Seagrass beds of the Philippines

[1]Hilconida P. Calumpong and [2]Ernani G. Meñez
[1]Siliman University Marine Laboratory, Dumaguete City 6200, Philippines
[2]Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, USA

ABSTRACT

Seagrass beds are widespread in Philippine nearshore areas. They are productive, hence, much fishing and gleaning occur. For *Enhalus acoroides*, growth was reported to reach 2 cm d^{-1} and primary production to 0.92 g C m^{-2} d^{-1}. A total of 13 species was recorded. *Thalassia hemprichii* is the most widely distributed and *Halophila beccarii* is endangered. The Philippine seagrass flora is closely related to the Indo-West Pacific. They form either monospecific stands or meadows of two major associations: *Syringodium-Cymodocea-Halodule* in sandy substrates, *Enhalus-Thalassia* in muddy substrates. Majority of the Philippine species flower during the warm months. The major contribution of seagrasses is organic matter in the form of leaf litter (average of 0.5 gdwm^{-2} tidal cycle^{-1}). As in other ecosystems, seagrass beds suffer from natural and human-induced stresses. Seagrass transplantation was explored as a possible mitigating intervention. Research is still lacking in terms of management strategies and the biology of certain species, including a study of obligate inhabitants of seagrass beds.

Keywords: *Seagrass, Philippines, ecology, biology, management*

INTRODUCTION

Seagrass beds are ecosystems dominated by grass-like flowering plants adapted to saline aquatic habitats. The bed is composed of seagrass plants themselves, their associated root-dwelling and leaf-dwelling organisms and parasites, their associated fauna including plankton and microbes, and regulated by the spatial and temporal arrangement of its living and non-living components (Phillips and Meñez, 1988).

Seagrass ecosystems are widespread in Philippine waters occupying intertidal to subtidal areas (Fig. 1). In most cases, these are productive areas where much fishing and gleaning take place.

Most seagrasses are very similar in gross external morphology. Except for *Syringodium* whose leaves are terete, the rest have flat, thin and blade-like leaves. Except for *Halophila* whose leaves are ovate, elliptic, lanceolate to linear oblong, the rest have thin and strap-shaped leaves.

SPECIES COMPOSITION

In terms of species number, the marine flora excluding marsh plants and mangroves is pre-

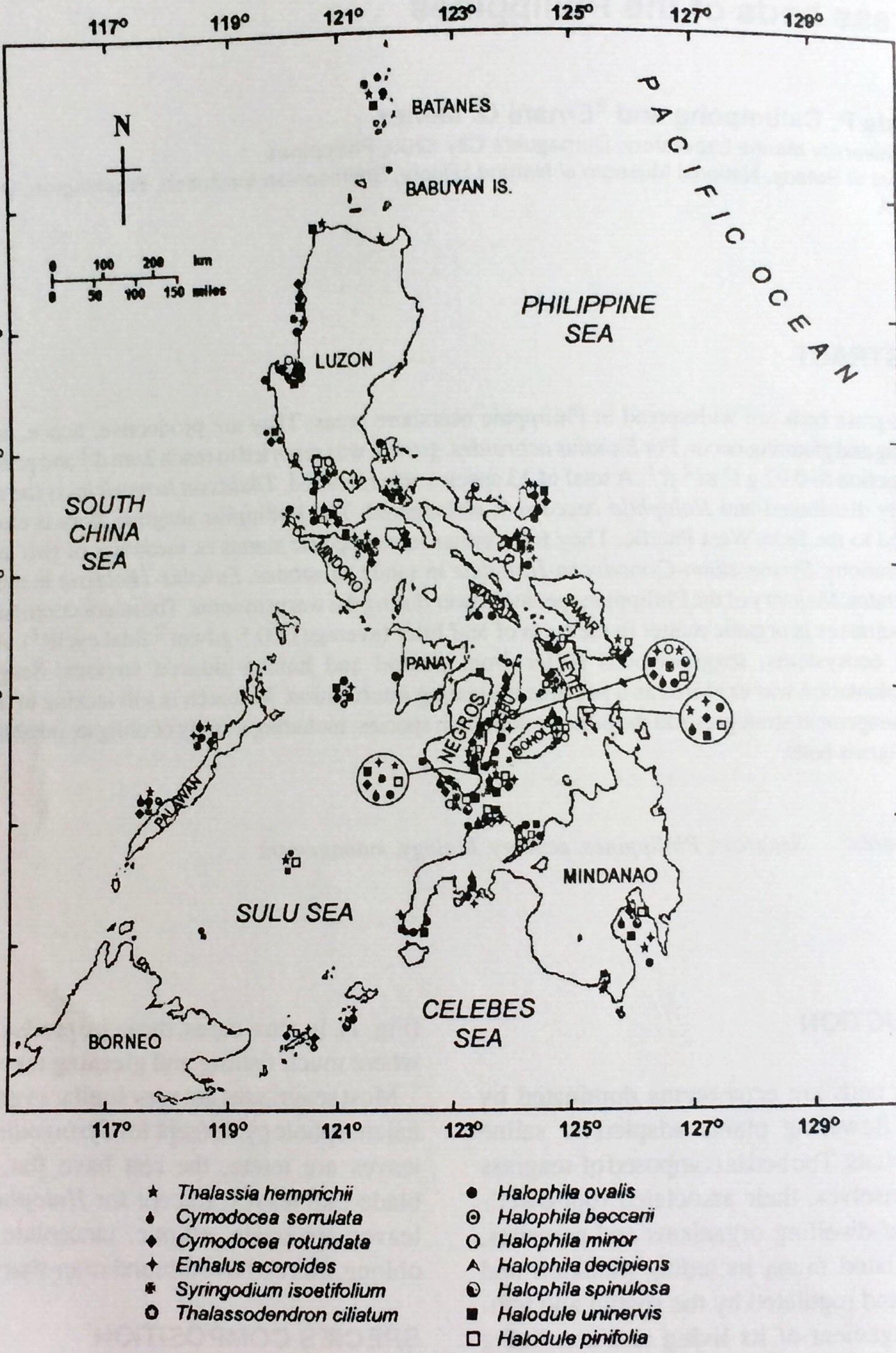

Figure 1. Map of the Philippines showing seagrass beds. Data from published reports and authors' surveys.

dominated by algae, followed by fungi, then seagrasses. The latter are flowering monocotyledonous angiosperms (Division: Anthophyta, Class: Monocotyledoneae) belonging to order Helobiae distributed between two families: Hydrocharitaceae (3 genera: *Enhalus, Halophila, Thalassia*) and Potamogetonaceae (9 genera: *Amphibolis, Cymodocea, Halodule, Heterozostera, Phyllospadix, Posidonia, Thalassodendron, Syringodium, Zostera).*

A total of 13 species was recorded in Philippine waters (Meñez, et al., 1983; Meñez and Calumpong, 1983; 1985). However, Fortes (1986) reported 16, including an undescribed species of *Halophila*, an undescribed new variety of *H. minor* and *Ruppia maritima* L. var. *rostrata* Agardh. A key to the species in the Philippines is given below. This represents 27% of the total species reported worldwide, second only to Australia which has 23 species (Phillips and Meñez, 1988). Tsuda (1984) compared the seagrass flora in five islands in Micronesia with those of the Philippines. He noted a decrease in the number of species as one goes away from mainland Asia, and also the typical dispersal pattern with the farthest island from the mainland harboring only one species (Table 1).

Key to the Philippine Seagrasses
(revised from Meñez, et al., 1983)

1. Leaves cylindrical... .... *Syringodium isoetifolium* (Ascherson) Dandy
   Leaves flat 2
2. Leaves elliptic, ovate, lanceolate or linear-oblong .... *Halophila*
   A. Leaves lanceolate, without cross-veins .... *H. beccarrii* Ascherson
      Leaves otherwise, with cross-veins .... B
   B. Leaves with 12-22 pairs of cross-veins .... *H. ovalis* (R. Brown) Hooker f.
      Leaves with less than 10 pairs of cross-veins C
   C. Leaves distichous on long shoot .... *H. spinulosa* (R. Brown) Ascherson
      Leaves in pairs on very short shoot .... D
   D. Margins serrulate .... *H. decipiens* Ostenfeld
      Margins entire .... *H. minor* (Zollinger) den Hartog
   E. Leaves linear or strap-like 3
3. Leaves ligulate 4
   Leaves not ligulate 6
4. Leaf veins no more than 3 .... *Halodule*
   A. Leaf tip irregularly serrated; tip of midrib often truncate .... *H. pinifolia* (Miki) den Hartog
      Leaf tip tridentate; tip of midrib not truncate .... *H. uninervis* (Forsskål) Ascherson
      Leaf veins more than 3 5
5. Unbranched or once-branched shoots produced at every 4th internode or rhizome; roots borne on internode with numerous tough, wiry laterals .... *Thalassodendron ciliatum* (Forsskål) den Hartog
   Shoots and roots not as above .... *Cymodocea*
   A. Leaf tip smooth or slightly serrulate; leaf blades linear .... *C. rotunda* Ehrenberg and Hemprich ex Ascherson
      Leaf tips serrate; leaf blades linear-falcate .... *C. serrulata* (R. Brown) Ascherson and Magnus
6. Rhizome more than 1 cm in diameter, generally bulbous; roots naked; leaves linear with persistent basal black fibers .... *Enhalus acoroides* (Linnaeus f.) Royle
   Rhizome less than 1 cm in diameter; roots dense beset with filiform laterals; leaves linear-falcate without basal black fibers .... *Thalassia hemprichii* (Ehrenberg) Ascherson

Table 1. Distribution of seagrasses in the Pacific. After Tsuda, 1984.

Species	Phil	Palau	Yap	Truk	Ponape	Marshalls
T. hemprichii	X	X	X	X	X	X
E. acoroides	X	X	X	X	X	
C. rotundata	X	X	X	X		
C. serrulata	X	X	X	X		
S. isoetifolium	X	X	X	X		
H. ovalis	X	X	X			
H. decipiens	X	X	X			
H. uninervis	X	X				
H. pinifolia	X	X				
T. ciliatum	X	X				
H. beccarii	X					
H. minor	X					
H. spinulosa	X					

The Philippines has two major seagrass associations which in most cases are dependent on substrate. Those that thrive on sand-dominated substrates are generally of the *Syringodium-Cymodocea-Halodule* complex (Fig. 2) while those that thrive on muddy substrate are generally of the *Enhalus-Thalassia* associations (Fig. 3). Monospecific stands are generally encountered in very specific environments: e.g., *Enhalus acoroides* in highly turbid protected embayments (Fig. 4), *Halophila decipiens* in 11-23 m deep habitats (Meñez and Calumpong, 1985; Fig. 5) and *Thalassia hemprichii* in the northernmost part of its Philippine distribution (Imnajbu, Batan I.: Calumpong et al., 1986). Most surveys (Ogawa, 1987; pers. obs.) found at least two species growing in one bed.

DISTRIBUTION AND AFFINITIES

Representatives of the seven genera considered characteristic of tropical seas are found in the Philippines (Phillips and Meñez, 1988). The most widely distributed tolerating a whole range of temperature and habitat is *Thalassia hemprichii* colonizing as far north as 20°26'20" N latitude in Batanes (Calumpong et al., 1986), to 06°17' N latitude in Malita, Davao Gulf in the south (Calumpong et.al., 1985). Compared to its distribution worldwide, this species is found as far north as the Ryukyu Islands in Japan, down to Queensland in Australia, as far west as the east coast of Africa and east to Micronesia (Phillips and Meñez, 1988). It thrives in mud, sand and coral substrates.

Two species, *Thalassodendron ciliatum* and *Halophila decipiens* are limited in their distributions (Meñez and Calumpong, 1983, 1985; Phillips and Meñez, 1988). *T. ciliatum,* although found in shallow places, is associated only with clear waters and coarse and rocky substrates (Meñez and Calumpong, 1983) whereas *H. decipiens* was collected in depths greater than 3 m (Meñez and Calumpong, 1985) and associated with sand-silt substrates.

Perhaps the only species that may be considered endangered is *Halophila beccarii.* Although this was reported as growing in abundance in the South China Sea and Bay of Bengal (Phillips and Meñez, 1988), the only specimens collected from the Philippines were from Manila Bay reported

Figure 2. *Syringodium-Cymodocea-Halodule* mixed bed in the subtidal area in front of the Silliman University Marine Laboratory in Bantayan, Dumaguete City, Negros Oriental. Photo courtesy of R. Phillips.

Figure 3. *Enhalus-Thalassia* mixed bed in the intertidal area in Bais City, Negros Oriental.

Figure 4. Monospecific stand of flowering (arrow) *Enhalus acoroides* in the subtidal area in Bais Bay, Negros Island.

Figure 5. Monospecific bed of *Halophila decipiens* in Siaton, Negros Oriental at 11-23 m deep.

by Merrill in 1912 and subsequently cited by other workers (Mendoza and del Rosario, 1967; den Hartog, 1970; Meñez, et al., 1983) and from the east bank of Agno River in Lingayen Gulf, Pangasinan (Fortes, 1986).

In terms of ecological affinities, Rollon and Fortes (1991) reported that more seagrass species was often found in moderately exposed, sandy-muddy substrate. They predicted a high probability of finding *Halodule uninervis* and *Syringodium isoetifolium* together indicating that the two share close ecological requirements.

In terms of geographical affinities, Table 2 clearly shows that the Philippine seagrass flora, which is part of the Indo-West Pacific flora, is presently closely related to the Caribbean and Australia. It does not share any seagrass species with Western America. Such affinities may be explained by movement of once-widely distributed ancestral biotas by tectonic events, followed by parallel speciation and extinction as evidenced by similarities in generic richness of hermatypic corals and mangroves (McCoy and Heck, 1976).

REPRODUCTIVE PATTERNS

Clear-cut flowering and fruiting seasons were observed in most seagrass species (Figs. 6, 7). Six species (*Halophila decipiens, H. ovalis, H. minor, H. spinulosa, Enhalus acoroides* and *Syringodium isoetifolium*) flower during the warm months. *Cymodocea serrulata* probably also flowers during these months as fruits were collected in August (Fig. 7). For all the other species, no flowers and fruits were collected although their flowering and fruiting seasons have been reported elsewhere (Phillips and Meñez, 1988; den Hartog, 1970).

PRIMARY PRODUCTIVITY

Seagrasses are noted for their fast growth and therefore higher productivity. Table 3 summarizes primary productivity values obtained for certain species in the Philippines.

Primary productivity of seagrasses is enhanced by epiphytic algae (Fig. 8). In Bantayan Beach,

Table 2. Geographical distribution of 12 genera of seagrasses. Data from den Hartog, 1970.

Genus	Indo-West Pacific	Caribbean	Australia	Western Americas	Eastern Americas	Europe	West Africa
Zostera	X		X	X	X	X	
Posidonia			X			X	
Heterozostera			X	X			
Amphibolis			X				
Phyllospadix	X			X			
Syringodium	X	X	X		X		
Halophila	X	X	X		X	X	
Halodule	X	X	X				X
Thalassia	X	X	X		X		
Thalassodendron	X		X				
Enhalus	X		X				
Cymodocea	X		X			X	X

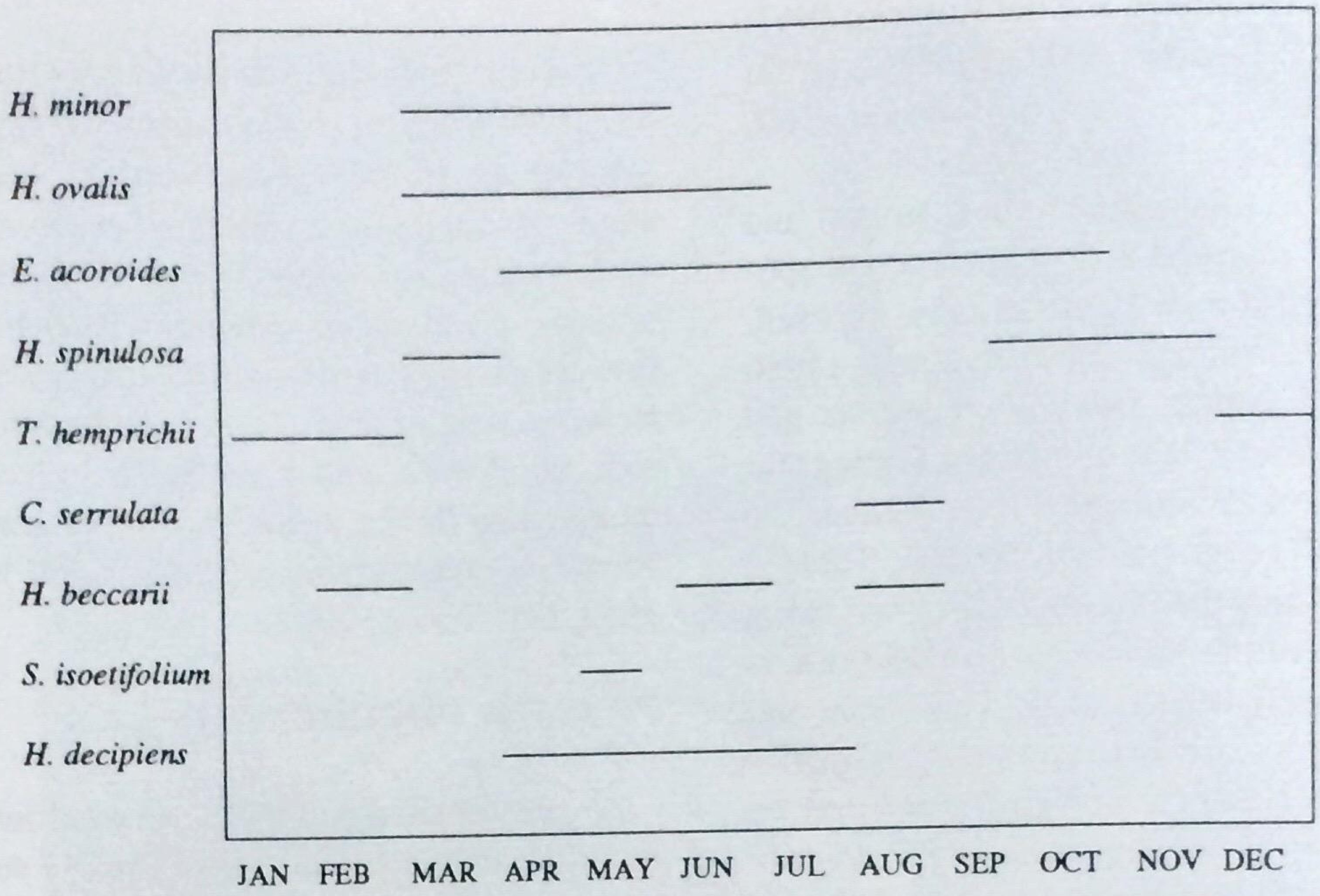

Figure 6. Reproductive patterns in Philippine seagrasses. (Solid line refers to flowering or fruiting or both.

Figure 7. Fruiting (arrow) *Thalassia hemprichii* growing in the intertidal area of Bais Bay, Negros Island.

Table 3. Summary of primary productivity values.

Species	Mean Growth Rate (Range) (cm leaf^{-1} day^{-1})	Primary Production (Range) (g C m^{-2} day^{-1})	Site	Source
E. acoroides	0.93 (0.74-1.06)	0.92(0.78-1.08)	Bais Bay (Negros I.)	Estacion & Fortes, 1988
	n.d.	0.68*	Bolinao (Pangasinan)	Fortes, 1984
	2.0	0.37*	Calatagan (Batangas)	Fortes, 1982
	n.d.	0.44*	Hundred I. (Pangasinan)	Fortes, 1986
	n.d.	1.55*	P. Galera (Mindoro)	Fortes, 1986
	1.33	1.87*	Siyt Bay (Negros I.)	(unpubl.)
T. hemprichii	n.d.	0.66*	Mactan I.	Largo, 1993
	n.d.	0.13*	Bolinao	Fortes, 1986
	n.d.	5.72*	Calatagan	Fortes, 1984
C. rotundata	n.d.	0.15*	Bolinao	Fortes, 1984

n.d. = no data
* = extrapolated from dry weight by using Westlake's (1963) formula.

Figure 8. *Thalassia hemprichii* and *Syringodium isoetifolium* with epiphytes dominated by the green alga, *Chaetomorpha crassa* growing in the intertidal area of Siquijor Island.

Dumaguete, Negros Island, this could reach 0.8-20.4 per cent of blade weights (Tomasko et al., 1993) with *Cymodocea serrulata* and *Thalassia hemprichii* being the preferred substrates.

SECONDARY PRODUCTIVITY

The occurrence of various organisms in seagrass beds and the latter's role as fishery nurseries was well-documented (Alcala and Alcazar, 1984; Estacion and Alcala, 1986; Oñate-Pacalioga et al., 1991). In five sites in northern Philippines (Bolinao in Pangasinan, Pagbilao in Quezon, Puerto Galera in Mindoro, Ulugan in Palawan and Banacon in Bohol), Vergara and Fortes (1991) recorded a total of 55 species of fish dominated by members of the Family Apogonidae with most fishes in the juvenile stage. In Bais Bay in Negros, Dolar (1991) recorded 49 species dominated by siganids and 19 species of crustaceans among the fishes collected were juveniles (Fig. 9). Figure 10 shows a bamboo trap specifically used to capture siganids. Dolar (1991) further showed that seagrass beds have more fish and crustaceans in terms of biomass than to sandy flats.

Seagrass beds provide not only habitat and substrate to marine organisms but also food. Lepiten (1992) reported that the population of *Siganus canaliculatus* (Park) alone in Bais Bay consumes 0.637 MT (metric tons) wet-weight of *Enhalus acoroides* per day (0.217 MT dw) equivalent to 0.32 g wet-weight (0.108 g dw) m^2 day^{-1} On an individual basis, this is equivalent to approximately 0.84 g wet-weight of *E. acoroides* $fish^{-1}$ d^{-1} with a calorie value of 633.941 kcal g^{-1} AFDW. This figure represents 4-5% of the organic production of *E. acoroides* in Bais Bay or 0.04 g C m^{-2} d^{-1} (calculated from mean value given by Estacion and Fortes, 1988). Salita-Espinosa et al. (1992) reported values of 0.223 and 0.289 g dw $fish^{-1}$ day^{-1} for *Siganus fuscescens* Houttuyn in Bolinao, Pangasinan.

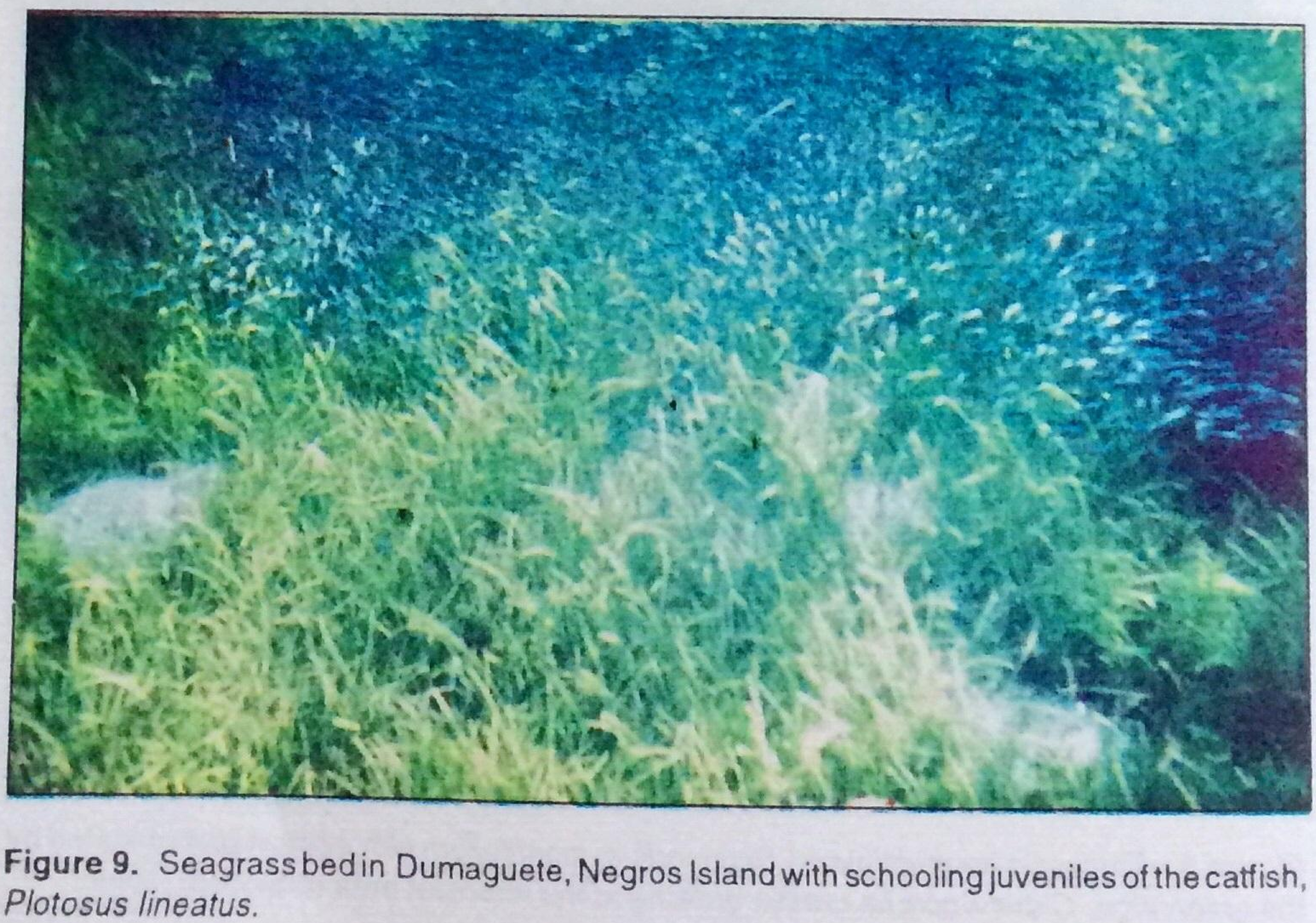

Figure 9. Seagrass bed in Dumaguete, Negros Island with schooling juveniles of the catfish, *Plotosus lineatus*.

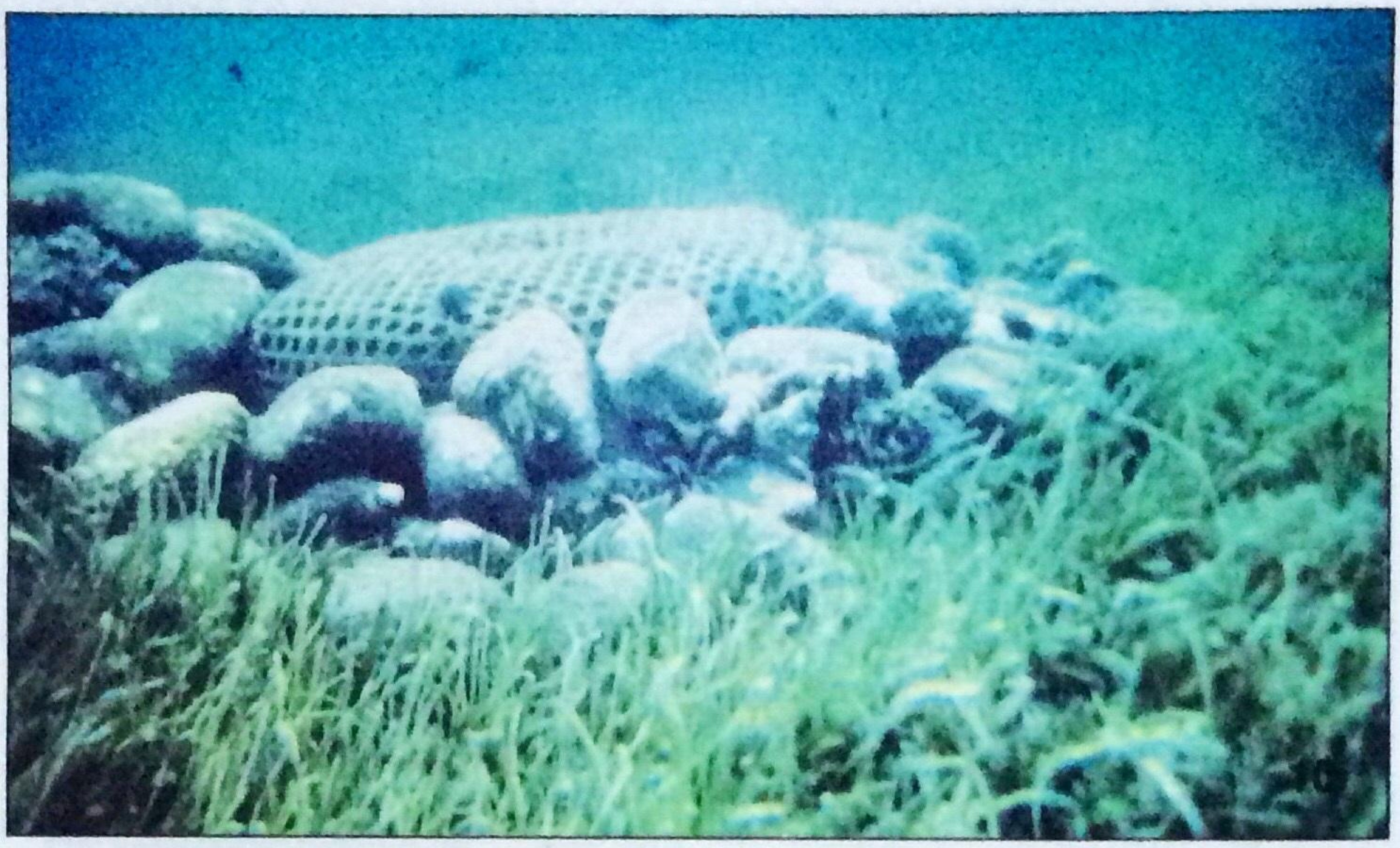

Figure 10. Bamboo trap used in Bantayan, Dumaguete, specifically for the capture of siganids placed at depths of 2 - 5 m.

CONTRIBUTION TO THE DETRITUS FOOD CHAIN

A big part of primary productivity of seagrass beds is not directly eaten by herbivores but shed as litter. This is because seagrasses do not only have high productivity but they also replace their leaves fast. Leaf turnover rates were as fast as 3.2 ± 0.7 days in *Cymodocea serrulata* (Tomasko et al., 1993) to an average of 67 days in *Enhalus acoroides* (Estacion and Fortes 1988) were reported. For leaf litter production, Oñate-Pacalioga (1990) reported an average of 0.529 ± 0.598 g dw • m^{-2} per tidal cycle in a mixed seagrass bed in Bais Bay, Negros Island, mostly contributed by *T. hemprichii*. As the leaves decompose, their nutrients are subsequently liberated to be used again by other plants, macroalgae and phytoplankton.

The rate of decomposition was experimentally documented using 0.5 mm mesh bags. It was highest (>50% weight loss) during the first week of placement in three sites (mangroves, seagrass bed, coral reef) and complete after 10-14 weeks (Oñate-Pacalioga, 1992). Decomposition was found to be due to microbes (Fenchel, 1970; Harrison and Mann, 1975). The early colonizers were reported to be carbohydrate degraders (Wahbeh and Mahasneh, 1985). Subsequently, these microbes attract meoifauna (Wahbeh and Mahasneh, 1985), reduce decomposition by microbes but increase fragmentation due to the chewing and grinding action of the meiofauna (Fenchel, 1970; Harrison and Mann, 1975; Robertson and Mann, 1980). Oñate-Pacalioga (1992) found that the number of meiofaunal groups in her samples increased during the second to the third week after placement with crustaceans, mollusks, polychaetes and juvenile echinoderms dominating in that order.

Direct utilization of seagrass detritus by macrofauna was observed in deep ecosystems in the Caribbean by Suchanek et al. (1985). Using

Figure 11. Boat anchor in a seagrass bed off Bantayan, Dumaguete. Depth = 3 m.

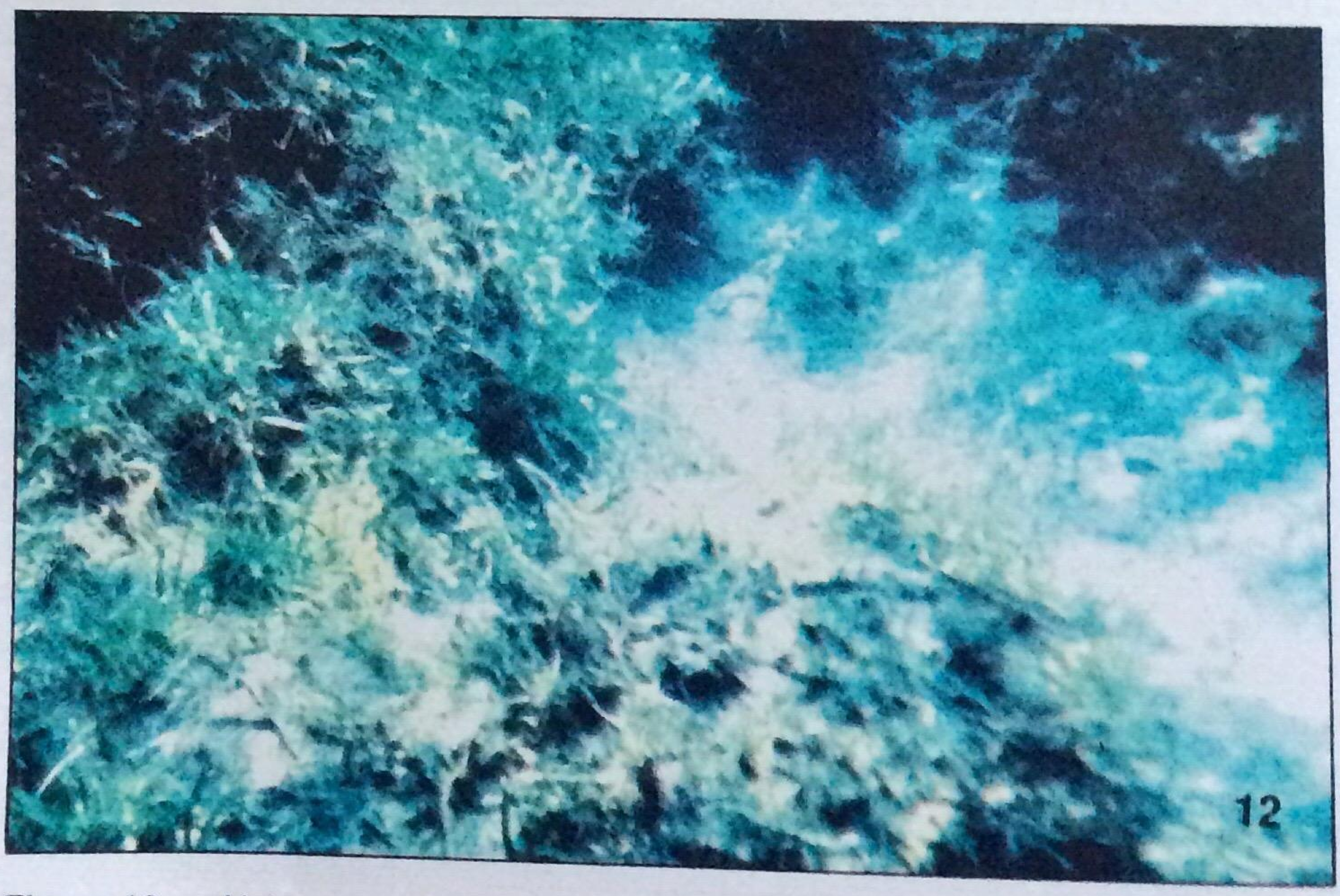

Figure 12. Holes caused by boat anchors causing excavations of seagrass beds. Depth = 3 m.

C^{13}, they to documented the direct utilization of seagrass detritus by three species of holothurians and two species of sea urchins at depths of 2,455-3,950 m.

MANAGEMENT PROBLEMS

Seagrass beds are continually being exploited not only for fishing but for developmental purposes. Figures 11 and 12 show that damage done to seagrass beds by something as small as a boat anchor can be substantial. One can just imagine the degree of damage to such ecosystems when these are converted into docks, roads, resorts, airports, or when used as dumping sites for domestic as well as industrial wastes.

The use of seagrass transplants (Fig. 13) as a viable mitigation option was explored by Calumpong et al. (1993). Using reciprocal transplants in three sites in Negros Island, the performance of five species of seagrass depended on several factors including substrate type, wave and currents, grazing and siltation with *Cymodocea serrulata* exhibiting fastest increase in shoot density in shallow areas (Calumpong et al., 1993). Other experiments on transplantation were done by Largo (1993) who obtained only 8-month survival of plugs of *Thalassia* but found *Halodule* to survive longer.

RESEARCH PRIORITIES

More information about the biology and ecology of Philippine seagrasses is needed. Only the primary productivity of three species is known and methods of determining productivity in seagrasses have yet to be standardized. Even with the taxonomy of seagrasses, questions on the conspecificity of broad-leaved and narrow-leaved *Halodule uninervis* are raised. Most importantly, schemes to manage seagrass beds must be developed. A thorough study of organisms that are obligatory seagrass inhabitants is critical to fully evaluate the impact of the loss of seagrass beds.

Figure 13. A seagrass sod from the intertidal transplanted into the subtidal in Bantayan, Dumaguete. Depth = 5 m.

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