

countries pay much attention to economic development relegating environmental protection to the background. Environmental pollution and degradation leading to loss of amenity, resource depletion, and health impairment of affected communities are often ignored or neglected. Protests by affected groups and non-governmental organisations (NGOs) are not uncommon in the region. In the Philippine, it has been noted that provincial governments are under pressure to showcase developmental progress in the respective provinces. Re-election of officials depends on the level of development achieved in the previous term of office. In such situations, long-term plans for environmental and natural resources management are often sacrificed in favour of short-term developmental policies (Tan, 1998).

## **11. Conclusion and Recommendations**

It is clear that at least some of the national teams that participated in the TDA-SCS project have been frank and open about the problems of land-based pollution and the causes that give rise to them in their respective countries. Over the entire region, the level of environmental awareness on the part of the common people, government, and industrialists is high. Albeit, the problems enumerated above, are deep-rooted and persistent and the measures that need to be adopted must be decisive and treated with urgency. It is not the intention, in this report, to be critical of the situation in the region and it is no comfort that similar problems exist in advanced countries in Europe and elsewhere. There are positive developments and successes in the East Asian region itself. Technical and human resources and financial assistance are available within the wider East Asian region but co-operation and co-ordination of efforts internationally are needed to bring about improvements in the management of land-based and other forms of pollution in the marine and related environments.

Drawing from the national TDA reports, a set of recommendations are given below:

- (1) Set clear policies and achievable targets to address land-based pollution problems. These policies and objectives should be publicly and widely debated before being adopted;
- (2) Develop a comprehensive set of laws and regulations appropriate to the level of development of the country to deal with land-based pollution bearing in mind the interrelated multiple sources of pollution;
- (3) Create an organisational framework capable of dealing with land-based (and other forms of) pollution on an integrated basis. Ideally, there should be a single well-funded and empowered environmental authority. Where this is not feasible, a powerful co-ordinating body at a ministerial level or within the Prime Minister's, or President's, office is needed to ensure that land-based pollution in all its manifestations can be dealt with effectively;
- (4) Urban and regional planning should be undertaken with long-term environmental protection in mind. All sectoral development plans should be harmonised with basic national land-use plans to enable the proper control of both government as well as private development projects. The approach should be to anticipate rather than solve environment problems after they occur;
- (5) Long-term environmental protection planning to control land-based pollution should be undertaken with the view to build strong capacity in terms of manpower needs. These needs should be based on carefully assessed requirements to deal with projected pollution loads and the spatial distribution of the various sources of pollution. Environmental impact assessment requirements have proven to be much less effective unless there is sufficient well-trained technical scientists and managers available to the implementing agency;
- (6) Similar long-term plans are needed to provide for essential waste disposal, collection, and treatment facilities and services, drainage and sewerage systems, and to estimate the necessary financial requirements for making them available;
- (7) In addition to the command and control approach based on legal means, a system of management using the pollutor-pays principle should be adopted to bring about a more equitable system of paying for the costs of land-based pollution control. Such an approach is necessary to deal with industrial enterprises and all other commercial establishments including tourist resorts and condominiums;
- (8) Arising from (7), privatised pollution control services, such as garbage collection and disposal, sewerage and sewage treatment services, should be considered with due regard to the need for some degree of subsidy and other forms of support on the part of the government;
- (9) Promote a long-term broad-based programme of public education and awareness building beginning with the education institutions and using all public media including the internet;
- (10) The above (9) should be based on a well-conceived system of long-term monitoring beginning with a baseline survey of marine and coastal resources and environmental quality assessment. Information gathering, which is costly, should be programmed to meet specific needs;

- (11) Develop a detailed system of environmental information storage and retrieval using available powerful technical systems, e.g. satellites and global positioning systems, computer software systems, e.g. geographic information systems, to ensure that all available information is captured and shared by all environmental, planning, and implementing agencies and made available to educational and research institutions and the public;
- (12) Privatising environmental services is simply a way of engaging private enterprises that can be encouraged to contribute in sharing their technical know-how and financial support for specific projects and participating in environmental awareness programmes;
- (13) In both developed and developing countries in the region, involve local-level government agencies, local communities, traditional organisations, NGOs, schools, universities and research institutions in public awareness campaigns. Help in monitoring water and other environmental quality measures; report illegal activities and pollution incidents. Properly organised they can form the basis for resource protection schemes to prevent land-based and other forms of pollution and resource degradation;
- (14) Develop a system of nature conservation schemes to guarantee the long-term protection of critical and sensitive marine and coastal resources. Such schemes will help to focus efforts to prevent or minimise land-based and other sources of pollution;
- (15) Undertake detailed systems for disaster management to deal with: floods, forest fires, earthquakes, tsunamis, volcanic eruptions, landslides, leakage (into aquatic environments) of toxic substances from mines and factories; that have considerable consequences on land-based pollution of the marine and coastal environment;
- (16) Initiate and augment international co-operation involving countries in the East Asian region to deal with the problems of transboundary marine, coastal and related aquatic environments from land-based sources of pollution. Much can be done to share scientific information, undertake joint research projects and pollution control exercises, human resource development, technical and financial support, and other ventures; and
- (17) Make better use of international environmental agencies and organisations with environmental and resource management capabilities, e.g. Asia Development Bank, development agencies of advanced countries, to obtain technical and management assistance.

The strategies listed above are premised on basic problems of poverty, political stability, social order and good governance. The dilemma of economic development and sustainable environmental management is likely to haunt policy makers given the urgency to achieve economic growth. It will require strong and unwavering political will based on clear understanding of valuable sustainable development of marine and coastal resources to meet long-term national aspirations

## References

- Anon (1967), *Meteorology for Mariners*, London: H.M.S.O.
- Anon (1995), *China Environment Yearbook 1994*. China Environment Yearbook, Inc.
- Australian International Development Assistance Board (AIDAB)(1994), *Country Environment Profile of Indonesia*, Commonwealth of Australia.
- Awaji Takehisa and Teranishi Shun'ichi (2000), *The State of the Environment in Asia 1999/2000*, Japan Environmental Council, Springer-Verlag, Tokyo.
- ASEAN Secretariat (1997), *First ASEAN State of the Environment Report*, Association of South East Asian Nations, Jakarta, 220 pp.
- Atkinson, N. (1999), 'Environmental policy and management in Asia: a learning experience', *Journal of Environmental Assessment and Policy* 1(1): 81-104.
- Bernard, Stephane and Rodolphe De Koninck (1996), 'The retreat of the forest in Southeast Asia: a cartographic assessment', *Singapore J. Trop. Geog.* 17: 1-14.
- Bleakley, C. and Lawrence, D. (1997), *Land-based Sources of Marine Pollution*, Great Barrier Reef Marine Park Authority, Canberra (mimeo).
- Bleakley, C. and Wells, S. (1995), *A Global Representative System of Marine Protected Areas. Great Barrier Reef Marine Park Authority*, The World Bank and the World Conservation Union (IUCN). Vol. III: pp 107-136.
- Brown, Barbara (1997), 'Disturbance to reefs in recent times', pp. 370-172, in C. Birkeland (ed.), *Life and Death of Coral Reefs*, Chaptman and Hall, New York.
- Bryant, D., Burke, L., McManus, J. & Spalding, M. (1998), *Reefs At Risk: A Map-Based Indicator of Threats to the World's Coral Reefs*, World Resources Institute (WRI) and International Center for Living Aquatic Resources Management (ICLARM), World Conservation Monitoring Centre (WCMC), and United Nations Environment Programme (UNEP), 56 p.
- Burbridge, Peter R. and Koesoebiono (1981), 'Coastal management in Southeast Asia', pp. 110-135, in Chia Lin Sien and Colin MacAndrews (eds), *Southeast Asian Seas: Frontiers for Development*, McGraw Hill, Singapore.
- Business International (1992), *Asia/Pacific and the Environment: Investing in the Future*, Report, No. Q 148, Hong Kong.
- Chamber of Shipping (n.d.), *Lord Donaldson's Inquiry into the Prevention of Pollution from Merchant Shipping*, London (mimeo).
- Chia Lin Sien (1979a), 'Weather and climate', pp. 15-30, chapter 2 in R.D. Hill (ed.), *South-East Asia: A Systematic Geography*, Oxford Univ. Press.
- Chia Lin Sien (1979b), 'Planning and environmental management in Singapore', pp. 201-32, in Colin MacAndrews & Chia Lin Sien (eds), *Developing Economies and the Environment: the Southeast Asian Experience*, MacGraw Hill, Singapore.
- Chia Lin Sien (1992), *Singapore's Urban Coastal Area: Strategies for Management*, ICLARM Tech. Rept no. 31, International Center for Living Aquatic Resources Management, Manila.
- Chia Lin Sien (1995), *Protecting the Marine Environment of Asean from Ship-Generated Oil Pollution and Japan's Contribution to the Region*, VRF Series No. 245, Institute of Developing Economies, Tokyo, 141 pp.
- Chia Lin Sien and Chionh Y.Y. (1987), 'Singapore', pp.109-168, in Chia Lin Sien (ed.), *Environmental Management in Southeast Asia*, Faculty of Science, National Univ. of Singapore.
- Chou, L.M., Wilkinson, C. R., Licuanan, W.R.Y., Alino, P.M., Cheshire, A.C., Loo, M.G.K., Tangjaitrong, S., Sudara, S., Ridzwan, A.R. & Soekarno (1994), 'Status of coral reefs in the ASEAN Region', pp. 1-10, in Wilkinson, C., Sudara, S. & Chou, L.M. (eds), *Proc. Third ASEAN-Australia Symposium on Living Coastal Resources*, 16-20 May 1994, Thailand. Volume 1: Status Reviews. Australian Agency for International Development, 454 pp.
- Chua, T-E. (1995), 'Marine pollution: developments since UNCLOS III and prospects for regional cooperation', pp. 144-176, in K.L. Koh, R.C. Beckman and Chia Lin Sien (eds), *Sustainable Development of Coastal and Ocean Areas in Southeast Asia: Post-Rio Perspectives*, SEAPOL Singapore conf. on Sustainable Development of Coastal

and Ocean Areas in Southeast Asia: Post-Rio Perspectives, 26-28 May 1994, Singapore, org. Southeast Asian Programme in Ocean Law, Policy and Management (SEAPOL), Law Faculty, National Univ. Singapore, and IUCN Commission on Environmental Law.

Chua T-E. and Nancy Bermas (ed)(1999), *Challenges and Opportunities in Managing Pollution in the East Asia Seas*, Proceedings of the International Conference, Manila, 22-24 March 1999, Global Environmental Facility (GEF), United Nations Development Programme (UNDP), International Maritime Organisation (IMO) Regional Programme for the Prevention and Management of Marine Pollution in the East Asian Seas (PEMSEA), Quezon City, Philippines, 567 pp.

Collins, N. M. Sayer, J.A. and Whitmore, T.C. (1997), *The Conservation Atlas of Tropical Forests: Asia and the Pacific*. New York: Simon and Schuster.

Den Hartog, C. (1970), *Seagrasses of the World*, Amsterdam: Elsevier, 275 pp.

Dow, K. (1997), 'An overview of pollution issues in the Straits of Malacca', pp. 61-102, in Hamzah Ahmad (ed.), *The Straits of Malacca: International Co-operation in Trade, Funding & Navigational Safety*, Maritime Institute of Malaysia (MIMA).

Economic and Social Commission for Asia and the Pacific (ESCAP)(1985), *Marine Environmental Problems and Issues in the ESCAP Region*, United Nations Economic and Social Commission for Asia and the Pacific, Bangkok.

Economic and Social Commission for Asia and the Pacific (ESCAP)(n.d.), *State of the Environment in Asia and the Pacific, Vol. 1: Summary*, United Nations Economic and Social Commission of the Asia Pacific, Bangkok.

Economic and Social Commission for Asia and the Pacific (ESCAP) and Asian Development Bank (ADB)(1995), *State of the Environment in Asia and the Pacific*, United Nations, New York, 638 pp.

Fortes, M.D. (1988), 'Mangrove and seagrass beds of East Asia: Habitats under stress', *Ambio* 17(3): 207-213.

Fortes, M.D. (1989), *Seagrasses: A Resource*

*Unknown in the ASEAN Region*, ICLARM Education Series no. 5, International Center for Living Aquatic Resources Management, Manila.

Fortes, M.D. (1994), 'Philippine seagrasses: status and perspectives', pp. 291-310, in C. Wilkinson, S. Sudara, S. & Chou, L.M. (eds), Proc. Third ASEAN-Australia Symposium on Living Coastal Resources, 16-20 May 1994, Thailand. *Volume 1: Status Reviews*, Australian Agency for International Development, 454 pp.

Fortes, M.D. (1995), *Mangrove and Seagrass Beds of East Asia*. RCU/EAS Tech. Rept No. 6, UNEP, Bangkok.

GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group Of Experts on the Scientific Aspects Of Marine Pollution) (1993), *Impact Of Oil and Related Chemicals and Wastes on the Marine Environment*, UNEP Rep. and Stud. 50, 180 pp.

Gomez, E. (1988), 'Achievements for the Action Plan for the East Asian Seas', in *Cooperation for Environmental Protection in the Pacific*, UNEP Regional Seas Rep. and Stud. No. 97, Nairobi.

Gomez, E.D. et al. (1990), *State of the Marine Environment in the East Asian Seas Region*, UNEP Reg. Seas Rep and Stud. 126.

Greer, Anthony and M. Perry (forthcoming), 'Environment and natural resources: toward sustainable development', in Chia Lin Sien (ed.), *Southeast Asia Transformed: A Geography of Change*, Institute of Southeast Asian Studies (ISEAS), Singapore.

Guerrero, R.III D., R.R. Tejero and P.A. Caoili (1995), 'An Assessment of the Monitoring and Warning Systems for Red Tide in the Philippines and Policy Implications', pp. 372-375, in D. Watson, K.S. Ong and G. Vigers (eds), *ASEAN Criteria and Monitoring: Advances in Marine Environmental Management and Human Health Protection*, Proceedings of the ASEAN-Canada Midterm Technical Review Conference on Marine Science (24-28 October 1994), Singapore. EVS Environment Consultants, Vancouver and National Science and Technology Board, Singapore, 422 pp.

Hamzah bin Abdul Majid (1979), 'Toward environmental management: the Malaysian experience', pp. 46-69, in C. MacAndrews and Chia Lin Sien (eds),



*Developing Economies and the Environment: the Southeast Asian Experience*, McGraw Hill, Singapore.

Hattori, Tamio (1993), "Environment and development: South Korea's Taegu water pollution case", in Reetsu Kojima, Yoshihiro Nomura, Shigeaki Fujisaki and Naoyuki Sakumoto (eds), *Development and the Environment: the Experiences of Japan and Industrializing Asia*, Proceedings of Conference, 20-21 December 1993, Tokyo, Institute of Developing Economies, Tokyo.

Heck, K.L. Jr. & McCoy, E.D. (1978), 'Biogeography of seagrasses: evidence from associated organisms', pp. 109-128, *Proc. International Symposium on Marine Biogeography and Evolution in the Southern Hemisphere*, July 1978, Auckland, NZ. Volume 1, N.Z. DSIR Information Series 137, 355 pp.

Hernandez, J. (1993), *The Hazardous Waste Manager's Manual, Workbook and Database*, United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), Bangkok.

Hinrichsen, D. (1998), *Coastal Waters of the World: Trends, Threats, and Strategies*, Washington, D.C.: Island Press, 275 pp.

International Trade and Tourism Organisation (ITTO)(1998), 'Country Profile - Cambodia', *Tropical Forest Update*, 8 (4): 24.

Johannes, R.E. (1975), 'Pollution and degradation of coral reef communities', pp. 52-62, in C. Wood and R.E. Johannes (eds), *Tropical Marine Pollution*, Elsevier Oceanographic Series no. 12, Elsevier Scientific Publ., Amsterdam.

Kelleher, G.C., Bleakley, C. and Wells, S. (eds)(1995), *A Global Representative System of Marine Protected Areas*, Great Barrier Reef Marine Park Authority, The World Bank and World Conservation Union (IUCN).

Kirkman, H. (n.d.), *Land-based Sources And Activities Affecting The Marine Environment In The East Asian Seas: An Overview*, UNEP, EAS/RCU, Bangkok (mimeo.).

Koe, Lawrence C.C and M.A Aziz (1995), *Regional Programme of Action on Land-based Activities Affecting Coastal and Marine Areas in the East Asian Seas*, RCU/EAS Tech. Rept Series No.

5, United Nations Environment Programme (UNEP), Bangkok, 117 pp.

Koh, K. L. (1996), *Selected ASEAN Documents on the Environment*, Asia Pacific Centre for Environmental Law (APCEL) Documents Series, Issue No.1.

Lai Pencheng, Huang Yaoling, and Cao Jianhua, (1992), 'International encyclopaedia of laws: China', in R. Blanpain (ed.), *International Encyclopaedia of Laws: Volume 1 Environmental Laws*, The Hague: Kluwer Law International.

Leis, J.M. (1991), 'The pelagic stage of reef fishes: the larval biology of coral reef fishes', pp.183-230, in P.F. Sale (ed.), *The Ecology of Fishes on Coral Reefs*, San Diego: Academic Press.

Liang, J.F. (1985), 'Holocene reef corals of China', in Z.X. Zeng (ed.), *Coral Reefs and Morphological Essays of South China*, Geography Series No.15. Guangzhou, China: Institute of Geomorphology, South China Normal University.

Loh Wah Sing, Chia Lin Sien, Chin Kee Kean and Lin Yucheng (1995), *Environmental Management of the Newly Industrialising Economics: Lessons from East Asia - Singapore*, The World Bank (unpubl.).

Maaliw, M. A. L. L. (1990), 'Pollution', pp. 32-37, in L. Talaue-McManus, and T-E. Chua (eds), *The Coastal Environmental Profile of Lingayen Gulf, Philippines*, ICLARM Technical Reports 22, 69 pp., International Center for Living Aquatic Resources Management, Manila, Philippines.

Maclean, J. L. (1989), 'An overview of *Pyrodinium* red tides in the Western Pacific', pp. 1-8, in G. M. Hallegraeff and J. L. Maclean (eds), *Biology, Epidemiology and Management of Pyrodinium Red Tides*, ICLARM Conf. Proc. 21, 286 pp., Fisheries Department, Ministry of Development, Brunei Darussalam, and International Center for Living Aquatic Resources Management, Manila, Philippines.

Marr, J.C. (1976), *Fishery and Resource Management in Southeast Asia*, RFF/PISFA Paper 7, Resources for the Future, Washington D.C.

Marr, J.C. (1981), 'Southeast Asian marine fishery resources and fisheries', pp. 75-109, in Chia Lin Sien and C. MacAndrews (eds), *Southeast Asian*

*Seas: Frontiers for Development*, MacGraw Hill, Singapore.

Menasveta, P. (1997), 'Intensive and efficient shrimp culture system – the Thai way – can save mangroves', *Aquaculture Asia* 2(1): 38-44.

Morgan, J. R. and M. J. Valencia (eds), *Atlas for Marine Policy in Southeast Asian Seas*, University of California Press, Berkeley.

Nomura, Yoshihiro, and Naoyuki Sakumoto (1997), *Environmental Law and Policy in Asia: Issues of Enforcement*, Institute of Developing Economies, Tokyo.

Ong, Augustine S.H. (1987), 'Malaysia', pp. 44-76, in Chia Lin Sien (ed.), *Environmental Management in Southeast Asia*, Faculty of Science, National Univ. of Singapore.

Pauly, D. and V. Christensen (1993), 'Stratified models of large marine ecosystems: a general approach and an application to the South China Sea', pp. 148-174, in K.L. Sherman, M. Alexander and B. D. Gold (eds), *Large Marine Ecosystems: Stress, Mitigation and Sustainability*, Washington, D.C.: American Association for the Advancement of Science, AAAS Press, 376 pp.

Philipps, R.C. (1978), 'Seagrasses and the coastal environment', *Oceanus* 21(3): 30-40.

Ramade, F. (1984), *Ecology of Natural Resources*, Chichester: John Wiley & Sons.

Roop, R., A. Banskrove, S. England, N.N. Sinh and H. C. Thang (1994), *State of Coastal and Marine Environment Report*, ESSA Technologies Ltd. and National Environment Agency, Viet Nam, Hanoi.

Ross, P. (1974), *The Effects of Herbicides in South Viet Nam, Part B*, National Academy of Sciences/National Research Council, Washington D.C., 33 pp.

Ruddle, Kenneth (1981), 'Pollution in the marine coastal environment of ASEAN countries', pp. 136-176, in Chia Lin Sien & C. MacAndrews (eds), *Southeast Asian Seas: Frontiers for Development*, McGraw Hill, Singapore.

Sharifah Mastura (1995), 'Impacts of mineral extraction and tourism on coastal waters: issues and prospects', pp. 113-122, in K.I. Matics and T.L. McDorman (eds), *Summary and Selected Papers of the SEAPOL Tri-regional Conference*, South-

East Asian Programme in Ocean Law, Policy and Management (SEAPOL), Bangkok.

Smith, S.V. (1978), 'Coral reef area and contributions of reefs to processes and resources of the world's oceans', *Nature* 273: 225-226.

Smith, S.V. and Buddemeier, R.W. (1992), 'Global change and coral reef ecosystems', *Ann. Rev. Ecol. Syst.* 23:89-118.

Soegiarto A. (1981), 'The oceanographic features of Southeast Asian waters', pp. 75-109, in Chia Lin Sien and C. MacAndrews (eds), *Southeast Asian Seas: Frontiers for Development*, MacGraw Hill, Singapore.

Soegiarto A. (1985), *Oceanographic Assessment of the East Asian Seas*, UNEP Regional Seas Reports Studies No. 69, Nairobi.

Soegiarto, A. and S. Birowo (eds) (1976), *Atlas of Oceanology of the Indonesian and Adjacent Waters, Book 1: The Present State of Our Knowledge in Indonesia*, National Inst. Oceanology, Jakarta (in Indonesian).

Soegiarto, A. and N. Polunin (1982), *The Marine Environment of Indonesia*, The Government of the Republic of Indonesia, Jakarta.

Silvestre, G. and D. Pauly (1997), 'Management of tropical coastal fisheries in Asia: an overview of key challenges and opportunities', pp. 8-25, in G. Silvestre and D. Pauly (eds), *Status and Management of Tropical Coastal Fisheries in Asia*. ICLARM Conf. Proc. 53, International Center for Living Aquatic Resources Management, Manila, 208 pp.

Sudara, S., Fortes, M., Nateekanjanalarp, Y. & Poovachiranon, S. (1994), 'Human uses and destruction of ASEAN seagrass beds', pp. 110-113, in C.R. Wilkinson (ed.) *Living Coastal Resources of Southeast Asia: Status and Management*, Report of the Consultative Forum Third ASEAN-Australia Symposium on Living Coastal Resources, May 1994, Thailand. Australian Agency for International Development.

Talau-MacManus, L. (1999), *Transboundary Diagnostic Analysis for the South China Sea*, version 4, 25 February 1999, UNEP EAS/RCU, Bangkok. 84 pp + annex.

Tan, Alan K, J. (1998), *Environmental Laws of the South Asian Countries: A preliminary Assess-*

ment, Asia Pacific Centre for Environmental Law (APCEL), Singapore.

Tan, Sumiko (1999), *Home, Work and Play*, Urban Redevelopment Authority, Singapore.

Tomascik, T., Mah, A.J., Nontji, A. & Moosa, M.K. (1997), *The Ecology of the Indonesian Seas. Part 1*, Dalhousie University, 642 pp.

Tuan, V.S. and D.T. Ho (1991), 'The preliminary studies on coral reefs of Nha Trang and Van Phong-Ben Goi Bay', *Collection of Marine Research Works*, Vol.111: 150-158, Nha Trang (in Viet Namease).

Tuan, V.S. (1992), 'Some studies on coral reef degradation in coastal waters of South Viet Nam', pp. 54-59, *National Symposium on the Research and Management of Coastal Zones in Viet Nam*, Hanoi (in Viet Namease).

Tuan, V.S. and Yet N.H. (1995), 'Coral reef and reef building corals of Viet Nam', *Collection of Marine Research Works*, Vol. VI: 118-131.

Wilkinson, C., Gomez, E. & Sudara, S. (1994), 'Status of coral reefs in the ASEAN region', pp. 8-12, in C.R. Wilkinson (ed.), *Living Coastal Resources of Southeast Asia: Status and Management*. Report of the Consultative Forum Third ASEAN-Australia Symposium on Living Coastal Resources, May 1994, Thailand, Australian Agency for International Development.

World Conservation Union (IUCN)(1995), *The Law of the Sea: Priorities and Responsibilities in Implementing the Convention*, A Marine Conservation and Development Report.

World Resources Institute (1996), *World Resources 1996-97*, Oxford: Oxford University Press, 365 pp.

United Nations Environment Programme (UNEP)(1982), *The Review of the Health of the Oceans*, UNEP Reg. Seas Rept and Stud. 16.

United Nations Environment Programme (UNEP)(1990), *GESAMP: The State of the Marine Environment*, UNEP Reg. Seas Rep and Stud. 115.

United Nations Environment Programme (UNEP)(EAS/RCU, 1997). *Integrated Management of Watersheds in Relation to Management and Conservation of Nearshore Coastal and Marine Areas in the East Asian Seas Region: Phase 1 - Assessment*

of Effects of River Discharges of Sediments, Nutrients and Pollutants on Coastal Wetlands, Seagrass Beds and Coral Reefs. A Regional Overview.

United Nations Environment Programme (UNEP)(EAS/RCU (1997), *Integrated Management of Watersheds in Relation to Management and Conservation of Nearshore Coastal and Marine Areas in the East Asian Seas Region: Phase 1 - Assessment of Effects of River Discharges of Sediments, Nutrients and Pollutants on Coastal Wetlands, Seagrass Beds and Coral Reefs. A Regional Overview*. United Nations Environment Programme, Bangkok, RCU/EAS Technical Reports Series No.13. Bangkok, Thailand, 143 pp.

United Nations Environment Programme (UNEP) and Global Environment Monitoring System (GEMS)(1993), *Global Biodiversity*, UNEP/GEMS Environment Library No.11 UNEP, Nairobi.

United Nations Environment Programme (UNEP) and World Conservation Union (IUCN)(1988), *Coral reefs of the world*. Volume 2: Indian Ocean, Red Sea and Gulf. World Conservation Union, Gland, Switzerland and Cambridge, U.K.: IUCN.

Velasquez, I.B. and G.S. Jacinto (1995), 'Wet and dry season nutrient regimes in Manila Bay', pp. 278-284, in D. Watson, K.S. Ong and G. Vigers (eds), *ASEAN Criteria and Monitoring: Advances in Marine Environmental Management and Human Health Protection*, Proceedings of the ASEAN-Canada Midterm Technical Review Conference on Marine Science (24-28 October 1994), Singapore. EVS Environment Consultants, Vancouver and National Science and Technology Board, Singapore.

Veron, J.E.N. (1986), 'Distribution of reef building corals', *Oceanus* (Summer), p. 29.

Veron, J.E.N. (1992), 'Conservation of biodiversity: A critical time for the hermatypic corals of Japan', *Coral Reefs* 11: 13-21.

Wilkinson, C.R. and Buddemeier, R.W. (1994), *Global Climate Change and Coral Reefs: Implications for People and Reefs*. Report of the UNEP-IOC-ASPEI-IUCN Global Task Team on the implication of climate change on coral reefs. IUCN, Gland, Switzerland, pp. x + 24.

Wong, P.P. (1998), 'Beach resorts : the South-east Asian experience', pp. 241-260, in V.R. Sav-

age, L. Kong and W. Neville (eds), *The Naga Awakens: Growth and Change in Southeast Asia*, Singapore: Times Academic Press.

World Resources Institute (1996), *World Resources 1996-97*. Oxford University Press, Oxford, UK, 365 pp.

World Wildlife Fund, Economy and Environment Program for South East Asia (WWF-EEPSEA) (1999), *Indonesia's Fires and Haze: the Cost of Catastrophe*. Institute of Southeast Asian Studies (ISEAS) and Canadian International Development Research Centre (IDRC), Singapore.

Wyrski, K. (1961), *Physical Oceanography of the Southeast Asian Waters*, NAGA Report No. 2, Scripps Inst. Oceanography, La Jolla, Calif.

Editing and printing by:

**G R I D**  
A r e n d a l

Produced by:



**Global Programme of Action for the Protection of the  
Marine Environment from Land-based Activities, The Hague**

**East Asian Seas Regional Coordinating Unit,  
Bangkok**

Additional copies of this and other publications of the Global Programme of Action  
can be obtained from:

GPA Co-ordination Office  
United Nations Environment Programme  
P.O. Box 16227  
The Hague  
The Netherlands

Telephone: (31 70) 311 4460  
Fax: (31 70) 345 6648  
Email: [gpa@unep.nl](mailto:gpa@unep.nl)