United Nations Environment Programme

UNEP/GEF South China Sea Project

Global Environment Facility

NATIONAL REPORT

on

Seagrass in the South China Sea

MALAYSIA

Mr. Kamarruddin bin Ibrahim
Focal Point for Seagrass
Head, Turtle and Marine Ecosystem Center (TUMEC)
Department of Fisheries Malaysia
23050 Rantau Abang, Dungun, Terengganu, Malaysia

Table of Contents

List of Tables

List of Figures

List of Annexes

1. INTRODUCTION

Seagrass ecosystems have been greatly neglected globally (Duarte, 1999; Fortes, 1995;) and especially in Malaysia (Japar, 1994; Mohd Kushairi, 1992; Phang, 1998). Seagrasses are the only group of flowering plants that inhabit the submerged coastal and marine water. They have adapted to environment with a root system that can withstand wave action and a reproductive system that distributes pollen by water.

2. REVIEW OF NATIONAL DATA AND INFORMATION

2.1 Geographic Distribution of Seagrass

2.1.1 Status of Seagrasses

The majority of seagrasses in Malaysia are restricted to sheltered areas in the shallow intertidal associated ecosystems, semi-enclosed lagoons and subtidal zones, between mangrove and coral reef ecosystems (Japar and Muta Harah, 2003). Seagrasses are also found around offshore islands with fringing reefs. They can be several hundred metres wide and a few kilometres length along the coast.

In Peninsular Malaysia, seagrasses are found in Langkawi Islands, Penang, Pangkor Island, Port Dickson, Melaka, Sungai Pulai estuary, Tanjung Adang, Strait of Johor, Sungai Johor, Mersing Islands Marine Park, Kemaman, Paka, Merhang, Setiu Laggon, Pulau Redang, Pengkalan Nangka and Pantai Baru (Kelantan).

In Sabah, seagrasses have been extensively surveyed and found mainly at Tunku Abdul Rahman Park, Sepangar Bay, Tanjung Kaitan, Karambunai, Sungai Salut, Sungai Mekabong, Sulaman Lake (personal observation), Tanjung Mengayau, Bak-bak, Pulau Mantanani, Pulau Banggi, Pulau Balambangan, Pulau Jambongan, Sandakan, Darvel Bay, Pulau Sipadan, Pulau Labuan and Pulau Layang-layang. Table 1 shows the locations of known seagrass areas and estimated coverage in Malaysia.

Table 1 Locations of known seagrass areas and estimated coverage in Malaysia.

State	Location	Area (ha)	Reference/Remarks
Kelantan	• Pengkalan Nangka Lagoon	40.0	(Japar and Muta Harah, 2003)
	• Kampung Baru Nelayan – Kampung Sungai Tanjung	27.0	(Japar and Muta Harah, 2003)
	• Pantai Baru Lagoon	20.0	(Japar and Muta Harah, 2003)
Terengganu	• Setiu Lagoon	?	Orosco (2002)?
	• Gong Batu (Setiu Lagoon)	5.0	(Japar and Muta Harah, 2003)
	• Sungai Terengganu	0.6	(Orosco and Amir Sharifudeen, 2004)
	• Sungai Kemaman	17.0	(Japar and Muta Harah, 2003)
	• Chukai, Kemaman	3.3	(Japar and Muta Harah, 2003)
	• Telaga Simpul	28.0	(Japar and Muta Harah, 2003)
	• Sungai Paka Lagoon	4.7	(Japar and Muta Harah, 2003)
	• Sungai Paka shoal	43.0	(Japar and Muta Harah, 2003)
	• Sungai Paka (river bank)	1.5	(Japar and Muta Harah, 2003)
	• Merchang	3.0	(Japar and Muta Harah, 2003)
Negri Sembilan	• Teluk Kemang	11.0	(Japar and Muta Harah, 2003)
Johor	• Tanjung Adang Laut shoal	40.0	(Japar and Muta Harah, 2003)
	Tanjung Adang Darat shoal	42.0	(Japar and Muta Harah, 2003); most areas destroyed recently by ship navigation, reclamation and port development projects
	• Merambong shoal	30.0	(Japar and Muta Harah, 2003)
Sarawak	• Kuala Lawas (along the coast)	?	Personal observation; coverage not estimated, but very significant
Sabah	• Sepangar Bay, Karambunai Laggon, Salut and Kuala Sungai Mekabong	> 50.0	Personal observation and estimation
	• Sulaman Lake	> 50.0	Personal observation and estimation
	• Pulau Banggi and Pulau Balambangan	?	Coverage very significant

2.1.2 *Floristic and Biogeography of Seagrasses*

Based on various publications, unpublished data, field observation and discussion with seagrass experts, there are currently 18 species of seagrasses recorded in Malaysia, including 4 new *Halophila* species (Table 2). All the seagrass species are placed into three families (Japar *et al.* 2003). Table 3 shows the distribution of seagrass species in various sites in Peninsular Malaysia. Figure 1 and Figure 2 show the distribution of seagrass in Sarawak and Sabah.

Table 2 Seagrass species recorded in Malaysia.

Family	Species	Status / Remarks
Cymodoceae	*Cymodocea rotundata*	Common and widespread throughout Sabah, rare in Peninsular Malaysia.
	Cymodocea serrulata	Common and widespread throughout Sabah, rare in Peninsular Malaysia.
	Halodule pinifolia	Common and widespread throughout Malaysia, especially in the east coast of Peninsular Malaysia
	Halodule uninervis	Common and widespread throughout Malaysia.
	Syringodium isoetifolium	Not common, restricted to a few sites in Malaysia.
	Thalassodendron ciliatum	Only recorded in Tanjung Kaitan (Sabah) by Phang (2000).
Hydrocharitaceae	*Enhalus acoroides*	Common and widespread throughout Malaysia.
	Halophila beccarii	Common and widespread throughout the east coast of Peninsular Malaysia. Presently not found in west coast of Peninsular Malaysia, Sarawak and Sabah.
	Halophila decipiens	Not common, restricted to a few sites in Malaysia.
	Halophila minor	Some records previously recognised as *Halophila ovata*. Rare and restricted to a few sites in east coast of Peninsular Malaysia and Sabah.
	Halophila ovalis (Figure7)	Common and widespread throughout Malaysia.
	Halophila spinulosa	Rather rare and restricted to a few sites in southern and east coast of Peninsular Malaysia and Sabah.
	Halophila sp. 1	Recorded from east coast of Sabah (Japar *et al.* 2004).
	Halophila sp. 2	Refer to Field Guide to the Identification of East Asian Seagrasses (in press); recorded in east coast of Sabah and the location is not revealed in this report as the researcher is currently preparing a journal article on this species.
	Halophila sp. 3	Recorded from east coast of Sabah (Japar *et al.* 2004).
	Halophila sp. 4	Recorded from east coast of Sabah (Japar *et al.* 2004).
	Thalassia hemprichii	Common in Sabah.
Potamogetonaceae	*Ruppia maritime*	Very rare. Only recorded in Seberang Prai by Burkill (1935); no recent survey to re-confirm the occurrence of this species.

Table 3 The checklist of seagrasses distribution in Malaysia.

Region	West coast of Peninsular Malaysia			Southern coast of Peninsular Malaysia	East coast of Peninsular Malaysia								Sarawak		West coast of Sabah							East coast of Sabah
Species / Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Cymodocea rotundata	+				+									+		+	+	+	+		+	+
Cymodocea serrulata	+			+	+												+	+	+		+	
Halodule pinifolia		+		+		+	+	+		+	+	+		+			+	+	+	+		
Halodule uninervis	+	+		+	+										+		+	+	+			+
Syringodium isoetifolium				+	+												+		+		+	+
Thalassodendron ciliatum																		+				
Enhalus acoroides		+		+	+											+	+	+	+		+	
Halophila beccarii					+	+	+		+		+	+										
Halophila decipiens		+				+					+		+				+	+		+	+	
Halophila minor	+										+						+	+				+
Halophila ovalis	+	+		+	+						+			+			+	+	+	+	+	+
Halophila spinulosa				+	+										+		+	+				
† *Halophila sp. 1*																					+	
* *Halophila sp. 2*																						
† *Halophila sp. 3*																						
† *Halophila sp. 4*																						
Thalassia hemprichii				+	+									+		+	+	+	+		+	+
Ruppia maritime			+																			
Total	5	5	1	8	9	3	2	1	1	1	5	2	1	4	2	3	11	11	8		8	6

Note: Location: 1 – Langkawi Islands (Kedah); 2 – Seberang Prai (Penang); 3 – Port Dickson (Negri Sembilan); 4 – Sungai Pulai estuary, Tanjung Adang & Merambong shoal (Johor); 5 – Mersing Islands National Park (Johor); 6 – Kemaman (Terengganu); 7 – Paka (Terengganu); 8 – Merchang (Terengganu); 9 – Sungai Terengganu (Terengganu); 10 – Setiu Lagoon (Terengganu); 11 – Pulau Redang (Terengganu); 12 – Pengkalan Nangka (Kelantan); 13 – Sematan (Sarawak); 14 – Kuala Lawas (Sarawak); 15 – Pulau Layang-layang; 16 – Pulau Labuan; 17 – Tunku Abdul Rahman Park (Sabah); 18 – Sepangar Bay, Tanjung Kaitan, Karambunai, Sungai Salut & Sungai Mekabong (Sabah) ; 19 – Tanjung Mengayau & Bak-bak (Sabah); 20 – Pulau Mantanani (Sabah); 21 – Pulau Banggi and Pulau Balambangan (Sabah); and 22 – Darvel Bay (Sabah).

** Refer to Field Guide to the Identification of East Asian Seagrasses (in press); recorded in east coast of Sabah and the location is not revealed in this report as the researcher is currently preparing a journal article on this species.*

† Recorded from the east coast of Sabah (Japar et al. 2004).

Source: (Japar, 1994; Moh Kushairi, 1992; Gan, 2003; Gumpil, 1997; Gumpil 2002; Japar, 1994; Japar et al. 1997a; Japar et al. 1997b; Japar et al. 1999a; Japar et al. 1999b; Japar et al. 2000; Japar et al. 2001a; Japar et al. 2001b; Japar and Muta Harah, 2003; Japar et al. 2003; Japar et al. 2004; Muta Harah et al. 1999; Muta Harah et al. 2003a; Muta Harah et al. 2003b; Muta Harah et al. 2004; Norhadi, 1993; Orosco and Amir Sharifudeen, 2004; Phang, 2000; Sasekumar et al. 1990; Wong et al. 2003).

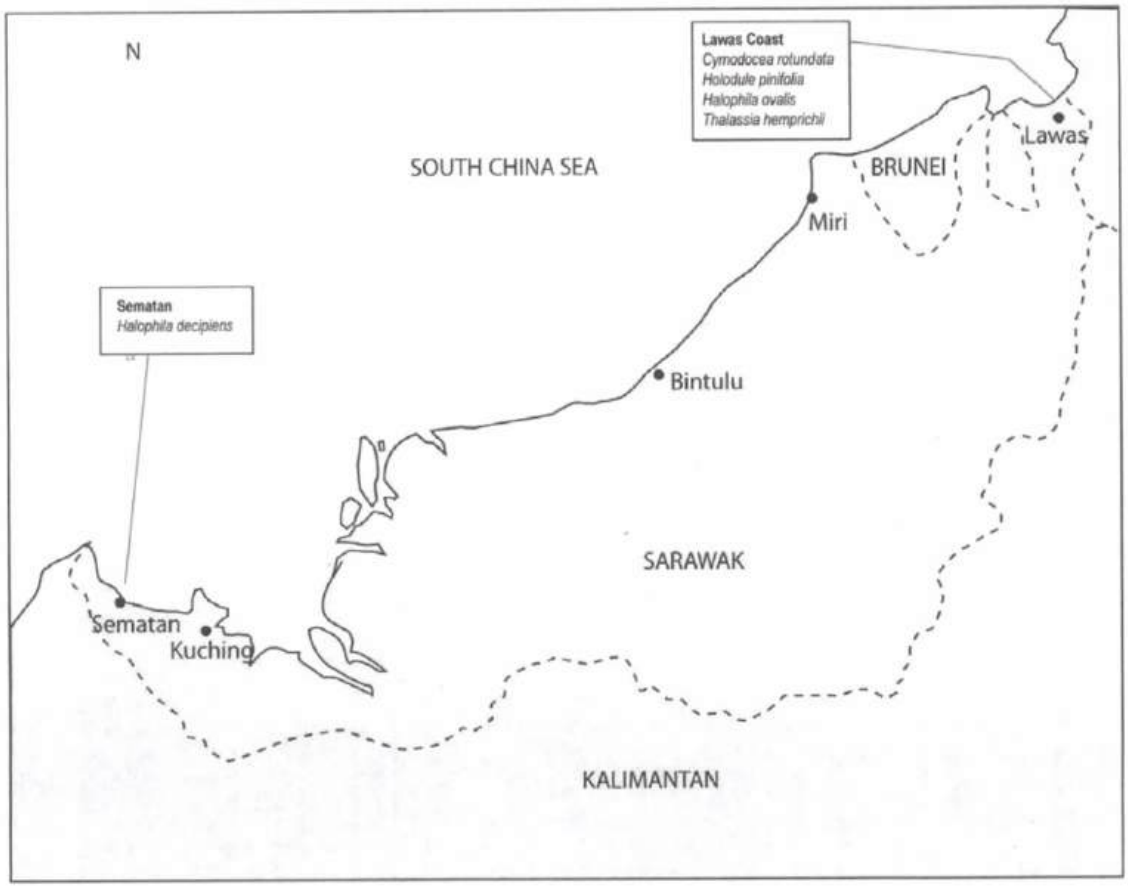

Figure 1 Distribution of seagrass species in Sarawak.

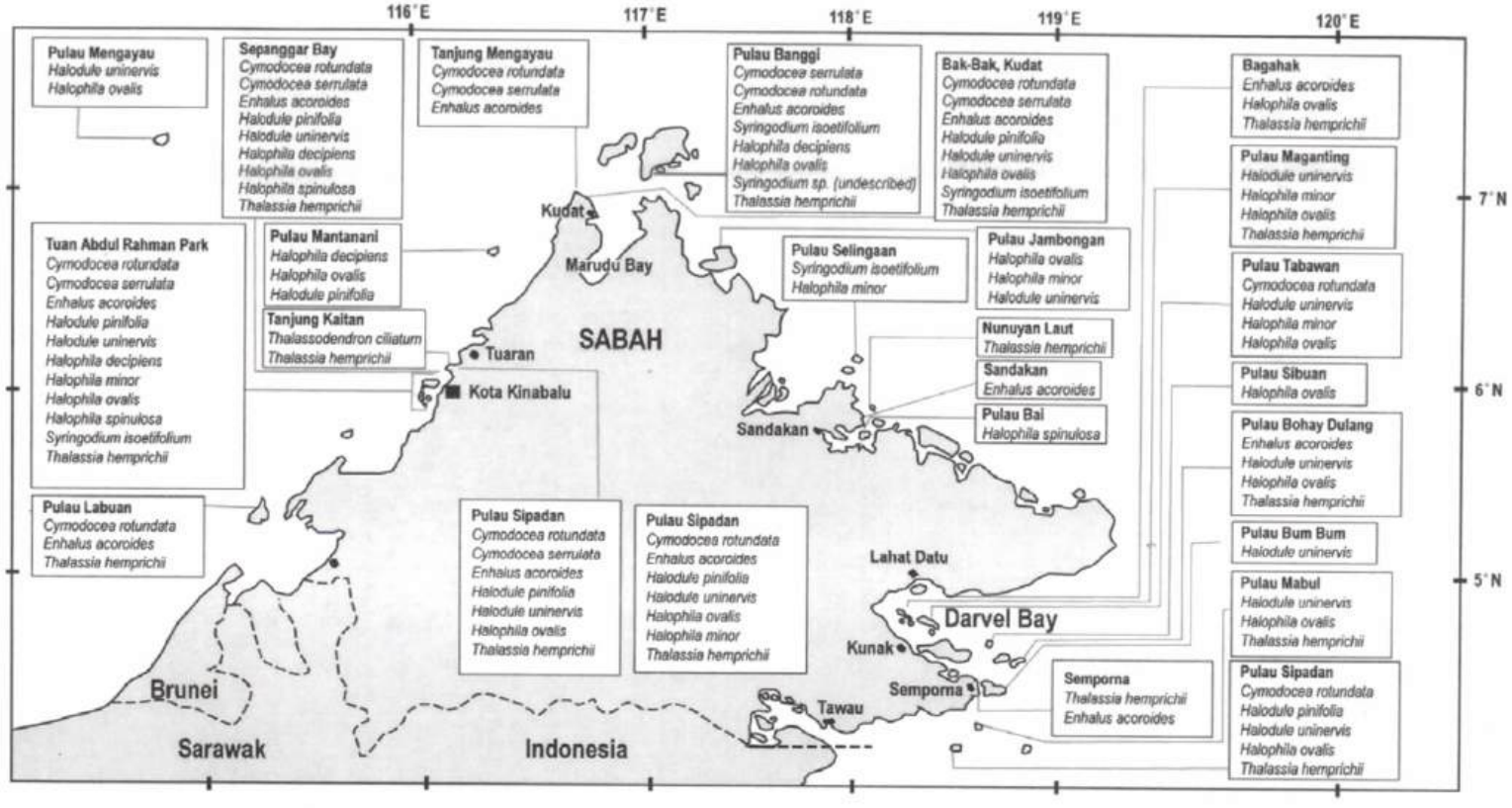

Figure 2 Distribution of seagrass species in Sabah.

2.2 Biological Aspects

2.2.1 Associated Marine Biota

The interactions between seagrass, mangrove and coral reef ecosystems are known to exist (Fortes, 1995; Fortes, 1988; Fortes, 1991; UNESCO, 1983; UNEP, 1997). These ecosystems are intricately linked by physical and nutrient interactions, fish migrations and human impacts.

In Malaysia, many known seagrass beds are associated with either mangrove or coral reef ecosystems, and sometimes all three ecosystems exists together (Table 4). To a lesser extent, seagrasses may also associate with seaweed habitat (Gan, 2003; Japar *et al.* 1999a; Japar *et al.* 1999b).

Table 4 Seagrass beds and associated coastal and marine ecosystems in Malaysia.

State	Location of Seagrass Beds	Associated Ecosystems
Negri Sembilan	Port Dickson	Coral reefs, mangroves and seaweeds
Kelantan	Kampung Baru Nelayan	Mangroves
Johor	Sungai Pulai estuary, Tanjung Adang and Merambong shoal	Mangroves and seaweeds
	Mersing Islands National Park	Coral reefs and mangroves
Terengganu	Setiu Lagoon	Mangroves
	Sungai Redang estuary, Pulau Redang	Coral reefs and mangroves
Sarawak	Pulau Talang-talang and Sematan	Coral reefs and mangroves
	Kuala Lawas (along the coast)	Mangroves
Sabah	Tunku Abdul Rahman Park	Coral reefs and mangroves
	Krambunai, Tanjung Kaitan, Salut and Mekabong River	Mangroves
	Sulaman Lake	Mangroves
	Pulau Banggi and Pulau Balambangan	Mangroves, coral reefs and seaweeds
	Sandakan	Mangroves and coral reefs
	Darvel Bay (Semporna, Kunak and Lahad Datu, and associated islands)	Coral reefs, mangroves and seaweeds

2.2.2 Marine Endangered Species

Dugongs were rarely reported in the Malaysian waters prior to the 1990s and there are no estimates of the size of dugong population (Marsh *et al.* 2002). Presently, in Peninsular Malaysia, dugongs are found in the waters of Johor Straits (Sungai Johor estuary, Pulau Ubin, Pulau Tekong and the Changi area) (Sigurdson *et al.* 1990), Sungai Pulai estuary and Pulau Langkawi (Japar and Muta Harah, 2003; Marsh *et al.* 2002). The islands off the east coast of Johor, Johor Marine Parks (also known as Mersing Islands National Park) also support significant of seagrass resources and dugong population. During the recent survey, dugongs were sighted in the waters of Pulau Besar, Pulau Sibu, Pulau Tinggi and Pulau Rawa.

There have been numerous sightings of dugongs by researchers from Universiti Malaysia Sabah. These areas include Kota Kinabalu, Kudat, Pulau Banggi and Pulau Balambangan, Sandakan and Semporna. The local people also reported the occurrence of dugongs in Sulaman Lake, which support significant seagrass resources (especially *Enhalus acoroides*) and mangrove ecosystems (Tan Kim Hooi, personal observation).

In Sarawak, dugongs are known to occur in Tanjong Datu (Bank, 1931) and Brunei Bay (Lawas and Limbang districts). The evidence that dugongs are resident in the Brunei Bay and Lawas Bay is strengthened by the recent sightings by Universiti Malaysia Sabah and recent findings of probably the largest known seagrass beds in Sarawak (Japar *et al.* 2004).

For the sea turtles, green turtles (*Chelonia mydas*) are well-known to use seagrass ecosystem as their feeding and foraging ground. Green turtles and seagrasses can be found in Pulau Redang, Mersing Islands National Park, Pulau Talang-talang National Park (Sarawak), Tunku Abdul Rahman Park, Pulau Banggi and Pulau Balambangan.

2.2.3 *Associated Fisheries Resources*

Seagrass meadows are known to play an important role in providing habitat and food resources for fish, shellfish and shrimps (Arshad *et al.* 2001; Fortes, 1995; Aung *et al., 1995;* Fortes, 1988; Fortes, 1991; Jimmy *et al.* 2003; Sasekumar *et al.* 1990 (UNESCO, 1983). From these studies, many species recorded are commercially important species.

Arshad *et al.* (2001) recorded 47 fish species (30 families) and 95 invertebrate species from Merambong shoal, respectively. In another study, 76 species fish species were identified from Sungai Pulai estuary (Sasekumar *et al.* 1990). In Sungai Pulai estuary where seagrasses thrives, spotted seahorse (*Hippocampus kuda*) was discovered by researchers from KUSTEM. This precious species are abundant, but their future is uncertain due to port development and expansion, ship navigation, land reclamation for industrial park and power plant.

In Sabah, 19 species of prawns and shrimps, including 9 species of Penaeid shrimps, were caught in Sepangar Bay seagrass habitat (Aung *et al., 1995*). The most abundant and economically important prawns are *Penaeus semisulcatus, P. japonicus, Metapenaeus tenuipes and Heteropenaeus longimanus*.

2.3 Threats to Seagrass Resources

2.3.1 *Natural Threats*

The impacts caused by natural processes are the damages of seagrass beds due to typhoon and storm, coastal erosion, and potential impacts from global warming and sea level rise.

The occurrence of typhoon and storm are very rare in Malaysia. In December 1996, a major storm, Hurricane Greg struck Kota Kinabalu and Tunku Abdul Rahman Park from the west, having a dramatic effect upon coral reefs and seagrasses of the park and adjacent areas such as Sepangar Bay and Menggatal. The northeast monsoon from November to March may also have impacts on seagrass resources of the islands of the east coast of Peninsular Malaysia. The monsoon also causes severe coastal erosion along the east coast of Peninsula Malaysia.

2.3.2 *Human Activities*

Table 5 summarises various human induced threats to seagrass beds in Malaysia. The current human activities that affecting the seagrass habitat are:

- Nutrient enrichment
- Runoff of sediments
- Coastal reclamation
- Sand mining
- Traditional harvesting of fisheries resources
- Illegal encroachment of trawlers
- Destructive fishing method (fish blasting and cyanide)
- Marine Pollution

Table 5 Threats human activities to selected seagrass beds in Malaysia.

State	Location of seagrass beds	Conservation status	Threats
Kedah	Pulau Langkawi (Tanjung Rhu and Teluk Ewa)	None	• Land reclamation for tourism facilities • Pollution from cement industry • Impacts from boating and recreational activities
Negri Sembilan	Port Dickson	None	• Reclamation for tourism facilities • Sand/coral mining • Pollution from solid wastes and sewage • Uncontrolled tourism and recreational activities

Table 5 *cont.* Threats human activities to selected seagrass beds in Malaysia.

State	Location of seagrass beds	Conservation status	Threats
Johor	Sungai Pulai estuary, Tanjung Adang and Merambong shoal	Mangrove Forest Reserves and RAMSAR site	• Land reclamation for port development and expansion (Tanjung Pelepas Port), and industrial parks. • Massive ship navigation / movement • Ship-based pollution • Potential pollution from petrochemical industries • Heat water and wastes from Tanjung Bin power plant (coal) • Clearing of mangroves • Impacts from harvesting of fisheries resources
	Sungai Johor estuary and adjacent areas (Straits of Johor, Pulau Tekong and Pulau Ubin, Singapore)	Mangrove Forest Reserves	• Land reclamation (Pulau Tekong, Pulau Ubin and Changi area) • Sand mining • Industrial wastes from Pasir Gudang, Tebrau and Woodlands (Singapore) Industrial Parks • Massive ship navigation/movement • Ship-based pollution • Domestic wastes and sewage
	Pulau Sibu, Pulau Tinggi, Pulau Besar, Pulau Rawa and adjacent islands	Johor Marine Parks and Mersing Islands National Park	• Sedimentation from the impacts of illegal trawling at marine park • Impacts from boating and recreational activities • Untreated wastes
Terangganu	Sungai Paka estuary and Paka Shoal	Mangrove Reserve	• Sand mining • Impacts from harvesting of fisheries resources
Sarawak	Kuala Lawas	Mangrove Reserve	• Impacts from harvesting of fisheries resources
Sabah	Tunku Abdul Rahman Park	National Park	• Land reclamation at Kota Kinabalu and adjacent areas • Destructive fishing (cyanide and fish bombing) • Direct discharge of wastes from illegal settlement from Pulau Gaya and mainland of Kota Kinabalu • Impacts from boating and recreational activities • Ship-based pollution
	Karambunai, Sepangar Bay, Sungai Salut and Sungai Mekabong	None	• Land clearing for Kota Kinabalu Industrial Park, naval base and settlements (Figure 3) • Destructive fishing (cyanide and fish bombing) • Impacts from boating and recreational activities pollution from petrochemical industries • Ship-based pollution (Sepangar and Kota Kinabalu Ports)
	Sulaman Lake		• Impacts from boating and recreational activities • Aquaculture development • Illegal cutting of mangroves
	Pulau Banggi and Pulau Balambangan	To be gazetted as Tun Mustapha Marine Park and Mangrove reserves	• Sand and coral mining • Destructive fishing (cyanide and fish bombing) • Illegal trawling activities • Illegal clearing of mangroves • Impacts from harvesting of fisheries resources
	Darvel Bay	Mangrove reserves (Lahad Datu, Kunak and Semporna) and some islands proposed as Tun Sakaran Marine Park	• Sand and coral mining • Destructive fishing (cyanide and fish bombing) • Illegal trawling activities • Illegal clearing of mangroves • Impacts from harvesting of fisheries resources

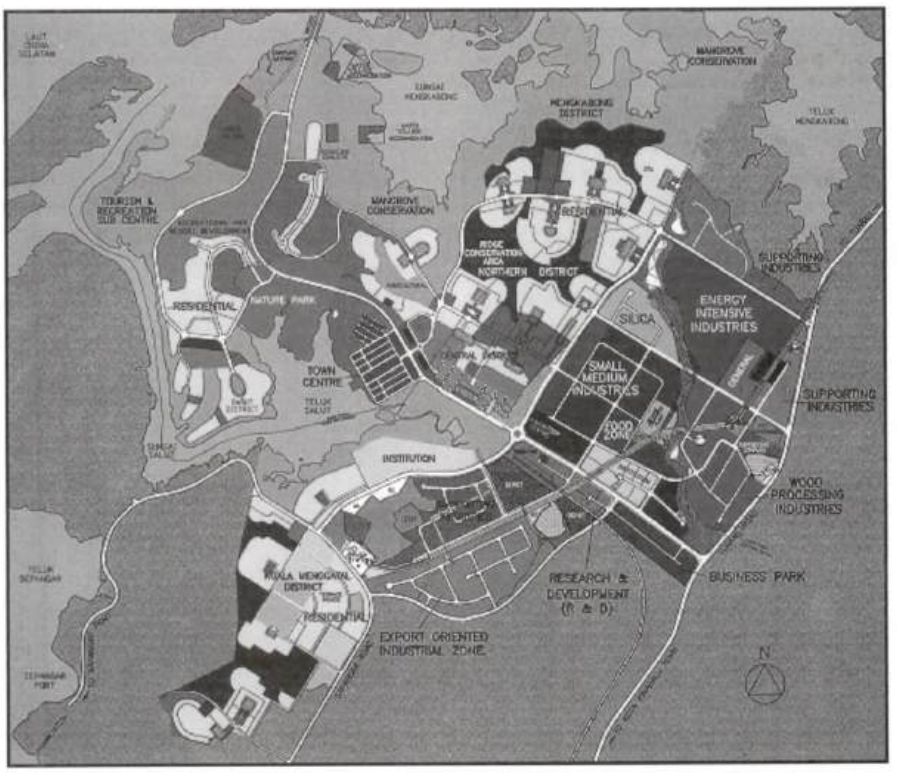

Figure 3 Development of Kota Kinabalu Industrial Park near Sepangar Bay and Karambunai Lagoon may also pose severe threats (land clearing and sedimentation) to the Seagrass Beds of Sepangar Bay, Karambunai Lagoon and Kuala Sungai Merkabong.

3. ECONOMIC VALUATION (IMPORTANCE AND USE OF SEAGRASSES)

Apart from serving as breeding and feeding grounds for many species of fishes, crustaceans, invertebrates, to larger endangered species such as dugongs and green turtles, there are very few direct uses of seagrasses to human.

Enhalus fruits/seeds are edible (Burkill, 1935) and is still eaten by the coastal communities of Sungai Pulai, Johor (Japar and Muta Harah, 2003), Indonesia (Kiswara, 1994) and the Philippines (Fortes, 1993). The nutritional value of the flour derived from *Enhalus acoroides* is comparable to that of wheat and rice flour in terms of carbohydrate and protein content and energy values surpass these types of flour in calcium, iron and phosphorus content (Montana *et al.* 1999). Burkill (1935) noted that the softer fibbers from *Enhalus acoroides* can be made into fishing nets. In Indonesia, the rhizomes of Cymodoceae are also eaten by the local people (Kiswara, 1994).

4. INSTITUTIONAL ARRANGEMENTS AND NATIONAL LEGISLATION

4.1 Constitutional Arrangement

The Federal Constitution of Malaysia defines the jurisdiction, roles and functions of the Federal and State governments. The division of jurisdiction is enforced through legislative, policy and administrative arrangements. In summary there are 19 articles in the Constitution which relates to the protection of the environment, ecosystems and endangered species. The articles cover a wide range of issues and divide the scope of responsibility into a Federal list, a State list and a Concurrent list. Four articles from the Federal, State and Concurrent lists impact directly on the conservation of marine biodiversity:

i) Article 9 (c) of the Federal list which gives the Federal government jurisdiction over marine fishing and fisheries, except for turtles;
ii) Articles 2 and 3 of the State list which give States jurisdiction over land and land use matters including forestry and agriculture;
iii) Article 12 of the State list which gives control over turtles and riverine fishing to the States; and
iv) Article 3 of the Concurrent list which provides for joint responsibility for the conservation of wildlife and the establishment of National Parks.

4.2 National Legislations

4.2.1 The Fisheries Act, 1985 (Amended 1993)

The Fisheries Act, 1985 is the principal act for the conservation of marine biodiversity. Apart from providing for the establishment of marine parks and regulating the activities in the marine parks (Section 41-45), the Fisheries Act also provides the powers for the State governments to enact legislation for the protection of turtles (Section 38). The latest amendment to the act made in 1999 provides the necessary powers for the Minister of Agriculture to promulgate laws to protect species deemed to be endangered (Article 61). Prior to this amendment no direct protection was extended to endangered species such as dugong *Dugong dugon*.

It is widely acknowledged that the Fisheries Act does not provide full protection to marine ecosystems, particularly from land-based activities. Indeed the 'divorce' between the management of the marine and the terrestrial components of the marine parks has often been used as an example of problems created by the Federal-State dichotomy. In order to address this problem, the policy makers and managers of marine protected areas have often resorted to using other laws such as the Environmental Quality Act.

The other major point raised about the Fisheries Act is that it is not an act which is intended to protect marine biodiversity. The protection accorded to ecosystems is by virtue of the ecosystems being inside a marine park area. Ecosystems outside marine park areas, particularly seagrass beds, are without any real protection from the Fisheries Act. Indirect protection is provided by the fisheries zoning procedures which limit the size of boats and gear used in coastal areas where ecosystems such as seagrass occur.

4.2.2 The Environmental Quality Act, 1974

The Environmental Quality Act, 1974 (EQA) is an umbrella act aimed primarily at pollution control and management of development activities. Pollution control is carried out through the numerous regulations under the EQA specifically those related to the discharge of sewage and effluents for example the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979.

Development control is achieved through the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment Order, 1987). Under the provisions of this order there are 19 activities requiring the preparation of, at the very least, a preliminary environmental impact assessment (EIA). In marine parks the requirements are even more stringent and all tourism development projects in marine parks would require an EIA. The implementation of the EIA provisions in as far as the EIA study is concerned is satisfactory. However, concern has been raised about the monitoring of development activities particularly where compliance with mitigating measures are concerned. Furthermore the operations of facilities such as hotels and chalets or infrastructure such as jetties are not subject to continuous monitoring. This brings into picture the need for post EIA or post development monitoring especially in sensitive areas such as marine parks.

4.2.3 National Forestry Act, 1984 (Amended 1993)

National Forestry Act 1984 (Amended 1993) provides a legal platform for the multiple-use management of the permanent forest estate (i.e. mangroves). The Act has been endorsed by all the states in Peninsular Malaysia. In Sarawak and Sabah, the administration and management of mangroves as forest reserves is governed by Forest Ordinance 1954 and Forest Enactment 1968, respectively. The area gazetted as mangrove forest reserves includes mangrove forests, rivers/water bodies and river beds. In many cases, seagrass beds are apparently found in the mangrove reserves.

4.3 State Legislation

Recently, several states especially Sabah and Sarawak have enacted new legislation related to coastal and marine environment. Table 6 shows some of the state legislation which is relevant to seagrass ecosystems.

5. MANAGEMENT PERSPECTIVES

5.1 Management Efforts

Generally, the conservation and management of seagrasses in Malaysia has received far less attention. There are no specific management plan, action plan, legislation, policy and guidelines for seagrasses. Unlike seagrasses, mangrove reserves have been established under National Forestry Act 1984 and state forest ordinances (i.e. Sabah's Forest Enactment 1968 and Sarawak's Forest ordinance 1954); and coral reefs are protected under Fisheries Act 1985 (via the Marine Park Establishment Order 1994 and Fisheries [Prohibited Area] Regulations 1994) and state national park ordinances (i.e. National Park [Johor] Corporation Enactment 1989, Sabah's Parks Enactment 1984 and Sarawak's National Parks and Reserves Ordinance 1965). At the moment, seagrass beds are partly protected under the marine parks, state parks, fisheries protected area (i.e. Pulau Talang-talang, Sarawak), mangrove forest reserves and RAMSAR site (i.e. Sungai Pulai). Many significant areas such as Paka, Kemaman, Setiu Lagoon, Kuala Lawas and Darvel Bay are not protected. The associated endangered species such as dugongs and sea turtles are protected under the Fisheries Act 1985, Protection of Wildlife Act 1972, Sabah's Fauna Conservation Ordinance 1963 and Sarawak's Wildlife Protection Ordinance 1990.

5.2 National Policies

Malaysia's overall effort to conserve marine biodiversity is guided by a number of principal policy and planning documents. Primary among these are the National Policy on Biological Diversity, National Policy on Environment, and the five yearly Malaysia Plan documents more specifically the Seventh and Eighth Malaysia Plans. Together, these documents provide the rubric under which biodiversity conservation work is implemented in the country. This section discusses these documents as well as other policy documents which impact on the conservation of marine biodiversity in Malaysia.

5.2.1 National Policy on Biological Diversity (NPB)

The Government of Malaysia in 1998 officially accepted the NPB as the primary document to guide biodiversity conservation effort in the country. This is in response to the recommendation of Convention on Biological Diversity for countries to

> *"develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity ..."*

In summary the NPB provides direction in implementing strategies, action plans and programmes for the conservation of biodiversity with the aim of using this resource in a sustainable manner. At the core of the NPB is a fifteen point strategy which includes measures such as improving scientific knowledge, strengthening the institutional framework for biodiversity conservation, integrating biodiversity conservation into sectoral planning, reviewing legislation, minimising human impact on biodiversity and enhancing awareness.

In general all the strategies and action plans of the NPB apply to the conservation of marine biodiversity. However, the NPB made several important observations concerning marine biodiversity conservation:

i) The lack of consideration given to the landmass adjoining marine parks in the gazettement of marine park areas. This has indeed caused the perennial problem of marine parks being adversely affected by development activities on land;

ii) Species conservation efforts focus too much on large and 'charismatic' terrestrial species. Some emphasis should also be given to marine species particularly fish species; and

iii) There is a lack of regional and international cooperation for the protection of transboundary protected areas.

The implementation of the NPB in the conservation of marine biodiversity however has been patchy and there is a lack of awareness among marine biodiversity managers as to the NPB and its content. Similarly, there also appears to be a lack of awareness on marine biodiversity among biodiversity conservation policy makers, planners and managers in the country. This is reflected in the fact that most of the NPB related projects carried out during the Seventh Malaysia Plan period were terrestrial

biodiversity conservation programmes. The NPB notes that the lack of knowledge and documentation on seagrass in Malaysia is an issue which needs to be addressed within the broader context of the strategies and action plans identified in the document. However, no specific programme has been identified for seagrass conservation and management.

5.2.2 National Policy on the Environment

In November 2002, Malaysia launched its National Policy on the Environment to enhance the national efforts to protect the environment and promote sustainable development. The objectives of the Policy are to achieve:

- A clean, safe, healthy and productive environment for present and future generations;
- Conservation of the country's unique and diverse cultural and natural heritage with effective participation by all sectors of society; and
- Sustainable lifestyles and patterns of consumption and production.

The policy statement sets out the principles and strategies necessary to ensure that the environment remains productive, both ecologically and economically. The eight principles are:

(1) Stewardship of the environment – Exercise respect and care for the environment in accordance with the highest moral and ethical standards.

(2) Conservation of nature's vitality and diversity – Conserve natural ecosystems to ensure integrity of biodiversity and life support systems.

(3) Continuous improvement in the quality of the environment – Ensure continuous improvement in the productivity and quality of the environment while pursuing economic growth and human development objectives.

(4) Sustainable use of natural resources – Manage natural resource utilisation to sustain the resource base and prevent degradation of the environment

(5) Integrated decision-making – Integrate environmental dimensions in the planning and implementation of the policies, objectives and mandates of all sectors to protect the environment.

(6) Role of the private sector – Strengthen the role of the private sector in environmental protection and management.

(7) Commitment and accountability – Ensure the highest commitment to environmental protection and accountability by all decision-makers in the public and private sectors, resource users, non-governmental organisations and the general public, in formulating, planning and implementing their activities.

(8) Active participation in the international community – Participate actively and effectively in regional and global efforts towards environmental conservation and enhancement.

The Green Strategies in the Policy are directed towards the following key areas:

(i) Education and Awareness
(ii) Effective management of natural resources and the environment
(iii) Integrated development planning and implementation
(iv) Prevention and control of pollution and environmental degradation
(v) Strengthening administrative and institutional mechanisms
(vi) Proactive approach to regional and global environmental issues and
(vii) Formulation and implementation of Action Plans

5.2.3 National Marine Parks Malaysia: Policy and Concept

The "National Marine Parks Malaysia: Policy and Concept" document was prepared in 1990 and to date remains the only document which outlines the philosophy behind the establishment of marine parks and the broad management objectives for these areas. The document also proposes management approaches such as zoning for multiple uses. However the document by itself is insufficient for the purpose of day-to-day management of marine park areas and is in need of updating considering the changes which have occurred in the marine parks and the areas surrounding it.

The updating of the document should among others consider reviewing the objectives of the establishment of the marine parks to better reflect the important role which marine parks in Malaysia play in conserving marine biodiversity. In addition, due consideration should also be given to resolving the quandary over the function of marine parks as a tool for conservation and its role as a venue for tourism activities. Apart from the document, other documents related to marine parks management should be reviewed. These would include the Conceptual Plan for Marine Parks Management report and others.

5.2.4 Malaysia Plans

The Malaysia Plan documents first noted the need to conserve marine biodiversity in the Sixth Malaysia Plan (1991-1995) document. During this period of the Malaysia Plan, emphasis was given to the establishment of Fisheries Prohibited Areas for the conservation of marine biodiversity and the promotion of tourism and scientific research. The Sixth Malaysia Plan further noted the importance of coral ecosystems to the conservation of marine biodiversity and warned of the dangers of uncontrolled sewage discharge, land clearing and clearing of mangroves and the impact these activities have on the marine environment.

Following-on from the Sixth Malaysia Plan, the Seventh Malaysia Plan (1996-2000) saw the completion and acceptance of the National Policy on Biological Diversity. Where marine biodiversity is concerned, a change of status was affected to the Fisheries Prohibited Areas which were gazetted as Marine Parks, thus according these areas better protection. The Seventh Malaysia Plan also calls for expansion of the protected area system to include more critical habitats. As part of an overall national effort to protect coastal zones a draft National Coastal Zone Policy was also completed during this period. The Government is presently considering this policy. There was also a proposal to establish a National Islands Development Board to coordinate development on islands and reduce the detrimental impact of island development on the marine environment. The status of this proposal however is not known.

The Seventh Malaysia Plan also saw the start of efforts to implement the NPB, although as noted earlier these were mostly for terrestrial biodiversity. Recognising this problem, the Eighth Malaysia Plan has called for an expansion of the NPB implementation programme to include all States. Presumably, this would include marine biodiversity conservation in marine parks as well.

5.2.5 The Third National Agricultural Policy (1998-2010)

The Third National Agricultural Policy recommends the establishment of more marine parks to conserve marine resources and ensure the sustainability of the fisheries sector, but does not make any specific mention of the ecosystems that need to be conserved.

5.2.6 Draft National Integrated Coastal Zone Management Policy (NICZM)

In October 2004, the Government of Malaysia through the Economic Planning Unit of the Prime Minister's Department completed a draft NICZM policy document. The draft policy comprising a Draft Policy Document and five Technical Annexes envisages a "A healthy and productive coastal zone, rich in biological diversity, wisely managed, and developed for the equal distribution of benefits for all, now and in the future." The vision statement is supported by fifteen goals aimed at among others higher economic growth in the coastal zone; preservation and restoration of environmental health and biological diversity in the coastal zone; achieve integrated and ecosystems-based management of the coastal zone; and practice good governance and management of the coastal zone.

While the draft report is yet to be finalised, the completion of the policy study is an important step for coastal zone management and its implementation, possibly during the 9th Malaysia Plan period of 2006-2010 would contribute significantly to coastal ecosystems conservation in Malaysia.

5.3 Development Guidelines

5.3.1 Government Circular No. 5/1987 on Control of Development in the Coastal Zone

The Circular 5/1987 establishes a set of regulations for the approval and implementation of projects in the coastal zone with the primary aim of protecting the coast from coastal erosion. The implementation of the circular has been quite uniform in all the States in Malaysia and this has contributed to the effort to address coastal erosion in the country.

5.3.2 Guidelines for Erosion Control for Development Projects in the CZ (JPS 1/97)

The guideline JPS 1/97 reinforces the implementation of the Circular 5/1987 by specifying the technical inputs needed for decision-making in coastal zone development. These inputs include information such as existing uses, biodiversity, and location of infrastructure and fisheries activities. More importantly, JPS 1/97 establishes setback limits for backshore development. The recommended setback limits are:

i) 60 metres for sandy coast from Mean High Water Mark; and

ii) 400 metres for muddy coast measured from the seaward edge of mangrove forest. However, no development should be allowed where mangrove forest have been gazetted as Permanent Forest reserve under the National Forestry Act 1984.

Table 6 Selected state legislation related to coastal and marine ecosystems.

State	Legislation	Agencies	Provisions
Sabah	**Sabah Water Resources Enactment 1998**	▪ Water Resources Council ▪ Drainage and Irrigation Department	▪ Establishment of river and shore reserves (i.e. coastal waters, estuary and lagoon, seagrass, mangrove forest, riparian forest, aquatic and wetland vegetation)
	Sabah Forest Enactment 1968	▪ Forestry Department	▪ Establishment of mangrove forest reserves (Class V) – mangroves and their water bodies (i.e. associated ecosystem such as seagrass beds)
	Parks Enactment 1984	▪ Sabah Parks	▪ Establishment, administration, planning and management of marine protected areas (MPAs) ▪ Prohibition on removal of vegetation and animal ▪ Prohibition on fish bombing and coral exploitation
	Wildlife Conservation Enactment 1997	▪ Wildlife Department	▪ Protection of endangered species associated with seagrasses (i.e. dugongs and turtles)
	Environment Protection Enactment 2002 (superseded Conservation of Environment Enactment 1996)	▪ Environment Protection Department	▪ Prescribed activities (i.e. sand mining, forest land clearing) ▪ Restrictions on activities along coastal area and affecting river bed ▪ Restrictions on discharge of pollutants into water ▪ Restrictions on activities affecting vegetation
Sarawak	**National Parks and Nature Reserves Ordinance 1998**	▪ Sarawak Forestry Department ▪ Sarawak Forestry corporation	▪ Establishment of national parks including MPAs ▪ Administration, planning and management MPAs
	Forest Ordinance 1954	▪ Sarawak Forestry Department	▪ Establishment, administration, planning and management of mangrove forest reserves
	Wildlife Protection Ordinance 1998	▪ Sarawak Forestry Department	▪ Protection of dugongs and all marine turtles ▪ Establishment and administration of wildlife sanctuaries
	Natural Resources and Environment Ordinance 1993	▪ Natural Resources and Environment Board	▪ Conservation and improvement of natural resources ▪ Prohibition, restriction and control of pollution
Johor	**National Park (Johor) Corporation Enactment 1989**	▪ Johor National Park Corporation	▪ Establishment of national parks ▪ Administration, planning and management of parks ▪ Research on ecosystems

5.3.3 Guidelines for Development Planning in the CZ (JPBD 6/97)

The Town and Country Planning Department guideline on development in the coastal zone complements the JPS 1/97 guideline on the control of erosion in the coastal zone. Because its scope covers development activities in general, JPBD 6/97 is able to provide specific guidelines for development of different types of coastal areas or activities. JPBD 6/97 is divided into two set of guidelines.

5.3.4 National Ecotourism Plan (NEP)

The National Ecotourism Plan, Malaysia (1997) consists of 25 easy-to-use guidelines for the management and promotion of ecotourism in Malaysia. The guidelines are divided into four categories and those which would be of great interest to marine biodiversity managers and policy makers are:

i) **Category 1:** Guidelines for Categorising Sites and Activities (Guideline 1);

ii) **Category 2:** Carrying Capacity and Limits of Acceptable Change (Guideline 2);

iii) **Category 3:** Guidelines according to Ecosystems (Guideline 3: marine park and islands; Guideline 5: mangrove forests; and Guideline 9: coastal areas); and

iv) **Category 4:** Guidelines according to Activities (Guidelines 1-25 covering issues such as local community participation, marketing, visitor behaviour, monitoring and conservation in general.

5.3.5 Other Guidelines

Other useful guidelines concerning protection of seagrasses are the Guidelines for Island Physical Development (JPBD 1/96), Integrated Physical Planning Guidelines for the Coastal Zone of Sarawak (2000), and Code of Practice for Mangrove Production Forest (1997).

6. RECOMMENDATIONS/ACTION PLAN

6.1 Protected Area for Seagrass Beds

The important seagrass beds in Malaysia should be urgently safeguarded by gazetting as the "Fisheries Protected Area" using the current legislations such as Fisheries Act 1985. Such instrument and approach have been used for the coral reefs (i.e. Pulau Talang-talang, Pulau Satang, and Tanjung Tuan). In Sabah, the Water Resources Enactment 1998 can be used to gazette reserves with seagrass resources.

6.2 Integrated Management of Seagrass, Mangrove and Coral Reef Ecosystems

Scientific studies and management intervention have mainly focused on single coastal/marine ecosystem or endangered species, in spite of the fact that interactions between seagrass, mangrove and coral reef ecosystems are known to exist (Fortes, 1995; Fortes, 1988; Fortes, 1991; UNESCO, 1983). There is no point to conserve and manage seagrass beds where their associated ecosystems such as mangroves and corals reefs are not protected. Similarly, there is impossible to conserve dugong population without protecting the seagrass habitat.

There is an urgent need to change the current approach which conserve and manage single ecosystem or single species, to integrated management and ecosystem approach. In Malaysia, the important and unprotected seagrass beds and their associated ecosystems and endangered species that need the integrated approach are seagrass beds in Pulau Banggi and Pulau Balambangan, Darvel Bay, Karambunai-Sepangay-Mekabong River, Kuala Lawas, Paka, Kemaman, and Tanjung Adang-Merambong shoal.

6.3 Legislation and Policy

Judging the importance of the seagrass ecosystems and their function on fisheries production, habitat for endangered species and coastal protection, the development of specific legislation (i.e. through the amendment of Fisheries Act 1985 and Forestry Act 1984), policy and guidelines should be given due consideration.

6.4 Management Plan and Conservation Programme

As the management issues of seagrasses are critical, priority actions to be taken are the development of management plan and programmes that focuses on the management issues regarding seagrass communities and human surroundings that impact them. The management plan and programmes will be incorporated in the overall management plan (i.e. integrated coastal zone management plan, marine park management plan, mangrove forest management plan, etc.).

6.5 Research Priorities

There is a need to prioritise seagrass research in Malaysia due to limited research funding and experts. Such research programmes should aim at improving current knowledge and management of seagrass resources, and develop human capacity for future seagrass research. The research areas to be given top priority the following:

- Seagrass resource inventory, mapping, classification and monitoring of significant seagrass beds;
- The interactions between seagrasses and other critical ecosystems, and their role in fisheries ecology and production;
- Seagrass and coastal processes – nutrient recycling and coastal protection;
- Seagrass rehabilitation and restoration, and marine ranching.

6.6 Education and Awareness Programmes

As implementation of management plan, policy and legislations will not be successful without public participation, especially from local communities and developers, the Government and relevant agencies have to start initiating education and public awareness programmes targeting all levels of people. Such programmes should emphasise on the importance of seagrass beds to human and endangered species (dugongs and sea turtles), linkages of seagrasses to mangrove and coral reef ecosystems, and the function of fisheries production.

REFERENCES

Arshad, A., Japar Sidik, B. and Muta Harah, Z. 2001. Fishes associated with seagrass habitat. pp.151-162. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Current Research and Review. MASDEC, UPM, Serdang, Malaysia.

Aung, H., Almah, A. and Arbain, H.K. 1995. Shrimp and prawn fauna of some seagrass and mangrove areas on the west coast of Sabah. pp.92-100. In: Almah, A. *et al.* (eds.). Proceedings of the Seminar on Marine Fisheries Resources of Sabah, 8-9 June 1994, Kota Kinabalu, Sabah.

Bank, E. 1931. A popular account of mammals of Borneo. Journal of Malayan Branch of the Royal Asiatic Society 9: 1-139.

Burkill, I.H. 1935. A Dictionary of the Economic Products of the Malay Peninsula. Volume 1 (939p.) and 2 (1954p.). Government of Malaysia and Singapore. Ministry of Agriculture and Co-operatives, Kuala Lumpur, Malaysia.

Duarte, C.M. 1999. Seagrass ecology at the turn of the millennium: challenges for the new century. Aquatic Botany 65: 7-20.

Fortes, M.D. 1988. Mangrove and Seagrasses beds of East Asia: Habitats under stress. Ambio 17: 207-213.

Fortes, M.D. 1991. Seagrass-mangrove ecosystems management: A key to marine coastal conservation in the ASEAN region. Marine Pollution Bulletin 23: 113-16.

Fortes, M.D. 1993. Seagrasses – their role in marine ranching. pp.131-151. In: Ohno, M. and Critchley, A.T. (eds.). Seaweed Cultivation and Marine Ranching. Kanagawa International Fisheries Training Centre and Japan International Cooperation Agency, Japan.

Fortes, M.D. 1995. Seagrasses of East Asia: Environmental and Management Perspectives. RCU/EAS Technical Reports Series No. 6. UNEP, Bangkok. 79p.

Gan, M.H. 2003. Distribution of *Gracilaria* Species in Selected Areas in Peninsular Malaysia and its Agar Evaluation. Unpublished thesis for B. Agrotechnology. Kolej Universiti Sains dan Teknologi Malaysia, Terengganu. 161p.

Gumpil, J. 1997. A Study on Seagrass Biodiversity, Distribution and Biomass in Tunku Abdul Rahman Park, Sabah, Malaysia. Final Year Project Report (Unpublished B. Sc. Thesis). Universiti Kolej (UPM) Terengganu. 149p.

Gumpil, J. 2002. Status, Utilisation and Suggested Management Strategies of Seagrass Beds in Darvel Bay, Sabah, Malaysia. Unpublished M. Sc. Thesis. Universiti Malaysia Sabah. 287p.

Japar Sidik, B. and Muta Harah, Z. 2003. The Seagrasses of Malaysia. pp.152-160. In: Short, F.T. and Spalding, M.D. (eds.). World Atlas of Seagrasses. California University Press.

Japar Sidik, B., Arshad, A., Hishamuddin, O. and Muta Harah, Z. 1999a. Seagrass and macroalgal communities of Sungai Pulai estuary, south-west Johore, Peninsular Malaysia. pp. 3-12. In: Kuo, J. *et al.* (eds.). Proceedings of an International Workshop on Seagrass Biology, 25-29 January 1996, Western Australia.

Japar Sidik, B., Arshad, A., Hishamuddin, O. and Shamsul, B. 1995. *Halophila decipiens* Ostenfeld: a new record of seagrass for Malaysia. Aquatic Botany 52: 151-154.

Japar Sidik, B., Lamri, A., Muta Harah, Z., Muhamad Saini, S., Mansoruddin, A., Gumpil, J. and Fazrullah Rizally, A.R. 1997a. *Halophila decipiens* (Hydrocharitaceae), a new seagrass record for Sabah. Sandakania 9: 67-75.

Japar Sidik, B., Muta Harah, Z. and Arshad, A. 2003. The occurrence of *Enhalus acoroides* fruits, seeds and seedlings. pp.111-116. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Managing the Straits Through Science and Technology. MASDEC, UPM, Serdang, Malaysia.

Japar Sidik, B., Muta Harah, Z. and Arshad, A. 2004 (*In Press*). Comparative morphology of *Halophila ovalis-Halophila minor* complex from Malaysia. JSPS Multilateral Cooperative Research 2002-2010.

Japar Sidik, B., Muta Harah, Z. Kanamoto, Z. and Mohd Pauzi, A. 2001a. Seagrass communities of the Straits of Malacca. pp.81-98. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Current Research and Review. MASDEC, UPM, Serdang, Malaysia.

Japar Sidik, B., Muta Harah, Z. Kanamoto, Z. and Mohd Pauzi, A. 2001b. Responses of *Halophila ovalis* and *Cymodocea serrulata* under the shade of *Enhalus acoroides*. pp.111-116. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Current Research and Review. MASDEC, UPM, Serdang, Malaysia.

Japar Sidik, B., Muta Harah, Z. Mohd Pauzi, A. and Madhavan, S. 1999b. *Halodule* species from Malaysia – distribution and morphological variation. Aquatic Botany 65: 33-45.

Japar Sidik, B., Muta Harah, Z., Lamri, A., Francis, L. and Fazrullah Rizally, A.R. 1997b. *Halophila spinulosa* (R. Br.) Aschers. – An unreported seagrass in Sabah, Malaysia. Sabah Parks Nature Journal 2: 1-9.

Japar Sidik, B., Muta Harah, Z., Lamri, A., Francis, L., Gumpil, J. and Fazrullah Rizally, A.R. 2000. *Halodule pinifolia* (Miki) Den Hartog from Tunku Abdul Rahman Park, Sabah. Sabah Parks Nature Journal 3: 29-39.

Japar Sidik,.B. 1994. Status of seagrass resources in Malaysia. pp. 283-289. In: Wilkinson, C.R. *et al.* (eds.). Proceedings of Third ASEAN-Australian Symposium on Living Coastal Resources. Australian Institute of Marine Science, Townsville.

Jimmy, A., Arshad, A. Japar Sidik, B. and Muta Harah. 2003. The stomach content analysis on several fish species from seagrass beds of Sungai Pulai, Johore. pp.125-131. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Managing the Straits Through Science and Technology. MASDEC, UPM, Serdang, Malaysia.

Kiswara, W. 1994. A review – seagrass ecosystem studies in Indonesia waters. pp. 259-281. In: Wilkinson, C.R. *et al.* (eds.). Proceedings of Third ASEAN-Australian Symposium on Living Coastal Resources. Australian Institute of Marine Science, Townsville.

Marsh, H., Penrose, H., Eros, C. and Hugues, J. 2002. Dugong: Status Report and Action Plan for Countries and Territories. UNEP, IUCN and WCMC. UNEP/DEWA/RS.02-1. 162p.

Mohd Kushairi, M.R. 1992. The areas and species distribution of seagrasses in Peninsular Malaysia. Paper presented at the First Symposium on Natural Resources, 23-26 July 1992, Kota Kinabalu, Malaysia. 8p.

Montana, N.N., Bonifacio, R.S. and Rumbaoa, G.O. 1999. Proximate analysis of the flour and starch from *Enhalus acoroides* (L.f.) Royle seeds. Aquatic Botany 65: 321-325.

Muta Harah, Z. and Japar Sidik, B. 2004 (In Press). Seagrass communities of Punang-Bt. Sari-Lawas River Estuary, Sarawak, East Malaysia. Bio-Science Research Bulletin (In Press).

Muta Harah, Z., Japar Sidik, B. and Fazrullah Rizally, A.R. 2003a. Occurrence and morphological description of seagrasses from Pulau Redang, Terengganu, Malaysia. Jurnal Teknologi 38: 29-39.

Muta Harah, Z., Japar Sidik, B. and Hishamuddin, O. 1999. Flowering, fruiting and seedling of *Halophila beccarii* Aschers. (Hydrocharitaceae) from Malaysia. Aquatic Botany 65: 199-207.

Muta Harah, Z., Japar Sidik, B., Law, A.T. and Hishamuddin, O. 2003b. The seagrass, *Halophila beccarii* (Hydrocharitaceae) and its distribution in Peninsular Malaysia. pp.165-173. In: Japar Sidik, B. *et al.* (eds.). Aquatic Resources and Environmental Studies of the Straits of Malacca – Managing the Straits Through Science and Technology. MASDEC, UPM, Serdang, Malaysia.

Norhadi, I. 1993. Preliminary Study of the seagrass flora of Sabah, Malaysia. Pertanika Journal of Tropical Agricultural Science 16(2): 111-118.

Orosco, C.A. and Amir Sharifudeen, A. 2004. The distribution of the seagrass, *Halophila beccarii* Aschers., in Terengganu River estuary. pp.192-195. In: Norhayati, M.Y. *et al.* (eds.). Proceedings of the KUSTEM Third Annual Seminar on Sustainability Science and Management, 4-5 May 2004, Kuala Terengganu, Terengganu.

Orosco, C.A. and Ung, Y.C. 2004. The growth and reproduction of the seagrass, *Halophila beccarii* Aschers., in Terengganu River estuary. pp.299-303. In: Norhayati, M.Y. *et al.* (eds.). Proceedings of the KUSTEM Third Annual Seminar on Sustainability Science and Management, 4-5 May 2004, Kuala Terengganu, Terengganu.

Phang, S.M. 1998. The Seaweed Resources of Malaysia. pp. 79-91. In: Critchley, A.T. and Ohno, M. (eds.). Seaweed Resources of the World. Japan International Cooperation Agency, Tokyo.

Phang, S.M. 2000. Seagrasses of Malaysia. Botanical Monographs No.2. University of Malaya, Kuala Lumpur.

Sasekumar, A. Leh, C.M.U., Chong, V.C., D'Cruz, R. and Audrey, M.L. 1990. The Sungai Pulai (Johor): A unique mangrove estuary. pp. 191-211. In: Phang, S.M. *et al.* (eds.). Proceedings of the 12th Annual Seminar of the Malaysian Society for Marine Science. Malaysian Society for Marine Science, Kuala Lumpur.

Sigurdson, J.B. and Yang, C.M. 1990. Marine mammals of Singapore, pp. 25-37. In:Chou, L.M. and Ng, P.K.L. (eds.). Essays in Zoology. Department of Zoology, National University of Singapore, Singapore.

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

UNESCO. 1983. Coral reefs, Seagrass Beds and Mangroves: Their Interaction in the Coastal Zones of the Caribbean. Report of a Workshop. UNESCO. 133p.

Wong, C.L., Masuda, M. and Phang, S.M. 2003. Seaweed and seagrass resources along the east coast of Peninsular Malaysia. Poster presented at the PEMSEA International Conference on the Sustainable Development of the Seas of East Asia. 4p.

ANNEX 1

Species, depth range, substratum, ambient salinity, temperature and habitat characteristics of seagrasses along the straits of Malacca.

Species	Depth range (m) MSL	Substratum	Salinity (ppt)	Temp. (°C)	Habitat characteristics
E. acoroides	-1.0 to -2.7	Compact sand, sandy-mud, muddy, soft mud and calcareous sandy-mud	24-34	29-34	Intertidal area, degraded coral reef, subtidal shoal
T. hemprichii	-1.0 to -1.8	Calcareous sandy-mud, sand covered coral and muddy	24-34	29-34	Degraded coral reef, rocky area, subtidal shoal
H. beccarii	-1.8 to -2.0	Calcareous muddy	25-32	30-32	Mudflat of mangrove, upper fringes of subtidal bottom
H. decipiens	-1.5 to -3.1	Sandy-mud and silty-mud	31-34	31-34	Subtidal area, lower intertidal area
H. minor	-1.8 to -2.1	Calcareous sandy-mud	28-31	29-30	Subtidal shoal
H. ovalis	-1.0 to -3.5	Calcareous sandy-mud, soft mud, sand covered coral, sandy-mud, silty-mud, muddy, calcareous muddy and sandy	24-34	29-34	Degraded coral reef, subtidal area and shoal
H. spinulosa	-1.8 to -2.1	Calcareous sandy-mud and soft mud	28-31	29-30	Subtidal shoal
C. rotundata	-1.8 to -2.1	Calcareous sandy-mud and sandy-mud	28-31	29-30	Subtidal shoal
C. serrulata	-1.0 to -2.1	Calcareous sandy-mud, sand covered coral and sandy-mud	24-34	29-34	Degraded coral reef, subtidal shoal
H. pinifolia	-1.0 to -2.1	Calcareous sandy-mud, sand covered coral, sandy-mud, silty-mud, compact sand and muddy	28-34	29-33	Intertidal area, subtidal shoal
H. uninervis	-1.2 to -2.1	Calcareous sandy-mud, sandy-mud and sandy	28-34	29-33	Intertidal area and subtidal shoal
S. isoetifolium	-1.0 to -2.1	Calcareous sandy-mud and sand covered coral	28-34	29-33	Degraded coral reef, subtidal shoal

Source: Japar Sidik and Muta Harah (2001a).

ANNEX 2

Location, latitude and longitude and habitat characteristics of *Halophila Beccarii*.

Location	Latitude N and Longitude E	Associated system	Substrate	Form and association	Depth range (m) HHWS	Salinity (psu)	Water Temp (°C)
Pulau Perhentian	05°53'34.56"N 102°44'11.6"E	Subtidal	Sand, silty sand	Mixed with *H. ovalis* and *Halodule pinifolia*	-4.6 to -12	28-31	29-31
Pulau Redang	05°46'30.5"N 103°02'12.4"E	Subtidal	Sand	Monospecific	-5 to - 6	28-32	27-30
Merchang	05°01'N 103°19'E	Intertidal, lagoon	Sand, muddy sand	Mixed with *H. pinifolia*	-2.2 to -2.5	0-18	29-31
Tanjung Adang	01°19'52.9"N 103°34'0.05"E	Subtidal, shoal	Calcareous muddy sand	Mixed with *H. ovalis*, *H. spinulosa* and *Enhalus acoroides*	-1.8 to -2.1	28-31	29-30
Pulau Manukan	05°58'25.3"N 116°00'31.9"E	Subtidal, degraded coral	Coralline sand, coral rubble	Mixed with *Thalassia hemprichii* Presence of *H. ovalis*	-2.0	28-29	30-31
Pulau Gaya	06°00'11.0"N 116°02'30.4"E	Subtidal, degraded coral	Sand, coral rubble	Mixed with *Halodule uninervis* Presence of *H. ovalis*	-1.5 to -2.5	29-31	30-32
Teluk Kerambunai	06°08'01.8"N 116°07'50.4"E	Intertidal, coastal lagoon	Sand	Monospecific Presence of *H. ovalis*	-2.0 to -2.5	29-30	30-31
Pulau Jambongan	06°40'58.8"N 117°32'15.3"E	Subtidal, degraded coral	Sand, coral rubble	Mixed with *H. ovalis*	-5.0	30-31	30-32
Pulau Selingan	06°10'25.0"N 118°3'39.0"E	Subtidal, degraded coral	Coralline sand	Monospecific. Presence of *H. ovalis*	-5.0 to - 7.0	29-31	30-32

Source: Muta Harah et al. (2003).

ANNEX 3

Habitat characteristics, associated system, form and association of seagrass species at Punang-Bt. Sari-Lawas River Estuary Beach Front, Lawas, Sarawak, East Malaysia.

No.	Seagrass species	Associated system	Form and association	Depth Range (m)	Salinity (ppt)	pH	Water Temp. (˚C)	Substrate
1.	*Halodule pinifolia* (Miki) den Hartog	Flatland of the upper to lower sub-littoral zone. Exposed during low tide	Monospecific and sometimes mixed with *H.ovalis* or *C. rotundata*	1.0-2.5	24-32	7.43-8.81	26-29	Fine sand to mud Substrates
		Channels and pools of the middle sub-littoral zone	Monospecific and sometimes mixed with *H. ovalis* or *C. rotundata*	1.5-2.0	24-25	7.34-8.05	25-27	Sand to mud substrates
2.	*Halophila ovalis* (R.Br.) Hook.*f.*	Flatland of the middle to lower sub-littoral zone. Exposed during low tide	Monospecific patches	1.5-2.5	29-32	8.38-8.81	26-27	Fine sand substrates
		Channels and pools of the middle sub-littoral zone	Mixed with *H. pinifolia* or *C. rotundata*	1.5-2.0	20-26	7.50-7.55	25-26	Sand to mud substrates
3.	*Cymodocea rotundata* Ehrenb. & Hempr. ex Aschers.	Channels and pools of the middle sub-littoral zone	Pure as well as mixed with *H. ovalis* or *H. pinifolia*	1.5-2.0	18-20	6.88-8.50	25-26	Sand to mud substrates
		Sometimes observed in mangrove mudflat of sub-littoral zone in pools and channels	Monospecific patches	1.0-1.5	18-20	7.33-7.50	25-29	Soft mud substrates
4.	*Thalassia hemprichii* (Ehrenb.) Aschers.	Mangrove mudflat of the upper sub-littoral zone in pools and depressions	Monospecific patches	1.0-1.5	10-19	7.56-8.34	25-26	Soft mud substrates with hydrogen sulphide

ANNEX 4

Macroalgae species at seagrasses meadows Merambong, Tanjung Adang (Darat and Laut), Teluk Kemang and Port Dickson.

No.	Division/Species	Merambong	Tanjung Adang	Teluk Kemang	Pantai Dickson
	Chlorophyta				
1.	*Avrainvillea erecta*	+	+		
2.	*Bryopsis plumose*	+			
3.	*Bryopsis sp.*		+		
4.	*U. occidentalis*	+	+		+
5.	*U. javensis*			+	+
6.	*Caulerpa lentillifera*			+	+
7.	*C. manorensis*	+			
8.	*C. microphysa*				+
9.	*C. prolifera*			+	+
10.	*C. racemosa*			+	+
11.	*C. sertularioides*	+	+	+	+
12.	*Chaetomorpha spiralis*	+	+		
13.	*Chaetomorpha spp.*		+		
14.	*Cladophora fascicularis*	+			
15.	*C. fuliginosa*		+		
16.	*C. patentiramea*	+			
17.	*Enteromorpha clathrata*	+	+		
18.	*Halimeda opuntia*	+	+		
19.	*Ulva spp.*	+	+		
	Phaeophyta				
20.	*Dictyota dichotoma*	+	+		
21.	*Lobophora variegate*				+
22.	*Padina tetrastomatica*			+	
23.	*Sargassum cristaefolium*			+	
24.	*S. ilicifolium*			+	
25.	*S. polycystum*			+	
	Rhodophyta				
26.	*Acanthophora spicifera*	+	+		+
27.	*Amphiroa rigida*	+	+		+
28.	*A. fragilissima*	+			
29.	*Ceramium affine*		+		
30.	*Gracilaria coronopifolia*		+		
31.	*G. fisherii*	+			
32.	*G. salicornia*	+	+		
33.	*G. textorii*	+			
34.	*Gracilaria sp.*				+
35.	*Hypnea cervicornis*	+	+		
36.	*Hypnea esperi*	+			
37.	*Jania decussate-dichotoma*			+	
38.	*Laurencia corymbosa*			+	

Source: Japar et al. 2001a.

ANNEX 5

Lists of fish and Crustacean species caught within Merambong seagrass shoal.

Family	Species	Local Malay Name
Fish		
Ariidae	*Arius sagor*	Duri/Pedukang
Balistidae	*Alutera monoceros*	Kerosok
Balistidae	*Abalistes stellaris*	Jebong
Belonidae	*Tylosurus strongylurus*	Todak
Carangidae	*Caranx sexfasciatus*	Selar
Carangidae	*Selaroides leptolepis*	Selar
Carangidae	*Scomberoides lysan*	Talang
Clupeidae	*Sardinella fimbriata*	Tamban
Clupeidae	*Anodontostoma chacunda*	Selangat
Drepanidae	*Platax teira*	Berbaharu
Engraulidae	*Setipinna taty*	Mempurung
Engraulidae	*Stolephorus indicus*	Bilis
Gerridae	*Gerres abbreviatus*	Kapas
Hemiramphidae	*Hemiramphus far*	Puput
Leiognathidae	*Leiognathus equulus*	Kekek gedabang
Leiognathidae	*Gazza minuta*	Kekek
Leiognathidae	*Leiognathus spelendens*	Kekek
Leiognathidae	*Leiognathus brevirostris*	Kekek
Lethrinidae	*Lethrinus lentjan*	Mempinang
Lutjanidae	*Psammoperca waigiensis*	Gelam
Lutjanidae	*Lutjanus argentimaculatus*	Ungar
Lutjanidae	*Lutjanus vitta*	Mentimun
Mugilidae	*Valamugil seheli*	Belanak angin
Nemipteridae	*Nemipterus japonicus*	Kerisi
Platycephalidae	*Platycephalus indicus*	Baji-baji
Plotosidae	*Plotosus caninus*	Unsat
Plotosidae	*Plotosus lineatus*	Sembilang
Pomadasyidae	*Pomadasys maculatus*	Serkut
Pomadasyidae	*Pomadasys hasta*	Gerut-gerut
Pomadasyidae	*Pomadasys argenteus*	Gerut-gerut
Polynemidae	*Polynemus sextarius*	Senangin
Pristigastridae	*Ilisha elongata*	Beliak mata
Scatophagidae	*Scatophagus argus*	Kitang
Sciaenidae	*Chrysochir aureus*	Gelama kuning
Sciaenidae	*Otolithes ruber*	Gelama
Siganidae	*Siganus javus*	Dengkis
Siganidae	*Siganus canaliculatus*	Dengkis
Sillaginidae	*Sillago sihama*	Bebulus
Sphyraenidae	*Sphyraena jello*	Kekacang
Stromateidae	*Pampus argenteus*	Bawal putih
Tetradontidae	*Chelanodon patoca*	Buntal
Tetradontidae	*Ostracion tuberculatum*	Buntal kotak
Theraponidae	*Therapon jarbua*	Kerong-kerong
Triacanthidae	*Pseudotriacanthus strigilifer*	Barat-barat
Trichiuridae	*Lepturacanthus savala*	Timah
Trygonidae	*Dasyatis uarnak*	Pari beting
Trygonidae	*Dasyatis zugei*	Pari ketukak
Crustacean		
Portunidae	*Portunus pelagicus*	Ketam renjung
Portunidae	*Charybdis feriata*	Ketam rimau
Calappidae	*Matuta lunaris*	Ketam ragi
Penaeidae	*Penaeus merguiensis*	Udang putih
Penaeidae	*Penaeus indicus*	Udang kaki merah
Squillidae	*Oratosquilla quinquedentata*	Mentadak laut

Source: Arshad et al, 2001.

UNEP

United Nations Environment Programme

UNEP/GEF South China Sea Project

GEF

Global Environment Facility

NATIONAL REPORT

on

Seagrass in the South China Sea

PHILIPPINES

Dr. Miguel Fortes

Focal Point for Seagrass

Marine Science Institute, University of the Philippines (MSI/UP)

Diliman 1101, Quezon City, Philippines

Table of Contents

List of Tables

1. INTRODUCTION

Seagrass beds are a discrete community dominated by flowering plants with roots and rhizomes (underground stems), thriving in slightly reducing sediments and normally exhibiting maximum biomass under conditions of complete submergence (Fortes, 1995). In the Philippines, they grow best near estuaries and lagoons where they are often associated, physically and ecologically, with mangrove forests and coral reefs, often forming the ecotone between these two divergent ecosystems. As such the habitat mediates the structural and dynamic components of the neighbouring ecosystems via control of material, water, and energy flows between them. More importantly, these seagrass meadows support a rich diversity of species from adjacent systems and provide primary refugia for both economically and ecologically important organisms. Hence, the plants are sensitive to fluctuations because species coming from their neighbouring systems encounter 'marginal conditions' and are at the extremes of their tolerance levels to environmental alterations. This sensitivity makes seagrasses useful indicators of changes not easily observable in either coral reef or mangrove forest (Heck and McCoy, 1978).

The extensive coastal zone in the country wraps around the islands and peninsulas, making probably the most exciting and rapidly growing economic section in the region. Of interest is that 75% of Southeast Asian population of about 500 million lives in coastal villages (World Resources Institute, 1990). This puts pressure on the seagrass resources through both direct effects, like fishing (Pauly and Chua, 1988), and indirect effects, like pollution and sediment runoff (Chou, 1994). The pressure is increasing as communities migrate to cities while the latter are now being built along coasts. In addition, the growth of Southeast Asian coastal tourism market is probably the most rapid in the world.

2. REVIEW OF DATA AND INFORMATION

2.1 Seagrass Distribution

2.1.1 Geographic Distribution

There are large discontinuities in the distribution of seagrasses in Southeast Asia. This observation is due to the lack of data resulting from unsystematic studies and incidental collections than the true pattern of distribution of the species (Fortes, 1995). Only three major accounts of seagrass biogeography in the region exist (Den Hartog, 1970; Fortes, 1988; Mukai, 1993). Using cluster analysis, Fortes (1988) has shown that the seagrasses in the Indo-West Pacific can be delineated into 7 seagrass 'provinces' with the Philippines, belonging to Province A, the area of second highest number of seagrass species and numerical similarities in the world.

Seagrasses of the Philippines show a pattern that may reflect their ecology. *Halophila spinulosa* and *Thalassodendron ciliatum* were generally found in deeper (2-17m) clearer waters off the eastern coast of Indonesia and southern and western coasts of the Philippines. Samples of *T. ciliatum* collected from Cuyo Island, Philippines (10° 51' N lat.; 121° 00' E long.) (Fortes, 1986) represent the northernmost limit of its distribution in the Pacific.

From ocular surveys, the Philippines has sizeable seagrass areas spread discontinuously along the shallow portions of its coastlines. The number of species present appears to be largely a function of the extent of studies made, the length of the coastline, and the emphasis countries give on the habitats.

The total of 978km^2 of seagrass beds in the Philippines have been measured from 96 sites (Table 1). Of this figure, 343km^2 have been estimated using combined satellite images and ground truth surveys. On the other hand, 635km^2 are gross estimates from satellite images only, no ground truth surveys; as the places are clusters or parts of big islands, and they cannot be delimited by single grids. The areas of seagrasses reported are estimates from selected study sites, not reflecting the area for the country.

Table 1 Initial area estimates of seagrass beds in the Philippines.

REGION	PROVINCE	LOCATION	LAT	LONG	AREA (km^2)
I	Pangasinan	Cape Bolinao	16.40	119.88	25
II	Cagayan	Cape Engaño/ Escarpada Point	18.45	122.28	9
II	Cagayan	Fuga	18.83	121.33	3
II	Isabela	Divilacan Bay/ Palanan Bay	17.28	122.42	5
IV	Marinduque	Calancan Bay	13.55	121.92	7
IV	Oriental Mindoro	Puerto Galera	13.45	120.95	9
IV	Palawan	Bacuit Bay	10.72	119.50	11
IV	Palawan	Bugsuk Island	8.23	117.40	12
IV	Palawan	Malampaya Sound	11.17	119.40	21
IV	Palawan	Puerto Princesa/ Honda Bay	9.85	118.93	43
IV	Palawan	Ulugan Bay	10.10	118.77	11
IV	Quezon	Calauag Bay	14.02	122.17	9
IV	Quezon	Polilio Island	15.03	121.80	13
IV	Quezon	Ragay Gulf	13.23	122.70	14
V	Sorsogon	Sorsogon Bay	12.77	123.25	17
VI	Negros Occidental	Bais Bay	10.57	123.15	9
VII	Bohol	Northern Bohol	10.15	124.43	19
VII	Negros Oriental	Apo Island	9.02	123.32	7
VIII	Samar	Catbalogan Area	11.73	127.95	11
X	Camiguin	Mantigue	9.08	124.78	9
X	Misamis Occidental	Baliangao	8.70	122.63	7
X	Misamis Occidental	Lopez Jaena	8.63	123.77	16
X	Misamis Oriental	Naawan	8.62	124.38	9
XI	Davao	Samal Island	6.88	125.78	17
XI	Davao Oriental	Mati	6.83	126.28	17
XIII	Surigao del Norte	Dinagat Sound	9.87	125.68	12
			TOTAL		**342**

(combined satellite images and ground truth surveys)

ADDITIONAL AREAS (gross estimates from satellite images only, no ground truth surveys; as the places are clusters or parts of big islands, they cannot be delimited by single grids)

1.	Northern Palawan	$89km^2$
2.	Spratlys	$22km^2$
3.	Sulu Archipelago	$167km^2$
4.	Hundred Islands	$31km^2$
5.	Tubbataha Reefs	$13km^2$
6.	Panay Island	$42km^2$
7.	Southwestern Palawan	$47km^2$
8.	Pacific coast of Sorsogon Province	$41km^2$
9.	Malangas Bay	$17km^2$
10.	Sarangani Islands	$19km^2$
11.	Batanes Islands	$21km^2$
12.	Calatagan Peninsula	$11km^2$
13.	Rest of Batangas Province	$22km^2$
14.	Rest of Marinduque	$33km^2$
15.	Southern Zamboanga	$25km^2$
16.	Sequijor	$21km^2$
17.	Lingayen Gulf (southern and eastern)	$14km^2$
TOTAL		**$635km^2$**
GRAND TOTAL		**$978km^2$**

Spatial and temporally analysis of data from all seagrass study sites in Ulugan Bay indicates that there was no significant change in the composition of the seagrass from February 1999 to March 2000. All seven species were found in the Bay throughout the study period. *Enhalus acoroides* was found in all the six sites. In Buenavista, all 7 species were found throughout the study period and in March *S. isoetifolium* was flowering profusely. During this month, the seagrass were highly epiphytised by the red seaweed, *Liagora farinosa*.

In terms of frequency, *E. acoroides* markedly dominated the sites (frequency range from 12.3%, February, in Buenavista, to 72.1%, February, in Umalagan). The small often sand-occluded seagrass, *Halophila ovalis*, had the lowest (range from 0.2%, October, in Tarunayan, and November in Buenavista, to 2.1% at the latter site).

Halodule uninervis consistently demonstrated its 'pioneer' nature, being present at the shallowest portions of the sites. Its seasonality was not as pronounced as the other five species, favouring both the transition period as well as the summer months.

However, it was not found at the more protected sites and at any time during the study. *S. isoetifolium* had a very limited distribution, being found only in Tarunayan in October. It was, however, found in Buenavista throughout the entire period of the study.

Six of the seven species showed distribution patterns that appeared to be dictated both by site conditions and periods of the year. Hence, *C. rotundata* appeared to favour the summer months at the more exposed, coralline sites of Rita-Manaburi and Tarunayan. However, it showed no temporal variability in Buenavista, occurring throughout the entire period of the study, and with remarkably consistently high frequency of occurrence. It was not recorded at the three other sites in the Bay.

T. hemprichii and *C. serrulata* exhibited similar occurrences (throughout the entire period of the study) and only in sites which are relatively exposed to surf, nearer the mouth of the Bay (Rita/Manaburi, Tarunayan, Oyster Bay, and Buenavista). *Halophila ovalis* showed a similar pattern of distribution except that, with slight site-specific variations, it appeared to favour only periods that were cooler thus providing a transition to the warmer months. It should be noted, however, that the sampling for frequency of occurrence focused only on the presence/absence of the species as seen through the water column and at the surface of the vegetation.

2.1.2 Temporal Distribution

This section gives some highlights of the studies in two types of features of seagrass beds: structural and dynamic/functional. These parameters are described in relation to their responses to the temporal and spatial conditions at the study sites.

Structural Features

Distribution – In Ulugan Bay two distinct types of seagrass communities are present: in the silted southern part of the Bay the seagrass communities were markedly dominated by only one species (*Enhalus acoroides*), a species known to be resistant to high levels of siltation, while in areas with clearer, less silted waters highly diverse mixed seagrass communities were found (*Halodule, Syringodium, Cymodocea and Thalassia*). The relationship found between community structure and gradient of siltation is in line with results reported by other authors.

It is known that *H. ovalis* thrives relatively well in the 'understories' of the bigger species and even underground. They are therefore not normally seen by ocular surveys.

From the data, it is interesting to note that the distribution of the seagrass species amongst the sites in the Bay follows a pattern wherein more protected sites had fewer species. However, their relative frequencies were much higher. On the other hand, those from more exposed sites had more species, but their frequencies were much lower. This demonstrates the classical inverse relationship between diversity and dominance, the latter being represented by relative density (RD).

It appears that the bay, as represented by the seagrass from the six sites, is characterised by varying stages of ecological development. These stages likewise represent the varying degrees of perturbation, natural or man-made, to which these sites are being subjected. Hence, the vegetation progresses from the apparently most stable, highly diverse mixed seagrass community at Buenavista and Rita/Manaburi to the lowly diverse one at Tarunayan (*Enhalus acoroides* and *Thalassia*

hemprichii, *Cymodocea serrulata*) and Oyster Bay (*Cymodocea serrulata*, *Thalassia hemprichii*, *Halodule uninervis*, *Halophila ovalis*), to the even less diverse community at Macarascas and Umalagan (*Enhalus acoroides*). It should be noted that Umalagan and Oyster Bay are deeper indentations of Ulugan Bay, hence, relatively more protected from waves, with substrates, which are muddier. On the other hand, Tarunayan, Buenavista, and Manaburi are more frequently exposed to wave action and with coarser sediment substrates.

Percentage cover – In five quarterly samplings (October 2001 - October 2002), the highest mean percentage cover for all species was recorded in April 2002, with a mean value of 16%. Conversely, January 2002 had the least mean value for seagrass cover with 8.48%. There was a general similarity in the cover values of the species during the rest of the period.

Among the seagrass species, *H. uninervis* had the highest mean percentage cover of 17.43%, while *H. ovalis* had the lowest with 3.98%. In a mixed community of seagrasses, *H. ovalis*, can be shaded by the other taller and broad-leaved species, so that the species could be hidden and not sampled. In an experiment, it was found that *H. ovalis* has a very limited tolerance to light deprivation when compared to other species of seagrasses.

Across transects, Transect C (the deeper transect), had the highest observed seagrass cover of 13.36%. Seagrasses along this transect have wider leaves to compensate for reduced irradiance. Transect A (the shallowest transect), had the lowest mean cover of 9.6%. It can be surmised that indeed irradiance affects seagrass growth and morphology along a natural depth gradient.

Canopy Height – Across sampling periods, April 2002 was the month when the highest average canopy height values for all five species from all three transects were derived with a mean of 11.53 cm. January 2002 had the lowest mean value of 6.90cm.

Among the transects, Transect B (middle depth) consistently had the highest average canopy height value of 11.82cm, followed by Transect C with 7.81 cm and Transect A, with a lowest value of 6.57 cm. Transect A has always been exposed and subjected to desiccation at varying times of the day, throughout the year. It can also be observed that seagrass blades in this portion of the bed were narrower compared to those in Transects B and C. Transect C is home to several species of herbivores mostly invertebrates, such as sea urchins or fishes. Bite marks from grazing were evident on the leaves in this part such that during wave surges, leaves are torn off, explaining the rather lower canopy height of the seagrasses in the area.

Density (using small quadrat) – Using the small quadrat ($100cm^2$), results across the sampling periods showed that the highest mean seagrass density occurred in April 2002 with 3.49 shoots/$100cm^2$. Lowest mean shoot counted 1.82/$100cm^2$. On the other hand, it occurred in October 2002. April is a summer month when conditions are best for growth e.g. high light and temperature, least sediment movement, during most parts of the period, facilitating the needed growth for bed expansion through shoot production. On the other hand, October is a rainy windy month, with low temperature and light values, and higher degree of sediment movement, reducing light penetration, which could perhaps explain the relatively lower density in the seagrasses.

Among the seagrass species, *H. uninervis* had the highest density of 8.79 shoots/$100cm^2$. *Enhalus acoroides* has the lowest density with 0.12/$100cm^2$.

Seagrass density (using core sampler) – Across sampling periods, the highest shoot density using a core ($0.0035m^2$) was also in April 2002 with 8.15 shoots/.$0035m^2$. However, the lowest density was recorded in July 2002 with 1.86 shoots/.$0035m^2$.

Above-ground: below-ground biomass ratio – From October 2001 to October 2002 and with the exception of *E. acoroides*, belowground seagrass biomass (dry weight, g) was significantly greater than aboveground biomass in the same plants. For belowground biomass, *Halodule uninervis* had the highest mean biomass with .25g DW m^2, with *H. ovalis* having the lowest with .02g DW m^2. *Enhalus acoroides* had the highest computed mean aboveground biomass value (dw) for all sampling periods with 0.14g DW m^2, while *Halophila ovalis* had the least with .01g DW m^2 . The above findings are consistent with those found in the literature.

Belowground parts constitute 50-90% of the total biomass of seagrasses and that aboveground parts may constitute 10-50% of the total dry weight of most seagrasses. It is interesting to note that below-ground biomass in all species (except *E. acoroides*) was consistently higher than aboveground biomass.

2.2 Physical/Chemical Characteristics

Sediment properties – Marine sediment properties in the Philippines were quantified along siltation gradients and across different habitat types to assess the extent of terrestrial sediment influence and derive indicators of terrestrial sediment input. The following main habitat types were covered: mangroves, seagrass beds, coral reefs, mud flats, river mouths and deep channels. Particularly in Bolinao and El Nido, distinct fronts in siltation were identified at about 7km from the source. Mud (<63_m), water content, organic matter, total nitrogen, total phosphorus and iron co-varied along the first axis of a principal components analysis, which correlated negatively with the pattern in medium to coarse sand (>250_m), total and inorganic carbon as well as calcium. Interstitial ammonia and phosphate varied with the fine sand fraction along the second axis. Two-way analysis of variance showed that water depth, distance from silt source, site and habitat type all contributed to the variance, but site explained most. Linear regressions showed positive correlations between silt and water content, organic matter, total nitrogen, total phosphorus and iron, but negative correlations with calcium suggesting iron and calcium as markers for terrigenous and marine origin, respectively. The composition of the sediment particulate matter groups the habitat types in two clusters: (1) silty types as river mouths, shallow mud bottoms, deep channels and mangrove stands with high contents of organic matter and nutrients versus (2) non-silty types as seagrass beds and coral reefs with low contents of nutrients and organic matter. Median settling velocities of the silt loads varied from 0.6m d_1 to 27m d_1. Experimentally determined susceptibility to resuspension identified critical water content of 50%.

At the demonstration sites in Puerto Galera, substrate type ranged from sandy-muddy at the left and middle portion of Transects A and B, to sandy towards the right marker. Transect C, which is adjacent to coral reefs, has a fine to coarse sand, which provides a more favourable substrate for seagrass growth.

Salinity – Salinity readings were relatively constant for PH4 at 35ppt. This value is known to be optimum for photosynthetic activities in seagrasses.

Water Quality – Water quality at the various sampling sites showed no significant difference in temperature or levels of suspended solids, sulphate, and nitrite/nitrogen. However, significant differences in the level of dissolved oxygen, colour and turbidity were recorded.

The differing results reflect the basic differences in topography and degree of *embayment* prevailing at the sites at the time of sampling. The more protected Bay sites, mainly Umalagan, Bulalakaw, and Buenavista, displayed lower dissolved oxygen content, higher colour values and higher turbidity in comparison with the more open sites outside the Bay proper, such as St. Paul and Sabang.

2.3 Biological Aspects

2.3.1 Seagrass Plants

2.3.1.1 Diversity of Seagrass Species

The most diverse seagrass flora is found in the Indo-West Pacific, the centre of marine generic richness and diversity in the world (Heck and McCoy, 1978). The Philippines, with its extensive coastline of more than 32,000km (World Resources Institute, 1990), is the country with the second most diverse seagrass flora so far recorded (second to Australia), contributing the greatest number of species in East Asia (19 or about 55%). Below are the species recorded in the Philippines.

Cymodocea rotundata
Cymodocea serrulata
Halodule pinifolia
Halodule uninervis
Syringodium isoetifolium
Ruppia maritima
Thalassodendron ciliatum
Enhalus acoroides
Halophila beccarii
Halophila decipiens
Halophila minor
Halophila minor var. nov.
Halophila ovalis
Halophila spinulosa
Halophila sp.
Thalassia hemprichii

Seven species of seagrass were identified from the study sites in Ulugan Bay. This number comprises 40% of the total number of seagrass species recorded in the Philippines and Southeast Asia, and 18% of that in the whole world. Species dominance in seagrass was site-specific. *Halodule uninervis* was the densest at 875.8 individuals/m^2. This was recorded at Buenavista. *Syringodium isoetifolium* from the same site followed with 491.3 individuals/m2 *Cymodocea rotundata* (337.3 individuals/m^2) from Manaburi was third overall in density, followed by *Thalassia hemprichii* from Umalagan with 4 individuals/m^2.

In Puerto Galera, five seagrass species were found in Study Site (PH4.1): *Cymodocea rotundata, Halophila ovalis, Enhalus acoroides, Thalassia hemprichii* and *Halodule uninervis*. This is 0.70% of the total number of seagrass species (=9) so far reported for the area, and 30% of that found in the country and for the whole of Southeast Asia (Fortes, 1986). It should be noted that no intensive taxonomic survey of the site was conducted, as this is not the thrust of the project. In addition, it is most likely that two other species, *Halodule pinifolia* and *Halophila minor*, are present, mixed with their generic counterparts at the most exposed and shallowest areas. More detailed survey and taxonomic studies are required to address this need.

In terms of diversity, Buenavista and Tarunayan in Ulugan Bay exhibited the highest number of species (Fortes, 1986). Rita-Manaburi with six, Oyster Bay with four, Umalagan, with three, and Macarascas with one followed this.

2.3.1.2 Utilisation of Seagrasses and Seagrass Beds

2.3.1.2.1 Commonly known uses

In the Philippines, the historical and contemporary uses of seagrass ecosystems are fairly well known. Hence, seagrasses have been used as packing material, children's toys, compost for fertiliser, fodder, for direct human consumption, the habitat itself is a fishing ground, especially for the juveniles and small adults of the rabbitfish, an industry base in many parts of coastal Asia; near resort areas, low tide exposes seagrass beds and their associated organisms which are the object of curiosity of tourists; as important natural components in marine parks and reserves; and in many typhoon-prone areas in the region, as effective retainers of sediments, hence, serving as buffer against waves and storm surges.

The importance of seagrass systems primarily as a source of income and as a livelihood base of coastal populations in the Philippines resides on the major components of seagrass beds (i.e., seagrasses, fish, reptiles and mammals, invertebrates, and seaweeds) which make them useful in the protection of the coastal environment and which justify sound management of this valuable resource.

Most coral reefs are in developing countries where they are associated with seagrasses. These two ecosystems potentially could supply more than one fifth of the fish catch in these countries. Five times as many fish live over seagrass beds as over sea floors made up of mud, shells, and sand. The importance of fish movement between coastal habitats is currently receiving attention particularly in the Indo-West Pacific region. This is largely because of its role in defining the ecological interactions between tropical coastal ecosystems, which has significant implications to coastal resource management.

The sea turtles at Turtles Islands of the South Sulu Sea, are known to consume both seagrasses and algae. Sea turtles have been hunted around the world for both subsistence and commercial trade. Its eggs are used as a protein source for both people and livestock in many coastal regions, the meat is consumed by humans, the cartilage of the green sea turtle is the source of the green turtle soup, and the scutes of the carapace, especially those of the hawksbill are the only natural source of 'tortoise shell' used for jewelry, eyeglass frames, Japanese ceremonial combs, etc. However, as with marine mammals such as whales and manatees, sea turtles are becoming increasingly valuable alive in a growing tourism industry based on viewing their nesting and hatching.

In the Aru Islands, South Sulawesi, and in Bangka Island, Indonesia, around 1,000 dugongs are caught annually in shallow waters, and form an important part of the coastal diet. In Calauit Island, Palawan, Philippines, more than five dugongs on average were seen per survey day in March and July, coinciding with seagrass peak biomass. The actual population status of the mammal in the region is unknown.

The fact that they bear few young and, in general, are slow to reach reproductive age makes dugongs and sea turtles especially vulnerable to exploitation. Thus they are species of special concern by virtue of their evolutionary persistence, their values to humans, and their vulnerability and current rarity. As a result the dugong and sea turtles are listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

2.3.1.2.2 Uncommon Uses and Functions

Seagrass beds have other 'uncommon' uses. Hence, they have 'elimination' functions, i.e., their uses once they are removed or converted into other uses, and 'environmental' uses. These are given below (Table 2):

Table 2 Elimination functions of seagrass habitats in coastal East Asia.

		Indo.	Mal.	Phil.	Sing.	Thai.
Aquaculture						
fish		L3	L2	L3	X	L2
crabs	X	X	L1	X	L1	
prawns	L2	X	L2	X	LW	
Rice fields		X	X	X	X	X
Sugarcane		X	X	L1	X	X
Palm plantation	X	X	X	X	X	
Other agriculture		X	X	X	X	X
Pasture		X	X	X	X	X
Solar salt		L1	X	L2	X	X
Industrial development	L2	L2	W3	W3	W3	
Urban development		L2	W2	L3	W3	L3
Ports		X	X	W3	W3	L1
Airports	X	X	L1	L3	L1	
Recreation		X	W	W3	W2	L3
Mining	X	L1	L3	X	L2	
Waste disposal	X	W	W2	X	X	
Flood run-off engineering	X	L1	L2	X	X	
Boat traffic		L	X	W2	W2	L1

L, use is localised
W, use is widespread
X, information inadequate

1, a minor use
2, a moderate use
3, a major use

Oatmeal cookies from Seagrass seed flour

The seeds of *Enhalus acoroides* (L.F.) Royle are known to the coastal people to be edible. Its proximate composition is similar to rice. It is eaten raw or boiled and tastes like sweet potato when cooked. Some fishermen believe that it is an aphrodisiac. Further investigations will include nutritional evaluation of seagrass plant parts to support the protection of the ecosystem.

With the aim to develop seagrass seed as human food in small island systems, researchers from the University of the Philippines have developed flour made from dried mature seeds of *E. acoroides*. Using a standard recipe for oatmeal cookies, seagrass seed cookies were made using seagrass flour half substituted for half of the usual wheat flour. Responses to a taste test were very positive. Further development is planned.

2.3.2 *Associated Marine Biota*

A vast array of plants and animals live in seagrass beds of the Philippines. Seagrasses have high organic production rates, which probably accounts for the high biodiversity in the ecosystem. Table 3 gives a comparison of species diversity among the major coastal ecosystems in the Philippines. Next to coral reefs, seagrass beds have the highest biodiversity. As in the whole of Southeast Asia, the figures may be grossly underestimated due to the paucity of documented information. There are indications largely through observations and ocular surveys, however, that the species richness in the habitats, particularly the fish and invertebrates, could be much higher than previously thought.

Table 3 Comparison of species diversity among the major coastal ecosystems in the Philippines.

Taxon	Seagrass Beds	Coral Reefs	Soft Bottoms	Mangroves
Seagrass	**18**	14	3	5
Algae	**154**	1,043	0	72
Corals	**8**	381	0	0
Other inverts	**73**	1,485	67	39
Fish	**218**	1,030	2	241
Mammals	**1**			
Reptiles	**11**	14		16
TOTAL	**483**	**3,967**	**72**	**373**

Modified from DENR/UNDP 1997

2.3.2.1 Seaweeds

Seaweed communities at the study (demonstration) sites were closely associated with seagrass and coral reefs, i.e., recorded along transects where these latter habitats were surveyed. From the nine sites where corals and seagrass were assessed, 13 different species of seaweeds were found at the seagrass sites, while 8 species were recorded at the coral reef sites. Four species belonging to *Rhodophyceae* (red algae) were found. These were *Amphiroa fragilissima*, *Laurencia sp.*, *Liagora farinosa*, and *Ceratodictyon spongiosum*. On the other hand, six species of *Chlorophyta* (green algae) and seven species of *Phaeophyta* (brown algae) were found. It should be noted that the record of the seaweeds might not have been complete as seaweeds have different habitat requirements and they were surveyed at sites dominated by seagrass and corals.

The three studies undertaken within the period May 1999 - March 2000 showed the presence of at least 56 species of macrobenthic algae in Ulugan Bay. The algae were categorised under the following groupings: *Cyanophyceae* (blue green algae), 1 species; *Chlorophyceae* (green algae), 26 species; *Phaeophyceae* (brown algae), 16 species; and *Rhodophyceae* (red algae), 26 species.

Another site in Oyster Bay was surveyed in March 2000. This was because of the report from the local inhabitants that indicated that the area is the source of a seaweed delicacy, 'lato' (*Caulerpa lentillifera*). Indeed, beds of the species were found close to the mangroves. These were highly silted. Estimated mean frequency was high (62.3% in 10 quadrats).

Interestingly, the results point to a certain degree of seasonality in the occurrence of the macrobenthic algae. The colder, wetter season represented by November is characterised by the presence of a significantly lower number of species (Gibbs, 1995) when compared to the warmer, drier months of May and March (with 47 and 56 species, respectively). While this might be true, the total biomass of the seaweeds, particularly contributed by the browns, could be more significant during the former period.

This is consistent with the known seasonal or temporal ecology of the seaweeds from both tropical and temperate latitudes. Hence, the trend in biodiversity as far as the seaweeds are concerned suggests a shift to higher dominance by a few well-adapted species (*Sargassum spp.*, *Hormophysa*, *Padina*) as the year approaches the colder, wetter months. True to the tropics, the summer months from March to April yield the highest biodiversity in most other marine communities.

On a per-site basis, the following sequence of sites with decreasing number of seaweed species results: Manaburi (51spp.), Buenavista (37spp.), Rita Island (21spp.), Oyster Bay (13spp.), Umalagan (12spp.), Bulalakaw (3spp.).

As in the case of the seagrass species, the local distribution of seaweeds showed a pattern that reflected the influence of the natural substrate and the degree of exposure to wind and waves. The north (western and eastern) sections of the Bay yielded significantly greater number of species when compared to the southern portions.

Hence, sites with more varied substrates (e.g. sandy, rocky, and coralline) and which are relatively moderately exposed to waves yield greater number of species. This was true for the Manaburi, Buenavista, Rita Island sites. On the other hand, sites which are distinctly muddy (hence, affording little opportunity for seaweeds to attach themselves) and which are relatively more protected yield smaller number of component species.

This is true for Oyster Bay and Umalagan (12spp.). Bulalakaw, while rocky coralline is a reef promontory exposed to sun and wind during low tides, could hence support only small cryptic, not many macrobenthic, and seaweeds.

Some of the seaweeds recorded are known to be of economic importance (Table 4). These point to their potential in adding income to the coastal population if the resources and their uses are properly tapped and managed.

Table 4 Seaweeds in Ulugan Bay with known economic value.

Species	Economic Use/Importance
Caulerpa	human food; medicinal antifungal; lowers blood pressure
Caulerpa racemosa	
Caulerpa sertularoides	
Cadium arabicum	human food
Cadium edule	
Dictyospheriae cavernosa	medicine; antimicrobial
Halimeda spp.	with growth regulators (auxin; gibberelin, cytokinin)
Dictyota dichotoma	human food; source of phenols, vitamin, folic and folinicacids
Padina australis	human food; source of alginic acid
Sargassum spp.	human food; source of algin, auxin-like substance; controls heavy metal (Pb, Cd) pollution
Turbinaria sp.	human food; source of algin, minerals
Laurencia spp.	human food; source of agar, carbohydrates, medicine, antifungal, antibacterial

2.3.3 Marine Animals and Endangered Species

Many animals live in seagrass beds of the Philippines where they form a major fishery. This is due to the rich nutrient pool and diversity of physical structures protecting young marine life from predators. This fact, in turn, is the basis of the economic usefulness of seagrass beds in these countries where major commercial fisheries occur immediately adjacent to seagrass beds (Fortes, 1994). Fish and shrimp are probably the most important components of the beds, although coastal villages derive their sustenance from other components of the grass beds. The major invertebrates found in the beds are shrimps, sea cucumbers, sea urchins, crabs, scallops, mussels, and snails, while the major vertebrate species include fishes, reptiles, and mammals. Some endangered species of sea turtles reported in seagrass beds include the green sea turtle, the Olive Ridley, the loggerhead, and the flatback. In the Philippines, as in most parts of the world, the sea cow (*Dugong dugon*), a mammal, which is almost completely seagrass-dependent (Fortes, 1995), is an endangered species.

In the Philippines, coral reefs with their associated seagrasses potentially could supply more than 20% of the fish catch (Talaue-McManus, 2000). A total of 1,384 individuals and 55 species from 25 fish families were identified from five seagrass sites in the country (Fortes, 1995).

In Ulugan Bay, a total of 3,000 individual fish were recorded at six transect sites. They represented 63 species, 35 of which are of commercial value. Of the 25 families recorded, *the highest number of species with 10, 9 and 8 represented Labridae, Pomacentridae and Chaetodontidae* respectively. This finding is consistent with similar studies performed elsewhere in the Philippines.

Comparing the six sampling sites, Sabang and Rita-Manaburi were the most similar. These sites were richer in terms of number of species, but had lower species diversity indices when compared with some of the sites with a lower total number of species, such as St. Paul and Bulalakaw. This indicates a more even distribution of fish among the various species at the latter sites. At Sabang and Rita-

Manaburi, evenness values were significantly reduced by the dominance of a few species – in Sabang *Abudefduf*, and at Rita-Manaburi *Pterocaesio diagramma* and *Pomacentrus*.

Offered the highest degree of protection from waves and wind of all sampling sites, and located adjacent to thick mangrove vegetation, Umalagan had the lowest number of fish individuals and the weakest association with the other sites. However, some similarities were noted with neighbouring Bulalakaw, and comparison of the two sites showed a similarity index of 56%.

Rita-Manaburi had the overall highest species diversity at 34 recorded species, and also the highest number of individuals: 1,028. This site is the most representative of the Bay as a whole. Species distribution did not correlate well with the corresponding feeding habits, in that all feeding groups were found at practically all locations. This implies that limiting factors other than food are shaping the community structure.

2.4 Threats to Seagrass

2.4.1 Nature of Threats

A significant portion of the coastal habitats of the Philippines is at high risk of being lost in the next decade. At present about half of its coastal resources have either been lost or are severely degraded during the past 56 years (5, 10) and the rate of degradation is increasing. Human impacts are the primary cause for most of these losses and these are increasing as human populations increase. There is rapid economic and human population growth, with the population doubling in the next 25-35 years (World Resources Institute, 1990). At least 60% of its human population lives close to shallow bays, lagoons and islands fringed by seagrass beds. Living in poverty, a large percentage of this population derives basic needs from these coastal resources. With or without conservation they will use this environment in order to survive. Infrastructure development is doubling at almost decadal rates. People extract about 68% of the country's animal protein from the sea. These changes are resulting in greater demands for coastal zone resources, especially quality seafood products and space. Our experiences in the past show that an explosive population growth, uncontrolled modification of the coasts, coupled with rapidly dwindling resources, will bring about short-term economic development mostly at the expense of the environment.

The major long-term threat to seagrass ecosystems around the world is derived from coastal eutrophication. A particular problem in embayment with reduced tidal flushing, nutrient loading or eutrophication results from wastewaters which reach the coasts from industrial, commercial and domestic facilities, inadequate septic systems, boat discharge of human and fish wastes, and storm drain run-off carrying organic waste and fertilisers. Its direct impact is the enhancement of growth in many plant forms resulting in reduction of light. Ultimately the cause of nutrient loading along coasts is people, increased population density increases the problem.

In the last decade the coastal environmental problems perceived as exerting the most severe impact on the coastal and marine environment in the Philippines are given in Table 5. They are ranked in order of priority and classified into urgency categories i.e., immediate, short-term or within the next five years, and long-term or within the next 10 years or more. Problems marked with asterisks are those which are known to impact heavily on seagrass beds, 3 asterisks indicating severe impact, 2 asterisks, moderate impact, and one asterisk, slight or no impact.

2.4.1.1 Coastal environmental problems

Table 5 Coastal environmental problems in the Philippines.

PROBLEM	Immediate	Short-term	Long-term
Sewage pollution***	2	2	3
Industrial pollution***	3	3	2
Fisheries overexploitation***	4	4	6
Siltation/sedimentation***	5	5	4
Oil pollution**	6	6	8
Hazardous waste*	7	7	7
Agricultural pollution**	8	8	5
Red tides*	9	9	11
Coastal erosion**	10	10	10
Natural hazards*	11	12	12
Sea level rise*	12	11	9

On a site basis, the project sites are subjected to the following threats (natural and man-induced):

	NATURAL					MAN-INDUCED		
	Wind	**Wave**	**Sedi move**	**Pollution**	**Over-harv**	**Rem-oval**	**Silt**	**Convert**
Fuga Is.	x	x						
Escarpada Pt.	x	x						
Cape Bolinao			x	x	x	x	x	
Masinloc-Oyon Bay						x	x	x
Puerto Galera			x	x				
Malampaya Sound					x		x	
Bacuit Bay						x	x	
Ulugan Bay							x	
Puerto Princesa/Honda Bay						x	x	x
Bugsuk Is.	x	x				x		x

(UNEP, 1990).

2.4.1.2 Threats at the site level

Below are the threats, given in the order of importance (1, most important; 5, least important) to seagrass habitats documented at each of the four selected sites in the Philippines. With the exception of non-transparency, they give observable physical manifestations. While there are similarities, there are also differences, which are dictated by the nature of the relatively more influential activities at the sites. Hence, in Ulugan Bay in the province of Palawan, it is the non-transparency of the navy in its plan to develop a naval base that is of prime importance. In addition, being a deep indentation (the most 'protected' among the four) and without significant disturbance from development, sedimentation from rivers is the number 2 priority. On the other hand, Puerto Princesa/Honda Bay in the same province is subjected more to siltation/sedimentation, not from river run-off but from man-influenced disturbance (e.g. resort and infrastructure development).

The relationships among these threats can be seen in Table 6. Eight threats are documented to affect the sites. Among those, which occur at all sites, 'siltation/sedimentation' remains as the most important, while 'boat scour', the least important. 'Unsustainable fishing practices' was intermediate. It is interesting to note that Transparency and 'oil pollution' are an issue in only one site (Ulugan Bay) and both associated with naval movement and the planned establishment of the naval base. Infestation by micro-organisms was found to be important only in Cape Bolinao.

Table 6 Threats at the project sites in the Philippines.

	Ulugan Bay	**Pto. Princesa**	**Cape Bolinao**	**Pto. Galera**
Siltation/Sediment (8)	2	1	2	3
Unsustainable fishing (13)	3	4	1	5
Boat scour (19)	5	5	5	4
Tourism development	NAP	2	NAP	1
Domestic discharges	NAP	3	4	2
Non-transparency	1	NAP	NAP	NAP
Oil pollution	1	NAP	NAP	NAP
Infestations	NAP	NAP	3	NAP

Numbers in parentheses are sums of the priority ranks. The lowest sum would mean that threat is the highest priority for all sites; NAP, not a problem.

2.4.2 Causal Chain Analysis

An effective way to understand the nature of threats to ecosystems is to subject them into a 'causal chain analysis'. This analysis 'regressively' links a threat to an immediate cause of that threat, and the latter is likewise linked to its immediate cause, and so on. The end point is a few, 'root causes'. These are the ones that need to be addressed effectively if one desires a resolution of the problems.

There is an indicative 'causal chain analysis' of siltation/sedimentation as the priority environmental issue at the selected sites. It is obvious that basic needs (food, shelter) among the coastal inhabitants are the primary forcing factor which degrade the environment and cause the loss or destruction of the habitats at the study sites. With slight variation, all four sites have generally similar problems.

With slight variations in the intensity of use and gear or means used, 'unsustainable fishing practices' occur at all four sites. Interestingly, there is co-action among all the factors concerned, indicative of the tightly coupled system that has evolved in the process. As in the case of 'siltation/sedimentation', it is again the lack of proper education that emerged as the root cause of the problem. This is shown below:

In all cases, the roots of the problems are basically the same: the inability of the people to meet the basic needs. This is hand in hand with the lack of proper education, and the desire for a higher quality of life. In many cases, the roots even touch the most basic 'sins' on humankind. The fundamental demand to survive and to improve the quality of life among the inhabitants is documented to bring forth unregulated or unplanned activities at the expense of environmental imperatives. This drive is aggravated by the lack of proper education, the root of most of the problems.

2.4.2.1 Impediments to Addressing the Threats

The major obstacles to solving the environmental problems and issues with regards to the seagrasses of The Philippines can be summarised below. It should be noted that these impediments were basically similar to those recorded 6 years ago:

1. Lacks of trained seagrass researchers
2. Limited scope of work
3. The works are largely descriptive, not synthetic
4. There are gaps in basic knowledge i.e., extent, status, and uses of seagrass beds
5. Lack of appreciation of seagrasses resources
6. Limited and uncoordinated research
7. Misguided management efforts
8. Lack of implementation of laws
9. Lack of effective linkages and
10. Non-consideration of the social and cultural dimensions

3. ECONOMIC VALUATION

No serious attempt has been made to valuate seagrass resources in the Philippines. In an isolated case (which was not followed up), the Marine Science Institute was requested to convert the destruction wrought by an oil barge that ran aground in Bolinao due to a typhoon. Initially, the value estimated for the associated seagrass resources e.g. biomass as feeds, fish, fertilisers, was US$20,000. On the other hand, it is worthwhile mentioning some cases wherein seagrass resources have been given monetary value if only to emphasise the point that indeed they are valuable.

Today we are stuck with the notion introduced by Giarini that in economic planning and decision making, it is an 'objective yardstick' to measure in monetary terms all factors that contribute to economic development. In the process, however, we should realise that we face the dilemma of pricing the priceless, of quantifying the unquantifiable, of creating common standards for things apparently unequatable. Fonseca (personal communication) argued that trying to determine the monetary value of an obviously rich and biologically diverse resource as a seagrass ecosystem might be a waste of time, for this will only further delay its development. But until better instruments and methodologies are found, giving money values to ecosystem functions (where possible) may help convince decision makers and financiers of development projects of the importance of nature conservation and the true meaning of environmentally sustainable economic development. In the valuation process, however, ecologists should be involved more actively with the view that the whole exercise is purely for the purpose of management. The low values attached to coastal resources are the principal reason for their continued destruction and degradation.

4. INSTITUTIONAL ARRANGEMENTS AND NATIONAL LEGISLATION

Among the legislation that has something to do with the marine and coastal environment, only one explicitly aims to protect seagrass: Executive Order 02-01. It is a local municipal legislation declared by the mayor of Puerto Galera, as a result of a workshop on *Seagrass*Net, which is an ongoing project to assess and monitor the condition of seagrass beds in shallow coastal areas in Asia-Pacific. All the other laws are either indirectly or directly relating to the protection of the coasts in general, or protecting the coral reefs, mangroves, or fishery resources of the country.

The chronology of the legislation relevant to the conservation and utilisation of the coastal and marine resources of the Philippines are given in Table 7.

At least 245 legislations with direct or indirect relevance to the concerns of the Seagrass Component of the project were reviewed. They are categorised under: Presidential Decrees, Laws Declaring Marine Protected Areas in the South China Sea side of the Philippines under NIPAS, Major Policies that Influenced DENR's Role in Coastal Area Management, Key Legislation that Influenced BFAR's Role in Fisheries Management in the Last 40 Years, Laws providing other National Agencies with specific and implied mandates for CRM, Selected Administrative Issuances Related to Pollution, Selected Administrative Issuances Related to Protected Areas, Selected Administrative Issuances Related to Mangroves, Selected Administrative Issuances Related to Foreshore, Selected Administrative Issuances Related to Fisheries, Administrative Issuances Related to Coastal Tourism, Selected Administrative Issuances Related to the Role of Local Government Units, Selected Municipal Ordinances, Pending Legislative Proposals on Pollution, Pending Legislative Proposals on Protected Areas, Pending Legislative Proposals on Mangroves, Pending Legislative Proposals on Fisheries, and Pending Legislative Proposals on Tourism.

It should be noted that only 1 (a local ordinance, Executive Order 01-02, *Bantay*Isay, or *Seagrass*Watch) pertained solely to the protection of seagrass habitats. Only a few explicitly mentioned seagrass habitats and their resources. This is a reflection of the relative 'new' recognition of the habitat in the legal circles. Unlike the coral reefs and mangroves, the documented importance of seagrasses to fisheries and coastal management and protection has been known in the Philippines and the region only since the early 80's.

Fortes (1990 and 1995) have reviewed the seagrass resources of East Asia, discussing their status and potential as a resource, as well as their environmental roles and prospects for management. So far, 16 species of seagrasses have been identified in Philippine waters (Fortes, 1986). In other parts of the country where conditions are favourable, seagrass beds can also be extensive, though often less dense (Soegiarto and Polunin, 1982; ESCAP, 1995). The boundaries of seagrass bed distribution in the Philippines are uncertain as there have been few detailed studies and only shallow beds can be seen in satellite and aerial images.

Table 7 Chronology of national and local legislation relevant to the concerns of the seagrass component.

Legislation	Title/Description
Republic Act No. 9003 (2001)	The Ecological Solid Waste Management Act
Republic Act No. 8550 (1998)	Fisheries Code, clarifies jurisdiction of municipalities and cities in the management of municipal waters to include functions pertaining to enforcement, legislation, regulation of fishing activities, conservation and planning
Republic Act No. 8435 (1997)	Agriculture and Fisheries Modernization Act, provides extension services to municipalities and provides for agriculture and fisheries zoning plan irrespective of political boundaries
Republic Act No. 8371 (1997)	Indigenous Peoples Right Act (IPRA)
Executive Order No. 6 (1996)	Institutionalised the multi-sectoral committee on coastal development plan
Executive Order No. 240 (1995)	Creation of Fisheries and Aquatic Resources Management Committees (FARMCs) in coastal barangays, cities and municipalities
Republic Act No. 7942 (1995)	The Philippine Mining Act
Republic Act No. 7881 (1994)	Amendments to RA 6657, Comprehensive Agrarian Reform Law, pertaining to coverage of fishponds
Executive Order No. 117 (1993)	Created the Inter-Agency Task Force on Coastal Environment Protection (IATFCEP)
Republic Act No. 7586 (1992)	National Integrated Protected Area Systems Act
Republic Act No. 7160 (1991)	Local Government Code
Republic Act No. 7061 (1991)	The People's Small-Scale Mining Act
Republic Act No. 7161 (1991)	Amendments to National Internal Revenue Code of 1977, bans the cutting of all mangrove species
Republic Act No. 6969 (1990)	The Toxic Substances and Hazardous and Nuclear Wastes Control Act
Executive Order No. 192 (1986)	Establishes the jurisdiction of DENR in the use of all public lands including foreshore areas
Presidential Decree No. 1151 (1986?)	Philippine Environment Policy declares it a policy of the State to create, develop, maintain, and improve conditions under which man and nature can thrive in productive and enjoyable harmony with each other; fulfil the social, economic, and other requirements of present and future generations of Filipinos, and ensure the attainment of an environmental quality conducive to life and well-being. It also laid the basis for requiring Environmental Impact Statement (EIS) for all projects and programmes that affect environmental quality.

Table 7 *cont.* Chronology of national and local legislation relevant to the concerns of the seagrass component.

Legislation	Title/Description
Presidential Proclamation No. 2146 (1981)	Identifies environmentally critical projects, heavy industries, resource extractive industries and infrastructure projects. Also defines environmentally critical areas including all declared protected areas, critical habitats of wildlife, prime agricultural lands, mangrove areas and coral reefs, areas of significant historical, cultural or aesthetic values and areas often hit by natural calamities
Presidential Proclamation No. 1801 (1978) UNESCO's Man and Biosphere Programme (1977) Presidential Decree No. 354 (1973)	Puerto Galera Biosphere Reserve
Presidential Decree No. 1067 (1976)	Water Code of the Philippines, establishes recreation/easement zones in banks of rivers and streams and shores of seas and lakes
Presidential Decree No. 1586 (1976)	The Environmental Impact Statement System
Presidential Decree No. 984 (1976)	The National Pollution Control Law
Presidential Decree No. 979 (1976)	The Marine Pollution Decree
Commonwealth Act No. 141 (1936)	The Public Land Act
	A policy document that provides general guidelines for air quality management, water management, land use management, and natural resources management and conservation. The water quality management provisions are concerned mainly with freshwater resources, but the management of these resources is also of concern to fisheries management since a number of freshwater rivers and lakes form part of the inland fisheries resources
Republic Act No. 9147	The Wildlife Resources Conservation and Protection Act
Republic Act No. 7611	The Strategic Environmental Plan for Palawan Act, creating a special environmental management regime for the island-province of Palawan and sets up the multi-sectoral Palawan Council for Sustainable Development as the administering authority
Presidential Decree No. 474	The Maritime Industry Development Decree
Presidential Decree No. 825	Penalises the improper disposal of garbage and other forms of uncleanliness
Presidential Decree No. 857	Sharing of port management between the Philippine Ports Authority and the local government units (LGUs)
Presidential Decree No. 1152	Philippine Environment Code, prescribes environmental quality standards for air, water, land, fisheries and aquatic resources, wildlife, soil, etc.
Presidential Decree No. 1198	Requires the rehabilitation of damaged foreshore areas to their original condition
Executive Order No. 114	Created the Presidential Committee on Illegal Fishing and Marine Conservation
Executive Order No. 263	Establishes the community-based forest management
Executive Order No. 247	Bioprospecting law
Commonwealth Act No. 383	Prohibits the dumping into any river of any refuse, waste, matter or substances of any kind whatsoever that may bring about the rise or filling of river beds or cause artificial alluvial formations
National Marine Policy	Adopts the archipelagic nature of the Philippines in development planning, implementation of UNCLOS and all maritime and coastal concerns
Philippine Agenda 21	The national agenda for sustainable development for the 21st century
Medium-Term Philippine Development Plan (MTPDP)	The blueprint that spells out the development strategy to boost, among others industry, trade and tourism

5. MANAGEMENT PERSPECTIVES (KEY PROBLEMS AND ISSUES)

Why manage our seagrasses resources? Considering the benefits derived from the natural functions and resources of seagrass ecosystems, their management is justified. But in East Asia where most of the countries need to develop, living and non-living coastal resources remain an object to exploit, often on an unsustainable basis, in the long-term causing the loss of the habitats. As with their natural functions, the elimination functions of seagrass habitats strongly justify why they should be managed.

The traditional orientation of marine science in Southeast Asia has been to view the ocean as a deep-water mass, neglecting the shallow coastal fringes where seagrasses abound. Investigators with the interest on seagrass research are few and priorities for research and developmental activities are usually directed towards other resources with immediate economic impacts i.e., corals, seaweeds, animals, or fish that either live in coastal habitats or are associated with them (Fortes, 1989). Ironically, in Southeast Asia seagrass ecosystem has been a focus of scientific inquiry only in the last 15 years and, as an object of natural resource management, only in the last 5 years. This is particularly true in the Philippines. Since the early 1990s, the current rate at which we are gaining information on seagrasses in the region is lower than the rate the resources are being degraded and lost.

Quantitative data that justify management of seagrass systems are few. These focused mainly on numerical relationships of certain components, the observed effects of perturbations, patterns of use of their resources, and their potential to rehabilitate degraded coasts and help coastal economies. The high similarity in the kinds of seagrasses in East Asia and the comparable values obtained on their

biomass and productivity imply the prevalence of equally similar patterns of local climate and coastal conditions. In addition, the similarity in the impacts to which the resources are subjected suggests similar patterns and strategies for regional protection and utilisation of the resource. On the other hand, the high diversity and abundance of seagrass habitats and their resources in East Asia make them highly vulnerable and susceptible to both man-induced and natural perturbations. While a growing awareness on the fundamental ecological and economic potential of seagrass ecosystems have very recently occurred, there are indications that natural recovery of a significant percentage of the habitats in the region is improbable within this generation.

If one considers the fundamental functions of seagrass ecosystems and their potential role in coastal environmental and socio-economic well-being of coastal populations, it becomes imperative to use the resource on a sustainable basis. Hence, integrated coastal zone management should be the goal. The strategies to attain this goal include: establishing national plans; fostering cooperation; implementation of policies for sustainable uses; expanding the resources; legislation and administration; and adherence to certain appropriate recommendations.

1. There is a low level of environmental awareness among community members. In general, communities do not sense the need to respond to environmental problems, for as long as their communities are not affected. Many of those interviewed admitted to know about the environmental problems in Sabang (e.g. domestic sewage) but for most of them, Sabang's problem is its own.
2. The field interviews indicated a low awareness about the Man and Biosphere Programme of UNESCO. When asked if they know the programme, one pointed out the MAB building while another said it is a refugee centre. It seems that were no chances in the past where MAB was explained to the community nor used in any planning exercise, either by the local or national government or non-governmental institution. Some interviews pointed out that the MAB has been negatively perceived and erroneously understood by the people in Puerto Galera because when it started in the 1970s, most people are suspicious of any development programmes or initiatives that may appear to curtail the basic human rights of the people. In the case of MAB, people saw it machinery of the late President Marcos to seize and grab major land holdings in Puerto Galera for him and his cronies. Such impressions need to be corrected by providing more information on the benefits and advantages of having Puerto Galera as a Biosphere Reserve.
3. There is poor enforcement of laws and policies. For example, field observations show the existing establishments in the foreshore land or the 20-meter setback from the high tide mark. Also, there are no sufficient septic tanks in Sabang mainly due to the lack of inventory and monitoring of conditions of building permits. Some people account the non-compliance to laws to the political connections of those who violate the laws.
4. There is minimal experience among communities to mobilise around specific issues. In the past, the issue of the power barge in Minolo Bay united and mobilized the people of Puerto Galera. However, there were allegations that there was an intense political intervention such that some people were convinced to either keep quiet or support the set up of the power barge. In the end, the issue that initially united the people of Puerto Galera ended up dividing them.
5. Despite the power barge experience, there are indications that the people can be united around issues on livelihoods. Community members, for example, expressed their willingness to be part of an organisation or cooperative that can either collectively or individually manages a livelihood project. Initial impressions point out that people are generally willing to enhance existing livelihoods such as fishing and farming but more information is needed to show if they are willing to shift from their present economic activities.
6. There is a general impression that the people in Puerto Galera have always been at the receiving end of development. There are no organised community groups and there is an absence of an active local media and pro-active citizens' group.
7. Stakeholders in tourism like the diver shop owners, tourists, local government, etc. agree on taxation for tourism. However, there is a conflict on how these taxes should be allocated. Stakeholders should collectively decide on what would be a fair or equitable distribution of tourism-related taxes.
8. There is an apparent lack of government support on economic activities other than tourism. The possibility of making tourism as a core industry but supporting other industries as well should be carefully considered. Some suggested economic activities include coconut product processing, backyard vegetable gardening and cogon papermaking.

9. Tourism is generally associated with a change in the lifestyle of the youth, change in basic family values and a strong tendency to be materialistic. Other factors apart from tourism should be looked into as possible causes in these perceived social changes.
10. There is a lack of comprehensive database on basic demographic information related to tourism. To do this, the multiple points of entry should be considered as well as the inclusion of basic demographic information that relates with tourism.

5.1 The People and Their Perceptions of the Environment (Ulugan Bay)

Five *barangays* comprise the human communities around the bay. Some population characteristics of these communities are given below:

Number of Households and Their Population (1995)

Barangay	No. of Households	Total Population
Bahile	330	1,754
Buenavista	109	506
Cabayugan	289	1,516
Macarascas	220	1,334
Tagabinet	195	922
TOTAL	**1,143**	**6,032**

Annual growth rate of the population is 10.4%, higher than that of the city of Puerto Princesa (6.66%) due to resettlements by some coastal residents. Most of the population does not own lands (squatters). Only 18% do, and these are located far from where they reside around Ulugan Bay.

In relation to perceived changes in the environment in the last decade, 85% of the households observed significant changes in the environment. On the other hand, 15% remained unaware of any such changes in the bay area. This perception is reflected in the table below:

Observed Environmental Changes
and the Corresponding Degree of Change (June 1998)

Observed Changes	Degree of Change
Fishing/Shellfish harvest	Lesser
Fishing grounds	Smaller, farther
Water pollution	More polluted
Factories/Establishments	More
Forest cover	More, since 1992
Flooding in lowlands	Lesser

Among the six perceived changes, those in fishing and fish harvest were the main concern as most of the people are fishermen. Water pollution was the second major concern, followed by the change in forest cover. The improvement in forest cover in the last few years was the result of the implementation of *Bantay Gubat* (Forest Watch) programme of the City Government, which started in 1992.

98% of the population is well aware of the coastal resources of the bay. About 59% of its residents are dependent upon these resources for livelihood. The latter is mostly fishing and farming. Fishing boats enter through the mouth of the bay in the north to trade fish and other domestic and commercial commodities with the inhabitants. The most popular resources include fish, seaweeds, oysters, crabs, shrimps, shells, octopus, squid, and lobster. However, only a few are aware of the ecological significance of mangroves, coral reefs, and seagrass beds. Hence, it is not surprising that people are more aware only of the resources, which could directly benefit them or can give them cash. Average monthly income in the area is Philippine Pesos (PHP) 3,900 (roughly US$97.50 at current exchange rate).

People are very much willing to participate in the effort to protect and conserve the bay. However, they are not knowledgeable on how exactly to do it. But some have proposed concrete activities that they can do to help in the effort. These include:

- Reporting to the proper authorities any illegal activities;
- Abiding by the fishing regulations set by the environment sector and other agencies;
- Not cutting mangroves;
- Cleaning the coastal area and not dumping waste into the sea;
- Disseminating information on protection and conservation to fellow residents.

77% of the population are willing to take the opportunity to have additional sources of income in the bay at the same time contribute to the sustainable management of the bay resources and eventually help the community. However, 13% showed no such interest for the reason that they already have businesses.

The agencies most helpful in the conservation of the bay resources include: *Bantay Dagat* (Sea Watch); Ulugan Bay Foundation, Inc.; The Naval Station; Bureau of Fisheries and Aquatic Resources Monitoring Committee (BFARMC); and the City Government. 89% of the people believe that they all should continue their missions of helping the people improve their conditions.

5.2 Management Problems and Issues (Ulugan Bay)

The following are the current and perceived problems and issues in Ulugan Bay:

- *Use of compressor in spear fishing* – there has been a significant decline in the use of hook-in-line as a fishing method in the bay. This was primarily due to the emergence of the compressor (hookah diving using compressed air);
- *Overfishing caused by large commercial trawlers* – the smaller boats of the local fishermen and their less powerful lights (used to attract fish) are no match to the much bigger boats and more powerful lights of trawlers. A prohibited activity, this problem trawling at shallow waters threatens the livelihood base of the coastal inhabitants.
- *Proposed naval reservation and training facilities* – in the light of the Spratlys controversy (i.e., the islands west of Palawan being claimed by at least four countries bordering the South China Sea), Ulugan Bay is at a very strategic location, most favourable for setting up a naval station. The huge area to be encompassed by this planned facility (9,080ha) in the bay would displace a greater portion of the coastal population in the area;
- *Resettlement of Tarunayan residents* – the planned relocation of the fishermen-residents from Rita Island to Sitio Manaburi (due to private ownership of large portions of the island) was opposed by these residents. So they inched their way into the nearby forest, degrading and cutting them.
- *Proposed wildlife sanctuary and ecotourism centre* – the proposal to convert the forestland west of the bay into a *Wildlife Sanctuary and Wildlife Research, Rescue and Breeding Centre*, was opposed by the people. They claim that the area cannot support exotic species to be introduced because of the terrain and type of vegetation. Many fear displacement once an ecotourism centre is developed.
- *'Kaingin' ban* – '*Kaingin*' ('slash-and-burn' agriculture practiced mostly at slopes of mountains) was banned in the bay area, recognised by the people as a good move by the City Government. However, the latter did not put in place an alternative livelihood means for the affected residents. The temporary alternative – rationing of rice to this people – is perceived to be unsustainable.
- *Declining marine resources due to siltation* – silt was perceived to be the main factor causing the decline of the corals in the bay. The earth-movements especially from road building and land-clearing for agriculture, and mining operations at the eastern and southern shores of the bay have largely been responsible for the siltation (*'paglabo ng tubig'* or the increase in water turbidity).

REFERENCES

Chou, L.M. (ed) (1994) Implications of Expected Climate Changes in the East Asian Seas Region: An Overview. RCU/EAS Technical Report Series No. 2. UNEP.

Den, Hartog C. (1970) Seagrasses of the World. Elsevier, North-Holland, Amsterdam.

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

Fortes, M.D. (1989) Seagrasses: A Resource Unknown in the ASEAN Region. ICLARM Education Series 5. International Centre for Living Aquatic Resources Management, Manila, Philippines. 46pp.

Fortes, M.D. (1986) Taxonomy and Ecology of Philippine Seagrasses. PhD Dissertation, University of the Philippines, Diliman, Quezon City, 245pp.

Fortes, M.D. (1988) Indo-West Pacific Affinities of Philippine Seagrasses. Bot Mar 31: 207-213.

Fortes, M.D. (1990) Seagrass Resources in East Asia: Research Status, Environmental Issues and Management Perspectives. In: ASEAMS/UNEP Proc. First ASEAMS Symposium on Southeast Asian Marine and Environmental Protection. UNEP Regional Seas Reports and Studies No. 116. UNEP pp. 135-144.

Fortes, M.D. (1994) Status of Seagrass Beds in ASEAN. In: Clive R. Wilkinson (ed) ASEAN-Australia Symposium on Living Coastal Resources 3rd October 1994, Bangkok, Thailand. Consultative Forum. Living Coastal Resources of Southeast Asia: Status and Management Report. pp. 106-109.

Fortes, M.D. (1995) Seagrasses of East Asia: Environmental and Management Perspectives. RCU/EAS Technical Report Series No. 6, United Nations Environment Programme, Bangkok, Thailand. 75pp.

Gibbs, W.W. (1995) Lost Science in the Third World. Scientific American August 1995, pp. 92.

Heck, K.L. and McCoy, E.D. (1978) Biogeography of Seagrasses: Evidence from Associated Organisms. Proceedings of the International Symposium on Marine Biogeography and Evolution in the Southern Hemisphere. New Zealand DSIR Information Service, pp. 109-127.

Mukai, H. (1993) Biogeography of Tropical Seagrasses in the Western Pacific. Australian Journal of Marine and Freshwater Research. 44: 1-17.

Pauly, D. and Chua, T.E. (1988) The Overfishing of Marine Resources: Socio-economic Background in Southeast Asia. Ambio 17 (3): 200-206.

Soegiarto, A. and Polunin, N.V.C. (1982) The Marine Environment of Indonesia. A report for the government of Indonesia under sponsorship of IUCN and WWF, 257pp.

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

UNEP (1990) Report of the Fourth Meeting of Experts on the East Asian Seas Action Plan, Quezon City, Philippines, 3-6 December 1990. UNEP (OCA)/EAS WG 4/6, UNEP OCA/PAC, Nairobi.

World Resources Institute (1990) World Resources 1990-95. Oxford University Press, New York.