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A Review: Biodiversity, Distribution and Conservation of Philippine Seagrasses

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Eighteen seagrass species were found from 529 sites in the Philippines. In relation to seagrass as a resource in need of protection, its status as such is yet largely unknown, becoming a focus of scientific inquiry only in the last 30 years and, and as an object of conservation, only in the last 15 years. The coastal nature of Philippine demography, in addition to numerous development facilities, have caused eutrophication of marine waters, which, along with habitat loss, is a major long-term threat to seagrass ecosystems. Some advancements in seagrass research were made locally that are useful steps to reverse seagrass habitat loss. These steps include (1) focusing research on management issues; (2) developing an integrated framework for action; (3) undertaking an economic valuation of the resource; (4) using available scientific knowledge as a means to forge public-private partnerships; (5) ensuring a functional coordination among concerned agencies; and (6) ensuring high quality scientific publications.

Key Words: *Halophila gaudichaudii*, coastal habitat, conservation, Southeast Asia

INTRODUCTION

Seagrasses are angiosperms thriving best in slightly reducing sediments of shallow tropical and subtropical coasts. Here, they form an ecosystem, dominating it as a discrete functional, not as a taxonomic group (McKenzie et al. 2010). As ecotone between mangrove forests and coral reefs, it is home to many marine organisms with economic value, including shrimps, sea urchins, various fish species, and endangered animals like sea turtles and the charismatic dugong, *Dugong dugon*, some 95% of whose diet is seagrass. Many seaweed farms in Southeast Asia and in eastern tropical Africa are established in seagrass beds, although its environmental soundness remains questionable. Seagrasses are sensitive to both biological and physical fluctuations, making them useful indicators of changes not easily observable in either coral reef or mangrove forest. As an ecosystem, its unique ecological functions provide numerous benefits to coastal dwellers. Unknown to these communities, the contribution of seagrass ecosystem to the high biodiversity in coastal areas plus their ability to supply amenities from its resources account for much of their daily incomes. Recently, because of its vast areal extent in the continental shelf of the world and its ability to absorb 166 gC per sq m per yr (Duarte & Cebrian 1996), the most significant and high-level statement about seagrass vis-à-vis climate change was made: "…when healthy, mangrove forests, saltwater marshlands and seagrass meadows are extremely effective at storing atmospheric carbon, thereby mitigating climate change" (UNEP/IUCN 2009). All these ecosystem services make the conservation of seagrass habitats a high priority in the action agenda of coastal states in Southeast Asia.

The center of seagrass distribution in the world has a clear focus in Southeast Asia, reaching up to southern Japan. There are still wide areas in the region where the existence of seagrasses likely remains unknown. Ironically, seagrass

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is comparatively the least studied among the coastal habitats in this region. This is largely due to the fact that the interests of marine scientists focus mainly on coastal resources with immediate economic value or impacts (e.g. coral reefs, seaweeds, animals, or fish, tourism, coastal development) (Fortes 1989, Fortes 2012). Suggesting a shift in regional and national conservation focus, this paper gives a taxonomic and distributional account of the seagrasses in the Philippines from 1983 to 2012, placed within the context of a more recent national conservation initiatives. The account serves as a compelling reason for promoting more research and a stronger and more vigorous advocacy focused on seagrass conservation in the Philippines in particular and in Southeast Asia in general. In addition, with recent works published from various projects, which dealt with basic scientific data useful as guides to sound coastal developmental activities, a shift in direction of seagrass research in the Philippines and in Southeast Asia towards addressing environmental issues commenced.

MATERIALS AND METHODS

Data and information used in this paper were selected from literature citations on seagrass and seagrass ecosysems in the Philippines (Fortes 1986), in Southeast Asia (UNEP/GEF 2007, Ogawa et al. 2011) and the world (Hartog 1970, Spalding et al. 2001, Green & Short 2003). Focus was made on those which give detailed accounts on the taxonomy and distribution of seagrasses from the Philippines. The data and information are synthesized to draw a realistic picture of the status and problems of a natural coastal resource that needs urgent protection and policies for their sustainable use.

RESULTS AND DISCUSSION

Taxonomy and distribution of Philippine Seagrasses

Fortes (2012) summarized a historical account of seagrass studies in the Philippines: "The earliest records on the plants in the country include reports of *Vallisneria sphaerocarpa* (=*Enhalus acoroides*) from Zambales (Blanco 1837, 1845, 1879). Merrill (1918) made another report of *Vallisneria sphaerocarpa* from Palawan. Ostenfeld (1909) recorded *Halophila ovata* (= *Halophila minor*) from the Philippines, based on Loher's specimen from Luzon and later, Merrill's collection from Manila Bay. Pascasio and Santos (1930) published a critical morphological study of *Thalassia hemprichii*. Domantay (1962) listed eight species of seagrasses in his study of the marine vegetation of the Hundred Islands in Pangasinan. Merrill (1912, 1915, 1918, 1925) and Mendoza and del Rosario (1967) included seagrasses in vascular plant floras. In his most comprehensive account of the seagrasses of the world, Hartog (1970) reported 11 species from the Philippines. Calumpong (1979) reported three seagrasses from Central Visayas region while Cordero (1981) illustrated and described the morphology and distribution of three species of seagrasses. The most comprehensive ecological account of seagrasses from the Philippines was made by Fortes (1986). Three studies (Fortes 1988, Mukai 1993, Fortes 2010) augment our knowledge on seagrass biogeographical affinities in East Asia. Spalding et al. (2001) gives an account of the geographical distribution of the flora of 115 countries, including Southeast Asia".

To date, debate continues among seagrass practitioners on the details (particularly below sub-class) of the correct classification of seagrasses (McKenzie et al. 2010). In the Philippines, 18 seagrass species from three families (*sensu* Hartog & Kuo 2007) have been found from the 529 sites visited (Fortes 2008, Fortes 2012, Figure 1). The species so far recorded are:

Family Cymodoceaceae	Family Hydrocharitaceae
Cymodocea rotundata	*Enhalus acoroides*
Cymodocea serrulata	*Halophila beccarii*
Halodule uninervis	*Halophila decipiens*
Halodule pinifolia	*Halophila gaudichaudii*
Syringodium isoetifolium	*Halophila minor*
Thalassodendron ciliatum	*Halophila ovalis*
	Halophila ovata
	Halophila spinulosa
Family Ruppiaceae	*Halophila sp1*
Ruppia maritima	*Halophila sp2*
	Thalassia hemprichii

Key to the families of Philippine seagrasses

1. Leaves differentiated into a sheath and a blade, with a ligule..Cymodoceaceae

1. Leaves differentiated into a sheath and a blade, without a ligule..2

2. Flowers dioecious or monoecious, with a trimerous perianth...Hydrocharitaceae

2. Flowers monoecious, without a perianth................ ....Ruppiaceae

There are no representatives of the Families Posidoniaceae, , Zannichelliaceae and Zosteraceae in the Philippines.

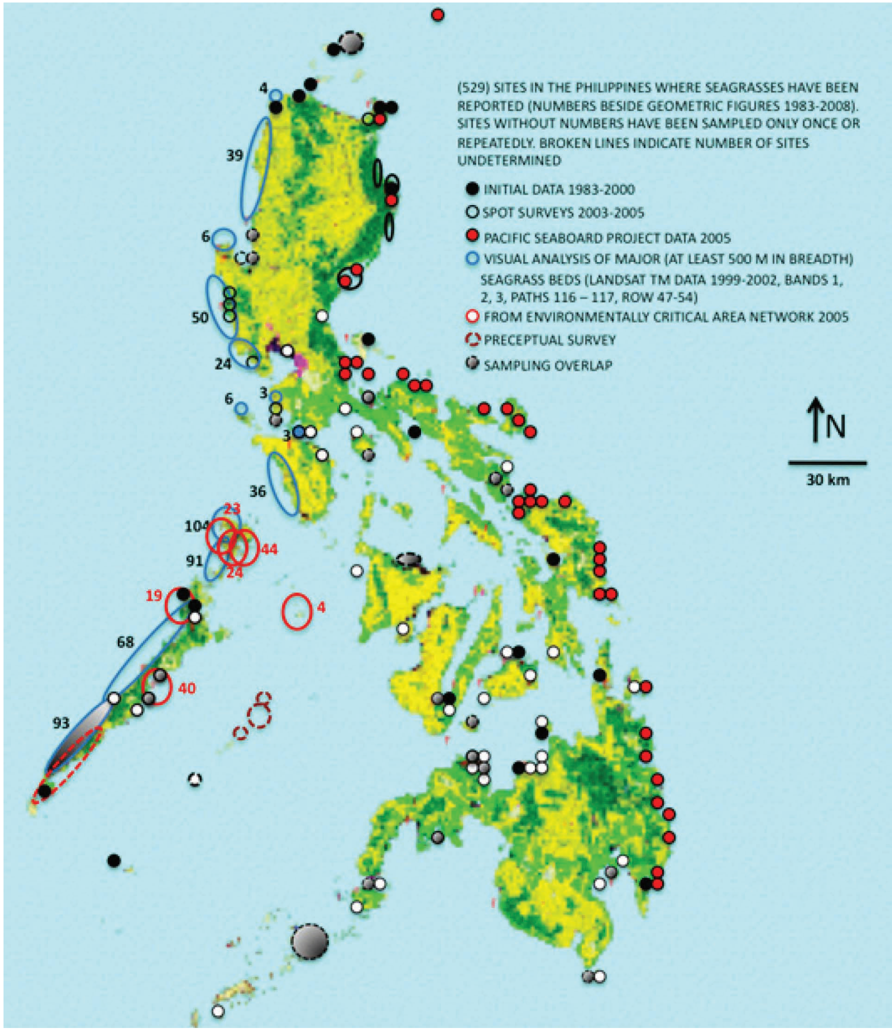

Figure 1. Distribution of seagrasses from 529 sites in the Philippines from 1983 to 2012.

Key to the marine taxa of Cymodoceaceae in the Philippines

1. Leaves subulate or terete, flowers a cymose inflorescence ....*Syringodum isoetifolium* (Fig. 2)

1. Leaves flat, flowers otherwise....................................2

2. Flowers not solitary within leaf sheaths; found in brackish waters or salt pans ..... *Ruppia maritima* (Fig. 3)

2. Flowers solitary within leaf sheaths...........................3

3. Rhizome ligneous, with one or more little-branched shoots mostly at every fourth internode.......................... ....*Thalassodendron ciliatum* (Fig. 4)

3. Rhizome herbaceous, with short unbranched shoots at each node...4

4. Leaves with 3 nerves; ovary with 1 undivided style ....*Halodule*

4. Leaves with from 7-17 nerves, style divided into 2 stigmata..*Cymodocea*

Key to the species of *Halodule* in the Philippines

1. Leaf tip tridentate, with well-developed lateral teeth .... *H. uninervis* (Fig. 5)

1. Leaf tip rounded, more or less serrulate, lateral teeth faintly developed or absent............... *H. pinifolia* (Fig. 6)

Key to the species of *Cymodocea* in the Philippines

1. Leaf scars closed; leaf tip rounded, serrulate.......... .... *C. serrulata* (Fig. 7)

1. Leaf scars open; leaf tip obtuse, set with triangular teeth ....*C. rotundata* (Fig. 8)

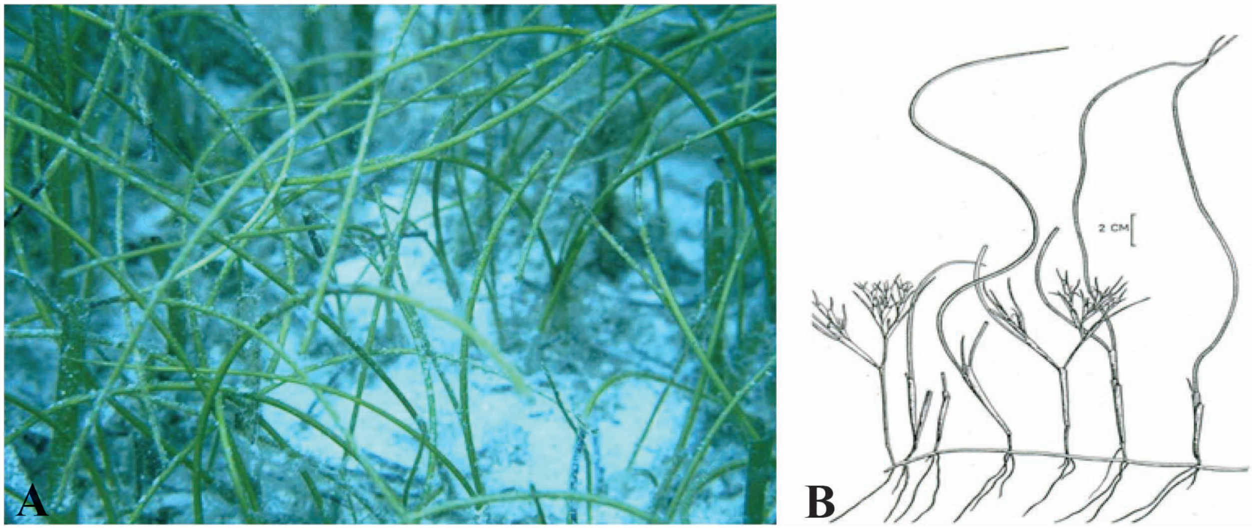

Figure 2. *Syringodium isoetifolium*, naturally occurring in pure stand (A) and in line drawing to show habit with flowers (B).

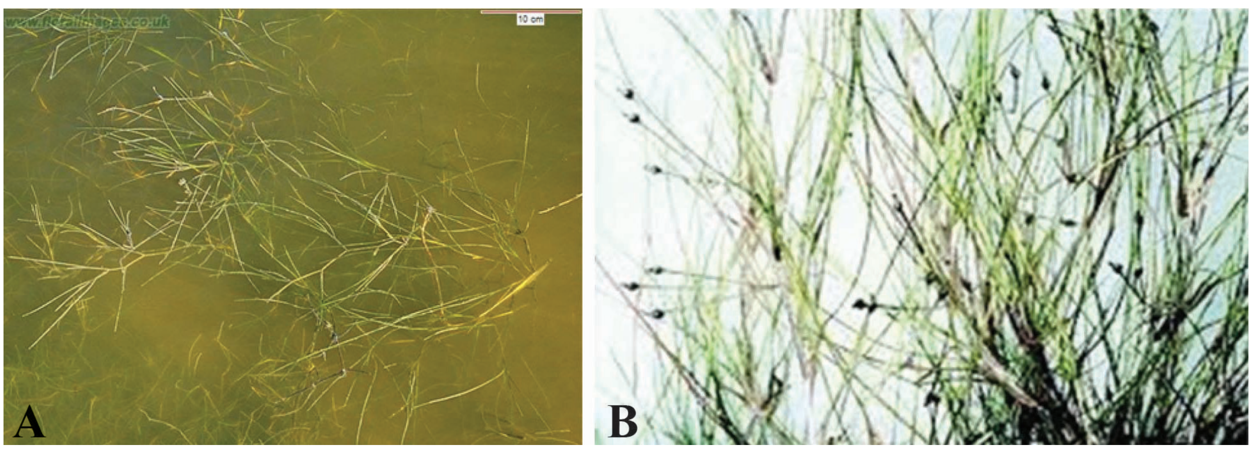

Figure 3. *Ruppia maritima*, in its natural habitat (A) and showing flowers (B). (Photo-courtesy: Dr. Japar Sidik Bujang)

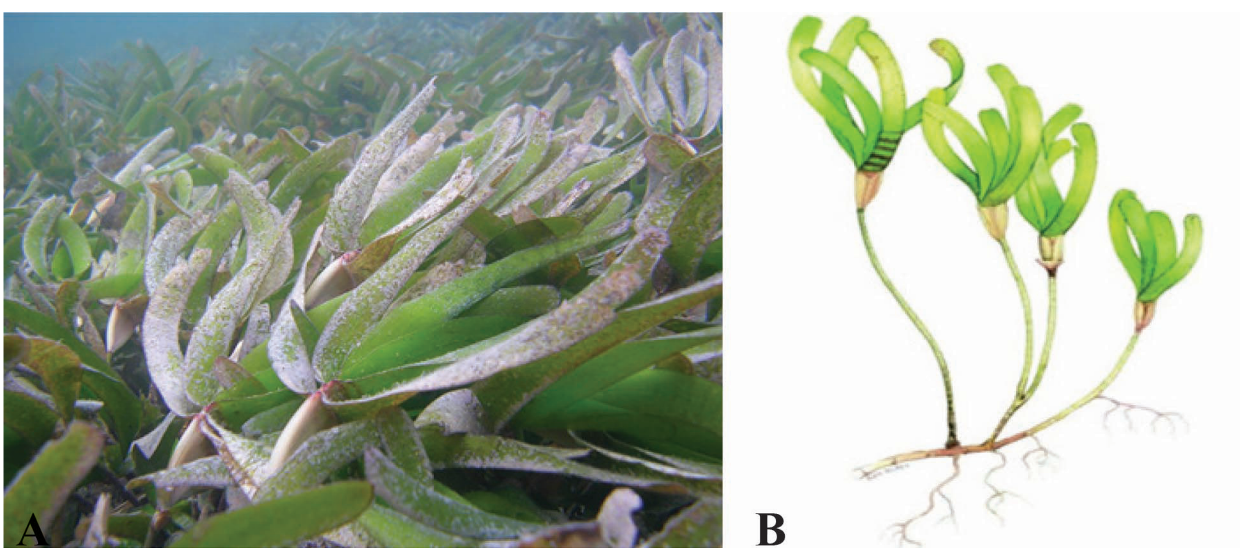

Figure 4. *Thalassodendron ciliatum* in its natural habitat (A) and showing details of its morphology (B).

Key to the marine taxa of Hydrocharitaceae in the Philippines

1. Leaves in pairs, in pseudo-whorls, or differentiated into petioles and blades.................................. *Halophila*

1. Leaves distichous, nit so differentiated 2

2. Rhizome covered with black, fibrous strands....... .... *Enhalus acoroides* (Fig. 9)

2. Rhizome without the strands.................................. .... *Thalassia hemprichii* (Fig. 10)

Key to the species of *Halophila* in the Philippines

1. Leaves elliptic to ovate; petioles not sheathing or sheathing lopsidedly.. 2

1. Leaves lanceolate to oblong-linear, sessile or with broadly sheathing petioles... 4

2. Monoecious.............................. *H. decipiens* (Fig. 11)

2. Dioecious 3

3. Leaves with 11-25 pairs of cross-veins ascending at angles of 45-55^{O} .... *H. ovalis* (Fig. 12)

3. Leaves with 3-10 pairs of cross-veins ascending at angles of 65-95° 4

4. Cross-veins 7-12; found in 0.2 m – 1 m depth........... .... *H. minor* (Fig. 13)

4. Cross-veins 3-6; found in at least 2 m depth................. .... *H. gaudichaudii* (Fig. 14)

5. Leaves without cross-veins; midrib crossing the intramarginal nerves .... *H. beccarii* (Fig. 15)

5. Leaves with perpendicular cross-veins; midrib not crossing the intramarginal nerves.................................. 6

6. Stems branched, leaves somewhat distichously arranged, serrulate......................... *H. spinulosa* (Fig. 16)

6. Stems unbranched, the leaves in pseudo-whorls, entire...7

7. Midrib distinct; found in less than 4 m of water............ .... *Halophila* sp1 (Fig. 17)

7. Midrib diffuse, indistinct; in at least 4 m of water................ .... *Halophila* sp2 (Fig. 18)

Conservation of Philippine seagrasses

In relation to seagrass as a resource in need of protection, its status as such is yet largely unknown (Fortes 1989, 2001, 2004, 2008). Its management, however, is recognized as a key to coastal conservtion in the region (Fortes 1991, 1995). This effort, nevertheless, should be science-based (Fortes 2010a, 2010b). Ogawa et al. (2011) gives a more recent account of the status and trends in seagrass resources in 5 countries in fhe region (including Japan). Coles & Fortes (2001) reported the approaches and methods to protect seagrass. In Southeast Asia where the second highest seagrass diversity in the world is found,

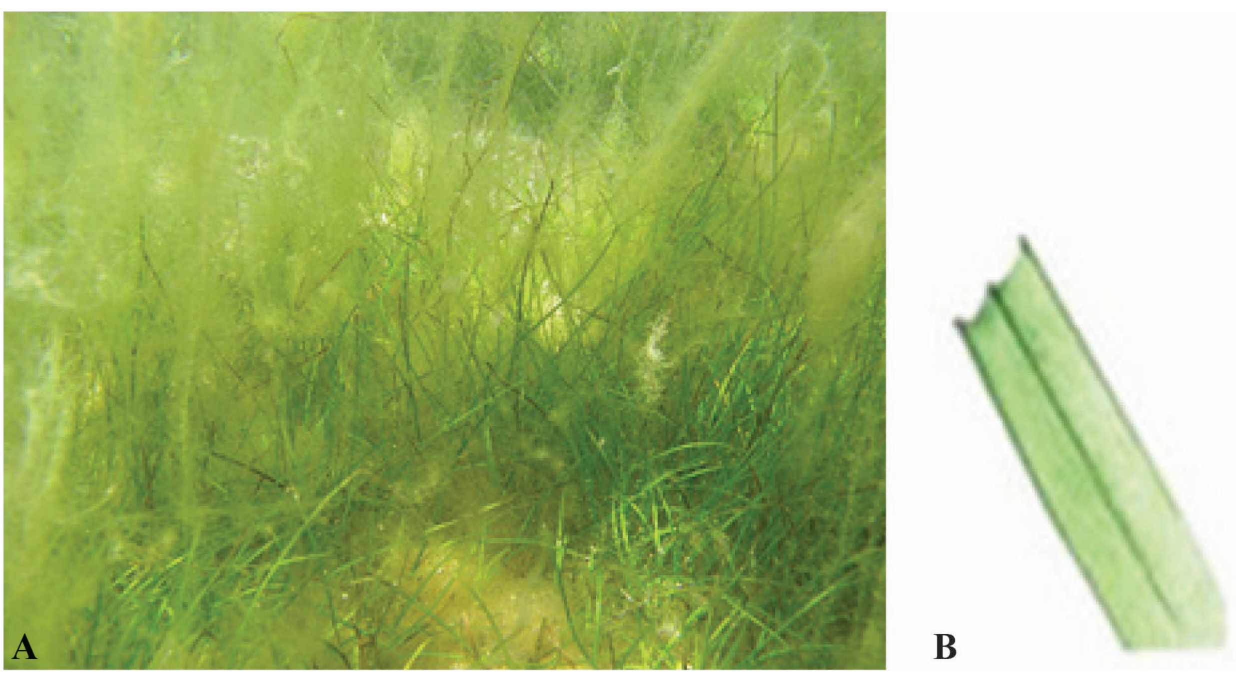

Figure 5. *Halodule uninervis,* overgrown by the filamentous green alga *Enteromorpha* sp. in Sabang Cove, Pto. Galera (A). Details of its leaf tip is shown in (B).

Figure 6. *Halodule pinifolia*, habit (A) and leaf tip (B).

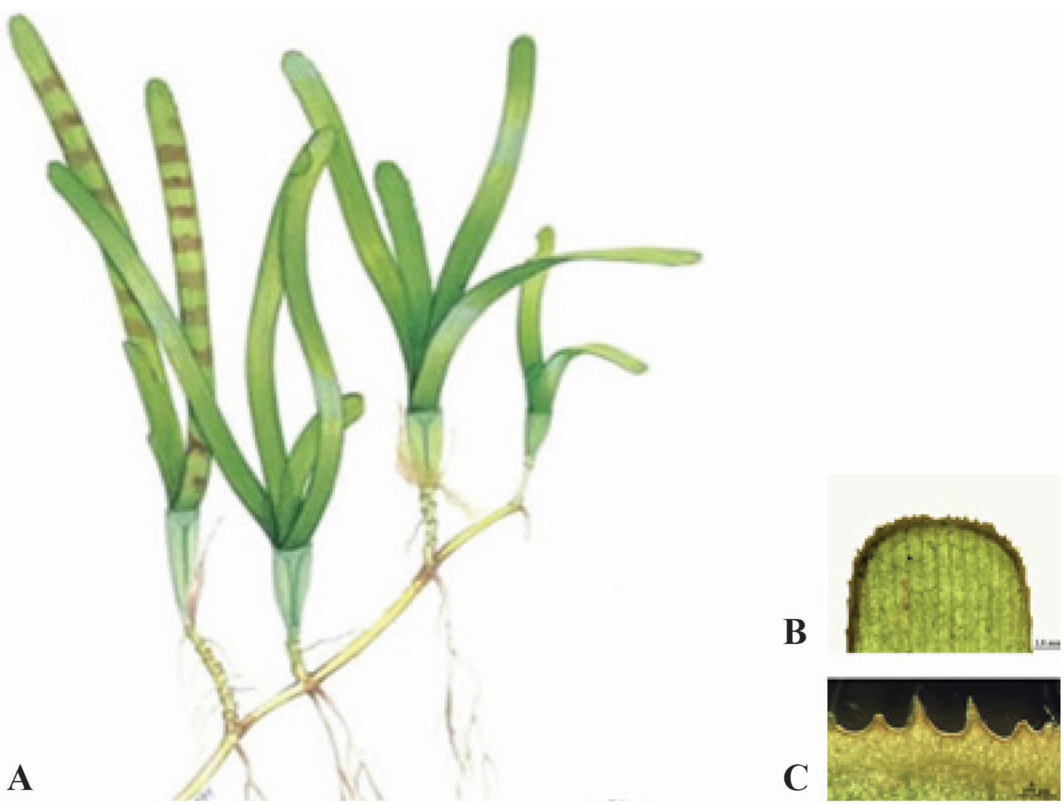

Figure 7. *Cymodocea serrulata*, showing its habit (A), leaf tip (B) and serrations on leaf tip (C).

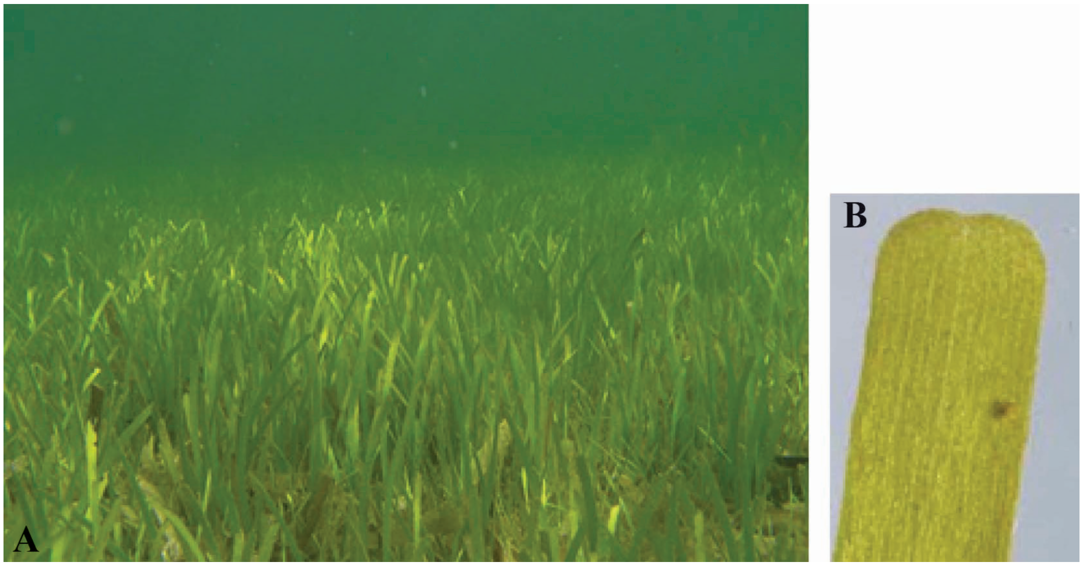

Figure 8. *Cymodocea rotundata,* showing a natural bed (A) and details of a leaf tip (B).

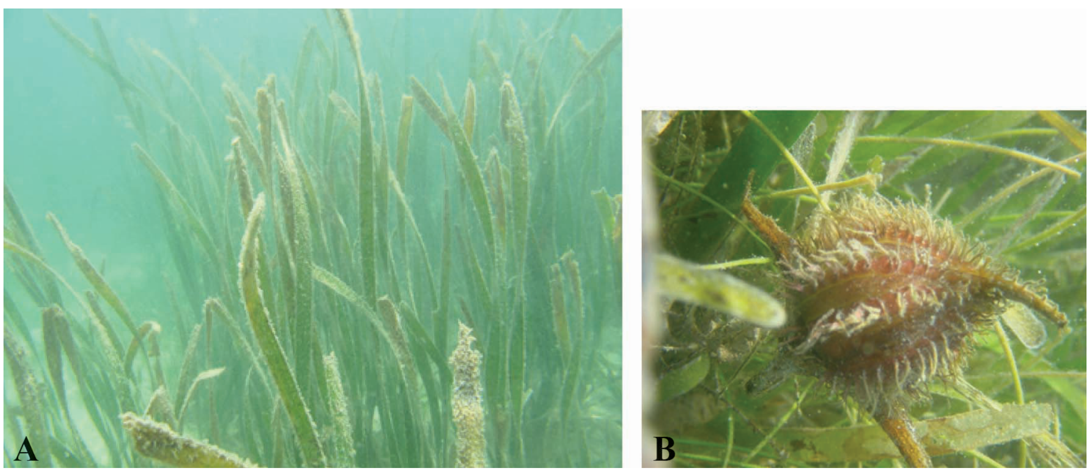

Figure 9. *Enhalus acoroides,* epiphytized leaves (A) and a fruit (B).

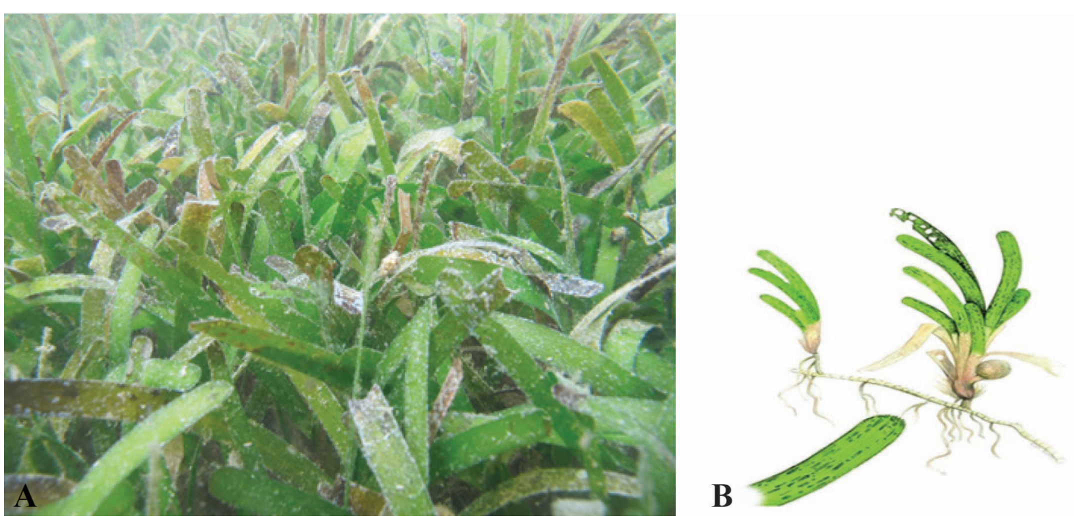

Figure 10. *Thalassia hemprichii,* showing dense natural bed (A) and details of its morphology including a leaf tip and fruit (B).

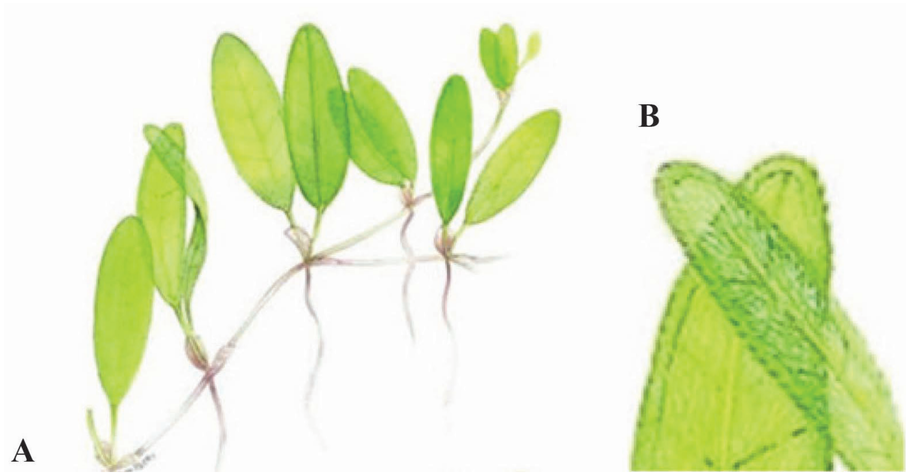

Figure 11. *Halophila decipiens,* habit (A) and details of leaves (B) (Photo-courtesy: Anonymous).

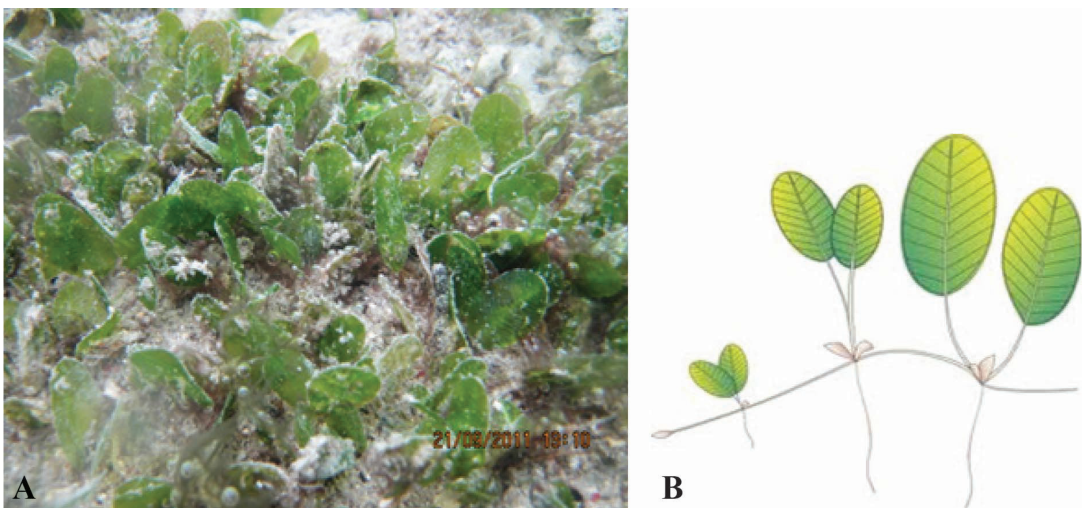

Figure 12. *Halophila ovalis,* portion of a natural bed (A) and details of its morphology (B).

Figure 13. *Halophila minor* showing the edge of its bed as it creeps seaward (A). Details of its morphology are shown in (B).

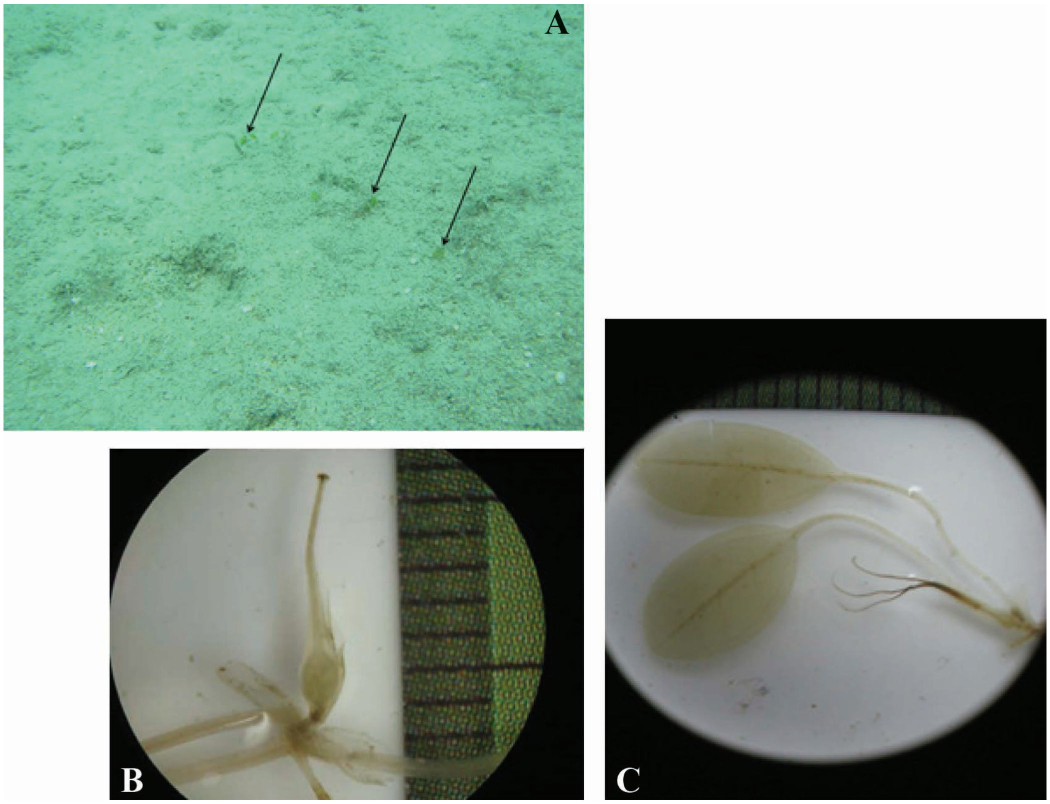

Figure 14. *Halophila gaudichaudii,* normally inconspicuous at the deeper end of its natural habitat (A), three arrows pointing at protruding leaves, a meter distance from the camera. Photomicrographs showing fruit (B) and shoot with female flower (C). Scale = 1 mm each. [Note: the distinctiveness of *H. gaudichaudii* has been questioned. A synonymy with either *H. ovalis* or *H. nipponica* has been proposed in different publications].

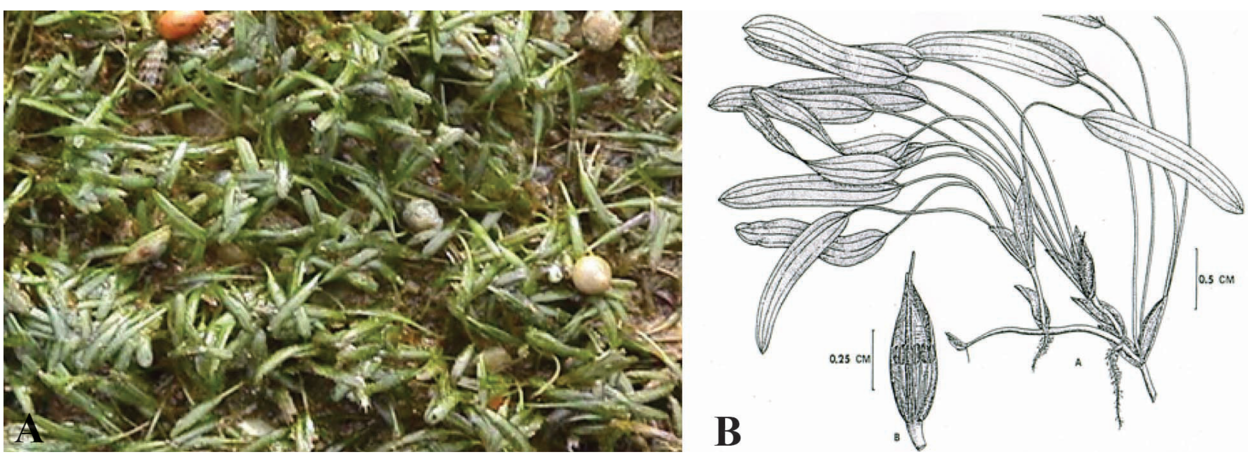

Figure 15. *Halophila beccarii,* portion of a bed (A) (photo-courtesy: Dr. Japar Sidik Bujang) and details of shoots with a flower (B).

seagrass ecosystem has been a focus of scientific inquiry only in the last 30 years and, as an object of natural resource conservation, only in the last 15 years! It took more than five decades after the morphological account of Pascasio & Santos (1930) to follow up the works on taxonomy and distribution and initiate an ecological research on seagrasses in the Philippines (Fortes 2012). In the last 50 years, a mix of research works appeared, presenting various methods of conservation, rehabilitation and management of the seagrass habitats in the country, together with the organisms associated with them. This impetus resulted into a rapidly increasing importance of integrated studies, including genetic markers as a means to understand their phylogeography in the region

Figure 16. *Halophila spinulosa,* close-up of three branches (Photo-courtesy: Anonymous).

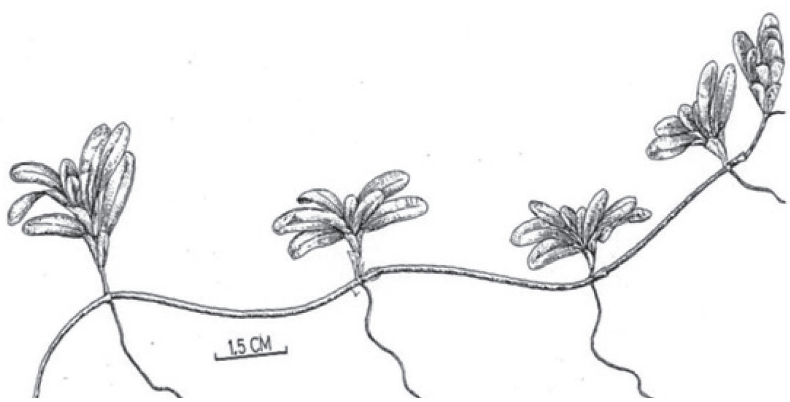

Figure 17. *Halophila* sp1, portion of a sterile plant, showing the leaves in pseudo-whorls.

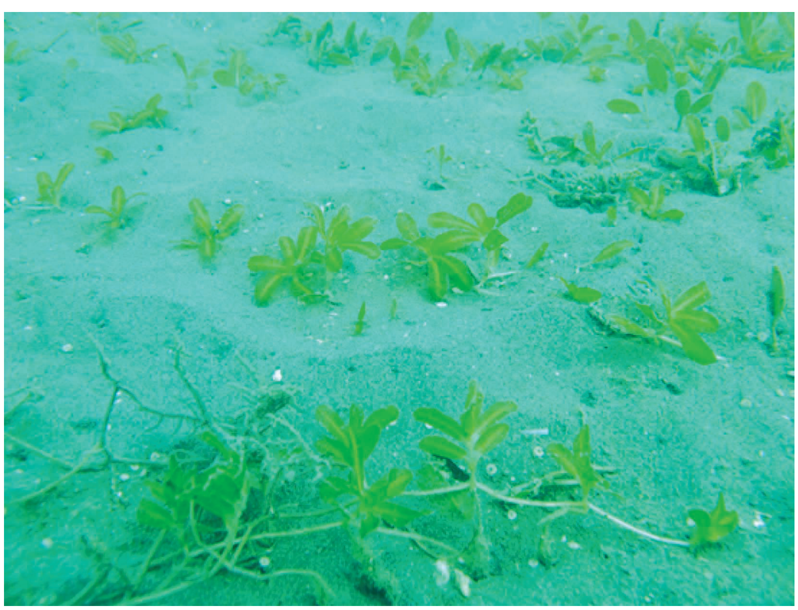

Figure 18. *Halophila* sp2 in its natural habitat. Note the diffuse and broad midribs.

(Matsuki et al. 2012, Nakajima et al. 2012). Focus on interconnectivity among coral reefs, seagrass beds and mangroves gained prominence with the findings that the inherent ecological relationships among these habitats are crucial to their conservation. Partly in these studies, the meadows' distinct role in providing a stable foundation for all marine ecosystems emerged. More recently, its unique role came at the forefront in global environmental awareness due largely to their effectiveness in mitigating the impacts of climate change (UNEP/IUCN 2009). The shifting needs of the times, aggravated principally by an alarming reduction and loss in resources resulting from a decline in coastal water quality and degradation of the environment, dictated a corresponding shift in seagrass research focus from basic to its applications, from purely scientific initiatives to those that now require support and collaboration from social and behavioral sciences (Fortes 2012).

From then on, this new research thrust on seagrasses was and is being pursued, sustained by numerous funding agencies and institutions. With the promising outcome of research initiated by the Philippine Government (1983-1990), the European Union (1996-2002), the Australian International Development Assistance Bureau (1986-1996), and the Association of Southeast Asian Nations (1998-2000), other agencies followed suit, e.g. the United Nations Educational, Scientific and Cultural Organization (2003-2006), United Nations Environment Programme/ Global Environment Facility (2002-2008), and Japan International Cooperation Agency-Japan Science and Technology Agency (2010-2015). The Asia-Pacific Network for Climate Change Research (APN, 2011-2013) is supporting a regional research on the 'bioshield' functions of seagrass ecosystem in the Philippines, India and Indonesia, in collaboration with Australia and Japan. Nationally, the Department of Science and Technology (DOST) and jointly with the Japan Society for the Promotion of Science, is funding research on the coastal protection role of the habitat and link this to conservation policies.

Seagrass decline in the Philippines: the issues

822 out of 1,502 municipalities in the Philippines are coastal, with 429 fishing and 821 commercial ports (http://www.census.gov.ph), in addition to numerous coastal development facilities which, together, have caused eutrophication of marine waters, a major long-term threat to seagrass ecosystems in the Philippines (Fortes 2001, Holmer et al. 2002). This condition results from waste waters drained into the coasts from industrial, commercial and domestic facilities, inadequate septic systems, boat discharge of human and fish wastes, and storm drain run-off carrying organic waste and fertilizers. Its direct impact is the enhancement of growth in many plant forms resulting in reduction of light. In addition, the growth of Philippine coastal tourism market is one of the most rapid in the region. Together, these degradation factors put a significant portion of the coastal habitats of the country at high risk of being lost in the near future. No wonder, about half of its coastal resources have either been lost or are severely degraded during the past 56 years (Fortes et al. 1994) and the rate of degradation is repidly increasing. Hence, for the first time in decades, a seagrass (*Halophila becarrii*) has been included in the IUCN Red Book as a locally threatened species (Short et al. 2011). Living in poverty, a large percentage of the coastal population derives basic needs from these coastal resources. With or without conservation they will use this environment in order to survive.

Since 1990, the coastal environmental problems perceived as exerting the most severe impact on the seagrass ecosystems in the Philippines have remained basically the same, the only significant difference from the current and long term condition is the degree some of these have been intensified (e.g. sewage pollution, siltation/ sedimentation, agricultural pollution, sea level rise) (Table 1). Causal Chain Analysis revealed that these problems arise not only from overpopulation but also as a result of the use of inappropriate technology, people's consummate attention to the material and political, and insensitivity to the cultural aspects of human life. With the growing complexity of the interrelationship between society and the oceans as a resource, marine science has emerged to have a very defined role. This role is likely to be even greater in the future. Interestingly, the perception tends to remain until 2020.

Reversing seagrass habitat loss in the Philippines

After more than three decades, some advancements in seagrass research and development exist, which could be useful in recommending steps in order to arrest or reverse coastal habitat destruction in the Philippines. Central to the formulation and implementation of these steps are conditions which should be adhered to in order to ensure positive feedback from the people. These include: adherence to rules and regulations; participation of stakeholders; consensus building; capacity development and institutional strengthening; gender sensitivity; and regional and global perspective. These recommended steps are:

1. Focus research on priority management issues - Despite the documented loss of seagrass habitats, there is a dearth of data on the current status of the seagrasses in the Philippines: their actual overall coverage, density, their responses to perturbations, asociated organisms, links with nearby ecosystems, and use patterns. The

Table 1. Coastal environmental problems with the most severe impacts on sea grasses in the Philippines, ranked in the order of priority and classified into urgency categories i.e., immediate, short-term or within the next five years, and long-term or within the next 10 years or more. Three asterisks indicate severe impact; two asterisks, moderate impact; and one asterisk, slight or no impact.

Problem	Immediate	Short-term	Long-term
Habitat destruction***	1	1	1
Sewage pollution***	2	2	3
Industrial pollution***	3	3	2
Fisheries overexploitation***	4	4	6
Siltation/sedimentation***	5	5	4
Oil pollution **	6	6	8
Hazardous waste*	7	7	7
Agricultural pollution**	8	8	5
Red tides*	9	9	11
Coastal erosion*	10	10	10
Natural hazards*	11	12	12
Sea level rise*	12	11	9

few data that exist are scattered and inconclusive and do not provide sufficient detail for the development of parameters to guide and monitor the sustainable extraction of seagrass resources. In order to work towards more sustainable seagrass management in the country, key gaps in data collection need to be addressed. Data need to be collected on key biological and human-environment indicators that will guide policy and set parameters for sustainable resource use. Complementing remotely sensed images of the coasts, there is an urgent need for basic and directed research, the results of which are useful in the development of an integrated information management and decision support system. This is indispensable in monitoring the rate of change of seagrass resources, and in making the information available for coastal planners and decision makers. These facts serve as the major driving force for the esablishment of the Bolinao Seagrass Demonstration Site (UNEP 2007a).

2. Develop an integrated framework for action: putting our acts together -

Recent initiatives have shown great promise in addressing not only seagrass depletion all over the country, but also the degradation and loss of the country's coastal habitats. In this paper some of these initiatives have been selected to focus attention to 'wise practices', which may be replicated to meet similar challenges in other parts of the region.

In its 15th year, the International Seagrass Biology Workshop (ISBW) series have produced the essential elements in conserving and sustainably utilizing the seagrass resources of the world. These elements consists of: (1) the needed linkages among seagrass scientists and practitioners from all parts of the world; (2) the mechanisms to ensure access and transmission of data and information; (3) sustained research activities on the dynamics of the ecosystem; and (4) modest support from academic and funding institutions. With support from various institutions, the association initiated the establishment of the World Seagrass Association (WSA), which is now holding conferences for similar purposes. The association now serves as the clearing-house of all activities on seagrasses in the world.

At the time of its establishment, the Seagrass Watch and Seagrass Network (SeagrassNet) were developed and operationalized to implement the plan of action for seagrass research and monitoring. Approved at the 3rd International Seagrass Biology Workshop in the Philippines (1998), the Charter for Seagrasses was adopted, laying the principles that guide research and development of seagrasses in the world.

As in Australia and the United States, a coastal initiative tasked to codify information needs in different regions should be developed. A knowledge base can then be used to formulate local, regional, and national conservation strategies for seagrasses that are biologically and ecologically acceptable and economically sustainable. The goal of these strategies should be net enhancement of the natural capital for the sustainable use by present and future generations. These strategies should include mechanisms for managing and protecting the ecosystem sustainably in the face of global change; they should also employ the best, most up-to-date scientific information available, and should evolve to incorporate new information as it is generated. A periodic review will have to be designed to answer among others, the following questions: Is the scientific information being used actually relevant to the policies and decisions that must be made? Has information been provided in a way that facilitates its use? Is the information timely? Is it credible? Do decision makers and stakeholders understand it?

Under the aegis of the UNEP/GEF South China Sea Project, entitled, "Reversing Environmental Degradation Trend in the South China Sea and the Gulf of Thailand (2002-2008)", the Philippine National Seagrass Committee (PNSC) was established. It is tasked to oversee and support all activities that relate to seagrass in the country. This task was translated into the Philippine National Seagrass Conservation Strategy and Action Plan (PNSCSAP). The action program is the Philippines' collective response to the UNEP/GEF South China Sea Project's goal of restoring 80% of the region's seagrass cover to the 1995 level. In the plan, each of the programme components has a defined course of action, objectives, outputs, a timeframe and specific line up of collaborators in each area of implementation. This framework defines the course of management and project implementation for the seagrasses of the Philippines from 2002- 2012. The interactive nature and interdependence among the various components of the plan is also emphasized. These interactions are guided by the following key questions, which only research could answer:

Q1: How do long-term and short-term human impacts interact to alter seagrass ecosystem structure and function?

Q2: How can the biological characteristics of the ecosystem be both the causes and consequences of fluxes of energy and matter?

Q3: How do changes in seagrass ecosystem dynamics affect ecosystem services?

Q4: How do changes in seagrass ecosystem services feed back to alter human behavior?

Q5: Which human actions influence the frequency, magnitude, and form of humanimpacts across the ecosystem, and what determines these human actions?

The answers to these fundamental questions provide the basis of an integrated decision support system arrived at after thorough and timely consultation with the stakeholders. The end point or ultimate product is policy, which should be institutionalized, i.e., legislated, incorporated in management decisions, and infused into the social norm.

The PNSCSAP has set the stage for the research and development agenda for seagrasses in the country. Past efforts of the scientific community, and the lessons learned from previous coastal resource management initiatives should serve as a jump off point for future achievements in seagrass research. In the Philippines, it must be overly emphasized that the continuous support and transparency between all sectors are vital to the success of seagrass conservation and management (Montaño 2007).

3. Undertake an economic valuation of the resources and of relevant policy changes -
At present, environmental problems and their impacts have become more complex than previously thought. This realization gave rise to market-based approaches to environmental regulation. However, market mechanisms will only be successful if they reflect the users' preferences as individuals, both nationally and internationally (Garrod & Willis 1999). Environmental valuation of the resources and the benefits of policy change relative to these resources are thus extremely important.

The ecological coastal value of seagrases is obviously substantial. However, UNEP (2007b) reports that the value of annual production of goods and services by seagrass habitats from 7 countries bordering the South China Sea totals a mere US$86 million. The primary reason is the almost complete lack of data and, where these exist, they are 'outrageously' unreliable. In the Philippines, the value of the total annual production of the goods and services of seagrass from the few study sites (with a total area of 23,245 ha) was worth only US$809,766 (UNEP 2007a). This is because only data from capture fisheries were considered reliable, so that seagrass goods had a total value of only US$34.84. On the other hand, seagrass services had no value, since none of the data submitted were considered and reliable. Interestingly, Fortes et al. (2007), in connection with the total valuation of damages due to the grounding of the coal Barge APOL in Bolinao, northwestern Philippines, in 2007, submitted to the insurance company a valuation of the lost benefits from a 35 ha seagrass beds (and a small portion of an unproductive reef) with six years recovery allowing for some spread of the rubble costing US$60,000. These data emphasizes the need for a more thorough accounting of the services from the habitats.

The economic return obtained from seagrass bed can be up to US$ 86,000 per acre (IUCN/UNEP 1984). Watson et al. (1993) reported that the potential total annual yield from Cairns Harbor seagrasses for the three major commercial prawn species were 178 tons per yr with a landed value of US$12,325 annually. In most parts of the developing countries of East Asia, however, the goods and services from the habitat are being used unsustainably without regard to the external costs that their actions impose upon the ecosystems and upon others who also depend upon them. The "total economic value" of seagrass ecosystems should be estimated using a cost-benefit analysis to compare the sustainable management of the habitats with alternative use scenarios.

It should be emphasized, however, that in the process of valuation we face the dilemma of pricing the priceless, of quantifying the unquantifiable, of creating common standards for things apparently unequatable (de Groot 1992). Fonseca (personal communication) argued that trying to determine the monetary value of an obviously rich and biologically diverse resource as a seagrass ecosystem might be a waste of time, for this will only further delay its development. But until better instruments and methodologies are found, giving money values to ecosystem functions may help convince policy makers and financiers of development projects of the importance of nature conservation and the true meaning of environmentally sustainable economic development. In the valuation process, however, ecologists should be involved more actively with the view that the whole exercise is purely for the purpose of management. This is because if they are not, others who are less informed of the true worth of the environment eventually will, and attach to it a much lower price. The low values attached to coastal resources are one principal reason for their continued loss.

4. Use available scientific knowledge as a means to forge public-private partnerships -
In order to manage the seagrass resources sustainably, it is necessary to use the relevant scientific information that is currently available. It should inform conservation strategies at the local, national, and regional levels. It is also necessary to generate new knowledge to fill in gaps in our understanding of the ecosystem in the face of environmental change. Hence, we should start by using the knowledge that we have, organizing it electronically, and providing it to those who need it. To accomplish this, we will need to form partnerships among governmental organizations at international, regional, national and local levels, and between them and the private sector. These partnerships, using up-to-date information, can begin the process of developing coordinated strategies by designing best management practices and further sharing information.

5. Ensure a functional coordination among concerned agencies -
The absence of coordinated actions for conservation is one factor that allows continued degradation of the region's coastal resources. At present, the Philippines is probably not gaining the full value of lessons learned from coastal policy successes and failures. This makes it more difficult to translate the results of scientific research into management and policy decisions. Coordinated actions among agencies mandated to protect the coasts is badly needed. This is to (1) eliminate duplication of effort and therefore save and invest funds more wisely; (2) illuminate research areas of cooperation research between agencies and academia; (3) to facilitate the development of information systems that would serve not only management agencies but also the public; and (4) provide forums for discussion, so that lessons learned by one entity can be instructive to many.

6. Ensure high quality scientific publication: a shift from description to synthesis -
The problems of insufficient information arising from the relatively low priority the Philippine Government accord seagrass research and the poor quality, largely descriptive, data available are reflected in the share Third World countries have in the so-called international scientific literature. Hence, data available have low predictive value, especially in mitigating disasters and managing resoruces. Although developing countries encompass 24.1% of the world's scientists and 5.3% of its research spending, most leading journals publish far smaller proportions of articles by authors from these regions (Gibbs 1995).

Impediments to addressing the issues
The major obstacles to solving the environmental problems and issues with regards to the seagrasses in the Philippines are given below. They are directly or indirectly related to the improper or non-use of scientific knowledge that has been generated, coupled with the small importance (hence, support) governments in the region give to seagrasses. Addressing them effectively would substantially reverse the trend in seagrass ecosystem degradation in the country:

1. Lack of trained seagrass researchers –
Scientists principally from only two local institutions produce half of the production of scientific papers on seagrasses in primary literature in the country;

2. Limited scope of work –
Most of the studies are focused only on 10% of the seagrass flora and from only two biogeographic areas of the country. The works are largely descriptive, and published works are largely qualitative and not synthetic, hence, with low predictive value useful to resource management;

3. There are gaps in basic knowledge –
No information exists on the extent, status, and uses of seagrass beds that are affected by eutrophication, sedimentation, pollution, unsustainable fishing practices and climate change;

4. Lack of appreciation of seagrasses –
The importance of seagrasses and of managing these resources is generally academic and peripheral;

5. Limited and uncoordinated research –
Coordination in the country's seagrass research is extremely limited and fragmented;

6. Misguided management efforts –
These have remained focused mainly on identifying the problems and planning remedial or curative, not preventive measures; therefore, not actually solving the problems that the seagrass ecosystem and coastal environments face;

7. Lack of implementation of laws –
Simple rules and regulations protecting the coastal environment and resources are violated and/or not implemented. Marine policy in many municipalities remain unenforced for various reasons;

8. Lack of effective linkages –
This is especially between marine science institutions (scientific production) and the productive sector (application); and

9. Non-consideration of the social and cultural dimensions –
The sociocultural aspect of the problems seagrass studies are facing is either not yet studied or not perceived as an integral part of the process.

Unless there is a substantial change in the local and national legislative agenda on marine coastal research and development within the majority of the country's municipalities, the lack of national commitments to support and encourage the development of the science and an effective conservation program on seagrasses will remain a major deterrent.

CONCLUSION

The Philippines needs scientists who can make good plans and initiate actions for the conservation of the country's seagrass resources. The planning process must start with a value discussion that ends up with general and operational goals: what do we want of our seagrass habitats in the midst of the kind of coastal development the country wants? What kind of social, cultural and environmental qualities does its people want to keep or strive for? Because of great variety in culture and interests in the region, such goals should be decided after a comprehensive planning process with broad input from all interest groups. These comprehensive plans need to be tested for realism under conditions of limited resources and established environmental quality requirements. These relatively scarce resources must be managed in the context of competing demands, and the environment must be considered as the region's inhabitants change their social, technical, or economic activities.

Here, natural and social scientists and engineers have a social obligation to seek a solution. They should develop a stronger sense of ethical responsibility. In the longer term, sound management of seagrass and marine ecosystems would depend on an educated community in which members understand the importance of a mix of conservation, development and community participation. Past, and probably present governments have not tried to educate the population towards a more realistic way of life, nor to convince them that because of globalization, for example, the world is shrinking, that modernization needs hard work, and that we are obliged to support the sustainability of our environment. The science community needs to develop and nurture an ethic that views seagrass as a resource in need of our stewardship and not simply a commodity. The extent to which local community participation in marine environmental protection and resource management can be fostered will be a significant factor in determining the quality of the marine environment and the availability of its resources in the future.

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