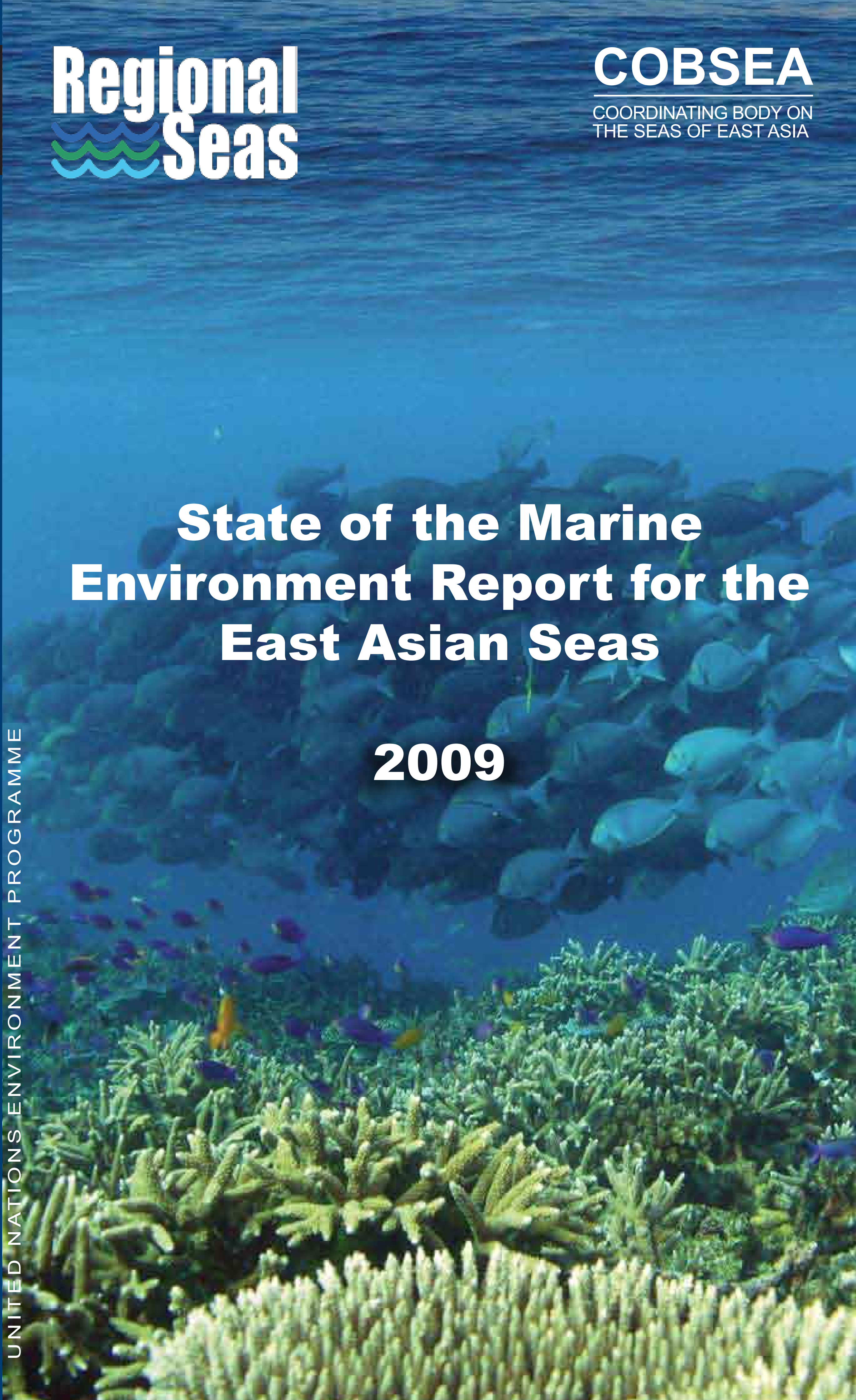
UNEP

Regional Seas

COBSEA

COORDINATING BODY ON THE SEAS OF EAST ASIA



State of the Marine Environment Report for the East Asian Seas

2009

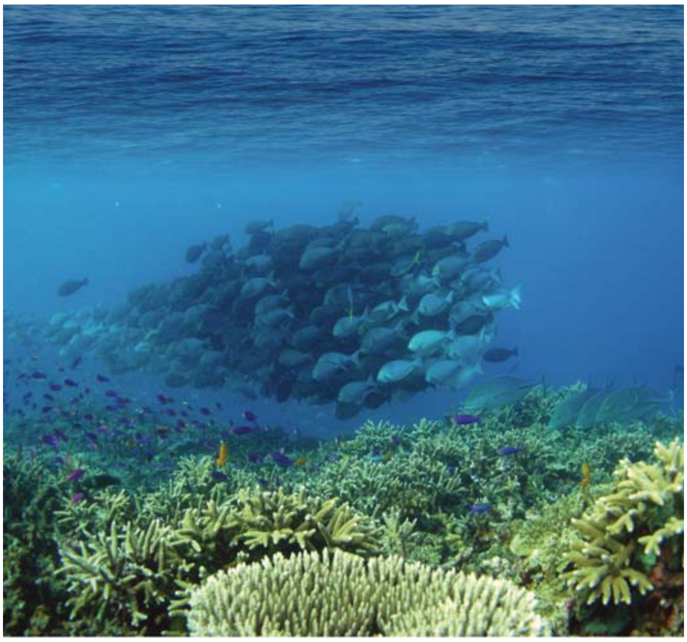
UNITED NATIONS ENVIRONMENT PROGRAMME

Regional Seas

COBSEA
COORDINATING BODY ON
THE SEAS OF EAST ASIA

State of the Marine Environment Report for the East Asian Seas

2009



State of the Marine Environment Report for the East Asian Seas 2009.

Acknowledgements: This Report was prepared for the Coordinating Body on the Seas of East Asia (COBSEA) of the United Nations Environment Programme (UNEP).

UNEP/COBSEA is grateful to Dr. CHOU Loke Ming (Professor, Department of Biological Sciences, National University of Singapore) for heading this project and developing the report as Chief Editor. He was assisted by research assistants, Dr. Zeehan Jaafar and Mr. Michael Meadows. UNEP thanks the following institutions and regional experts for their contributions, on which this report is based:

Institutions:
Southeast Asian Fisheries Development Center (SEAFDEC)
Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)
Coordinating Unit, UNEP-GEF project "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand

Regional experts:
Dr. Gullaya Wattayakorn (Chulalongkorn University, Bangkok, Thailand)
Dr. WONG Poh Poh (National University of Singapore)
Ms. Karenne TUN Phyu Phyu (National University of Singapore)

UNEP also acknowledges the COBSEA National Focal Points and the reviewers Dr. Beverly Goh, Pro. Edgardo Dizon Gomez, Dr. Ljubomir Jeftic, Mr.Vellayutham Pachaimuthu and Dr. Ellik Adler for their constructive comments and inputs.

The preparation of this report was financed by UNEP/COBSEA

For bibliographic purposes, this document may be cited as:
UNEP/COBSEA, 2010. State of the Marine Environment Report for the East Asian Seas 2009. Ed. Chou, L.M., COBSEA Secretariat, Bangkok. 156 p.
ISBN: 978-92-807-3070-8

UNEP promotes environmentally sound practices globally and in its own activities. This publication is printed on 100% recycled paper, using vegetable – based inks and other eco-friendly practices. Our distribution policy aims to reduce UNEP's carbon footprint.

CONTENTS

CONTENTS *(continued)*

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES *(continued)*

PREFACE

The Coordinating Body on the Seas of East Asia (COBSEA) consists of ten member countries: Australia, Cambodia, the People's Republic of China (henceforth referred to as China), Indonesia, Republic of Korea, Malaysia, the Philippines, Singapore, Thailand and Viet Nam. COBSEA was formed in 1981 by the original five member states of ASEAN (Indonesia, Malaysia, Philippines, Singapore, and Thailand) as a UNEP Regional Seas Programme to oversee the implementation of the "Action Plan for the Protection and Sustainable Development of the Marine and Coastal Areas of the East Asian Seas Region", commonly referred to as the East Asian Seas Action Plan. Its membership was expanded subsequently to the present composition of ten countries. The East Asian Seas Regional Coordinating Unit (EAS/RCU) acts as the secretariat of COBSEA. China and Republic of Korea participate in the North West Pacific Regional Seas Programme while Australia in the Pacific Regional Seas Programme. For the purpose of this report, the entire sea area of these countries are included.

Information management and state of marine environment reporting are some of the fundamental components of the East Asian Seas Action Plan. At the 18th Meeting of COBSEA in Sanya, China, 24-25 January 2006, the need for improved information management on coastal and marine data and activities was re-emphasized by the COBSEA member countries and it was decided that COBSEA should give this aspect a higher priority. It included the development of an East Asian Seas Knowledgebase initiated in 2006, meant to improve information flow regarding the state of the marine environment, and ongoing activities dealing with the coastal and marine environment. Complementing this, a pilot national database on the state of the marine environment is also being developed by Viet Nam's Environmental Protection Agency.

The 2009 East Asian Seas State of the Marine Environment Report (EAS SOMER) presents current information regarding the present state of and outlook for the region's marine and coastal environment, and is intended to enhance COBSEA's activities on information management in support of improved policy implementation towards sustainable coastal and marine development in the East Asian Seas (EAS) region. Trends were analysed based on information over a 25-year period between 1981 and 2006 with new information up to 2009 included as far as is possible, and the outlook for the region is projected up to 2012.

The report has been prepared with the intention of providing the latest scientifically credible information in order to raise awareness amongst policy makers and the general public regarding the state and trend in the region's marine environment through a number of facets:

- Presenting the current status and projected trends for the coastal and marine environment.
- Analyzing all ongoing management initiatives at national and regional levels.
- Identifying emerging coastal and marine environmental issues.
- Analyzing case studies (e.g. economic valuation), best practices, and effective management measures to address current and emerging coastal and marine environmental concerns.

In the preparation of this report, the findings and recommendations of a number of recent and relevant regional reports have been incorporated, including the Sustainable Development Strategy for the Seas of East Asia (PEMSEA, 2003), the Third ASEAN State of the Environment Report 2006 (ASEAN, 2006), and the Strategic Action Programme for the South

China Sea (UNEP, 2008). Other more recent initiatives such as the Regional Plan of Actions of the Coral Triangle Initiative adopted in May 2009 through the Coral Triangle Declaration were also taken into account.

The close collaboration with partner organizations and experts from the East Asian Seas region and the information that they provided greatly facilitated the development of the report. The partner organizations and the information that they contributed were the Southeast Asian Fisheries Development Center (SEAFDEC) on fisheries, Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) on the geophysical environment and natural disasters, and the Coordinating Unit of the UNEP/GEF project “Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand” on economic valuation. Regional consultants and their areas of contribution were Dr. Gullaya Wattayakorn from Chulalongkorn University (water quality), Ms. Karenne Tun from the National University of Singapore (coastal habitats), and Dr. Wong Poh Poh from the National University of Singapore (climate change). The constructive criticisms of the independent reviewers and national focal points all helped to significantly augment the value of this report.

Loke Ming CHOU

(National University of Singapore)

LIST OF ACRONYMS

ADB	Asian Development Bank
ASEAN	Association of Southeast Asian Nations
BOD	Biochemical Oxygen Demand
bscfd	Billion Standard Cubic Feet Per Day (measure of natural gas production)
bstb	Billion Stock-Tank Barrels (measure of oil reserves)
CCRF	Code of Conduct for Responsible Fisheries
COBSEA	Coordinating Body on the Seas of East Asia
COD	Chemical Oxygen Demand
CPUE	Catch per Unit Effort (measure of fisheries efficiency)
DDT	Dichloro-diphenyl-trichloroethane
DO	Dissolved Oxygen
DSP	Diarrhetic Shellfish Poisoning
EAS	East Asian Seas
EAS/RCU	East Asian Seas Regional Coordinating Unit
ESA	European Space Agency
EEZ	Exclusive Economic Zone
ESD	Ecological Sustainable Development
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GDP	Gross Domestic Product
GNI	Gross National Income
GT	Gross Tonnage
HAB	Harmful Algal Bloom
HCH	Hexachlorocyclohexane
ICZM	Integrated Coastal Zone Management
IMO	International Maritime Organization
IPCC	Intergovernmental Panel on Climate Change
ITQs	Individual Transformed Quotas
IUU	Illegal, Unregulated and Unreported (fishing)
kbpd	Thousand Barrels per Day (measure of oil production)
LAFG	Lost and Abandoned Fishing Gear
LMEs	Large Marine Ecosystems
MARPOL	International Convention for the Prevention of Pollution from Ships
MCS	Monitoring, Control and Surveillance

MPA	Marine Protected Areas
MSY	Maximum Sustainable Yield
NPOA	National Plan of Action
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
POPs	Persistent Organic Pollutants
PPP	Purchasing power parity
PSP	Paralytic Shellfish Poisoning
RPOA	Regional Plan of Action
RTF-E	Regional Task Force on Economic Valuation
SAP	Strategic Action Programme
SDS-SEA	Sustainable Development Strategy for the Seas of East Asia
SEAFDEC	Southeast Asian Fisheries Development Center
SLR	Sea Level Rise
SWQS	Sea Water Quality Standard of China
TAC	Total Allowable Catch
TBT	Tributyl Tin
tscf	Trillion Standard Cubic Feet (measure of natural gas reserves)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP SCS	United Nations Environment Programme South China Sea
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

The East Asian Seas (EAS) region stretches from the northern to the southern hemisphere of the western Pacific Rim, with the link between the Pacific and Indian Oceans separating the eastern part of the Asian continent from the Australian continent. Almost all COBSEA member countries have extensive coastlines and a combined sea area equivalent to about 30% of the world's sea space under national jurisdiction. The region therefore has a large influence and a major role in maintaining the health of earth's marine environment.

The region's coastal and marine ecosystems are among the richest and most productive in the world and are of vast social and economic importance. However, dynamic economic development and rapid population growth have dominated the coast at tremendous pressure on coastal and marine ecosystems. Almost 75% of the region's human population of almost 2 billion live in the coastal area. Together with swift coastal development, the pressures manifest in unsustainable resource exploitation and environmental degradation. Intensifying the concern are threats from climate change and natural hazards.

Trends are examined for socio-economic status, exploitation of resources (both renewable and non-renewable), environmental quality and vulnerability to natural hazards. The process and thinking underlying a regional approach to the economic valuation of the coastal and marine environment is described as the lessons are applicable for policy formulation.

There is growing awareness to manage the marine environment and its resources and various strategies have been adopted. In response to the current state of the region's marine and coastal environment, and in view of the future trends and threats identified, a number of recommendations for action are proposed. Importantly, the actions being advocated are not only a response to the current threats facing the region, but also an attempt to account for future threats and trends that have been identified and discussed in the report.

The greatest priority for all member countries would be the development and rapid implementation of improved management strategies, which are capable of integrating economic and environmental concerns more cohesively, facilitating improved data collection and management, encouraging greater stakeholder participation and community ownership more actively, and adopting and adhering to international conventions more extensively.

Other priorities include the improved management and regulation of the fisheries industry, especially with respect to the rapid growth of aquaculture throughout the region and the potential dangers that this poses. Also important is the need to address emerging problems such as marine litter and invasive species as early as possible, before they become much larger and more costly to manage.

Measures to prevent or mitigate the various damages associated with different kinds of natural disasters are equally important, especially in light of the increasing frequency and severity of those disasters related to climate change. Recommendations to improve climate change adaptation capabilities include: improving access to high quality information on climate change impacts, setting early warning and information dissemination systems to enhance disaster preparedness, reducing vulnerability of livelihoods and infrastructure to climate change, promoting effective governance, empowering communities and stakeholders to participate more energetically in vulnerability assessment and adaptation implementation, and mainstreaming climate change into development planning at all levels and sectors.

Encouragingly, with increased awareness of environmental problems and a growing political will to devote the necessary resources to developing solutions, there is much that can be done to address the current problems facing the region and to prevent – or at least mitigate – the impacts of future problems.

The report highlighted that the capacity to deal with these problems differs widely across the region because of varying socio-economic situations. The state of the marine environment differs among countries because of varying pressures and intensity, and capacity building remains a need particularly for those countries that face enormous pressures. Regional capacity development and transfer are of paramount importance to all member countries. There is great opportunity for regional capacity transfer as the experiences gained across the region are varied and valuable to all. National efforts can then be consolidated and combined to strengthen the region's capacity to address the common goal of improved sustainability of the coastal and marine environment.

CHAPTER 1: INTRODUCTION

Coastal and marine ecosystems of the East Asian Seas (EAS) region (Figure 1) are among the richest and most productive in the world and of enormous social and economic importance to the region's countries. Historically, the coastal zones have been the site of, and often the drive for the region's most dynamic economic development and population growth. Globally, 2.2 billion people or 39% of the population (1995 figures) live within 100 km from the coast (WRI, 2008e). Despite the undeniable economic gain from coastal development, tremendous pressures on coastal and marine ecosystems increasingly compromise their sustainable use. It is vitally important that these pressures be better monitored, understood and managed, and translated into a more effective and integrated management system that achieves the necessary balance between current social and economic needs, and conservation for future needs.

The EAS countries support almost two billion people making the region one of the world's most populous, with almost 75% concentrated in the coastal areas (see Chapter 2). The continuing growth trend of coastal settlements and urbanization poses a great threat to fragile and globally-significant coastal ecosystems.

One of the main reasons for the region's high marine biodiversity and production (accounting for more than 40% of the world's total fish catch), is that it contains almost half of the world's coral reefs (Wilkinson, 2008). While some of these reefs are still fairly healthy, the majority particularly those close to populated coastal areas have suffered serious degradation from pollution, over-fishing, destructive fishing, sediment discharge and unsustainable tourism. It has been suggested that if management strategies do not improve soon, the region risks losing much of its healthy reefs over the coming decade (Wilkinson, 2004). The coral reefs of Southeast Asia alone are estimated to generate goods and services valued at US$ 112.5 billion annually (PEMSEA, 2003).

A number of other important coastal habitats are currently at risk as well, particularly in light of the high and ever-rising rate of coastal infrastructure development that is often poorly regulated, shipping activity that is one of the world's highest, and unsustainably high fisheries production. The result is direct loss of many major coastal habitats including mangroves, seagrass, wetlands and salt-marshes, whose significance is derived from the range of essential services that they provide, including coastal protection and stabilization, biodiversity reservoir, nursery function and environmental conditioning.

All of these activities cause the ongoing degradation of water quality due to pollution from industrial, domestic, agricultural and maritime sources, and the loss of both diversity and abundance of fisheries stocks. Despite this, both marine and coastal fisheries production has continued to increase significantly over the last decade, especially with the introduction of modern fishing methods, but demand still exceeds production. However, it is becoming increasingly evident that current exploitation rates are unsustainable and must be reduced if permanent damage to the environment and fisheries is to be avoided. To make up for the inevitable shortfall in supply, aquaculture activities are growing throughout the region. The EAS region provided 87% of the global aquaculture production in 1992 (FAO/RAPA, 1994). Aquaculture expansion has its impact on the coastal areas through exotic species introduction, increased use of chemicals, excess nutrients, and habitat clearing and conversion. As a result, aquaculture has been cited as a major cause of the destruction of over 3 million hectares of Southeast Asia's mangrove forests (UNEP, 1999b).

Figure 1: **Map of the East Asian Seas region, showing the ten COBSEA member countries and the major seas**

There are indications of a steady decline in quality of the region's marine and coastal waters resulting from oil spills and other contaminants from shipping, sewage and other domestic wastes, industrial effluents, and urban and agricultural run-off. The levels of suspended solids in Asia's rivers have quadrupled since the late 1970s (ADB, 2001) and two-thirds of the world's total sediment transport to oceans occur in Southeast Asia (UNEP, 1999a). One of the most serious issues is the decline in water quality caused by rising levels of nutrients from land-based sources. This is a major factor in the increased risk of harmful algal blooms HABs, which have become a strong concern in several EAS countries, including Australia, China, Republic of Korea and the Philippines (UNEP, 1999b).

Despite these growing pressures and adverse impacts on the coastal environment, the importance and popularity of coastal tourism have grown steadily throughout the region. Several countries now depend heavily on the income derived from this sector. However, the high rate of construction and development of tourism infrastructure has placed further pressure on coastal environments, through infilling, dredging, discharge of untreated or partially treated sewage, operational leaks, waste dumping, and the erosion of sand dunes by tourism activities.

Global warming and associated changes in climate and sea-level are also predicted to have significant negative impacts on the region's coastal areas in the near future. Regional climatic changes have already affected marine ecosystems in many parts of the world including the EAS region. It is forecasted that global warming, through higher evaporation rates, will result in more extreme weather events and associated disasters, such as typhoons, storms, floods and coastal erosions that will affect the coastal environment and populace. Warming waters will also adversely affect the survival rates of marine species with low thermal tolerance, such as corals.

Rising sea-levels will inundate low-lying coastal wetlands, other flat and low elevation coastal areas and coastal cities, resulting in land loss, population displacement, and socio-economic impacts that affect a number of sectors, such as agriculture, coastal aquaculture, and coastal tourism. The cost of response measures to reduce the impact of sea-level rise is potentially immense. For this reason, it is essential that global environmental issues such as warming trends are acted on early, whilst simultaneously addressing the more immediate economic, social and environmental issues confronting each of the EAS countries.

Finally, the devastating effects of the Indian Ocean tsunami in 2004 highlighted the need for an increased focus on disaster prevention and response, especially in coastal areas. In addition to the human tragedy and widespread destruction of infrastructure, the environmental impacts of natural disasters include increased coastal erosion and the destruction of important habitats. Improved and integrated coastal development planning and the strengthened implementation of policies and plans to prevent and respond to coastal natural disasters are now being given increasing priority by the EAS countries.

CHAPTER 2: SOCIO-ECONOMIC DEVELOPMENT (1981-2006)

The East Asian Seas (EAS) region accounts for 14 of the world's 64 semi-enclosed and interconnected Large Marine Ecosystems (LMEs). Seven are distributed along the borders of Cambodia, China, Indonesia, Republic of Korea, Malaysia, Philippines, Singapore, Thailand and Viet Nam, and another seven along that of Australia. They are globally-significant, rich in natural resources, extensively linked by large-scale atmospheric, oceanic, and biological processes such as ocean currents and species migration, and of great ecological, social, and economic importance to the region (IISD, 2006; PEMSEA, 2003).

The extent of coastlines varies greatly between the ten COBSEA countries, with Singapore having the shortest coastline of 246 km and the Indonesian archipelago the longest at 81,290 km (Table 1). According to recent estimates, close to 75% of the region's human population of almost 2 billion live in the coastal area (WRI, 2008e). Cambodia and China have the lowest proportion of costal populations at 24% each, while for the Philippines, Republic of Korea and Singapore, the entire population lives within 100 km of the coast.

Human civilizations and their accompanying cities have historically evolved along the banks of rivers and lakes, or in deltas and along coastlines. Of these, coastal areas have always been the preferred location for human settlements, and this still holds true today. Cities located near the sea have an obvious advantage of access to sea trade routes. Proximity to the sea is therefore an important factor in the economic and demographic growth of cities.

Table 1: Coastline extent and percentage of population living within 100 km of the coast (COBSEA countries and globally)

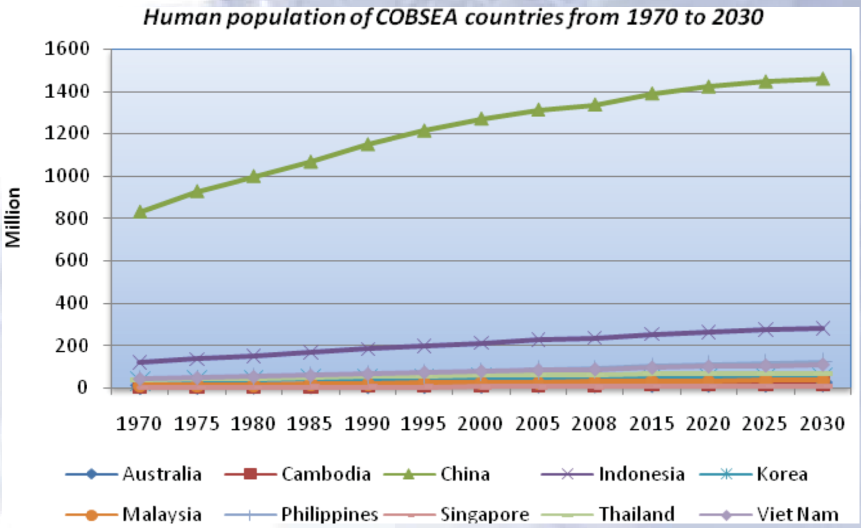
	Coastline Extent (km)	Coastal Population (percentage within 100 km of coast)
Australia	59,736 [a]	89.8
Cambodia	443 [b]	23.8
China	32,000 [c]	24
Indonesia	81,290 [c]	95.9
Republic of Korea	11,542 [c]	100
Malaysia	4,809 [d]	98
Philippines	26,289 [e]	100
Singapore	246 [f]	100
Thailand	2,880 [g]	38.7
Viet Nam	3,260 [e]	82.8
COBSEA Countries	**222,495**	**73.7**
World	**1,634,700** [h]	**39**

[a] Includes islands, ABS, 2008.
[b] National Institute of Statistics Cambodia, 2006.
[c] PEMSEA, 2003.
[d] Department of Irrigation & Drainage Malaysia, 2008.
[e] CIA, 2008.
[f] Singapore Department of Statistics, 2008.
[g] World Bank, 2007c.
[h] WRI, 2008b.

2.1 SOCIAL DEVELOPMENT

The population of the ten COBSEA countries, just over 1.9 billion in 2008, is expected to reach 2.2 billion in 2030 (Figure 2). Population growth rates remained positive but have gradually decreased in all countries, from just over 2% for the period 1970-1975 to 1.3% in 2000-2005 (Figure 3). This is projected to decrease further to 0.6% in 2025-2030. From 2005, the region's population growth rate is projected to dip below the average global rate. The greatest increase in the region's population is mostly attributed to China's population growth.

(a)



(b)

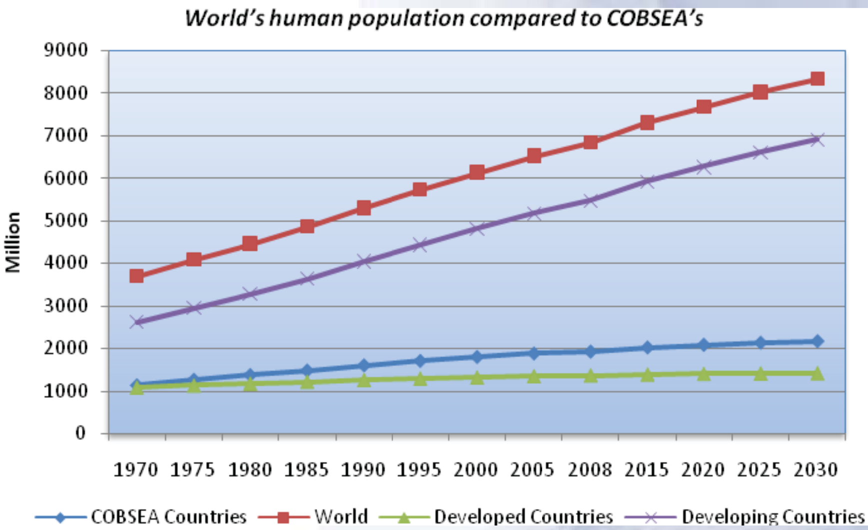
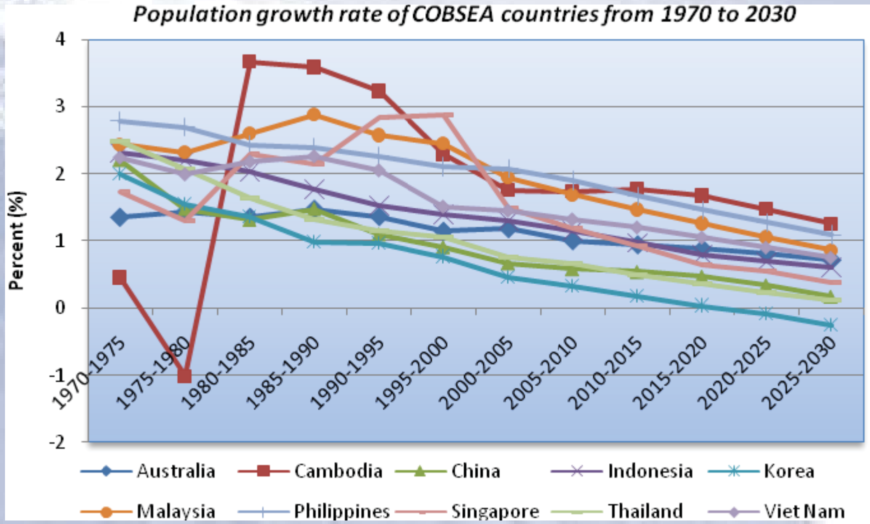


Figure 2: Changes in actual and projected total populations between 1970 and 2030 within: (a) the COBSEA countries; and (b) globally
Adapted from: WRI, 2008e.

(a)



(b)

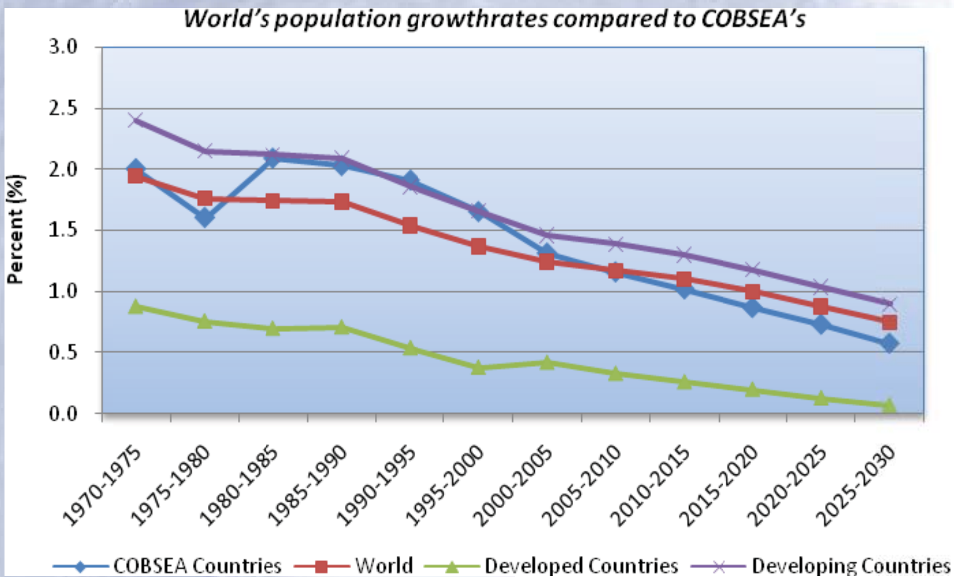


Figure 3: Changes in actual and projected population growth rates between 1970 and 2030 (five-yearly averages) of: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008e.

The region as a whole is highly urbanized, with populations fast transforming from rural to urban. In 1980, about 42% of COBSEA countries' population lived in urban areas. This proportion is estimated to grow to 69% (a regional total of 1.5 billion people) by 2030, a rate of increase that is about 9% higher than the global average. Currently, at least 50% of the combined population of Singapore, Australia, Republic of Korea, Malaysia and the Philippines live in urban areas, with Indonesia and China projected to join this list by 2030 (Figure 4).

Although coastal zones do not usually constitute a large proportion of total land area, they tend to be the most urbanized, with the country's largest cities typically located near the sea, along a river bank, or in a delta. With increasing migration from rural to urban areas, the number and density of coastal urban cities are also projected to increase. Coastal settlements that have developed into major EAS cities are among the most populated in the world. Five of the 21 global megacities (cities in excess of 10 million inhabitants) are located in the region (Demographia, 2007) and it is estimated that more cities will achieve this status within the next five decades.

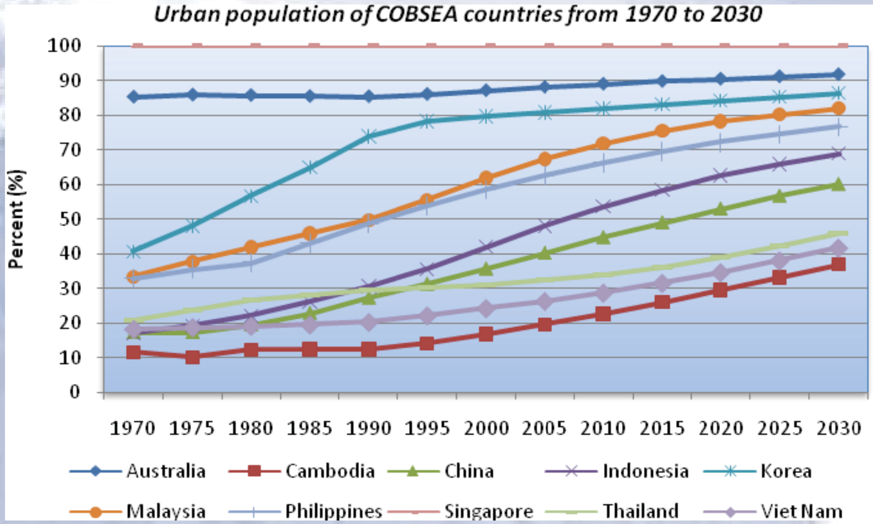
World's top 21 megacities (urban areas with a population over 10 million), of which 5 (shaded rows) are in coastal areas of COBSEA member countries.

Rank	Country	Urban Area (Urban Agglomeration)	2005 Population	Year of Base Population Estimate[1]	Base Population Estimate	Land Area Estimate (km^2)	Estimated Density (km^2)
1	Japan	Tokyo-Yokohama	34,250,000	2005	34,250,000	7,835	4,350
2	New York	New York	20,160,000	2000	19,712,000	11,264	1,750
3	Korea	Seoul-Incheon	19,850,000	2002	19,500,000	1,943	10,050
4	India	Mumbai	18,550,000	2001	17,000,000	648	26,250
5	Indonesia	Jakarta	18,200,000	2005	18,200,000	3,108	5,850
6	Mexico	Mexico City	18,100,000	2005	18,100,000	2,525	7,150
7	Brazil	Sao Paulo	17,800,000	2005	17,800,000	2,784	6,400
8	India	Delhi	17,380,000	2001	15,250,000	1,360	11,200
9	Japan	Osaka-Kobe-Kyoto	17,250,000	2005	17,250,000	3,497	4,950
10	Philippines	Manila	16,750,000	2005	16,750,000	1,334	12,550
11	Egypt	Cairo	15,500,000	2006	15,750,000	1,554	10,150
12	United States	Los Angeles	15,080,000	2000	13,829,000	5,812	2,400
13	India	Kolkata	14,090,000	2001	13,217,000	984	13,450
14	Russia	Moscow	14,000,000	2005	14,000,000	3,885	3,600
15	China	Shanghai	13,900,000	2004	13,600,000	2,979	4,550
16	Argentina	Buenos Aires	13,220,000	2001	12,740,000	2,979	4,300
17	China	Beijing	11,540,000	2004	11,250,000	3,043	3,700
18	China	Shenzhen	11,000,000	2005	11,000,000	1,295	8,500
19	Brazil	Rio de Janeiro	10,900,000	2005	10,900,000	1,580	6,900
20	Turkey	Istanbul	10,670,000	2004	10,500,000	1,256	8,350
21	Paris	Paris	10,400,000	2005	10,400,000	3,043	3,400

Source: Demographia Urban Areas Database (http://www.demographia.com/db-megacity.pdf).

[1] 2005 estimate based upon growth rate from base year.

(a)



(b)

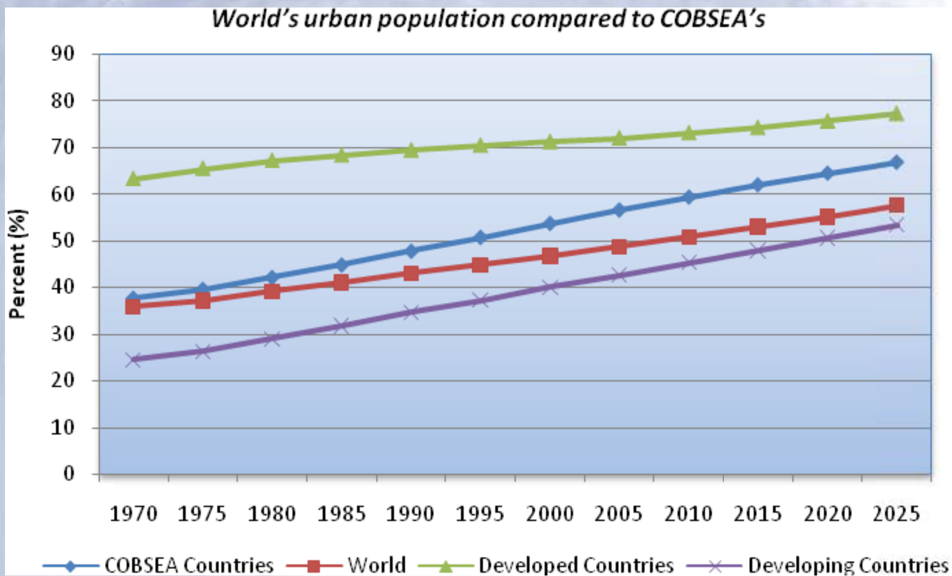


Figure 4: Changes in actual and projected urban population proportion (%) between 1970 and 2030 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008e.

Economic disparity varies greatly within the region. In 2007, the Gross National Income (GNI) per capita at Purchasing Power Parity (PPP) ranged from 47,950 current international US$ for Singapore to 1,720 current international US$ for Cambodia (Figure 5). The GNI per capita refers to the dollar value of a country's final income in a year divided by its population, and reflects the average income of a country's citizens. The GNI for Australia, Republic of Korea, Singapore and Malaysia, countries ranked as upper middle to high economies, were higher than the global average GNI of 9,947 current international US$. The average regional GNI of 14,425 current international US$ was higher than the global average, although the value was inflated largely by the elevated GNI of Australia, Republic of Korea and Singapore. The regional economic disparity parallels many other social, economic and environmental indicators like average life expectancies, literacy rates, education access to safe water and GDP (gross domestic product) (Table 2).

Interestingly, all stages of national economic development are represented in the ten COBSEA countries (World Bank, 2009).

COBSEA countries classification of economies based on 2008 GNI per capita using the World Bank Atlas method (World Bank, 2009)

Low	Middle		High
	Lower	Upper	
Cambodia	China	Malaysia	Australia
Viet Nam	Indonesia		Rep of Korea
	Philippines		Singapore
	Thailand		

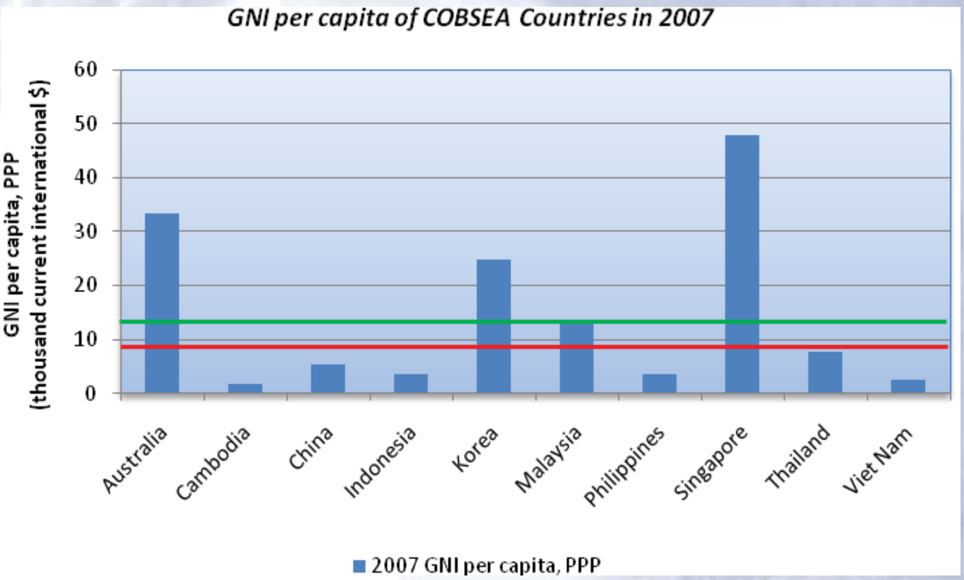


Figure 5: GNI per capita (PPP, current international US$) in 2007 (The World Bank, 2009). Green line: average regional GNI. Red line: average global GNI

The United Nations Development Programme (UNDP) Human Development Index (HDI), which combines normalized measures of life expectancy, literacy, educational attainment, and GDP per capita for countries worldwide, is a standardized measure of human development that reflects a country's overall development (UNDP, 2008). Of the 179 countries assessed globally, Australia is the third highest ranked nation in the world, with Singapore, Republic of Korea and Malaysia joining Australia in the High Human Development group (Table 2). The remaining six countries are positioned within the Medium Human Development category, and no COBSEA country is placed within the Low Human Development category. Unlike the GNI, the GDP per capita is more reflective of the HDI ranking.

Poverty varied within the region, with the populations of Australia, Republic of Korea and Singapore free from poverty (Table 2). Poverty rates varied considerably between the remaining COBSEA counties, with the Philippines having the highest proportion of the population (36.8%) living below the national poverty line. However, the national poverty lines differed between countries, and the percentage of population living below US$ 2 per day was higher than the percentage living below national poverty lines in Thailand, China, Philippines, Indonesia and Cambodia.

Table 2: Selected socio-economic indicators for COBSEA countries

Human Development Index (HDI) Rank of COBSEA country		HDI	Adult literacy rate (% aged 15 and older) [a]	Life expectancy index	Education index	GDP index	GDP, PPP (current intl US$ billion)	GDP per capita, PPP (2005 int/ US$) [b]	GNI per capita, PPP (int/ US$) [c]	Population living below the national poverty line (%)	Population living below US$ 2/ day (%)
		2005	1995-2005				2005	2005	2007	1990-2004[d]	1990-2005 [d]
High Human Development											
3	Australia	0.962	..	0.931	0.993	0.962	646.3	31,794	33,400	..	..
25	Singapore	0.922	92.5	0.907	0.908	0.95	128.8	29,663	47,950	..	..
26	Republic of Korea	0.921	..	0.882	0.98	0.9	1,063.9	22,029	24,840	..	<2
63	Malaysia	0.811	88.7	0.811	0.839	0.783	275.8	10,882	13,230	15.5[b]	9.3
Medium Human Development											
78	Thailand	0.781	92.6	0.743	0.855	0.745	557.4	8,677	7,880	13.6	25.2
81	China	0.777	90.9	0.792	0.837	0.703	8814.9[g]	6757	5,420	4.6	34.9
90	Philippines	0.771	92.6	0.767	0.888	0.657	426.7	5,137	3,710	36.8	43
105	Viet Nam	0.733	90.3	0.812	0.815	0.572	255.3	3,071	2,530	28.9	..
107	Indonesia	0.728	90.4	0.745	0.83	0.609	847.6	3,843	3,570	27.1	52.4
131	Cambodia	0.598	73.6	0.55	0.691	0.552	38.4[i]	2727	1,720	35	77.7

[a] Data refer to national literacy estimates from censuses or surveys conducted between 1995 and 2005, unless otherwise specified. Due to differences in methodology and timeliness of underlying data, comparisons across countries and over time should be made with caution. For more details, see http://www.uis.unesco.org/.

[b] GDP values expressed in 2005 constant prices.

[c] Data from The World Bank, 2008. World Development Indicators Online. Washington, D.C.: The World Bank.

[d] Data refer to the most recent year available during the period specified.

For complete description of data sources, refer to Human Development Report 2007/2008 (http://hdr.undp.org/en/statistics/data/)

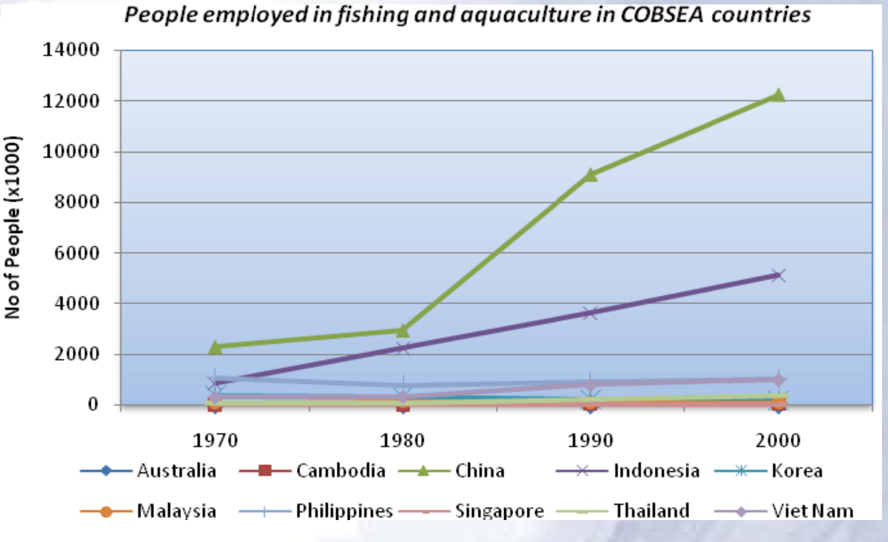
2.2 COASTAL DEVELOPMENT

A relatively large proportion of economic activity has traditionally been concentrated in coastal cities, where an estimated 80% of the region's incremental economic activity takes place. A significant proportion of the region's population depends directly or indirectly on the coastal and marine environment for nutrition, materials and income. Coastal ecosystems of the EAS region contribute significantly to the socio-economic enrichment of coastal establishments.

Today, coastal activities have greatly diversified, with traditional resource-based practices such as fisheries, aquaculture, forestry, and agriculture giving way to more profitable ones such as heavy industry, shipping, and tourism. The coastal zone has facilitated trade, commerce and economic growth for centuries through vast maritime and shipping networks, and played a pivotal role in social and cultural development, binding the region's people together through common beliefs, practices and traditions. This, as well as the perceived availability of greater economic opportunities in coastal cities, is a strong attraction, drawing people from the often economically depressed rural areas. These future coastal residents will require employment, housing, energy, food, water, and other goods and services, presenting a substantial development challenge (PEMSEA, 2003).

Despite widespread economic diversification, fisheries remain one of the major economic activities along the region's coastal area, with a large proportion of local people still dependent on marine food production for their living. In 2000, over 20 million people in the region were dependent on fisheries for a major portion of their livelihood, accounting for a staggering 58% of the global total (Figure 6).

(a)



(b)

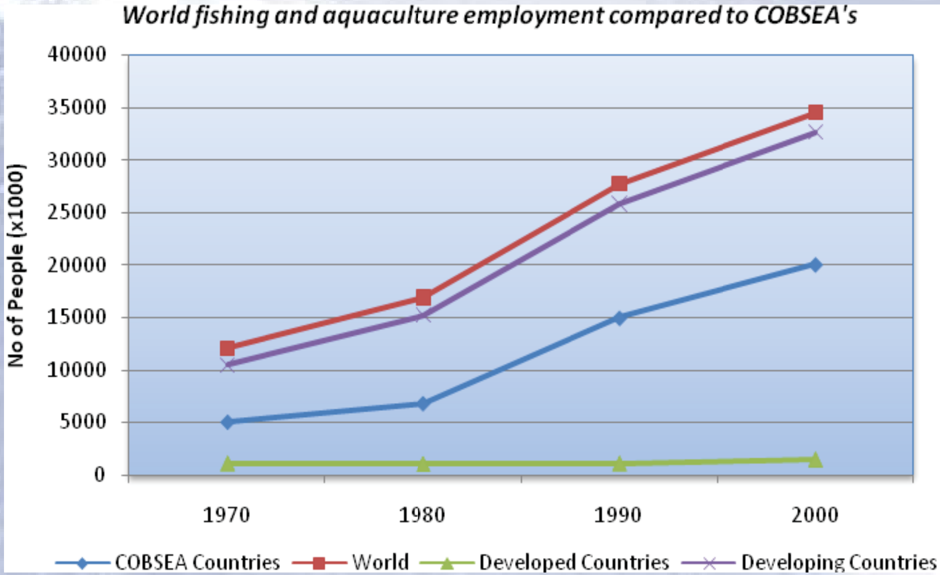


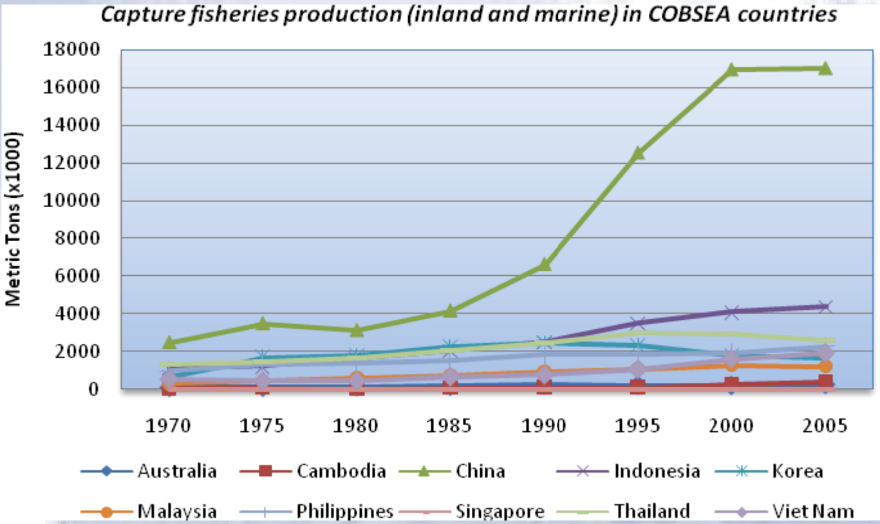
Figure 6: Changes in the total number of people employed in fishing and aquaculture between 1970 and 2000 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008b.

Coastal, inland, and marine capture fisheries in the EAS region have been increasing since the 1970s in direct contrast to global trends and accounted for about half of the global capture production in 2005. Much of this may be attributed to China and, to a lesser extent, Indonesia. However, regional capture production began to plateau between 2000 and 2005 (Figure 7). With over 60% of the world's fisheries stock either over-exploited or fully exploited, and a further 20% moderately exploited, there is a clear danger of a fisheries crisis in the region (World Bank, 2005b). This is reflected by reported decreases in the mean size of individual fish, the value of catches, increased catch-per-unit-effort, and the deployment of better-equipped vessels with highly efficient gear. As it becomes harder to catch large, valuable fish, fishers switch their targets and gear to take smaller and often less valuable species, resulting in the systematic removal of fish down the food chain.

> Marine and particularly fresh water fisheries play a significant role in Cambodia's national economy, and are a major source of employment and income for people in rural areas. Recent estimates indicate that four million people (about 29% of the country's population) derive employment from fisheries-related activities.

In addition, the influx of large and well-equipped commercial fishing fleets places a strain on small-scale, artisanal fishers. This is especially true for the EAS region, where a substantial proportion of rural coastal populations still depend heavily on small-scale, low-technology fishing techniques for a living.

(a)



(b)

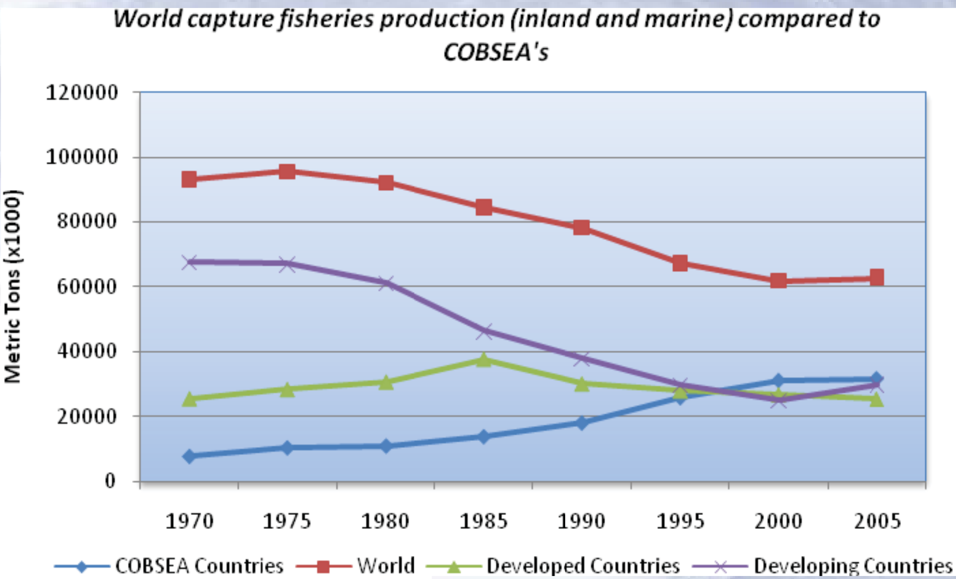
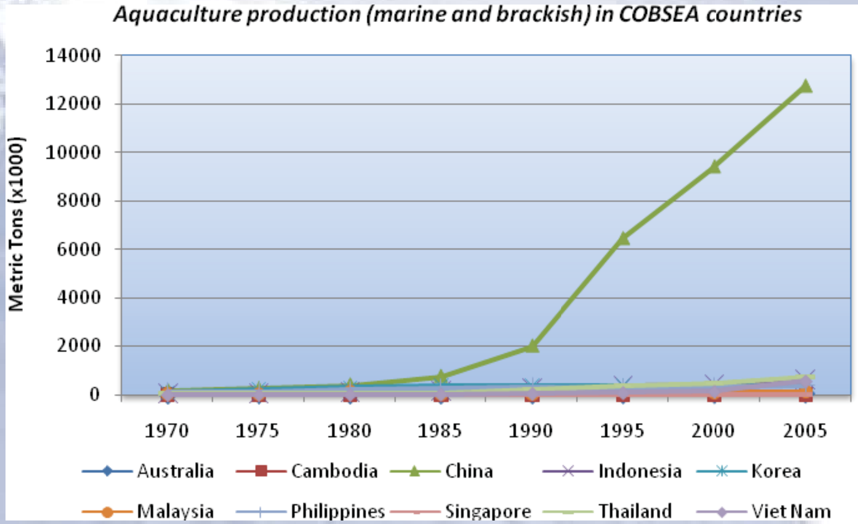


Figure 7: Changes in the total inland and marine fisheries capture production between 1970 and 2005 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008b.

While global capture fisheries have been declining since the 1970s, marine and brackish aquaculture production have increased significantly. Aquaculture production between 1970 and 1985 was relatively low at regional and global levels. In 1985, it accounted for about 19% and 3.6% of total fisheries production, in the EAS region and the world, respectively. However, it has increased significantly since then, with figures reaching 27% and 13%, respectively, in 2005. By this time, aquaculture production totalled almost half of the capture production in the EAS region, and contributed almost 80% of global aquaculture production. Much of this was contributed by China (Figure 8).

(a)



(b)

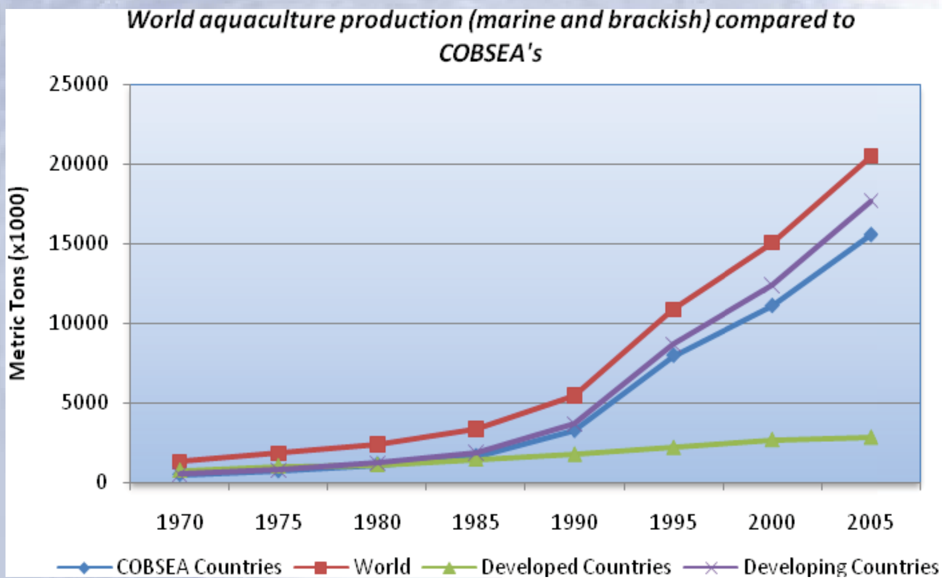
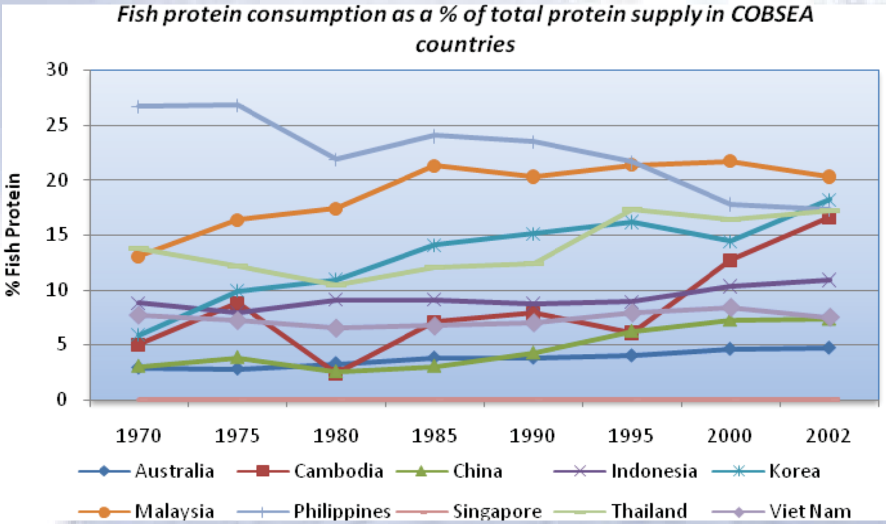


Figure 8: Changes in total aquaculture production between 1970 and 2005 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008b.

Despite the region's significant contribution to global fisheries production, export contributed only 25% of the total fisheries-related income. As well as relevant economic factors, this disparity is likely linked to factors such as the low value of target species, export quality of fisheries products, and high local consumption resulting in lower capture-to-export quantity ratios. With the exception of the Philippines, there was a general increase in fish consumption from 1970 to 2002, with fish accounting for 12% of the total animal protein intake in the EAS region. This is slightly more than double the global average (Figure 9).

(a)



(b)

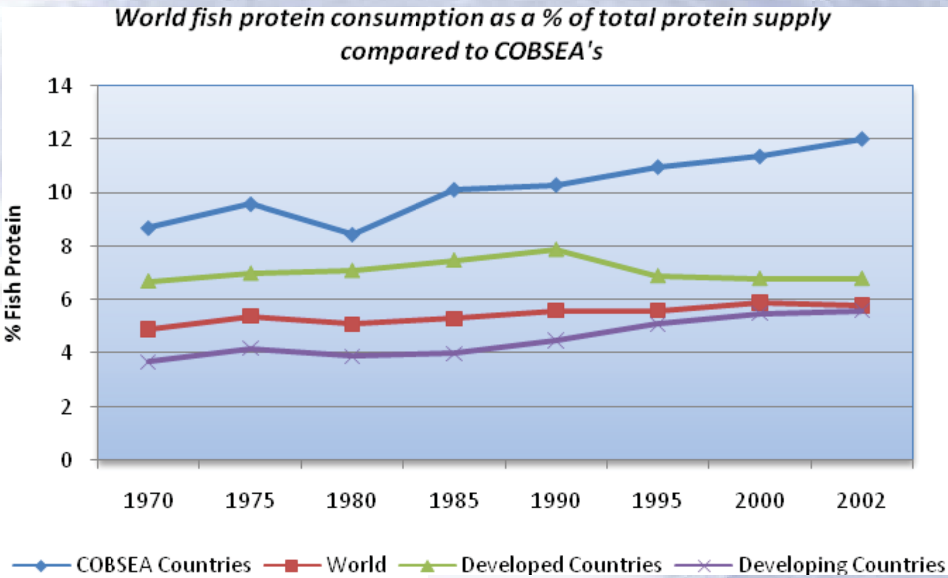
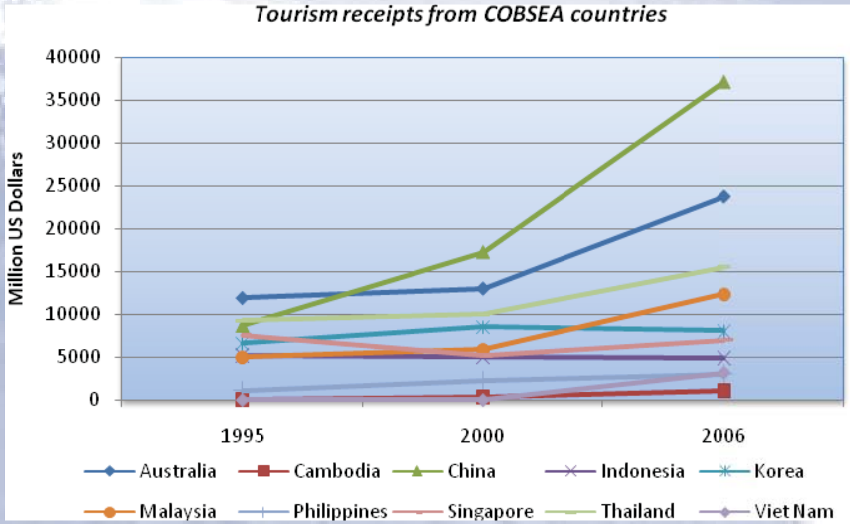


Figure 9: Changes in consumption of fish protein (as a percentage of total animal protein) between 1970 and 2002 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008b.

The coastal tourism industry has over the last two decades become increasingly important to the economic growth and development of many COBSEA countries. As a result of the region's rich biodiversity, unique ecosystems, favourable climate and relatively low prices, coastal tourism has contributed significantly to economic growth and local employment, making the region one of the fastest developing tourism areas in the world. Total tourism receipts for the region doubled from 1995 to 2006 although the proportion contributed by coastal tourism is not known. However, the region is not currently a high-end tourism destination and total tourism receipts represent only about 13% of the international total (Figure 10). There is significant development potential for the region's coastal tourism industry from the numerous pristine and unique coastal areas still present. With responsible investment to improve local infrastructure, safety and publicity, these areas could be used for the ever-increasing tourism market. However, due diligence and foresight in coastal management are required to avoid damage and loss of coastal habitats and degradation of the marine environment.

(a)



(b)

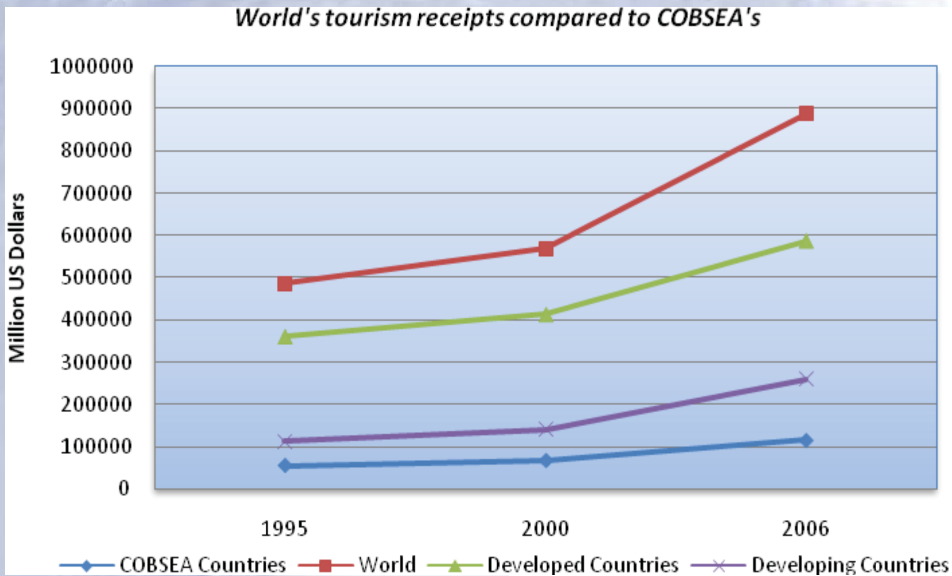


Figure 10: Changes in total tourism receipts between 1995 and 2006 in: (a) COBSEA countries; and (b) world
Adapted from: WRI, 2008c.

Overall, the region has achieved unprecedented sustained growth and development in the past three decades, despite the economic crisis of 1997-1999. Significantly, this growth was also accompanied by a dramatic decline in the incidence of absolute poverty, significant increases in per capita incomes, and notable improvements in key social indicators. Gross Domestic Product per capita almost tripled in several countries. However, aggregated success does not reveal the great diversity of development experiences. The region includes economies at very different stages of development, as not all have shared equally in the benefits of the region's growth.

The less developed economies in the EAS region are generally resource-dependent, with coastal and marine resources responsible for 40% of their GDP (PEMSEA, 2003). This is, however, changing within the current socio-economic landscape of the countries, as their economies expand and diversify to meet global challenges.

2.3 IMPACT OF CLIMATE CHANGE ON SOCIO-ECONOMIC DEVELOPMENT

Climate change has been of great socio-economic concern for some time now, but challenges faced by some countries include the lack of adequate information and reliable projection information; uncertainty regarding costs and benefits of various mitigation and adaptation measures; lack of adequate institutional and human capacity to deal with climate change; insufficient knowledge of ways to transform current energy-intensive economies into climate-friendly societies; lack of knowledge in getting benefits such as transfer of technologies, financial assistance and capacity building; and insufficient development of climate-oriented market mechanisms (Tae *et al*., 2005).

Given its geographical and socio-economic characteristics and natural threats, coastal areas of the EAS region (especially the delta, wetland and coral reef ecosystems), are at considerable risk. Of these, deltaic areas are most vulnerable to climate change. This results from a combination of extreme climatic and non-climatic events, which may cause coastal flooding and result in substantial economic losses and fatalities (Cruz *et al*., 2007). The most exposed countries have densely populated coastal areas, such as the deltas and mega-deltas of China, Viet Nam and Thailand. These deltas are vulnerable to geo-hazards such as storms, floods, droughts and sea-level rise and have been subjected to anthropogenic impacts from geo-engineering projects, urbanization and land-use changes (Carrajal, 2007). In particular, the region's floodplains are most threatened by tropical cyclones and flooding. Wetlands would similarly be affected by flooding, as well as other factors such as changes in sedimentation, land-use conversion, logging and human settlement. The coral reefs of the EAS region, which are of immense ecological and economic value, would also be impacted by climate change and human-induced damage (Cruz *et al*., 2007).

As socio-economic conditions vary widely within the EAS region, climate change has potentially varying impacts on the coastal and marine environments of its constituent countries. It seems likely that the most affected countries would be China, Viet Nam and Cambodia, particularly their deltaic areas (WGCCD, 2007). Significantly, the rural poor in coastal areas are the most vulnerable, as they have very few resources to protect themselves with from the potential impacts of climate change (Cruz *et al*., 2007). Sea-level rise on low elevation coastal zones is estimated to affect as much as 55% of the population in Viet Nam, 26% in Thailand, 18% in the Philippines, and 11% in China (McGranaham *et al*., 2007). In a separate projection, Dasgupta *et al*. (2007) undertook a comparative study of some of the EAS countries, looking at the percentage of land area, population, and GDP that would be affected by Sea Level Rise (SLR) ranging from one to five metres (Figure 11; Figure 12; Figure 13).

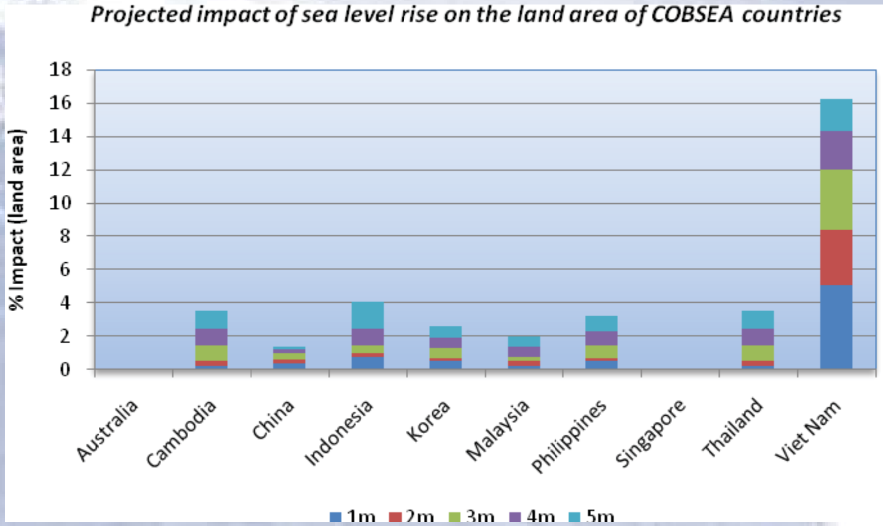


Figure 11: Impact on the land area of various EAS countries by sea-level rises of 1-5 m. No data available for Australia and Singapore
Source: Dasgupta *et al*., 2007.

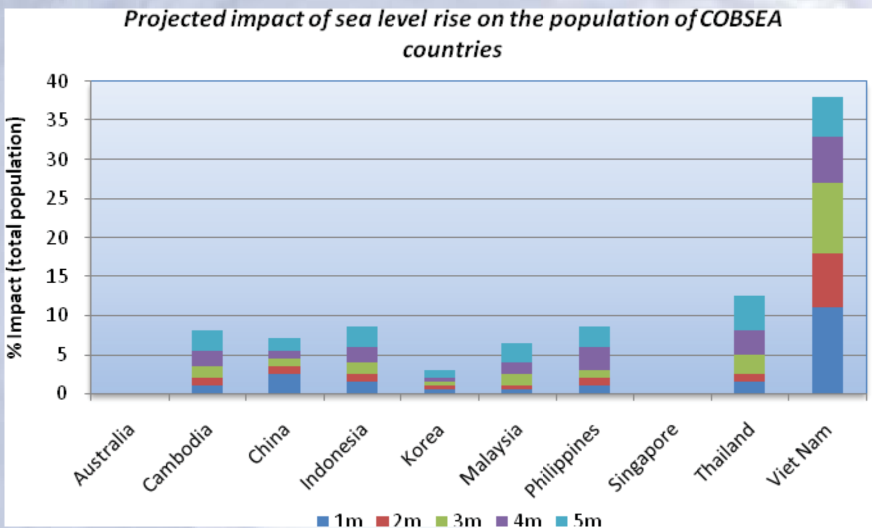


Figure 12: Impact on the populations of various EAS countries by sea-level rises of 1-5 m. No data available for Australia and Singapore
Source: Dasgupta *et al*., 2007.

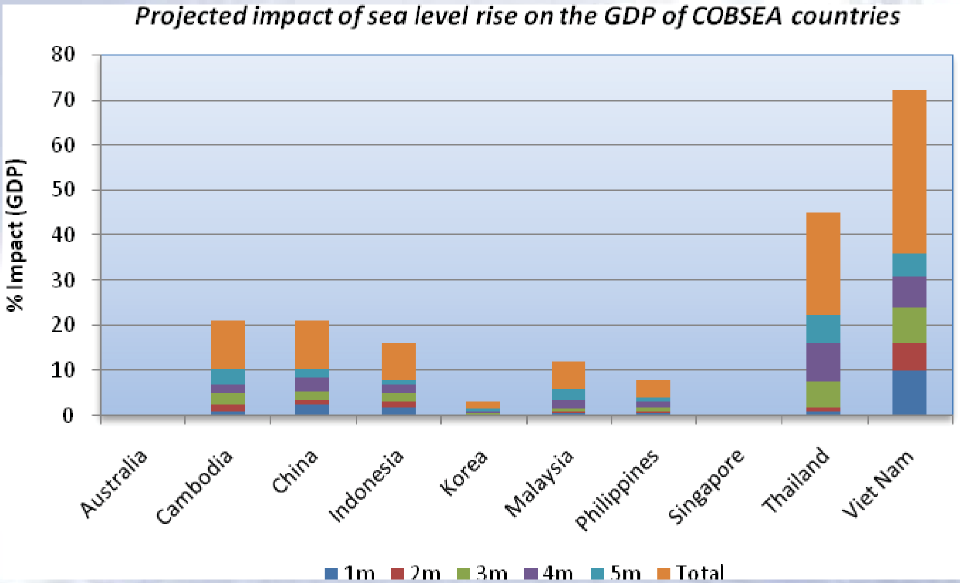


Figure 13: Impact on the GDP of various EAS countries by sea-level rises of 1-5 m. No data available for Australia and Singapore
Source: Dasgupta *et al.*, 2007.

Climate-related hazards always have an associated economic burden and it seems inevitable that ongoing climate change will result in substantial socio-economic costs to the EAS region. For example, the cost of direct damage by tropical cyclones and flood-related damages has increased sharply in recent decades, and is likely to increase still further in the future, as the impact of climate change becomes more and more pronounced (Cruz *et al.*, 2007). Preston *et al*. (2006) provided some indication of the economic burden that climate change could impose on the EAS region (Table 3).

Table 3: National and regional impacts of various rises in sea-level

Rise in sea-level	Type of study	Impacts
<30 cm	National	Viet Nam: 69-91% of land area in the Mekong Delta affected by sea-level rise during flood season
30-50 cm	Regional	South East Asia: Nearly 30,000 km^2 of shoreline affected, with direct costs of US$ 226 million/year
	National	China: US$ 13.6-19 billion/year in total costs for sea-level rise in Pearl Delta Region
		Indonesia: 34,000 km^2 of land lost affecting 3.1 million people
		Viet Nam: 86-100% of land in Mekong Delta affected by sea-level rise during flood season
50 cm	National	China: US$ 38.9-67.1 billion in total costs from sea-level rise in Pearl Delta Region
		Malaysia: 7,000 km^2 lost affecting approximately 500,000 people
		Viet Nam: 40,000 km^2 of land area lost affecting 26.9 million people
Adapted from: Preston *et al*., 2006.		

CHAPTER 3: STATE AND TREND OF THE COASTAL AND MARINE ENVIRONMENT (1981-2006)

A. NATURAL ENVIRONMENT

3A.1 PHYSICAL FEATURES

3A.1.1 OCEANOGRAPHIC FEATURES

The East Asian Seas (EAS) region is situated between two major oceans, the Indian and the Pacific. The Indian Ocean extends northward from the Southern Ocean to India, and joins the Pacific Ocean to the east, (near Australia). The Pacific Ocean also stretches northward from the Southern Ocean, to the Arctic Ocean, covering the area between Australia, Asia, North America and Oceania. The Pacific Ocean encompasses a third of the Earth's surface with an area of 178 million km^2 that surpasses Earth's entire landmass. Its greatest east-west width occurs at 5^oN latitude, stretching approximately 19,800 km from Indonesia to the coast of Colombia and Peru. The western limit of the ocean is often placed at the Strait of Malacca and it is the only ocean which is almost totally bounded by subduction zones.

The region contains a number of large marine ecosystems and regional seas: the East China Sea, South China Sea, Gulf of Thailand, Sulu-Celebes Sea, Indonesian Seas, North Australian Shelf and Northwest Australian Shelf, and the Andaman Sea. The connection between the Indian and Pacific Oceans separate the continental shelves of Asia and Australia. Almost all COBSEA member countries have extensive coastlines particularly the archipelagic states of Indonesia and the Philippines. The marine areas of all member countries add up to about 5.5 million km^2, which is about 30% of the world's sea space under national jurisdiction. This ranges from the large marine areas of Indonesia of 3.2 million km^2 to Singapore's marine area of less than 750 km^2.

One of the most important characteristics of any ocean system is the degree of energy transfer from the atmosphere to the ocean surface, which essentially corresponds to the scale of wave development. This is generally dependent upon three factors: wind speed, wind duration, and the distance over which the wind blows. The common classifications of different wave types in the EAS region are storm waves, west coast swell, east coast swell, and tropical cyclone-influenced waves (Viles and Spencer, 1995).

Tides are another vital component of coastal dynamics, in that they influence the movement of currents, the transport of sediment, the zonation and ecology of coastal organisms, and the geomorphology of coastlines. Tidal fluctuations determine the extent of wetting and drying of coastlines, which is especially significant in areas with low wave energy, such as lagoons, tidal bays and estuaries. Tidal ranges in the EAS region vary from mesotidal (a tidal range of 2-4 m) for most coastlines, to macrotidal (in excess of 4 m) in the far north (China and Republic of Korea) and far south (Australia).

3A.1.2 GEOMORPHIC AND TECTONIC FEATURES

Different coastal types may also be classified according to plate tectonics, particularly the movements and interaction of these plates, which may result in collisions, trailing edges, and marginal sea coasts (Viles and Spencer, 1995). Coastlines of the EAS region are considered to be mostly either collision coasts or trailing-edge coasts. Collision coasts are typically characterized by the delivery of coarse sediments from montane catchments to coastal zones. Along this type of coastline, it is usual to find narrow continental shelves and deep waters relatively close to the shore. Other features of this coastline category include rocky shores with poor beach or reef development as is observed in Indonesia, an archipelagic country with 17,508 islands and a coastline stretching 81,000 km.

Trailing-edge coastlines, on the other hand, are often fed by large river drainage systems and contribute huge volumes of fine sediment to wide, low gradient, continental shelves. For example, the geomorphology of Viet Nam is dominated by its extensive deltaic regions. These regions exemplify the trailing edge category of coastline, with their broad littoral zones, relatively shallow waters, gentle slopes, and tidal amplitudes of approximately 4.5 m.

In terms of tectonics, the EAS region is in a relatively vulnerable location, between the active Eurasia-Australia and Pacific plates. Where these two plates meet there is a significant zone of subduction, with the Pacific plate being pushed downwards into the mantle. This is the source of frequent earthquakes and volcanism throughout the region, generating some of the most severe geohazards in the world, and resulting in extensive infrastructural and economic damage, as well as human tragedy.

3A.2 NATURAL RESOURCE EXPLOITATION

The primary form of natural resource exploitation that currently poses the biggest threat to the environment in the EAS region is the burgeoning energy sector, particularly with regards to developments in oil and gas exploration and production (CCOP, 2007). This section will consider the current status of the industry, including ongoing exploration and total reserves, as well as some areas in which improvement is possible.

3A.2.1 OIL AND GAS EXPLORATION

Many COBSEA countries have significant reserves of oil and gas, revealed by numerous past studies as well as a myriad of ongoing exploration efforts throughout the region. These exploration activities normally consist of some combination of airborne gravity and magnetic surveys, onshore and offshore drilling, and seismic surveys. In general, the result of this exploration has been government support for further exploitation of the reserves discovered. Countries of the region have granted in the last few years permits and concessions to allow for larger quantities of exploited oil and gas.

Exploration is also being conducted into new forms of natural resources, such as gas hydrates. In the Republic of Korea, the recent Gas Hydrate Development Project discovered a massive bed of gas hydrate in the East Sea using piston coring. The samples obtained contained at least 99.9% of the normalized composition by volume, and drilling is ongoing to investigate further. In addition, there has been an increase in the involvement of EAS oil and gas companies in overseas projects, with PetroVietnam (Viet Nam) now operating in Cuba and Venezuela, and KNOC (Republic of Korea) in Canada.

3A.2.2 TOTAL OIL AND GAS PRODUCTION AND RESERVES

Much of this exploration and research has been to determine the total reserves available in each country, as well as to establish reasonably sustainable extraction rates. In 2007, Malaysia reported an average crude oil production of 541 kbpd (Thousand Barrels per Day), as well as average natural gas production levels of 6.5 bscfd (Billion Standard Cubic Feet per Day). Total reserves at that time were estimated to be roughly 5.4 bstb (Billion Stock-Tank Barrels) of crude oil and 89 tscf (Trillion Standard Cubic Feet) of natural gas.

In the same year, Thailand produced 130 kbpd of crude oil, (a very slight decrease on previous years), and 2.42 bscfd of natural gas, (a slight increase). Of this crude oil production, only 17% came from onshore fields (with the remainder from the Gulf of Thailand) and only sufficient to supply roughly half of the country's demand. Total reserves were estimated at 0.53 bstb of crude oil and 30.7 tscf of natural gas.

In China, crude oil and natural gas production in 2006 from offshore areas alone amounted to about 27.5 million tonnes and 7 billion m^3, respectively. Newly proven oil and gas reserves in 2006 reached over 600 million tonnes and 300 billion metres,^{3} respectively. Viet Nam's 2006 production levels were 17.3 million tonnes of crude oil and 7 billion m^3 of natural gas.

3A.2.3 LEGISLATIVE AND MANAGEMENT GAPS

In many COBSEA countries, the legal framework governing the petroleum sector is either inadequate or still being developed. In general, this reflects a scarcity of local experts on the legal and technical aspects of the petroleum industry. While this problem may be (and usually is) overcome through consultation with international experts and governing bodies, the process takes time, requiring many drafts and revisions before a full legal framework may be approved and implemented. For example, Cambodia has long adhered to an interim Petroleum Agreement, a Production Sharing Contract model used in relation to the Foreign Investment Law and the Petroleum Regulation, for the licensing of petroleum companies to conduct exploration activities, development and production, while a more detailed legal framework is being developed.

Despite the extent of past and ongoing exploration efforts, there is still much scope for the improvement of the ways in which generated data are stored and used. For example, a project undertaken in the Republic of Korea, "Construction of Petroleum Information System on the Korean Continental Shelf", consisted of designing a better data model, developing a software system, settling on the hardware system, and collecting all relevant petroleum exploration data. This information system now includes well data, seismic data, maps and reports, and the data are being further processed for integration and re-interpretation into a database system.

There has also been an increase in the levels of international cooperation and joint research projects. For example, Republic of Korea recently carried out a project called "Cooperative Research for Overseas Petroleum Resource Information, and Exploration and Production Technology". This involved three separate research projects, coordinating with Viet Nam, Russia and Kazakhstan, to summarize general and fiscal system information on sedimentary basins.

B. WATER QUALITY

The EAS region comprises some of the most densely populated countries in the world, with some of the fastest growing economies, and an estimated coastal population of 1.47 billion (WRI, 2008e). Many areas lack the water quality infrastructure necessary to cope with such a large population that continues to expand. Domestic waste and sewage are often untreated or only partially treated before discharge. Other land-based activities such as deforestation, land clearing, agriculture, aquaculture, mining, and heavy industry contribute significantly to contaminants entering waterways that eventually flow to the sea. Approximately 70% of contaminants entering the East Asian Seas are from coastal rivers. For example, the Yellow Sea receives a large water and contaminant load from the Yellow River and, to lesser extents, the Changjiang (Yangtze), Pearl, and Mekong Rivers.

Contaminants from ports, mining activities, and heavy industry include oils, hydrocarbons and heavy metals. The types of activities responsible for these contaminants are often concentrated in or around major urban centres, which often discharge untreated or partially treated domestic sewage and other organic wastes that encourage microbial growth and further compound water pollution problems. Another major issue is deforestation and land clearing for agriculture, aquaculture or urban expansion, which results in extensive soil erosion and run-off. The latter, carrying the products used in agriculture and aquaculture such as nutrients, herbicides, pesticides, biocides, fertilizers and antibiotic solutions, causes significant water pollution levels in both waterways and groundwater. These organic and inorganic wastes constitute the region's primary water contaminants.

> The South China Sea contains some of the world's busiest international sea-lanes, as well as two of the world's busiest ports, (Singapore and Hong Kong). As a result, shipping, port, and harbour-related activities contribute significantly to the seawater quality of the region.

In consonance with UNEP's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, COBSEA's Action Plan for the Protection and Development of the Marine and Coastal Areas of the East Asian Seas Region (adopted in 1981 and revised in 1994) represents one of the major regional efforts focusing on protecting the region's marine and coastal environment. Four main priority issues relating to the control of land-based activities in the EAS region are identified: sewage, agricultural run-off, industrial waste and habitat modification (UNEP, 2000).

A summary of the regional programme plan of action for the region is listed in Appendix 1.

3B.1 COMMON CHEMICAL CONTAMINANTS AND POLLUTANTS

Land-based contaminants enter the marine environment either through point sources, such as ports, harbours and industrial discharges or through non-point sources, such as rivers and contaminated groundwater. Significant point source pollutants are microbial pathogens, nutrients, oxygen-consuming materials, heavy metals, and Persistent Organic Pollutants (POPs). Major non-point source pollutants are suspended sediments, nutrients, pesticides and oxygen-consuming materials.

3B.1.1 ORGANIC AND MICROBIAL CONTAMINANTS

Sewage is the major source of organic pollution in the region's more populous coastal areas. Large cities including megacities are commonly located in the coastal area especially at the mouths of large rivers, as in the case of Seoul, Shanghai, Guangzhou, Hong Kong, Ho Chi Minh, Bangkok, Jakarta, Surabaya and Manila. Few of these cities have adequate sewage treatment facilities and the high volume of untreated or partially treated domestic waste discharged into rivers and seas puts tremendous pressure on the coastal and marine environment. Overall emissions of organic pollutants, measured in terms of Biochemical Oxygen Demand (BOD) vary widely among countries (Table 4). In Indonesia, for example, organic waste emissions increased significantly from 214 tonnes/day in 1980 to over 537 tonnes/day in 1993 (UNEP/GIWA, 2005b). High BOD levels cause oxygen depletion in the water column, jeopardising the survival of fish and other aquatic species. In addition, untreated or partially treated domestic sewage results in increased bacterial contamination (specifically faecal coliform) of coastal waters.

A recent Malaysia Environment Quality Report indicated that the primary contaminants exceeding marine water quality standards in that country are total suspended solids, *E. coli*, oil, and grease (DOE, 2007c). In many coastal areas of Malaysia, coliform levels have exceeded the interim water quality standard for recreation, (set at 100 MPN/100 ml).

Table 4: Organic pollutant emissions of countries in the South China Sea region

Country	BOD load (kg/day)		Food industry contribution (%)
	1980	1993	
Cambodia	No data	12,078	No data
China	No data	6,500,000	No data
Indonesia	214,010	537,000	59
Malaysia	77,215	136,055	32
Philippines	182,052	181,714	53
Singapore	No data	33,331	No data
Thailand	No data	355,800	No data

Adapted from: UNEP/GIWA, 2005b.

Available data strongly suggest that surface and coastal water quality in the EAS region are deteriorating. Upstream river water quality is generally unaffected but downstream sections of major rivers reveal poor water quality, generally attributed to their potential as sewage sinks. Monitoring of 30 rivers in Indonesia indicated that the water quality of most did not meet drinking water quality standards. However, coastal water quality in the region generally lies within the various national standard limits, with the exceptions of some localized bays and estuaries. Coastal water quality in the Gulf of Thailand, for example, is considered mostly fair to good. However, the quality of the inner Gulf areas, especially near the mouths of large rivers or coastal tourism hotspots, exceeds acceptable limits due to high loads of coliform bacteria and ammonia (PCD, 2005).

The situation is similar in major urban centres along the coasts of the Sulu-Celebes (Sulawesi) Sea. This is the result of inadequate sewage treatment and disposal, and the cause of massive fish kills, harvest failures in aquaculture ponds, and threats to human health in virtually all populated and/or highly industrialized areas of Indonesia (Dahuri, 1999). However, there are some areas where water pollution is not a high concern, such as northern Australia, where sewage discharge is minor and restricted to localized areas downstream of urban settlements. Concentrations of contaminants in coastal areas of northern Australia are not high enough to be of immediate concern (Chia, 2000).

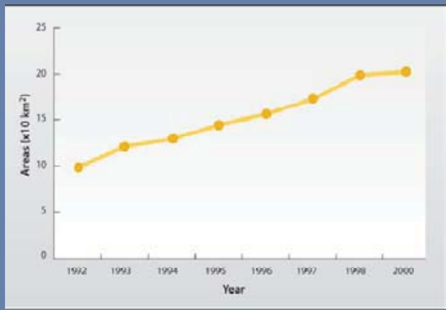
A 1997 study indicated that only 19% of China's coastal waters met the highest water quality standards, but by 1999 this figure had fallen to 15%. The most severe pollutants were sewage and agricultural contaminants in the coastal areas of the Pearl River estuary. Of the four major seas, the East China Sea was the most polluted by a significant margin (Talaue-McManus, 2000). This is largely because the Changjiang River flowing into the East China Sea receives 45% of the total industrial effluent and 37% of the domestic sewage produced in China overall. Of the 21 cities located along this river, which produce a total annual sewage discharge of 6.3 billion tonnes, a figure that increases by 3.3% annually, 70% of them do not comply with national discharge standards (SEPA, 2006).

The lack of adequate sewage treatment throughout parts of the region has resulted in rampant cases of water-borne diseases (Table 5). Considering coastal waters in particular, microbial contamination has led to significant incidences of contracting infectious diseases by bathing and swimming, or from consuming seafood harvested from affected areas. Water-borne pathogens cause a range of diseases, such as cholera, typhoid, shigellosis, amebiasis, viral infections, gastroenteritis and colitis. An investigation of the bacterial index of edible shellfish in the coastal areas of some Chinese provinces in 2001 indicated faecal coliform counts above the national biological standard by a factor of eight. In other areas, the total count of heterotrophic bacteria was 3,400-83,000 cells/g of fresh meat and the count of *Vibrio* was as high as 3,960 cells/g fresh meat (UNEP/GIWA, 2005b). In 1988, a serious outbreak of hepatitis A in Shanghai City, as well as nearby provinces, was caused by the consumption of blood clams contaminated with viruses during transportation in a boat containing manure. This raised concerns over the health issues of coastal populations. The ensuing collapse of the local clam fisheries for several years resulted in significant economic losses (SEPA, 2004).

Table 5: Water-borne diseases in some countries of the EAS region

Country	Number of inhabitants affected	
	Total	% of population
Cambodia	500,000	4.9
Philippines	782,000	1.1
Thailand	1,040,000	1.8
UNEP/GIWA, 2005a.		

In 1999, the total amount of sewage generated in human settlements from 11 provinces along the coasts of China was 10.8 billion tonnes, of which almost four billion tonnes was directly discharged into the sea, with 40% of this entering the East China Sea (Li and Daler, 2004). Historically, this practice has had a significant impact on the country's coastal water quality.



Area comparison of water quality worse than Class I of Sea Water Quality Standard along China coastal waters in the 1990s
Source: Li and Daler, 2004.

3B.1.2 EXCESSIVE NUTRIENTS

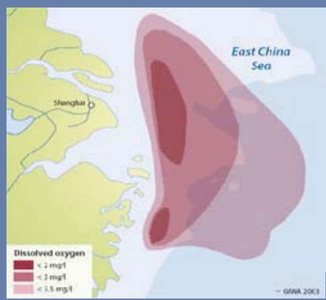
The contamination of rivers and coastal seas by excessive nutrients, originating mostly from municipal wastewater treatment plants, as well as agricultural and urban non-point source run-offs, has extensive health and hygiene implications for the EAS region. In particular, increasing nitrogenous and phosphorus inputs are causing a deterioration in water quality, coming from the elevated use of agricultural fertilizers, booming mariculture industries, and normal household sewage. The annual load of nitrogen and phosphorus from the rivers of China and Republic of Korea is estimated to be twice as high as it was ten years ago. In the Changjiang River, nutrient input from anthropogenic activities has increased three- to five-fold over the past 20 years. Furthermore, the total nitrogen concentration off the coast of Incheon (Republic of Korea), more than doubled in a decade from the 1980s (Yoo and Kim, 2005). Rivers running through Cambodia, China, Malaysia, Thailand and Viet Nam delivered at least 636,840 tonnes of nitrogen to coastal waters overlying the Sunda Shelf. Of this, China contributed at least 55%, and Viet Nam and Thailand 21% and 20% respectively (Talaue-McManus, 2000).

Eutrophication hotspots usually occur near coastal cities and estuarine areas which lack adequate sewer connections to centralized sewage treatment facilities. This is common in China, Republic of Korea, Indonesia, Thailand, Viet Nam, and the Philippines. Excessive nutrient content encourages the rapid growth of phytoplankton, resulting in algal blooms. The elevated algal count depletes oxygen content in coastal waters, creating "dead" zones that result in mass mortality of aquatic organisms. Globally, over 400 marine systems have been identified as "dead zones", caused by eutrophication. Of these, at least 13 are located within the East Asian Seas, mainly in the Republic of Korea, China and Australia (Diaz & Rosenberg, 2008).

In addition, some algae species may produce toxins that cause shellfish poisoning and present serious health hazards to human consumers. Harmful Algal Blooms (HABs), also known as red tides, are a major concern in many countries. In the EAS region, countries such as China, Republic of Korea, Japan, the Philippines, Thailand, Indonesia and Australia have all experienced an increasing frequency of red tide events in recent years (UNEP/GIWA, 2005a; 2005b). Massive algal blooms of phytoplankton have been known to be several metres thick, and distributed up to several kilometres offshore.

In Jakarta Bay (Indonesia), total organic waste discharge increased from 214 tonnes/day in 1980 to over 537 tonnes/day in 1993. During that period, extensive toxic algal blooms caused paralytic shellfish poisoning and shellfish from most parts of the Java Sea could no longer be eaten. Most of China's large-scale HAB occurrences were in the coastal areas of the East China Sea, the Changjiang River estuary, Bohai Bay and Hangzhou Bay. Along the South China Sea, the rapid growth in population and mariculture industries exerted a great deal of stress on the coastal environment, resulting in more frequent HABs. While HAB events in the Yellow Sea and Bohai Sea were lower in frequency, they tended to affect larger areas over a longer duration (SEPA, 2006).

Hypoxia in the East China Sea was first documented in the bottom waters of Changjiang estuary in 1981 (Limeburner *et al*., 1983). Li *et al.* (2002) showed that a large zone of low Dissolved Oxygen (DO) was oriented along the coast extending approximately 150 km offshore from the Changjiang River mouth in 1999. By 2003, this low DO region extended even further (approximately 400 km) offshore as a plume from the Changjiang River mouth, covering an area of almost 12,000 km^2.

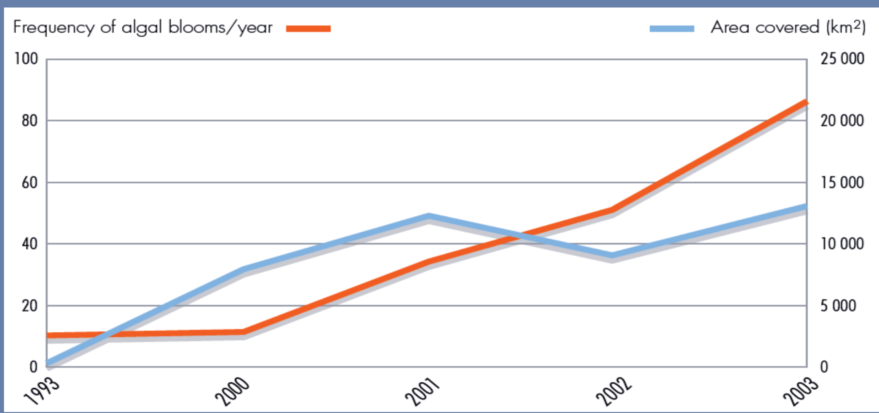


Hypoxia in the East China Sea
Source: UNEP/GIWA, 2005a.

Even when HABs end, the death of the phytoplankton which makes up these algal blooms presents further problems as the dead cells fall to the sea-bed, consuming oxygen as they decay. This eventually leads to anaerobic conditions and the virtual desertification of the sea-floor. These low Dissolved Oxygen (DO) conditions, (also known as hypoxia), have been reported in Republic of Korea, China, and Japan (Lim *et al*., 2006; Chen *et al*., 2007). In Republic of Korea, hypoxia occurs during the summer when the water column is thermally stratified, severely affecting the benthic community structure. Major ecological impacts of hypoxic and anoxic environments include a decrease in biodiversity and the alteration of community structures and ecology. In Korean coastal areas, hypoxia and associated HABs have been linked to catastrophic mortality of marine life (Cho, 1991; Kim, 1990).

The potential impacts of HABs include paralytic, diarrhetic, neurotoxic, and amnesic shellfish poisoning, which occurs when the toxic phytoplankton are filtered out of the water by bivalves such as clams, mussels and oysters. The resulting accumulation of the algal toxins may reach levels lethal to humans and other shellfish consumers (Shumway, 1990). Paralytic Shellfish Poisoning (PSP) and Diarrhetic Shellfish Poisoning (DSP) have been frequently reported in the region. Cases of ciguatera-caused human intoxication have also been recorded in southern China (Zhou *et al*., 1999).

Harmful Algal Blooms (HABs) occur every summer in the East China Sea, and the areal extent of these blooms has increased dramatically in the last decade (Figure 15). During 1950-2000, 118 HABs were reported in the vicinity, accounting for 35-40% of the national total. Since then, HAB-affected areas in China have increased by a factor of five to ten. Data from 2003 show HABs covering a total area of 12,990 km^2, while in 2005 this increased to approximately 27,000 km^2 (SEPA, 2006). Between these two years, fertilizer application in the area had increased by 250%, notably in upstream and coastal provinces, contributing to a high nutrient input to the sea. These blooms resulted in the elevated mortality of fish and benthic organisms, affecting the well-being of both coastal ecosystems and the human populations dependent on coastal resources (UNEP/GIWA, 2005a; 2005b).



Algal blooms in the East China Sea
Source: UNEP/GIWA, 2005a.

In addition to these human health impacts, HABs can have significant economic repercussions. In Hong Kong, they resulted in the collapse of mariculture industries worth US$ 10 million in 1997, and an additional US$ 32 million in 1998. In 2005, HABs impaired coastal fisheries and algae cultivation in China, causing a direct economic loss of US$ 8.6 million (SEPA, 2006). In Republic of Korea, 126 incidences of HABs were recorded in 1996 alone, with losses to aquaculture estimated at US$ 10 million (UNESCAP, 2000).

3B.1.3 TOXIC POLLUTANTS

Toxic pollutants have significant negative impacts on the health of both marine creatures and humans who consume them. The most important of these toxic pollutants include trace metals (such as cadmium, copper, lead and mercury), a variety of biocides (such as DDTs and tributyltin) and their by-products, industrial organic chemicals (such as Polychlorinated Biphenyls [PCBs] and tetrachlorobenzene), and by-products of industrial processes and combustion (such as Polycyclic Aromatic Hydrocarbons [PAHs] and dioxins). These pollutants are widespread and persistent in the environment, and have a propensity to either accumulate in biological tissues or induce biological effects at extremely low concentrations. Relatively high levels of organic pollutants such as DDTs, PCBs and PAHs have been found in river channels connected to direct waste drainage. As might be expected, organic pollutants in coastal sediments showed a gradient of decreasing concentration away from the shore.

In 2005, nearly 32 billion tonnes of wastewater from land-based activities in China, (accounting for 60% of the country's total sewage), was discharged into the seas. This wastewater contained 9.5 million tonnes of Chemical Oxygen Demand (COD), 500,000 tonnes of ammonia and nitrogen, 30,000 tonnes of phosphate, 4 million tonnes of suspended materials, 80,000 tonnes of Biological Oxygen Demand (BOD), 120,000 tonnes of oil pollutants, 20,000 tonnes of heavy metals, 800 tonnes of cyanide, and 70,000 tonnes of other pollutants (SEPA, 2006).

3B.1.3.1 HEAVY METALS

Heavy metals are a known contaminant in most coastal waters of the EAS region. Levels of heavy metals such as arsenic, cadmium, chromium, copper, mercury, lead and zinc have generally increased in the coastal waters of the region over the past two decades (UNEP, 2007b). Major sources are industrial and domestic effluent, as well as the dumping of land-based solid waste into the sea. For example, in China, untreated wastewater from industrial and municipal activities, as well as upstream run-off from mining sites and agricultural land, contributed to a significant increase in the levels of heavy metals, (particularly zinc, lead, copper, chromium and cadmium), in marine sediments over the last 20 years (Yang *et al*., 1997; Kang *et al*., 2000; Li *et al*., 2000; Yang, 2000).

In Thailand, heavy metal pollution, (mainly cadmium, nickel, and cobalt), from discarded electric and electronic equipment, as well as batteries, is an increasing problem. It is estimated that around nine million batteries are disposed of inappropriately each year. As a mitigation measure, approximately 5,000 containers for hazardous wastes were placed in convenience stores and electric and electronic goods shops throughout the nation (UNEP/GPA, 2006).

In another study, not only were levels of heavy metals in the sediments found to be high, but levels in typhoon shelters were extremely high, suggesting ongoing pollution on a large-scale (EPD, 2001). Depth profiles of sediment cores from the Pearl River estuary indicated that heavy metal inputs were probably from the recent, rapid development of industries such as ship repainting, electronic and chemical industries, and leaded fuel within the surrounding region (Zhou *et al*., 2007). In some areas, the heavy metal content of harvested seafood was found to exceed standard limits, making them unacceptable for human consumption (Tam, 2006). Encouragingly, core sediment samples in the Changjiang delta indicated that maximum heavy metal concentrations were reached in the 1970s, sustained for some time, and then began to decrease after the 1990s, most likely as a result of new treatment facilities.

The concentrations of most chemical constituents, including heavy metals, in surface sediments change markedly with water depth in the Sulu Sea and the South China Sea, where ratios of Si, Mg, Na, K, Co, Cr, Cu, Ni, Pb, Rb, Y, Zr and Zn to Al all decreasing with increasing water depth due to changes in mineralogy and sediment texture. However, Sr/Al ratio was higher in shallower water, reflecting the supply of aragonitic shell debris from the shallow banks and shelves around the basins (Calvert *et al*., 1993)

The marine waters of north Australia have consistently reported low levels of heavy metals (Wrigley *et al*., 1990). As for the presence of heavy metals in the sediment, the few surveys carried out thus far suggest low levels overall, with some variability between different sites and sediment types.

Concentrations of Cu, Zn and Pb in coastal sediments of Singapore were highly correlated with sediment grain size, with the highest levels recorded for muddy nearshore areas compared to sandy offshore areas (Goh *et al*., 1993).

Trace metal levels within the Gulf of Thailand showed little evidence of significant metal contamination of seawater, as the concentrations were comparable to estuaries elsewhere in the world (Hungspreugs, 1982). However, concentration of heavy metals were high in sediments, with enriched concentrations of Cd and Pb at sediment surfaces near the mouth of the Chao Phraya, Mae Klong, Ta Chin and Bang Pakong rivers, as well as the Bang Pakong river estuary (Cheevaporn *et al*., 1994; Hungspreugs & Yuangthong, 1983; Menasveta & Cheevaparanapiwat, 1981), with sites near intense industrial activities receiving the highest anthropogenic inputs of heavy metals.

3B.1.3.2 PERSISTENT ORGANIC POLLUTANTS (POPs)

POPs and other organic compounds originate from industrial activities and from the use of pesticides and herbicides in agriculture. They accumulate in the food chain, resulting in diseases and the genetic modification of affected species. Marine organisms which have accumulated POPs in this way are consequently unsuitable for human consumption, limiting them as a food resource. Most COBSEA countries have discontinued the registered use of POPs over the last 20 years, but these toxic chemicals are still widely prevalent in various environmental matrices. POPs are disseminated both by water run-off and the atmosphere. The concentrations of POPs in seawater are difficult to measure due to typically low levels. However, despite limited data availability, it seems clear that POPs are present in coastal marine sediments of the EAS region, and at levels higher than in other parts of the world. Encouragingly, studies have shown declining trends in those POPs that have been banned from use (Kannan *et al*., 1997).

> China has historically employed a broad spectrum of pesticides for agricultural activities and vector control. HCHs and DDTs were used extensively from the 1960s up until 1983, with a total cumulative usage believed to be in excess of 10,000 and 100,000 tonnes, respectively (Voldner and Li, 1995). As would be expected, relatively high concentrations of DDTs and HCHs have since been detected in fish, soils, and sediment from these areas. However, these levels have been gradually declining in recent years (Wu *et al*., 1997; Zhu *et al*., 1999). The monitoring of HCH and DDT contents in core sediments of the Changjiang River estuary showed a rapid decrease in concentrations after the government banned the use of organochlorine pesticides in 1983.

Most monitoring studies measured PCBs, DDTs, HCHs, endosulfan and/or chlordane as indicators of overall POP pollution. Endosulfan was found in most coastal sediments in the region, particularly Malaysia, suggesting its recent use. DDT and PCB levels in sediments from the region generally exceeded quality guideline values of 1.6 and 23.0 µg/kg respectively. However, for many areas the situation is improving significantly. For example, sediment cores obtained from the Macau estuary (China) revealed that levels of HCHs and DDTs peaked in 1993 and have subsequently decreased to levels below detection limits (Zhang *et al*., 1999).

From a regional perspective, it seems clear that overall levels of POPs such as DDTs, HCHs and PCBs, are now declining. Recent data from fish collected in various EAS countries consistently showed concentrations lower than the maximum residual limits for PCBs, DDTs, HCHs, and chlordanes (Hong *et al*., 2002; Sudaryanto *et al*., 2002; Monirith *et al*., 2000; Tanabe *et al*., 2000).

3B.1.3.3 POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

Concerns over PAHs, which are often present in water, aquatic sediments, and organisms, have grown recently following reports that they are capable of disrupting the endocrine system (Clemson *et al*., 1998). The primary sources of PAHs in the EAS region are industrial wastes, vehicle emissions, and power plant emissions. Mobile combustion emissions are thought to be the primary source of contamination in the atmospheric environment of several urban cities including Guangzhou, Hong Kong, Macau, and Bangkok (Fu *et al*., 1997; Qi *et al*., 2001; Boonyatumanond *et al*., 2006). However, since PAH emissions are mainly from non-point sources, such as wet and dry atmospheric deposition and river run-offs, they are very difficult to monitor (Zakaria *et al*., 2008).

> A recent study in the East China Sea observed a correlation between PAH variation in core samples and China's historical changes in energy usage. While the PAHs found were mostly pyrogenic in origin, the contribution from petrogenic sources is thought to have increased during recent years (Guo *et al*., 2006).

Studies reveal varying trends regarding PAH levels across the region. Data from 66 sites around the Hong Kong coastline indicated that total PAHs were declining between 1987 and 1996, with an estimated half-life of three to ten years (Connell *et al*., 1998). A comprehensive Southeast Asian monitoring survey of mussel tissue from 1994-1999 reported that PAH concentration ranges were low to moderate, with extensive input from petrogenic PAHs (Isobe *et al*., 2007). A more recent study in the Gulf of Thailand indicated that PAHs were still present in water, sediment, and biota samples (Wattayakorn, 2003). In general, contamination levels in Thailand's coastal areas were reported to range from low to moderate, from both petrogenic (a result of incomplete petroleum combustion) and pyrogenic (caused by the incomplete combustion of coal and other organic materials) sources (Boonyatumanond *et al*., 2006). In the upper part of the gulf, levels of PAH contamination in sediments seemed to be increasing, indicating a potential risk (Wattayakorn, 2003).

3B.1.4 OIL SPILLS

The shipping of oil, coupled with an increasing emphasis on offshore oil exploration and general shipping activities, means that many areas in the EAS region are extremely vulnerable to oil pollution (Figure 14) (UNEP/GPA, 2006). Oil spills in these locations have the potential to seriously affect marine life and sea birds, as well as posing very negative effects on fisheries stocks and over the long-term, on human health.

The region has already been exposed to numerous oil spill incidences. Some are accidental, while others result from the release of ballast water from oil ships, deliberate oil release, cleaning of oil tankers, and marine transportation. Over 100,000 oil tankers and container and cargo vessels transit through the Straits of Malacca and Singapore annually, carrying over three million barrels of crude oil per day (Tookey, 1997). In the Straits of Malacca alone, 490 shipping accidents were reported between 1988 and 1992, cumulatively spilling a considerable amount of oil into the sea (UNEP/GPA, 2006).

As might be expected, data from 1995-1998 indicated that most oil spills were along international shipping routes or in areas with intensive, large-scale oil exploitation activities.

The highest number of oil slicks occurred in the Gulf of Thailand, the South China Sea (south of Viet Nam), and the Straits of Malacca (Figure 15) (Lu *et al*., 1998). Chronic oil pollution was also observed from production facilities and oil refineries along the Sunda Shelf and offshore platforms near East Kalimantan (Hopley and Suharsono, 2000). Recent statistics suggest that the incidence of oil spills in Chinese waters have increased substantially (SEPA, 2004). However, it also appears that those resulting from maritime activities have recently come under control as a result of effective governmental enforcement (SEPA, 2004).

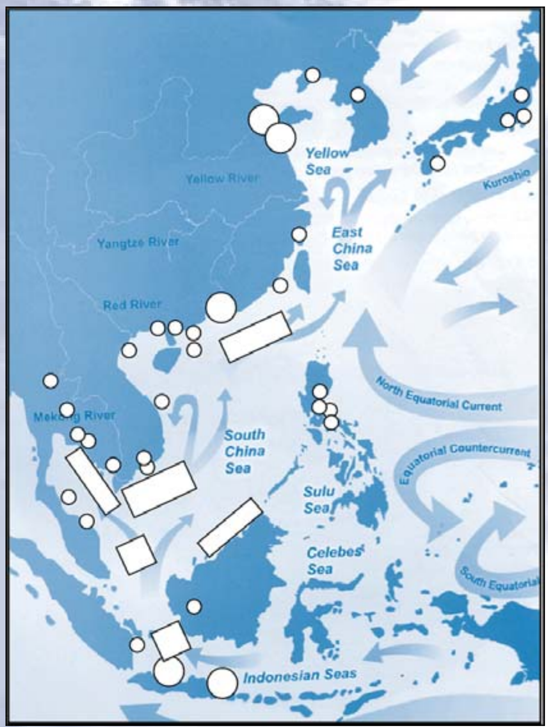


Figure 14: Pollution hotspots (circles) and high-risk areas (boxes) for oil pollution in the East Asian Seas region, (large circles: BOD estimates of about 1 million tonnes/year; small circles: 20,000-500,000 tonnes/year
Source: UNEP/GPA, 2006.

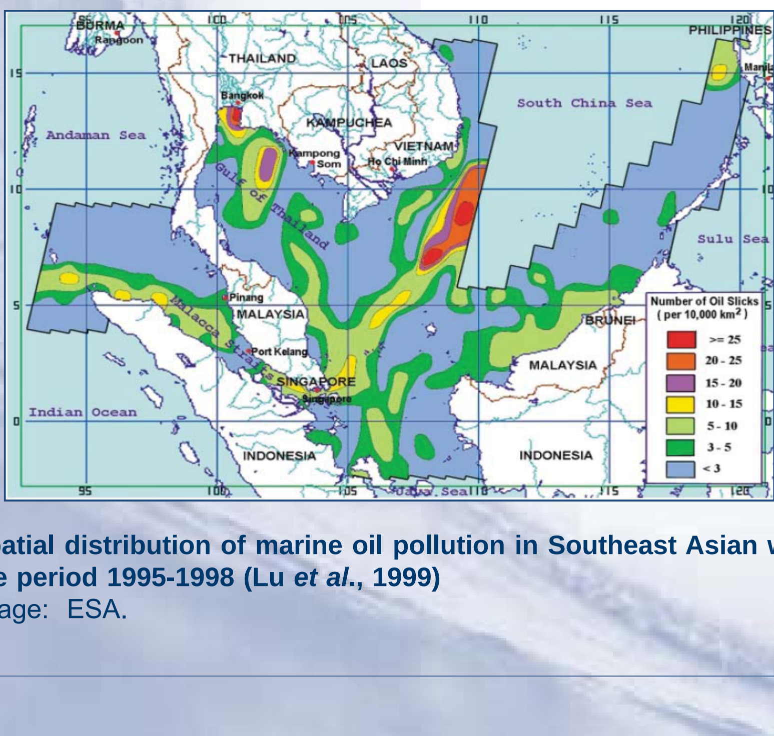


Figure 15: Spatial distribution of marine oil pollution in Southeast Asian waters during the period 1995-1998 (Lu *et al*., 1999)
Image: ESA.

3B.1.3.5 TRIBUTYL TIN (TBT)

Contamination due to Tributyl Tin, (TBT; a type of organotin), in EAS waters has been of increasing concern since its discovery in gastropods around Southeast Asia (Ellis and Patisina, 1990; Swennen *et al*., 1997). TBT is most frequently introduced to the marine ecosystem through the leaching of ship paints, and areas with high shipping activities usually experience elevated concentrations. This is a major problem because TBT is known to be extremely toxic and to disrupt the hormone cycles of marine invertebrates, even at low concentrations. For these reasons, the use of TBT and other forms of organotin, (such as phenyltin), in anti-fouling paints have been banned in many European and North American countries since the late 1980s. To date, few COBSEA countries have such regulations.

TBT has been shown to be widespread in the aquatic environments of China (Jiang *et al*., 2001), Singapore (Basheer *et al*., 2002), Thailand (Wattayakorn, 2008), Malaysia, Viet Nam (Harino *et al*., 2008), and the Philippines (Prudente *et al*., 1999). Despite the lack of a comprehensive inventory of organotin emissions in the region, the main contributors to this contamination are thought to be anti-fouling paints, ship-scraping activities, and sewage disposal.

The Pearl River delta in China has several large harbours where both domestic and international vessels dock. These vessels, with their coatings of TBT-laden anti-fouling paint, were found to be the main source of contamination in the area. Further upstream, sediments from the Pearl River were also found to contain high levels of TBT. The primary source is thought to be the activities carried out by some 30 shipyards located along the river's banks. This widespread organotin pollution has raised concerns over its accumulation in the food chain and the associated health risks to human consumers (UNEP/GEMS, 2006).

3B.2 SOLID WASTE POLLUTION

Marine litter refers to any solid waste of anthropogenic origin that is found on the coast, on the sea surface, in the water column and/or on the sea-bed, including all forms of plastics, general garbage, debris, and Lost and Abandoned Fishing Gear (LAFG), from both land- and sea-based sources. It is a significant problem because it can cause a wide range of ecological, environmental and socio-economic impacts, including ingestion by and entanglement of marine life, the fouling of coastlines, and interference with navigation. There have been a number of major shipping accidents (some involving the loss of human life) as a result of vessel propellers and rudders becoming entangled in marine debris. There are also serious public health issues associated with hazardous materials, medical wastes, syringes, glass and other dangerous debris that may be washed up on beaches.

All over the world, increasing levels of litter are being washed up on coastlines and accumulating out at sea (perhaps 70% of which eventually sinks to the sea-bed). Although there is currently a serious dearth of relevant research and data regarding this issue, it seems likely that the EAS region is no exception to this general trend, with levels equal to or exceeding global averages (UNEP EAS/RCU, 2008). This is probably due to a number of regional factors, such as the massive urban and industrial development currently ongoing in coastal areas, the very high levels of shipping activity, and the lack of effective marine litter prevention and control measures. However, much more research is necessary in order to understand this issue more clearly, and to design and implement effective strategies to counter it.

The **International Maritime Organization (IMO)** was established in 1948 to develop and maintain a comprehensive regulatory framework for shipping, covering aspects such as safety, environmental concerns, and legal matters. Six important conventions which deal with various aspects of the impact of shipping on marine and coastal environments are:

1. The International Convention for the Prevention of Pollution from Ships (MARPOL) – provides regulations preventing pollution from: oil; noxious liquid substances in bulk; harmful substances carried by sea in packaged form; sewage from ships; garbage from ships, (including a total ban on the disposal of plastics from vessels anywhere in the world); and air pollution from ships. It also places a legal requirement on ports to provide adequate waste disposal facilities.

2. The International Convention on the Control of Harmful Anti-fouling Systems on Ships – prohibits the use of harmful organotins in anti-fouling paints used on ships, as well as any other similarly harmful substances developed as alternatives. These compounds have been shown to leach into the water, persisting there, harming the environment and potentially entering the food chain.

3. The Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS Protocol) – provides a framework for international cooperation in combating major incidents or threats of marine pollution from any harmful substance other than oil, requiring ships carrying such substances to have preparedness and response regimes in case of any incidents.

4. The International Convention on Oil Pollution Preparedness, Response and Co-operation – requires the establishment of oil pollution emergency plans for ships and offshore units, involving coordination with national systems, the stockpiling of relevant equipment, and regular drills and exercises.

5. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (commonly known as the London Convention) – regulates the dumping of waste at sea, (prohibiting some altogether, requiring a special permit for others, and a general permit for less harmful wastes).

6. The International Convention for the Control and Management of Ships' Ballast Water and Sediments – attempts to minimize the transfer of harmful aquatic organisms and pathogens. This involves the provision of adequate port facilities for cleaning and repairing ballast tanks, inspection and certification of ships, and research and monitoring regarding ballast water management.

A particularly serious aspect of marine litter is the problem of Lost and Abandoned Fishing Gear (LAFG), which includes nets, lines, traps and floats that are either accidentally lost or intentionally abandoned by fishers. The impacts of LAFG include navigational hazards and threats to human life and property, (when vessels entangle LAFG); "ghost-fishing", when LAFG continues to catch target species resulting in economic and ecological loss; the entanglement of non-target species, (such as sea-turtles, marine mammals and seabirds, many of which may be endangered); the accumulation and transport of foreign fouling organism communities on LAFG into new habitats; the eventual beaching of LAFG, (causing amenity impacts, and preventing or hampering the use of beaches and foreshores); and the economic costs involved, (including emergency response for entangled vessels, LAFG recovery and clean-up campaigns, and scientific research and monitoring).

3B.3 BIOLOGICAL POLLUTION

Invasive species – species introduced by humans to locations outside their natural area of distribution – are widely acknowledged as one of the most significant growing threats to biodiversity in general. While not all introduced species manage to adapt to and survive in their new environment, others are able to not only survive but also reproduce in quantities sufficient to negatively impact native species or humans. These species are classed as "invasive" and must be dealt with if significant damages, (such as the population decline or even extinction of many native species), are to be avoided. For example, a small number of comb jellyfish – transported to the Black Sea in the ballast water of a U.S. tanker in 1993 – eventually grew into a population that accounted for 90% of living organisms in the Black Sea, decimating the commercial fishing industry and costing thousands of jobs.

Recent research has suggested that roughly 84% of the world's marine ecosystems are currently impacted by invasive species, and also that invasive species that have settled into a new habitat are extremely difficult to remove. More than half of the marine invaders considered were found to harm local species or otherwise disrupt the natural systems they had been introduced into. There are a number of ways in which they had been transported, although the majority were unintentionally transported to new habitats through shipping, particularly inside the ships' ballast water (carried for stability purposes), or through the "bio-fouling" of the ships' hulls. Aquaculture is another potential problem if it involves the farming of non-native fish and shellfish, which may escape from the farms. Attention should also be given to the "rafts" of accumulated marine litter that sometimes traverse vast oceans, which may carry species with them (Kiessling, 2003).

The problem of invasive species is especially relevant to the EAS region due to the ever-increasing levels of shipping throughout the region, which raises the risk of the transfer of ballast water containing foreign organisms from other marine ecosystems all over the world. Marine scientists have been aware of the problem of invasive species since at least 1903, although it wasn't until the late 1980s that the International Maritime Organization (IMO) began to address the issue. In 1991, the Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges was published, which has been reviewed a number of times since then with the view towards developing internationally applicable, legally-binding provisions that might be implemented in all member countries.

C. COASTAL ECOSYSTEMS

3C.1 CURRENT STATUS AND EMERGING TRENDS

Coastal ecosystems are among the most productive in the world. Despite occupying less than 5% of the global land area, they offer disproportionately more services relating to human well-being than most other and often larger ecosystems (Burke *et al*., 2001; MEA, 2005). However, despite their value to people, coastal ecosystems around the world are fast degrading, with remaining areas increasingly vulnerable. Recent estimates indicate that coastal habitats are disappearing at a rate of 1.2 to 9% a year globally (four to ten times faster than that of the tropical rainforest), and are currently considered the most imperilled of all ecosystems on earth (FBBVA, 2007).

The many causes for these losses are primarily anthropogenic, including rapidly growing coastal populations, urban development, and infrastructure provision. In addition, increased discharges of nitrogen, phosphorus, organic and particulate matter have resulted in water quality deterioration in many of the world's coastal zones. These anthropogenic impacts along coastal zones will be further aggravated by the impending threat of climate change (MEA, 2005; IPCC, 2003). Associated rises in sea-level could potentially accelerate the loss and degradation of coastal habitats, reduce the effectiveness of conservation programmes, and create a global environmental problem with huge economic impacts on coastal societies (IPCC, 2003). Thus, managing urbanization in a sustainable manner, especially the growing coastal urban populations, presents a major challenge.

The coastal environment of the EAS region is predominantly depositional, consisting of a wide range of ecosystems such as beaches, mudflats, marshes, mangrove forests, seagrass beds, and coral reefs (Bleakley and Wells, 1995). The region has been the incubation bed for coral reef, mangrove, and seagrass diversity, and is a globally important region in many regards (Table 6). Its coastal and marine ecosystems comprise an estimated 47% of the world's coral reefs, 37% of the mangrove area, 72% of the seagrass area, accounting for over half of global fishery production and 80% of global aquaculture production, and contributing almost 60% of the GDP of some countries in the region (Wilkinson, 2008; FAO, 2007b; Green and Short, 2003).

However, the region's coastal ecosystems, which have always been central to its economic development, are subject to tremendous human pressures, making them some of the most threatened in the world. Perhaps the greatest threat results from the presence of large and ever increasing human settlements and extensive economic activities, which is predicted to be exacerbated by global warming and sea-level rise (Burke *et al*., 2001, 2002; Wilkinson, 2008; FAO, 2007a; Green and Short, 2003; ASEAN, 2006). Compounding these problems are transboundary environmental management issues related to coastal management that confront the whole region, including weak implementation of preventive measures against over-exploitation of coastal and marine fisheries, particularly of shared stocks and endangered and threatened species (ASEAN, 2006).

Table 6: Summary of the three major coastal and marine ecosystems in COBSEA member countries

	Habitats (thousands of km²)			Biodiversity (number of species)		
	Mangroves[1]	Seagrass[2]	Coral reefs[3]	Mangroves[1]	Seagrass[2]	Hard corals[3]
Australia	14.5 (2005)	96.3	49.0	37	34	405
Cambodia	0.73 (1997)	N/A	0.05	16	8	111
China	0.22 (2001)	0.02[4]	1.51	28	12	174
Indonesia	30.6 (2003)	30.0	51.0	43	13	590
Republic of Korea	N/A	0.07	N/A	N/A	8	N/A
Malaysia	5.65 (2005)	0.003	3.6	41	14	400
Philippines	2.47 (2003)	0.98	25.1	35	15	464
Singapore	0.005 (2009)	<0.001	0.05	32	11	250
Thailand	2.44 (2000)	0.094	2.13	34	12	250
Viet Nam	1.58 (2000)	0.44	1.27	27	14	400
COBSEA Total	58.2	128	132.5	≥ 43	≥ 34	≥ 590
Global Total	157.1	177	284.8	68	59	704
COBSEA as % of Global Total	37.1%	72.3%	46.9%	≥ 63.2%	≥ 57.6%	≥ 83.8%

[1] FAO, 2007c.
[2] Green and Short, 2003.
[3] Spalding *et al.*, 2001.
[4] Huang *et al.*, 2007.

3C.1.1 CORAL REEFS

A recent report highlighted the disturbing fact that corals reefs may be lost altogether if current trends continue unchanged, particularly within Southeast Asia and the EAS region (Wilkinson, 2008). The 2004 Indian Ocean tsunami and continued human pressures on the coastal environment have slowed or reversed the recovery of previously damaged reefs and continue to degrade existing reefs throughout the region. However, the condition of coral reefs (outside the influence of projected climate change) varies for different countries, with those in Southeast Asia the most affected and those in Australia the least (Table 7).

The report also highlighted the increasing threat to coral reefs near major population centres, especially those within the “Coral Triangle”, the world’s centre of marine biodiversity. Anthropogenic threats are exacerbated by increasing concerns over global climate change and ocean acidification, which are expected to have direct impacts on all the world’s coral reefs (Wilkinson, 2008; MEA, 2005; IPCC, 2003).

Table 7: Summary of the current status of the world's coral reefs. Individual country summaries are not available, but the values for each of the three regions effectively represent all COBSEA member countries

Region	Coral Reef Area (km²) [1]	Reefs effectively lost (%) [2]	Reefs at critical stage (%) [3]	Reefs at threatened stage (%) [4]	Reefs at low threat level (%) [5]
Southeast Asia	91,700	40	20	25	15
Northeast Asia	5,400	20	22	18	40
Australia & Papua New Guinea	62,800	3	4	10	83
Global Total	284,803	19	15	20	45

Adapted from: Wilkinson, 2008.

[1] Spalding *et al*., 2001.
[2] 90% of corals lost and unlikely to recover soon.
[3] 50-90% of corals lost and likely to join "effectively lost" category in 10-20 years.
[4] 20-50% of corals lost and likely to join "critical stage" category in 20-40 years.
[5] Reefs under no immediate threat (except for global climate change).

3C.1.2 MANGROVES

Of the three major ecosystems, perhaps the most comprehensive information exists for mangroves. This is likely due to the terrestrial nature of mangroves, compared to seagrass and coral reef ecosystems, which allows for easier mapping using satellite and other remote technologies.

The most current and comprehensive report by FAO (2007c) showed that 20% (or 36,000 km²) of the global mangrove area have been lost since 1980. The greatest extent of mangroves is found in the EAS region, and with the exception of Australia, where mangrove areas have not changed by more than 1% since the 1980s, effective mangrove loss between 1980 and 2005 ranges from 14% in Thailand to over 70% in Singapore (Figure 16). Encouragingly, the report also noted that the rate of mangrove loss declined between 2000 and 2005, compared to the previous two decades.

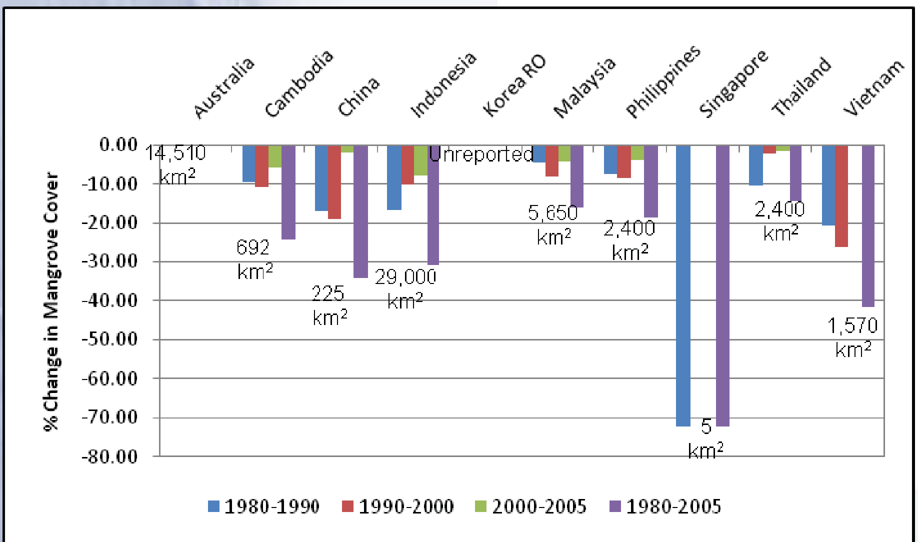


Figure 16: Percentage change in mangrove cover of COBSEA member countries
Adapted from: FAO, 2007c.

3C.1.3 SEAGRASS

Seagrasses are considered the world's most widespread shallow marine ecosystem, but only crude estimates of their extent are currently available (Green and Short, 2003) (Table 5). The EAS region has 72% of the world's total seagrass area, yet it is the least studied of the three major ecosystems regionally. Coastal development and eutrophication are considered the greatest threats to seagrass ecosystems all over the world, with those of the EAS region among the most threatened. The region's seagrass habitat status remains largely unknown and its future is the most uncertain of the three main ecosystems. Future research is required to address this gap.

3C.2 ENVIRONMENTAL IMPACTS

The combined threats to the region's coastal ecosystems have a significant impact that is clearly outstripping their capacity to maintain current levels of productivity (MEA, 2005; UNEP, 2001; ASEAN, 2006). As a result, environmental degradation often outpaces the establishment of appropriate and necessary policies and management interventions. In a vicious cycle of positive feedback, economic development and poverty reduction initiatives that contribute to environmental degradation increase the stress further. Human pressures on the region's coastal resources compromise the delivery of many ecosystem services crucial to the well-being of coastal peoples and national economies in general. The rapid physical transformation of the coastal zone has inadvertently led to habitat alteration and biological transformations, often affecting areas much greater than the immediate impact zones (FBBVA, 2007; MEA, 2005). Effects from upstream, land-based human activities such as agriculture and industry eventually reach the coast, further impairing the coastal ecosystems.

A large proportion of the region's coastal areas are low-lying and greatly affected by large-scale natural processes such as monsoons, typhoons, earthquakes, and tsunamis, making them particularly vulnerable (Table 8). For example, the 2004 Indian Ocean tsunami resulted in considerable damage to the coral reefs of Thailand and Indonesia. This damage is expected to be exacerbated by climate change in the future, with coastal ecosystems further impacted by future sea-level rises, warming oceans, and changes in storm frequency and intensity, and ocean acidification (IPCC, 2003).

Close to 75% of the region's population live within 100 km of the coast (WRI, 2008e), and continued degradation of coastal ecosystems places them at risk. The management of coastal resources and human impacts for most of the region is insufficient or ineffective, leading to conflict, decreases in services, and decreased resilience of natural systems to changing environmental conditions (MEA, 2005). In many cases, management inadequacies are a result of inadequate funding and resources, poor infrastructure, an insufficient understanding of the multi-faceted processes that affect the coastal environment, and the limited development of forward planning that takes into account potential new threats. This often leads to the implementation of ineffective management interventions and action plans that rarely address problems in their entirety.

Table 8: Summary of natural hazards and current environmental issues of significance affecting the coastal environment of COBSEA member countries

	AU	KH	CN	ID	KR	MY	PH	SG	TH	VN
Natural Hazards (Coastal)										
Cyclones	X								X	
Typhoons			X		X		X			X
Monsoons		X				X			X	
Floods		X	X	X		X	X	X		X
Tsunamis			X	X			X		X	
Droughts	X	X	X	X					X	
Forest/bush fires	X			X		X				
Earthquakes/seismic activity			X	X	X		X			
Volcanic activity				X			X			
Land subsidence									X	
Landslides			X				X			
Current										
Current Environmental Issues (Local land-based sources)										
Air pollution (acid rain)			X	X	X	X	X		X	
Water pollution			X	X	X	X	X	X	X	X
Deforestation/land clearing	X	X	X	X		X	X		X	X
Soil erosion	X	X					X		X	X
Desertification	X		X							
Habitat degradation (reefs/ mangroves)		X		X			X			
Trade in endangered species			X						X	
Coastal development			X	X		X		X	X	X
Industrial development	X		X	X		X	X	X	X	X
Urbanization	X		X			X	X	X	X	X
Current Environmental Issues (Local marine-based sources)										
Shipping	X		X	X		X	X	X	X	
Tourism	X			X		X	X		X	
Over-fishing		X		X		X	X		X	X
Illegal fishing		X		X			X			
Destructive fishing				X	X		X			
Dredging								X		
Land reclamation								X		
Current Environmental Issues (Global)										
Climate change	X	X	X	X	X	X	X	X	X	X
Ocean acidification	X	X	X	X	X	X	X	X	X	X

Adapted from: CIA, 2008.

Note: Australia AU, Cambodia KH, China CN, Indonesia ID, Republic of Korea KR, Malaysia MY, Philippines PH, Singapore SG, Thailand TH, Viet Nam VN.

The issues associated with deteriorating marine and coastal ecosystems are varied and impacts differ among COBSEA countries. Despite the variability, some common regional trends and emerging threats are evident. Perhaps the most significant is the rapid expansion of coastal populations, one of the main drivers of coastal degradation. With increased migration of inland populations to coastal areas, coupled with increased urbanization, exploitation pressures in coastal areas are greatly magnified. In addition, coastal communities also tend to aggregate near areas that provide the most ecosystem services, such as mangroves and coral reefs, which usually tend to be the most vulnerable areas (MEA, 2005).

A consequence of living in or near coastal areas is the proportionately high dependence on these systems for food and sustenance. EAS coastal fisheries provide up to 12% of the total protein consumed in the region, twice the global average (WRI, 2008). Coastal capture and aquaculture fisheries also account for half of the global fisheries production, but only 20% of this is exported, indicating that a high proportion of fisheries production is consumed locally. With decreasing fisheries stocks worldwide and ever increasing coastal populations, it is expected that demands on both capture and aquaculture fisheries within the region will increase in the future.

Coastal and marine ecosystems in the EAS region are likely to continue deteriorating as they face increasing, and sometimes conflicting, human demands for coastal space and resources (UNEP, 2001; UN-HABITAT, 2008). Habitat degradation and loss occur when coastal development is not managed effectively, or when marine resources are exploited in a destructive or unsustainable manner. Within the region, transboundary issues related to the coastal and marine environment are expected to become increasingly critical, due to the downstream nature of ocean systems that act as a medium to transport pollutants, the movement of resources between countries, and the expansion of marine-related activities, (such as shipping, fishing, and the movement of migratory and alien species). The causes and impacts will invariably involve more than one country and will therefore require multilateral action to address the issues. Some of the most critical transboundary issues within the EAS region are summarized below (PEMSEA, 2003).

Pollution: Projected growth in production will also generate increasing industrial and domestic wastes, the major sources of marine pollution in the region. The current level of sewage treatment is low, (for example, sewage treatment in countries bordering the South China Sea removes only around 10% of the organic component). Unless this is drastically improved, increasing sewage due to population growth will accelerate eutrophication and associated threats to public health at transboundary levels. Non-point sources of pollution are also increasing in volume. International trade is anticipated to triple in the next 20 years and between 80 to 90% of this is expected to be transported by shipping. As for oil pollution, about 300 oil spills (over 200 million gallons of oil) occurred in the region since the mid-1960s. Although this has been largely in decline recently, the projected increase in shipping increases the likelihood of oil spills.

Introduction of alien species: International shipping also transfers approximately ten billion tonnes of ballast water around the world annually. Although necessary for ship stability, ballast water can contain foreign marine organisms that threaten local ecosystems and public health. For example, in some countries, red tide organisms have been introduced by ballast water and have contaminated shellfish. As ships get larger and faster, and maritime trade increases, the problem will become more acute.

Over-exploitation: Most of the small pelagic species comprising the South China Sea capture fisheries, which could be shared or straddling stocks, are already fully exploited. There is also indication that the large pelagic stocks are also in a state of full exploitation. The discard of by-catch, estimated at over a quarter of total marine catch, contributes to inefficient and wasteful exploitation.

Destructive fishing practices: These practices include fishing with explosives, trawling with nets and chains, and using cyanide to stun fish so that they can be caught alive (a trade valued at US$ 1 billion per year), and other practices which degrade fish habitats such as reefs and mangroves. Destructive fishing practices in one country can impact on the viability of migratory fish in another country.

Change in consumption and use patterns and international trade: The rising global demand for shrimp was largely met by exports from the EAS region, despite major adverse environmental impacts through the deforestation of mangroves, the introduction of alien shrimp species and associated pathogens, and the threat to public health from chemicals associated with shrimp culture. The degradation of coastal habitats, which contributes to a loss of biodiversity, has transboundary impacts (such as the connectivity between seagrass and reef ecosystems). Furthermore, they contribute significantly to fisheries shared by neighbouring countries.

Climate change: Geographically, the largest impact to coastal ecosystems will be caused by global climate change, and since rates of warming are generally expected to increase in the near future, projected climate change-related impacts are also expected to rise (IPCC, 2003). The warming of the world's seas degrades coastal ecosystems and affects species in many ways: by raising sea-levels faster than most biomes can adapt; by stressing temperature-sensitive organisms such as corals and causing their death or morbidity (in corals, this is most often evident as coral bleaching); by changing current patterns and thus interfering with important physiobiotic processes; and by causing increased incidence of pathogen transmission (MEA, 2005). Coral reefs may be the most vulnerable, having already evidenced rapid change, and some projections predict the loss of all reef ecosystems during this century (Hughes *et al*., 2003). Climate change also alters the temperature of estuary and near-shore habitats, making them inhospitable to species with narrow temperature tolerances. Warming can also exacerbate the problem of eutrophication, leading to increased algal overgrowth, fish kills, and dead zones.

The projected rise in sea-level will cause continued inundation of low-lying areas, especially where natural buffers have been removed (Church *et al*., 2001). Both thermal expansion of ocean waters and melting of land-based ice are expected to increase, raising the sea-level (IPCC, 2003). In most if not all cases, global climate change impacts act in negative synergy with other threats on marine organisms and could tilt ecosystems over threshold levels of stability and productivity. In some cases, new habitats may be created. However, changes in weather patterns modelled in some extreme scenarios of climate change (including increased precipitation in some areas, abrupt warming at the poles, and increased frequency and intensity of storm events) would affect oceanic currents and circulation (perhaps even leading to the collapse of thermohaline circulation), as well as the ability of organisms to live or reproduce.

Ocean acidification: The oceans are an important CO_2 reservoir, absorbing approximately 25% of the CO_2 produced by human activities and effectively buffering the impacts of climate change. Accompanying increased CO_2 dissolution in seawater is carbonic acid increase, resulting in lowering of pH. This acidification process is driven largely by the uptake of carbon, nitrogen and sulphur compounds by the ocean from the atmosphere. Although research on ocean acidification is still in its infancy, the impacts have already been detected in living organisms in several regions around the world (Orr *et al*., 2005). The biggest concern with regards to increasing ocean acidification is the effect it will have on the marine environment, specifically the impacts on calcifying organisms such as corals or calcifying plankton. Knock-on effects cascading through the food chain will cause damage to very valuable marine ecosystems, as well as threatening the food security of millions of the world's poorest nations. The projection by Rogeli *et al*. (2009) that CO_2 concentrations could exceed 500 parts per million shortly after 2050, will result in all coral reefs halting their growth and beginning to dissolve (Silverman *et al*., 2009). The impact to the region will be significant, particularly to its coral reefs. Almost half of the world's coral reefs occur in the region; Indonesia has the largest share followed by Australia and the Philippines. For Indonesia, the Philippines and most of Southeast Asia where millions depend on coral reef resources and shellfish for subsistence, the implications are enormous.

3C.3 LEGISLATIVE AND TECHNICAL MANAGEMENT INITIATIVES

The coastal and marine ecosystems of the EAS region are important socially and economically, contributing between 40-60% of each country's GDP. Various national and regional reports have consistently indicated that the state of these ecosystems continues to deteriorate as nations strive for economic growth amidst increased globalization and the expansion of coastal and maritime activities. Development over the last few decades has come at a considerable cost to the environment, with large areas of coastal habitats destroyed and many more in imminent danger of destruction.

On a more positive note, leaders and legislators are increasingly aware of the need to attain a sustainable balance between healthy economic growth and the responsible management of the natural environment. International programmes are increasingly calling for integrated coastal and ocean management (such as Agenda 21, the World Summit on Sustainable Development Plan of Implementation, and the Sustainable Development Strategy for the Seas of East Asia), further reinforcing this shift in focus. At present, coastal management initiatives within the EAS region vary greatly between countries, and are still considered largely ineffectual in most countries. On the other hand, most governments have undertaken the necessary institutional and structural reforms to protect their marine environments more effectively (Tropical Coasts, 2003).

Legislative and technical initiatives that have already been instituted to strengthen the management of EAS coastal ecosystems include the development and implementation of National Agenda 21, the adoption of institutional arrangements, the establishment of national marine affairs institutes, the formulation of national legislations, and the ratification of international instruments (Appendix 2; Appendix 3).

A number of transboundary management initiatives have been developed and demonstrates the feasibility of cooperative frameworks. One example is the Turtle Island Heritage Protected Area (TIHPA), established in 1996 and possibly the first entirely marine transboundary conservation initiative in the world (http://www.arbec.com.my/sea-turtles/tihpa2.php). Administered by Sabah Parks (Malaysia) and Department of Environment and Natural Resources (Philippines) with technical assistance from the Institute of Biodiversity and Environmental Conservation at the University Malaysia Sarawak, Malaysia, TIHPA is aimed at protecting sensitive turtle nesting beaches and surrounding coral reefs, seagrass beds and other marine ecosystems.

Under the UNEP/GEF Project "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand", known as the South China Sea project, cooperative frameworks for resource management were developed between Trat Province (Thailand) and Koh Kong (Cambodia), and also between Kampot (Cambodia) and Kien Giang (Viet Nam).

3C.4 CHALLENGES FACING LEADERS AND LEGISLATORS IN THE EAS REGION

A number of challenges have been identified as being crucial to the development of any long-term and sustainable strategy to combat the various threats facing the coastal ecosystems of the EAS region. If such a strategy is to have any real success, it is vital that leaders and legislators address the points discussed below (ASEAN, 2006; PEMSEA, 2003):

- The socio-economic divide both among and within COBSEA countries must be narrowed, whilst still ensuring a proper balance between economic development and environmental protection.

- Attempts must be made to prevent or reduce the effects of natural and man-made disasters, and to minimize the damage caused by them. Unless communities and property are made safer from disasters, the sustainable development of the region may be impeded.

- Increasing urbanization, (and all that that entails), requires redoubled efforts to address worsening air pollution, noise and congestion, lack of adequate infrastructures, and waste disposal and management in the urban areas of most COBSEA countries.

- The region's biological and genetic resources must be either conserved or used in a more sustainable manner, reversing the current trends of land degradation, deforestation, depletion of natural resources, and loss of biodiversity. In particular, habitat fragmentation and destruction resulting from human encroachment, reduced genetic diversity resulting from excessive application of modern agricultural techniques, and the depletion of primary forests (whether due to legal, illegal and unmonitored) logging and clearing for agriculture are some of the most urgent issues requiring immediate attention.

- The region's marine and coastal areas – recognized as a global centre for marine, shallow water and tropical diversity – must be more effectively protected from physical habitat alteration, pollution from human and economic activities, and unsustainable use and over-exploitation.

- There are a number of global environmental issues which must be addressed, (such as ozone depletion and climate change, loss of biodiversity, transboundary movement of hazardous wastes, and trade in tropical timber). At the same time, there are immediate and pressing economic, social and environmental issues that confront each country in unique and multifarious ways (such as poverty, disease, lack of water and sanitation facilities, and waste disposal).

- Regional institutional arrangements must be made more effective in promoting environmental sustainability, requiring institutions which are able to make binding decisions, mobilize resources and support worthwhile programmes, engage other international and regional partners in meaningful partnerships, and harness the support of civil society organizations and the private sector. There is also a need for national governments and regional institutions to ensure better integration of their development plans and environmental policies, promote more active public involvement in environmental management, and improve regional environmental monitoring processes.

D. FISHERIES RESOURCES

3D.1 BACKGROUND

Fisheries of COBSEA member countries are characterized by a considerable diversity of economies, cultures, fishing practices, and fishing management approaches. The fishing grounds exploited also show varied fishery resources. However, the history of the region's fisheries development reveals a common trend of boom-and-bust development. One by one, stocks and habitats are exploited by new or improved fishing techniques to supply a rapidly increasing regional population and developing export markets. In most of the EAS region, exploitation of the fishery resources has been often uncontrolled and unregulated because of the absence or loose enforcement of effective laws. This has resulted in the over-exploitation of fishery resources, to various extents.

In the past, effective laws did not exist for many areas and so the uncontrolled and unregulated exploitation common to the region was technically not illegal. However, the declaration of Exclusive Economic Zones (EEZs) in the 1980s saw a shift in the jurisdiction of fishing grounds in the region to a national level, and it became illegal to fish in waters other than that of the country of origin of the vessel in question.

The globalization of fisheries that led to the rapid expansion in regional fishing has been the cause of many conflicts, not only between large- and small-scale fishers but also among the various other users of the aquatic resources. Moreover, although the present trend of increasing aquaculture production in the region could potentially offset the growing discrepancy between supply and demand for fish products, it competes with other human activities utilizing the same natural resources, meaning that its development is constrained by issues related to socio-economics, human health and food security.

History also reveals that the expansion of fishing industries often precedes a decline in local demersal catch rates. In the early 1970s, many Thai vessels were built or converted for purse seining of small pelagic species from the Gulf of Thailand. This new fishing method led to an immediate increase in the landings of these species by more than eight times in the first few years of practice. However, the unregulated catches led to the oversupply of several economically important species, which inevitably resulted in significant price declines. This shortfall in regulatory measures also resulted in the over-exploitation of wild stocks.

Declines in catch rates and the prices of targeted small pelagic species prompted the development of tuna purse seining in the late 1970s. This was most apparent in Thailand, where the fishery supplied a newly evolved regional tuna-canning industry. The large investment in post-harvests and canneries shaped the development of regional fisheries today. By 1991, the bulk of tuna supplied to Thai canneries was obtained by purse seining within the waters of countries in the Asia-Pacific region. At present, there is considerable concern regarding the status of regional tuna stocks.

3D.2 CURRENT REGIONAL TRENDS

The total fisheries production from the EAS region has steadily increased, primarily due to contributions from rising levels of aquaculture production. While productions from capture fisheries levelled off in the mid-1990s, aquaculture simultaneously gained momentum. The fluctuating production from capture fisheries could imply that the maximum potential of the fishing grounds of COBSEA countries has already been met. It is probable that some stocks are already depleted from over-fishing. At present, roughly 89% of the total regional production from capture fisheries comes from marine capture fisheries (99% of this from the region's seas), while 11% comes from inland waters.

There is concern regarding the adequacy of future fisheries in providing for the rapidly growing population of the EAS region, especially when threats to fisheries are considered. It has been estimated that based on currently projected growth rates, the region will need more than 50 million tonnes of fish to feed its people by 2012. It is possible that the fish supply-demand gap could be filled by aquaculture if multi-faceted threats to the aquatic ecosystem are addressed.

The increasing demand for fish by the growing population has placed much pressure on the fishery resources, resulting in severe negative impacts to the aquatic ecosystem. Conversely, the severely threatened ecosystem also impacts the resource user. This vicious cycle is further exacerbated by developmental and social factors. Rapid globalization and coastal industrialization has led to various forms of pollution (biological, ecological and industrial) threatening the existence and sustainability of the aquatic ecosystem and especially the fisheries resources.

> The Philippines' fisheries sector has identified the following inter-linked issues and problems (most of which are equally relevant to the other COBSEA countries): (1) depleted fishery resources largely brought about by excessive fishing effort and open access regimes; (2) degraded fishery habitats due to destructive fishing methods, the conversion of fishery habitats for economic reasons, and negative impacts from land-based activities; (3) intensified resource use competition and conflict among fishers and other economic sectors; (4) poverty among small-scale fishers; (5) post-harvest losses due to limited technological know-how and a lack of infrastructure facilities (such as fish ports, market roads and dry/cold-storage facilities); (6) limited institutional capabilities, from the local up to the national levels of governance; (7) inadequate/inconsistent fisheries policies; and (8) weak institutional partnership among government agencies, civil society organizations and private sector.

3D.2.1 COASTAL AND MARINE CAPTURE FISHERIES

Regardless of the trends mentioned earlier, fishing efforts in the EAS region have continued to rise (FAO, 2005). In the East China Sea, the total fishing capacity of Chinese vessels increased by 7.6% between the 1960s and 1990s, while Catch Per Unit Effort (CPUE) declined over the same period by a factor of three. There has been a shift in catches from large high-value fish to smaller low-value species, from demersal and pelagic predatory fishes to pelagic plankton feeders, and from larger to smaller individuals.

Environmental problems affecting fisheries in the EAS region include land reclamation, heavy metal pollution (She, 1999), oil spills, and the impacts of extensive mariculture. There appears to be an increasing frequency of red tides. In the Yellow Sea, bacterial epidemics have resulted in high mortality rates for cultured shrimps. The Sea of Okhotsk is the site of frequent earthquakes and also subject to a high risk of oil spills, due to the oil drilling presently ongoing.

Despite the rapid and continued development of fisheries in the region, knowledge regarding the state of the resources is currently insufficient. Gear and area restrictions (zoning according to gear) are common measures and limited entry schemes have begun to be used in Indonesia and Malaysia. In the southern part of the region, especially Australia, scientific consultation has been an integral part of the management process.

Increased fishing pressure has been attributed to the increasing number of fishermen and the increased use of efficient gears. For example, the development of trawl fishing in the Gulf of Thailand has resulted in the relatively rapid over-exploitation of demersal resources (ICLARM, 2001; FISHCODE, 2001). Recent studies also indicate that the current CPUE of trawl is between seven to ten percent of what it was when fishing started in the early 1960s.

Amongst the various fisheries around the EAS region, that of Australia is widely regarded as the most developed, characterized as it is by an extremely collaborative approach between government and industry through various arrangements, which ensures consistency across all jurisdictions. Being participatory in nature, this approach involves all stakeholders in policy development and implementation, typically resulting in the broad acceptance of management measures by all stakeholders.

Recently, the country has adopted a “user pays” system, where participants in each fishery are made responsible for funding management, research and compliance costs required to support the fishery. Another policy adopted is the broadening of management objectives away from a “single-species” approach to a more general ecosystem management approach, part of a commitment to promote the principle of Ecological Sustainable Development (ESD).

In an attempt to ease the ever-increasing fishing pressures, various management measures have been implemented in most COBSEA countries. The strength of the fishery management institutions is variable in the northern part of the South China Sea (Menasveta, 1997). Among the developing countries in Southeast Asia, Malaysia is relatively advanced in the area of fisheries management, having recently made great efforts to strengthen their MCS (monitoring, control and surveillance) capabilities. Some of their common management measures include zoning by fishing gear, closed season and mesh size limit. Indonesia and the Philippines have placed a ban on trawling in the western seas of the country and inshore areas, respectively. Ever since 1982, Australia has made it mandatory to use by-catch reduction devices for shrimp trawling in the Arafura Seas.

3D.2.1.1 FISH STOCKS AROUND THE REGION

A large portion of the marine catch from the EAS region is made up of small pelagic marine fishes such as herrings, sardines and anchovies. Large pelagic fishes such as tuna are also caught, but not in such great quantities. Other catches include demersal organisms, such as flounders, halibuts, soles and crabs. Naturally, there is significant variation in fish stocks, varieties, and the level of exploitation, in different parts of the region.

In the northern part of the Eastern Indian Ocean, fishers deploy multi-gears and target multiple species, concentrating their efforts on inshore areas. Fishing pressure in areas such as the west of Thailand and the east coast of Sumatra is continuously on the rise. FAO (2005) determined that knowledge regarding the status of fish stocks in these areas is generally poor and management actions have thus far been taken on an ad hoc basis. Poaching is still a problem in this area due to the weakness of MCS capabilities in many coastal states. An exception to this is in the south, near Australia, where fishing pressure is less intense due to the relatively low population density, low local fish demand, and more active MCS.

However, in the northern areas of the Eastern Indian Ocean, over-exploitation is an accelerating problem, due primarily to population pressure in coastal areas and the lack of alternative employment opportunities. Although inadequate, numerous management measures have already been put in place. For example, zoning schemes of the coastal waters according to fishing gears have been adopted in Indonesia and Malaysia. Closures during certain seasons for the management of the Indo-Pacific mackerel (*Rastrelliger* spp.) have been adopted in Thailand. In Malaysia and the Philippines, area closures in association with marine parks are common measures. Although many of the fisheries are managed by the allocation of fishing rights in the form of catch effort (Caton, 2000), insufficient MCS has undermined the implementation of effective management of the region's fisheries resources.

While sharks have been harvested for their meat for thousands of years, the excessive and uncontrolled exploitation of shark populations for shark fin soup has been increasing recently. As a preferred dish at weddings and other prestigious celebrations, the market for shark fins has risen constantly, since practically no laws or regulations exist with regard to finning. However, many COBSEA countries have recently adopted the International Plan of Action for Sharks.

Some fisheries statistics data registered the trading of approximately 3,000 tonnes of shark fins, although the true amount could be much higher. Statistics from Taiwan, Singapore and Hong Kong (the world's centre of fin trading), have indicated an explosive increase in the trading of shark fins.

The rapid development of aquaculture through the EAS region may perhaps be at least partly attributed to the over-exploitation of penaeid shrimp resources in coastal waters. However, with limited access to waste treatment systems in most countries, organic materials and eutrophication have resulted in major aquatic pollution problems. Climate change has also affected fisheries in this area. Cyclones that enter the Bay of Bengal are considerable natural hazards to fisheries, particularly given the absence of good weather forecasts and the limited capacity of electronic equipments on most fishing vessels.

In the Northwest Pacific Ocean, the largest resource variations concern the sardine (*Sardinops melanostictus*) population. The sardine fisheries off Japan grew rapidly in the 1930s to become the largest single-species fishery existing in the world at that time. In the early 1940s, the population abruptly collapsed and remained depleted for nearly three decades, followed by a population explosion in the mid-1970s (Kawasaki, 1983). In the 1980s, this led to catches of more than twice the peak catches prior to the collapse. At present, the population having sustained major fishery exploitation for a long period of time has gone into rapid decline for a second time. FAO believes that the fluctuations in sardine abundance are attributed to ecosystem changes and may be related to climate change rather than fishing pressures.

Interestingly, the decline in sardine catches is simultaneous with a strong rebound of Japanese anchovy (*Engraulis japonicus*) catches. There is a strong pattern of alternation of sardine and anchovy stocks in many fishing areas throughout the world. The Japanese anchovy has also prospered due to the removal of demersal and larger predatory fishes, which account for the largest catch in the area.

The over-exploitation of the Alaska Pollock (*Theragon chalcogramma*) in the Northwest Pacific is becoming more apparent. There has been a continuing trend toward an increasing proportion of Pollock juveniles and of low value, undifferentiated fish of other species in the catch. All the major Pollock stocks are currently believed to be at a lower sustainable biomass than in the 1980s, and decreasing catches are expected for at least several years into the future. Pacific herring support an extremely valuable fishery, much of it sourcing high-value roe for the Japanese market.

The shelf areas of the Western Central Pacific are rich in demersal resources (such as penaeid shrimps and small pelagic resources), while the wider oceanic waters of the Pacific are rich in tuna resources. Total catches from these areas have increased steadily with the majority of the catches being consumed locally by the large populations in bordering countries, as well as constituting the major export commodities of the region. However, some areas are already undeniably heavily exploited, such as the Gulf of Thailand and some parts of the international waters of Indonesia and the Philippines. In the east of the Central Pacific, capture fish production comes mainly from small and large pelagic fishes, followed by squids, shrimps, and coastal demersal fish. Most coastal demersals are moderately exploited, particularly where juveniles represent a large proportion of the by-catch. Catches of the small pelagic species (herrings, sardines, anchovies) are highly variable and subject to large, environmentally-driven fluctuations. The shrimp fishery is considered to be heavily or over-exploited in this area.

In the Southwest Pacific, which is mostly exploited by Australia, capture fisheries include more than 100 commercial species. However, just 17 of these species account for the bulk (>80%) of trawl landings and are limited to Total Allowable Catches (TACs) allocated as Individual Transformed Quotas (ITQs). The number of trawlers in the area has decreased since 1992, but the total fleet capacity and horsepower have increased, and the annual fishing effort (in terms of hours fished) has almost doubled. Unfortunately, the discarding of some species at sea, particularly in shelf waters, remains a major issue. In the nearby waters of the Southeast Pacific, catches such as large and highly migratory tunas, as well as the eastern Pacific bonito (*Sarda chiliensis*), support an important coastal pelagic fishery.

3D.2.2 AQUACULTURE

Aquaculture is practiced in the EAS region in an extremely diverse manner in terms of both the species cultured and the aquatic environments used. Having originated in Asia, the first aquaculture activities focused on freshwater fish such as carp and other cyprinids. With the global spread of this practice, a wide range of aquatic species are now cultured, some of which have been introduced only to non-native countries. Efforts to intensify aquaculture activities have unfortunately adversely affected the sustainability of the aquatic environment, and the rapid development of aquaculture is often blamed as the source for much biological and ecological pollution.

3D.2.2.1 AQUACULTURE AS A SOURCE OF POLLUTION

The irresponsible discharge of untreated pond effluents degrades water quality, resulting in adverse impacts to coastal and marine environments. Additionally, in an ultimately misguided attempt to enhance productivity, chemicals such as therapeutants, pesticides, disinfectants and water quality enhancers are often used. The resultant water released directly into the natural aquatic environment exacerbates biological pollution, especially when the volume exceeds the carrying capacity of the water.

In particular, the discharge of untreated pond effluents could stunt the growth and endanger the survival of reef and seagrass communities, thereby affecting many economically important organisms from these habitats. The deterioration of the aquatic environment by industrial effluents is considered a major obstacle to the further development of aquaculture in certain coastal areas, and is often cited as one of the main reasons to push aquaculture activities offshore.

Poorly managed pen and cage culture systems may harm the environment in other ways as well. Nutrient effluents containing uneaten feed and faecal matter are sources of pollution, potentially resulting in localised water quality degradation and sediment accumulation, posing a danger to adjacent ecosystems. Densely spaced and poorly planned pond and cage culture systems could also suffer from “self-pollution”, leading to low dissolved oxygen and high assimilated wastes in the farmed areas themselves. Any resultant biological pollution and disease and parasite outbreaks could pose a threat to both the farmed organisms and adjacent ecosystems.

The intensification of aquaculture systems involves high level stocking of cultured species per unit production area. This intensification necessitates additional feed inputs as the culture environment is no longer able to support the food requirements of the cultured species. Uncontrolled feeding increases the nutrient loads from faecal excretion and unconsumed feeds. The wastewater released from these culture environments can also contribute to nutrient pollution in coastal waters, thereby threatening the resources in the near shore ecosystems.

Various technologies and farming practices have already been developed in an attempt to make aquaculture more environmentally-friendly. Baliao and Tookwinas (2002) detailed the technology packages developed by SEAFDEC and the ASEAN countries for the proper management of pond effluents. As a result, many pond managers are now adopting the use of settling ponds or canals, where suspended waste is allowed to settle and the resulting sludge is removed and collected for other agricultural uses.

3D.2.2.2 LAND USE FOR AQUACULTURE

The rapid growth of aquaculture in the region can be partially attributed to newly available areas, from the conversion of large tracts of mangrove forests, swamps, wetlands, and even agricultural lands to aquaculture farms. Unfortunately, mangrove deforestation and the clearing of other natural areas have altered coastal systems and habitats, further contributing to the ecological degradation of these valuable resources. Mangrove areas are known as spawning grounds for many aquatic species, as well as providing food and shelter to juveniles of many economically important species. Mangroves filter and clean nutrients from the water by trapping sediments, ultimately using these nutrients to support the existence of both ecologically and economically valuable species. Due to the connectivity of the marine environment, healthy mangroves result in healthy coral reefs and seagrass beds. Mangroves also protect the coasts from storms and typhoons, serve as flood control, and mitigate the effects of siltation on coral reefs and sea-bed communities. If aquaculture is to be made truly sustainable, it is vital that it does not develop at the expense of important habitats such as mangroves, freshwater marshes and other wetlands.

Considering the importance of mangroves in sustaining many aquatic species, it is obvious that the loss of such habitats to establish aquaculture farms instead is likely to have an adverse impact on local wild fish stocks. Naylor *et al*. (2001) attempted to quantify that impact, estimating that for every kilogram of shrimp farmed, about 400 grams of wild fish are lost from near shore catches. They also suggested that if fish, crustaceans, and molluscs were collected from waterways and mangrove areas, aquaculture farms would tend to lose about 450 grams per kilogram of the shrimps produced. Both findings highlight the close relationship between mangroves and local fish stocks. With the loss of these key habitats, the net value of shrimp production from aquaculture farms would be significantly lower.

Techniques have already been developed integrating the utilization of mangroves for both forestry and aquaculture production. This is known as “aquasilviculture” or “silvofisheries”. SEAFDEC has successfully implemented a programme aimed at adopting better aquaculture practices that are compatible with mangrove ecosystem conservation and management (Platon *et al*., 2007; Aldon *et al*., 2008). Samonte-Tan and Cruz (2007) indicated that adopting environmentally-friendly shrimp farming practices allows the flourishing of mangrove-supported fisheries, thus increasing its overall economic value. Aquaculture farms should now be required to internalize the environmental costs of waste discharge, through making sewage treatment mandatory and adopting integrated systems that reduce waste generation.

3D.2.2.3 SUPPLY OF FRY AND FINGERLINGS

At present, the natural supply of fry and fingerlings is no longer sufficient and its seasonality can no longer be relied upon to support the requirements of the aquaculture industry. While most aquaculture activities use hatchery-raised fingerlings, wild-caught juveniles are still used in many others. This practice is pervasive in marine and brackish water environments for the culture of high-value species such as groupers, snappers and shrimps. The culture of milkfish in Indonesia and the Philippines still depends on wild-caught fry and fingerlings, as well as wild-caught brood fishes for spawning activities. However, the rearing of wild-caught fry to marketable size through culture techniques is contrary to the objective of aquaculture as an alternative to capture fisheries. Furthermore, the irresponsible removal of wild fry and fingerlings of non-target species reduce resource populations. Collecting wild seed stocks for aquaculture can have negative impacts on biodiversity, especially if it includes high quantities of by-catch.

Naylor *et al*. (2001) reported that the Philippines would require about 1.7 billion wild milkfish fry annually to sustain their aquaculture industry. However, reports have indicated that milkfish fry collected from inshore waters using seine nets and sorted visually, constitute only about 15% of the total fish fry catch. The remaining 85% of the wild fry catch, of unknown aquatic species, are simply discarded and left on the beach. To supply the country's milkfish aquaculture demand of 1.7 billion fry, more than 11 billion fry of various aquatic species are collected of which about 10 billion fry are discarded and destroyed.

3D.2.2.4 COMPETITION FOR FISHMEAL

The continued growth of the aquaculture industry is also dependent on the availability of fishmeal and other fish-based products, such as fish oil for fish feeds. Preference for the culture of high-value species for greater economic returns requires lower-value fish or fish meal-based feeds. Fishmeal is also widely used in the formulation of livestock feeds, resulting in the over-exploitation of these resources. When stocks of small ocean fish exploited for fishmeal are overfished or depleted, available food supplies for marine predators such as marine mammals and sea birds decline. Since these same fish resources are also used for human consumption, a conflict emerges between the formulation of meal-based feeds or making the fish available for human consumption.

Research has been conducted to find suitable cost-effective substitutes for fishmeal and fishery products in fish diets. Potential alternative sources include agricultural proteins, such as vegetable and animal meals, which can be economically incorporated into the diets of several fish species. Enzyme treatment and bio-conversion have also been adopted to improve the nutritional value of plant ingredients for use as fish feeds.

3D.2.2.5 SPREAD OF AQUATIC DISEASES

A major concern is the occurrence of infectious aquatic diseases. In the early 1990s, diseases of this type brought about considerable damage to several aquatic ecosystems in many EAS countries. At the farm level, it is necessary to identify and control diseases through reliable diagnostic methods. There are now available methods for knowledge transfer to create awareness amongst farmers, and to build capabilities for disease diagnosis at farm level, so that farmers can apply prevention and control measures. In the past, occurrence of diseases in aquaculture systems was largely a result of irresponsible farm management practices bringing about deteriorated culture conditions.

New technologies and innovations for controlling diseases at the farm level do not necessitate the use of chemical inputs but follow the Code of Conduct for Responsible Aquaculture (Platon *et al*., 2007). An efficient and timely reporting system on disease outbreak is paramount in preventing the further spread and occurrence of any aquatic diseases. Aquaculture can also affect the wild fish stocks through non-native species escape and the spread of diseases to both farmed and wild fish.

The movement of captive fish stocks can also increase the risk of spreading pathogens around the aquatic ecosystem. The widespread transmission of diseases such as the whitespot and yellowhead viruses, has caused catastrophic, multi-million dollar crop losses in Asia's shrimp aquaculture industry. Additionally, the movement of seed stocks within or between countries may significantly alter the genetic characteristics of local stocks due to inevitable escapees and/or stock enhancement practices. The escape of alien aquatic species from aquaculture farms could eventually result in their establishing spawning populations in the country of introduction and thereby dislodging native species from their established niches.

E. VULNERABILITY TO NATURAL DISASTERS

A considerable part of the EAS region rests above the tectonic convergence of the Eurasian, Australian and Pacific plates, increasing its vulnerability to natural disasters. Plate movement can result in earthquakes and volcanic eruptions along the interacting boundaries. The collision of the Pacific and Eurasian plates results in the Pacific being subducted below the Eurasian plate, resulting in some of the most severe geohazards in the world. The Pacific "Ring of Fire", extending around the boundary of the Pacific Ocean, (including a number of COBSEA countries), is the world's foremost belt of explosive volcanism, with several hundred active volcanoes sitting above the various subduction zones. Asia's disproportionate vulnerability to geohazard impacts on its people and economies is illustrated in Table 9.

Table 9: Summary of natural disasters from 1991-2000

	Number of Disasters	Number of people killed	Total number of affected people	Damage (US$ billions)
World	2,961	754,026	2,116,593,188	687
Asia	1,137 (38%)	588,654 (78%)	1,888,686,026 (89%)	374 (54%)
Adapted from: ADRC, 2002.				

There are a variety of geohazards which can cause extensive economic damage and human tragedy. Floods appear to be the more dominant natural disaster throughout Asia, affecting 60% of the total number of people exposed to all types of natural disasters (Figure 17).

The region's vulnerability was demonstrated by the tragic events surrounding the tsunami that struck the coastlines of several EAS countries in December of 2004. The worldwide response to the tragedy, which killed more than a quarter of a million people, was immediate and overwhelming in terms of the provision of emergency aid. However, the event posed some fundamental questions regarding disaster preparedness and response.

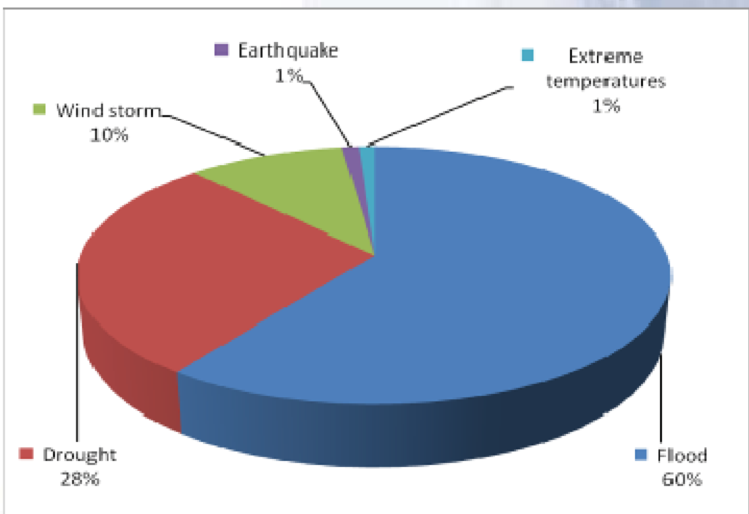


Figure 17: Proportion of total affected population for each disaster type in Asia between 1975 and 2000
Adapted from: ADRC, 2002.

3E.1 VOLCANIC HAZARDS

The tectonic presence of the “Ring of Fire” places a number of COBSEA countries at significant risk from volcanic activity. There is a long history of such activity, particularly in Indonesia and the Philippines, and its consequent damage in the loss of human life, structural damage to buildings, and the loss of habitat for both humans and other organisms.

There are approximately 129 active volcanoes situated among the Indonesian islands, as a result of the collisions between several plates in the region. The subduction rate is so high that usually a few eruptions occur every year. The lava of these volcanoes is andesitic in composition, meaning that the volcanoes are of the explosive type. This equates to a huge risk to the roughly three million Indonesians who live on and around volcanoes, and often requires a rapid evacuation to avoid enormous loss of life. Indonesians account for more than 50% of the global total of people that have been affected by volcanoes.

The Philippines currently has 21 active volcanoes, similarly related to the subduction and convergence zones of the region’s tectonic plates. More than 700,000 people live on or near the slopes of these volcanoes. Many volcanic eruptions in the Philippines are of the *Plinian* type, an extremely dangerous kind of eruption associated with hot, heavy, toxic gases. The most recent example of a volcanic disaster is the case of Mount Pinatubo, which erupted in 1991 and displaced 8.4 to 10.4 km^3 of pyroclastic material. Not only did this material result in the immediate deaths of about 400 people, but it also then became the main source of *lahar* flows (essentially volcanic mudslides) along the major river systems draining the volcano, constituting a continuing threat to downstream provinces (Bornas, 2000).

3E.2 EARTHQUAKE/TSUNAMI HAZARDS

Earthquakes, (and the related phenomena of tsunamis), are a major hazard in many parts of the EAS region and have been responsible for significant loss of life and property. Countries located on or near the boundaries of different plates (such as Indonesia and the Philippines) are especially vulnerable. Seismicity along the whole of the Indonesian archipelago accounts for about 10% of total seismicity in the world, with the Philippines accounting for a further 3.2%. On average, this equates to about 400 earthquakes annually in Indonesia, with roughly ten classified as high magnitude.

It is well-known that tsunamis are caused by earthquakes whose hypocentres are located beneath the sea-floor. Most of the tsunamis affecting the EAS region occur due to the development of graben-like basins as a result of local tectonics beneath the sea-floor. This results in an abrupt flow of water into the basin, which causes a sudden drop in sea-level along the adjacent coastal areas. As the basin fills up, huge currents or “tsunamis” flow from the ocean to the coastal areas and can cause massive damage (Simandjuntak, 1995).

Japan is another country located in a region where multiple plates collide, making it one of the most violent seismic zones in the world. There are roughly 1,500 to 2,000 active faults throughout the Japanese archipelago, with recurrence periods ranging from several hundreds of years to a few thousand years. Tsunamis have recurrence periods in much the same way, and a disturbing trend has recently been identified in the north-west of the archipelago, with tsunami recurrence periods seemingly much shorter, (down from roughly 100 years to 10-24 years since the middle of the 20th century).

Earthquakes can result in a wide variety of other hazards such as landslides, rock-falls, liquefaction, land subsidence, and surface ruptures along fault-lines. China, although not located along or above major plate boundaries, is subjected to a high level of seismic activity due to intra-plate dynamics. This seismic activity may be characterized in terms of its high frequency, large magnitude, and extensive distribution. Of its 30 provinces, regions and municipalities, 21 have experienced earthquakes of magnitudes equal to or greater than six. Ding (1994) assessed that there were more than 715 earthquakes on the Chinese mainland over the last 90 years, resulting in the death of 615,000 people and injuries to almost 930,000 more. Fortunately, tsunamis are relatively rare along the Chinese coastline, although there have been notable and catastrophic exceptions to this (Shi, 1995).

Even some COBSEA countries which have traditionally not been at significant risk of earthquakes are now taking at least some precautionary measures. For example, while earthquakes do frequently occur in Thailand, they are generally small in magnitude and do not cause much damage. However, an increasing number of cities and towns are being built on soft marine sediments, which are subjected to a relatively high level of ground-shaking during earthquakes, as a result of soil amplification. For this reason, awareness of both the seismic hazard and the need for appropriate mitigating measures has increased substantially in Thailand (Chaimanee, 1997). The Republic of Korea is another country that has traditionally not been severely affected by earthquakes, but is now experiencing increased seismicity in its eastern regions, believed to be related to tectonic structure. Certain active faults have been identified that require careful observation.

Viet Nam is located in a moderately active seismic area, particularly the north of the country. While this has historically resulted in some incidence of earthquakes, (since 1900, a total of 22 with magnitudes greater than five), these have mostly occurred in the mountainous zones, where low population densities equate to low casualty rates. However, rapid economic development and urbanization mean that more and more people are settling in high seismic activity zones, making precautionary measures increasingly important (Nguyen, 1994; Tran, 1997).

Other COBSEA countries are relatively safe from earthquake hazards due to their geographical or tectonic location. Cambodia is protected by surrounding highlands, such as the Cardamom Range in the south and west, and the Anamia Range in south Viet Nam, meaning that it is relatively immune to seismic and volcanic hazards. Singapore and Malaysia's peninsular region lies over a tectonically stable region and is essentially seismically inactive. However, the East Malaysian state of Sabah overlies a moderately active seismic area with a number of active faults and experienced an earthquake of magnitude 5.8 in 1976.

3E.3 LANDSLIDE HAZARDS

Landslides are another major natural hazard in many COBSEA countries, both in terms of damage to property and loss of life. In the Republic of Korea alone, it has been estimated that landslides result in an average annual loss of 60 lives and property valued at US$ 10-30 million.

A number of factors affect the likelihood and severity of landslides. These include topographic (mainly the steepness of the slope), geologic (the type of rock and surface materials), rainfall (intensity and duration), seismic (movement due to earthquakes or any sort of seismic activity), and anthropogenic activity (DeGraff, 1989). For example, Indonesia is at a relatively high risk of landslides, mostly because of its topography (many mountainous areas, with steep slopes), geology (various types of weak zones, such as bedding discontinuities and fault planes), and rainfall characteristics (heavy rainfall, for long durations). This results in roughly 300 major landslides every year in Indonesia.

At present, more than 400 cities and towns in China are at serious risk of landslide hazards. These landslides are generally over 10,000 m^3 in volume, while the largest can be as big as one billion m^3. Historical records of landslides in China go back almost 4,000 years to 1789 BC. The landslide at Wudu, (central China), which killed 760 people in 186 BC, is probably the earliest recorded disaster of that kind. Since then, total deaths due to landslides in China up until 1989 has been estimated to be at least 257,000. This high figure is related to earthquakes, very heavy rainfall, and flooding after the failure of landslide dams (Ding, 1994; Li and Wang, 1992).

An increasing trend in landslides is evident in recent years. They are caused, or at least made more likely or extensive, by anthropogenic activities. These include cutting into slopes for settlement or agricultural expansion, which resulted in a landslide in Garunt (Indonesia) that killed 37 people in 1985 (Siagian, 1998). A study in Thailand revealed that if the areas damaged by a large landslide had not earlier been deforested, the extent of the landslide would have been at least 20-30% less severe.

Any kind of construction work that creates an unstable slope can also precipitate landslides, particularly in regions that receive prolonged or heavy rainfall. The construction of roads through mountainous areas is one such activity, as investigated by a study in Malaysia (Mohamad, 1994). Quarrying for construction materials in mountainous or hilly areas can also have the same result, as was seen in 1987 when 130 people were killed in a quarry landslide in Padangpanjang (Indonesia).

3E.4 HAZARDS OF CLIMATE CHANGE

Recent evidence shows that climate change has already begun to affect the coastal areas of the EAS region. Overall, trends indicate both rising temperatures and also an increase in rainfall variability. An overall increase of 0.1-0.3^{o}C per decade was reported for Southeast Asia between 1951 and 2000 (Cruz *et al*., 2007). As for rainfall, trends vary in different parts of the region (Table 10).

Particularly important is the increasing number of extreme weather events affecting the EAS region. In China, the number and intensity of cyclones has clearly increased since the 1950s, (of a total of 21 extreme storm surges during 1950-2004, 14 occurred during 1996-2004). In the Philippines, which has historically seen an average of 20 cyclones each year, the frequency of such events increased by 4.2 during the period 1999 to 2003 (Cruz *et al*., 2007).

Table 10: Summary of key observed past and present trends, for selected countries and regions

Region	Country	Change in temperature	Change in precipitation
East Asia	China	Warming during last 50 years, more pronounced in winter than summer, and rate of increase more pronounced in minimum than in maximum temperatures	Annual rain declined in past decade in the north and north-east, but increased in the west and along the south-east coast
Southeast Asia	Republic of Korea	0.23°C rise in annual mean temperature per decade, and an increase in diurnal range	More frequent heavy rain in recent years
	General	0.1-0.3°C increase per decade reported between 1951-2000	Decreasing trend between 1961 and 1998. Number of rainy days have declined throughout Southeast Asia
	Indonesia	Homogeneous temperature data not available	Decreased rainfall in the south; increased in the north
	Philippines	Increase in mean annual, maximum, and minimum temperatures by 0.14°C between 1971-2000	Increase in annual mean rainfall since 1980s and in number of rainy days since 1990s. Increase in inter-annual variability of rainfall
Adapted from: Cruz *et al*., 2000.			

Overall, the EAS region is projected to have a warming trend, accompanied by an increase in both summer precipitation and intense precipitation events. Although the region as a whole is projected to become warmer, the extent of this warming differs for each region. For example, East Asia is expected to experience temperatures above the global mean, fewer cold days, and more frequent summer heat waves of longer duration and higher intensity. Southeast Asia is expected to see the least rapid warming. In terms of rainfall, summer precipitation is likely to increase in East and Southeast Asia, as is the incidence of extreme rainfall associated with tropical cyclones (Christensen *et al*., 2007; Cruz *et al*., 2007). Additionally, there is likely to be an increase in the frequency of intense precipitation in East Asia.

The frequency and intensity of severe climate-related events are also projected to increase significantly due to climate change. For example, an increase of 10-20% in tropical cyclone intensities is expected for a rise in sea surface temperature of 2-4°C, (relative to the region's current threshold temperature). Storm surge heights could also increase as a result of stronger winds, higher sea surface temperatures, and the low pressures associated with tropical storms, resulting in an increased risk of coastal disasters (Cruz *et al*., 2007). Such an intensification of tropical storms could also have devastating consequences for coral reefs (Carrajal, 2007).

3E.4.1 EFFECT OF RISING SEA-LEVELS

The projected rise in sea-levels would have very serious impacts on the coastal areas of the EAS region. The current rate of Sea Level Rise (SLR) in the EAS region is 1-3 mm/yr, which is marginally higher than the global average (Cruz *et al*., 2007). However, in East Asia specifically, the rate of SLR has varied considerably from 1.5-4.4 mm/yr, due to regional variation in land surface movement. The potentially catastrophic consequences of even a small rise in sea-levels are obvious. In some coastal areas, a 30 cm SLR could result in 45 m of landward erosion (Cruz *et al*., 2007). Even with a conservative SLR estimate of 40 cm by 2100, nearly 19 million people living in the low-lying coastal areas of the region would be flooded annually, with Thailand, Viet Nam, Indonesia and the Philippines hardest hit (Cruz *et al*., 2007). In China alone, a SLR of just 30 cm would inundate more than 80,000 km^2 of coastal lowland (Cruz *et al*., 2007). Many megacities in the EAS region are located in coastal deltas, and are therefore especially vulnerable to threats by climate change, sea-level rise and extreme events (Cruz *et al*., 2007).

The low-lying coastal areas of EAS countries will be most impacted by any rise in sea-level and it is worth considering them in more detail. It is projected that Viet Nam would suffer the most from a SLR of 1 m. In this scenario, 5,000 km^2 of the Red River delta and 15,000-20,000 km^2 of the Mekong river delta would be inundated. Roughly 2,500 km^2 of mangroves would be lost, and 1,000 km^2 of cultivated farmland and mariculture would become salt marshes. The number of people living in the Mekong Delta area that would lose their homes is projected to be around 14 million (WGCCD, 2007).

Sea-level rise in China has been recorded at about 2-3 mm/yr for the past 50 years. It is expected that by 2050, the sea-level will have risen by almost 0.5 m in certain areas, such as Huanghe Delta, making storm surges a major challenge (WGCCD, 2007). For Indonesia, it has been estimated that sea-level rises may result in 2,000 small islands being lost by 2030, up to 160 km^2 of northern Jakarta being flooded by 2050 (Figure 18), and a total land loss of more than 90,000 km^2 by 2100 (WGCCD, 2007; Francisco *et al*., 2008).

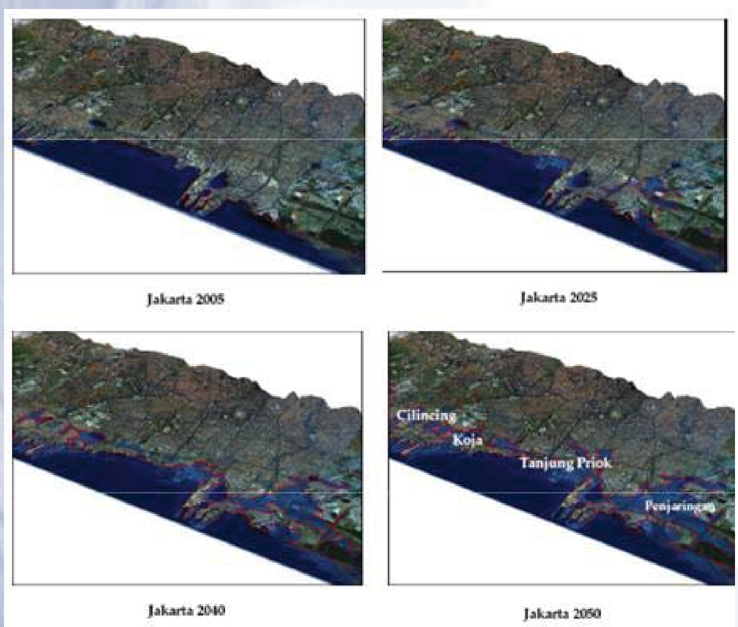


Figure 18: Modelling of projected sea-level rise near Jakarta, Indonesia
Source: DFID, 2007.

Sea-level rises along Thailand's coastline could result in significant saltwater intrusion up rivers, threatening the country's most fertile agricultural of projected sea-level rise near Jakarta, Indonesia land, which is situated in low-lying plains along the river deltas (WGCCD, 2007). In the Philippines, a recent study concluded that a SLR of 1 m would affect 64 out of 81 provinces, inundating almost 700 km^2 (WGCCD, 2007).

A recent regional study assessing the vulnerability of the Southeast Asian coasts to sea-level rise using the Dynamic Interactive Vulnerability Analysis (DIVA) tool reported that Viet Nam with a high coastal floodplain population would experience a high land loss of wetland areas due to submergence; Malaysia, Thailand and the Philippines a moderate land loss; and Cambodia and Singapore a low land loss (David *et al*., 2008). Additionally, analyses of DIVA simulations using combinations of various adaptive strategies of the IPCC Special Report on Emission Scenarios (IPCC SRES) storylines showed that Cost-Benefit Analysis (CBA) protection of seawalls and dikes were most effective in mitigating the number of people experiencing floods and land loss due to submergence, while full beach nourishment (including rehabilitation of coastal vegetation) was more effective in mitigating migration due to flooding, loss of land due to erosion and loss of total wetland (David *et al*., 2008).

3E.4.2 EFFECT ON COASTAL AND MARINE ECOSYSTEMS

Coastal and marine ecosystems (such as mangroves and coral reefs), would inevitably be affected by a rise in sea-level and increasing water temperatures. Their degradation would have serious implications for the well-being of coastal communities, many of which are poor and rely on these coastal ecosystems as a major source of goods and services. Recent analysis of coral reefs suggests that that 24 and 30% of the reefs in Asia are likely to be lost during the next 10 years and 30 years respectively, unless the stresses are removed and relatively large areas are protected (Cruz *et al*., 2007).

Coral bleaching results from an increase in ocean temperatures and can kill off entire coral reefs, which work as supporting systems for fish and other marine organisms, as well as affecting their capacity to recover. However, a new study suggests that corals severely affected by high temperatures in recent years may contain some species that show greater tolerance to higher temperatures than others. If this is the case, bleaching thresholds may then be viewed as a broad spectrum of responses, rather than a single response for all coral species (Cruz *et al*., 2007).

> Coral reefs in Indonesia cover 50,000 km^2 (representing 18% of world's total) and are in a dire condition. They did not recover fully from the 1983 El Niño event, and this damage was exacerbated by a second El Niño event four years later. In Pari Island (part of the Thousand Islands National Park), 50 to 60% of the coral reefs were found to be bleached in 1997 (DFID, 2007).

The rising level of atmospheric carbon dioxide (CO_2) poses additional threats to the coastal and marine environment. Higher levels of atmospheric CO_2 result in higher concentrations dissolved in seawater, causing ocean acidification that reduces the calcification rates of calcifying organisms, which include organisms from throughout the food chain, from autotrophs to heterotrophs.

Sea-level rise may result in mangrove areas dying back or being lost altogether. One estimate suggests that a 90 cm SLR could result in the loss of one-third of Viet Nam's nature reserves and over one-quarter of the known biodiversity contained in them (WGCCD, 2007). Coastal ecosystems have also been affected by general climatic variation, such as in China's delta regions, where precipitation decline has resulted in the drying up of wetlands and the severe degradation of local ecosystems (Cruz *et al*., 2007).

3E.4.3 EFFECT ON DELTAS AND ESTUARIES

Climate change is also likely to have an impact on the deltas and estuaries of the EAS region. The evolution of the major deltas depends on changes in both ocean processes and sediment flux. Rising sea-levels would result in intensified extreme events, (such as storm surges), increasing the coastal erosion of deltas, (often further exacerbated by the excessive pumping of groundwater). Climate change also has an impact on rainfall, (as described above), which affects the run-off into the rivers. As a result of decreasing run-off, saltwater intrusion into estuaries may be pushed 10-20 km further inland by rising sea-levels (Cruz *et al.*, 2007).

> The Mekong Delta is one mega-delta in the EAS region that will be severely impacted by climate change. Projections suggest that there will be an increased flooding risk during the wet season, and an increased possibility of water shortages during the dry season (Cruz *et al.*, 2007). By comparing past and present natural and socio-economic data, another study predicts more flooding, crop failures, erosion of roads, riverbanks and coastlines, and water supply shortages even in the wet season. As for the dry season, increasing depletion of groundwater, deteriorating freshwater quality, seawater intrusion, and biodiversity loss are anticipated (Francisco *et al.*, 2008).

Climate change would also affect the quality of both surface and groundwater in the deltas. The increasing frequency and intensity of droughts in the catchment area would lead to more extensive saltwater intrusion into the estuary, thus deteriorating water quality (Cruz *et al.*, 2007). Rising water temperatures in estuaries and resulting eutrophication could also lead to an increase in both the frequency and intensity of red tides (Cruz *et al.*, 2007). Finally, projected increases in the frequency and intensity of extreme weather events would exert adverse impacts on estuarine flora distribution.

3E.4.4 EFFECT ON FISHERIES

It is well known that general climatic variability has a strong influence on the fishery sector, and therefore obvious that climate change will likewise have an impact. At present, the EAS region is one of world's largest producers of fish, from both aquaculture and capture fishery, and fish sources account for roughly a quarter of total animal protein consumed in the region. However, changes in oceanic circulation due to the warming atmosphere have already resulted in a decline in primary production in tropical oceans. In socio-economic terms, this poses a particularly acute threat to the livelihoods of many poor households dependent on small pelagic fisheries, especially in Indonesia and the Philippines (Carrajal, 2007).

Although global warming implies an expansion of marine habitats, from the tropics toward more distant latitudes, there are many other factors influencing fisheries, such as over-fishing, pollution, red tides, and other climatic and environmental pressures. In the future, these factors may result in substantial changes to fish breeding habits and food supply, ultimately altering their abundance in EAS waters. Studies have shown that even marginal changes in water temperature can have grave effects on the vitality, growth and reproductive rates of fish (DFID, 2007). However, it is also possible that moderate warming may actually improve the prospects of some economically gainful fisheries, such as cod and herring, at least in the short-term (Cruz *et al.*, 2007).

CHAPTER 4: ECONOMIC VALUATION OF THE COASTAL & MARINE ENVIRONMENT

4.1 BACKGROUND

Modern society is heavily dependent on the environment as both a source of raw materials and a provider of a range of services (together known as "natural capital"). Additionally, society uses (or much of the time misuses) the environment as a "sink" or repository for contaminants and waste. These source and sink services are limited, and are being continually degraded and reduced by increasing economic activities and development. This necessitates the adoption of more conservative patterns of use, which will increase the base of environmental assets over time, thus rehabilitating the capacity of the environment to provide goods and services sustainably.

In this context, economic valuation is the attempt to assign quantitative or monetary values to the goods and services provided by the environment, whether or not market prices are available to assist in the process (Barbier and Aylward, 1996; Bateman *et al*., 2002). The National Research Council defines economic valuation as an attempt to provide an empirical accounting of the value of the services and amenities provided, or of the costs and benefits of a proposed action (project or policies), that would affect the flow of those services and amenities (NRC, 1995). Both definitions are in agreement regarding the usefulness of attempting to quantify the value of the goods and services provided by environmental resources, in order to gain a better understanding and appreciation of their economic importance to society.

Valuation in the context of habitat management is generally used to provide an indication of the overall economic efficiency of the various competing uses of habitats and resources. The underlying assumption is that habitat resources should be allocated to those uses that yield an overall net gain to society, as measured through the methodical valuation of the economic benefits of each use, minus its economic costs. It is vitally important that this valuation should be based on a logical methodology as speculative assumptions will not contribute to sound decision-making (Munasinghe, 1995).

The determination of accurate economic values for ecosystem goods and services is fraught with problems, ranging from disagreements regarding the methodologies to be used to disagreements regarding what constitutes the total economic value of a habitat or ecosystem. Nevertheless, it is obvious that without some agreed procedure and economic values for ecosystem goods and services, appropriate levels of payment for these services cannot be satisfactorily determined. Various types of valuation assessments have been made based on ecosystem goods and services values (such as tourism, fisheries, coastal protection) and at global, regional and site-specific scales (CI, 2008).

The publication by Costanza *et al*. (1997) of a seminal paper on the value of the world's ecosystem services and natural capital assigned a total economic value of US$ 33 trillion to the annual global production of ecosystem services. This estimate was based on a simplification of global ecosystems and their classification into marine and terrestrial systems, the former being divided into open ocean and coastal systems, and the latter into nine major terrestrial biomes. These were further sub-divided, leading to a total of 16 primary categories of "biome". The term "ecosystem services" was used to cover both goods (such as food) and true services (such as waste assimilation).

The results of the work of Costanza *et al*. (1997) were based on published data covering various, albeit limited geographic locations, and this approach has subsequently been challenged on both economic and scientific grounds. Since the results were based on comparatively few empirical studies largely from the northern hemisphere, and since the values were averaged and then multiplied by the global extent of the appropriate biome, a *de facto* "benefits transfer" approach was used, which might not actually be appropriate. In addition, values for some services, such as nutrient cycling, are available for some ecosystems but not others, despite the fact that they constitute a very significant fraction of the total value for certain kinds of systems, such as seagrass and algal beds.

An additional point of some significance is that of the 17 categories of ecosystem services distinguished by Costanza *et al*. (1997), only three (food, raw materials, and genetic resources) are for goods; the remaining 14 being for true services such as erosion control, nutrient cycling, and waste assimilation. One explanation is that this reflects the greater emphasis in the developed countries of the northern hemisphere on the protection of natural habitats, rather than the emphasis on use, sustainable or otherwise, that is the norm in developing countries such as those of the EAS region.

4.2 DEVELOPING A REGIONAL ECONOMIC VALUATION MODEL

A project of more direct relevance to the COBSEA countries, entitled "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand", was funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UNEP), in partnership with the seven states bordering the South China Sea, (Cambodia, China, Indonesia, Malaysia, the Philippines, Thailand and Viet Nam) (UNEP, 2007e; 2007f). This project undertook a focussed study of the economic value of coastal habitats, or "ecotones", first developing a technique for deriving "standard" or weighted national and regional economic values for the mangroves, coral reefs, seagrass, and coastal wetlands bordering the South China Sea.

During the development of this project (from 1996 to 1999), a framework Strategic Action Programme (SAP) was prepared in parallel. This programme included a cost-benefit analysis of actions proposed to halt environmental degradation, compared with the eventual costs of non-action (UNEP 1999). The cost-benefit analysis made use of the economic values of ecosystem services that had been proposed by Costanza *et al*. (1997). Although the Project Steering Committee (composed of senior government representatives from the countries involved), accepted the general outcome of the cost-benefit analysis, it was concerned about the applicability of these global values in the context of the EAS region. For this reason, it was decided to establish a Regional Task Force on Economic Valuation (RTF-E) consisting of nine economists from the region, who were charged with providing economic assistance and advice to the national and regional working groups addressing habitat, fisheries and pollution issues. They were also tasked with determining regionally applicable economic values for environmental goods and services, to facilitate a more accurate and relevant economic valuation of the region's marine and coastal ecosystems.

While the exact region considered by the RTF-E (the coastal ecosystems of the South China Sea) does not correlate exactly with the EAS region, it is considered of sufficient similarity as to be of great relevance to COBSEA. For this reason, an overview of the methodology used is given in Appendix 4.

4.3 RESULTS

The results of the project are presented in terms of the Mean National and Regional Values calculated for all the goods and services derived from mangroves, coral reefs, seagrass, and coastal wetlands in Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam. It can be seen in all cases that for a significant number of countries, data were not available regarding the values of certain goods and services.

In the case of mangroves, the annual value of production per hectare for both goods and services varies from US$ 450 in Viet Nam and the Philippines to in excess of US$ 21,000 in the case of China. The latter value reflects the high-value for the service of sediment retention by mangroves, which was determined by the difference in the annual cost of dredging the Fangchenggang Port, before and after the removal of mangroves. However, as the total area of mangroves in China is only 23 thousand hectares, compared with nearly 2 million hectares along the Indonesian coast of the South China Sea, this very high-value does not necessarily distort the regional value for this service, which computes at a modest US$ 66 per hectare annually.

The most comprehensive dataset is that for mangroves, whilst the least comprehensive are those for coral reefs and wetlands. Only three national datasets were found for coral reef goods and, in the case of wetlands, the bulk of the data come from Viet Nam. This results in a regional coral reef production value of a modest US$ 1,500 per hectare per annum and for wetlands of around US$ 300 per hectare per annum. These values should be compared with the regional value for mangroves of nearly US$ 3,000 per hectare per annum and US$ 1,118 per hectare per annum for seagrass meadows.

4.4 DISCUSSION

It might be expected that the value of mangrove goods would exceed those of coral reefs and seagrass because the former includes values for mangrove timber and other direct derivatives, which have few if any equivalents in coral reef and seagrass habitats. Likewise, one would expect that the service values for coral reefs would be greater than those for the other three habitats given the extensive levels of coral reef tourism throughout the region.

An interesting result of the examination of the value of total annual production of goods and services by the four habitats in this region is that it demonstrates unequivocally the economic importance of mangroves. The total annual value of mangrove production exceeds US$ 5.1 billion annually, compared with around US$ 1.2 billion for wetlands and coral reefs and a mere US$ 86 million for seagrass habitats.

However, it is vitally important to recognize that the values for goods and services, both individually and collectively, are extremely conservative, as a consequence of the manner in which they have been calculated (using weighted means). Where data are lacking for a good or service from one country (and this is often the case), the consequence is a lowering of the Weighted Mean Regional Value. Given the absence of values for many goods and services in each habitat, the values calculated are likely to be as low as 50%, or even less, of the true value. For comparison, the values derived by Costanza *et al*. (1997) are presented alongside those from the present study in Table 11.

Table 11: Comparison of the Total Economic Value of coastal habitats, as determined by Costanza *et al*. (1997) and UNEP (2007f)

Habitat	Area (ha)	US$/ha/annum		Total Economic Values for the total area of each habitat in the South China Sea (US$ billions)	
		Costanza *et al*., 1997	UNEP 2007f	Costanza *et al*., 1997	UNEP 2007f
Mangroves	1,799,136	9,990	2,872	17,973	5,168
Coral Reefs	750,307	6,076	1,543	4,559	1,157
Seagrasses	73,769	22,400	1,182	1,652	87
Wetlands	4,201,145	14,785	295	62,114	1,240

In all four cases, the absolute values cited by Costanza *et al*. (1997) are greater than those determined in the present study, and would result in Total Economic Values ranging from three to 22 times greater than those determined by the RTF-E. This disparity would be even greater if the 1997 values of Costanza *et al*., were adjusted to the 2005 values of the present study.

It is important to appreciate that these two sets of values are not directly comparable, since those of Costanza *et al*. (1997) reflect the influence of high service values characteristic of developed countries, whilst the present study was able to assemble far more data on direct uses and comparatively fewer data on service values. An examination of the summary table of average global values of annual ecosystem services in the paper of Costanza *et al*. (1997) suggests that a hugely significant 51% of the total value derives from the nutrient cycling function.

CHAPTER 5: OUTLOOK (2007-2017)

Projections regarding the outlook for the EAS coastal and marine environment based on observed trends are important as they serve to enhance general awareness and understanding of current and emerging issues, and enable more appropriate planning and strategy. The specific outlook issues considered here relate to coastal and marine ecosystem conservation strategies, water quality, natural resources, natural hazards, coastal development, marine litter, invasive species, climate change, fisheries, and various environment-related conventions, including those of the International Maritime Organization (IMO).

5.1 COASTAL & MARINE ECOSYSTEM CONSERVATION & MANAGEMENT STRATEGIES

The outlook for the coastal and marine environment of the EAS region could be said to have improved of late. Over the last two decades, general awareness regarding the need for more responsible environmental stewardship has increased. This has resulted in a deeper level of commitment to environmental conservation and protection in all COBSEA member countries, with some corresponding development and implementation of national policies and strategies for long-term environmental sustainability.

However, this increased awareness and professed commitment have not always been effectively translated into positive action on the issues that matter most. A possible explanation might be the overall lack of institutional coordination between various agencies which have a stake in environmental protection and management, a weakness that appears to be largely common to the region.

Most of the COBSEA member countries have developed, and at least partially implemented detailed policy documents establishing current and future environmental policies, strategies, objectives and targets (Table 12). However, with the exception of Australia (the Ocean Policy) and the Philippines (National Wetland Action Plan), plans of many of the other countries are more general policy and strategy documents, in which coastal and marine systems are only two of many other components. Some of the documents and strategies mentioned below are discussed in more detail in Chapter 6.

Transboundary environmental issues (like land-based pollution, sub-regional pollution hotspots and habitat destruction) pose critical challenges regionally, and efforts to address specific transboundary issues have been undertaken through international agreements and conventions developed and facilitated through various international and intergovernmental institutions. Examples include the UNEP/GEF South China Sea project (concluded at the end of 2008) and the Coral Triangle Initiative launched at the Coral Triangle Initiative Summit in Manado, Indonesia, in May 2009, involving six countries, three of which are COBSEA member countries (Indonesia, Malaysia, Philippines). In addition, a workshop on "Addressing Transboundary Issues through Regional/Subregional Seas Cooperation: Initiatives in East Asia" is being organized for the East Asian Congress 2009 on Coastal and Ocean Governance (http://pemsea.org/about-pemsea/pemsea-news/eas-congress-transboundary-issues- as-catalysts-for-cooperation).

Table 12: Environmental strategies relating to the marine and coastal environment of COBSEA member countries

Country	Environmental Strategies (Coastal & Marine Environments)
Australia	Ocean Policy
Cambodia	Cambodia National Environment Plan 1998-2002
China	National 11th Five-year Plan for Environmental Protection 2006-2010
Indonesia	National Long-term Development Plan 2005-2025
Korea	Comprehensive National Environmental Plan 2006-2015
Malaysia	9th Malaysia Plan 2006-2010
Philippines	National Wetland Action Plan (1993)
Singapore	Green Plan 2012
Thailand	Natural Resource and Environmental Strategies in the Ninth National Economic and Social Development Plan 2002-2006
Viet Nam	National Strategy of Environmental Protection 2001-2010

5.2 WATER QUALITY

Available data strongly suggest that coastal water quality in most of the EAS region will continue to deteriorate for the foreseeable future. Land-based sources of pollution continue to increase, affecting not only near-shore areas but likely also the main seas. Assuming that current levels of population, economic, and agricultural growth continue, coastal water quality degradation will persist, unless both governments and the general public assign it a higher priority.

Many sources contribute to this degradation, most of which are associated with growth and development. The projected growth in production will continue to generate increasing industrial and domestic wastes, believed to be the major sources of marine pollution in the region. Unless the level of sewage treatment is drastically improved, sewage from ever-increasing populations will accelerate eutrophication and result in greater threats to public health possibly at transboundary levels.

For pesticides and industrial contaminants, even just those already present are likely to persist in the region for years to come, against a background of any new contaminants being introduced into the environment currently or in the future. For example, HCHs and DDTs (long-banned insecticides) have been detected in tissues and sediments at levels high enough for them to remain present for the foreseeable future. Similarly, heavy metals and PCBs are likely to continue being transported to coastal areas. In addition, many newly-developed pesticides and industrial compounds are being released into the environment, further compounding pollution problems and necessitating significant new research into their effects and importance. For oil pollution, although the incidence of spills has declined over the past decade, projected increases in shipping traffic are expected to raise their likelihood.

A major challenge in the next decade is to manage water quality data including how they are collected and used, and to take advantage of new capabilities that revolutionize information effectiveness and cost-efficiency of data and assessment programmes at national and regional levels.

5.3 NATURAL RESOURCES

The region's coastal and marine natural resources are generally degraded to varying degrees and face ever-increasing risk as a result of rapid development trends. There are two primary reasons for why ongoing development is having such a pronounced effect on the environment. Firstly, the infrastructure necessary to provide basic living standards such as clean water and proper waste disposal to growing populations is often either outdated or simply inadequate. This has resulted, (and is likely to continue to result), in considerable pollution beyond the sink capacity of the environment.

Secondly, despite the region's significant economic growth, substantial poverty still exists, particularly in the rural population. The rural poor, almost exclusively dependent on primary production activities such as fisheries and forestry, experience high levels of under-employment, restricted cultivable land per capita, inadequate supply of materials, poor access to markets, and little opportunity for value-added processing of their own produce (ADB, 1995). The combination of these factors inevitably leads to over-exploitation of the natural resources available, for simple reasons of subsistence and survival.

5.3.1 PETROLEUM RESOURCES

The petroleum sector in particular is likely to be one of great economic opportunity over the coming decade, due in part to the stable political climate in many COBSEA member countries and also to the region's general economic development. Increasing global demand for energy has been attracting international companies to invest in both the offshore and onshore petroleum sectors throughout the region, a trend which is expected to continue. At present, the energy sector as a whole is mainly driven by petroleum exploration activities, such as geophysical surveys, explorative drillings, resource assessments, natural gas plant developments, production sharing contracts, and integrated feasibility studies.

The outlook for the petroleum sector over the coming decade is still likely to involve significant increases in exploration activities undertaken by an expanding number of COBSEA member countries. For example, Indonesia drilled 33 new exploration wells in 2006 (22 offshore and 11 onshore), 14 of which proved to be discovery wells, giving a success ratio of approximately 42%. During 2007, Malaysia carried out extensive exploration activities, acquiring a total of 360,000 line km of 3D seismic data and drilling 35 new exploration wells (as well as 53 development wells). This trend is expected to continue over the coming decade.

Another important aspect of the outlook for the petroleum sector is the ongoing development of an adequate legal framework to govern the sustainable exploitation of available reserves. This is proving difficult for some COBSEA member countries, due to a scarcity of local experts in the legal and technical aspects of the petroleum industry. However, increasing cooperation with international legal experts and authorities is providing a solution.

Other COBSEA member countries with long histories of petroleum exploitation are looking to extend this further over the coming decade. For example, recent breakthroughs in geologic exploration theories and progress in exploration technology have enabled China to extend their exploration to risk areas and complex reservoir systems, such as lithologic strata and foreland basins. In 2006 alone, newly proven oil and natural gas reserves in the country were estimated at over 600 million tonnes and 300 billion m^3, respectively. Some COBSEA member countries are even beginning to expand their petroleum exploration and production activities into the international marketplace. Perhaps the best example of this is PetroVietnam, which has actively pursued such expansion and recently signed two contracts in Cuba, as well as an agreement on petroleum exploration and production in Venezuela.

5.3.2 MINERAL RESOURCES OF THE COASTAL AND MARINE ENVIRONMENT

Another natural resource issue anticipated to worsen in the coming decade is that related to the over-exploitation of mineral resources, primarily sea sand. Many COBSEA member countries are currently alert to the impact of current and projected rates of resource extraction, and attempting to find sustainable ways of exploiting these resources in the future.

An interesting example of a cooperative research effort to ascertain the outlook for marine resources was the 4th Viet Nam – Philippines Joint Oceanographic and Marine Scientific Research Expedition (JOMSRE–4). This project included survey, research, measurement, and sampling techniques, carried out to investigate various aspects: hydrometeorology, plankton biology, coral diversity, chemistry, marine environment, ecological toxicity, and marine geology.

For example, a 2006 project by the China Geologic Survey used geological and geophysical methods to evaluate China's offshore sea sand and other solid mineral resources. This evaluation is now being used by land and resource authorities to better manage mineral resources under a clearly-defined legal process, which will ultimately contribute to improved economic development, environmental protection, and the strengthening of government action.

As well as sea sand, future surveys are also likely to be concerned with other valuable solid mineral resources and oil sand resources. A variety of surveys will be used to investigate seabed surface sediment, coastal processes and sand bank formation.

5.4 NATURAL HAZARDS

Over the coming decade, a significant challenge to the governments of COBSEA member countries is expected to be posed by the intense natural hazards that frequently affect the region, the effects of which are often exacerbated by rapid urbanization and the accelerating development of often fragile coastal zones. These effects are projected to become even more serious in the future, as climate change increases the frequency and severity of such events. A number of the most significant factors will be considered here, in terms of their risk outlook over the coming decade.

5.4.1 NATURAL DISASTERS

The massive impact of the Indian Ocean tsunami of 2004 resulted in an increased level of awareness regarding the potential dangers of not only tsunamis, but also a wide variety of other natural hazards. This concern has been expressed in terms of a great number of studies and projects to ascertain the region's outlook in this regard, as well as in attempts to prepare for, and mitigate the impacts of any future events.

A recent coastal geology mapping study in Korea moved into its second phase in 2008 with an expanded scope – "Study on Mitigating Geological Hazards in the Asia-Pacific Region" under the United Nations Development Programme.

Most of these projects involve some form of high-resolution coastal geology mapping, in order to study and mitigate the effects of coastal flooding, particularly those events induced by typhoons, coastal erosion, and storm surges. Other research methods include sediment sampling, photo documentation, and the gathering of historical and anecdotal accounts.

Many research projects and institutional developments regarding seismic activity, earthquakes, and tsunamis have also been proposed or are currently ongoing. For example, Viet Nam launched the Earthquake Notification and Tsunami Warning Centre in 2007, which now operates as a national key point, cooperating with tsunami warning centres throughout the EAS region to collect information, and provide prompt notification and warning of any earthquake and tsunami risk. The outlook for this aspect involves a further expansion and improvement of these sorts of facilities and capabilities.

5.4.2 RAISING AWARENESS REGARDING NATURAL HAZARDS

Throughout the region, there is increased recognition of the need for greater awareness regarding the different kinds of natural hazards, their causes and effects, and how their adverse impacts can best be prevented or mitigated. Many COBSEA member countries are addressing this need through the use of seminars, workshops and international symposiums. For example, in preparation for the 2008 Ramsar conference in the Republic of Korea addressing coastal wetland issues, a number of such events were held, involving a wide representation from UN, international, inter-governmental or governmental organizations, academic societies, NGOs, and the civil sectors.

There is also a growing emphasis on information and education campaigns amongst the general populace of coastal regions. These campaigns aim to promote a greater public awareness regarding a wide variety of relevant issues, including coastal and marine geohazards, their causes and effects, and also the recommended preventive and mitigation measures available. Importantly, attempts are generally made to place the emphasis on the specific conditions and needs of each particular location, rather than taking a general, formulaic approach.

One component of this strategy could be to make easily available the types of coastal and marine geohazard survey maps, which indicate the degree of vulnerability or susceptibility of each coastal area to a particular geohazard. These maps will be useful not only to the local community, policy makers and land use planner and developers, but also to the residents themselves.

5.4.3 EROSION

Coastal and river bank erosion is a problem of increasing importance throughout the EAS region, particularly so over the last few years, and is anticipated to worsen over the coming decade. This change in the structure of coastlines and river banks is often a result of human activities, whether directly or indirectly. Some activities actually result in new sources of sediment to the coast, which change the coastal environment profoundly, and may promote an associated increase in coastal erosion elsewhere and the overall degradation of the coast.

An investigation of erosion along Thailand's coastal zone was recently conducted, including bathymetric surveys, study of ocean floor sediments in the Upper Gulf of Thailand, Cone Penetration Test (CPT) investigation in coastal areas of the Upper Gulf, and finally some guidelines for solving shoreline erosion were proposed. Of the total length of Thailand's shoreline (2,637 km), it was found that 375 km (or approximately 14.2%) were eroded.

When coastal development or other relevant human activities are undertaken without an adequate understanding of the local coastal ecosystem and conditions, it often results in the loss of economically valuable coastal habitats through erosion and other factors. For example, coastal development in West Java (Indonesia), which involved the deforestation of mangroves from local wetlands, resulted in changed coastal dynamics which are now causing extensive erosion along that coastline, estimated to retreat 1-10 m annually. However, a number of other factors are implicated. Firstly, a large part of that coast's sediment budget has historically been supplied by nearby rivers, but many of these have now been dammed for flood control purposes and water catchments, resulting in a decreased amount of sediment supplied to the coast. Additionally, many countries are also practising coastal sand mining usually for the purposes of land reclamation, which may change beach gradient and hasten coastline erosion.

The traditional response to coastal erosion has been to build coastal structures such as groynes, piers and jetties to prevent beach sediment loss. However, these structures also delay the littoral drift of sand naturally caused by long-shore currents, resulting in a change to the coastal sediment budget. This may result in the gradual formation of a new coastline altogether, with degradation in some coastal areas and progradation in others. Progradation, or sand drift, can result in significant problems. Viet Nam has identified an increasing number of areas already suffering from sand drift (roughly 284 km^2), the landscapes of which have been dramatically impacted by the phenomenon. Valuable habitats and cultivable land may be compromised or even effectively destroyed, as sand drift eventually results in desertification. Human settlements affected by sand drift may have to be relocated, and road sections buried by the sand often require significant expenditure to be restored.

In order to more accurately determine the outlook regarding erosion issues, many COBSEA member countries are currently undertaking research to delineate and map areas potentially affected by erosion and determine the controlling factors, as well as establishing relevant guidelines to minimize its extent and severity. Many of these studies use remote sensing, such as comparing temporally-spaced aerial photos, and also include sea-floor topography, beach profiling, and sediment sampling.

5.5 COASTAL DEVELOPMENT

There is increasing concern regarding the outlook for coastal development, which has been progressing at increasingly rapid rates throughout the region. For example, a recent study in Indonesia investigated the effects of ongoing development on the Tirtamaya coastline, looking specifically at the deforestation of mangroves (cleared to make space for new coastal fisheries), the construction of dams along upstream rivers and channels, and the dredging of coastal sand for reclamation. The resulting erosion of these coastal areas may have been temporarily stabilized by the construction of numerous groynes and jetties for that purpose, but it seems likely that this measure has actually contributed to altered coastlines in other areas. Significantly, the study concluded that irresponsible coastal development may have resulted in enormous profits in the short-term, but recovery of the damaged coastal environment will cost much more in the long-term.

Other studies are examining the outlook for coastal areas which have historically undergone very high levels of development. For example, a coastal geological mapping project is currently underway in Penang (Malaysia), developing a geohazard mapping methodology for the coastal areas with regard to the effects of tsunamis, oil and waste pollution, and cliff instabilities around the backshore areas.

Particularly in the aftermath of the Indian Ocean tsunami in 2004, the re-occupation of areas abandoned during or following a major natural disaster is an issue receiving greater attention. A recent study into this situation in the Philippines showed that the main coastal degradation problems affecting these regions were coastal flooding, landslides, storm surges, and erosion. This issue is likely to be of great significance over the coming decade.

5.5.1 INCREASING LEVELS OF WASTE ASSOCIATED WITH COASTAL DEVELOPMENT

One of the myriad impacts of escalating coastal development, rapid economic and industrial growth, and accelerating urbanization is the increasingly significant amount of waste produced and often dumped, directly or indirectly into the coastal and marine environment. Potential sources of this waste include industrial effluents, domestic sewage, coastal fisheries, shipping, and oil tankers.

The region's coastal habitats such as mangroves and coral reefs, as well as many other marine biota, have profoundly deteriorated. This is at least partly due to the effects of waste dumping, which is having (and will continue to have over the coming decade) an adverse impact on the environment and society.

One project in Viet Nam delineated areas in which elevated concentrations of toxic elements were found (such as lead, zinc, arsenic). These toxic mineral zoning maps can be consulted by the population and urban planners, and action implemented to mitigate the adverse impacts on community health. Measures such as these are likely to become more and more useful and common over the foreseeable future.

5.6 MARINE LITTER

It is not easy to comment on the outlook for the region's marine litter issue over the coming decade, simply because little is currently known about it. A recent COBSEA report revealed that data or references on the sources, causes, quantities and distribution of marine litter at the regional level are limited and only sporadic information is available for a few COBSEA member countries (UNEP EAS/RCU, 2008). However, a number of predictions may be made with some confidence, considering related trends and relationships.

The specific problem of Lost and Abandoned Fishing Gear (LAFG) is likely to become of increasing concern throughout the region, as a result of the large size and economic significance of the fisheries industry and the difficulties involved in effectively regulating it, as well as the consistently high levels of Illegal, Unregulated and Unreported (IUU) fishing. More generally, marine litter is likely to increase as a result of ongoing urban and industrial development along the region's coastlines, the projected exponential growth in regional shipping activity, and the current lack of any effective marine litter prevention and control measures in many COBSEA countries.

A number of recent conventions and strategies attempted to address at least some of these problems. The IMO's International Convention for the Prevention of Pollution from Ships (MARPOL) includes regulations regarding the disposal of garbage from vessels at sea (especially plastics), and the provision of adequate waste-processing facilities in major ports. UNEP has also considered this problem in the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, which aims to reduce the generation of solid waste which may end up in the marine environment, and to establish environmentally-sound facilities for the processing of such litter where prevention is not possible. Despite this, there is a conspicuous lack of any single global convention, initiative or programme covering the reduction and control of marine litter, and the ever-increasing severity of the problem clearly indicates that currently existing initiatives are relatively ineffective.

One aspect of the problem is an inadequate understanding of the ocean currents which determine the fate and transport of marine litter. Marine litter accumulated on coastlines around the world often originate from a very distant source, possibly even the other side of a major ocean (Brainard, 2000). One priority is certainly for scientists, regulators and industry to develop a better understanding of detailed ocean circulation patterns. While broad-scale ocean circulation patterns can be easily obtained from general navigation and oceanographic texts, more detailed scales over shorter time periods are of greater relevance for assessing and managing marine litter. This is likely to be much more complex, highly variable and seasonally dynamic, influenced by a combination of wind-driven currents, wave-driven currents, and thermohaline or density-driven currents.

A few general conclusions could be drawn from the report (UNEP EAS/RCU, 2008). Perhaps the most important is that despite the fact that it is likely to become one of the major threats to the world's oceans in the near future, very little is currently known. It also looks set to be an especially significant problem in the EAS region, due to the high levels of economic and industrial activity, the ever-increasing level of shipping, the large and often-unregulated fisheries industries resulting in high LAFG, and the current lack of marine litter prevention and control measures.

5.7 INVASIVE SPECIES

Unless effective prevention and control measures are adopted and implemented soon, the problem of marine and coastal invasive species is likely to worsen over the coming decade, primarily due to the projected increase in the level of shipping throughout the region. Organisms picked up from one region of the world by one of these ships and usually contained in the ship's ballast water, may be later deposited in a totally different region containing very different ecosystems and local species.

Not all introduced species can survive but some will thrive at the expense of local species and habitats. The most harmful of these invaders displace native species, potentially changing natural community structures and food webs significantly. These species may have an impact on human health (such as causing disease), or the economy (through diminished fisheries, the fouling of ships' hulls, and clogged intake pipes).

A few recent studies provided quantitative data showing that the rate of species invasion around the world is increasing (often at exponential rates), and that it is closely related to increasing shipping activity. Ship traffic is projected to continue growing into the coming decade and the outlook for the problem of invasive species should raise some concern. The EAS region has one of the world's highest concentrations of shipping and fishing vessel activity. Increasing levels of marine litter are also likely to contribute to this problem over the coming decade (Kiessling, 2003).

IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments (2004) requires undertaking by signatories to prevent, minimize and ultimately eliminate the transfer of potentially harmful aquatic organisms and pathogens through the control and management of ballast water. A vital aspect of this undertaking is the provision of adequate reception facilities for the cleaning and repair of ballast tanks at large ports and terminals. Other important components of the convention are individual or cooperative research efforts into responsible ballast water management, adequate monitoring programmes to assess results, and the regular inspection and certification of ships with regards to their ballast water quality and management systems. However, none of the COBSEA countries have thus far adopted this convention.

GloBallast Programme and Partnerships

In 2000, the International Maritime Organization (IMO), Global Environment Facility (GEF), United Nations Development Programme (UNDP), member governments and the shipping industry teamed up to assist less-industrialized countries to tackle the ballast water problem through a four-year programme called "Removal of Barriers to the Effective Implementation of Ballast Water Control and Management Measures in Developing Countries", or Global Ballast Water Management Programme (GloBallast for short). The programme included Dalian, China, as one of the six demonstration sites.

The main objectives of the programme were to assist developing countries to implement effective measures to control the introduction of foreign marine species by focusing on:

1. Reducing the transfer of harmful organisms from ships' ballast water;
2. Implementing the IMO ballast water guidelines; and
3. Preparing for implementation of the newly adopted IMO Ballast Water Convention.

Following the success of the GloBallast Programme, a follow-up project simply referred to as GloBallast Partnerships was initiated, with the overall goal of reducing the risks and impacts of marine bio-invasions caused by international shipping, and to assist vulnerable developing states and regions to implement sustainable, risk-based mechanisms for the management and control of ships' ballast water and sediments in order to minimize the adverse impacts of aquatic invasive species transferred by ships. It aims to do these by increasing global efforts to design and test technology solutions, and enhance global knowledge management and marine electronic communications to address the issue. The partnership effort is three-tiered, involving global, regional and country-specific partners, representing government, industry and non-governmental organizations. Private sector participation will be achieved through establishing a GloBallast Industry Alliance with partners from major maritime companies.

Thirteen countries, from six high priority regions, have agreed to take a lead partnering role focusing especially on legal, policy and institutional reform. It is expected that 70 countries from 14 regions across the globe will participate, including the six pilot countries whose expertise and capacities will be used for the global scaling-up effort.

(http://globallast.imo.org/)

5.8 PROJECTED IMPACT OF CLIMATE CHANGE

Global climate change is now widely accepted as a very real threat and that at least some of its impacts are now inevitable, assuming that current rates of change continue over the coming decade (IPCC, 2007). Consequently, the adaptation approach strategy is increasingly being recognized as the most appropriate for adoption. However, a more precise assessment of projected environmental impacts is still required, with the ultimate goal of improving the information base, strengthening planning and coordination, and promoting increased participation and consultation with all stakeholders.

The World Bank (2007) reported that the EAS region is particularly vulnerable to climate change because of the large percentage of the population living along the coast and in low-lying land areas, a heavy reliance on agriculture, mounting water use, and the high dependence on marine resources. In addition, the region's increasing energy demand heavily reliant on fuel-based solutions pose a potential constraint to future adaptation and sustained economic growth. A recent assessment of climate change impact on Southeast Asia further emphasised that four developing countries (Indonesia, Philippines, Thailand and Viet Nam) were particularly vulnerable because of their large coastal populations, impending sea-level rise and dependence on agriculture products that are sensitive to droughts and floods (ADB, 2009).

In order to mitigate these threats and address some of the concerns, a number of COBSEA countries have recently completed national climate change plans or strategies, which vary widely due to many factors and national interests. For example, Indonesia's National Action Plan (NAP) on climate change issued in 2007, focuses on adaptation and attempts to coordinate and integrate the efforts of various relevant institutions. It contains policies on mitigation and adaptation, institutional strengthening, capacity building, technology and transfer, and key sectors such as fisheries, and marine and coastal area management (Francisco *et al*., 2008). It was established that the main problems facing Indonesia are a lack of technical and financial support from donor countries and a lack of ownership of climate change projects by several agencies, due to the inadequacy of capacity building. This is often complicated by the fact that donor assistance is generally targeted at emission-reduction projects, instead of assisting adaptation projects implemented in the NAP, a problem common to many other developing countries in the region (DFID, 2007).

China also issued its national climate change programme in 2007, outlining the objectives, basic principles, key actions, policies, and measures that it deemed appropriate to address climate change, applicable for the period up to 2010. For the coastal areas, the programme attempts to establish or improve relevant laws and regulations, promote technological development and extension, improve the capacity of marine environmental monitoring and early-warning systems, and strengthen adaptation strategies addressing sea-level rise.

Thailand's strategy, implemented in 2008, consists of six main aspects: research and development; adaptation capability building; mitigation of greenhouse gases; public awareness; capacity building; and international cooperation. Viet Nam has taken advantage of international assistance and projects (such as a Dutch-funded project identifying vulnerability of the coastal area to sea-level rise and outlining initial steps towards integrated coastal zone management to address this), and is currently preparing its national programme. The Philippines has also received assistance to carry out a wide range of climate change studies, leading to several bills that will eventually constitute its national action plan on climate change. Singapore released a national climate change strategy in early 2008, addressing two broad areas: vulnerability and adaptation; and the mitigation of greenhouse gas emissions.

While climate change issues and the impacts of rising sea surface temperature have received considerable attention, the impacts of ocean acidification, which is projected to gain significance with projected increases of atmospheric CO_2 concentrations, has only recently attracted growing attention. Research to address ocean acidification has been initiated in Australia (Ocean Acidification Research Programme, http://www.comalco.com/documents/Ocean_Acidification_Research_Programme.pdf), and some COBSEA countries like Singapore are also planning to address the issue through research.

Action from the national and local government as well as public participation in adaptation strategies, Bang Khun Thian District, Bangkok (Jarungratttanapong and Manasboonphempool, 2008).

Bangkok is one of the most vulnerable cities to sea-level rise in the whole of Asia. Bang Khun Thian, (the only district in Bangkok province that is located on the coast), has a coastline of 4.7 km where coastal erosion is taking place, (at a rate of 20-25 m per annum near one particular village). The major economic activity in the area is coastal aquaculture, focussing on shrimp and blood cockles. A study was recently conducted to determine household adaptation strategies for coastal erosion/flooding in this district (Jarungratttanapong & Manasboonphempool, 2008). It is based on site visits, discussions with local residents, a review of the existing literature, and household surveys.

Within Bang Khun Thian District, the households have been trying to protect their shrimp ponds for more than 30 years. However, although much is known about natural phenomena and climate change issues in general, residents do not have enough details regarding the potential of global warming to cause sea-level rises in the near future. In general, they have acted individually and applied one or more of the three types of autonomous adaptation strategies: protection, (such as stone breakwaters, bamboo revetments or dyke heightening), retreat inland, and accommodation, (rebuild/renovate after flooding). Each household usually has more than one adaptation option, with protection strategies being the most popular. The annual adaptation cost from 1993-2007 was US$ 3,130 per household, (roughly 23% of an average household income). Existing government assistance has not been very effective over this period.

The study highlights the weakness in individual adaptation, where individual decision to adapt becomes a negative externality to neighbours. For example, conflicts sometimes occur when neighbours cannot afford to pay for the maintenance of structures, which are subsequently allowed to deteriorate. However, the households did act as a group when the former headman requested government assistance to cope with coastal erosion.

The study shows that individual household adaptation strategies, without any collective aspect, may not be a good solution to problems associated with rising sea-levels. For example, protective structures need to be built along the entire coastline and not only some parts. Secondly, due to low levels of education and a lack of knowledge, farmers cannot shift to other occupations – thus they were willing to pay highly for protection structures since they have no other option. Lastly, protection measures should be planned for the upper Gulf of Thailand and not for each coastal area by the local government. Action from the national and local government as well as public participation is essential.

5.9 FISHERIES

The region's fisheries certainly have the potential for further development over the coming decade, especially for aquaculture. Since 1999, aquaculture production surpassed that of capture fisheries (Figure 19). It seems likely that such a trend is a result of various management schemes, which have attempted to address concerns regarding over-fishing and the over-exploitation of marine fisheries resources, (Appendix 5). If this is the case, then this trend is certainly expected to continue in the coming decade.

COBSEA countries currently use a wide range of fisheries management schemes, approaches, and tools to address concerns of over-capacity and over-fishing, and to reduce the pressure being placed on the over-stressed marine fisheries resources (Appendix 6), but the relatively low socio-economic conditions prevalent in many parts of the region may be influencing governments to focus primarily on increasing fish production and trade. Efforts to implement more sustainable management strategies are often hampered by the constant changes in governance brought about by various political structures in the central and local governments.

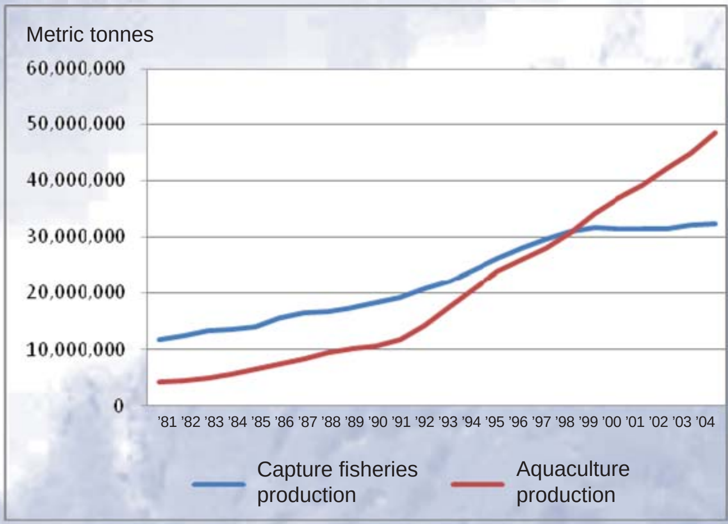


Figure 19: Total EAS production from capture fisheries and aquaculture for the period 1981-2004
Source: FAO, 2006a.

However, at least some of the COBSEA countries are already shifting their focus from increased production to more sustainable fisheries management. Others have also devolved from a centralized authority to provincial and district, or local government units, although still retaining central government support and oversight. These could be interpreted as healthy signs for the outlook of the fisheries sector, in terms of their sustainable development over the coming decade. Much improvement is still possible, since most COBSEA countries have still not fully adopted participatory management practices that truly involve the various stakeholders and welcome their participation. If achieved, stakeholders (especially fishers) will be empowered to take up the responsibility of joint stewardship of the fisheries resources with the government.

The Third National Agriculture Policy of Malaysia set an annual capture fisheries production target of 1.4 million tonnes by 2010, projected to comprise 0.5 million tonnes from offshore production and 0.9 million tonnes from coastal production (compared to 2004 coastal production of roughly 1.3 million tonnes). Malaysia has implemented strategies for fishing effort reduction which include: (1) moratorium on new coastal commercial fisheries licenses since 1980s; and (2) exit plan – buy back scheme. However, the coastal waters of Peninsular Malaysia are fully exploited with large proportions of undersized fish of commercial species being caught. For example, by 1998 the density of the demersal fish resources in certain coastal waters of Peninsular Malaysia was only 5% of the 1967 value, while in offshore waters the 1998 density was around 5-10% of the density in 1986 (Nuruddin, 2007).

Further potential exists in the use of NGOs to assist governments in bringing the management structures to the fisheries communities. NGOs have the capacity to bridge the management and communication gaps between the central governments, or devolved government systems, and the various stakeholders in the fisheries communities. Thus far, this potential has been best realized in the Philippines, with a variety of impressive results (Domenden, 2008).

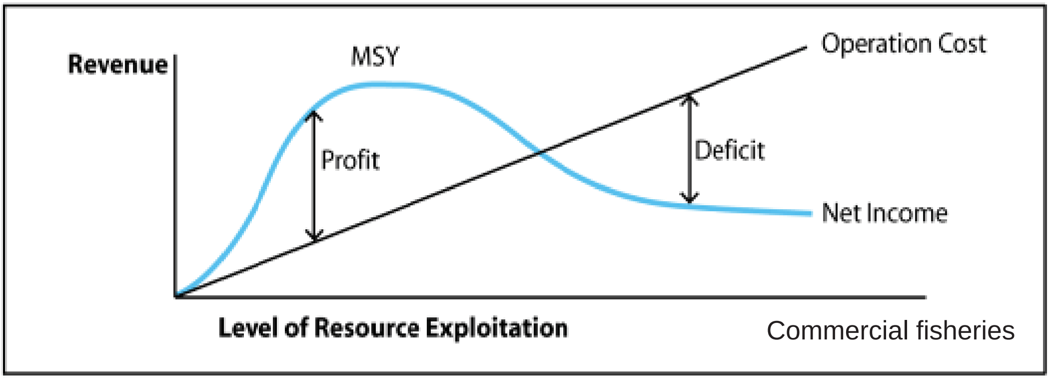
5.9.1 OUTLOOK FOR SMALL-SCALE FISHERIES

In the past, a common misconception regarding marine fisheries has been that the resources are essentially infinite, which led to the rapid growth of largely unregulated operations in most major fishing grounds throughout the world. This has been especially true in the EAS region, particularly the trawl fishing grounds in the Gulf of Thailand and the Java Seas (Kato, 2007). Most of the fisheries in the over-crowded seas of the region are small-scale, since large-scale fisheries face increasing difficulty operating in an economically viable manner in most fishing grounds, as a result of various economic, political and legal constraints. Requiring lesser inputs than large-scale fisheries, many small-scale ones have survived to continue providing livelihoods to many people living in coastal areas.

In the past, technological limitations meant that the marine fisheries industry was not an economically attractive livelihood, and was generally taken up only by people who had no alternatives. Although the situation changed during the 1960s, following the introduction of modern fisheries technologies, the economic viability of small-scale fisheries deteriorated as a result of resource depletion due to unregulated fishing operations. However, many fishers continue to engage in small-scale fisheries as a result of poverty and a lack of alternative livelihoods.

> In 2000, a major reform of Cambodia's fisheries strategies saw a significant reduction in the total fishing lot area and also the establishment of Community Fisheries (CFs) throughout the country. This involved the transfer of roles and responsibility from the central government to local communities, introducing a co-management arrangement in which the local communities were encouraged to manage the fishery areas and activities themselves. In an indication of the success of this reform, the number of CFs has grown from 165 in 2001 to a final total of 509 in 2007, with the focus now being on strengthening and empowering them further (Vuthy, 2008).

Kato (2007) developed a simple model for the relationship between the incomes and operation costs, and the level of resource exploitation, for both commercial and small-scale fisheries (Figure 20). In the case of commercial fisheries, operation costs increase as the level of exploitation amplifies (because operators are forced to navigate further in search of good fishing grounds, to extend their operation time, and to invest in improved gear and equipment as a result of fish stock depletion). At a certain exploitation level, commercial fisheries are no longer financially viable and operators are forced to quit. However, for small-scale fisheries, operation costs are much less and fishers could still continue, although at the cost of deepening irreversible resource deterioration.



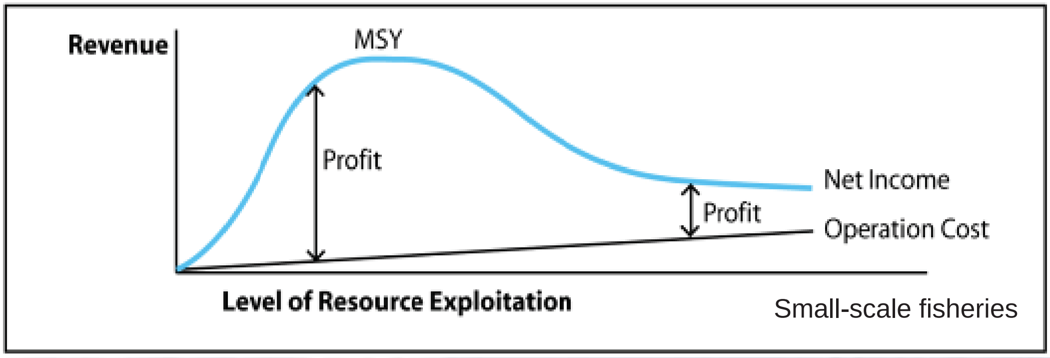


Figure 20: The relationship between income and operating cost, as a function of resource exploitation (Kato, 2007)
Source: SEAFDEC.

Fishers whose incomes are not insufficient for their daily needs may resort to destructive fishing gears such as fine mesh nets and illegal fishing using dynamite or toxic chemicals. An added threat is posed by the fact that small-scale fishers often operate in inshore waters, which are known to be spawning and nursery grounds for the commercially important species. Such unregulated practices have significant negative impacts on the entire fisheries resource and must be controlled over the coming decade.

In the Philippines, current programme interventions to alleviate poverty among small-scale fishers include distribution of fishing gear paraphernalia, input assistance (fingerlings, seaweeds and others), establishment of seaweed nurseries and mariculture parks, assistance in livelihood enhancement, improvement of marketing, loan access and fisheries infrastructure, distribution of post-harvest equipment, and technology demonstrations.

Coastal fisheries resources have also deteriorated because of frequent encroachment by the more technically-equipped operators into areas that lack effective fisheries management systems. Considering inadequate systematic government support, Kato (2008b) postulated two vicious cycles generally observed in the region's small-scale fisheries, which deter efforts toward achieving sustainable fisheries (Figure 21).

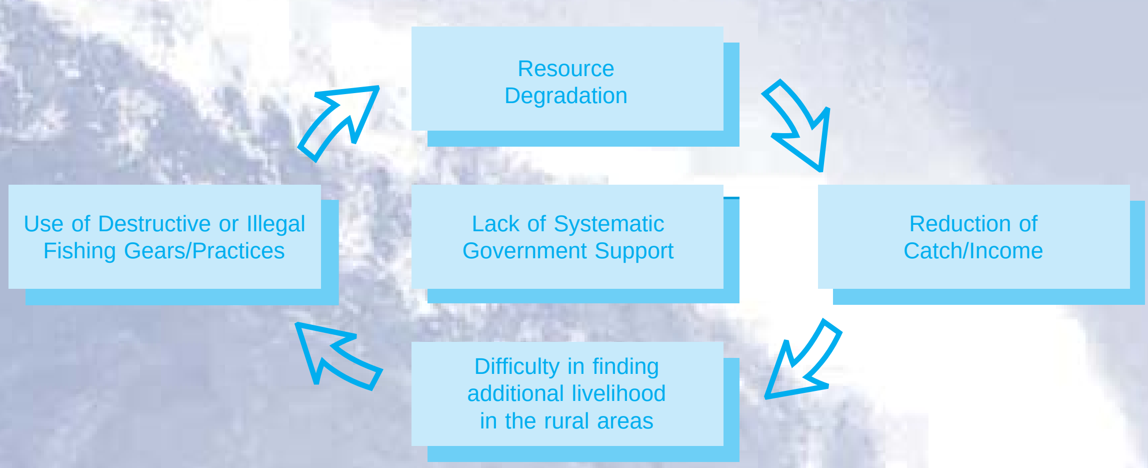


Figure 21: Vicious cycle of resource utilization (Kato, 2008b)
Source: SEAFDEC.

Small-scale fishers have always encountered difficulties in finding additional sources of income in rural communities, sources that could potentially alleviate their financial difficulties. This leads to a vicious cycle, which aggravates the resource situation by their continued involvement in unsustainable fishing practices. Since this lack of alternative livelihoods is usually related to the general poverty status in fishing communities and the economic divide between urban and rural areas, the best solution may be the economic development of the country as a whole, and not just using fisheries intervention. However, such analyzes have often discouraged the government fisheries sector from being actively involved in finding solutions to this basic problem (Figure 22). Either way, this is a very significant problem that has to be addressed over the coming decade.

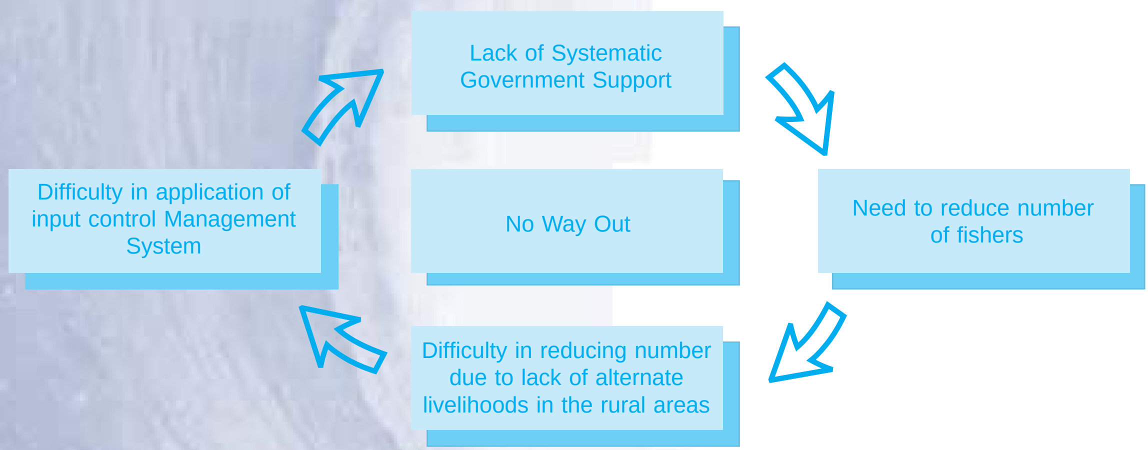


Figure 22: Vicious cycle in achieving sustainable fisheries (Kato, 2008b)
Source: SEAFDEC.

5.9.2 INCREASING IMPORTANCE OF AQUACULTURE

The present trend of increasing aquaculture production in the EAS region seems capable of closing the gap between the regional supply and demand for fish products over the coming decade. However, in order for aquaculture to continue contributing to the sustainable and long-term growth and development of the region, practices must be made as environmentally-friendly and socially equitable as possible.

Most COBSEA countries view the aquaculture sector as a very promising means to mitigate the already over-stressed marine fisheries resources, and have been actively promoting and encouraging the sustainable development of aquaculture as a means of ensuring food security for their people. For example, as part of its fisheries reform programme, Cambodia is promoting the expansion and improvement of its indigenous aquaculture activities to provide alternative livelihoods and to alleviate poverty in the fisheries communities (Chun, 2008). As China embarks on a catch-limit system in its traditional capture fisheries, which will lead to a decreased supply of fish to its growing population, it is aiming to further intensify and diversify its aquaculture activities in order to make up the inevitable short-fall in supply.

In recent years, a continual decrease in Korea's capture fisheries production has led to increased attention being paid to aquaculture as a sustainable alternative. The country's aquaculture production increased from 667,883 tonnes in 2000 to 952,856 tonnes in 2004, (a rise of more than 40%), accounting for more than a third of total fishery production in that year. As well as playing an important role in national food security, aquaculture is also an important provider of employment for the rural population, accounting for 63,570 jobs in 2004, roughly a third of the total number of fishers (KNSO, 2004).

A number of COBSEA countries have included aquaculture as one of the major focuses of their integrated coastal zone management strategies for the coming decade. For example, as part of Viet Nam's process of restructuring its coastal fisheries (aimed at reducing pressure on its coastal areas), groups of fishers were encouraged to move to other sectors such as aquaculture (which was identified as important for accelerating the country's economic growth). This process included both, improving aquaculture facilities and also increasing culture areas in the country's aquaculture centres (Nhung, 2008). In general, many other COBSEA countries are also looking at aquaculture as an alternative source of livelihood for their people in the future. As this planned development is implemented, it is vitally important that it is done sustainably, in a manner that is environmentally-friendly, economically sound, and socially equitable.

An honest appraisal of some of the evident threats posted by aquaculture, as well as a wide-ranging consideration of possible mitigation or prevention measures is necessary. For example, FAO (2006c) have already identified a number of problematic issues regarding aquaculture and its interaction with the environment. As the rapid development of aquaculture continues, and projected to do so over the coming decade, these potentially negative impacts must be addressed if the sustainability of the activity is to be ensured:

- Discharge of aquaculture effluents leading to degraded water quality, (potentially resulting in eutrophication), and the accumulation in farming areas of sediment rich in organic matter.

- Alteration or destruction of natural habitats and the related ecological consequences of conversion and changes in ecosystem function.

- Competition for freshwater, as well as for the use of fishmeal and fish oil, (with livestock sector).

- Improper or irresponsible use of chemicals, raising health and environmental concerns.
- Introduction and transmission of aquatic animal diseases through poorly regulated translocations.
- Impacts on wild fisheries resources through collection of wild seed and brood organisms.
- Effects on wildlife through methods used to control predation of cultured fishes.

5.9.3 OVERALL OUTLOOK FOR FISHERIES

Over recent history, the EAS region has witnessed remarkable development in its fisheries industries (both capture and aquaculture), which is perhaps best illustrated in the case of China. Records show that China's average annual fish production (from both capture and aquaculture), has increased rapidly from roughly 10 million tonnes (during the 1980s), to around 55 million tonnes in 2004. Of the latter, a surprisingly high 70% was contributed by aquaculture (marine and freshwater) production.

However, in the present time and for the foreseeable future, fisheries are faced with a great number of environmental, ecological and social threats, all of which raise the question of whether these limited resources can sustainably support anything close to the current rates of exploitation. An additional, and growing, threat to fisheries is climate change, which has already resulted in rises in sea-level, altered rainfall patterns, and changes in temperature and currents. These changes have already critically affected many, if not most, of the primary fish habitats in the region, especially mangroves and coral reefs. This has already had a noticeable impact on the productivity of the fisheries, an impact which is projected to increase further over the coming decade.

Many of the other important adverse impacts on the marine environment are directly anthropogenic in nature, such as over-fishing, collection of by-catch, and the rampant use of destructive fishing methods, (which degrade fish habitats). Other anthropogenic activities which are projected to continue affecting the marine and coastal environment over the coming decade, albeit less directly, are mining, agriculture, shipping, tourism, industrial development, forestry, urban development, waste dumping, land reclamation, and dam construction. Therefore, if fisheries and aquaculture development is to be conducted sustainably in the region, it is essential that healthy aquatic ecosystems are protected, restored, and maintained. The outlook for this involves setting goals and standards to define a healthy ecosystem, promoting awareness and education regarding all relevant threats, ensuring that appropriate monitoring systems are in place, collecting all data necessary for determining the state of the environment, and utilizing that data to continually improve management techniques and strategies.

5.10 INTERNATIONAL MARITIME ORGANIZATION (IMO) CONVENTIONS

The EAS region has one of the highest concentrations of shipping and fishing vessel activity in the world (Figure 23). Considering the projected rate of economic development over the coming decade, it is inevitable that most of the region's major industrial ports will undergo significant expansion and that many new ones will be developed to cope with increasing levels of shipping. Despite the economic benefits to the region, it will also have a number of adverse (and potentially very costly, in the long-term) impacts on the marine and coastal environment. For example, countries along the Malacca Straits, one of the busiest shipping lanes in the world, already face constant threats from oil and ship-based pollution, and these are likely to grow considerably over the coming decade. It is important for COBSEA countries to establish regulatory frameworks to protect the marine and coastal environment from the potentially negative impacts associated with the increase in shipping activity.

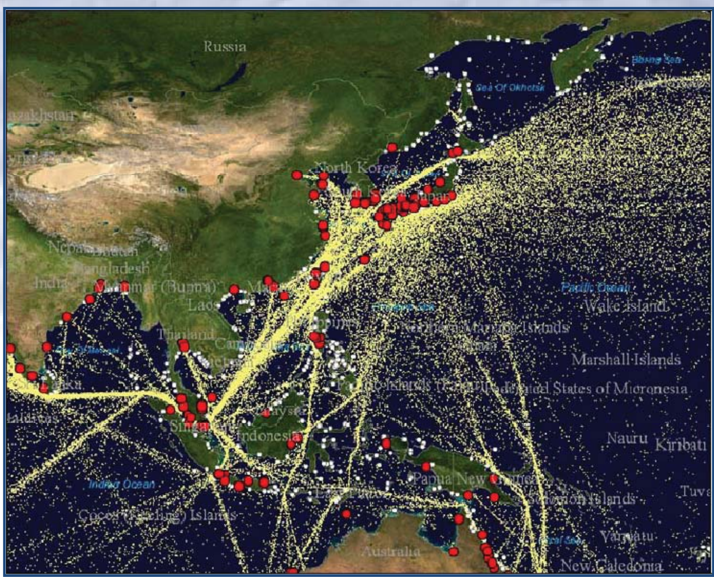


Figure 23: Shipping densities as represented by real ship position reports and major ports (red dots)
Source: Globallast Programme, IMO; http://globallast.imo.org.

Over the last sixty years, the IMO has developed a comprehensive regulatory framework for shipping activities, covering such aspects as safety, environmental concerns, and legal matters. A number of these conventions, relating to the protection of the environment, were briefly discussed in Chapter 3B: Water Quality. As shipping activity increases, the importance of these regulations and of the preventive and precautionary approach espoused in them, is likely to become ever more appropriate for the outlook of the EAS region. The current status of certain relevant IMO conventions ratified by each of the COBSEA countries is shown in Table 13.

The reluctance in ratifying and implementing various IMO conventions by some COBSEA countries may be due to uncertainty over the benefits of such actions. In addition, there is a perceived apprehension of the capacity to honour all obligations involved with ratification. The socio-economic circumstance of some COBSEA countries influences governments to give higher priority to sectors such as agriculture, education and health, than to the maritime sector.

To address both concerns, the GEF/UNDP/IMO Regional Programme of Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) is working to provide institutional strengthening and capacity building to countries to implement IMO conventions relating to marine pollution. Demonstration sites were established in several of the region's coastal cities, showing various measures to reduce and manage marine pollution. The second phase of the project began in 2000, expanded the number of demonstration sites and broadened the focus to include integrated coastal zone management strategies.

In light of changing circumstances and technologies, the regulatory frameworks developed by the IMO are also changing, and the outlook for the coming decade is likely to see a number of updates and revisions to reflect changing trends and priorities. For example, a revision of Annex V of the MARPOL convention (relating to the disposal of garbage from ships), is currently being undertaken in order to provide clearer regulations regarding the disposal of cleaning residues, lining and packaging materials, and livestock wastes, and the upgrading of port reception facilities for various kinds of waste.

Table 13: Status of various environmental IMO conventions in different COBSEA countries

	IMO Convention 48	IMO Amendments 91	IMO Amendments 93	MARPOL 73/78 (Annex I/II)	MARPOL 73/78 (Annex III)	MARPOL 73/78 (Annex IV)	MARPOL 73/78 (Annex V)	MARPOL Protocol 97 (Annex VI)	London Convention 72	London Convention Protocol 96	OPRC Convention 90	HNS Convention 96	OPRC/HNS 2000	Anti Fouling 01	Ballast water 04
Australia	X	X	X	X	X	X	X	X	X	X	X		X	X	
Cambodia	X			X	X	X	X								
China	X	X	X	X	X	X	X	X	X	X	X				
Indonesia	X	X	X	X											
Malaysia	X	X		X		X	X				X				
Philippines	X	X	X	X	X	X	X		X						
Korea	X	X	X	X	X	X	X	X	X	X	X		X	X	
Singapore	X	X	X	X	X	X	X	X			X		X		
Thailand	X	X	X	X							X				
Viet Nam	X		X	x											

Source: http://www.imo.org.

CHAPTER 6: OPTIONS FOR ACTION

In response to the current state of the marine and coastal environment of the EAS region, and in light of the future trends and threats identified and discussed in this report, a number of options for action can be established. Perhaps most importantly, improved management strategies are necessary, which are capable of integrating economic and environmental concerns more harmoniously, facilitating improved data collection and management, actively encouraging greater stakeholder participation and community ownership, and implementing international conventions more extensively. Specifically, there is much that should be done as soon as possible with regards to emerging problems such as marine litter and invasive species.

A number of other options for action have also been suggested, relating to the improved management and regulation of the fisheries industry, especially with respect to the rapid growth of aquaculture throughout the region, and measures to prevent or mitigate the various damages associated with natural disasters and the global phenomenon of climate change.

6.1 IMPROVED MANAGEMENT OF THE COASTAL & MARINE ENVIRONMENT

6.1.1 INTEGRATED MANAGEMENT STRATEGIES

One of the main problems in effectively managing the coastal resources of the EAS region is the prevalence of short-term and sectoral management in many countries, despite numerous policies and legislation with direct relevance to coastal and marine protection (Ward and Butler, 2006). A paradigm shift in this area is necessary, moving away from short-term, sectoral management towards a more systematic and integrated approach to managing coastal and oceanic issues and threats.

Such reform would likely provide more effective governance through the delivery of more appropriate solutions, as well as increasing efficiency by reducing the large amount of duplication and redundancy evident in existing governance systems. This would ultimately translate to reduced monetary costs to governments, communities, and the private sector.

In order to achieve this reform, it is vital that each of the COBSEA countries develops a systematic and strategic policy or operational framework that provides for the national-level monitoring and assessment of the condition of the ocean features, biodiversity and key resources, as well as widely disseminating this information for better-informed decision-making and the creation of focussed political will. Each country's strategic policy would have to define clear leadership responsible for coordinating the cooperation of all involved departments and agencies, so as to avoid the overlapping of roles and responsibilities (DEQP, 2006).

However, while strong leadership is critical, it is just as important that this policy is fully integrated with any other relevant long-term strategies and that it is effectively implemented at all relevant levels, through the development of institutional and local capacity for coastal management. This would require the establishment of a clear monitoring and control system, reinforced by strict and efficient law enforcement to ensure compliance (BAPPENAS, 2008).

Thailand's Coastal Resources and Environment Report 2007 (ONEP, 2007) and the World Bank's Thailand Environment Monitor Report 2006 (World Bank, 2007a) both observed that although Thailand has in place a number of policies and regulations for protecting and preserving resources, their effective implementation is hindered by overlapping and outdated laws, a lack of coordination among agencies, and limited resources. The reports recognized the need for the review and improvement of existing legislation to address pressing challenges to the coastal environment, and made the following recommendations:

1. Enabling strong leadership from the Department of Marine and Coastal Resources (DMCR).
2. Enacting a Marine and Coastal Resource Management Act.
3. Coordination of national and regional policies, regulations and activities, led by the DMCR.

6.1.2 BALANCING ECONOMIC GROWTH AND ENVIRONMENTAL PROTECTION

It would be unrealistic, and ultimately counter-productive, to advocate environmental protection and conservation at the cost of all economic growth. However, it is imperative that the sustainable balance between these two, often competing, priorities be identified and adopted in the national policies of all COBSEA countries. Rather than focussing solely on economic growth and measuring success in those terms, there should be a paradigm shift such that equal emphasis is placed on environmental protection and the responsible, sustainable use of natural resources, particularly where those emphases may be addressed simultaneously rather than in competition. Strategies are required which ensure the protection and sustainability of the region's ecosystems, as well as local livelihoods, while still contributing to the national economy.

Economic development and environmental protection should ideally be synchronised as far as possible, rather than always competing against each other. For example, Korea's Comprehensive National Environmental Plan (Ministry of Environment, 2007) aims to proactively develop environmental policies in which environmental conservation and economic development are well-balanced. Rather than simply placing limits on the use of natural resources, environmental regulation will also be used as a way to facilitate technological development, enhance the environmental-friendliness of goods and services, and to create new markets. This long-term strategy will also foster the development of environmental industry as a new economic growth engine for the future.

The Ninth Malaysian Plan 2006-2010 (EPU, 2006), developed by the country's Economic Planning Unit, commits to applying a greater focus on preventive measures to mitigate negative environmental effects at their source, reducing illegal acts against the environment, and intensifying conservation efforts to sustainably manage natural resources. However, it also highlighted the growing awareness of environmental stewardship, and the government's continued commitment to promote it in order to ensure the optimal balance between development and social needs, and the protection of the environment.

An essential aspect of this plan is the education of the general public regarding the importance of using natural resources sustainably and of limiting or preventing pollution. However, this education and raising of awareness will only be successful if it is simultaneously supported by the improvement of local livelihoods and socio-economic conditions (World Bank, 2005b).

Needless to say, current environmental protection and rehabilitation efforts must also be improved and strengthened, particularly with regards to essential ecosystems such as coral reefs and mangroves. As urbanization increases particularly in coastal cities, general environmental conservation plans for cities become more and more important. For example, city plans should prioritise the development and expansion of green areas and waterfront areas, both for the sake of making the urban environment more liveable and also for the environmental services that these areas provide.

6.1.3 IMPROVING DATA COLLECTION AND MANAGEMENT

Many of the COBSEA countries have already recognized an urgent need for improved data collection and management to support decision-making in the fields of environmental conservation, regulation, policy and sustainability. This would include national assessments of each country's coastal and ocean resources and conditions, as well as improved measurement of environmental progress for general "State of the Environment" reporting (Ward and Butler, 2006).

However, improved data collection and monitoring are simply not enough. Better technologies, knowledge, skills and investment strategies are needed to transform the scientific data into practical products that can be easily understood and used by all stakeholders. Ideally, these data and their practical products could then be shared among countries throughout the region, so that lessons learned can benefit all.

6.1.4 ENCOURAGING GREATER STAKEHOLDER PARTICIPATION

It is essential that all sectors of society are educated and engaged in as many environmental issues as possible to encourage shared responsibility, participation, and a sense of ownership (Ward and Butler, 2006). Some environmental issues are equally relevant to all COBSEA countries, such as raising awareness regarding climate change, its causes, its potential effects, and plans for mitigation. However, other issues are more specific to certain countries or areas, such as the dangers of destructive fishing practices in Cambodia (DEQP, 2006).

As well as raising the level of environmental awareness of the general public, it is equally important that enhanced partnerships be developed with private enterprise (BAPPENAS, 2008). For example, Viet Nam's Five-Year National Environmental Action Plan 2001-2005 (VEPA, 2001) issued a number of policies offering economic incentives for private sector involvement in environmental protection efforts. The plan encouraged the involvement and active participation of individuals, enterprises, organizations, and environmental management bodies at all levels, as well as taking advantage of the assistance of any relevant international organization and funding.

For increased community involvement and participation to be achieved and sustained, it is important that relevant stakeholders are identified at a very early stage, and invited to become active in the planning, decision-making, and implementation of strategies to conserve the environment and encourage the sustainable use of resources. This early and prolonged involvement will result in a sense of identification with, and ownership of, the project or programme.

6.1.5 RESEARCH AND DEVELOPMENT OF RELEVANT TECHNOLOGIES

Research and development of relevant environmental technologies are increasingly recognized as an integral aspect of effective environmental and economic strategies. For example, Singapore is aiming to build up the technology base of the local environmental industry, to serve as its key driver and to catalyse the growth of the industry from idea conceptualisation to commercialization (MEWR, 2008). This strategy involves supporting appropriate research and development, test-bedding, encouraging early adoption of new technologies, bringing new technologies to the market (through incubators), and grooming specialist manpower. This is identified as an option for action that is relevant to many COBSEA countries.

Specific research and development needs that have already been identified include improved bio-prospecting, sustainable wealth generation from biodiversity resources, the development and improved efficiency of renewable energy, and other cross-sectoral initiatives that would have the potential of delivering multiple benefits (EPU, 2006; World Bank, 2005b).

6.1.6 PREVENTING OR REDUCING MARINE LITTER

In addressing the emerging problem of marine litter, perhaps the most important option for action is to attend to the urgent need for improved knowledge regarding the extent and causes of the problem, which will require significant effort to accomplish. Specifically, a central, regional database could be developed and maintained, to which national administrations can report annual statistics regarding the sources, causes, quantities and distribution of marine litter, so as to build up a comprehensive and easily accessible understanding of the increasingly important issue.

Much more needs to be done, as was acknowledged by a recent COBSEA report on the problem (UNEP EAS/RCU, 2008). This identified a number of barriers and gaps, at the regional level, of relevance to the prevention and control of marine litter, the most significant of which are outlined here. A major part of the problem is widespread ignorance at all levels, resulting in a very low political will to address the issue at all. This is exacerbated by an ongoing and sometimes exclusive focus on economic development as well as a number of other competing developmental policies, which often sideline or marginalize environmental considerations. This is partly as a result of insufficient regional data concerning the nature and full extent of the problem. However, this persistent lack of awareness regarding the issue of marine litter may also be explained by the absence of any regional multi-lateral legal instrument that might otherwise place legally binding obligations on signatories, providing a basis for regional and cooperative action (with other countries, as well as the private sector).

In terms of the specific actions that are required, the report recommended the development and implementation of a regional action plan on marine litter, which recognizes the transboundary nature of the problem. This necessitates extensive cooperation between COBSEA countries in the prevention or reduction of land- and sea-based marine litter, as well as Lost and Abandoned Fishing Gear (LAFG), the mitigation of its effects, raising awareness regarding the problem, and improved monitoring and assessment. At the national level, this would require not only the adoption and implementation of the regional plan, but also the adoption of a progressive approach to port waste reception facilities; sustained awareness campaigns targeting industry, community and government groups; national surveys and monitoring; relevant capacity building; integration of marine litter concerns into existing environmental strategies; the development of marine litter trajectory models; and close coordination with all relevant bodies and organizations.

To sum up, six major actions were identified as the highest priorities in addressing the issue of marine litter:

- Preventing and reducing marine litter from land-based sources.
- Preventing and reducing marine litter from sea-based sources.
- Preventing and reducing Lost and Abandoned Fishing Gear (LAFG).
- Mitigating the impacts of marine litter.
- Raising awareness of the problem of marine litter.
- Monitoring and assessing marine litter.

6.1.7 PREVENTING THE MOVEMENT OF POTENTIALLY INVASIVE SPECIES

Considering the increasing threat posed by marine and coastal invasive species, it is very important that decisive measures are taken soon to prevent and control their potentially devastating effects. Prevention is better than cure, considering the massive cost of trying to eradicate foreign species which have firmly established in a new habitat, as well as the dubious prospects of success for such efforts. Additionally, the eradication of a well-settled invasive species may actually have a negative overall effect on the ecosystem which has already been forced to adjust, opening up niches for different invasive species to take the place of local species.

For these reasons, it is much more sensible, both environmentally and economically to focus on the prevention of the transport of invasive species in the first place. It has been shown that this transport typically occurs via international shipping, either in the discharge of ballast water from different regions or through the “bio-fouling” of ships’ hulls. Current efforts to prevent both of these transport pathways are showing some promise, and it is also becoming increasingly clear that ballast water transport accounts for the major movement of foreign species. It is recommended that all EAS countries consider adopting the IMO’s International Convention for the Control and Management of Ships’ Ballast Water and Sediments (IMO, 2004).

Aquaculture is also acknowledged as an important source of invasive species that must be controlled. Stricter control measures, applicable across the whole industry, must be developed and effectively enforced to restrict the intentional or accidental introduction of harmful invasive species into local habitats.

COBSEA countries should take concerted action to prevent this from becoming a major and very costly problem. This involves halting the introduction of any new foreign species by focussing on priority pathways (particularly with regards to strict ballast water management programmes), closely screening new species before they are introduced into local aquaculture farms, providing the relevant governmental departments and agencies with sufficient resources to combat invasions, and addressing the increasing problem of marine litter as well.

6.1.8 INTERNATIONAL MARITIME ORGANIZATION (IMO) CONVENTIONS

There is a general lack of attention paid to maritime issues, legislation, infrastructure, enforcement, funding and training in the EAS region. Several countries have specified a number of issues which are currently acting as barriers to their ratification of IMO conventions or as difficulties in their effective implementation. These include issues relating to the International Convention for the Prevention of Pollution from Ships, (raising public awareness, and establishing oil reception facilities and systems for monitoring and controlling vessels in ports), the International Convention on Oil Pollution Preparedness, Response and Cooperation, (in terms of the absence of contingency plans and of advanced oil combating technologies), the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, and the International Convention on the Control of Harmful Anti-fouling Systems on Ships. Considering that they have been identified by the COBSEA countries themselves as being priorities, these areas are obvious candidates for necessary options for action.

Other actions recommended include the extended ratification and implementation of IMO conventions, the restructuring or amendment of existing laws in order to incorporate the provisions and requirements of these conventions, general capacity building at every level involved in this activity, and also increased participation in the Voluntary IMO Member States' Audit Scheme.

This audit scheme is intended to provide member states with a comprehensive and objective assessment of how effectively they are implementing and administering those mandatory IMO instruments covered by the scheme. It addresses issues such as conformance in enacting appropriate legislation for relevant IMO conventions, the administration and enforcement of applicable laws and regulations, the delegation of authority to recognized organizations, and the country's control and monitoring capabilities. The benefits of such an audit would include identifying where capacity building activities (such as the provision of technical assistance or funding by IMO), would be most useful. The member state would also receive a great deal of valuable feedback, assisting them to improve their own capacity to put the conventions into practice, and any generic lessons learned could be shared with other member states. Finally, the audit results could also be used to improve the IMO conventions and instruments themselves.

6.2 OPTIONS FOR PREVENTING OR MITIGATING NATURAL HAZARDS

There is much scope for improvement in the area of geohazard prevention and mitigation, particularly with regards to monitoring techniques. Essentially, satellite, airborne and ground-based observations need to be integrated, assimilated, and better used in models in order to generate more accessible and useful information products (IGOS, 2004). The resulting data must then be properly managed and made readily accessible to the geohazards community in a timely fashion. For this to be possible, an infrastructure capable of supporting this has to be put in place. Elements of the wider community should also be integrated into this process, so as to ensure that the right products are created and given to those who need them most. The biggest, long-term challenge is to build on existing capacity within the geohazards community and promote the global application of local best practice, through programmes of education, training and technology transfer.

For this to be successful, integration will be needed on many levels, in terms of the observation systems, the observations made, and the communities which make them. Systems integration is needed in order to ensure that observations made by different observing technologies are compatible and mutually informative. The integration of these separate observations would release the synergy between them and produce a richer information product (for example, adding temporal continuity from ground-based observations to spatial coverage from satellite observations). Integrating the geohazards community is perhaps the most difficult challenge, because it involves building on the capacity of disparate groups of people and organisations across the region, to help them perform their functions more effectively, efficiently and sustainably.

The World Summit on Sustainable Development (Johannesburg, 2002), placed this issue at the heart of the sustainable development agenda. However, the sheer complexity of developing an integrated global or regional approach to geohazard mitigation demands better international networks and partnerships. If these can be established, they will support the development of new tools, provide wider access to knowledge, and enable better coordinated sharing of experience and expertise.

6.2.1 DATA MANAGEMENT

Some examples of relevant databases of this kind include IRIS, the global archive for seismic records supported by the US National Science Foundation, which makes data freely available to participating institutions and investigators, and the International GPS Service (IGS), which has 8.

The first set of integration issues concerns the establishment and maintenance of properly collected and evaluated observational data covering all relevant geohazards. Observations from the various systems, as well as the information products that are created based on them, need to be added to databases to ensure their long-term preservation.

These databases must be complete in terms of global or regional geographic coverage (depending on the scope of the programme considered), and the range of appropriate data types. They must also contain validated, consistent, geographically registered data and be archived securely. Their very existence would encourage the long-term continuity of observations, support ongoing monitoring and research whilst at the same time ensure that historic data exist should they be required during a specific event. Both update and access must be rapid and efficient, even when operating in remote locations, and should be supported by appropriate metadata. Pricing, intellectual property rights and copyright would naturally apply to any data, but it is vital that policies not hinder access to those who need multiple repeat data acquisitions in order to solve geohazard problems or make predictions.

Data formats and database designs should foster data sharing and inter-operability. Many essential databases and archives already exist for selected geohazards data. For example, the Smithsonian Global Volcanism Project and its monthly bulletin archive global volcanic activity. The USGS National Earthquake Information Centre (NEIC) also maintains online files regarding major earthquakes, with some supporting descriptive material, but it does not include full descriptions of all related data and events, and nothing comparable for ground instability hazards. Similar international initiatives for developing a global landslide database for the collection, storage and dissemination of landslide information have not yet been organised, although the International Consortium on Landslides formed after the Kyoto summit in 2002 may support this in the longer-term.

6.2.2 DATA INTEGRATION AND MODELING

The existence of adequate databases of the type described above would facilitate the development of software capable of usefully integrating the different streams of geohazard data. This integration would create a richer data product that ideally contain the strengths, but overcome the weaknesses, of each contributing dataset. A common approach to help users visualise satellite or airborne data and understand its information content in a more familiar context is to combine it with a terrain model and topographic base map. Most common image analysis and GIS software can perform these basic types of integration. This type of global sharing of data and information products will be easier in the future as improved scientific information technology infrastructure is developed.

Scientists in monitoring and observation services and research institutes could also access these databases in order to feed data into models that describe the behaviour of various geohazards. A research agenda must be developed that results in increased knowledge of geohazards and a continuing commitment to improve these models further. As the science develops, more complex models will require the integration of a large number of in-situ, airborne, satellite and other geoscience data sources to fully describe a given aspect of the Earth system, to characterise the processes affecting it, and to provide reasonable predictions on what can be expected to happen under various scenarios.

Such models support scenario planning and would be extremely useful for better informed decision-making. Process modelling software is also therefore required, current examples of which include LAHARZ, which models lahar development and run-out (Schilling, 1998). Data assimilation could also be used to bridge the gap between detailed observations that are limited to specific sites, and regional observations at reduced resolution. Such applications tend to be computing-intensive and require access to disparate data sources. Hence, they are also a candidate for the development of new approaches based on improved information technology infrastructure.

6.2.3 CAPACITY BUILDING

The final critical step in improving regional or global mitigation of geohazards is capacity building essential for strengthening scientific and monitoring infrastructure. This requires the involvement of various organizations that could form the building blocks of a regional geohazards community. For example, the World Organisation of Volcano Observatories (WOVO) already develops materials to support global monitoring activities, including a directory of member observatories. There is a Remote Sensing Commission currently looking at the application of such technologies to the mitigation of volcanic hazards.

6.3 IMPROVED MANAGEMENT OF FISHERIES

Although many of the COBSEA countries have already agreed to a number of high level principles relating to the sustainable development of fisheries, (such as the World Summit on Sustainable Development, UNCED's Agenda 21, and the FAO Code of Conduct for Responsible Fisheries), the commitments have not been translated into effective action. These principles are often alluded to in legislation and policies but this alone is not enough to bring about improved management. Concrete decisions are required for the effective implementation of the principles for both small- and large-scale fisheries.

If current trends are to be reversed, one of the most important requirements is to resolve conflicts between competing policies. These include optimal versus sustainable use of fish resources and their supporting ecosystems; economic objectives, especially in relation to either small- or large-scale fisheries; social objectives, including maximizing employment and improving livelihoods; objectives related to equity, including priority access for small-scale fisheries; and accounting for any other objectives which may have impacts on this sector (such as trade liberalization and market access).

This requires a comprehensive consideration and resolution of the trade-offs amongst these objectives, attempting to find the optimal compromise, an objective that very few fisheries, both in the EAS region and globally, have satisfactorily achieved. For

Thailand's recent master plan for fisheries (2007-2016) is significantly different to those that have preceded it, advocating sustainable development that places people at the centre, based on five main strategies:

1. Improving the marine fisheries management system by encouraging the active participation of all stakeholders.
2. Improving all fisheries infrastructure and organizational potentials.
3. Promoting more responsible and sustainable marine fisheries resource exploitation.
4. The rehabilitation of ecological systems and the development of marine fishing grounds to maintain biodiversity and the marine environment.
5. Promotion and development of distant fishing.

example, the right compromise must be found between equity and efficiency; exports and national food security; large- and small-scale fisheries; foreign vessels and local fleets; maximizing sustainable options and maintaining sufficient employment levels; regulation and open access; market liberalization and protection of local, small-scale fisheries; long- and short-term management goals; and regional cooperation and national self-interest. Unless this lack of clarity in objectives is resolved, it will continue leading to conflict amongst competing sub-sectors (such as small-scale fishing versus large-scale fishing), necessitating the implementation of various management interventions. Unfortunately, these interventions often only alleviate the symptoms without solving the problem itself.

In addition to signing international agreements such as those mentioned above, it is essential that COBSEA countries come to similar agreements at the regional and sub-regional level, coordinating their efforts to mitigate negative trends within the fisheries sector. As a first step, the ASEAN Fisheries Management Mechanism (AFMM) and the Regional Plan of Action to combat IUU fishing (RPOA-IUU) were both developed with these aims in mind, and both recommend further sub-regional cooperation and management. Some other ongoing projects addressing regional and transboundary issues relevant to fisheries include the SEAFDEC-Sida cooperative programme, the UNEP/GEF South China Sea programme, and the Wetlands Alliance Programme. However, much more regional coordination and cooperation of this nature is necessary.

Ongoing regional cooperation of this type has already identified a number of actions of particularly high priority. Two of the most important of these will be considered in more detail, beginning with the more effective management of fish capacity. This would require more accurate assessments of current capacity to be carried out on a regular basis, based on improved registers of fishing vessels, as well as regular and detailed census of fishing vessels and effort. In order to support this, a capacity management programme must be initiated, setting meaningful targets for change (specifically, reduction where over-fishing is occurring), for an initially small number of major fisheries. This may then be used to establish a National Plan Of Action (NPOA) for capacity management, based on a consultative process involving inter-agency collaboration and consensus building. Specific management measures, which take into account local socio-economic conditions, may then be implemented to ensure that excess fishing capacity is removed altogether, rather than simply being transferred elsewhere. Finally, it is very important that regional cooperation is achieved, so as to harmonize such initiatives.

The second action of particularly high priority is that information needs be more effectively addressed in the near future. This will require COBSEA countries and fisheries to work together to improve and harmonize data, as well as consequently re-evaluating national standards. A regional information hub should be established to collect, store and share data amongst all members. This would involve assessing the status of the resource and fleet capacity, as well as strengthening Monitoring, Control and Surveillance (MCS) capability and sharing. Again, the involvement and cooperation of other relevant regional organizations is vital.

6.3.1 MORE EFFECTIVE MANAGEMENT STRATEGIES

If the development of the region's marine coastal fisheries, which are generally small-scale is to be done sustainably, then a stronger and sounder management system is undoubtedly required. There are many challenges to the sustainability of small-scale fisheries in the EAS region which needs to be overcome, such as the large number of fishers, extensive poverty in coastal areas, inadequate monitoring, and weak law enforcement. These factors have made it very difficult to establish effective management systems, despite the range of management tools that have been introduced and adopted thus far.

The Code of Conduct for Responsible Fisheries (CCRF) is an international standard that encourages countries to establish appropriate management systems in order to promote sustainable fisheries, although it is commonly criticized for not providing clear guidelines and methodologies detailing exactly how to do so. Specifically, the CCRF emphasizes the importance of community-based fisheries management, in order to address issues related to small-scale fisheries, leading to the adoption of such schemes in many of the COBSEA countries. However, the implementation processes have generally failed thus far because the respective countries' specific laws and traditions may have not been closely considered in the formulation of new fisheries regulations. This leads to conflict with local fishers, the target beneficiaries and executors of such regulations.

More often than not, the management of marine capture fisheries in many COBSEA countries rests with their central governments, although in some countries such as the Philippines, the management of municipal waters has already been delegated to the local government level. While there are many advantages to this type of management strategy, the devolution of some resource management authority to local governments should be carefully reviewed in each case, since many local governments have not been technically prepared to implement and enforce such authority.

Kato (2007; 2008b; 2008d) suggested that another important factor to be considered in the development of sustainable fisheries management is to involve the fishers themselves as important stakeholders in the sector. This involves empowering them and the organizations that represent them, so that they are able to participate actively in any fisheries management activities, such as human capacity building. Therefore, the biggest challenge for any government agency is to identify appropriate management systems for small-scale fisheries, considering the special characteristics of the fisheries sector such as unclear ownership of the fisheries resources, and government intervention in fisheries management (Kato, 2008a; 2008d).

At present, most fisheries in the EAS region are characterized by the open access regime. In addition, there are many instances in which ownership of resources cannot be easily clarified, due to the nature of some common resources and the migrating nature of the fisheries resources. This is part of the reason why fisheries operations tend to be irresponsible when utilizing such common resources. In order to rectify this situation (as current national and international legal instruments have been unable to clarify the ownership of these resources) it has been suggested that general national policy should provide clear ownership through the introduction of rights-based fisheries (Kato, 2007; 2008a).

Rights-based fisheries in the small-scale arena should be differentiated from those relating to commercial fisheries, as a result of the different nature of small-scale fisheries operation. A fairly recent regional policy, developed by ASEAN in 2001, specified the need to encourage the effective management of fisheries through delegation of selected management functions to the local level. Another priority was the recognition of the need to progressively replace open-access regimes with limited-access regimes, in terms of fisheries resources. It was suggested that this could be accomplished through the introduction of rights-based fisheries, which might also facilitate the management of fishing capacity and promote the use of more responsible fishing gears and practices. Based on this policy framework, SEAFDEC published a number of additional regional guidelines regarding co-management using group user rights for small-scale fisheries.

In terms of specific options for action, the Philippines' Bureau of Fisheries and Aquatic Resources (BFAR) plan to accelerate ongoing efforts in aquaculture for rural development, expand seaweeds production to non-traditional areas, promote aquaculture and mariculture technologies, and implement Monitoring, Control and Surveillance (MCS) systems, as well as coastal resource management programs. New initiatives will include promoting organic aquaculture, the culture of high value species, deep sea mariculture parks for seaweeds, and the culture of ornamental fish. More post-harvest facilities will be established and assistance on HACCP (Hazard Analysis and Critical Control Point) compliance will be enhanced. BFAR will start capacitating the most vulnerable sector, the small-scale fishers, to adapt to changing situations caused by climate change by teaching them new skills. Fisheries cooperatives will also be strengthened and linked with financial institutions and access markets for their products.

Government intervention in fisheries management is necessary, considering the common nature of many fisheries resources and the ease with which various users might exploit such resources irresponsibly and unsustainably. However, there is currently a need to provide stronger support and capacity building to government fisheries administrations, especially in developing countries, since they were mostly established with the objective of providing technical support to the industry rather than administering any management or regulatory function. To mitigate such situations, governments could intervene to delegate management authority to the resource users themselves (Kato, 2008c).

Since 1998, SEAFDEC has cooperated with ASEAN to undertake a regional adaptation of the CCRF, addressing the regional specificities, scenarios and issues unique to Southeast Asia. This has resulted in the development of regional guidelines on issues, such as responsible fishing operations (SEAFDEC, 2000), responsible fisheries management (SEAFDEC, 2003), responsible aquaculture (SEAFDEC, 2001; 2005a), and responsible post-harvest practices and trade (SEAFDEC, 2005b). The subsequent extent to which the CCRF and the accompanying regional guidelines have been adopted by various COBSEA countries so far is shown in Table 14.

Table 14: Adoption of the Code of Conduct for Responsible Fisheries and the ASEAN Regional Guidelines on the CCRF

Country	Extent of Adoption of the CCRF and ASEAN's Regional Guidelines
Cambodia	The Fisheries Administration of Cambodia has translated the CCRF into the Khmer language and distributed it to all agencies engaged in fisheries development. The regional guidelines have been used in the development of the Cambodian Code of Conduct for Responsible Fisheries (CamCode), involving a series of consultations with key stakeholders.
Indonesia	As early as 1985, Indonesia has formulated fisheries laws promoting responsible fisheries. Since 2003-2004, the CCRF and the regional guidelines have been used as guiding principles in the establishment and/or revision of legislations in fisheries and aquaculture. Moreover, combating IUU (illegal, unreported and unregulated) fishing has been continually undertaken with significant achievements in both territorial and Indonesian EEZ waters.
Malaysia	The CCRF principles and regional guidelines, (which have been translated into Bahasa Malaysia), have been introduced to various stakeholders through dialogues, seminars, training sessions and meetings. Significant progress and achievements regarding the implementation of related national programmes have since been reported.
Philippines	The CCRF's thematic issues have been incorporated in various provisions of the Philippine Fisheries Code. In addition, the global CCRF and the regional guidelines have been used as a framework in the formulation of programmes included in the Comprehensive National Fisheries Industry Development Plan.
Singapore	As a coastal state, Singapore endorsed the Regional Plan of Action (RPOA) to promote Responsible Fisheries Practices including Combating IUU Fishing in the Region, and contributed towards the Guidelines on Development of Standard Operating Procedures (SOPs) for Health Certification and Quarantine Measures for Responsible Movement of Live Food Finfish within ASEAN. Singapore currently serves as a leader for the ASEAN Roadmap for Integration of Fisheries Sector Measure for the development and application of HACCP-based quality management system that may be applied to small enterprises in ASEAN to ensure food safety and support competitive position of ASEAN fisheries products on world markets.
Thailand	Thailand has promoted awareness and understanding of the CCRF through the distribution of translated (into Thai language) and even child-friendly versions. Measures for the long-term conservation and sustainable use of fisheries resources have been adopted, with the policy, legal and institutional framework of the CCRF used as the guiding principle.
Viet Nam	The global CCRF and regional guidelines have been used as framework in policy and legal improvements such as the Fisheries Law (2005) as well as other decrees, directives and regulations on fisheries, (such as fisheries resource protection and exploitation, aquaculture development, and post-harvest practices and trade).

Source: SEAFDEC, 2008b.

6.3.2 AQUACULTURE

A number of technologies and management options that would make the ongoing development of aquaculture more sustainable, and at the same time limit its negative impacts on the aquatic ecosystem and fisheries, have recently been proposed and adopted in various parts of the EAS region (Bueno *et al*., 2007). One such management option is the zoning of marine fish farm areas, which limits the number of fish farms, as well as fish outputs and feed inputs, thus ensuring that effluent loads keep within the capacity of the local environment, allowing the environment to assimilate wastes and limit the conflict over the use of coastal lands, mangroves and water.

Another option is the culture of low-trophic marine species, which could alleviate the current impacts associated with farming carnivorous fish species that require high levels of organic inputs. Low-trophic species, such as molluscs, sea cucumbers and seaweeds, could even act as "sink" for the waste products from high-input aquaculture. Alternatively, the possibility of replacing the production of carnivorous aquatic species like groupers, with omnivores such as milkfish or rabbitfish, has also been suggested.

The development of integrated aquaculture, which involves a range of trophic-level organisms such that the outputs of one can be utilized by another, may go a long way towards alleviating environmental pollution. China is currently the regional leader in integrated aquaculture, in marine waters as well as freshwater. In many Chinese aquaculture farms, scallops are cultured together with kelp, abalone and marine fishes to reduce the release of nutrients into the water and to facilitate re-circulation of the water, through nutrient removal by the bivalves and oxygenation by the seaweeds. Such systems efficiently use food and water resources from all levels of the pond ecosystem, thereby reducing both costs and wastes whilst simultaneously increasing productivity and eventually putting less pressure on the receiving aquatic environment.

Offshore cage farming, which is also widely practiced in China, greatly increases the area available for mariculture without occupying precious land, and also abates the eutrophication of seawater. Bueno *et al*. (2007) suggested some solutions to the "self-pollution" of sea cage sites: the adoption of good aquaculture practices such as efficient feed formulation and feeding practices; keeping stocking densities and cage numbers within the carrying capacity of the local environment; the minimal and responsible use of chemicals; locating cages so that there is adequate water depth below and sufficient water movement to disperse wastes; and moving cages regularly to allow the recovery of the bottom sediments in affected areas.

Offshore cage farming is an aquaculture option likely to be considered increasingly important in the near future, as urbanization and industrialization continue to limit the land area available for aquaculture, particularly in places where there are no appropriate land-use zoning practices. In some areas, aquaculture development has been perceived as a direct threat to traditional, land-based agriculture, especially in locations where water resources are limited. Mariculture also faces competition from other resource users of marine and coastal areas, usually related to the spatial use of water. Such competition typically comes from fisheries, tourism, navigation, urban development, and concerns regarding the conservation of biodiversity.

6.4 MITIGATING THE IMPACT OF CLIMATE CHANGE

Strong and urgent action for climate change adaptation measures should be taken as soon as possible, to avoid exponentially increasing future costs, in terms of loss of life, property and livelihoods. The Stern Review clearly highlighted that the benefits, even just from an economic perspective, of strong and early action on climate change outweigh the costs (Stern, 2006). However, it is also very important that spending on climate change adaptation does not undermine continued funding for sustainable development and put undue pressure on the budgets of many developing countries in the region.

Integrating climate change adaptation into national planning is fundamentally important to the EAS region, particularly with regards to long-term sustainable development (Tae *et al*., 2005; UNFCCC, 2007). However, in order for climate-associated risks to be more effectively integrated into national development projects and strategies, most developing countries in the EAS region will require greater institutional capacity (IIED, 2007). If this can be achieved, then national policies which are able to adapt to changing conditions will provide a critical supporting environment for adaptation processes at all scales and levels (McGray *et al*., 2007).

It is important to accept that adaptation policies and activities for the coastal and marine environment of different COBSEA countries have to be framed differently, considering the special and varied needs of individual countries. However, this continuum of varied approaches may be roughly divided into four major efforts, depending on their relative emphases on vulnerability and impacts. Firstly, addressing the drivers of vulnerability; secondly, building up response capacity; thirdly, managing climate risk; and fourthly, directly confronting climate risk (McGray *et al.*, 2007). They may also be understood in terms of their re-active or anticipatory characteristics, as is illustrated in Table 15 (UNFCCC, 2007).

Table 15: Examples of re-active and anticipatory adaptation

Vulnerable sector	Re-active adaptation	Anticipatory adaptation
Coastal zones and marine ecosystems	• Protection of economic infrastructure • Public awareness to enhance protection of coastal and marine ecosystems • Building sea walls and beach reinforcement • Protection and conservation of coral reefs, mangroves, sea grass and littoral vegetation	• Integrated coastal zone management • Better coastal planning and zoning • Development of legislation for coastal protection • Research and monitoring of coasts and coastal ecosystems
Adapted from: UNFCCC, 2007.		

In Climate Change Impact and Vulnerability Assessment (CCIAV) studies, climate change may be incorporated into a wider framework of general coastal hazard management. This involves an evolution of thinking from Integrated Coastal Zone Management (ICZM) to Disaster Risk Reduction (DRR). For example, in Thailand's Initial National Communication to the UNFCCC (ONEP, 2000), the adaptation options include a wider framework of coastal hazard management with the aim of developing policies and strategies, as well as providing general guidelines on the management and development of coastal areas. A related issue in adaptation measures is conducting more studies at the local level to better evaluate the impacts of climate change on communities, as the IPCC reports generally deal with large-scale changes only. Some downscaling work, relevant to small areas of concern, is certainly necessary (Francisco *et al.*, 2008). It is also important to consider the advantages and disadvantages of taking the "top-down" or "bottom-up" approach in adaptation measures and applying the strategy most appropriate to that situation.

Various international and regional organizations have already begun adaptation programmes or projects that include some of the COBSEA countries. For example, UNFCCC has developed a compendium on methodologies for assessing vulnerability and adaptation, and a database on existing local strategies for coping with climate variability and hazards. Based on observations of projects worldwide, nine key messages have been identified for adaptation: adapt now; create conditions to enable adaptation; integrate adaptation with development; increase awareness and knowledge; strengthen institutions; protect natural resources; provide financial assistance; involve those at risk; and use place-specific strategies (UNFCCC, 2007). Additional efforts are enabling the least developed countries to identify their immediate priorities for adaptation options via the National Adaptation Programme Action (NAPA). Such COBSEA countries include Cambodia, which has identified eight coastal projects (three of which involve coastal protection), for implementation (MOE, 2006). The Asia-Pacific Network for Global Change Research (APN) has also undertaken a project to help build adaptive capacity throughout the EAS region, by building better theories and models of resilience and adaptive capacity, and facilitating improved awareness amongst decision-makers in various sectors (UNFCCC, 2007).

Adaptation for tourism, Phuket (Raksakulthai, 2003)

Tourism is particularly vulnerable to external shocks, having the potential to be severely affected by climate change impacts. Phuket is the largest island in Thailand, (with an area of 503 km^2 and a population of 250,000), and relies heavily on tourism as a source of income. In fact, on an annual basis, tourists outnumber Phuket residents by 12 to 1.

Phuket experiences impacts from climate variability and severe weather events from the following sources: the southwest monsoon, storms and floods, droughts, and El Niño events. The seasonality that characterizes the weather pattern in Phuket is the defining factor in the distribution of tourist arrivals throughout the year and can have a major impact. Drought periods have often exacerbated the island's water supply problems. During El Niño events in 1991, 1995 and 197, higher sea surface temperatures led to coral bleaching.

Future threats to the island include further shortages in water supply; increased flooding exacerbated by increasing degradation of natural resources and the environment, already-stressed waste management systems and a projected sea-level rise; damage to coral reefs through coral bleaching; and shifts in seasonality. These combined factors result in greater uncertainty for planning activities and tourism demand. A number of measures have been proposed to cope with these climate risks, such as closing down for the monsoon season and living off six months' income for the year, or developing "climate-proof" attractions (for example, medical tourism facilities and convention centres).

Water supply itself is a major problem in Phuket, with tourism accounting for about 26% of its water consumption. To limit the risk of water shortages due to drought and excessive demand, the Tourism Authority of Thailand recommends several measures: creating land-use zones around the island; implementing a more efficient fee structure for water consumption; and establishing new water supplies, with new reservoirs, pumping stations and pipelines ensuring a sustainable water supply over next few decades. At present, one of the major problems facing tourism in Phuket is the haphazard management of land use, water, and ecological resources.

While there is a need to implement ICZM (integrated coastal zone management), this has not yet been achieved due to a combination of insufficient political will, a lack of coordination between relevant agencies, corruption, and relevant legislative gaps. Other potential adaptation measures include capacity building within the tourism sector to anticipate, and prepare for, risks from climate variability and change. The focus is on Small and Medium Size Enterprises (SMEs) and low-impact tourism, with a particular emphasis on tourism activities that minimise their impact on the environment.

It is clear that the phenomenon of climate change increases the potential for climate-related risk. Thus, it is vital that risk management and reduction be incorporated into adaptation planning and, conversely, that climate change be incorporated into disaster and risk management activities. For this reason, the International Strategy for Disaster Reduction (ISDR) is establishing national platforms on disaster risk reduction to include the participation of practitioners of climate change adaptation (UNFCCC, 2007).

6.4.1 INTEGRATED COASTAL MANAGEMENT (ICM) FRAMEWORKS

A wide variety of adaptation measures (Table 16) are applied to the coastal areas of the EAS region, many of them within the Integrated Coastal Zone Management (ICZM) framework. Some COBSEA countries still employ adaptation measures from initial IPCC strategies, whose basic tenets are: protect, accommodate, retreat. However, the more holistic integrated coastal management approach provides an effective coastal protection strategy, by maximizing the benefits provided by the coastal zone whilst also minimizing the harmful effects on social, cultural and environmental resources in order to promote the sustainable management and exploitation of coastal zones. The ICM framework is being used in China, Indonesia, Korea, Malaysia, Philippines and Viet Nam and can be easily adapted to incorporate climate change adaptation (Cruz *et al*., 2007).

Table 16: Time frame for a sample coastal resource adaptation strategy

Policy	Short-term (1-5 years)	Medium-term (5-20 years)	Long-term (>20 years)
Development of a long-term monitoring of sea-level rise	• Provision of medium-scale digital maps to enable GIS-based studies on sea-level rise impact • Provide sea-level observation data and coastline maps for sea-level rise study	• Continuation and extension of provision of digital maps • Continue to study and provide sea-level data and coastline maps	• Sea-level observation and coastline mapping; analysis and evaluation
Prepare a long-term adaptation strategy for the possibilities of sea-level rise due to climate change in various coastal areas	• Conduct thorough and comprehensive studies of the characteristics of the various coastal areas and the various impacts of climate change	• Prepare one of the three adaptation strategies – retreat, accommodate and protect – appropriate to deal with specific coastal problem areas • Inform local communities of the dangers of certain areas through public campaigns, and issue residential ban on certain coastal areas	
Promote Integrated Coastal Zone Management (ICZM)	• Conduct thorough and comprehensive studies to pilot community-based management of coastal resources as a key initiative to implement coastal zone management plans		
Adapted from: Ministry of Environment, 1999.			

COBSEA countries vary widely in the extent to which they are integrating adaptation into their national planning, and also in their prioritization of coastal areas in adaptation strategies. For example, in China, coastal zones constitute one of four areas (the others are agriculture, water resources and terrestrial ecosystems) in which present impact assessments are being made. Already, national and local laws have been written and enacted to protect the coastal environment. Future measures include new standards for raising dikes, improved coastal rehabilitation, and the establishments of marine protected areas (Government of PRC, 2004).

In Viet Nam, the priority is currently on the deltaic area and on food security for the nation's population. The country has adopted the IPCC adaptation framework, combining three strategic options – full protection, adaptation and withdrawal (also called avoidance) (Ministry of Natural Resources and Environment, 2003). Thailand has incorporated adaptation options into the wider framework of their coastal hazard management strategy (ONEP, 2000). Neighbouring Malaysia utilises an ICM framework based on five measures: defend, accommodate, retreat, counter-attack and coastal land buy-back (Ministry of Science, Technology and Environment, 2000). Coastal defence remains a high priority in Indonesia, where ICM is usually used as a short-term strategy only, although a long-term adaptation strategy for coastal areas has also been adopted (Ministry of Environment, 1999).

Unfortunately, effective adaptation in the EAS region is limited by several ecological, socio-economic, technical and political constraints, as well as the spatial and temporal uncertainties associated with forecasts of regional climate. Poverty has been identified as the largest barrier to developing adaptation capacity. Additionally, insufficient information on the actual impacts of climate change and the responses of natural systems are likely to continue to hinder effective adaptation not only in the region but in many other parts of the world too. This lack of information on adaptation costs and benefits also makes it difficult to select the best adaptation option. The political and institutional structures of most EAS countries have thus far responded slowly to climate change and many of these frameworks remain inadequate for facilitating the implementation of a comprehensive and integrated response to climate change (Cruz *et al*., 2007).

6.4.2 ACCOUNTING FOR THE EFFECT OF CLIMATE CHANGE ON NATURAL HAZARDS

More effective integration of disaster risk consideration into all levels of sustainable development planning is essential, with special emphasis to be placed on disaster prevention, mitigation, preparedness and vulnerability reduction. This is especially important for the COBSEA countries, as it is well-documented that the majority of people affected by various natural disasters live in Asia (ADRC, 2002), and in light of the increasing likelihood and severity of natural hazard events as a result of climate change. Fortunately, the region has consistently received the invaluable support of the global community, working together across national and cultural boundaries to prevent and/or mitigate the effects of natural disasters. An example of this is the demonstrable impact that myriad international projects and programmes have had over the years, and must continue to have, in terms of technology transfer, personnel training and influence on public policy.

6.4.3 SPECIFIC RECOMMENDATIONS

A number of recommendations may be readily made, in terms of improving the climate change adaptation capabilities of COBSEA countries. For example, strengthening measures such as those suggested by the Stern Review (Stern, 2006) include improving access to high quality information on climate change impacts, setting early warning systems and information distribution systems to enhance disaster preparedness, reducing the vulnerability of livelihoods and infrastructure to climate change, promoting good governance (including responsible policy- and decision-making), empowering communities and stakeholders to participate more actively in vulnerability assessment and adaptation implementation, and mainstreaming climate change into development planning at all scales, levels and sectors (Cruz *et al*., 2007).

With the exceptions of projects carried out in Australia and South Korea, research on vulnerability and adaptation to climate change specific to the EAS region is still very limited. Effective adaptation measures and strategies cannot be designed unless vulnerability is first better understood (Francisco *et al*., 2008). Naturally, as countries are at different levels of socio-economic development, they have different perspectives on the institutions and mechanism on adaptation strategies. Some have the capacity to take advantage of opportunities presented by international organizations for climate change adaptation, and might even be able to integrate international concerns into national adaptation strategies. However, others do not have such a capacity and the issue of equity at international and regional levels is currently not well addressed by various international institutions and mechanisms (Francisco *et al*., 2008).

However, several recent efforts have been made to improve research on adaptation measures in the EAS region. One example is the EEPSEA (Economy and Environment Program for Southeast Asia) Meeting in Bali (February 2008), with the aim of determining critical areas of research to support climate change adaptation strategies in Southeast Asia. Another is the ADB (Asian Development Bank) Meeting in Manila (April 2008), to provide a better picture of the economics of climate change in order to give policy makers better adaptation options. More efforts such as these are necessary, as soon as possible, to attain a clearer regional understanding of climate change and to formulate appropriate response strategies.

6.5 CONCLUSIONS

A great number of actions can be taken to improve the state and outlook of the EAS region's coastal and marine environment. Importantly, the actions being advocated are not only a response to the current threats facing the region, but also an attempt to account for future threats and trends that have been identified and discussed in the report. The highest priority perhaps would be the development and rapid implementation of improved management strategies, which are capable of integrating economic and environmental concerns more harmoniously, facilitating improved data collection and management, actively encouraging greater stakeholder participation and a sense of community ownership, and adopting and adhering to international conventions more extensively.

Amongst the other options for action that have been suggested, another priority must be the improved management and regulation of the fisheries industry, especially with respect to the rapid growth of aquaculture throughout the region and the potential dangers that this poses. Measures to prevent or mitigate the various damages associated with different kinds of natural disasters are also vitally important, especially in light of the increasing frequency and severity of these disasters as a result of the global phenomenon of climate change. Another priority is to address emerging problems such as marine litter and invasive species as early as possible, before they become much larger and more costly to manage.

Encouragingly, with increased awareness of environmental problems and a growing political will to devote the necessary resources to developing solutions, there is much that can be done to address the current problems facing the region and to prevent – or at least mitigate – the impacts of future problems. It is recognized that the capacity to deal with these problems differs widely across the region because of varying socio-economic situations. Capacity building and transfer is of paramount importance to the raising of capacity levels of all member countries so that national efforts can be consolidated to equip the region as a whole with greater efficiency for improved sustainability of the coastal and marine environment.

REFERENCES

ABS (Australian Bureau of Statistics), 2008. Yearbook Australia. Australian Bureau of Statistics, Canberra. 802 p.

ADB (Asian Development Bank), 1995. Proceeding of the Coastal and Marine Environmental Management. Manila, 331 p.

ADB (Asian Development Bank), 2001. Asian Environment Outlook 2001. Manila.

ADB (Asian Development Bank), 2009. The Economics of Climate Change in Southeast Asia: a Regional Review. Manila, 208 p.

ADRC (Asian Disaster Reduction Centre), 2002. ADRC 20th Century Asian Natural Disaster Data Book (http://www.adrc.or.jp).

Aldon, E., R. Platon, and V. Sulit, 2008. Mangroves or aquaculture? Why not both? Fish for the People: 5(2): 15-19. Southeast Asian Fisheries Development Center, Bangkok, Thailand.

ASEAN (Association of Southeast Asian Nations), 2006. Third ASEAN State of the Environment Report 2006. ASEAN Secretariat, Jakarta: November 2006.

Baliao, D. and S. Tookwinas, 2002. Best Management Practices for Mangrove-Friendly Shrimp Farming. Aquaculture Extension Manual No. 35. SEAFDEC Aquaculture Department, Tigbauan, Iloilo, Philippines. November 2002, 50 p.

BAPPENAS (State Ministry of Planning/National Development Planning Agency), 2008. Presentation: Government of Indonesia Policy in Integrating Marine, Coastal and Small Island Issues. (http://www.globaloceans.org/globalconferences/2008/pdf/WDarajati.ppt).

Barbier, E. and B. Aylward, 1996. Capturing the pharmaceutical value of biodiversity in a developing country. Environmental and Resource Economics: 8: 157-181.

Basheer C., K. Tan, and H. Lee, 2002. Organotin and Irgarol-1051 contamination in Singapore coastal waters. Marine Pollution Bulletin 44: 697-703.

Bateman, I., R.T. Carson, B. Day, M. Haneman, N. Hanley, T. Hett, M.J. Lee, G. Loomes, S. Mourato, E. Ozdemiroghu, D.W. Pearce, R. Sugden, and J. Swanson, 2002. Economic valuation with stated preferences techniques – A manual. Edward Elgar, Cheltenham, UK.

Bleakley, C. and S. Wells, 1995. Marine Region 13: East Asian Seas: A Global Representative System of Marine Protected Areas – Great Barrier Reef Marine Park. The World Bank and the World Conservation Union (IUCN), Washington, D.C., USA. 212 p.

Boonyatumanond R, G. Wattayakorn, A. Togo, and H. Takada, 2006. Distribution and origins of polycyclic aromatic hydrocarbons in estuarine, rivers and marine sediments in Thailand. Marine Pollution Bulletin: 52: 942-956.

Bornas, A.V., 2000. Applicability of remote sensing techniques to the mapping of Philippine active volcanoes: a PHIVOLCS perspective. CCOP Technical Bulletin: 29: 87-95.

Brainard, R.E., 2000. Origins, Types and Magnitude of Derelict Fishing Gear. Proceedings of the International Marine Debris Conference – Derelict Fishing Gear and the Ocean Environment, 6-11 August 2000, Honolulu, Hawaii.

Bueno, P.B., C.V. Mohan, M.J. Philips, K. Yamamoto, F. Corsin, and J. Clausen, 2007. Better management practices, public health and sustainable farming. In Fish for the People: 5(1): 2-9. Southeast Asian Fisheries Development Center, Bangkok, Thailand.

Burke, L., L. Selig, and M. Spalding, 2002. Reefs at Risk in Southeast Asia. UNEP-WCMN, Cambridge, UK. 72 p.

Burke, L., Y. Kura, K. Kassem, C. Revenga, M. Spalding, and D. McAllister, 2001. Pilot Analysis of Global Ecosystems: Coastal Ecosystems. 93 p.

Calvert, S.E., Pedersen, T.F. and Thunell, R.C., 1993. Geochemistry of the surface sediments of the Sulu and South China Seas. Marine Geology: 114: 207-231.

Carrajal, L., 2007. Impacts of Climate Change on Human Development. Human Development Report Office, Occasional Paper 2007/18, 30 p.

Caton, A. (ed.), 2000. Fisheries Status Reports 2000-2001. Resources Assessment of Australian Commonwealth Fisheries. Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry, 252 p.

CCOP (Coordinating Committee for Geoscience Programmes in East and Southeast Asia), 2007. Proceeding of the Forty-Fourth Session of the Coordinating Committee for Geoscience of East and Southeast Asia, Bangkok.

Chaimanee, 1997. The vulnerability of geohazards in the coastal lowland of Thailand, p. 35-46. In Kato, H. and Y. Shimazaki (eds.) Report of EANHMP: An Approach to Natural Hazards in the Eastern Asia. Geological Survey of Japan, Tsukuba.

Cheevaporn V., Jacinto, G.S. and San Diego-McGlone, M.L., 1994. History of heavy metals contamination in bang pakong river estuary, Thailand. J.Sci. Soc. Thailand. 20, pp. 9-22.

Chen, C.C., G.C. Gong, and F.K. Shiah, 2007. Hypoxia in the East China Sea: One of the largest coastal low-oxygen areas in the world. Marine Environmental Research: 64: 399-408.

Chia, L.S., 2000. Overview of Impact of Sewage on the Marine Environment of East Asia: Social and Economic Opportunities. EAS/RCU Technical Report Series No. 15. 82 p.

Cho, C.H., 1991. Mariculture and eutrophication in Jinhae Bay, Korea. Marine Pollution Bulletin 23: 275-279.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr, and P. Whetton, 2007. Regional Climate Projections, p. 843-940. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Chun, S., 2008. Fisheries human resources development of the Fisheries Administration, Cambodia. Paper presented during the ASEAN-SEAFDEC Regional Technical Consultation on Fisheries Human Resources Development for Poverty Alleviation, 2-5 July 2008, Bangkok, Thailand.

Church, J.A., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth, 2001. Changes in Sea-Level. In J.T Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. Van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.) Climate Change 2001: The Scientific Basis: Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press (Cambridge, New York), 639-694.

CIA (Central Intelligence Agency), 2008. Central Intelligence Agency World Fact Book (https://www.cia.gov/library/publications/the-world-factbook/index.html).

Clemson, J.H., L.M. Allan, C.H. Marvin, Z. Wu, B.E. McCarry, and D.W. Bryant, 1998. Evidence of estrogen and TCDD-like activities in crude and fractionated extracts of PM10 air particulate material using in vitro gene expression assays. Environmental Science and Technology: 32(12): 1853-1860.

Connell, D.W., R.S.S. Wu, B.J. Richardson, K. Leung, P.S.K. Lam, and P.A. Connell, 1998. Occurrence of persistent organic contaminants and related substances in Hong Kong marine areas: an Overview. Marine Pollution Bulletin 36: 376-384.

CI (Conservation International), 2008. Economic values of coral reefs, mangroves and seagrasses: a global compilation. Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA. 35 p.

Costanza, R., R. D'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neill, J. Paruelo, G. Raskin, P. Sutton, and M. Van Den Belt, 1997. The value of the world's ecosystem services and natural capital. Nature: 387: 253-260.

Cruz, R.V., H. Harasawa, M. Lal, S. Wu, Y. Anokhin, B. Punsalmaa, Y. Honda, M. Jafari, C. Li, and N. Huu Ninh, 2007. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, p. 469-506. In Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.) Asia Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge University Press, Cambridge, UK.

Dahuri, R., 1999. Coastal zone management in Indonesia: issues and approaches, p. 60-72. In Rais, J., I.M. Dutton, L. Pantimena, E.J. Plouff, and R. Dahuri (eds.) Integrated Coastal and Marine Resource Management, Proceedings of International Symposium, Malang.

Dasgupta, S., B. Laplante, C. Meisner, D. Wheeler, and J. Yan, 2007. The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis. World Bank Policy Research Working Paper 4136, Washington, D.C., 51 p.

David, L.T., Maneja, R., Goh, B., Lansigan, F., Sereywath, P., Radjawane, I.M., Matsumoto, B.M.M., Tantichodok, P., Snidvong, A., Nguyen, H.T., Nguyen, K.A.T., Saito, Y., and Hinkel, J., 2008. Sea-level rise vulnerability of Southeast Asian coasts. INPRINT: 3/2008: 3-6.

DeGraff, J.V., 1989. Landslide activity resulting from the November 1988 storm events in southern Thailand and associated resource recovery needs, p. 1-43. In Safeguarding the Future: Restoration and Development in the South of Thailand. Jiramedha Advertising and Printing, Bangkok.

Demographia, 2007. World Megacities (Urban areas 10 million and over). (http://www.demographia.com/db-megacity.pdf)

Department of Irrigation & Drainage (Malaysia), 2008. Coastal Management – Activities. (http://www.water.gov.my/index.php?option=com_content&task=view&id=30&Itemid=184#)

DEPweb, 2008. Beyond Economic Growth Student Book: Classification of Economies by Income and Region, 2000. World Bank. (http://www.worldbank.org/depweb/english/beyond/global/classification.html)

DEQP (Department of Environmental Quality Promotion, Thailand), 2006. Cambodia National Environmental Performance Assessment (EPA) Report. Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment, Thailand and Project Secretariat UNEP Regional Resource Center for Asia and the Pacific. 221 p.

DFID (Department for International Development), 2007. Indonesia and Climate Change: Current Status and Policies. Working Paper. 126 p.

Diaz, R.J. & R. Rosenberg, 2008. Spreading Dead Zones and Consequences for Marine Ecosystems. Science, 231:926-929.

Ding, G., 1994. Seismic Hazards and Mapping of China. Report No. 281, Geological Survey of Japan, 119-124.

DOE (Department of Environment, Malaysia), 2007c. Malaysia Environmental Quality Report 2006. Department of Environment, Malaysia. 73 p.

Domenden, N., 2008. The Philippines address poverty alleviation through people and resource development. Paper presented during the ASEAN-SEAFDEC Regional Technical Consultation on Fisheries Human Resources Development for Poverty Alleviation, 2-5 July 2008, Bangkok, Thailand.

Earthtrends, 2006. Environmental Information. World Resources Institute, (http://earthtrends.wri.org).

Ellis, D.V. and L.A. Pattisina, 1990. Widespread neogastropod imposex: A biological indicator of global TBT contamination? Marine Pollution Bulletin: 21(5): 248-253.

EPD (Environmental Protection Department), 2001. Marine Water Quality in Hong Kong in 2000. Environmental Protection Department, Government of the Hong Kong Special Administrative Region.

EPU (Economic Planning Unit), 2006. Ninth Malaysian Plan 2006-2010. 559 p. (http://www.epu.gov.my/rm9/html/english.htm)

FAO (Food and Agriculture Organization of the United Nations), 2005. Review of the state of world marine fishery resources. FAO Fisheries Technical Paper. No. 457. Rome. 235 p.

FAO (Food and Agriculture Organization of the United Nations), 2006a. FishStat Plus. Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations), 2006c. State of World Aquaculture 2006. FAO Fisheries Technical Paper No. 500. Rome. 135 p.

FAO (Food and Agriculture Organization of the United Nations), 2007a. Review of the state of world marine capture fisheries management: Pacific Ocean. FAO Fisheries Technical Paper – T488/1. 170 p.

FAO (Food and Agriculture Organization of the United Nations), 2007b. The State of the World Fisheries and Aquaculture 2006. Rome. 176 p.

FAO (Food and Agriculture Organization of the United Nations), 2007c. The World's Mangroves 1980-2005. 89 p.

FAO/RAPA (Food and Agriculture Organization of the United Nations – Regional Office for Asia and the Pacific), 1994. Selected Indicators of Food and Agricultural Development in Asia and the Pacific Region, 1983-1993. Publication 1994/24.

FBBVA (La Fundación del Banco Bilbao Vizcaya Argentaria), 2007. Foundation Newsletter: Loss of Coastal Ecosystems, a Global Threat. Newsletter No. 10, October-November 2007.

FISHCODE, 2001. Report of the bio-economic modeling workshop and a policy dialogue meeting on the Thai demersal fisheries in the Gulf of Thailand, 31 May – 9 June 2000. FI/GCP/INT/648/NOR: Field Report, FAO. Rome. 104 p.

Francisco, H., O. Nabangchang, B.D. The, and A.A. Yusuf, 2008. Climate Change: Impacts, Adaptation, and Policy in South East Asia. Proceedings, EEPSEA Climate Change Conference, 13-15 February 2008, Bali. IDRC, Singapore, 75 p.

Fu, J., G. Sheng, and Y. Chen, 1997. Molecular Markers in Environmental Geochemistry. ACS Symposium Series 671, p. 164.

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) and Advisory Committee on Protection of the Sea, 2001. Protecting the oceans from land-based activities – Land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment. Rep. Stud. GESAMP No. 71, 162 p.

Calvert, S.E., Pedersen, T.F. and Thunell, R.C., 1993. Geochemistry of the surface sediments of the Sulu and South China Seas. Marine Geology: 114: 207-231.

Government of PRC., 2004. The People's Republic of China Initial National Communication on Climate Change. Government of PRC, Beijing, October 2004. 156 p.

Green, E.P. and F.T. Short (eds.), 2003. World Atlas of Seagrasses. World Conservation Monitoring Centre. University of California Press. 801 p.

Guo, Z., T. Lin, G. Zhang, Z. Yang, and M. Fang, 2006. High-Resolution Depositional Records of Polycyclic Aromatic Hydrocarbons in the Central Continental Shelf Mud of the East China Sea. Environ. Sci. Technol. 40: 5304-5311.

Harino, H., R. Arai, M. Ohji, A. Ismail, G. Wattayakorn, and N. Miyazaki, 2008. Occurrence of Antifouling Biocides in Southeast Asia: Malaysia, Thailand and Viet Nam, p. 91-111. In Miyazai, N. and G. Wattayakorn (eds.) Proceedings of the ASEAN International Conference: Conservation on the Coastal Environment.

Hong, H.K., S. Takahashi, B.Y. Min, and S. Tanabe, 2002. Butyltin residues in blue mussels (Mytilus edulis) and arkshells (Scapharca broughtonii) collected from Korea coastal waters. Environmental Pollution 117: 475-486.

Hopley, D. and Suharsono, 2000. Status of coral reefs in eastern Indonesia. In Wilkinson, C. (ed.) Report for the Global Coral Reef Monitoring Network (GCRMN), Series 114. Australian Institute of Marine Science, Townsville.

Huang, X.P., L.M. Huang, Y.H. Li, Z.Z. Xu, C.W. Fong, D.J. Huang, Q.Y. Han, H. Huang, Y.H. Tan, and S. Liu, 2006. Main Seagrass Beds and Threats to Their Habitats in the Coastal Sea of South China. Chinese Science Bulletin: 51(2): 136-142.

Hungspreug, M., 1982. Baseline levels of Cadmium, Chromium, Copper, Lead, and Zinc in seawater from the Gulf of Thailand. J. Sci. Soc. Thailand. 8, pp. 193–204.

Hungspreug, M. & Yuangthong, C., 1983. A history of metal pollution in the Upper Gulf of Thailand. Mar. Pollut. Bull. 14, pp. 465-469.

Hughes, T.P., A.H. Baird, D.R. Bellwood, M. Card, and S.R. Connolly, 2003. Climate Change, Human Impacts, and the Resilience of Coral Reefs. Science: 301: 929-933.

ICLARM (International Center for Living Aquatic Resources Management), 2001. Sustainable Management of Coastal Fish Stocks in Asia, Final Report. ADB/RETA 5766, 34 p.

IGOS (Integrated Global Observing Strategy), 2004. IGOS Geohazards Theme Report. (http://www.igosgeohazards.org/pdf/theme_reports/igos_geohazards_report_2004.pdf)

IIED (International Institute for Environment and Development), 2007. Adaptation to Climate Change: An IIED Briefing. 4 p.

IISD (International Institute for Sustainable Development), 2006. EAS Congress 2006 Bulletin: 131(5). 14 p.

IMO (International Maritime Organization), 2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments. International Maritime Organization.

IPCC (Intergovernmental Panel on Climate Change), 2003. Climate Change 2007: Synthesis Report. 52 p.

IPCC (Intergovernmental Panel on Climate Change), 2007. Climate Change 2007: The Physical Science Basis. IPCC Secretariat, Geneva. 18 p.

Isobe, T., H. Takada, M. Kanai, S. Tsutsumi, K.O. Isobe, R. Boonyatumanond, and M.P. Zakaria, 2007. Distribution of polycyclic aromatic hydrocarbons (PAHs) and phenolic endrocrine disrupting chemicals in South and Southeast Asian mussels. Environmental Monitoring and Assessment: 135(1-3): 423-440.

Jarungrattanapong, R. and A. Manasboonphempool, 2008. Adaptation Strategies for Coastal Erosion/Flooding: A Case Study of Two Communities in Bang Khun Thian District, Bangkok. TDRI Quarterly: March 2008: 21(1): 11-18.

Jiang, G.B., Q.F. Ahou, J.Y. Liu, and D.J. Wu, 2001. Occurrence of butyltin compounds in the waters of selected lakes, rivers and coastal environments from China. Environmental Pollution: 115: 81-87.

Kang, Y., G. Sheng, J. Fu, B. Mai, G. Zhang, Z. Lin, and Y. Min, 2000. Polychlorinate biphenyls in surface sediments from the Pearl River delta and Macau. Marine Pollution Bulletin: 17: 246-250.

Kannan, K., S. Tanabe, J.P. Giesy, and R. Tatsukawa, 1997. Organochlorine pesticides and polychlorinated biphenyls in foodstuffs from Asian and Oceanic countries. Rev Environ Contam Toxicol: 15: 1-55.

Katili, J.A., 1994. Monitoring, forecasting and mitigation of volcanic eruptions along the active convergent margin of the Indonesian and Philippine region. Natural Disaster Reduction in Asia and the Pacific. ESCAP: 2: 105-188.

Kato, Y., 2007. Coastal Fisheries Management on Small-Scale Fisheries (SSF). Paper presented during Policy Briefs Workshop, Southeast Asian Fisheries Development Center, Bangkok, Thailand, 15 October 2007.

Kato, Y., 2008a. Application of rights-based fisheries for coastal small-scale fisheries. Paper presented during the ASEAN-SEAFDEC Regional Technical Consultation on Small-scale Fisheries in Southeast Asia, 29 April-2 May 2008, Bangkok, Thailand.

Kato, Y., 2008b. Considerations for mitigating poverty in rural communities of Southeast Asia through fisheries interventions, p. 4-10. In Fish for the People: 6(3). Southeast Asian Fisheries Development Center, Bangkok, Thailand.

Kato, Y., 2008c. Development of Alternate Fisheries Management System for the Tropical Fisheries, Especially for Southeast Asian Region. Paper presented during the First Meeting of the Regional Advisory Committee on Fisheries Management in Southeast Asia (RAC) Bangkok, Thailand, 22-24 September 2008.

Kato, Y., 2008d. Steering the small-scale fisheries of Southeast Asia towards responsible development, p. 3-9. In Fish for the People: 6(1). Southeast Asian Fisheries Development Center, Bangkok, Thailand.

Kawasaki, T., 1983. Why do some pelagic fishes have wide fluctuations in their numbers? Biological basis of fluctuation from the view point of evolutionary ecology, p. 1065-1080. In Sharp, G.D. and J. Csirks (eds.) Reports of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources. FAO Fisheries Report, No. 29(3); 1224 p.

Kiessling, I., 2003. Finding Solutions: Derelict Fishing Gear and Other Marine Debris in Northern Australia. Key Centre for Tropical Wildlife Management, Charles Darwin University. Prepared for National Oceans Office and Department of the Environment and Heritage.

Kim, H.G. 1990. Characteristics of flagellate red tide and environmental conditions in Masan Bay. Bulletin of National Fisheries Research and Development Agency 43: 1-40.

KNSO (Korea National Statistical Office), 2004. Korean Statistical Information System (KOSIS). On-Line Statistics Database, Korea National Statistical Office (http://kosis.nso.go.kr).

Li, D. and D. Daler, 2004. Ocean Pollution from Land-based Sources: East China Sea, China. AMBIO: 33(1-2): 107-113.

Li, D.J., J. Zhang, D.J. Huang, Y. Wu, and J. Liang, 2002. Oxygen depletion off the Changjiang (Yangtze River) Estuary. Science in China Series D-Earth Sciences: 45(12): 1137-1146.

Li, T. and S. Wang, 1992. Landslide Hazards and their Mitigation in China. Science Press, Beijing. 84 p.

Li, X.D., O.W.H. Wai, Y.S. Li, B.J. Coles, M.H. Ramsey, and I. Thornton, 2000. Heavy metal distribution in sediment profiles of the Pearl River Estuary, South China. Applied Geochemistry: 15: 567-581.

Lim, H.S., R.J. Diaz, J.S. Hong, and L.C. Schaffner, 2006. Hypoxia and benthic community recovery in Korean coastal waters. Marine Pollution Bulletin: 52: 1517-1526.

Limeburner, R., R.C. Beardsley, and J. Zhao, 1983. Water Masses and Circulation in the East China Sea. Proceedings of International Symposium on Sedimentation on the Continental Shelf, with special reference to the East China Sea. Beijing: China Ocean Press, 285-294.

Lu, J., H. Lim, S.C. Liew, M. Bao, and L.K. Kwoh, 1999. Oil pollution statistics in Southeast Asian waters compiled from ERS SAR imagery. Earth Observation Quarterly: 61:13-17.

MacNae, W., 1974. Mangrove Forests and fisheries. UNDP/FAO, IOFC/DEV/74/34. p 1-35.

McGranahan, G., D. Balk, and B. Anderson, 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanization: 19: 17-37.

McGray, H., A. Hammill, and R. Bradley, 2007. Weathering the Storm: Options for Framing Adaptation and Development. World Resources Institute, Washington, D.C. 57 p.

MEA (Millennium Ecosystem Assessment), 2005. Ecosystem and Human Well-Being: Current Status and Trends Assessment. Chapter 19 – Coastal Systems. p. 515-549.

Menasveta, D., 1997. Fisheries Management Frameworks in the Countries Bordering the South China Sea. FAO Regional Office for Asia and the Pacific, Bangkok, RAP Pub. 1997/33. 151 p.

Menasveta, P. And Cheevaparanapiwat, V., 1981. Heavy metals, organochlorine pesticides and PCBs in green mussels, mullets and sediments of river mouths in Thailand. Marine Pollution Bulletin 12 1 (1981), pp. 19-25.

MEWR (Ministry of the Environment and Water Resources, Singapore), 2008. State of the Environment 2008 Report Singapore. 119 p. (http://app.mewr.gov.sg/web/Contents/Contents.aspx?ContId=1233)

Ministry of Environment (Indonesia), 1999. Indonesia: the first national communication under the United Nations Framework Convention on Climate Change. State Ministry for Environment, Jakarta. 116 p.

Ministry of Environment (Korea), 2007. ECOREA: Comprehensive National Environmental Plan From 2006 to 2015, Korea. Ministry of Environment, Korea. 140 p.

Ministry of Natural Resources and Environment (Viet Nam), 2003. Viet Nam's Initial National Communication under the UNFCCC. Ministry of Natural Resources and Environment, Hanoi. 127 p.

Ministry of Science, Technology and Environment (Malaysia), 2000. Malaysia's Initial National Communication submitted to the UNFCCC. Ministry of Science, Technology and Environment, Kuala Lumpur. 120 p.

MOE (Ministry of Environment, Cambodia), 2006. National Adaptation Programme of Action to Climate Change (NAPA). Ministry of Environment. 115 p.

Mohamad, Z., 1994. Geohazard in Peninsular Malaysia. Report of Geological Survey of Japan: 281: 139-144.

Monirith, I., H. Nakata, M. Watanabe, S. Takahashi, S. Tanabe, and T.S. Tana, 2000. Organochlorine contamination in fish and mussels from Cambodia and other Asian countries. Water Science & Technology: 42: 241-252.

Munasinghe, M., 1995. Applicability of techniques of cost-benefit analysis to climate change. In Munasinghe, M. (ed.) Global Climate Change, Economic and Policy Issues. World Bank Environment Paper Number 12. The World Bank, Washington D.C.

National Institute of Statistics Cambodia, 2006. Cambodia Yearbook 2006. (http://statsnis.org/PERIODIC/Yearbook%2003/Yearbook06.htm)

Naylor, R.L., R.J. Goldsburg, J.H. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay, C. Filke, Lubchenco, H. Moony, and M. Troell, 2001. Effects of Aquaculture on World Fish Supplies. Issues in Ecology: 8.

Nguyen D.X., 1994. Seismicity, seismotectonics and seismic zoning of Viet Nam, Intern. Workshop on Seismotectonics and Seismic Hazards in SEA, Proc., 138-142.

Nhung, N.T.T., 2008. Viet Nam's National Policy relating to Poverty alleviation in the Fisheries Sector. Paper presented during the ASEAN-SEAFDEC Regional Technical Consultation on Fisheries Human Resources Development for Poverty Alleviation, 2-5 July 2008, Bangkok, Thailand.

NRC (National Research Council), 1995. Wetlands characteristics and boundaries. National Academy Press, Washington D.C.

Nuruddin, A.A. 2007. Demersal Fish Production in Peninsular Malaysia. Paper presented during the Regional Workshops on Information Collection of Demersal Resources as Surimi Raw Materials in Southeast Asian Waters and on the Findings of Demersal Resources from MV SEAFDEC 2, Chiang-Rai Province, Thailand, 18-20 December 2007.

ONEP (Office of Natural Resources and Environmental Policy and Planning), 2000. Thailand's Initial National Communication under the UNFCCC. Office of Environmental Policy and Planning, Bangkok. 100 p.

ONEP (Office of Natural Resources and Environmental Policy and Planning), 2007. Thailand's Coastal Resources and Environment Profile: 2007. 112 p.

Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R.A., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G-P,. Rodgers, K.B., Sabine, C.L., Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M-F., Yamanaka, Y. & Yool, A., 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying animals. Nature 437, 681-686 p.

PCD (Pollution Control Department), 2005. Thailand State of Pollution Report. Pollution Control Department of Thailand, 166 p.

PEMSEA (Partnerships in Environmental Management for the Seas of East Asia), 2003. Sustainable Development Strategy for the Seas of East Asia: Regional Implementation of the World Summit on Sustainable Development Requirements for the Coasts and Oceans. PEMSEA, Quezon City, Philippines. 116 p.

Platon, R.R., W.G. Yap, and V.T. Sulit, 2007. Towards sustainable aquaculture in the ASEAN region. Fish for the People: 5(1): 21-32. Southeast Asian Fisheries Development Center, Bangkok, Thailand.

Preston, B.J., R. Suppiah, I. Macadam, and J. Bathols, 2006. Climate Change in the Asia/Pacific Region. CSIRO, Aspendale, VIC., 89 p.

Prudente, M., H. Ichihashi, S. Kan-atireklap, I. Watanabe, and S. Tanabe, 1999. Butyltin, organochlorines and metal levels in green mussel, Perna viridis L. from the coast water of the Philippines. Fisheries Sciences: 65: 441-447.

Qi, S.H., J. Yan, G. Zhang, G.Y. Sheng, and J.M. Fu, 2001. PAHs in aerosols and dustfall in Macao. Environmental Monitoring and Assessment: 72: 115–127.

Raksakulthai, V., 2003. Climate Change Impacts and Adaptation for Tourism in Phuket, Thailand. Asian Disaster Preparedness Center, Klong Luang, Pathumthami. 22 p.

Rogelj, R., Hare, B., Nabel, J., Macey, K., Schaeffer, M., Markmann, K. & Meinshausen, M., 2009. Halfway to Copenhagen, no way to 20C. Nature Reports Climate Change, Vol. 3., 81-83 p.

Samonte-Tan, G. and P. Cruz, 2007. Quantifying benefits of an improvement to the environment: The economics of environment-friendly shrimp farming in mangrove areas. Fish for the People: 5(3): 39-47. Southeast Asian Fisheries Development Center, Bangkok, Thailand.

Schilling, S.P., 1998. LAHARZ: GIS programs for automated mapping of laha-inundation hazard zones. Open-file report, 98-638, US Geological Survey, Information Services. Denver, CO. 80 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2000. Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Fishing Operations. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 71 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2001. Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Aquaculture. 1st Ed. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 44 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2003. Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Fisheries Management. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 69 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2005a. Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Aquaculture. 2nd Ed. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 43 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2005b. Regional Guidelines for Responsible Fisheries in Southeast Asia: Responsible Post-harvest Practices and Trade. Southeast Asian Fisheries Development Center, Bangkok, Thailand. 58 p.

SEAFDEC (Southeast Asian Fisheries Development Center), 2008b. National Syntheses presented during the ASEAN-SEAFDEC Regional Technical Consultation on Small-scale Fisheries in Southeast Asia, 29 April – 2 May 2008, Bangkok, Thailand.

SEPA (State Environmental Protection Administration, China), 2004. Report on the State of the Environment of China 2003. State Environmental Protection Administration of China.

SEPA (State Environmental Protection Administration, China), 2006. Report on the State of the Environment of China 2005. State Environmental Protection Administration of China.

She, J., 1999. Pollution in the Yellow Sea Large Marine Ecosystem, p. 419-426. In Shernan, K. and Q. Tang (eds.) Large Marine Ecosystem of the Pacific Rim: Assessment, Sustainability and Management. Blackwell Science, Inc. Malda, Massachusetts. 465 p.

Shi, Y., 1995. Exacerbating Coastal Hazards and Defensive Countermeasures in China, p. 1-17. In Liu, S. and M. Liang (eds.) Geological Hazards and Environmental Studies of China Offshore area. Qingdao Ocean University Press.

Shumway, S.E., 1990. A review of the effects of algal blooms on shellfish and aquaculture. J. World Aquacult. Soc. 21: 65-104.

Siagian, Y.O.P., 1998. Landslide database of Indonesia, Bull. Geological Survey of Japan: 49: 2/3: 131-134.

Silverman, J., Lazar, B., Cao, L., Caldeira, K. & J. Erez, 2009. Coral reefs may start dissolving when atmospheric CO_2 doubles. Geophys. Res. Lett. 36.

Simandjuntak,T.O., 1995. Tsunami in active plate margin of Indonesia, Abstracts of International Symposium “Geological Aspects of Sustainable Development in Coastal and Offshore Areas of East and Southeast Asia”, AIST, GSJ and NEDO. 51.

Singapore Department of Statistics, 2008. Yearbook of Statistics: 2008. Department of Statistics, Ministry of Trade and Industry, Republic of Singapore. 302 p.

Spalding, M., C. Ravilious, and E.P. Green, 2001. World atlas of coral reefs. World Conservation Monitoring Centre. University of California Press, 424 p. Stern, N. 2006. The Economics of Climate Change: The Stern Review. Cabinet Office, HM Treasury. Cambridge University Press, Cambridge. 712 p.

Stern, N., 2006. The economics of climate change. Cambridge University Press. 700 p.

Sudaryanto, A., S. Takahasi, I. Manirith, A. Ismail, M. Muchtar, J. Zheng, B.J. Richardson, A. Subramanian, M. Prudente, N.D. Hue, and S. Tanabe, 2002. Asia Pacific Mussel Watch: Monitoring of butyltin contamination in coastal waters of Asian Developing Countries. Environmental Toxicology and Chemistry: 21: 2119-2130.

Swennen, C., N. Ruttanadakul, S. Ardseungnern, H.R. Singh, B.P. Mensink, and C.C. Hallers-Tjabbes, 1997. Imposex in sublittoral and littoral gastropods from the Gulf of Thailand and Strait of Malacca in relation to shipping. Environ. Technol. 18: 1245-1254.

Tae, T.J., A. Srinivasan, K. Tamura, T. Sudo, R. Watanabe, K. Shimada and H. Kimura, 2005. Asian Perspectives on Climate Regime Beyond 2012: Concerns, Interests and Priorities. Institute for Global Environmental Strategies, Hayama, Kanagawa. 97 p.

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

Tam, N.F.Y., 2006. Pollution studies on mangroves in Hong Kong and mainland China, p. 147-163. In Wolanski, E. (ed.) The Environment in Asia Pacific Harbours. Springer.

Tanabe, S., M.S. Prudente, A. Kan-atireklap, and A. Subramanian, 2000. Mussel watch: marine pollution monitoring of butyltins and organochlorines in coastal waters of Thailand, Philippines and India. Ocean and Coastal Management: 43: 819-839.

Tookey, D.L., 1997. Shipborne pollution and the ASEAN co-operation plan on transboundary pollution, p. 18-23. Oil and gas law taxation review. ESC Publisher, Oxford, England.

Tran V.T., 1997. Seismotectonic features of Viet Nam. Report of Eastern Asia Natural Hazards Mapping Project, Geological Survey of Japan, 13-15.

Tropical Coasts, 2003. Coastal and Ocean Governance of the Seas of East Asia: Towards an Era of New Regional Cooperation and Partnership. 10 p.

UN-HABITAT (United Nations Human Settlement Programme), 2008. State of the World's Cities 2008/2009. 280 p.

UNDP (United Nations Development Programme), 2008. Human Development Report 2007/2008. 383 p.

UNEP (United Nations Environment Programme), 1999a. Global Environment Outlook 2000.

UNEP (United Nations Environment Programme), 1999b. Strategic Action Programme for the South China Sea. Draft Version 3, 24 February 1999. UNEP SCS/SAP Ver. 3.

UNEP (United Nations Environment Programme), 2000. Regional Programme of Action for the Protection of the Marine Environment of the East Asian Seas from the Effects of Land-based Activities. UNEP/GPA Coordination Office & EAS/RCU. 24 p.

UNEP (United Nations Environment Programme), 2001. Asia-Pacific Environmental Outlook. 127 p.

UNEP (United Nations Environment Programme), 2004. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Second Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.2/3.

UNEP (United Nations Environment Programme), 2005b. Managing Multi-Lateral Intergovernmental Projects And Programmes: The Case of the UNEP/GEF Project Entitled: "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand". UNEP/GEF/SCS/Inf.1, 15 p. UNEP, Bangkok, Thailand.

UNEP (United Nations Environment Programme), 2006c. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Sixth Meeting of the Regional Working Group on Mangroves. UNEP/GEF/SCS/RWG-M.6/3.

UNEP (United Nations Environment Programme), 2007b. Land-based Pollution in the South China Sea. UNEP/GEF/SCS Technical Publication No. 10.

UNEP (United Nations Environment Programme), 2007c. Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand. Report of the Sixth Meeting of the Regional Task Force on Economic Valuation. UNEP/GEF/SCS/RTF-E.6/3.

UNEP (United Nations Environment Programme), 2007e. Guidelines for Conducting Economic Valuation of Coastal Ecosystem Goods and Services. UNEP/GEF/SCS Technical Publication No. 8.

UNEP (United Nations Environment Programme), 2007f. Procedure for Determination of National and Regional Economic Values for Ecotone Goods and Services, and Total Economic Values of Coastal Habitats in the context of the UNEP/GEF Project Entitled: “Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand”. South China Sea Knowledge Document No. 3. UNEP/GEF/SCS/Inf.3

UNEP (United Nations Environment Programme), 2008. Strategic Action Programme for the South China Sea. UNEP/GEF/SCS Technical Publication No. 16.

UNEP EAS/RCU (United Nations Environment Programme East Asian Seas Regional Coordinating Unit), 2008. Marine litter in the East Asian Seas Region. United Nations Environment Programme. 64 p.

UNEP-eKH, 2003. Major Environmental Legislation, Country-by-country. United Nations Environment Programme, Environmental Knowledge Hub (http://ekh.unep.org/)

UNEP/GEMS (United Nations Environment Programme Global Environment Monitoring System), 2006. Water Quality for Ecosystem and Human Health. 132 p. ISBN 92-95039-10-6.

UNEP/GIWA (United Nations Environment Programme Global International Waters Assessment), 2005a. East China Sea. In Qu, J., Z. Xu, Q. Long, L. Wang, X. Shen, J. Zhang, and Y. Cai (eds.) GIWA Regional assessment 36. University of Kalmar, Kalmar, Sweden. 100 p.

UNEP/GIWA (United Nations Environment Programme Global International Waters Assessment), 2005b. South China Sea. In Wilkinson, C., L. DeVantier, L. Talaue-McManus, D. Lawrence, and D. Souter (eds.) GIWA Regional assessment 54. University of Kalmar, Kalmar, Sweden.

UNEP/GPA (United Nations Environment Programme Global Plan of Action for the Protection of the Marine Environment from Land-based Activities), 2006. The State of the Marine Environment: Regional Assessments, part 4, Seas of East Asia, p. 158-192.

UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific), 2000. State of Environment in Asia and the Pacific 2000. 494 p.

UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific), 2007. Statistical Yearbook for Asia and the Pacific: 2007. 207 p.

VEPA (Viet Nam Environment Protection Agency), 2001. National Environmental Action Plan 2001-2005. Ministry of Natural Resources and Environment.

Viles, H. and T. Spencer, 1995. Coastal Problems. John Wiley & Son Inc, New York. 350 p.

Voldner, E.R. and Y.L. Li, 1995. Global usage of selected persistent organochlorines. Sci Total Environ 160/161: 201-210.

Vuthy, Ly, 2008. National synthesis of small-scale fisheries in Cambodia. Paper presented during the ASEAN-SEAFDEC Regional Technical Consultation on Small-scale Fisheries in Southeast Asia, 29 April-2 May 2008, Bangkok, Thailand.

Ward, T.J. and A. Butler, 2006. "Coasts and oceans", theme commentary prepared for the 2006 Australia State of the Environment Committee, Department of Environment and Heritage, Canberra. (http://www.deh.gov.au/soe/2006/commentaries/coasts/index.html)

Wattayakorn, G., 2003. Contamination of PAHs in Coastal Environment of Thailand. Proc. 1st Joint Seminar on Coastal Oceanography. Chiang Mai, Thailand, 14-16 December 2003. The Japan Society for the Promotion of Science.

Wattayakorn, G., 2008. Status of butyltin contamination in Thailand coastal waters. Coastal Marine Science: 32(1): 82-87.

WGCCD (Working Group on Climate Change and Development), 2007. Up in Smoke? Asia and the Pacific: The Threat from Climate Change to Human Development and the Environment. New Economics Foundation and IIED. 92 p.

Wilkinson, C.R. (Editor), 2004. Status of Coral Reefs of the World 2004. Australian Institute of Marine Science. Townsville.

Wilkinson, C.R. (Editor), 2008. Status of Coral Reefs of the World: 2008. Australian Institute of Marine Science. Townsville.

World Bank, 2005b. Turning the Tide: Saving Fish and Fishers. Building Equitable Fisheries and Governance. 20 p.

World Bank, 2007a. East Asia Environment Monitor 2007 (http://www.worldbank.org)

World Bank, 2007b. East Asia Environment Monitor 2007: Adapting to Climate Change. World Bank, Washington, D.C. 53 p.

World Bank, 2007c. Thailand Environment Monitor 2006. 42 p.

World Bank, 2009. World Development Indicators 2009. 434 p.

WRI (World Resources Institute), 2008a. Biodiversity and Protected Areas: Searchable Database. http://earthtrends.wri.org/searchable_db/index.php?theme=7

WRI (World Resources Institute), 2008b. Coastal and Marine Ecosystems: Searchable Database. http://earthtrends.wri.org/searchable_db/index.php?theme=1

WRI (World Resources Institute), 2008c. Economics, Business and the Environment: Searchable Database. http://earthtrends.wri.org/searchable_db/index.php?theme=5

WRI (World Resources Institute), 2008d. Environmental Governance and Institutions: Searchable Database. http://earthtrends.wri.org/searchable_db/index.php?theme=10

WRI (World Resources Institute), 2008e. Population, Health and Human Well-Being: Searchable Database. http://earthtrends.wri.org/searchable_db/index.php?theme=4

Wrigley, T.J., D.A. Cumberland, and S.A. Townsend, 1990. Ambient water quality of Darwin Harbour. Unpublished report, Power and Water Authority, Darwin.

Wu, W.Z., K.W. Schramm, B. Henkelmann, Y. Xu, A. Yediler, and A. Kettrup, 1997. PCDD/Fs, PCBs, HCHs and HCB in sediments and soils of Ya-er Lake area in China: Results on residue levels and correlation to the organic carbon and the particle size. Chemosphere: 34: 191-202.

Yang, G.P., 2000. Polycyclic aromatic hydrocarbons in the sediments of the South China Sea. Environmental Pollution: 108: 163-171.

Yang, Y.H., G.Y. Sheng, J.M. Fu, and Y.S. Min, 1997. Organochlorinated compounds in waters of the Pearl River Delta region. Environmental Monitoring and Assessment: 44: 569-575.

Yoo, S. and S. Kim, 2005. Marine Ecosystems of the North Pacific: Yellow Sea/East China Sea. PICES Special Publication 1. 19 p.

Zakaria, M.P., H. Takada, A. Machinchian, and M. Sakari, 2008. Coastal marine pollution of polycyclic aromatic hydrocarbons (PAHs) in the Asian waters, p. 70-80. In Miyazai, N. and G. Wattayakorn (eds.) Proceedings of The ASEAN International Conference: Conservation on the Coastal Environment.

Zhang, G., Y.S. Min, B.X. Mai, G.Y. Sheng, J.M. Fu, and Z.S. Wang, 1999. Time trend of BHCs and DDTs in a sedimentary core in Macao estuary, Southern China. Mar. Pollut. Bull. 39: 326-330.

Zhou, F., H. Guo, and Z. Hao, 2007. Spatial distribution of heavy metals in Hong Kong's marine sediments and their human impacts: A GIS-based chemometric approach. Mar. Poll Bull 54: 1372-1384.

Zhou, M., J. Li, B. Lucas, R. Yu, and T. Yan, 1999. A recent shellfish toxin investigation in China. Marine Pollution Bulletin: 39(1): 331-334.

Zhu, X., J. Liu, and A. Sodergren, 1999. Occurrence and distribution of organochlorine residues and metals in sediment, water and fish in the catchment area of Lake Baiyangdian, China. Toxicol Environ Chem 68: 287-296.

APPENDICES

APPENDIX 1

Summary of the Regional Programme of Action for the East Asian Seas (EAS)

Source of Pollution	Target	Action and ancillary action	Action to be taken by	Time frame (years)
Sewage	A regional agreement on waste water recycle management. Criteria and standards for sewage and urban run-off release into waterways. A regional action plan.	**Action S1:** Establish a data and information network to link with GPA Clearing House, based on the existing monitoring network in the region;	EAS/RCU, participating countries, and consultant if necessary.	2
		Action S2: Establish the infrastructure for enhancing the exchange of scientific information on sewage discharge and its impacts to the marine environment, marine habitats and human health;		3
		Action S3: Reduce the discharge of sewage using a treatment systems for the key sources, with potential technical transfer to other sewage sources;		5
		Action S4: Negotiate and establish a regional agreement on sewage discharge to protect marine environments in the region.		3
Agriculture run-off	To reduce the nutrient inputs from agriculture and aquaculture practices and to introduce sustainable use of seeds, fertilizer and pesticides. To reduce the suspended solids released from agricultural lands.	**Action A1:** Establish a data and information network to assess the quantities and types of fertilizers used and the quantity of solid and liquid manure produced by farm animals and aquaculture;	Participating countries, EAS/RCU, international organizations	2
		Action A2: Promote rational use of fertilizers and reduce the losses of nutrients by misuse of inorganic fertilizers and manure;	Participating countries, EAS/RCU.	4
		Action A3: establish sediment load targets with regard to the sensitivity of the receiving environment; develop integrated catchment plans to achieve the targets and implement these plans followed by a timely review of their impact;	Participating countries, EAS/RCU. Participating countries, EAS/RCU.	5
		Action A4: Develop, promote and implement integrated pesticide management plans.		5

Source of Pollution	Target	Action and ancillary action	Action to be taken by	Time frame (years)
Industry and mining	To reduce inputs of industrial waste. To determine the capacity of marine habitats to absorb industrial waste.	**Action In 1:** Establish a data and information network on the: (i) Sensitivity waters to outfall pollutants; and (ii) Technologies available to control the levels of pollutants to acceptable levels;	Participating countries, EAS/RCU, international organizations, and consultant if necessary.	2
		Action In 2: Undertake a feasibility study for the introduction of cleaner production in the region;		2
		Action In 3: Upgrade the capability of participating countries in controlling industrial wastes.		3
Habitat modification	To reduce environment impacts from modification of habitats in the region.	To provide guidelines for port development, land reclamation, forestry, logging and aquaculture to limit habitat destruction and marine pollution effects.	Participating countries, EAS/RCU, international organizations and consultant if necessary.	
PILOT PROJECTS **Pilot Project 1:** **To be identified – Urban discharges**	(i) To formulate and adopt regional guidelines for sewage treatment and disposal and environmental quality criteria and standards; (ii) To establish on environmentally suitable and economically feasible system of collection and disposal of urban solid waste; (iii) To assist the development of national plans and programmes for reduction of the pollution discharge from main cities in the demonstration sites.	(i) To set up a criteria for selection of a city in the region to be the site of pilot project. It is suggested that this city should be: • A coastal city near marine habitats that can be used to indicate effects of urban activities; • Population over 1,000,000; • With certain level of industry development during last 3 decades; • Some environment monitoring data available for the project; and • Reasonable infrastructure on environmental protection. (ii) To identify sources of pollution and decide on the monitoring scheme; These pollutants are mainly: • Municipal sewage; • Solid wastes; • Heavy metals; • POPs. (iii) To monitor the pollutants from identified sources, and to study the impacts to the marine and coastal environments; (iv) To establish a management plan to reduce the pollution discharge.	Participating countries, EAS/RCU, international organizations, and consultant if necessary.	5

Source of Pollution	Target	Action and ancillary action	Action to be taken by	Time frame (years)
PILOT PROJECTS **Pilot Project 1: To be identified – Urban discharges**	(i) To formulate and adopt regional guidelines for sewage treatment and disposal and environmental quality criteria and standards; (ii) To establish on environmentally suitable and economically feasible system of collection and disposal of urban solid waste; and (iii) To assist the development of national plans and programmes for reduction of the pollution discharge from main cities in the demonstration sites.	(i) To set up a criteria for selection of a city in the region to be the site of pilot project. It is suggested that this city should be: • A coastal city near marine habitats that can be used to indicate effects of urban activities; • Population over 1,000,000; • With certain level of industry development during last 3 decades; • Some environment monitoring data available for the project; and • Reasonable infrastructure on environmental protection. (ii) To identify sources of pollution and decide on the monitoring scheme; These pollutants are mainly: • Municipal sewage; • Solid wastes; • Heavy metals; and • POPs. (iii) To monitor the pollutants from identified sources, and to study the impacts to the marine and coastal environments; (iv) To establish a management plan to reduce the pollution discharge.	Participating countries, EAS/RCU, international organizations, and consultant if necessary.	5
PILOT PROJECTS **Pilot Project 2: Agriculture discharge and sediment run-off**	(i) To formulate and adopt regional guidelines for assessment of agriculture input of pollutants, and the relevant environmental quality criteria and standards; (ii) To establish an environmentally suitable and economically feasible methods for the sustainable use of fertilizer and pesticides in the demonstration site; and (iii) To assist the development of national plans and programmes for reduction of the agriculture discharge to the marine environment in the demonstration sites.	**Project Activities:** (1) Confirm that fertilizer and/or pesticides are affecting the marine environment. To formulate and adopt regional guidelines for assessment of agriculture input of pollutants, and the relevant environmental quality criteria and standards. (2) Work towards obtaining fertilizer pesticide scenarios which combine high agricultural outputs and low pollution levels. To assist the development of national plans and programmes for reduction of agriculture discharge to the marine environment at demonstration sites. (3) Determine the effects of decreased level of discharge of a river on salinity intrusion, sediment load and coastal erosion or accretion. (4) Assess impacts of mining activities to the coastal marine environment. (5) Communicate, educate and train all members of the community in being more environmentally aware and caring for marine ecosystems.	Participating countries, EAS/RCU, international organizations, and consultant if necessary.	5

Source: GESAMP, 2001.

APPENDIX 2

Major environmental legislation in the COBSEA countries

Country	Legislation	Year
Australia	Environment Protection and Biodiversity Conservation Act 1999 Environmental Reform Act 1999 Environment Reform (Consequential Provisions) Act 1999	1999
	Product Stewardship (Oil) Act 2000 Renewable Energy (Electricity) Act 2000 Renewable Energy (Electricity) (Charge) Act 2000	2000
	Environment Protection and Biodiversity Conservation Amendment (Wildlife Protection) Act 2001 Sydney Harbour Federation Trust Act 2001	2001
	Australian Heritage Council Act 2003	2003
	Environment Protection (Alligator Rivers Region) Act 1978 Antarctic Treaty (Environment Protection) Act 1980 Whale Protection Act 1980	1980
	Environment Protection (Sea Dumping) Act 1981 Antarctic Marine Living Resources Act 1981	1981
	Wildlife Protection (Regulation of Exports and Imports) Act 1982	1982
	World Heritage Properties Conservation Act 1983	1983
	Aboriginal and Torres Strait Islander Heritage Protection Act 1984	1984
	Protection of Movable Cultural Heritage Act 1986	1986
	Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 Hazardous Wastes (Regulation of Exports and Imports) Act 1989	1989
	Endangered Species Protection Act 1992	1992
	Great Barrier Reef Marine Park (Environment Management Charge-General) Act 1993 Environmental Management Charge-Excise Act 1993	1993
	National Environment Protection Council Act 1994	1994
	Meteorology Act 1995 Ozone Protection (License Fees-Imports) Act 1995 Ozone Protection (License Fees-Manufacture) Act 1995	1995
	Natural Heritage Trust of Australia Act 1997	1997
	National Environment Protection Measures (Implementation) Act 1998	1998
	Great Barrier Reef Marine Park Act 1975 Australian Heritage Commission Act 1975 National Parks and Wildlife Conservation Act 1975 Captains Flat (Abatement of Pollution) Agreement Act 1975	1995
	Environment Protection (Impact of Proposals) Act 1974	1974
Cambodia	Decree Law on Forestry Administration and Management	1987
	Sub Decree on Harbour Rules for Foreign Ships, No. 11	1983
	MoE Praka No. 292 on the Regulation of Industrial Solid and Liquid Waste Management	1994
	Petroleum Regulation	1991
	Joint Prakas of the Ministry of Environment and the Ministry of Agriculture on Prohibition of Hunting and Catching of Wildlife Animals	1996
	Decision No. 65 on the Annulment of the Existing Procedure for Timber Export	1994
	Law on Environmental Protection and Natural Resource Management	1996
	Law of Land Management of Urbanization and Construction	1994
	Royal Decree on the Creation and Designation of Protected Areas	1993
	Praka No. 1033 on the Protection of Natural Area	1994

Country	Legislation	Year
China	Constitution	1982
	Environment Protection Law	1989
	Law on Prevention and Control of Environmental Noise Pollution	1996
	Water Law	1988
	Law on Prevention and Control of Water Pollution	1984
	Fishery Law	1986
	Grassland Law	1985
	Mineral Resource Law	1986
	Law on Conserving Energy	1997
	Law on Promotion of Cleaner Production	2002
	Regulations on Nature Reserves	1994
	Measures on Management of Electromagnetic Radiation Environmental Protection	1997
	Law on Environmental Impacts Assessment	2002
Indonesia	Environmental Impact Assessment (EIA)	1999
	Hazardous Waste Management	1999
	Water Quality Management and Waste Water Control	2001
	Hazardous Material Management	2001
	Management Environmental Degradation and Environmental Pollution from Forest Fire	2001
	Alteration of Presidential Decree No. 108/2001 on the Organizational Unit and Duty of the First Echelons of State Ministers	2002
	Guidelines of Environmental Management Plan and Environmental Monitoring Plan	2002
	Ratification of the International Vienna Convention for the Protection of the Ozone Layer and Ratification of the London Amendment to the Montreal Protocol	1992
	Spatial Planning	1992
	Ratification of the International Basel Convention on the Control of Transboudary Movements of Hazardous Wastes and their Disposal	1993
	Ratification of the United Nations Convention on Biological Diversity	1994
	Ratification of the United Nations Framework Convention on Climate Change General Guidelines for Environmental Audit Implementation	1994
	Emission Standards for Vehicle	1995
	Clean River programme	1995
	Effluent Standard for Industry	1995
	Effluent Standard for Hotel	1995
	Noise Standards	1996
	Vibration Standards	1996
	Odor Standards	1996
	Environmental Management Act	1997
	Alteration of Presidential Decree No. 101/2001 on Position, Duty, Function, Authority, Organizational Structure and Management of State Ministers	1998
	Sea Pollution Management	1999
	Air Pollution Management	1999

Country	Legislation	Year
Korea	Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat	1992
	Convention for the Protection of the World Cultural and Natural Heritage	1972
	Convention on International Trade in Endangered Species of Wild Animals	1979
	Vienna Convention for the Protection of the Ozone Layer	1985
	Montreal Protocol on Substances that Deplete the Ozone Layer	1990
	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989
	United Nations Framework Convention on Climate Change (Kyoto Protocol)	1992
	Convention on Biological Diversity	1992
	United Nations Convention on the Law of the Sea	1982
	United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Part	1995
Malaysia	Environmental Quality Act	1974
	Exclusive Economic Zone Act	1984
	National Forestry Act	1984
	Fisheries Act	1963
	Sewerage Services Act	1993
	Merchant Shipping (Oil Pollution) Act	1994
	Merchant Shipping Ordinance	1952
	Mineral Development Act	1994
	Town and Country Planning Act	1976
	National Parks Act	1980
	Pesticides Act	1974
	Street, Drainage and Building Act	1974
	Petroleum Mining Act	1972
	Continental Shelf Act (Revised)	1972
	Land Conservation Act	1960
Philippines	The Philippine Clean Air Act of 1999	1999
	The Ecological Solid Waste Management Act of 2000	2000
	Philippine Clean Water Act of 2004	2004
	The 1977 Philippine Environment Code	1977
	The Marine Pollution Decree of 1974	1974
	The Marine Pollution Decree of 1976	1976
	The Philippine Water Code	1976
	Sanitation Code of the Philippines	1975

Country	Legislation	Year
Singapore	Vienna Convention for the Protection of the Ozone Layer	1985
	Montreal Protocol on Substances that Deplete the Ozone Layer	1990
	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	1989
	United Nations Framework Convention on Climate Change (Kyoto Protocol)	1992
	Convention on Biological Diversity	1992
	United Nations Convention on the Law of the Sea	1982
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	1986
Thailand	Environmental Act	1975
	Enhance and Conservation of National Institutional restructuring Environmental Quality Act 1992 The publication “Laws and Standards on Pollution Control’ (July 1989) summarizes relevant Thai Environmental Legislation	1992
Viet Nam	United Nations Convention on the Law of the Sea	1982
	Law on Environmental Protection	2005
	Law on Biodiversity	2008
	Law on Marine Resources and Environmental Protection	Draft
	Law of the Sea in Viet Nam	Draft
	Decree 25/2009/ND-CP of the Government on Integrated Management of Marine Resources and Environmental Protection for Seas and Islands	2009

Source: UNEP-eKH, [2003], with inputs from national focal points.

APPENDIX 3

Major international instruments related to coastal environmental protection signed (S) or ratified (R) by COBSEA countries

	AU	KH	CN	ID	KR	MY	PH	SG	TH	VN
Air Pollution – Persistent Organic Pollutants							S			
Antarctic – Environmental Protocol	R		R		R					
Antarctic – Marine Living Resources	R				R					
Antarctic Seals	R									
Antarctic Treaty	R		R		R					
Convention on Biodiversity	R	R	R	R	R	R	R	R	R	R
UN Framework Convention on Climate Change	R	R	R	R	R	R	R	R	R	R
Climate Change – Kyoto Protocol	R	R	R	R	R	R	R	R	R	R
UN Convention to Combat Desertification	R	R	R	R	R	R	R	R	R	R
Endangered Species (CITES)	R	R	R	R	R	R	R	R	R	R
Environmental Modification	R				R					R
Hazardous Wastes (Basel Convention)	R	R	R	R	R	R	R	R	R	R
UN Convention Law of the Sea	R	S	R	R	R	R	R	R	S	R
Marine Dumping	R		R		R		R			
Marine Life Conservation	R	R		R		R			R	
Ozone Layer Protection (Vienna Convention)	R	R	R	R	R	R	R	R	R	R
Ship Pollution	R	R	S	R	R	R	R	R		R
Tropical Timber 83	R		S	R	R	R	R		R	
Tropical Timber 94	R	R		R	R	R	R		R	
Wetlands (RAMSAR Convention)	R	R	R	R	R	R	R		R	R
Whaling	R	R	R		R		R			

Adapted from: CIA, 2008.

Note: Australia AU, Cambodia KH, China CN, Indonesia ID, Korea KR, Malaysia MY, Philippines PH, Singapore SG, Thailand TH, Viet Nam VN.

APPENDIX 4

ECONOMIC VALUATION METHODOLOGY USED IN THE SOUTH CHINA SEA PROJECT

Identifying Relevant Goods and Services

Initially, technical experts on each habitat were asked to prepare a list of all goods and services provided by each habitat. Based on these lists, the RTF-E produced a set of simple guidelines regarding the most appropriate methods for the economic valuation of each of the identified goods and services (UNEP, 2004). These were soon followed by procedures for valuing the impacts of land-based pollution (UNEP, 2005b). Finally, all of the goods and services identified, as well as the various methodologies proposed, were used as the basis for the guidelines regarding the economic valuation of coastal habitat goods and services (UNEP, 2007e).

Empirical Data Set of the Values of Relevant Goods and Services

In 2004, the RTF-E began to assemble an empirical dataset of the economic value of all goods and services provided by the coastal ecotones bordering the South China Sea. Data were obtained from published sources in international literature and from the “grey” literature of government reports. The focus was on data derived from studies along the coasts of the South China Sea although, in some instances, data from elsewhere in the seven participating countries were included. Most of the data represented “farm gate prices”, which are essentially the prices that farmers would receive for their produce at the farming location itself. These prices were assumed to be equivalent to the value of natural production (that is, the value of the labour involved in harvesting was considered negligible in comparison with the value of the natural production). Data derived from secondary markets were not included because the value added could not be accurately determined in most cases.

As the data were derived from diverse studies undertaken over the course of some twenty years, the methods used to determine the economic values were necessarily different, as were the forms of the data itself and the information contained in the publications and reports. For this reason, considerable efforts were made to ensure that the data contained in the final tabulations were based on primary data collection only.

It is very important to note that in a great number of cases, no values could be found in the published or even the informal literature for the economic values of certain goods or services, and others were assumed to be negligible. For example, in the case of mangroves, no values could be determined for insect larvae, plankton, algae, bark, honey, sap, wood tar, or jellyfish, although all of these had been identified as being used in the region. Of these, bark, honey, sap and wood tar are all well known products in the consumer market, so the absence of values for these goods simply reflects a lack of published values in the literature. However, the remainder of the mangrove goods listed above were dropped from further consideration for a different reason. It was agreed that they represented locally consumed products that were not entering the market economy, were not widely used, and were therefore of negligible significance in a regional context.

Standardization of the Data

In order to ensure that values were directly comparable, all data were expressed in terms of production values in US dollars per hectare per annum, (US\$ ha^{-1} yr^{-1}), including the values for ecosystem services. Values were converted to a standard year (2005) using the Consumer Price Index, and local currency values were then converted to US dollars using the 2005 exchange rate (UNEP, 2007c). The largest volume of data available relates to mangroves and the smallest to coastal wetlands, reflecting the restricted number of coastal wetland habitats reviewed (inter-tidal mudflats, estuaries, coastal lagoons, coastal peat and non-peat swamp forests).

Surprisingly few data were available for either coral reefs or wetlands, although this may be simply because scientific data and information tend to be highly compartmentalized in the participating countries and it is often difficult to access data from sources outside an individual's own institution or organization. The lack of data for seagrass habitats is less surprising because the actual extent of this habitat in the region has not yet been accurately determined, and the numbers of scientists currently involved in the study of seagrass ecosystems is quite limited. This naturally results in a comparatively small body of published literature.

All of these data sets underwent extensive review by the RTF-E and, where anomalies or questions remained unresolved, those data were excluded from further consideration. A number of published values (for the capture of wild fish, crab and prawns and for the natural production of molluscs) have been excluded from further consideration as the values were considered too high to represent natural production and more likely represent production from some form of extensive or intensive mariculture. The basis for this decision was the need to determine the economic value of natural production only. In the case of services, data were excluded from further consideration if deemed to represent unrealistically high, or low, values. For example, the extremely high value for ecotourism in Youstefa Bay (Indonesia) was excluded because it almost certainly represented the total annual value for all tourism at this location and not merely the value of tourism associated with the bay's mangrove habitat.

The valuation of the nursery function of mangroves is of some interest as there has apparently been no attempt thus far to value the natural production resulting from the use of mangroves by off-shore demersal fish and crustaceans as nursery areas. This is somewhat surprising in that there have already been a number of studies into this topic, such as the strong correlation between the off-shore catch of penaeid shrimp and the area of mangrove on the adjacent coastline (McNae, 1974). Therefore, unable to account for this influence, valuations have been only in terms of the market value of larval fish and crustaceans caught in the mangrove area, or through a shadow pricing method using the costs of producing such larvae through other means. Neither of these methods could be considered ideal, nor do they actually represent a true evaluation of the nursery function. However, they were still used in the absence of other data.

Examination of any one portion of this dataset often reveals wide variation in farm gate prices. For example, mangrove timber from Indonesia apparently varies in worth from US\$ 76 to over US\$ 5,000 per cubic metre. In this instance, a weak but significant negative correlation exists between the value per cubic metre and the stock, or more precisely, the area of mangrove. That is, timber prices associated with small stands of mangrove are generally higher than those associated with large stands. However, the issue of widely differing prices in different locations within each country is addressed through the calculation of weighted mean national values.

Determination of Weighted Mean National and Regional Values

As is well known, farm gate prices for environmental goods vary within countries, reflecting local supply and demand. For example, where blood cockle beds are located in close proximity to a centre of population, their unit farm gate price is higher than that of an equivalent-sized resource located farther away. In order to address this problem, it was decided to weight the data from each location and thence determine a “Weighted Mean National Value” that reflected both the prices for the same resource at each location and also the “stock” of that resource at the same locations. Hence, the price at location A was multiplied by the stock (or simply the area itself, where the stock could not be estimated) in area A, and this value was added to other values determined for locations B, C, and so on. The summation was then divided by the total stock in the country concerned, providing the Weighted Mean National Value. This reflects the totality of the national stock rather than being a simple arithmetic average of all values, and is lower than the price at any one location, since market values were not available for all locations (UNEP, 2007f).

The determination of “Weighted Mean Regional Values” was calculated similarly, but using data concerning the total stock (or area) in each country and the Weighted Mean National Values. Thus, the Weighted Mean National Value for each resource was multiplied by the stock for each country and the resultant values summed, then divided by the total stock (or area) of the habitat bordering the South China Sea.

The absence of values in a particular table may reflect one of three circumstances. Firstly, and most commonly, it may simply be that no data for farm gate prices were available. Secondly, it may be because a particular resource is not used in the country concerned, for cultural or religious reasons. Thirdly, it is also possible that the resource simply does not occur in the country concerned. A good example of the second circumstance would be sipunculid worms, which are highly prized in China and to a lesser extent in the Philippines, but are not consumed at all in the other countries. Consequently, there are no market values from Cambodia, Indonesia, Malaysia, Thailand and Viet Nam, reflecting the fact that the worms do not enter the market in these countries, despite being found in their mangrove areas. Although it is known that a thriving export of sipunculid worms from Viet Nam to southern China has developed over the last five years, farm gate prices in Viet Nam have not yet been published. The contribution of the Weighted Mean Regional Value for sipunculid worms to the total economic value of mangrove production in the region is therefore much smaller than if a benefits transfer method of determining value had been used to determine the potential value of the entire South China Sea stock of sipunculid worms.

In the case of mangrove “fruit” (or propagules), the value for China represents the price of a certain species’ propagule, which is used in soup and other dishes in southern China but is apparently not eaten elsewhere in the region. Propagules of other species are processed as sweets and eaten in Thailand but no farm gate price is available. Interestingly, there is an apparent absence of a market for mangrove propagules even in countries where it is known that propagules are purchased from local villagers for use in re-forestation and re-planting schemes. It has been observed that propagules from a demonstration site in Indonesia were being sold for replanting at a price of US$ 1 for 200 propagules (UNEP, 2006c). In Thailand and Viet Nam, the price was cited at around US$ 1 for 100 propagules, whilst in the Philippines it was even higher, at US$ 1 for 50 propagules. Markets thus do exist for these products but values are not yet formally recorded in the literature.

Determination of Total Economic Value

The Total Economic Value of the coastal habitats is estimated as the summation of the values of all goods and services produced by each habitat, on an annual basis. The summation of the regionally weighted values therefore represents the Total Economic Value of the annual production per hectare, whilst the Total Economic Value for the entire area of each habitat is derived from the product of this value multiplied by the total area of that habitat which borders the South China Sea.

APPENDIX 5

Weighted mean national and regional values (US$) of annual production per hectare, for goods and services provided by mangroves bordering the South China Sea (UNEP, 2007f)

	Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Regional
Mangrove Goods								
Timber/Poles	780	137	74	10	205	0	11	**73**
Firewood/Charcoal	88	0	81	0	85	109	243	**2**
Leaves/Palm fronds	14	0	0	0	2	0	0	**0**
Fruit/propagules	0	101	0	0	0	0	0	**1**
Medicine	0	0	238	0	0	0	0	**173**
Fish capture/fry	0	186	329	0	161	258	200	**268**
Eels/ Crabs/ Prawns/Shellfish	0	1,489	599	0	26	558	0	**494**
All fisheries resources	0	0	0	3,633	0	0	0	**514**
Wildlife/Worms	0	2,582	25	0	0	0	0	**59**
Total value of goods (US$/ha)	882	4,496	1,346	3,643	479	926	454	**1,585**
Mangrove Services								
Ecotourism	0	0	60	0	0	0	0	**43**
Nursery function	0	1,274	782	0	0	0	0	**573**
Sediment retention	0	11,345	0	0	0	0	0	**66**
Coastal protection	0	1,044	422	0	0	2,198	0	**444**
Windbreak	0	1,200	0	0	0	0	0	**7**
Carbon sequestration	0	326	116	0	0	60	0	**89**
Oxygen production	0	435	0	0	0	0	0	**3**
Option value	0	0	70	0	0	0	0	**51**
Aesthetic value	0	1,867	0	0	0	0	0	**11**
Total value of services (US$/ha)	0	17,492	1,449	0	0	2,259	0	**1,287**
Grand total of goods and services (US$/ha)	**882**	**21,987**	**2,795**	**3,643**	**479**	**3,185**	**454**	**2,872**
Total area of mangroves (ha)	**72,350**	**23,446**	**934,000**	**532,100**	**28,014**	**62,618**	**156,608**	**1,809,136**
Value of total annual production (US$ millions)	**64**	**516**	**2,610**	**1,938**	**13**	**199**	**71**	**5,196**

Weighted mean national and regional values for the per hectare annual production of goods and services by coral reefs along the South China Sea (UNEP, 2007f)

	Cambodia	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Regional
Coral Reef Goods							
Capture fisheries (food/aquarium fish)	0	285	0	151	0	0	**108**
Shrimp	0	0	0	0	0	0	**0**
Shellfish collection	0	0	0	0	0	0	**0**
Molluscs	0	0	0	0	0	0	**0**
Sea cucumbers	0	0	0	0	0	0	**0**
Echinoderms (sea urchins)	0	0	0	0	0	0	**0**
Coral – building materials (m^3)	0	483	0	0	0	0	**25**
Coral – curio trade	0	0	0	0	0	0	**0**
Seaweed	0	0	0	0	0	0	**0**
Total value of goods (US$/ha)	0	768	0	151	0	0	**134**
Coral Reef Services							
Tourism	0	0	0	270	7,150	964	**1,025**
Research	0	0	0	0	0	0	
Beach protection	0	7,331	0	0	0	0	**384**
Biodiversity Option Value	0	11	0	0	0	0	**1**
Total value of services (US$/ha)	0	7,341	0	270	7,150	964	**1,409**
Total value of goods and services (US$)	**0**	**8,109**	**0**	**421**	**7,150**	**964**	**1,543**
Total coral reef area in the South China Sea (ha)	**2,807**	**39,287**	**4,276**	**464,000**	**90,000**	**110,000**	**750,307**
Value of total annual production (US$ millions)	**0**	**319**	**0**	**195**	**643**	**106**	**1,157**

Weighted mean national and regional values for the per hectare annual production of goods and services provided by seagrass meadows bordering the South China Sea (UNEP, 2007f)

	Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Regional
Seagrass Goods								
Capture fisheries (food/aquarium)	452	176	0	0	35	0	0	**233**
Shrimp	96	159	0	0	0	0	0	**48**
Crabs	117	0	0	0	0	0	0	**54**
Crustaceans	0	0	0	0	0	0	118	**14**
Shellfish/molluscs collection	12	0	0	0	0	0	399	**54**
Acorn worms	0	794	0	0	0	0	0	**21**
Seaweed-algae	509	585	0	0	0	0	36	**253**
Seagrass fertilizer	0	0	0	0	0	0	29	**4**
Handicrafts	0	560	0	0	0	0	0	**15**
Cosmetics	0	1,008	0	0	0	0	0	**27**
Total value of goods (US$/ha)	1,186	3,282	0	0	35	0	582	**712**
Seagrass Services								
Seagrass tourism	0	0	0	0	0	0	1,264	**153**
Research	0	58	0	0	0	0	0	**2**
Beach protection	0	1,191	0	0	0	0	0	**58**
Nursery function	0	1,967	0	0	0	0	415	**103**
Biodiversity option value	0	439	0	0	0	0	0	**12**
Turtle nesting beaches	0	0	0	0	0	4,098	0	**142**
Carbon sequestration	0	2	0	0	0	0	0	**0**
Water quality/nutrient removal	0	39	0	0	0	0	0	**1**
Oxygen release	0	4	0	0	0	0	0	**0**
Total value of sevices (US$/ha)	0	3,657	0	0	0	4,098	1,679	**469**
Grand total of goods and services (US$)	**1,186**	**6,938**	**0**	**0**	**35**	**4,098**	**2,261**	**1,182**
Total known area of seagrass (ha)	**33,814**	**1,960**	**3,035**	**222**	**23,245**	**2,553**	**8,940**	**73,769**
Value of total annual production (US$ millions)	**40**	**14**	**0**	**0**	**1**	**10**	**20**	**87**

Weighted mean national and regional values for the per hectare annual production of goods and services provided by wetlands bordering the South China Sea (UNEP, 2007f)

	Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Viet Nam	Regional
Wetland goods								
Timber	0	93	0	0	0	0	148	**14**
Firewood/charcoal	0	0	0	0	0	0	141	**14**
Leaves/palm fronds	0	0	0	0	0	22	0	**1**
Medicine	0	0	0	0	0	0	23	**2**
Fish capture	0	110	0	0	0	439	967	**120**
Crab capture	0	193	0	0	0	0	0	**1**
Wildlife	0	0	0	0	0	4	0	**0**
Honey & wax	0	0	0	0	0	0	164	**15**
Total goods (US$/ha)	0	395	0	0	0	465	1,442	**167**
Wetland services								
Ecotourism	0	294	0	0	0	75	27	**9**
Research & education	0	955	0	0	0	0	0	**5**
Migratory species	0	374	0	0	0	0	0	**2**
Sediment retention	0	0	0	0	0	0	0	**0**
Nutrient retention	0	1	0	0	0	0	0	**0**
Coastal protection/ windbreak	0	0	0	0	0	0	0	**0**
Carbon sequestration	0	141	0	0	0	0	0	**1**
Oxygen production	0	0	0	0	0	0	0	**0**
Option value	0	0	0	0	0	0	0	**0**
Aesthetic value	0	0	0	0	0	0	1,201	**112**
Total services (US$/ha)	0	1,764	0	0	0	76	1,228	**128**
Grand total of goods and services (US$)	**0**	**2,159**	**0**	**0**	**0**	**540**	**2,670**	**295**
Total known area of wetlands (ha)	**77,202**	**20,276**	**3,252,780**	**0**	**183,818**	**274,653**	**392,416**	**4,201,145**
Value of total annual production (US$ millions)	**0**	**44**	**0**	**0**	**0**	**148**	**1,048**	**1,240**

APPENDIX 6

Summary of fisheries management schemes and approaches adopted by COBSEA countries

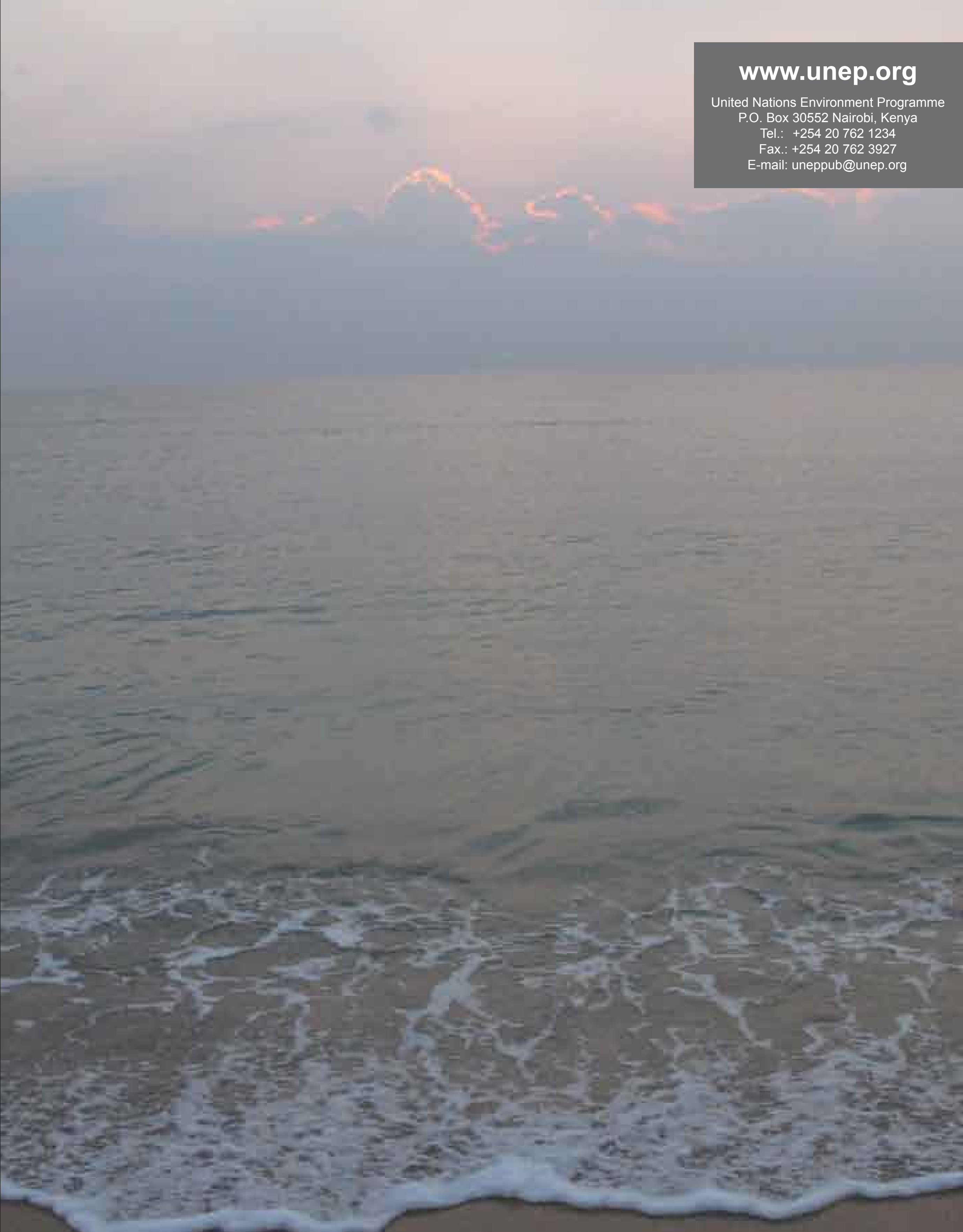
Country	Management Schemes/Approaches	Impacts/Remarks
Australia	Fisheries management highly developed, characterized by collaborative and participatory nature	Involvement of all stakeholders in policy development and implementation
	Limited entry in nature	Over-capacity is not a significant issue
	"User Pays' scheme	Participants in fisheries are responsible for funding research and compliance costs that support fisheries
	Shift from "single-species" approach to ecosystem management approach	Promote the principle of Ecological Sustainable Development (ESD)
Cambodia	Open-access policy for marine fisheries	Resource depletion and over-exploitation by national and foreign fishing fleets
	Adoption of fishery reforms	Improvement of indigenous aquaculture practices
	Adaption of successful community-based fisheries in inland fisheries to marine capture fisheries, including devolution of central authority	Promotion of participatory approaches and co-management in marine fisheries
China	Moratorium and buy-back programmes as well as catch limit system, (such as the hot season moratorium in Yellow Sea and East China Sea)	Decreased production from marine capture fisheries, thus intensifying development of aquaculture sector, (especially mariculture), since moratorium covers 120,000 fishing vessels and roughly 1 million fishermen
	Input controls	Aimed at decreasing the number of fishing vessels by at least 30,000 by 2010
	Output controls	Regulate allowable proportion of undersized fish in total catch
	Economic incentives	Reduction of taxes paid by fishermen
Indonesia	Licensing system by regulating fishing lanes and gear, and limiting harvests	Allows fisheries to operate in specific fishing belts to reduce conflicts between and among users
	Promotion of stakeholder participation in planning	Devolution of management authority to the provinces
	Regulating rights and obligations to migrating fishermen	Ejecting migrating fishermen not complying with local laws and regulations
Korea	Intensifying programme on sustainable coastal management	Promote transfer and use of environmentally-friendly sound technologies, and further development of aquaculture sector, (especially mariculture)
Malaysia	Zoning system	Equitable resource use and exploitation, specifically to reduce vessel and fishing gear conflicts
	Fisheries resource management community	Integration of responsibilities of various stakeholders in sustainable development of resources
	Establishment of prohibited fishing areas and marine parks, and installation of artificial reefs	Promoting conservation and rehabilitation of fisheries resources
	Adoption of Juvenile Fish Excluder Devices (JFEDs)	Reduction of trash fish and juvenile species catch

Country	Management Schemes/Approaches	Impacts/Remarks
	Establishment of effective Monitoring, Control and Surveillance (MCS) system, and strict enforcement of deterrent penalties on illegal fishing activities	Promotion of closed season, closed areas and gear restrictions to protect small-scale fishers who lack the mobility of large-scale fishers
	Establishment of Marine Protected Areas (MPAs)	40 MPAs already established
	Licensing system for fishing vessels and gear with certain regulations based on domestic laws, and adoption of limited entry fishing for all categories	Non-issuance of new fishing licenses, adoption of exit plan through buy-back scheme and matching grants, and collection of comprehensive and complete data for future fisheries management planning
Philippines	Adoption of co-management through the establishment of the Fisheries and Aquatic Resources Management Councils (FARMCs)	Enabling various stakeholders to actively participate in fisheries management
	Integrated coastal area management in specific fisheries management areas, supported by scientific data and evidence	Development of fisheries and aquatic resources in municipal waters and bays by fishers and their organizations, including accelerated efforts in aquaculture for rural development
	Adoption of representation mechanisms for fishers through the establishment of the National Anti-Poverty Commission (NAPC) in collaboration with NGOs and Peoples' Organizations (POs)	Empowering fishers to articulate their views and concerns to the government in terms of policy and programme formulation and implementation, and promoting close collaboration between government and NAPC in partnership with the peoples' organization (PAMPANO-broadcast alliance of fishers organization) and FARMCs
Thailand	Boat-tenure system, and monitoring, control and enforcement on illegal fisheries	Freezing the number of trawlers, no transfer of licenses, and renewal of licenses necessary to avoid cancellation
	Closed area and closed season including limitation of certain fishing methods	Conservation and rehabilitation of fisheries resources
	Reserved zone within 3 km of shoreline	Preserve zones for spawning and nursing of juvenile fish and invertebrate species, trawling not allowed in demarcated zone
	Resources and habitat rehabilitation including installation of artificial reefs, and resource enhancement	Promote the recovery of fishery resources, while artificial reefs obstruct trawling activities and support reseeding programmes in natural waters
	Limit cod-end mesh sizes of trawlers and mesh sizes of purse seiners	Promotion of fishing capacity reduction for trawlers and push netters
	Licensing of commercial fishing gear	Use of indicators as management tools, (such as CPUE, MSY and MEY)
Viet Nam	Further expansion of capture fisheries should be targeted at an ecologically recoverable level of the aquatic resources	Intensifying development of aquaculture sector, fishing operations in seas, rivers, lakes, lagoons and other natural waters should be done in compliance with regulations relating to fishing seasons, fishing time, fishing grounds, and annual allowable catch
	Coastal fisheries restructuring to reduce fishing pressure on coastal areas	Development of offshore fishing and shifting some groups of fishers to other sectors such as aquaculture, trading, and logistics

www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel.: +254 20 762 1234
Fax.: +254 20 762 3927
E-mail: uneppub@unep.org

UNEP



COBSEA
United Nations Environment Programme (UNEP)
United Nations Building, 2nd Floor, Block B
Rajdamnern Nok Avenue
Bangkok 10200, Thailand
Tel: +66 2 288 1889
Fax: +66 2 281 2428
www.cobsea.org

ISBN: 978-92-807-3070-8