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

SEAGRASS IN THE SOUTH CHINA SEA

UNEP/GEF
Regional Working Group on Seagrass

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UNEP/GEF Project Co-ordinating Unit, United Nations Environment Programme,
UN Building, 9th Floor Block A, Rajdamnern Avenue, Bangkok 10200, Thailand.
Tel. +66 2 288 1886
Fax. +66 2 288 1094
http://www.unepscs.org

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Authors:

Dr. Chittima Aryuthaka, Dr. Miguel Fortes, Dr. Hutomo Malikusworo, Mr Kim Sour, Mr. Suy Serywath, Professor Xiaoping Huang, Mr. Tri Edi Kuriandewa, Mr. Kamarruddin bin Ibrahim, Dr. Marco Nemesio E. Montaño, Dr Suvaluck Satumanatpan, Dr. Nguyen Van Tien, and Mr. Kelvin Passfield.

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FOREWORD

The centres of seagrass diversity have a clear focus in the seas of East Asia, reaching up to southern Japan, and a second focus of diversity in the Red Sea and East Africa. This pattern is similar to the global distribution of corals and mangroves. The uses of seagrass systems are well known. Hence, they support a rich diversity of species from adjacent systems and provide primary refugia for both economically and ecologically important organisms. Most of the major commercial fisheries in the region occur immediately adjacent to seagrass beds. As an ecotone between coral reefs and mangrove forests in tropical coasts, they mediate the structural and dynamic components of the neighbouring ecosystems. Ironically, seagrass beds in this region are the least studied among the coastal ecosystems. Only in the last 15 years have they been a focus of scientific inquiry and, only in the last 5 years, have they been subjected to any natural resource management. Globally, seagrass systems occupy an area of about 600,000 km^2, contributing 12% of the total carbon storage in the ocean. The contribution of seagrass beds of the East Asian seas to these figures is not known.

In the South China Sea region there has been a rapidly increasing rate of seagrass loss and decline. In recent years, Indonesia has lost about 30-40% of its seagrass beds, with as much as 60% being destroyed around Java. In Singapore, the patchy seagrass habitats have suffered severe damage largely through burial under landfill operations. In Thailand, losses of the beds amount to about 20-30% and in the Philippines, it is about 30-50%. Very little information on seagrass loss is available from Cambodia, China, Malaysia, and Vietnam. Loss of the beds in the region has been due largely to the loss of coral reefs (which act as buffer against waves) and mangroves (which act as a "filter" for sediment from land), coastal development, and urban expansion. Other impacts include, substrate disturbance, industrial and agricultural runoff, waste water and sewage discharges.

The economic return from seagrass beds in East Asia is very poorly known. In other parts of the world, it can be up to US$ 212,000 per hectare. Based primarily on the fisheries they support, seagrass beds in Cairns, Australia, return A $700,000 annually. In Monroe County, Florida, the commercial fishery for five seagrass-dependent species was estimated at US$48.7 Million Yr^{-1}. Worldwide, recreational fisheries, diving and snorkelling are industries, which depend directly or indirectly upon healthy seagrass beds. In an assessment of the economic value of the world's ecosystems, Costanza *et al*. (1) listed the value of the nutrient cycling function of seagrass beds at US$3.8 Trillion, the second highest value among all the other ecosystem values listed.

The UNEP/GEF South China Sea Project attempts to reverse the degradation trends in marine habitats, including seagrass beds, in the region. Hence, for the period 2002-2007, it is developing both national and regional initiatives for habitat interventions to facilitate the reversal process. It aims to establish sites where the effects of sound management on the environment, biodiversity, and lives of people can be demonstrated.

Dr. Miguel Fortes
Bangkok, Thailand
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Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand.

Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, Viet Nam

In 1996, the countries bordering the South China Sea requested assistance from UNEP and the GEF in addressing the issues and problems facing them in the sustainable management of their shared marine environment. From 1996 to 1998 initial country reports were prepared that formed the basis for the development of a Transboundary Diagnostic Analysis, which identified the major water related environmental issues and problems of the South China Sea. Of the wide range of issues identified the loss and degradation of coastal habitats, including mangrove, coral reefs, seagrass and coastal wetlands were seen as the most immediate problem. Over-exploitation of fisheries resources and land-based sources of pollution were also considered significant issues requiring action.

In 1999 the governments, through the Co-ordinating Body for the Seas of East Asia endorsed a framework Strategic Action Programme that established targets and timeframes for action. In December 2000, the GEF Council approved this project with UNEP as the sole Implementing Agency operating through the Environmental Ministries in the seven participating countries and with over forty Specialised Executing Agencies at national level directly engaged in the project activities.

INTRODUCTION

Global distribution. A generalised picture of global seagrass distribution has long been known (Den Hartog, 1970). Spalding *et al.,* (2001), however, give the most updated geographical distribution of the seagrass flora of 115 countries. Their work indicates that, a focus for distribution lies in the seas of East Asia reaching north to southern Japan, with a second focus in the Red Sea and East Africa. Some species have clearly restricted ranges whilst others are endemic to single countries. This review demonstrates that seagrass distribution extends further north and into the temperate waters of Japan, showing a global distribution much wider than previously known. The resulting pattern is remarkably similar to the global distribution of coral reefs and mangroves.

The recently published World Atlas of Seagrasses (Green and Short, 2003) provides information on the world's seagrass habitats globally, incorporating their status in the face of environmental change. This is part of an ongoing initiative of the United Nations Environment Programme-World Conservation Monitoring Centre (UNEP-WCMC) to develop a comprehensive global GIS dataset with data coming from multiple sources. However, there are still substantial information gaps to be filled, and for the South China Sea region this project will help to fill those gaps.

Regional Distribution. For East Asia, two related studies (Fortes, 1988; Mukai, 1993) augment our knowledge of seagrass biogeography. There are still wide areas however, where the existence of seagrasses has not been documented. The World Atlas of Seagrass (Green and Short, 2003) provides only a very general and large-scale representation of seagrass distribution in the South China Sea.

The diversity of seagrass species shows a tendency to increase from the sub-tropical north to the tropical south of the South China Sea region. The composition of the seagrass flora of the South China Sea therefore consists of a mixture of tropical and subtropical species.

Seagrass species. Of the approximately 60 seagrass species described worldwide, 18 species are found in, and adjacent to, the coastal waters of the South China Sea (Table 1). Fifteen species have been already described, while taxonomic work on three undescribed species of *Halophila*, found in Malaysia and the Philippines, is ongoing. Along the coast of the South China Sea, the numbers of seagrass species known to occur in each country are as follows: China, 8; Vietnam, 14; Cambodia, 8; Thailand, 12; Malaysia, 11; Indonesia, 12 and Philippines, 10, respectively.

The genus *Halophila* is the most diverse genus and is commonly found in coastal waters throughout the region. Further taxonomic work is essential to verify the description of species in this seagrass genus in the region.

Halophila ovalis

The coastlines of the northern sub-region, in China and northern Vietnam, have characteristics of subtropical areas, and the species include *Zostera japonica* together with *Halophila beccarii, Halophila ovalis, Halophila decipiens, Enhalus acoroides, Thalassia hemprichii, Halodule pinifolia, Halodule uninervis, Cymodocea rotundata* and *Ruppia maritima.* All but the first are widespread throughout the South China Sea region. Additional seagrass species recorded in the tropical zone include *Halophila spinulosa, Halophila minor, Cymodocea serrulata, Halodule pinifolia, Syringodium isoetifolium* and *Thalassodendron ciliatum.*

Thalassia hemperichii

The sub-tropical species *Zostera japonica* often forms mono-specific seagrass beds, and has been recorded in Tieshan Bay and Yingluo Bay, Guangxi Province, and Hong Kong in China. Its distribution also extends down to northern and central Vietnam. Its occurrence in the seagrass beds in Danang and Quang Nam Provinces represents the southernmost limit of this species in the Indo-west Pacific. This reflects a wide distribution of the species that is originally from the temperate region. Another species of this genus, *Zostera marina* has been reported in some papers (Japar *et al*., 2001; Tien, 2002) although this identification needs to be confirmed by taxonomic study.

Of the tropical species, *Thalassodendron ciliatum* is generally found in seagrass beds from the intertidal to the low sub-tidal zone (2 – 17 m) in the eastern part of Indonesia, and the southern and western shores of the Philippines. This species also occurs in the seagrass beds in Con Dao, southern Vietnam. In the Philippines, it has been reported in Cuyo Island, the northernmost limit of its distribution in the Indo-west Pacific.

Table 1 Seagrass species recorded from the countries bordering the South China Sea.

Family and species	China	Vietnam	Cambodia	Thailand	Malaysia	Indonesia	Philippines
Zosteraceae							
Zostera japonica	x	x					
Hydrocharitaceae							
Halophila spinulosa					x	x	x
Halophila decipiens		x		x	x	x	x
Halophila minor		x		x	x	x	x
Halophila beccarii	x	x		x	x	x	x
Halophila ovalis	x	x	x	x	x	x	x
Enhalus acoroides	x	x	x	x	x	x	x
Thalassia hemprichii	x	x	x	x	x	x	x
Cymodoceaceae							
Cymodocea serrulata		x	x	x	x	x	x
Cymodocea rotundata	x	x	x	x	x	x	x
Halodule pinifolia		x	x	x	x	x	x
Halodule uninervis	x	x	x	x	x	x	x
Syringodium isoetifolium		x	x	x	x	x	x
Thalassodendron ciliatum		x			x	x	x
Ruppiaceae							
Ruppia maritima	x	x		x	x		x
Undescribed taxa							
Halophila minor							x
Halophila sp.1*							x
Halophila sp.2**					x		
Total per country	**8**	**14**	**8**	**12**	**15**	**13**	**16**

Seagrass biodiversity. Numbers of species recorded in association with seagrass beds worldwide include 450 algae, 171 polychaetes, 197 molluscs, 15 echinoderms and 215 fish (Spalding *et al.,* 2001).

In the seas of East Asia few studies have been undertaken to identify seagrass associated biota. However, the demonstration site proposals from the seven countries participating in the Project, indicate that, along with 17 seagrass species, there are at least 25 species of epiphytic algae, 21 macrobenthic algae, 10 penaeid shrimps, 100 gastropods 5 siganids, 7 sea urchins, and 7 seahorses. Most of the major commercial fisheries of the region occur immediately adjacent to seagrass beds (Fortes and McManus, 1994).

Enhalus acoroides

The regional distribution of seagrass species in participating countries is shown in Table 1. Table 2 provides information on biodiversity and other environmental indicators for seagrass sites characterised under the project.

Worldwide and regional decline. Worldwide, there has been a rapidly increasing rate of seagrass loss. In the Asia-Pacific region decline in seagrass is documented for 10 sites, comprising 25% of the total number of areas where declines have been reported (Short and Wyllie-Echeverria, 1996). At least 45,000 hectares have been lost in Australia this century (Sheppard *et al*., 1989). Seagrass loss in Cambodia, China, and Malaysia, is largely unknown. Seagrass decline in Indonesia, Philippines, Thailand, and parts of Australia are well documented and are shown in Table 3, together with an estimate of worldwide decline. This table is incomplete since studies have not been made in many parts of the world where seagrass is found.

Rabbitfish and seagrass

Rabbitfish are a valuable seafood resource for subsistence fishers in the South China Sea region. They belong to the herbivorous Siganid family, and rely on seagrass for their food, as well as habitat for juveniles. There are at least 16 species of rabbitfish found in the South China Sea region. Reduction in seagrass coverage in the region will have a negative impact on rabbitfish stocks, and hence on food security of coastal subsistence communities in many countries

Table 2 Biodiversity and other environmental indicators for selected seagrass sites in the South China Sea.

Site Name	Area (ha)	% cover	Depth range	Seagrass spp.	Penaeid spp.	Gastropod spp	Siganid spp.	Urchin spp	Threatened spp.	Associated ecosystems	Migratory species
Cambodia											
Kampot	25,240	45	2	6	N/A	N/A	N/A	N/A	2	2	2
China											
Hepu	540	85	4	4	5	12	1	3	3	1	2
Liusha	900	90	3	2	5	11	1	1	2	2	2
LiAn	320	82	3.2	5	4	17	1	1	3	2	2
Xincun	200	87	2	4	4	6	1	1	2	2	1
Indonesia											
Trikora Beach	280	95	2	9	3	16	3	4	6	2	3
Mapur	275	85	3	9	3	11	3	4	5	2	3
Malaysia											
Tanjung Adang Laut Shoal	40	80	1.2	9	2	2	1	1	2	2	2
Tanjung Adang Darat Shoal	42	80	0.7	9	2	2	1	1	2	1	2
Merambong Shoal	30	80	0.7	10	2	2	2	N/A	2	1	2
Sungal Paka Shoal	43	N/A	4	2	N/A	2	N/A	2	1	1	1
Pulau Tinggi Mersing	3	70	3	6	N/A	N/A	2	2	2	1	2
Setiu Terengganu	3	70	6	3	N/A	3	2	N/A	1	1	1
Pulau Besar Mersing	3	70	4	5	N/A	1	2	N/A	2	1	2
Philippines											
Cape Bolinao	2,500	75	1.7	9	7	23	6	4	3	2	1
Puerto Galera	114	95	4.5	9	3	11	2	3	3	2	1
Ulugan Bay	11	90	2.5	8	3	10	2	5	4	2	0
Puerto Princesa/Honda Bay	670	90	4	8	4	18	4	5	3	2	1
Thailand											
Kung Krabane Bay	700	80	4	5	4	5	2	N/A	2	1	1
Surat Thani	500	65	3	6	2	73	3	1	2	1	2
Pattani Bay	273	80	3	4	8	35	5	N/A	2	1	2
Vietnam											
Bai Bon, Phu Quoc Is	2,000	70	6	7	3	46	1	3	5	2	2
Rach Vem, Phu Quoc Is	900	65	6	6	3	30	1	3	3	2	2
Con Dao Island	200	25	9.6	10	8	45	1	3	4	2	4
Phu Qui Island	300	50	2.5	6	2	35	3	3	3	2	2
Thuy Trieu (Khan Hoa)	800	60	1	7	4	10	3	2	4	2	0

Source: Site characterizations and demonstration site proposals for the South China Sea Project.

Table 3 Estimates of area of seagrass lost globally and in selected countries.

Country/Region	Area lost (%, km^2)	Causes	Source
Indonesia	30-40 %	siltation, pollution	Fortes and McManus, 1994
Philippines	30-50 %	siltation, eutrophication, unsustainable fishing	Short & Wyllie-Echeverria, 1996
Thailand	20-30%	siltation, pollution	Sheppard *et al.,* 1989
Vietnam	40-50%	Pollution, coastal development	This report
Gulf of Carpentaria, Australia	20%	cyclone	Hemminga &Duarte, 2000
Hervey Bay, NE Australia	1,000 km^2	2 floods + cyclone	Duarte & Cebrian, 1996
Botany Bay, Australia	unknown	dredging, urchin population explosion	Hemminga &Duarte, 2000
Cockburn Sound, Australia	7.2 km^2 70%	eutrophication from industrial development	IUCN, 1997
'world-wide'	12,000 km^2	unspecified	Japar *et al.,* 2001

TRANSBOUNDARY SIGNIFICANCE OF SEAGRASS BEDS.

Although not fully documented, the large area covered by seagrass along the coastlines of the South China Sea indicates the habitat's significance to the marine environment of the region. Seagrass beds, as an ecotone between coral reefs and mangrove forests, mediate the structural and dynamic components of the neighbouring ecosystems through the control of material, water, and energy flows between them.

Carbon storage. Worldwide, seagrass occupies about 600,000 km^2 of the continental shelf, contributing 12% of the total carbon storage in the ocean (Duarte & Cebrian, 1996). For the South China Sea, the amount of carbon that could be sequestered in seagrass beds is considerable. Seagrasses are an integral component of coastal marine protected areas but are generally not afforded specific protection in most countries.

Importance to biodiversity. Some species of seagrass listed as threatened in the IUCN Red List, including *Halophila johnsonii* and *Phyllospadix* (IUCN, 1997) are not found in the region but, dependent species such as seahorses, green turtles, and some snakes listed as threatened, are. Found in the South China Sea.

Dugongs and seagrass. Dugongs are listed as vulnerable to extinction on the IUCN redlist, are threatened throughout their distributional range, and feed almost exclusively on seagrass. All species of seagrass are eaten and populations are expected to decline because of the gradual loss of seagrass beds.

Dugong photographed in Con Dao, 1998

Dugongs can travel surprisingly long distances - up to 600 km in a few days. Evidence from Kien Giang Province in the South of Viet Nam, and Quang Ninh Province in the North where dugong populations survive close to national boundaries, suggests transboundary migration. Thus the decline is of regional, as well as national significance. It is also known that dugongs migrate from the eastern part of the Gulf of Thailand, west and across the southern part of the South China Sea to Sabah or northerly towards the coast of Vietnam and Hainan, China. It is not known where these mammals go from there. Individuals along the South China Sea coast of Palawan, in the Philippines, migrate from the northern and eastern coasts of the Indonesian Archipelago.

In Vietnam, and neighbouring countries, illegal and destructive fishing techniques in seagrass habitats are serious threats to seagrass ecosystems and in turn to the long-term survival of the dugong. Of more immediate and serious concern in Viet Nam however are the impacts of fishers on local dugong populations, known locally as *Bo bien*, and *Ca cui.* Recent news reports indicate that numbers of dugongs, are declining in Vietnam, as fishers continue to target them, and also catch them accidentally in their nets. It is estimated that there are now only around 10 dugongs remaining in Con Dao Island and between 100 and 300 others around Phu Quoc, Vietnam's largest offshore island.

Fishers use special nets that are also used to catch large stingrays and sharks. The dugong carcass can be very valuable, with meat selling for approximately 30,000/kg Vietnamese Dong (VND). But it is the tusks that are especially valuable, with a large pair (usually from a mature male) selling for up to 10 million VND, or approximately US$650. Two dugongs were caught and butchered for their meat in Vietnam in June 2003 in Ha Tien town, Phu Quoc Island, according to state media. The biggest direct threat to dugongs however is the use of fixed fishing nets in shallow seagrass beds. On Christmas day, 2003, a dead dugong was washed ashore on Phu Quoc Island, after becoming entangled in a gillnet.

Dugong skulls on Phu Quoc Island

The dugong's dependence on seagrass, its low reproductive rate and its gentle slow-moving habits have led scientists to conclude that the dugong is highly prone to extinction. According to WWF Vietnam, new legislation and enforcement, are the immediate priorities, as well as enhanced local awareness among coastal communities, and a collaborative programme of scientific research.

Green Turtles. The migration route of the green turtle (*Chelonia mydas*) is shared by several countries in the region. This prompted the governments of Malaysia and the Philippines to declare the migration route between Malaysia and the Philippines, including the islands along the way, an ASEAN Heritage Site.

Seagrass as breeding, nursery and feeding grounds. Seagrass beds serve as nurseries for many commercially important species of fish, crustaceans, and invertebrates. For example, juveniles of groupers (*Epinephelus spp*.) are abundant in seagrass beds off the east coast of Thailand. Tiger prawns, a very important commercial species for the South China Sea, settle into seagrass from the larval stage and remain until they mature.

Seagrass forms the food of many herbivorous fishes that are fished both commercially and by subsistence fishers, such as rabbitfish and wrasse Seagrass beds on islands in the South China Sea are the spawning grounds for fish and invertebrates that end up in the markets of neighbouring countries (Fortes, 1995). The protection of these seagrass beds is therefore crucial to sustaining the biodiversity and the economy of the region.

Seahorses and seagrass beds.

Seahorses belong to the genus *Hippocampus*, a name derived from the Greek words for horse (*hippos*) and sea monster (*campus*). They are fishes, and together with pipefish, pipefish, and sea-dragons, comprise the family Sygnathidae a family typically associated with seagrass habitats, though some are also associated with coral reefs and mangroves. The 2003 World Conservation Union (IUCN) Red list of Threatened Species lists 9 of the 33 seahorse species worldwide as vulnerable, and one as endangered. The other 23 are listed as data deficient, demonstrating the lack of knowledge of seahorse biology, and the urgent need for more research. Project Seahorse, an international and interdisciplinary marine conservation organization, has indicated that the following 10 seahorse species *Hippocampus barbouri, H. bargibanti, H. comes, H. denise, H. histrix, H. kelloggi, H. kuda, H. mohnikei, H. spinosissimus, and H. trimaculatus,* are found in countries bordering the South China Sea. Many of these are associated with seagrass beds for some or, all of their life cycles.

Hippocampus hystrix

Hippocampus comes

The combination of targeted and incidental catch by fishers, and habitat destruction, has placed seahorse populations at risk. Seahorses are also harvested for use in traditional medicines, aquariums, and as souvenirs. Traditional Chinese medicine is the largest market for seahorses in the region.

USE OF SEAGRASSES AND SEAGRASS RESOURCES.

Seagrass beds are best known for ecological services, such as providing habitat for marine species, preventing erosion, and as a sediment trap. Direct use of seagrass itself in the South China Sea region is limited largely to its use as fertilizer and animal feed in some countries, and as a source of material for handicrafts. In some countries seagrass is also of minor importance as food and medicine.

Direct use for food and medicine. While there is limited use of seagrass as a food source for humans, it is of minor significance in terms of food security. In Indonesia, fishermen sometimes use the rhizome of *Enhalus acoroides* as an emergency food source, while the seeds of this seagrass, are eaten by, local children, as snacks between meals. The seeds are also eaten by, fishermen and others in Thailand, Malaysia, and the Philippines. Recently in the Philippines there has been some experimental use of flour made from these seeds in the manufacture of cookies (see box). Another seagrass, *Halophila ovalis* is sometimes eaten as a vegetable in the Philippines.

People in some areas in Thailand also use dry seagrass leaves and rhizomes for the treatment of diarrhoea. At present, extracts from many species of seagrass are being screened for their pharmaceutical properties. Seahorses derived from seagrass habitats are, an important ingredient in Chinese traditional medicine.

Fertiliser and Animal feed. In some parts of Indonesia, Philippines, and Vietnam, people cut seagrass for feeding to their cows, goats, and other farm animals. Seagrasses are also used as a fertilizer in the Philippines. Coastal inhabitants from Quang Ninh province (bordering China) to Thua Thien-Hue and some districts of Khanh Hoa province, in Vietnam, harvest seagrass (mainly *Zostera, Ruppia, Enhalus, Thalassia* species and other Hydrophytes) for fertiliser and animal feed.

Using seagrass for fertilizer in rice fields in Khanh Hoa province, Viet Nam

Other direct uses. Seagrass leaves can provide a raw material for production of a variety of handicrafts. In the Philippines, leaves of *Enhalus acoroides* are used in various woven products as illustrated in the picture below. Also in the Philippines, *Enhalus acoroides* seeds are used in laboratories in germination tests for environmental toxicity.

Handicraft products made from seagras s, the Philippines

Fishing grounds. Seagrass beds are the primary habitat for a number of commercially important marine resources, and hence are important fishing grounds in all participating countries.

Collecting gastropods from seagrass beds, Viet Nam

In Cambodia, seagrass beds are commonly fished using small scale fishing gear. Juvenile crabs, shrimps and fish are collected and fed in captivity until they reach marketable size.

In the Philippines, *Acetes spp*. (small shrimp) and juvenile rabbit fish, important for food security of local communities, are harvested from seagrass beds as is the seahare, *Dolabella auricularia*, an economically important shell-less, mollusc. The egg mass of this species contains 60% protein and is consumed fresh.

Juvenile fish and invertebrates from seagrass beds are a common by-catch in trawl fisheries

In Indonesia seagrass associated organisms are harvested by, the local communities, during low tide. Fishers go to the reef flat and associated seagrass for juvenile milkfish, sea cucumber, octopus, cuttle fish, shellfish, sea urchins, and seaweeds for food and subsistence income. Some families of gastropods such as Cepraeidae, Olividae, Conidae and Tonnidae are also collected for handicraft manufacture and sale to tourists.

In Malaysia and Thailand, seagrass sites are gleaned for seafood, including fishes, gastropods, bivalves, portunid crabs and sea cucumbers.

Coastal water quality. Seagrasses also contribute significantly to maintaining the quality of the nearby coastal waters as they act as a sediment trap, stabilise the bottom with their roots (rhizomes), and also help reduce wave energy.

Most land-based pollution is discharged into the coastal zone. Seagrasses improve water quality by reducing particle loads and absorbing dissolved nutrients (Hemminga, & Duarte, 2000) and hence are particularly important where raw sewage is directly discharged to the sea.

Oatmeal cookies from Seagrass seed flour.

The seeds of *Enhalus acoroides* (L.f.) Royle are known to the Philippine coastal people to be edible. Its approximate nutritional composition is similar to that of rice. It is eaten raw or boiled and tastes like sweet potato when cooked. Some fishermen believe that it is an aphrodisiac. With the aim of developing seagrass seed as human food in small islands, researchers from the University of the Philippines have developed a 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 and further development is planned. Additional investigations will include the nutritional evaluation of seagrass plant parts to support the protection of the ecosystem.

Economic Value of Seagrass. In a recent assessment of the economic value of the world's ecosystems, seagrass beds, due to their nutrient cycling function, were valued at US$3.8 Trillion, the second highest among all the ecosystem values listed (Preen *et al.,* 1996). Attempts have been made to assign monetary values to goods and services from seagrass beds in many different parts of the world. The values determined to date have been based primarily on the value of the fisheries the beds support.

Some preliminary efforts have been made by some participating countries to value their seagrass beds located in the South China Sea. A value of 2 – 6.3 million baht per year in terms of fishery yield (net benefit) was determined for one seagrass bed in southern Thailand. The economic value of seagrass in China has been estimated at between US$16,640 and US$18,385 per hectare. In Vietnam one village surveyed obtained revenue of US$23,000 in a six-month period from harvesting seagrass for sale to the agricultural sector.

However, the value of seagrass meadows cannot simply be calculated in dollars. As is apparent from the information presented above, seagrass are an essential part of the marine environment. Not only do the plants stabilise substrate, they also form the basis of a complex ecosystem supporting threatened species such as dugong and turtles, economically important fishery species, and epiphytic plankton.

THREATS TO SEAGRASS IN THE SOUTH CHINA SEA

Seagrass beds in the region are subjected to a number of threats from various sources, although the root cause of these threats is the pressure associated with coastal human populations. Increased pollution, coastal development, and destructive fishing methods have all had a significant and negative impact on seagrass beds.

In Vietnam in recent years, the decline of seagrass has been greater than that, which could be expected from natural fluctuations. The seagrass habitat loss is estimated to be 40-50 % over the past 2 decades. The main causes of the losses are anthropogenic activities such as aquaculture, reclamation, and urbanization, which have resulted in sedimentation and land-based pollution. Pressure on seagrass beds stems from the lack of public awareness of their importance.

Past and recent research indicates that the seagrass beds in southern China have been badly degraded. The geographic distribution and the area covered by seagrass have been reduced. The main cause of this degradation is anthropogenic, though typhoons are also considered a significant factor. Most seagrass beds are adjacent to previously under-developed fishing villages, which have undergone rapid increases in population in the last two decades. As people look for income generating possibilities, more and more have turned to exploitation of the marine environment, through aquaculture, and capture fisheries, resulting in the destruction of seagrass beds. Shrimp and fish culture, shellfish collection, explosive fishing methods, electric fishing, poisons, trawling, pollution, and dredging for ports and channels are among the major threats to seagrass in China.

Push netters damage seagrass beds

In Thailand, the destruction and loss of seagrass beds and associated biota is caused by a number of factors, including:

- Fluctuation in freshwater input, causing high salinity variation, due to irrigation and land clearing.
- High sediment load, through destruction of mangroves, which serve as sediment traps, and coastal developments including construction of tourist resorts, ports and roads, channel dredging, and land reclamation.
- Wastewater discharge from shrimp farms and sewage from urban and industrial developments, with associated increase of nutrients, resulting in the accumulation of organic sediments and hypoxia.
- Fishery activities, including scouring of benthos by push nets and trawls, and harvesting of juveniles, and destructive disturbance to the seagrass while gleaning for clams, crabs, and other benthic burrowers at low tide.

In the Philippines, a significant portion of the seagrass habitats is considered to be at high risk of being lost in the next decade. Nationwide, this is due indirectly to rapid economic and human population growth, (with the coastal population expected to double in the next 25-35 years), and weak institutional support. Seagrass loss and decline result from habitat destruction, siltation, sewage, industrial and oil pollution, and fisheries overexploitation. These are prevalent at the proposed Philippine Seagrass demonstration sites.

Siltation resulting from habitat modification poses the single biggest threat to all sites. It is followed by unsustainable fishing practices, boat scour and unsound tourism development. In Ulugan Bay, the lack of transparency of the navy, in relation to their present and proposed activities that impact the seagrass beds, poses a significant problem for management of coastal habitats. A Causal chain analysis of these threats demonstrates their connectivity and points to basic needs, including improved environmental awareness and proper education.

In Cambodia, Illegal fishing by trawlers in seagrass areas for fish, shrimp, and other invertebrates, is a significant cause of damage to seagrass beds. Seaweed farming on the seagrass bed of Kampot province may inhibit the growth of seagrass due to increased competition for nutrients and sunlight. Along the developed coastal areas of Cambodia solid and liquid wastes are discharged directly to the sea, having a detrimental effect on seagrass and other marine habitats. Up-land forests have been cleared for timber and agriculture, and large amounts of sediment are carried by streams and rivers to seagrass beds, causing high turbidity and blocking the penetration of sunlight.

Seagrass uprooted by trawlers

Seagrass in Malaysia is subject to a high degree of resource exploitation and pollution, primarily associated with unplanned and unmanaged urban and industrial development. Land reclamation and expansion programmes cause problems for a number of Malaysian states. There are plans to completely reclaim the stretch of seagrass beds of the Merambong - Tanjung Adang shoals, an important feeding ground for dugongs. Dredging for sand is being carried out in some seagrass beds, leading inevitably to increased sedimentation and smothering of seagrass.

Small-scale destructive fishing in Malaysia with pull nets dislodges the seagrass and reduces seagrass cover. Harvesting of bivalves, and other gleaning and collection for food resources, causes damage, reducing seagrass cover, and retarding the spread and colonisation of seagrass.

In Indonesia, noticeable degradation of seagrass beds in Banten Bay started in 1990 due to reclamation for port and industrial estate. Almost 116 ha or about 26 % of the total area of seagrass beds were lost. Damage to seagrass is also caused by turbulent water induced by fishing boat movement and uprooting of seagrass by beach seines used to catch shrimp and small fishes.

Decline of seagrass beds in Indonesia is also evident at Grenyeng Bay and Bojonegara. The main damage is caused by land reclamation for harbours. Toxic effluents from pulp mills and power plants, and nutrient rich agricultural runoffs pollute seagrass ecosystems. Relatively little is known about the impact of industrial effluent on tropical seagrass meadows.

Response to threats. To date very little has been done in response to the specific threats to seagrass in the South China Sea Region. In addition to the ongoing UNEP/GEF South China Sea Project, two EU-funded projects have recently been completed. One of these investigated the response of seagrass (as well as coral reefs and mangroves) to deforestation-derived siltation at two proposed demonstration sites in the Philippines and at two sites in Thailand. The other attempted to predict the resilience and recovery of disturbed seagrass and mangroves at the same sites in the Philippines and two sites in Vietnam.

Indirectly a number of projects and programs that deal with coastal protection in the region likewise promote the protection and conservation of seagrass habitats. Some work on rehabilitation and transplantation of seagrass beds has been done at Pari Island in Indonesia and Cape Bolinao and Calancan Bay in Philippines. An Executive Order issued by the Mayor of Puerto Galera in the Philippines in January 2001, entitled ***"BantayIsay***" (seagrass watch), is the only legislation in the region, which solely and directly provides for the protection of seagrass beds.

PURPOSE OF THE DEMONSTRATION SITES

As stated in previous sections, the seagrass beds of the South China Sea have been suffering from serious degradation and rapid rates of loss over the recent past. Due to limited available financial resources, it is not possible to fund activities at all seagrass sites under threat. Sites therefore, should be selected with care according to agreed priorities in order to maximize the environmental and socio-economic benefits of the investment.

The primary goal of the demonstration sites within the context of the habitat component of this Project is to "demonstrate" actions that, either of themselves, "reverse" environmental degradation or, will demonstrate methods of reducing degradation trends if adopted and applied at a wider scale. Demonstration sites could be sites where actions are directed towards:

- Maintaining existing biodiversity; or,
- Restoring degraded biodiversity to former levels; or,
- Attempting to remove or reduce the cause, and hence reduce the existing rates of degradation; or,
- Attempting preventive actions that prevent the adoption of unsustainable patterns of use, before they commence.

In the context of this Project, the demonstration site proposals need not only to consider the goals and purposes of the sites themselves but also what is being demonstrated, to whom is it being demonstrated, and how is it being demonstrated.

An initial consideration of **what** is to be demonstrated leads to three types of potential demonstration site:

- *function related sites* which might include existing sites that demonstrate sustainable use for specific purpose;
- *process related sites* which might include existing sites that demonstrate innovative management interventions and/or regimes at the site level;
- *problem related sites*, which might demonstrate new modes of managing specific problems or causes of environmental degradation.

Table 4 The major purpose of the demonstration site proposals prepared to date.

Site	Purpose
Cambodia	Community Based Management
China	
Hepu	Community Based Management
Lian	Integrated Coastal Zone Management
Liusha	Community Based Management
Malaysia	Rehabilitating degraded seagrass ecosystem
Indonesia	Community Based Management of a seagrass sanctuary
Philippines	
Bolinao	Benefits of research Institute involvement in seagrass management
Puerto Galera	Benefits of Govt/Private/academic partnership in seagrass conservation and management
Ulugan Bay	Linkage between seagrass, mangrove, and coral reef habitats -developing partnerships among stakeholders
Thailand	
Pattani	Co-management Government/community
Surat Thani	Creation of public awareness to improve conservation of seagrass beds.
Vietnam	
Bai Bon	Maintaining seagrass beds for biodiversity, particularly endangered species
Thuy Trieu	Community Based Management

Whilst all the participating countries have identified national priority seagrass beds for conservation action and sustainable management the determination of national priority has rarely included a consideration of transboundary, regional or global considerations. Since the present project takes a regional approach to intervention it was necessary to develop a process by which regional as opposed to national priority could be determined in as objective a manner as possible.

DEMONSTRATION SITE SELECTION

The Project has undertaken a transparent, scientific and objective regional procedure to characterise, rank and select demonstration sites based on environmental and socio-economic criteria and indicators discussed and agreed at the regional level. To achieve maximum impact from a limited number of interventions, the Project Steering Committee adopted a three-step regional procedure to prioritise and select demonstration sites.

Full details of this procedure are contained in the reports of the Regional Working Group (RWG-SG) meetings (UNEP, 2002a; 2002b; 2003a; in press) but it may be outlined as follows:

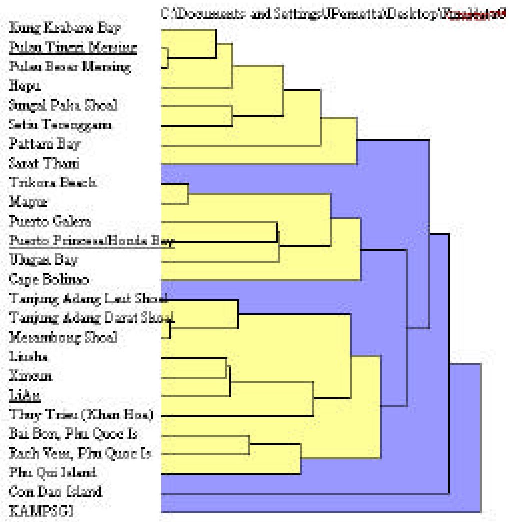
- Step 1. A cluster analysis was conducted to review the similarities and differences of all proposed sites, using data and information assembled at the national level that described the physical and biological characteristics of the systems under consideration. This analysis was used to group sites of high degrees of similarity within which priority could be determined.

- Step 2. The Regional Working Group on Seagrass developed a set of criteria and indicators with an associated numerical scoring system, encompassing environmental and socio-economic characteristics;

- Step 3. The proposed sites were scored according to the agreed system and ranked within each cluster. Rank order was considered to represent regional priority.

The initial task involved the assembly of data and information at the national level in order to characterise individual seagrass sites. The Regional Working Group on Seagrass discussed and agreed on the listing of parameters required to characterise the sites and data were assembled for a total of 41 sites around the South China Sea. These data were verified and the final selection of parameters was based on a compromise between the ideal data set and what was actually available for the sites concerned. A total of twenty-six sites were ultimately considered to have sufficient of the required data, and these were then compared using the Clustan6 software to identify similarities and differences between all sites. The resulting dendrogram is presented in Figure 1 and it can be seen that sites fall into three major clusters with two outlying sites.

Figure 1 Cluster analysis of twenty -six potential seagrass demonstration sites bordering the South China Sea.



Ranking Potential Demonstration Sites. At the same time the regional working group developed a set of criteria and indicators to be used in the ranking process. These criteria and indicators were grouped into two sets, the first being an environmental, and biological set, including indicators such as the area, numbers of seagrass, penaeid, gastropod, sea urchin, endangered and migratory species, and percentage cover. A scoring system was devised such that the full range of observed values was divided into a number of categories assigned different scores with increasing scores representing higher priorities or significance.

A similar table of social and economic criteria was developed encompassing indicators covering aspects of participation and management.

These socio-economic indicators include threats, national significance, financial considerations and level of local stakeholder involvement, reversibility of threats, national priority, level of stakeholder direct involvement in management, potential for co-financing.

Final rank scores for an individual site were determined using a combination of the environmental and socio-economic criteria and indicators in a 3:2 ratio. The combined scores and final ranking are presented in Table 5.

Table 5 Final scores and ranking for selection of demonstration sites.

Site Name	Environment score	Socio-economic score	Total score
First Cluster			
Hepu	49	94	143
Pattani Bay	50	81	131
Sarat Thani	48	67	115
Pulau Tinggi Mersing	33	52	85
Pulau Besar Mersing	29	52	81
Setiu Terengganu	25	30	55
Sungal Paka Shoal	17	30	47
Second cluster			
Cape Bolinao	66	82	148
Trikora Beach	60	76	136
Puerto Galera	50	73	123
Ulugan Bay	43	85	128
Third Cluster			
Bai Bon, Phu Quoc Is	57	83	140
Thuy Trieu (Khan Hoa)	50	70	120
LiAn	46	78	124
Liusha	45	66	111
Merambong Shoal	43	60	103
Tanjung Adang Laut Shoal	42	60	102
Xincun	40	64	104
Tanjung Adang Darat Shoal	40	60	100
Outlier			
KAMPSG1	39	43	82

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MEMBERS OF THE REGIONAL WORKING GROUP ON SEAGRASS

Dr. Chittima Aryuthaka, Department of Marine Science, Faculty of Fisheries, Kasetsart University, Bangkhen, Bangkok 10900, Thailand, Tel: (66 2) 579 7610; 561 3469, Fax: (66 2) 561 4287, E-mail: ffiscta@ku.ac.th

Mr. Kamarruddin bin Ibrahim, Department of Fisheries, Turtle and Marine Ecosystem Center (TUMEC) 23050 Rantau Abang, Dungun, Terengganu, Malaysia, Tel: (609) 845 8169; 845 3169 (direct), Mobile: (60) 13 9812500, Fax: (609) 845 8017, E-mail: kdin55@yahoo.com

Dr. Miguel Fortes, IOC Regional Secretariat for Western Pacific (WESTPAC), 196 Phaholyothin Rd., Chatujak, Bangkok 10900, Thailand, Tel: (66 2) 561 5118, Mobile: (66) 1 926 4721, Fax: (66 2) 561 5119, E-mail: westpac@samart.co.th; mdfortes138@yahoo.com

Mr. Xiaoping Huang, South China Sea Institute of Oceanology, Chinese Academy of Sciences, 164 West Xingang Road, Guangzhou 510301, Guangdong Province, China, Tel: (86 20) 8902 3210, Mobile: (86) 13 6004 84979, Fax: (86 20) 8445 1672,E-mail: xphuang@scsio.ac.cn

Mr. Tri Edi Kuriandewa, Puslit Oseanografi, LIPI, Pasir Putih 1, Ancol Timur, Jakarta, Indonesia, Tel: (62 21) 6471 3850; 316 9288, Mobile: (62) 81 5808 6468, Fax: (62 21) 6471 1948, E-mail: indo-seagrass@centrin.net.id

Dr. Hutomo Malikusworo, Indonesian Institute of Science, Pasir Putih 1, Ancol Timur, Jakarta 14330, Indonesia, Tel: (62 21) 6471 3850, Mobile: (62) 815 952 0650, Fax: (62 21) 6471 1948, E-mail: indo-seagrass@centrin.net.id

Dr. Marco Nemesio E. Montaño, Marine Science Institute, University of the Philippines, Diliman, Quezon City 1101, Philippines, Tel: (632) 927 2693; 922 3942, Fax: (632) 924 7678, Email: coke@upmsi.ph; montano.n@upmsi.ph

Dr. Suvaluck Satumanatpan, Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Nakorn Pathom 73170, Thailand, Tel: (66 2) 441 5000 ext. 182, Mobile: (66) 1 700 7512, Fax: (66 2) 441 9509-10, E-mail: ensnt@mahidol.ac.th

Mr. Kim Sour, Department of Fisheries, Ministry of Agriculture, Forestry, and Fisheries, 186 Norodom Boulevard, PO Box 582, Phnom Penh, Cambodia, Tel: (855 23) 210 565, Mobile: (855) 12 942 640, Fax: (855 23) 216 829, E-mail: *sourkim@hotmail.com ; catfish@camnet.com.kh*

Dr. Nguyen Van Tien, Haiphong Institute of Oceanology, 246 Da Nang Street, Hai Phong City, Vietnam, Tel: (84 31) 760 599, 761 523, Fax: (84 31) 761 521, E-mail: nvtien@hio.ac.vn

UNEP/GEF South China Sea Project Co-ordinating Unit
United Nations Building
Rajadamnern Nok
Bangkok 10200
Thailand

Department of Fisheries
Ministry of Agriculture, Forestry and Fisheries
186 Norodom Boulevard
P.O. Box 582
Phnom Penh
Cambodia

South China Sea Institute of Oceanology
Chinese Academy of Sciences
164 West Xingang Road
Guangzhou 510301
Guangdong Province
People's Republic of China

Puslit OSEANOGRAFI, LIPI
Pasir Patih 1
Ancol Timur
Jakarta,
Indonesia

Turtle and Marine Ecosystem Center (TUMEC)
Department of Fisheries Malaysia
23050 Rantau Abang
Dungun
Terengganu
Malaysia

Marine Science Institute
University of the Philippines
Diliman
Quezon City 1101
Philippines

Faculty of Environment and Resource Studies
Mahidol University
Salaya Campus
Nakorn Pathom 73170
Thailand

Haiphong Institute of Oceanology
246 Da nang Street
Hai Phong City
Viet Nam