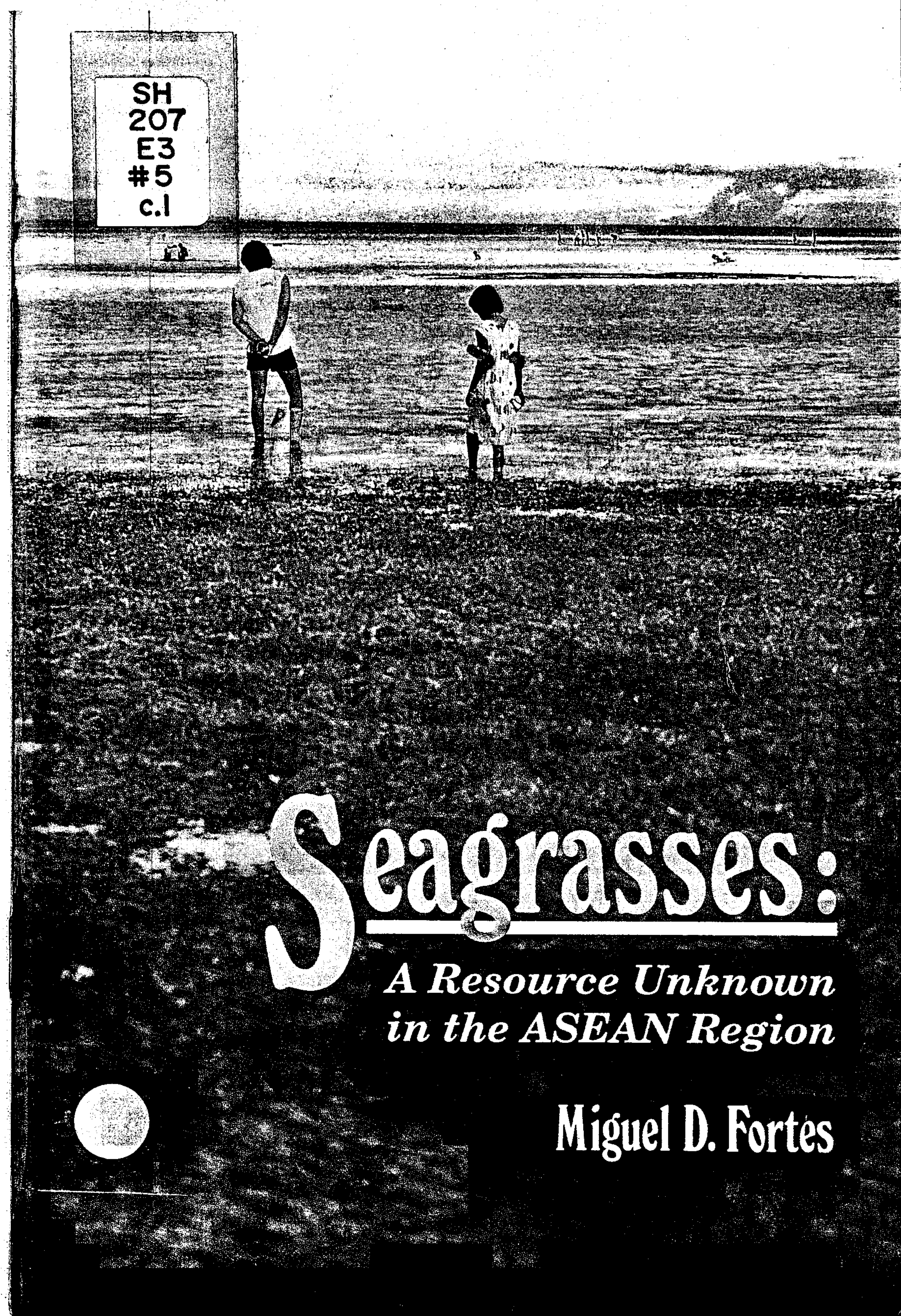

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A Resource Unknown in the ASEAN Region

Miguel D. Fortes

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**Association of Southeast Asian Nations/
United States Coastal Resources Management Project
Education Series 6**

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Published by the International Center for Living Aquatic Resources Management on behalf of the Association of Southeast Asian Nations/United States Coastal Resources Management Project

Printed in Manila, Philippines.

Fortes, M.D. 1989. Seagrasses: a resource unknown in the ASEAN region. ICLARM Education Series 5, 46 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Cover photo: During low tide, shallow seagrass beds are often exposed and walked on by people looking for edible marine life. Dumaguete, Philippines.

Color photos are by A.T. White, unless otherwise noted.

ISSN 0116-5720
ISBN 971-1022-51-6

Contents

Acknowledgements

I wish to thank Dr. Chua Thia-Eng (ICLARM) for the encouragement in writing this book, Drs. Alan T. White (ICLARM) and Mark S. Fonseca (US Department of Commerce, National Oceanic and Atmospheric Administration) for the insights and critical review of the manuscript, and my students for having been my source of inspiration. Gratitude likewise goes to the United Nations Environment Programme (Nairobi) and the ASEAN-Australia Coastal Living Resources Project for giving me the rare opportunity to be in direct contact with the seagrass scientists of the region.

Foreword

The coastal waters of Southeast Asian countries have some of the world's richest ecosystems characterized by extensive coral reefs and dense mangrove forests. Blessed with warm tropical climate and high rainfall, these waters are further enriched with nutrients from land which enable them to support a wide diversity of marine life. Because economic benefits could be derived from them, the coastal zones in these countries teem with human settlements. Over 70% of the population in the region live in coastal areas which have been recently characterized by high-level resource exploitation. This situation became apparent between the 1960s and 1970s when socioeconomic pressures were increasing. Large-scale destruction of the region's valuable resources has caused serious degradation of the environment, thus affecting the economic life of the coastal inhabitants. This lamentable situation is mainly the result of ineffective or poor management of the coastal resources.

It is essential to consider coastal resources as valuable assets that should be utilized on a sustainable basis. Unisectoral overuse of some resources has caused grave problems. Indiscriminate logging and mining in upland areas might have brought large economic benefits to companies undertaking these activities and, to a certain extent, increased government revenues, but could prove detrimental to lowland activities such as fisheries, aquaculture and coastal-tourism dependent industries. Similarly, unregulated fishing efforts and the use of destructive fishing methods, such as mechanized push-nets and dynamiting, have caused serious destruction of fish habitats and reduction of fish stocks. Indiscriminate cutting of mangroves for aquaculture, fuel wood, timber and the like have brought temporary gains in fish production, fuel wood and timber supply but losses in nursery areas of commercially important fish and shrimp, coastal erosion and land accretion.

The coastal zones of most nations in ASEAN are subjected to increasing population and economic pressures manifested by a variety of coastal activities, notably, fishing, coastal aquaculture, waste disposal, salt-making, tin mining, oil drilling, tanker traffic, rural construction and industrialization. This situation is aggravated by the expanding economic activities attempting to uplift the standard of living of coastal people, the majority of which live below the official poverty line.

Some ASEAN nations have formulated regulatory measures for their coastal resources management (CRM) such as the issuance of permits to fishing, logging, mangrove harvesting, etc. However, most of these measures have not proven effective due partly to enforcement failure and largely to lack of support for the communities concerned.

Experiences in CRM in developed nations suggest the need for an integrated, interdisciplinary and multisectoral approach in developing management plans providing a course of action usable for daily management of the coastal areas.

The ASEAN-US CRMP arose from the existing CRM problems. Its goal is to increase existing capabilities within ASEAN nations for developing and implementing CRM strategies. The project, which is funded by USAID and executed by ICLARM in cooperation with ASEAN institutions, attempts to attain its goals through these activities:

- Analyzing, documenting and disseminating information on trends in coastal resources development;
- Increasing awareness of the importance of CRM policies and identifying, and where possible, strengthening existing management capabilities;
- Providing technical solutions to coastal resources use conflicts; and
- Promoting institutional arrangements that bring multisectoral planning to coastal resources development.

One of the information activities of CRMP is to produce or to assist cooperating agencies in producing educational materials on coastal environments which are targetted for general audiences. In the form of books, booklets or leaflets, these materials primarily purport to create public awareness on the importance of rational exploitation of living coastal resources, environmental conservation and integrated CRM and planning.

Intended as a primer, **Seagrasses: a resource unknown in the ASEAN region** provides insights useful towards a better understanding of the seagrass ecosystem, its frailties and strengths in the face of acute coastal environment stresses. The book also identifies some common regional constraints that hamper full utilization of the seagrass ecosystem, as well as proposes a plan of action towards sustainable development of this ecosystem's resources.

Chua Thia-Eng
Project Coordinator
ASEAN/US Coastal Resources
Management Project

Introduction

Paradoxically, the greatest contribution of seagrass ecosystem to the chains of life...is death.[58]

What are Seagrasses?

Seagrasses are the only group of submerged flowering plants in the marine environment. They thrive in shallow-water coastal habitats. Like the terrestrial grasses from which they originated, they possess erect leafy shoots and creeping stems or rhizomes (Fig. 1) which are effective for propagation. In contrast to other submerged marine plants (e.g., seaweeds or algae), seagrasses flower, develop fruit and produce seeds. They also have true roots and an internal system for the transport of gases and nutrients.

Why are Seagrasses Important?

There are only about 50 species of seagrasses in the world, but this number is not proportional to their abundance, as well as to their economic and ecological importance. Usually existing in enormous quantities and often forming large, dense meadows in tropical areas, seagrasses perform a wide spectrum of biological and physical functions. The traditional and contemporary applications of mainly nontropical seagrass ecosystems,[56] summarized below, are also applicable in the ASEAN region. It should be noted, however, that the second category of uses is only anticipated (Fonseca, pers. comm.).

Traditional uses:
1. woven into baskets
2. burned for salt, soda and warmth
3. stuffing for mattresses
4. roof thatch
5. upholstery and packing material
6. compost for fertilizer

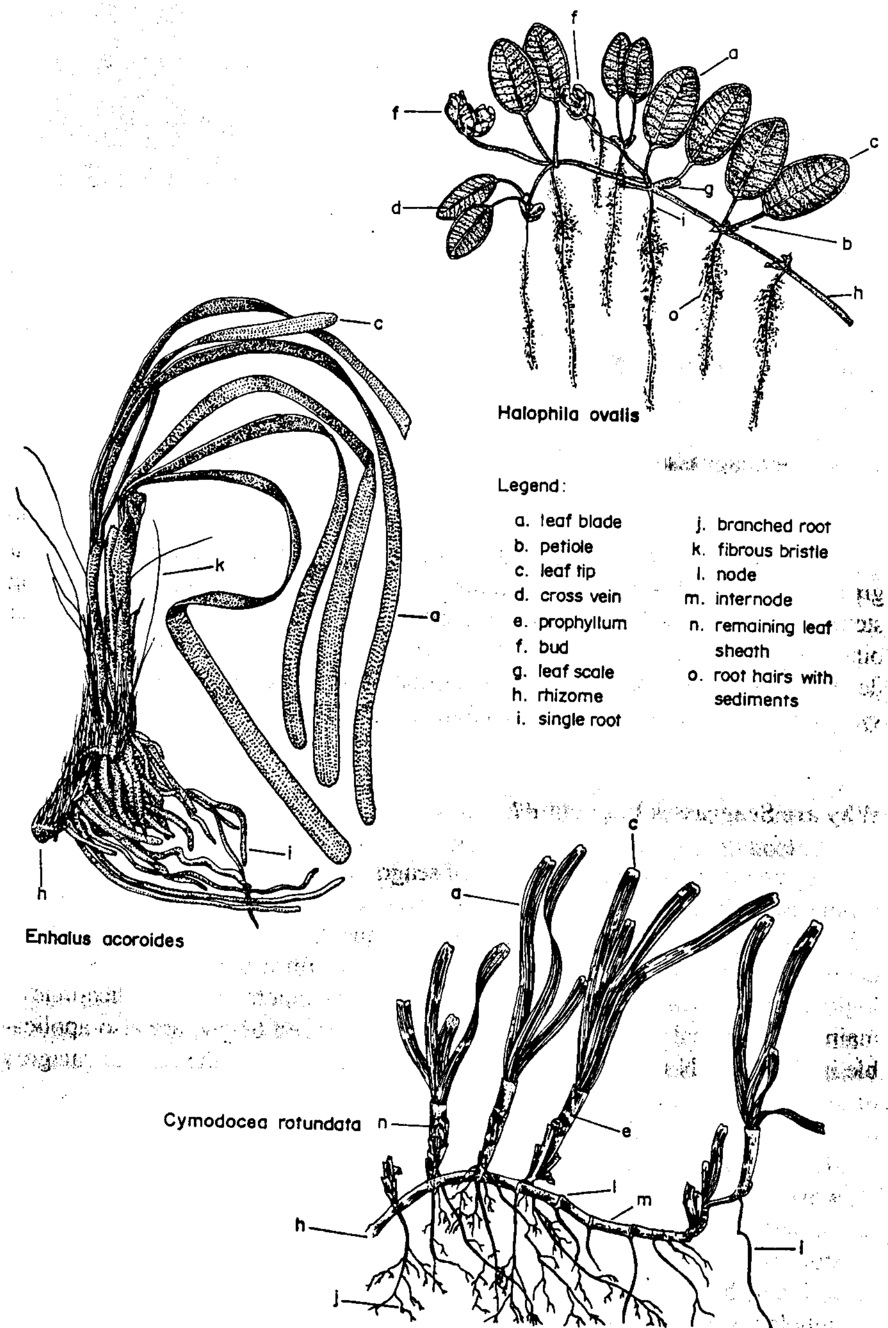

Fig. 1. Seagrass general morphology.

7. insulation for sound and temperature
8. fiber substitute in making nitrocellulose
9. piles to build dikes
10. cigars and children's toys

Contemporary uses:
1. sewage filters
2. coastal stabilizers
3. paper manufacture
4. source of useful chemicals
5. fertilizer and fodder
6. food and medicine for man

Seagrasses have been known to serve as food for turtles since the time of Darwin. However, it was Petersen[65] who first evaluated the contribution of the eelgrass to coastal fisheries. Seagrass beds serve as nursery, shelter and food for fish, invertebrates[42] and dugong or sea cow.[47] They also produce sediments and interact with coral reefs and mangroves in reducing wave energy and regulating water flow.[87]

Seagrass habitats can be viewed at two levels:[86]

- As a community - where a seagrass bed is a structural framework with plant and animal interrelationships; and
- As an ecosystem - where these interrelationships are viewed as discrete processes, controlled by the interactive effects of both biological and physico-chemical factors.

Seagrass biomass is a primary factor in determining the organization of marine macrofaunal communities,[82] as it controls the habitat complexity, species diversity and abundance of associated invertebrates.[39] It is this ecological role of seagrasses that links them directly to the improvement in the livelihood of many coastal inhabitants of the ASEAN region.

The well documented catastrophic effects of the "wasting disease" of eelgrass beds along the coasts of the North Atlantic in the early 1930s attest to the fundamental ecological importance of a seagrass community. With its demise, not only were the structure and composition of the associated fauna altered,[81] but regimes in salinity, temperature and nutrient load in the affected waters were changed.[72] Fisheries production in the area declined and fisheries management strategies had to be reoriented. This ecological disaster, coupled with the advent of scuba diving in the early 1970s, triggered renewed interest in seagrasses in most parts of the world.

Where are Seagrasses Found in the ASEAN Region?

Seagrasses, together with mangroves and coral reefs, have a center of generic richness and diversity in the Indo-West Pacific. Table 1, which gives the number of seagrass species from 27 countries, reflects this. It also shows the similarities in the numbers of species among the countries in the region. Province A of Fig. 2 shows the 15 countries lying in the area of highest number of seagrass species. This biogeographic area exhibits characteristic patterns of climate, habitat conditions and perhaps, productivity. The expansive nature of the seagrass system has developed extensive faunal communication and material exchange with other habitats (Fonseca, pers. comm.). For example, Province A holds about 30% of the coral reefs of the world.[46] Seagrasses are closely associated with the corals and yet they cover much more area on many fringing reefs than do the corals.[53] Vast seagrass meadows are often found between coral reefs and the coastal fringes that support most of the region's mangroves. In this transition zone, characterized by shallow, soft, sandy-muddy bottom, the plants have colonized all environmentally suitable areas.

Table 1. Seagrass provinces in the Indo-Pacific region.[a]

	No. of species	CCs		No. of species	CCs
Province A			Province C		
Philippines	16	-	Japan	7	11.1
Malaysia-Singapore	11	88.0			
Indonesia	12	84.6	Province D		
New Caledonia	10	83.3	Fiji	4	40.0
Papua New Guinea	13	88.9	Tonga	3	28.6
Queensland	12	78.3			
Micronesia	10	76.2	Province E		
Vietnam	8	73.7	Korea	1	0
Ryukyu Island	6	58.8			
Thailand	5	50.0	Province F		
Borneo	4	53.3	New Zealand	2	0
India	7	66.7			
Sri Lanka	6	58.8	Province G		
Burma	2	30.8	Western Australia	17	46.2
Hongkong	4	28.6	New South Wales	5	12.5
			South Australia	10	9.5
Province B			Tasmania-Victoria	6	11.8
Kampuchea	1	16.7			

[a]The 27 countries of the Indo-West Pacific grouped by cluster analysis into major provinces showing the number of seagrass species recorded for each country and Sorensen's similarity index (%CCs) with the Philippine flora.[34]

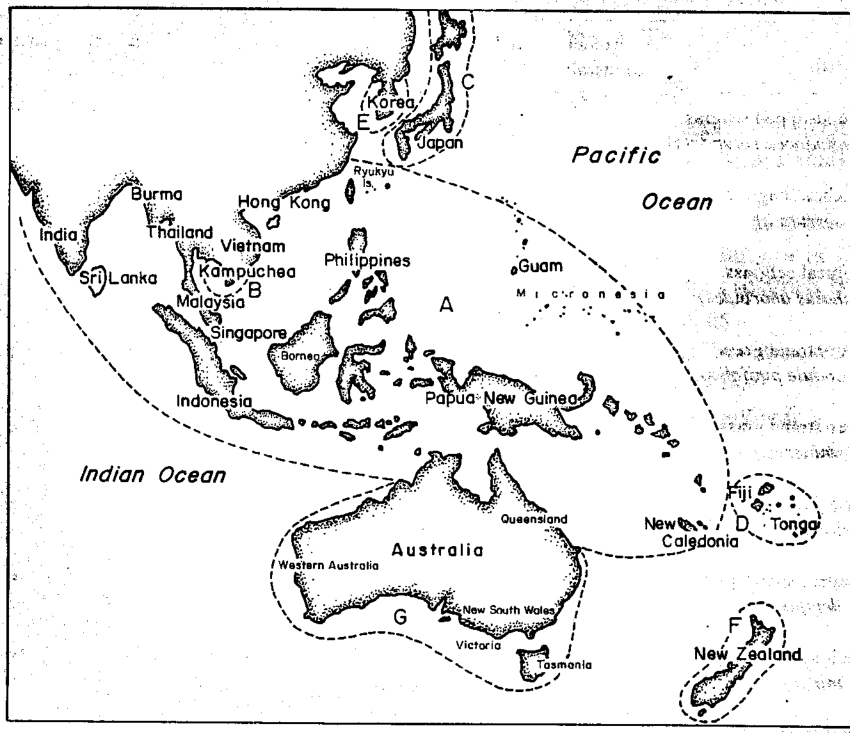

Fig. 2. The seven seagrass provinces in the Indo-West Pacific region (A through G) delineated by cluster analysis.[34]

The most authoritative account on the distribution of seagrasses (including the ASEAN region) was made by Den Hartog.[20] In the Philippines, Meñez and co-workers[58] published a comprehensive account on the local flora, and Fortes[31] produced the latest complete work on the taxonomy and ecology of Philippine seagrasses, adding three new taxa to the list. With the 16 taxa now recorded, the country has the second highest number of seagrass species in the world [Western Australia has 17 (Crossland, pers. comm.)].

The seagrass species report for the ASEAN region (Table 2) is summarized thus:

- Brunei Darussalam - Four species reported. These are the tropical eelgrass, spoon-grass, curled-based spoon-grass and dugong grass. The exposure and substrate condition of this country's coast appear unfavorable for seagrass growth.[15]
- Indonesia - Twelve species known. Seagrass beds were sighted at the Flores Strait, Jakarta Bay and Seribu Island. Dense beds of tropical

Table 2. Seagrass species reported for the ASEAN region.[20,31]

	Brunei Darussalam	Indonesia	Malaysia	Philippines	Singapore	Thailand
Round-tipped seagrass *(Cymodocea rotundata)*		x	x	x	x	x
Toothed seagrass *(C. serrulata)*		x	x	x	x	x
Tropical eelgrass *(Enhalus acoroides)*	x	x	x	x	x	x
Fiber-strand grass *(Halodule pinifolia)*		x		x	x	x
Fiber-strand grass *(H. uninervis)*		x		x	x	x
Estuarine spoon-grass *(Halophila beccarii)*			x	x	x	x
Veinless spoon-grass *(H. decipiens)*		x		x		x
Small spoon-grass *(H. minor)*		x	x	x	x	x
Small spoon-grass *(H. minor)*, a new variety				x		
Spoon-grass *(H. ovalis)*	x	x	x	x	x	x
Curled-base spoon-grass *(H. spinulosa)*	x	x	x	x	x	
Halophila sp.				x		
Ruppia maritima				x		
Syringe grass *(Syringodium isoetifolium)*		x	x	x	x	
Dugong grass *(Thalassia hemprichii)*	x	x	x	x	x	x
Woody seagrass *(Thalassodendron ciliatum)*		x		x		
Total	4	12	9	16	11	10

seagrass are associated with estuaries in Benten Bay and Riau Archipelago. Thinner beds of dugong grass, tropical eelgrass, fiber-strand grass, round-tipped seagrass and syringe grass are common among the coral islands in eastern Indonesia.[45]

- Malaysia - Nine species known. There are recent records of tropical eelgrass in Cape Rachado and Port Dickson, spoon-grass in a shallow bay in Kuah and a new variety of spoon-grass in Tanjung Rhu.[67]
- Philippines - Sixteen species are variably distributed in Bolinao Bay in the north, Palawan, Cuyo Islands, and the Cebu-Bohol-Siquijor area at the center and Zamboanga and Davao in the south. Other seagrass beds are scattered throughout the coastal expanse of the islands.
- Singapore - Eleven species are distributed in Pulau Semaku, Pulau Tekong, Terembu Jarat, Labrador Beach and Cyrene Reefs.[41]
- Thailand - Ten species reported. Dugong grass was sighted in the Andaman Sea together with spoon-grass, tropical eelgrass, round-tipped grass and toothed seagrass.[70]

The apparent discontinuity in the distribution of seagrasses in the region reflects more the lack of integrated and systematically collected data than their true pattern of distribution.

Status of Seagrass Beds as a Resource

Reasons for Neglect

Three reasons may be cited why in Southeast Asia, seagrasses are the least studied among the living resources of the coastal environment.

First, people perhaps think that seagrasses are not as important as coral reefs or mangroves.

Second, the main interests of marine and fisheries biologists working on seagrass habitats have been focused on the algae, animals or fish that either live there or are associated with the beds. It was only in the mid-1960s that the shallow benthic coastal fringe was recognized by oceanographers as a discrete ecosystem, forming a part of the larger ocean systems.[68]

Third, research and development priorities in ASEAN countries are usually directed towards other resources with immediate impact and which are easily measured in terms of monetary value.

Uses of Seagrass Beds

Seagrass beds have so far been valued for their role as fish nursery areas and as a source of food and nutrients for coastal ecosystems, but their economic importance to the region has not yet been quantified. Trying to determine the monetary value of an obviously rich and biologically diverse resource may indeed be a waste of time (Fonseca, pers. comm.), for this will only further delay its development. Policymakers should, therefore, give higher priority to research and development of the seagrass resource, despite the lack of documentation of its economic value, so that it can be used more productively for the service of humans and the environment.

Seagrass beds are nursery areas for young fish and foraging grounds for food fish (e.g., snapper and emperor fish), dugong, turtles and wading birds.[78] In remote parts of Indonesia, dugong and sea turtles are closely associated with seagrass beds.[46] Around Pari Island, Indonesia, 78 species of fish, including some valuable food fish like the white-dotted rabbitfish, Japanese filefish, cardinal fish and mojarra, were found in large numbers on seagrass beds.[44] In the trawl catches from Bolinao and Ulugan Bay in the Philippines, shrimp in the mysis stage were the most abundant (53%) of all the juvenile stages of fish, shrimp and other invertebrates collected.[32]

At these sites, seagrass beds yielded faunal densities at least three times higher than those yielded by nonseagrass areas. It is no wonder that in many coastal towns in the region, the collecting areas for fish and shrimp fry are in close association with either mangroves or seagrass beds. There is a significant coincidence between the shrimp exploitation areas in the East Asian seas[46] and the known occurrence of seagrasses in the region (see Fig. 3). Although there is a high coincidence between areas in Indonesia where dugong[17] and turtles[49] occur and where seagrasses are reported, dugong has become an endangered species in the region.

Seagrasses have other uses in the ASEAN region:

- Thailand - At the Phuket Marine Biological Center, dugong reared in captivity are fed spoon-grass.[13]
- Indonesia - At the Ancol Oceanarium in Jakarta, the animals are fed syringe grass at a rate of 50 kg wet wt/day.[45] In some places, the fruits of tropical eelgrass are eaten by people.
- Philippines - Fruits of tropical eelgrass are eaten raw, cooked or boiled. Together with the leaves, they are chewed or macerated and the spat mixture placed over wounds to check profuse bleeding.[5]

Tropical eelgrass and dugong grass are potential sources of fodder and fertilizer. Crude protein levels from their leaves reach as high as 23% of dry weight,[30] higher than those of terrestrial forage grasses.[64] Small amounts of six-month old leaf composts, when mixed with garden soil, appear to increase growth, pod fecundity and leaf chlorophyll content in mungbeans.[10] Interestingly, seagrasses have been used as substitute for animal straw and as a fertilizer component in coastal Denmark.[52,88] In Florida, fruit production in both tomatoes and strawberries was highest with mulch from syringe grass.[88] In Germany, the grass has been used in papermaking and as a substitute for cotton in the manufacture of nitrocellulose.[19] In the United States, dried seagrasses are used as fire retardant (Fonseca, pers. comm.).

Resource Potential

In order to evaluate the resource potential of seagrasses, their coverage area must be determined. In the Philippines, mapping of seagrass beds has been done using digitizer analysis of landsat images and low altitude photography, supplemented by intensive ground truth surveys and planimetry. In Bolinao Bay, northern Philippines (Plate 1), seagrass beds (green bands) abound in shallow portions, totalling 37 km^2. This total comprises 14 km^2 of truly dense seagrasses (> 400 shoots/m^2) and 23 km^2 of less dense beds (< 400 shoots/m^2). These are delineated by the dark green bands and light-to-greenish-blue bands, respectively (the dark green bands are more accurate).

At six sites in the country, seagrass surveys yielded a total area of 50.88 km^2 of which 2.56 km^2 covered the specific transect stations. These figures, broken down below, represent only a small percentage of the entire area where seagrasses abound.

Study site	Area (km^2)	
	(station)	(site)
Bolinao Bay	0.768	37.00
Pagbilao Bay	0.075	1.89
Puerto Galera	0.205	1.14
Ulugan Bay	0.479	2.97
Banacon Island	1.016	7.81
Calancan Bay	0.020	0.07
Total	2.563	50.88

Seagrasses can grow as fast as cultivated corn, rice, hayfields or tall grass prairies[68] even without the benefit of fertilizers. Per area production can be higher than phytoplankton production off Peru, one of the most productive areas in the world's oceans.[74] The production rate of tropical eelgrass in the Philippines (1.08 g C/m^2/day)[25] is comparable to those of wheat, corn, rice, hay and other crops.[57,61] Indeed, seagrass ecosystems are one of the richest and most productive, rivaling tropical agriculture, with a productivity apparently approaching the theoretical maximum for natural ecosystems.[57,93] It is this physiological adaptability which remains to be the most probable key to the high diversity of plants and animals in seagrass ecosystems.

The extremely prolific seagrass beds at Bolinao Bay produce at least 18,900 kg C/day (based on 0.9 g C/m^2/day production rate),[31] with the dense beds contributing two-thirds of gross production. This suggests that a square-meter area of the bed produces 8,635 calories daily or roughly 20% of the daily caloric requirement per kilogram of an ordinary individual. Thus, the daily caloric need of an adult individual weighing 70 kg is equivalent to that which is naturally processed daily by seagrass tissues within a 350 m^2 area of the bed. If productivity data for the whole region are considered, seagrass beds as nutrient providers might very well be the most important ecosystem in the marine environment of ASEAN countries.

At the First Southeast Asian Seagrass Resources Research and Management Workshop (SEAGREM 1) held at the University of the Philippines (17-22 January 1989), the sustainable and elimination uses of seagrasses in the region were assessed (see Table 3).

Table 3. Potentially sustainable and elimination uses of seagrasses in the ASEAN region.

	Indonesia	Malaysia	Philippines	Singapore	Thailand
Sustainable uses					
Food/drinks	W1	-	L1	-	-
Fertilizer	X	-	W2	-	X
Fodder	X	-	L1	-	-
Medicine	-	-	X	-	-
Construction	-	-	1	-	-
Toys	-	-	X	-	-
Footwear	-	-	X	-	-
Fish	W2	-	W3	-	LW
Crustacean	W1	-	W2	-	LW
Shellfish	L1	-	W3	-	LW
Use of other fauna	L1	-	W3	-	-
Recreation	X	-	L1	-	L1
Education	L1	W2	L1	-	L1
Preservation	L3	X	L1	L1	L1
Shoreline protection	X	-	W3	-	X
Elimination uses					
Aquaculture					
fish	X	-	L1	-	L1
crabs	X	-	L1	-	L1
shrimp	X	-	L1	-	LW
Ricefields	-	-	X	-	LW
Sugarcane	-	-	X	-	-
Palm plantation	-	-	X	-	-
Other agriculture	-	X	X	-	-
Pasture	-	-	X	-	-
Solar salt	-	-	L	-	-
Industrial development	X	L	W2	W3	-
Urban development	X	W	L2	W3	L1
Ports	X	-	W3	W3	-
Airports	X	-	L1	L3	L1
Recreation	X	W	W2	W2	L2
Mining	X	X	L3	-	L1
Waste disposal	-	W	W2	-	-
Flood runoff engineering	-	-	L2	-	-
Boat traffice	L	-	W2	W2	L1

Legend:

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

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

Monetary Value

Monetary values have been assigned to seagrass beds, based primarily on the fisheries they support. At Cairns North Queensland, fisheries supported by seagrass beds produce about A$700,000 (US$540,000) annually.[16] In Puget Sound, Washington, a 0.4 ha of eelgrass bed has a value of approximately US$412,325 annually, estimated from the amount of energy derived from the system as well as the nutrition it generated for oyster culture,[40] commercial and sport fisheries, sport charters and waterfowl. Judging from the revenues derived from seagrass fisheries alone, the economic value of seagrass beds in the ASEAN region could be substantial.

Biology and Ecology of Seagrasses: A Case Study in the Philippines

Biological and Ecological Bases for Management

Although very little is known about the biology and ecology of seagrasses in the ASEAN region, there is a practical need to incorporate all available scientific findings into their management. The coastal conditions are generally favorable to seagrass growth and development, as reflected partly in the high diversity of the seagrass flora. This diversity results directly from the varied responses of the species to particular environmental conditions along the coasts. The period of flowering and fruiting and adaptations to different habitat conditions which control distribution, abundance and production, are important considerations for deriving maximum economic benefits from these plant resources.

Flowering, Fruiting and Adaptation

Not much information is available on the time of flowering, fruiting and seed dispersal of seagrasses. However, ecological studies on some Philippine species may reveal similar patterns in closely related species present in the region.

Tropical eelgrass starts to flower in late April and continues until late August. This process is directly related to progressions in daylength, temperature and rainfall. On the other hand, growth, biomass and production of the species are inversely related to such progressions. Fruiting occurs at the latter half of the flowering period, with a peak in July when daylength and rainfall have their highest values.

In central Philippines, tropical eelgrass seeds germinate in August.[31] During the following months up to December, there are longer and more frequent low tides by day (day-minus tides), such that the plants are exposed to air and sun for a maximum period. Thus, rapid growth and biomass increase take place during these months, peaking in October.

Survival strategies of seagrasses consist of morphological and physiological or behavioral adaptations. The general form of a seagrass is itself the most remarkable feature which adapts the plant to its environment. Flexible, grasslike leaves and an extensive root and rhizome system enable it to withstand the impact of waves, tides and shifting sediments in the shallow coastal habitat. Smaller-leafed varieties are more abundant in areas frequently subjected to higher temperatures.[55]

Morphological variation is evident in four species:

- Spoon-grass - Five foliar forms or ecomorphs are exhibited which vary markedly in size and shape of the leaves.
- Tropical eelgrass - Form adaptation is observable in two types of populations: short, thin-leafed plants comprising sparser populations of shallow open reefs; and long, thick-leafed plants comprising denser populations of deeper protected coves.
- Toothed seagrass - The two morphological variants are differentiated by the presence or absence of the long, leaf-bearing branches, a feature controlled by water movement,[48] sediment type and depth of submergence,[54] or by crowding and competition (Poiner, pers. comm.).
- Fiber-strand grass - The three modifications in the leaf form (i.e., narrow-, wide- and intermediate-leaf varieties) appear to be a specific response to the nutrient and depth of the local environment.

Physiological or behavioral adaptations are exhibited by tropical eelgrass, toothed seagrass, fiber-strand grass and small spoon-grass. Each of these species has two varieties: one with a narrow range of tolerance (stenobiontic) to daylength, tides, rainfall and temperature, and the other with a wide range of tolerance (eurybiontic) to these factors. The stenobiontic variety of tropical eelgrasses is seasonal and is narrow, thin-leafed and sparse, usually occupying the intertidal portions of open reefs. The eurybiontic variety, on the other hand, occurs throughout the year, and is wide and thick-leafed. This variety occupies subtidal habitats and protected embayments in dense populations.

During summer, anoxia or very low oxygen levels characterize shallow intertidal habitats due to minimal water and wind movements, as well as elevated ambient water temperatures, which reach an annual maximum. Under this condition, seagrasses are overgrown by thick mats of blue-green or green algae with associated high turnover and oxygen demand. Consequently, the sediment becomes highly reducing and acidic, indicated by the smell of hydrogen sulfide gas when the plants are uprooted. However, even under such conditions, dugong grass, tropical eelgrass and round-tipped seagrass grow and develop due to an apparent adaptive metabolic strategy (aerobic root microzones) which enables them to colonize successfully such shallow-water marine habitats that have excluded most other plant groups. It is in these habitats where the highest levels in crude protein from the seagrasses have been recorded.[30]

Seagrass Density, Biomass and Production

Density in local seagrasses is generally bimodal, with highest values in summer (March-May) and in the wet season (July-November).[31] Highest biomass coincides with the latter period. Highest biomass value (61.7 g organic matter/m^2) was obtained in tropical eelgrass having a net production of 1.4 g C/m^2/day, and an average leaf growth rate of 1.1 cm/day. The recorded mean total turnover time in tropical eelgrass is 115 days, which means that the whole leaf biomass is produced every 16 weeks, forming two to four leaf crops annually. For management purposes, these data suggest a year-round supply of organic matter by the seagrass. Total dry leaf biomass of selected seagrass communities in the Philippines ranged from 8 to 132 g/m^2.[73]

Few ecological data on seagrasses from Indonesia are available. At Pari Island, mean leaf growth rates of 0.8 cm/day for old leaves of tropical eelgrass and 0.6 cm/day for young leaves were observed.[7] Mean leaf production rate was 3.37 g/m^2/day, with a biomass of 96.11 g/m^2 and 3.48% per day mean turnover rate. Dugong grass showed mean growth rates of 0.24 cm/day for new leaves and 0.2 cm/day for old leaves. Mean leaf production was 1.8 g/m^2/day, with a 3.74% per day turnover rate.[8]

Unit area measures of biomass and leaf growth are a function not only of plant size but of shoot density. All these measures of the plant community are mediated by environmental conditions. In the Philippines, shoot density in seagrasses is directly associated with water temperature.[31] Dugong grass has the widest range of temperature tolerance. In terms of biomass, however, daylength appears to be the most influential factor, while the number of extreme low tides during daytime creates a negative effect on seagrass abundance, biomass, growth rate and production. Generally, salinity and rainfall are ineffective in directly controlling the above features in local seagrasses.[31]

Fig. 4 shows the set of recurring biological events or phenological indices, plotted against the gradients in the environmental factors at Puerto Galera. It is probable that daylength, temperature and rainfall, interacting independently or in combination, make up the critical and primary environmental cues that control the reproductive periodicity, abundance and production of tropical eelgrass in the area. Identifying the influence of these cues would be useful in providing a solid ecological basis for seagrass management in tropical coastal areas.

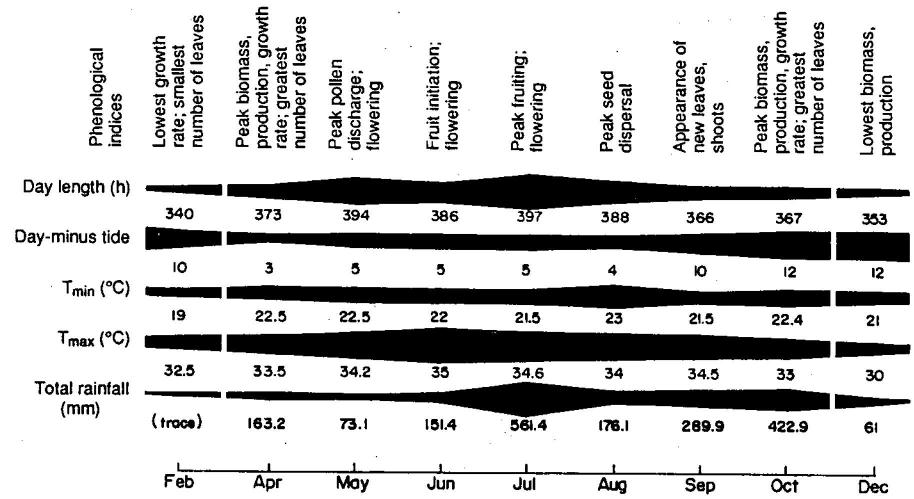

Fig. 4. Sets of recurring biological events (phenological indices) of the tropical eelgrass plotted against environmental gradients.[31] (Note: Day length and total rainfall figures are based on Philippine Atmospheric, Geophysical and Astronomical Services Administration records.)

Seagrasses in Philippine Coastal Food Chains

Under the conditions in Southeast Asia, the trophic hierarchy involved in the processing and transport of organic detritus from seagrass ecosystems to consumers appear rather intricate. Actual observations and simple experiments indicate that detritivores, herbivores, carnivores and omnivores are all well-represented. The primary source of organic material comes from production by the seagrasses themselves. This is followed by contributions from the associated epiphytes and macrobenthic algae,[29,31] and phytoplankton and terrestrial plants. The organic materials are utilized by the fauna either through grazing of the living plant tissues or consumption of the detritus.

Fig. 5 shows the generalized relationships among the major components identified from seagrass systems in the Philippines. The food and energy pathways are simplified, and the different trophic levels are represented only by species more commonly encountered in the beds. Fig. 5 also incorporates the functions and probable uses of the plants as these relate directly to past and ongoing activities on seagrass ecosystems in the country. Our understanding of seagrass ecology and their relationships is based largely on qualitative data. Many linkages within the trophic structure remain vague, unquantified or largely unknown.

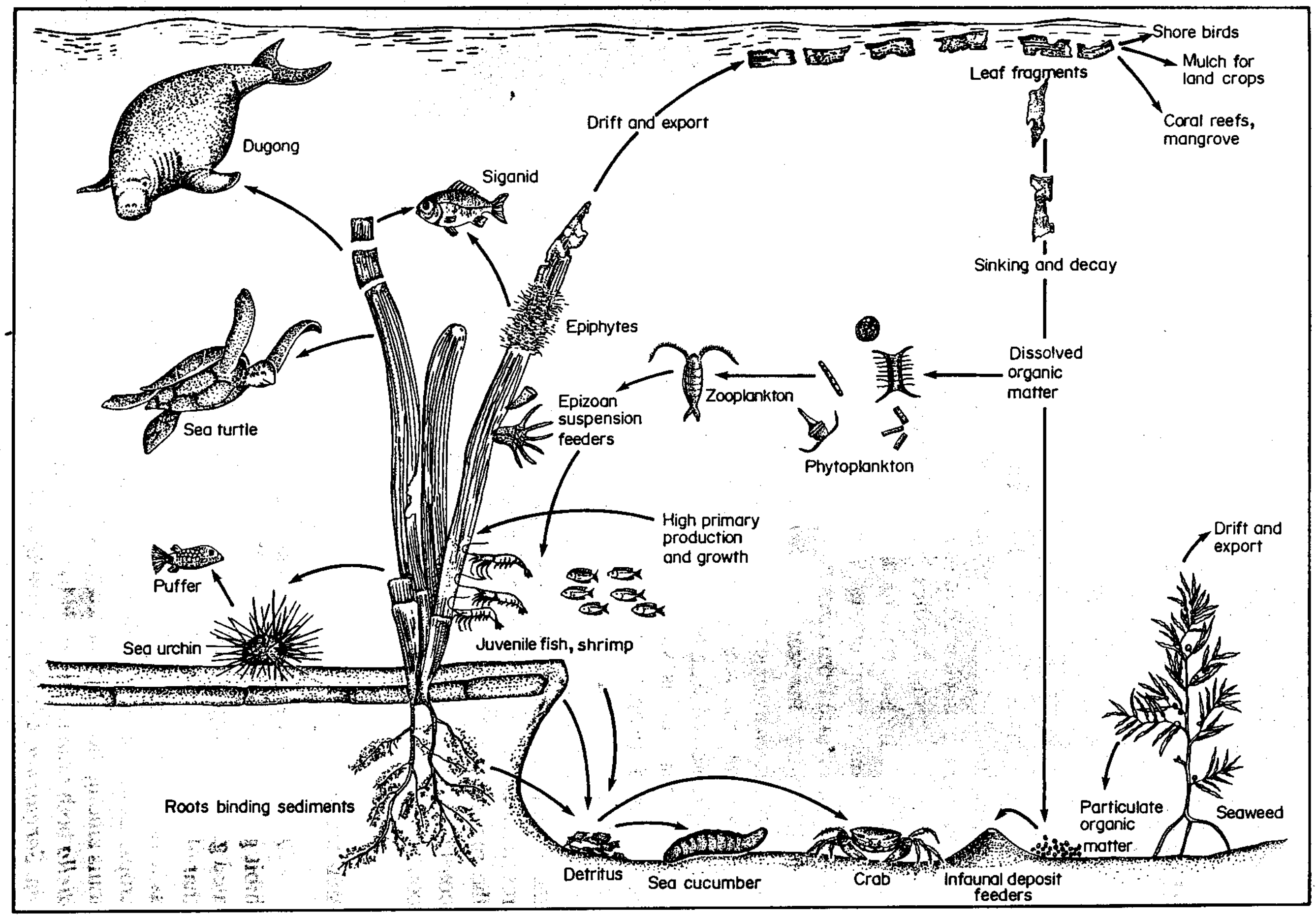

Fig. 5. Food chain in Philippine seagrass ecosystems showing the potential uses of the plants and their functions in the coastal environment.

Resource Components of a Seagrass Ecosystem

Among the diverse plant and animal life associated with Southeast Asian seagrasses, many are commercially important. Studies have identified epiphytes (organisms attached to plant surfaces), epibenthos (those on sediment surfaces), infauna (those living buried in sediments), nekton (those that live in or above the plant canopy), birds, reptiles and mammals, as components of the seagrass ecosystem. Fish and shrimp are probably the most important among these groups, although some coastal villages in the region derive a significant portion of their sustenance from other components of the grass beds.

At low tide, the reef flats are constantly being picked over by coastal families who gather a major portion of their daily nutrition from the seagrass and seaweed flats, and patches of coral.[53] The harvest from this "gleaning," an activity predicated on a healthy grass bed, includes edible seagrass fruits, algae, molluscs, sea urchins, sea cucumbers, crustaceans, eels and small fish. In Pamilacan Island (Bohol, southern Philippines), gleaning of seagrass beds contributed 7.1 t/km^2 or 40% of the total reef yield in the area.[76] In addition, shell industries have developed from the gleaning activities in many shore villages in the Philippines. Unfortunately, the actual contribution of this practice to coastal revenues and nutrition in the country is unknown. In the following portion, only the major components of seagrass beds which contribute substantially to the coastal economy of the countries in the region, as well as those related to conservation will be emphasized.

Benthic Seaweeds

Although there are few seaweed species in the ASEAN region, these exhibit great seasonal abundance. In summer, for instance, biomass of the associated green sea vegetables, such as the pond seaweed and the sea lettuce, exceeds that of the seagrasses themselves. Seaweeds are harvested from the beds as food, as a rich source of chemicals for many industries and as mulch fertilizer for crops. *Caulerpa*, a high-priced seaweed, grows profusely in muddy pond bottoms among the common seagrasses, and the agar-bearing *Gracilaria* and *Gelidiella* both dominate in beds found on open reefs in the Philippines and Indonesia. *Sargassum*, a brown seaweed used as a feedstuff and fertilizer, as well as a

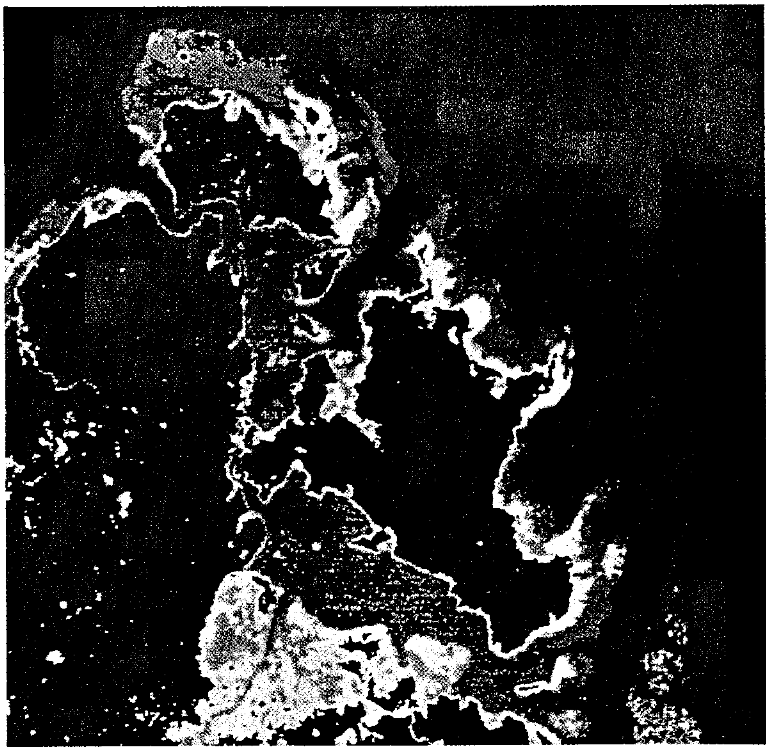

Plate 1. Landsat image of the coast of Bolinao Bay, digitally analyzed to show the seagrass areas (green bands). (Photo by J.W. McManus.)

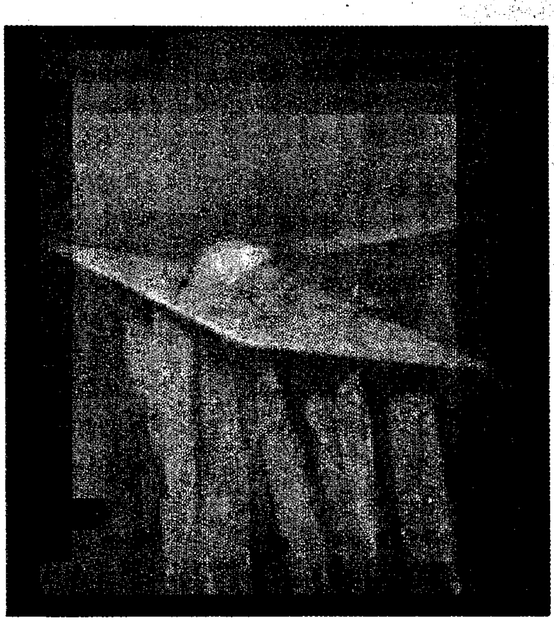

Plate 2. Artificial seagrass units. (Photo by M.D. Fortes.)

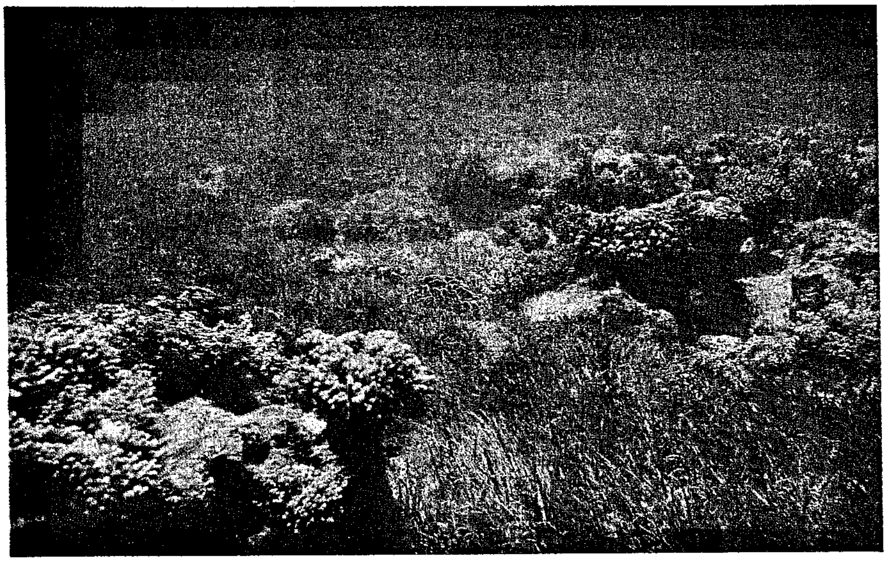

Plate 3. Seagrass beds often occupy areas immediately adjacent or within coral reefs as seen here on the reef flat at Pamilacan Island, Philippines.

Plate 4. A common jellyfish uses a seagrass bed as habitat on a Siquijor Island (Philippines) reef flat.

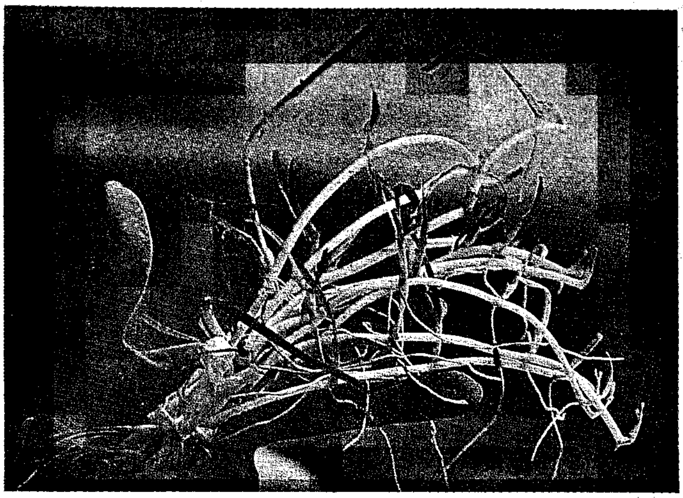

Plate 5. Sprigs (young shoots) of the toothed seagrass (*Cymodocea serrulata*) ready for planting (Calancan Bay, Marinduque, Philippines). (Photo by M.D. Fortes.)

Plate 6. Some wide reef seagrass flats are very productive of invertebrate animals collected by shoreline residents, Pamilacan Island, Philippines.

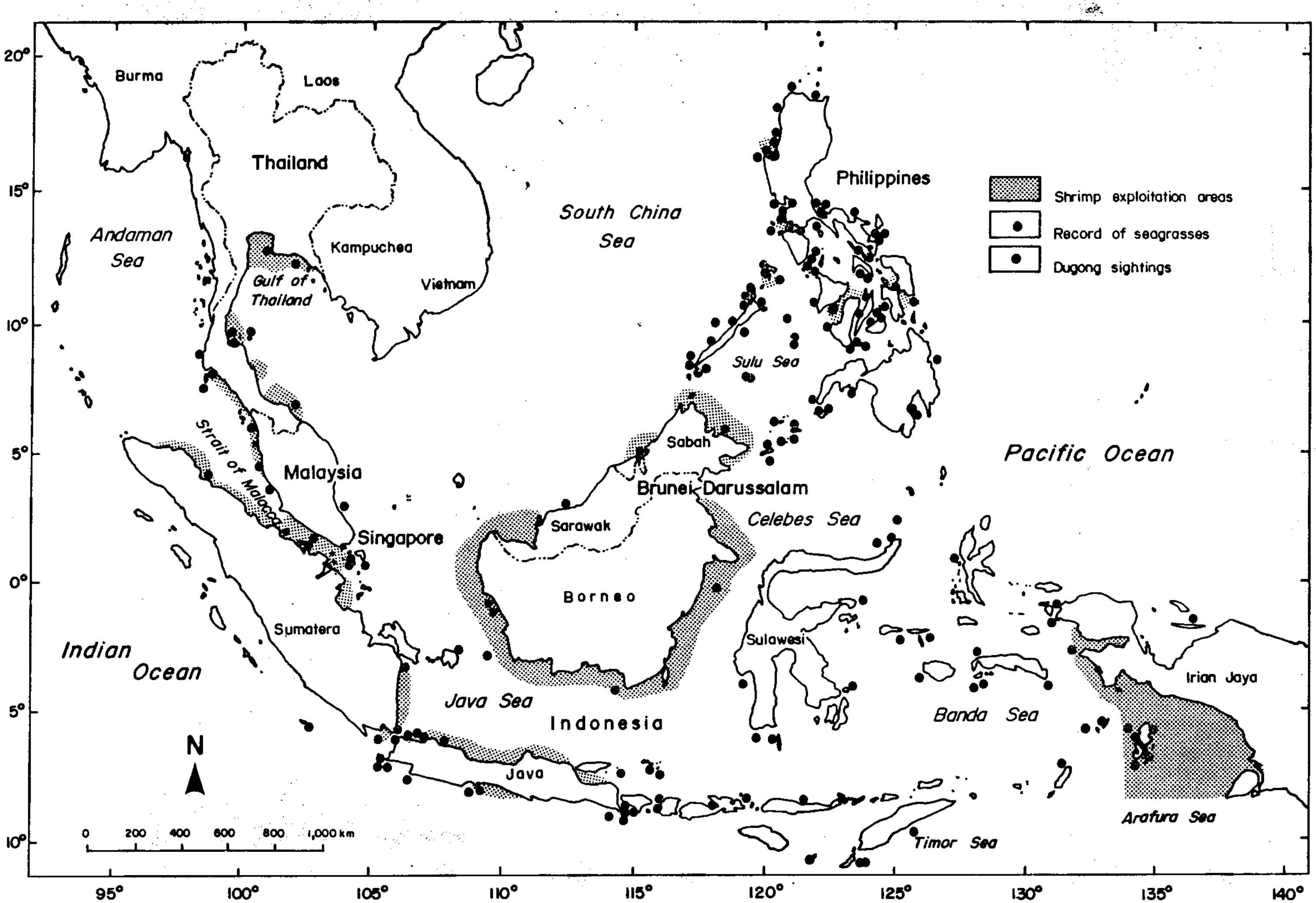

Fig. 3. Seagrass distribution in the ASEAN region.[90] (Note its close association with shrimp exploitation areas and dugong sightings in the Philippines and Indonesia.)

source of alginates, commonly colonizes bare rocky patches within reefs dominated by seagrasses. In Calatagan, north-central Philippines, a successful farm of the red seaweed, *Euchema*, is located in a lagoon dominated by tropical eelgrass and dugong grass.

It is interesting to note that the three seaweed-producing countries in the ASEAN region (Philippines, Indonesia and Thailand) produce at least 100,000 t of dried raw seaweeds worth about US$30 million annually.[71] The main species harvested are farmed *Euchema* and wild *Gracilaria, Caulerpa* and *Sargassum.* In the Philippines alone, the average yearly net income per hectare from farmed *Caulerpa* is ₱29,750 (US$1,430), and from *Euchema,* ₱20,675 (US$994).

Epibenthic Invertebrates

Most of the large and conspicuous epibenthic animals in seagrass beds are commercially important in their adult or juvenile stages. Hence, common in ASEAN countries are shrimp, sea cucumbers, sea urchins, crabs, scallops, mussels and snails. The ASEAN countries had the following shrimp production, some of which may be attributed to healthy seagrass beds: Thailand, 174,000 t (the highest); Indonesia, 130,000 t; Malaysia, 76,500 t; Philippines, 55,700 t; and Brunei Darussalam, 500 t.[26] In 1977 alone, the shrimp fisheries industry in Malaysia produced 50,000 t, contributing 12% of the total marine catch.[14] The high-priced banana shrimp feeds mainly on other crustaceans and on macrophytes; The latter comprises the highest percentage (64.4%) in the gut contents of nursery populations of the species. Of the 1,491 taxa trawled from seagrass beds, fish accounted for 28.6%, while shrimp, 71.4%.[33] At three sites in northern Philippines, eight commercial shrimp species have been collected at an average of 171 individuals/2-minute trawl/month.[32] Tropical eelgrasses were found to support the greatest number of shrimp followed by the round-tipped seagrass, dugong grass, syringe grass, spoon-grass and fiber-strand grass.

A survey of edible molluscs harvested by local fishermen in Bais Bay, southern Philippines, included 27 species of bivalves and univalves.[4] These were found in areas with either pure or mixed growth of the tropical eelgrass and the spoon-grass. In two seagrass areas in the bay, they estimated 69 kg/ha of molluscs. About 1,000-2,000 kg of the eggs of sea hare, valued at US$226-456, are gathered from the bay yearly.[2] The eggs are a marketable item, and interestingly, this mollusc has been a potential and low-cost source of anti-cancer agents.[66] All the other invertebrates observed in seagrass beds in Central Visayas, Philippines, are listed in Table 4.

Table 4. Invertebrates in seagrass beds in Central Visayas, Philippines.[24]

Molluscs

1. *Sepia* sp. (cuttlefish)
2. *Octopus* (octupus, two species)
3. *Strombus urceus* (fighting conch)
4. *Anadara* spp. (ark shell)
5. *Voluta vespertillo* (volute shell)
6. *Dolabella auricularia* (sea hare)
7. *Conus literatus* (lettered cone)
8. *C. leopardus* (leopard cone)
9. *C. generalis* (general cone)
10. *C. magus* (magus cone)
11. *Paphia semirugata* (Venus shell)
12. *Glaucoma rugosa*
13. *Pistris capsoides*
14. *Circe scripta* (Venus clam)
15. *Sanguinolaria togata* (sunset shell)
16. *Vasticardium flavum* (cockles)
17. *Atrina* sp. (penshell)
18. *Solen* sp. (jackknife)
19. *Pitar citrina*
20. *Trochus* sp. (top shell)
21. *Lambis* spp. (spider conch)
22. *Hippopus hippopus* (giant clam)

Sea urchins

1. *Tripneustes gratilla*
2. *Toxopneustes chlorocanthus*
3. *Salmacis spaeroides*
4. *Prinocidaris baculosa*
5. *Diadema setosum* (long-spined black urchin)
6. *Echinometra oblongata* (spiny urchin)

Sea cucumbers

1. *Actinopyga mauritana* (surf redfish)
2. *A. ecinites* (deepwater redfish)
3. *Bohadschia marmorata* (chalky fish)
4. *B. argus* (leopardfish)
5. *Holothuria leucospilota*
6. *Halodemia edulis* (pinkfish or red sea cucumber)
7. *H. hilla*
8. *H. pulla*
9. *Halodemia atra* (lollyfish)
10. *H. aculeata*
11. *H. scraba* (sandfish)
12. *H. fuscacinerea*
13. *H. imitans*
14. *H. impatiens*
15. *Stichopus variegatus*
16. *Thelonota ananas* (prickly fish)

Crustaceans

1. *Portunus trituberculatus* (blue crab)
2. *Matuta* sp. (armed crab)
3. *Thalamita* sp. (swimming crab)

In Indonesia, 66 species of benthic fauna comprised 26 crustaceans, 25 polychaetes, 10 molluscs and three echinoderms.[6]

In many coastal parts of the region, people gather invertebrates such as sea urchins, sea cucumbers and other echinoderms from seagrass beds, mainly to supplement their food and income. Production of sea cucumber in Indonesia was 207 t in 1977, although exports amounted to 266 t in the same year.[78] In Cebu, southern Philippines, smaller species of sea cucumbers are sold fresh, while the larger ones are usually sold in dried form called *trepang*.[84] Certain medicinal (e.g., anti-hemorrhagic,[22] fungicidal[9] and, possibly, anti-tumor) properties are attributed to some of the echinoderm species.[36] About 108 kg/month of the species, valued at US$133 annually, are collected in the seagrass beds of Bais Bay.[24]

Crabs in marketable size and young sea cucumbers and sea urchins are frequently caught by trawling in Philippine seagrass beds. These echinoderms are a delicacy in many parts of coastal Asia. The gonads of the urchins, gathered during the full moon, are eaten raw with vinegar, and are known as the "caviar" of the tropical Third World. Scallops and mussels are more common in muddy protected coves where seagrasses and mangroves abound. Economically useful molluscs, sea cucumbers and sea stars are common in algal and seagrass beds in Indonesia.[78]

Fish

For the ASEAN region, the usefulness of a seagrass ecosystem can best be appreciated in the context of the fisheries it supports and the income it generates. Its seagrasses are often associated with coral reefs, an ecosystem which could supply about 12% of the world's fish catch.[59] Because developing countries provide more than half of the world's catch,[59] and most coral reefs are in developing countries, then coral reefs and their associated seagrass beds are capable of supplying more than a fifth of the fish catch in those developing countries.[35,53,86,87,89,91]

In the Philippines, at least 9% of reported fish catches are coral reef fishes.[60] A total of 1,384 individuals and 55 species from 25 families have been identified from five seagrass sites in the Philippines.[89] All members of these families have economic values mostly as food and aquarium specimens. Important fish families found in the beds occurred in the following order of decreasing abundance: cardinal fish > gobies > rabbitfish. Rabbitfish or siganids, the most important commercial seagrass fish in many Asian countries, made up 1.23% of the total marine fisheries production in this country. Adults of about 52 species from 31 families were reported from seagrass beds in Central Philippines.[24] These include popular food fishes such as the carangids, sardines, snappers and parrotfish.

In an ongoing project, the author used artificial seagrass units (ASU), shown in Plate 2, to monitor the recruitment patterns and changes in diversity of fish communities, and to investigate their potential to improve biological production in a degraded coastal area in Bolinao Bay. It is quite interesting that the number of fishes so far identified from the ASU slightly exceeded that found in natural seagrass beds in the area. Some 62% of the species are new to the study station, and only 15.4% overlap with the fish fauna of an adjacent seagrass bed. These results implicate the potentials of the ASU as effective fish recruiting devices to improve and rehabilitate depleted areas. A mining firm in the Philippines was allowed to continue operations, with the submission of a rehabilitation plan as a precondition, including large-scale planting of seagrasses and artificial seagrass systems. Similar activities can complement fisheries management or pollution-control schemes in Southeast Asia.[63]

In Burung Island, Indonesia, 78 species of valuable food fish were found in seagrass beds.[44] Even more fishes inhabited denser seagrass vegetation in the area.[43]

In the Philippines, at least 123 fish species representing 51 families have so far been reported from both natural and artificial seagrass beds (Table 5). All the species are known to have economic uses.

Table 5. Fish recorded from seagrass beds in the Philippines.[24,33]

Family	No. of species	Uses	Family	No. of species	Uses
Acanthuridae (sailfin tang)	1	A	Mugiloididae (weaver)	1	F
Apogonidae (cardinalfish)	10	AE	Mullidae (goatfish)	4	F
Atherinidae	1	F	Muraenidae (eel)	1	F
Belonidae (needlefish)	3	F	Nemipteridae (spinecheek)	3	F
Blennidae (blenny)	5	A	Opistognathidae (jawfish)	1	F
Carangidae (jacks)	2	F	Ostraciontidae (cowfish)	1	AF
Centriscidae (shrimpfish)	1	A	Paralichthyidae (flounder)	1	F
Chanidae (milkfish)	1	F	Platycephalidae (flathead)	2	F
Clupeidae (sardine)	1	F	Plotosidae (catfish)	1	F
Eleotridae	3	-	Pomacentridae (damselfish)	7	AF
Elopidae (tarpon)	2	F	Scaridae (parrotfish)	1	F
Engraulidae (anchovy)	1	F	Scatophagidae (scat)	1	AF
Ephippidae (batfish)	2	-	Scorpaenidae (lionfish)	1	A
Fistularidae (flutemouth)	1	F	Serranidae (grouper)	1	AF
Gerridae (mojarra)	1	F	Siganidae (rabbitfish)	7	F
Gobiidae (goby)	1	F	Sillaginidae (northern whiting)	1	F
Haemulidae (sweetlips)	1	F	Soleidae (sole)	1	F
Hemiramphidae (halfbeak)	3	aF	Sphyraenidae (barracuda)	1	F
Kyphosidae (rudderfish)	1	F	Synanceiidae (stonefish)	1	AF
Labridae (wrasse)	7	aF	Syngnathidae (dragonfish)	4	A
Leiognathidae (ponyfish)	2	F	Synodontidae (lizardfish)	2	F
Lethrinidae (emperorfish)	7	F	Theraponidae (perch)	2	F
Lutjanidae (snapper)	8	F	Tetraodontidae (puffer)	4	A
Monacanthidae (Japan filefish)	4	AF	Toxotidae (archerfish)	1	AF
Monodactylidae (moonfish)	1	F	Zanclidae (Moorish idol)	1	A
Mugilidae (mullet)	2	F			

Legend:

A, as bigger aquarium fish
a, as smaller aquarium fish
E, as food for higher level consumer; important in reef ecosystem
F, as food for man

Reptiles and Mammals

Some endangered species of reptiles and mammals are known to occur in seagrass beds in the ASEAN region. Six species of marine turtles are reported from East Asia.[46] Among these species, the green sea turtle, the olive ridley, the loggerhead and the flatback are frequently found in dense seagrass meadows especially of Thailand, Malaysia, Indonesia and the Philippines. The sea turtles at Turtle Islands of the South Sulu Sea graze mostly on brown and green algae,[23] although they probably consume seagrasses, too.[24] The gut contents of two adult hawksbill turtles were found to include some seagrasses.[3]

An endangered species throughout its range, the dugong is confined mainly in the waters of East Asia and Northern Australia.[46] It feeds directly on seagrasses, especially the round-tipped seagrass and dugong (or turtle) grass. In the Aru Islands, south Sulawesi, and in Bangka Island, Indonesia, a thousand dugongs are caught annually in shallow waters and form an important part of the local diet. The actual production status of the mammal in the region is unknown. The coastal fringes of Indonesia, Papua New Guinea and Australia may be considered as important places of refuge for the species.[78]

Threats to Seagrass Resources

Seagrass ecosystems in the ASEAN region are being threatened by both natural and human-induced disturbances. The extent of their effects on the integrity of the resources, though largely unknown, may be viewed partly in the context of the fisheries resources which are depleted beyond the level of biological sustainability. Marine fisheries, which provide more than 60% of the animal protein required in coastal diets, partly depend upon seagrass ecosystem for productivity and maintenance.[11,50,51,62,69,85]

Natural Threats

Natural sources of stress in the region's seagrass ecosystems take the form of cyclones, typhoons, tidal waves, volcanic activity, population and community interactions (grazing and competition), shifting sediments and perhaps, pests and diseases.[35] Rabbitfish, parrotfish, surgeonfish and green turtles are the main vertebrate consumers in ASEAN waters. Dugong and some other turtles feed voraciously on dugong grass and spoon-grass beds.[13]

Among the invertebrates, sea urchins are the main grazers. Univalves and a host of microinvertebrates commonly feed on the leaves of the tropical eelgrass, dugong grass and round-tipped seagrass, often leaving holes that eventually weaken the plants and make them vulnerable to attack by microorganisms. Although the effect of overgrazing is localized, the plants are severely damaged when outbreaks of the grazers occur. In at least three sampling sites in the Philippines, competition with tunicates and blue-green algae was periodically observed under natural conditions, and when water temperature was too high, profuse blooms of small green seaweeds covered the seagrass beds.

Sand movement appears to be an important factor affecting the distribution of seagrass beds. In Semirara Island, central Philippines, the primary cause of the thinning of seagrasses was the movement of sediment towards the seagrass bed. The plants were smothered and displaced into depths beyond their ability to survive.

Mining Activities

Mining is a major activity affecting seagrass habitats in the region. Heavy deposits of spoil materials discharged into nearby seagrass-dominated areas have accumulated as a result of tin mining at Ranong, Phangnga and Phuket Provinces in Thailand,[1,12] nickle mining at Nonoc Island, and copper and coal mining and stockpiling in Malangas in the Philippines.

In the early 1970s, in Calancan Bay, north-central Philippines, a portion of the nearshore seagrass bed was almost completely buried due to the tailings dumped into the bay by a copper mine. Recently, this portion has shown signs of recovery, following the seaward extension of the discharge point. Similar activities by another copper mine in the south have buried long stretches of former coralline fishing grounds.[18]

In Indonesia, mining of tin, bauxite, iron, sand and shells is done very close to mangroves and seagrass beds.[79] The impact of these activities is disproportionately high and extensive, compared with the little attention it is getting. Planners fail to realize the economic potential and ecological functions of the areas, compromising environmental imperatives through unisectoral economic development.

Coastal Aquaculture

Coastal land conversion for shrimp cultivation was the major cause of the loss of coastal vegetation in the ASEAN region. Fortunately, in Singapore in recent years, this activity declined in favor of land-filling for housing and industry. In the last 15 years, about 31 km^2 has been added to the land area of Singapore through this activity. Brackishwater aquaculture in Malaysia, Thailand and the Philippines are being developed at the expense of vast tracts of coastal land and of coastal resources.

Deforestation

Deforestation and resulting runoffs also affect coastal vegetation. At least 60% of the forests of Southeast Asia have now been reduced significantly by logging and slash-and-burn agriculture.[92] Exposed slopes are eroded and the runoff substantially increases the sediment load of coastal waters. Subsequently, seagrasses tend to accumulate silt in their system, depressing the food-making potential of many less-adapted seagrasses to a point of virtual nonrecovery. Such stress favors the growth of only a few species, notably fiber-stand grasses.

For optimum production, seagrasses require good water quality with reduced turbidity, sedimentation and pollution.[46]

Blast Fishing

The most destructive fishing in Southeast Asia is blast fishing. It is a problem in Malaysia,[21] Thailand,[13] Indonesia[78] and the Philippines[37]. In the latter, especially in Bolinao Bay and Tabaco Bay, one- to two-meter diameter holes and depressions caused by blasting characterize the reef flats colonized by seagrasses. These blast holes are erosion-prone and have significantly reduced the fish nursery and spawning grounds in the vicinity, as well as the area of harvestable *Sargassum* beds. In Bolinao, as many as six blasts per hour could be counted from reefs at midday.[53] As a result, the fisheries of shallow-water environments in the Philippines have shown signs of depletion.[77]

Management Considerations

In the last two decades, the increasing industrial and commercial development of the ASEAN region's shorelines has caused too much pressure on its shallow coastal resources. The multifaceted demands of the population for food, transportation, waste disposal, living space, recreation and aesthetic pleasure have also added to this pressure. It is just unfortunate that most of these uses of coastal resources are not compatible and are hard to harmonize.[27]

Extensive sub- and intertidal filling (Singapore), cultivation for agriculture (Philippines) and mining (Thailand and Malaysia) have led to heavy siltation in estuarine areas, burying the seagrasses and causing high water turbidity and lower production of both seagrasses and their associated fauna. It is projected that the high sedimentation rate could reduce the Segara Anakan-Cilacap Lagoon (Indonesia) to only 40% of its present area by the year 2000,[83] and could significantly decrease its fisheries yield. Both natural and man-induced stresses on seagrass resources in East Asia are in need of intensive and sustained investigations.[35]

Since ASEAN countries depend greatly upon their marine resources, the improvement of marine environmental quality is a policy objective common to all of them. Seagrass ecosystems play a critical role in such an objective, as well as in promoting the socioeconomic well-being of the ASEAN region. It is thus imperative that the resource be sustained. Indonesia has already taken steps in this direction; nine of its proposed protected areas have seagrass beds as a major component.[75]

In 1986, the United Nations Development Programme/Food and Agriculture Organization, in cooperation with the United Nations Environment Programme, formulated a project on coastal fisheries rehabilitation through seagrass transplantation for the region. A regional study under the ASEAN-Australia Coastal Living Resources Project is currently being done on the structural and functional aspects of local seagrass resources directed to predictive management of the resource.

Management of fishing practices in seagrass beds has resulted in sustained fisheries harvests in Australia. Postlarvae of *Penaeus esculentus* and *P. semisulcatus* (green tiger prawn), two of the three most important commercial species of prawn in the continent, settle exclusively in seagrass beds.[80] The identification of these nursery grounds has led to the permanent ban on trawling in these large areas of seagrasses. The prawn industry of Australia earns A$60 million annually for its economy.

None of these management practices could be effectively implemented without a knowledge of where the seagrass beds are located. Mapping of seagrass areas for coastal management purposes has been undertaken successfully in some parts of the Philippines. The centers of distribution of seagrass in Bolinao Bay and other study areas have been identified as nurseries of juveniles of some economically important vertebrate and invertebrate species. Data from these activities would facilitate the classification of seagrass beds for coastal zoning and conservation purposes. The availability of photogrammetry makes ground truth surveys more economical and efficient.

For selective protection and use, the seagrass beds of the ASEAN region may be classified into two categories, based on the degree and nature of alteration to which they are subjected, and their general community response to specific habitat conditions. In the Philippines, the above criteria are used to further classify the seagrass areas into *pristine, disturbed, altered* and *emergent*.[31]

Pristine seagrass meadows - Those with high or low diversity of species, bordering land masses far removed from human habitations, disturbed only by the normal intensity of natural elements. These meadows form thick assemblages in shallow waters, usually dominated by tropical eelgrass, dugong grass and round-tipped seagrass. This type of habitat should be preserved and protected from any form of alteration, to be available only for scientific and educational purposes.

Disturbed seagrass meadows - Those of high or low diversity beds occupying bays and coves, near human habitation. These meadows are the constant victims of man's activities, suffering the destructive effects of domestic and industrial effluents. Under more favorable conditions, these areas may yield the highest biomass, protein levels and production rates. They should therefore be the subject of effective control measures.

Altered seagrass meadows - Those areas of low species diversity, permanently and completely changed or converted to other coastal uses like salinas and fish or shrimp ponds. They have the potential to be converted back into seagrass areas through hydrographic engineering, massive transplantation and rehabilitation. This type of seagrass habitat should be the subject of proper multiple use programs.

Emergent seagrass meadows - Those of low species diversity, largely controlled by extreme physico-chemical conditions. *Ruppia maritima* and estuarine spoon-grass, which form extensive growths in almost freshwater or in brackish-water habitats, belong to this category. In some parts, freshwater and terrestrial macrophytes and herbs may coexist with the seagrasses.

Being the cheapest and least expensive option, the unconditional conservation of seagrass systems in the ASEAN region remains as the ideal way to ensure their sustained productivity.[28] However, this western-inspired scheme seems unsuitable in the region, considering its stage of development. Such an approach is still unacceptable in this part of the world, where a significant portion of the population lives below the poverty line, and is largely dependent upon such resources.

It is encouraging to note that national governments have at least begun actively implementing means to conserve and integrate management of marine resources. This is borne out of an awareness of the need to preserve biological diversity and ecological balance. The prevailing perception of these governments is still focused on terrestrial rather than marine concerns.[38] Because environmental policies are not effectively enforced, pollution control and proper use and protection of marine resources are all compromised. In addition, related government projects miserably fail due to misdirected and highly unscientific priorities. As a result, the people have become skeptical of the bureaucracy and now participate less in information exchange among scientists, environmental planners and resource managers. Political commitment and active participation of the public are key factors for success in this endeavor.

In order to effectively manage the seagrass resources, we need a better understanding of their ecology, their frailties and strengths, in the face of a rapidly deteriorating marine environment. In the ASEAN region, this would require:

1. creating public awareness on the qualities and economic value of seagrass systems through the formulation and implementation of national seagrass management programs;
2. monitoring seagrass bed expansion, changes in standing stocks, impacts and disturbances;
3. studying the totally unaffected areas to yield baseline data on the inherent biological and ecological capabilities of the plant populations and communities;
4. incorporating a holistic approach in planning for both scientific research and environmentally related decisions; and
5. developing a program to intensify application of the most practical and proven means of rehabilitating or restoring degraded seagrass habitats.

Among the ASEAN countries, only the Philippines has formulated a National Seagrass Management Program and proposed the creation of a Philippine National Seagrass Committee. This was accomplished through inter-agency cooperation and agreement. Aimed at optimizing the use and conservation of seagrass systems, the program will consist of five major parts, namely, resource mapping and survey, research and development, information dissemination through education, training and publication, environmental management, and policy and legislation.

Conclusion

In the ASEAN region knowledge on the value of a seagrass habitat is beginning to emerge. Unfortunately, this natural resource is still threatened or rapidly destroyed by the impact of multiple demands upon the coastal environment. Perhaps this is inevitable since the region comprises mostly island-countries, such that population centers have developed around estuaries and bays--the very places colonized by seagrasses. Huge tracts of these productive habitats are being dredged, filled, polluted, overexploited, converted to other coastal uses or simply destroyed, all in the name of economic development. These activities have alerted national governments to the need for justifying management of seagrass resources.

Local management practices that deal directly with seagrass resources are few. Nevertheless, some pilot management projects have shown that with proper implementation, improvement in fish yields and quality of the environment can be achieved. More importantly, changes in attitude have occurred, reflecting in part, a greater awareness of the vital function and intrinsic values of the seagrass ecosystem among some communities and policymakers alike.

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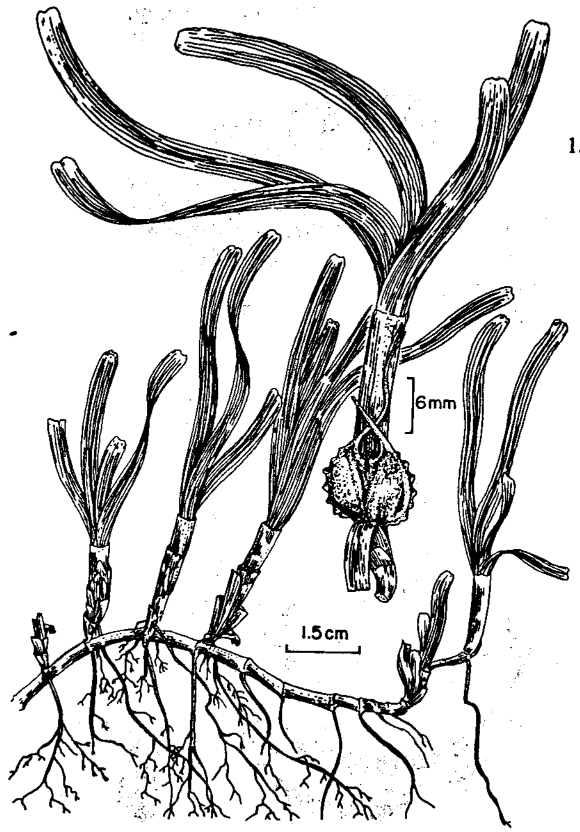
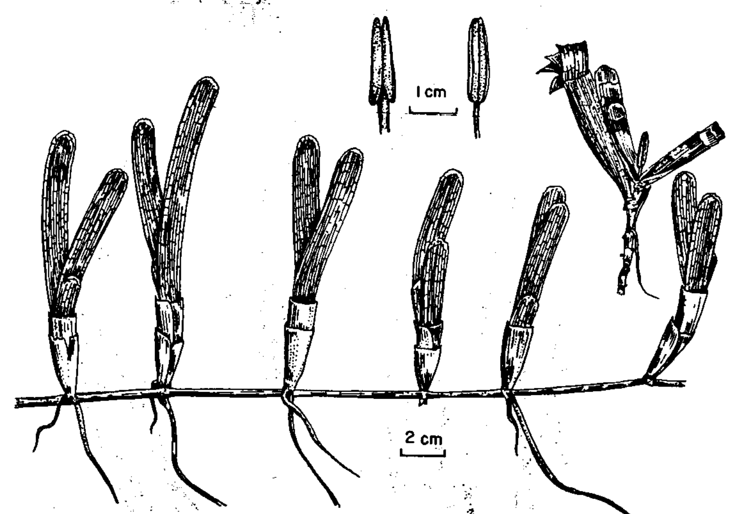
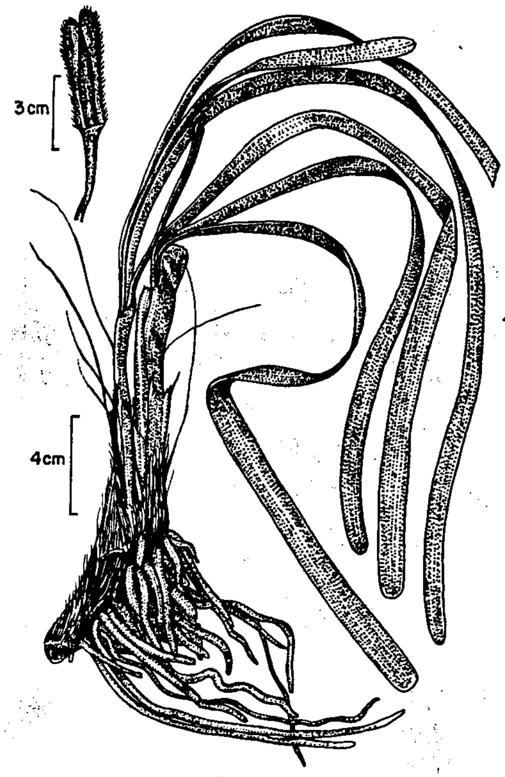
Appendix 1. Atlas of seagrasses in the ASEAN region.



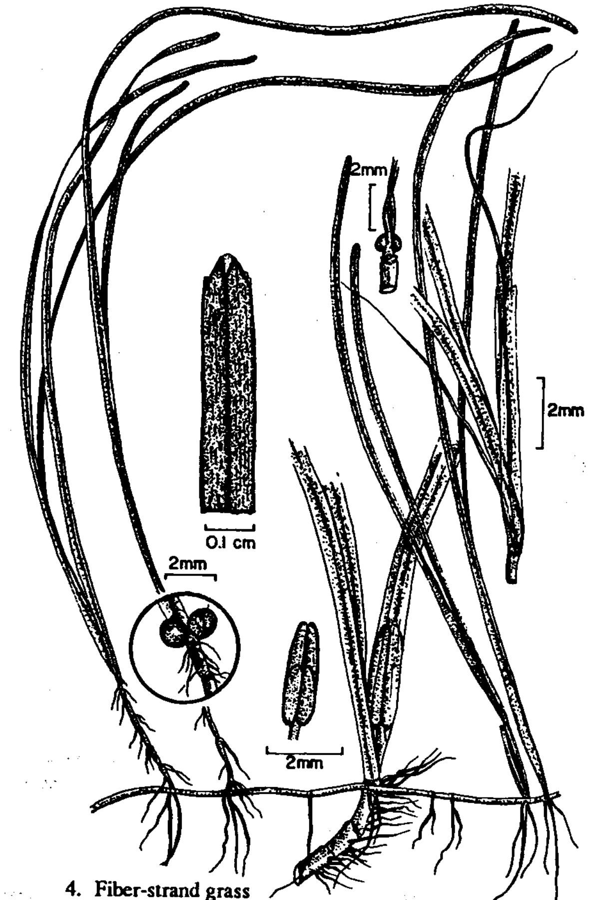
1. Round-tipped seagrass
(*Cymodocea rotundata*)



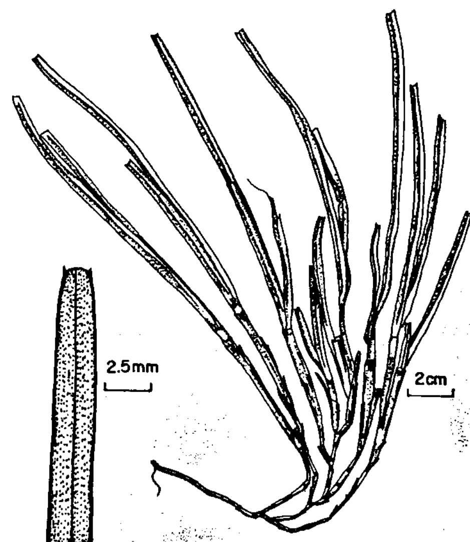
2. Toothed seagrass
(*Cymodocea serrulata*)

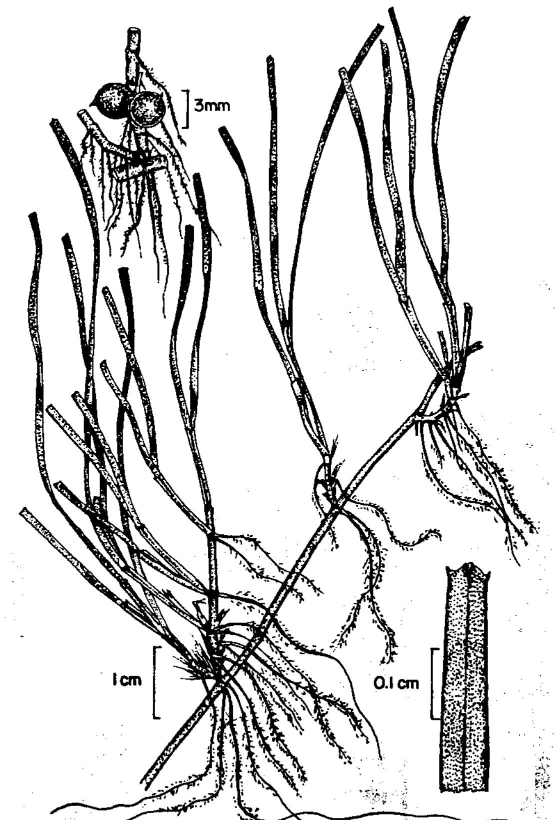


3. Tropical eelgrass
(*Enhalus acoroides*)

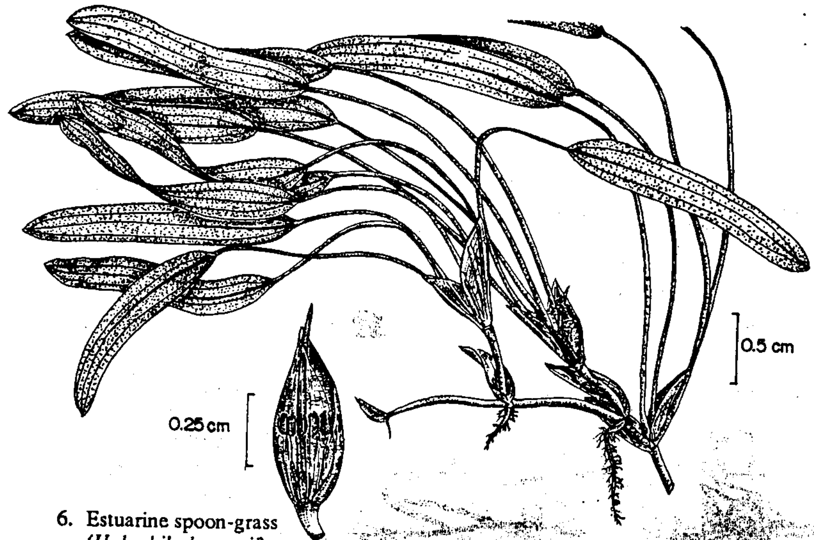


4. Fiber-strand grass
(*Halodule pinifolia*)

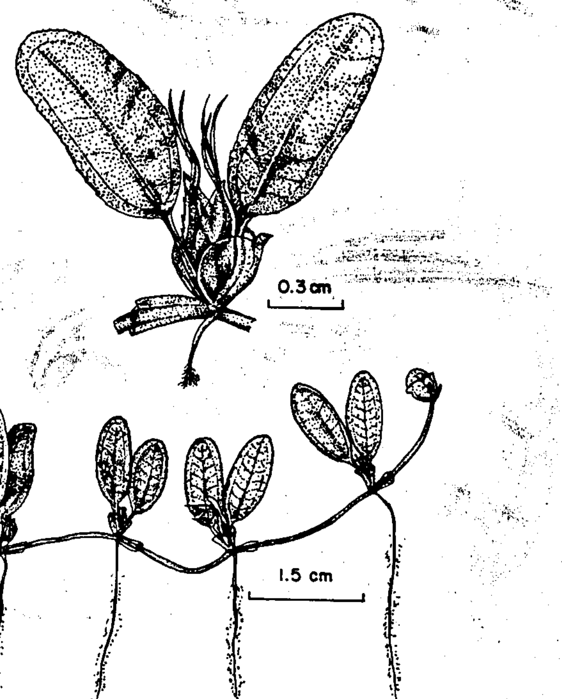




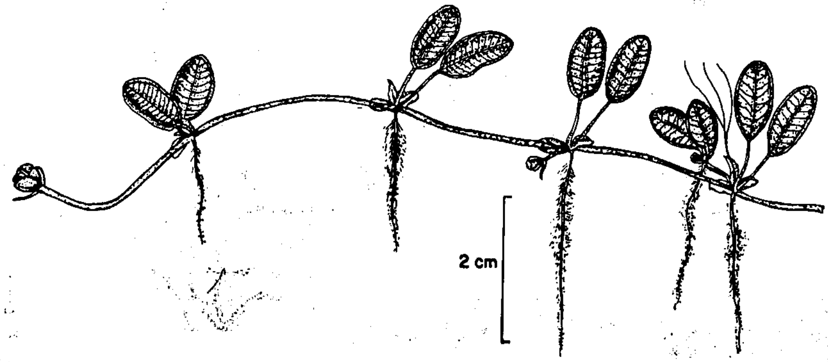
5. Fiber-strand grass
(*Halodule uninervis*)
wide-leaf variety (above)
narrow-leaf variety (right)



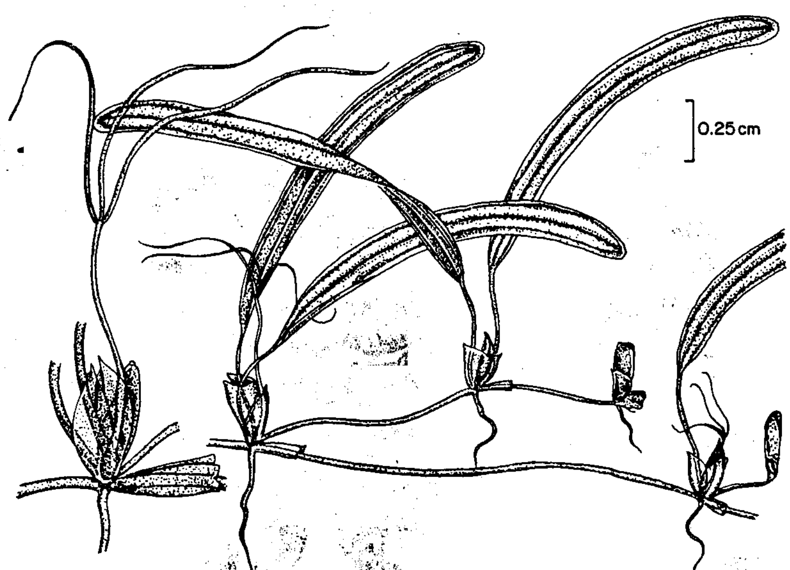
6. Estuarine spoon-grass
(*Halophila beccarii*)



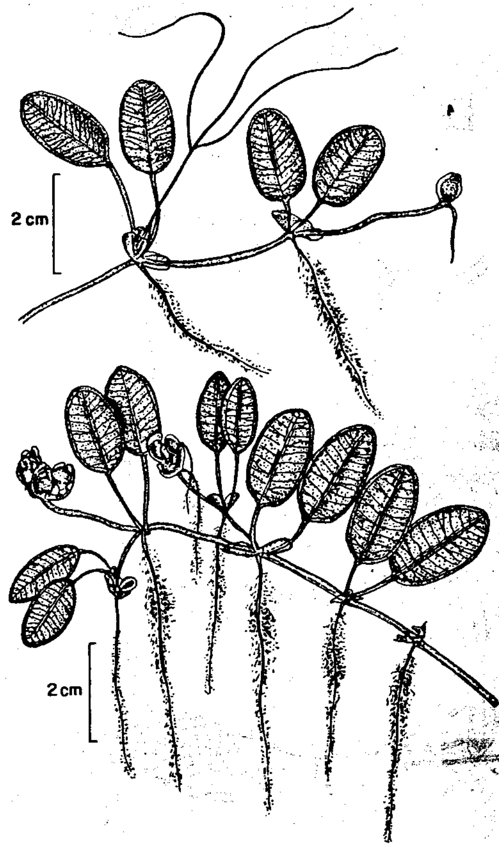
7. Veinless spoon-grass
(*Halophila decipiens*)



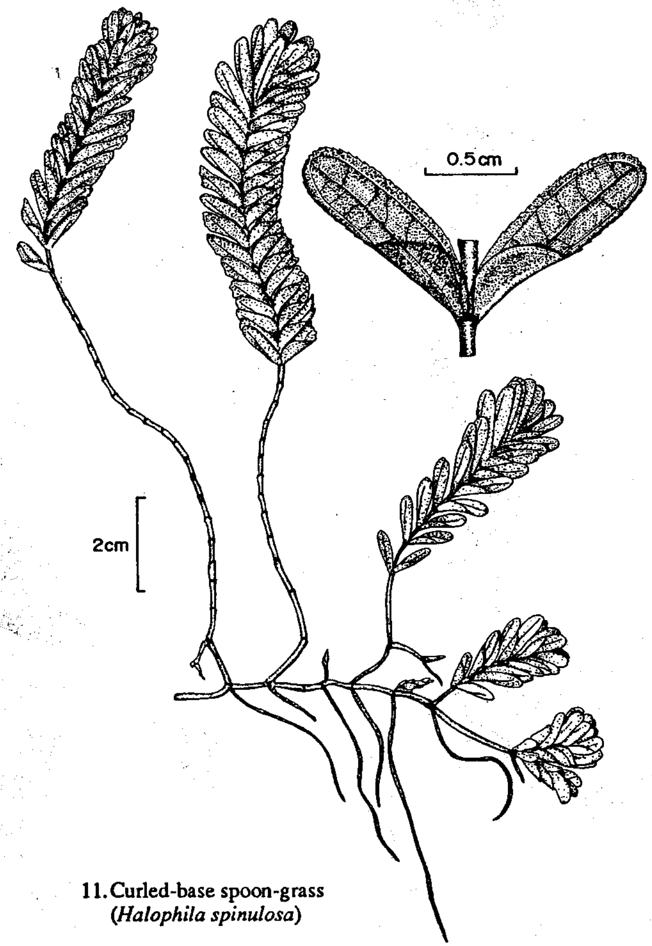
8. Small spoon-grass
(*Halophila minor*)



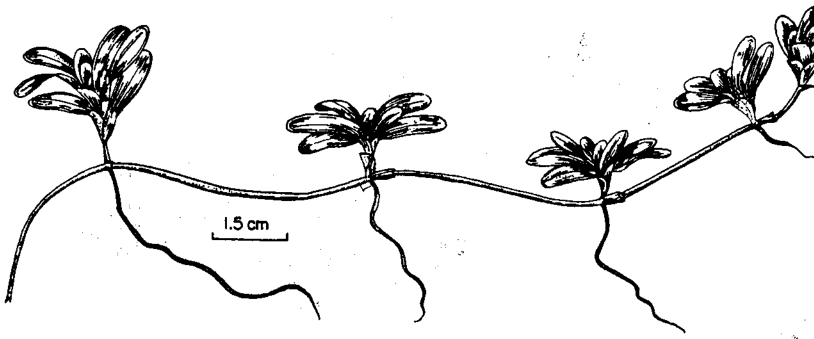
9. Small spoon-grass
(*Halophila minor*), a new variety



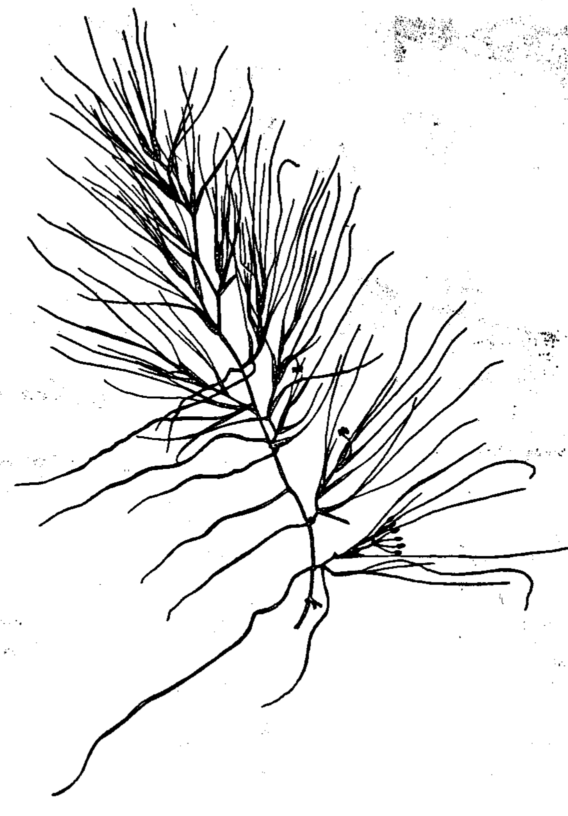
10. Spoon-grass
(*Halophila ovalis*)



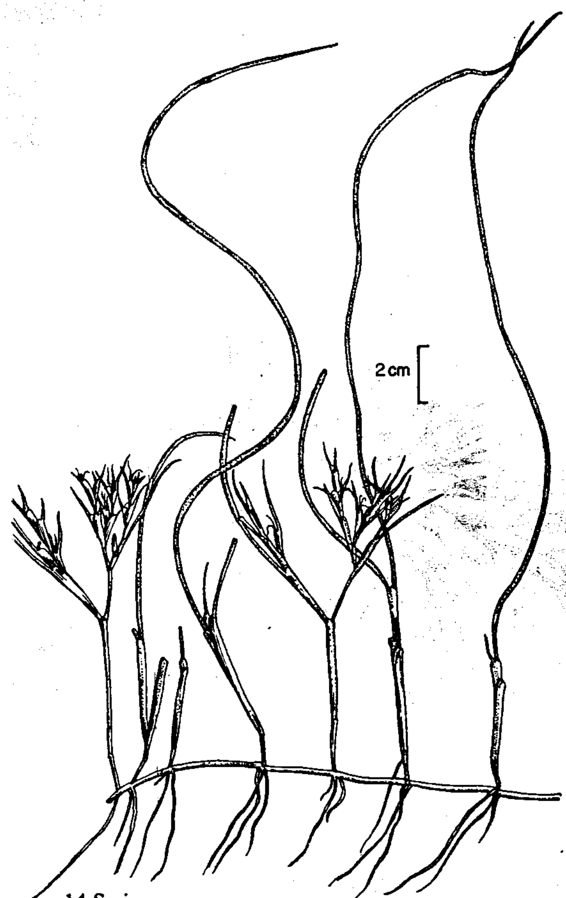
11. Curled-base spoon-grass
(*Halophila spinulosa*)



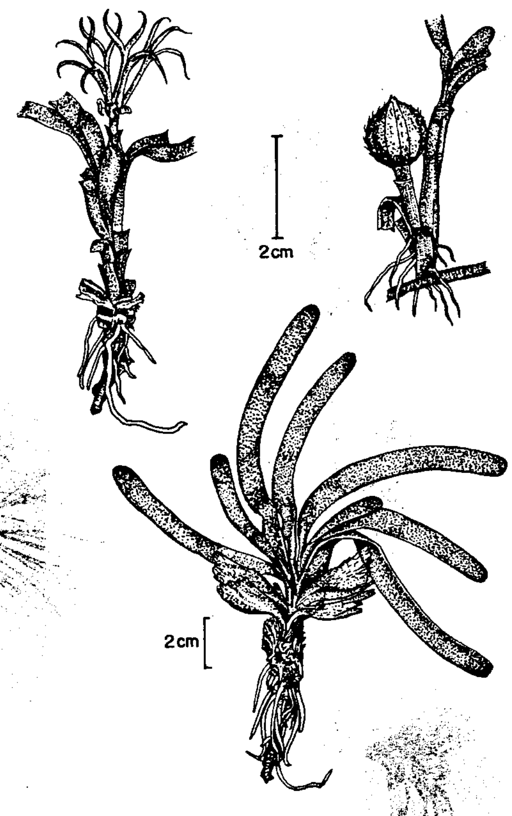
12. *Halophila* sp.



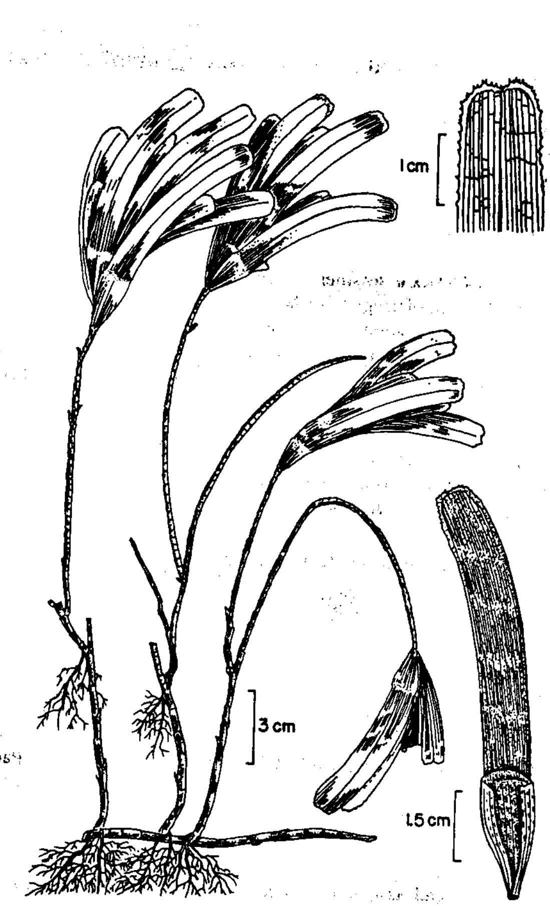
13. *Ruppia maritima*



14. Syringe grass
(*Syringodium isoetifolium*)



15. Dugong grass
(*Thalassia hemprichii*)



16. Woody seagrass
(*Thalassodendron ciliatum*)

Appendix 2. Philippine National Seagrass Management Program.

I. Resource mapping and survey
- Project 1: mapping
- Project 2: ground truthing

II. Research and development

Basic aspects
- Project 1: Inventory and stock assessment of the plant
- Project 2: Fishery resources of seagrass beds
- Project 3: Seagrass beds as nurseries for fish and fauna
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