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COMMUNITY STRUCTURE AND BIOMASS OF SEAGRASS BEDS IN THE ANDAMAN SEA. I. MANGROVE-ASSOCIATED SEAGRASS BEDS.

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ABSTRACT

The ASEAN-Australia Marine Science Project "Living Coastal Resources" included studies on mangrove-associated seagrass beds at 10 stations. Two species of seagrasses were found at almost all transects: *Enhalus acoroides* (33.4% coverage) and *Halophila ovalis* (18.2% coverage). Five species occurred sparsely: *Thalassia hemprichii, Cymodocea rotundata, Halodule uninervis, Halodule pinifolia* and *Halophila beccarii.* The overall grass coverage was 63%. Total seagrass biomass ranged from 55-1941 g w.w m^{-2} corresponding to 32-297 g d.w. m^{-2}. Leaf and root-rhizome biomasses of the 7 species were estimated; *Thalassia hemprichii* had the highest above-ground and below-ground biomass.

INTRODUCTION

Seagrasses are common in shallow marine waters throughout tropical and temperate regions of the world (den Hartog, 1970; McRoy and Helfferich 1977; Phillips and McRoy, 1980). However, in a recent 840-page treatise on seagrass biology (edited by Larkum *et al.* 1989) only 8% of the pages dealt with tropical seagrasses. This indicates how poorly known these tropical resources are. Recently more information has been published on seagrasses of Southeast Asia and Indo-West Pacific region (Alcala, 1991 (*ed.*); Chou and Wilkinson, 1992 (*eds.*) and Pollard *et al.*, 1993 (*eds.*)).

Based on estimated below-ground biomass for many seagrasses, Zieman and Wetzel (1980) and Thayer *et al.*(1984) suggested that roots and rhizomes contributed substantial amounts of organic matter to the sediment of the Atlantic coast. Kenworthy and Thayer (1984) presented hypotheses on the functional role of organic matter derived from the production of roots and rhizomes of seagrass. Biomass values of above-ground and below-ground for seagrasses are summarized by Lewis *et al.* (1985) and Virnstein and Howard (1987). But limited information is available on production and utilization of organic matter originating from roots and rhizomes of seagrass in the Asean region. Similarly, only a few studies on community structure, primary production and biomass of seagrasses have been reported from this region (Estacion and Fortes, 1988); Azkab, 1991; Rollon and Fortes, 1991). Seagrass habitat utilization by groups of animals, such as fishes and crustaceans, was investigated and reviewed by Dolar (1991), Sudara, *et al.* (1991), and Vergara and Fortes (1991).

Investigations of grass beds of the Andaman Sea were conducted under the ASEAN-Australia cooperative programme on marine science. Three types of Seagrass beds have been identified along the Andaman Sea coast of Thailand (Chansang and Poovachiranon, 1994): I) Mangrove-associated seagrass beds. II) Seagrass beds on shallow sandy bottom. III) Seagrass beds associated with coral reefs. This study provides information on seagrass species composition, biomass and zonation of mangrove-associated seagrasses in the Andaman Sea. The aim is to increase the knowledge of seagrass contributions to coastal ecosystems in Thailand.

MATERIALS AND METHODS

Site description

The Andaman Sea west coast of Thailand is approximately 740 km long. The shoreline is characterized by mangroves, river mouths and sandy beaches. Fringing reefs are commonly present around islands or rocky outcrops. The climate of the area is under monsoonal influence. There are two dominant seasons, *viz.*, a rainy season dominated by Southwest Monsoon (May-October) and a dry season when Northeast Monsoon predominates (November to April). The tide is semidiurnal with a range from 1.1-3.2 m. Tide was measured at mean low water (MLW) and mean high water (MHW) at various stations along the Andaman Sea from 1988-1992. Mean sea level is about 2.2 m (calculated from Tide Table of the Hydrographic Department, Royal Thai Navy).

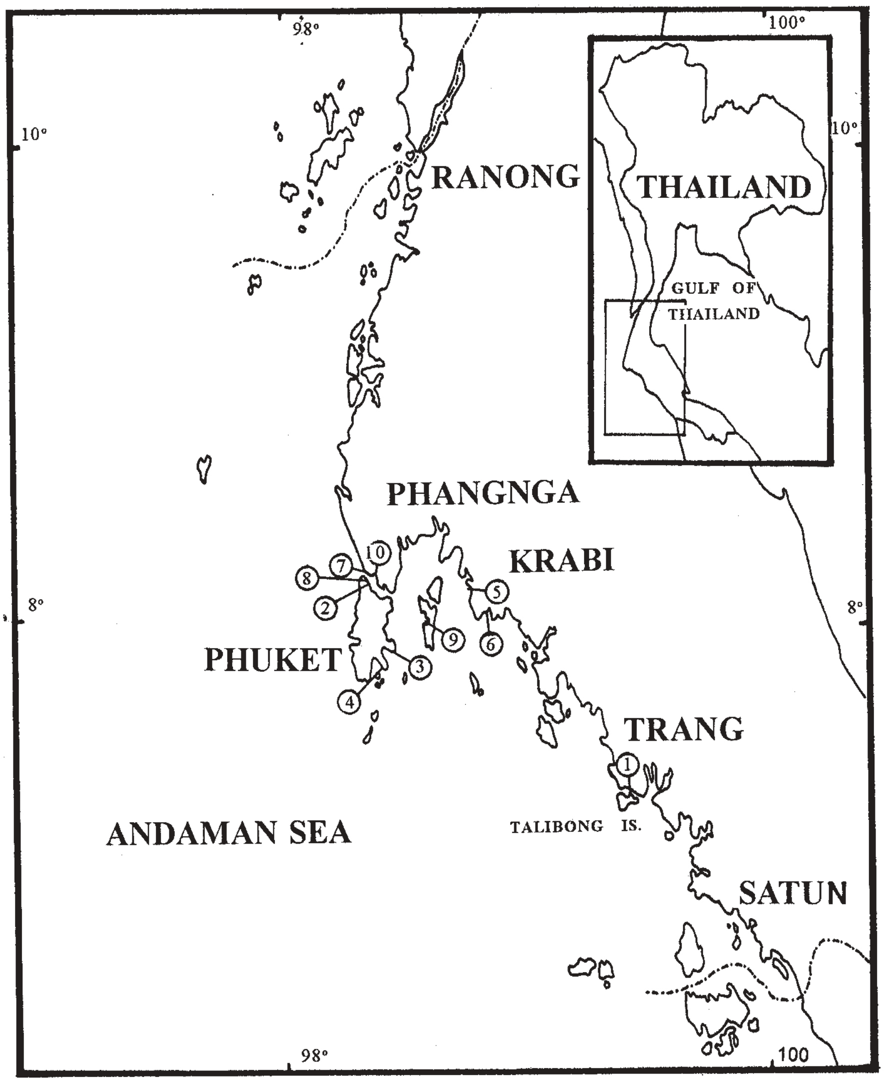


Figure 1. Mangrove-associated seagrass beds along the Andaman coast of Thailand. Numbered circles show 10 stations of this study.

Ten mangrove-associated seagrass beds were studied (Fig. 1). Four sites were in Phuket province: Banthayai (station 2), Banlaemphappha (station 3), Ao-Chalong (station 4) and Thachatchai (station 8); two study sites in Krabi province at Ao-Thalane (station 5) and Ao-Nang (station 6); three sites in Phangnga province at Banpakklongyid (station 7), Yaoyai-1 Island (station 9) and Ao-Tonong (station 10). One site was in Trang province at Talibong-1 Island (station 1). The grass beds in Phangnga province represent the greatest area of mangrove-associated seagrass beds among the 10 stations.

Transect profile and biomass study

The line transect method of Dartnall and Jones (1986) was used for transect profile, percentage seagrass species coverage, and seagrass biomass. Most grass beds were exposed during low tide. Transects started at mangrove edges and ran perpendicular to the shore line. Transect depth profiles were measured at maximum high tide at 50 m intervals using small buoys placed on the transect during low tide. Mean water depth for each species was obtained by averaging the range of depth distribution at each site. The shore profile was calculated in relation to MHW using time of day and tidal data for the Andaman Sea.

Four quadrats (50 x 50 cm) were sampled at random along the transects (unless otherwise indicated). Leaves, roots, and rhizomes were collected by hand inside each quadrat. The samples were rinsed, cleaned of adhering debris, and sorted to species. The shoots of each species were weighed, and material of the same species combined from the four samples. Fifty shoots from each species were separated into leaves, rhizomes and roots for biomass study. Each portion was blotted, weighed wet (w.w.), and dried at 90 °C to constant weight (d.w.). The above and below ground biomasses were weighed for each station and species. Finally, percentage species coverage and species composition were estimated along transect lines. Intervals for these estimates were selected after visual inspection of the grass bed.

RESULTS

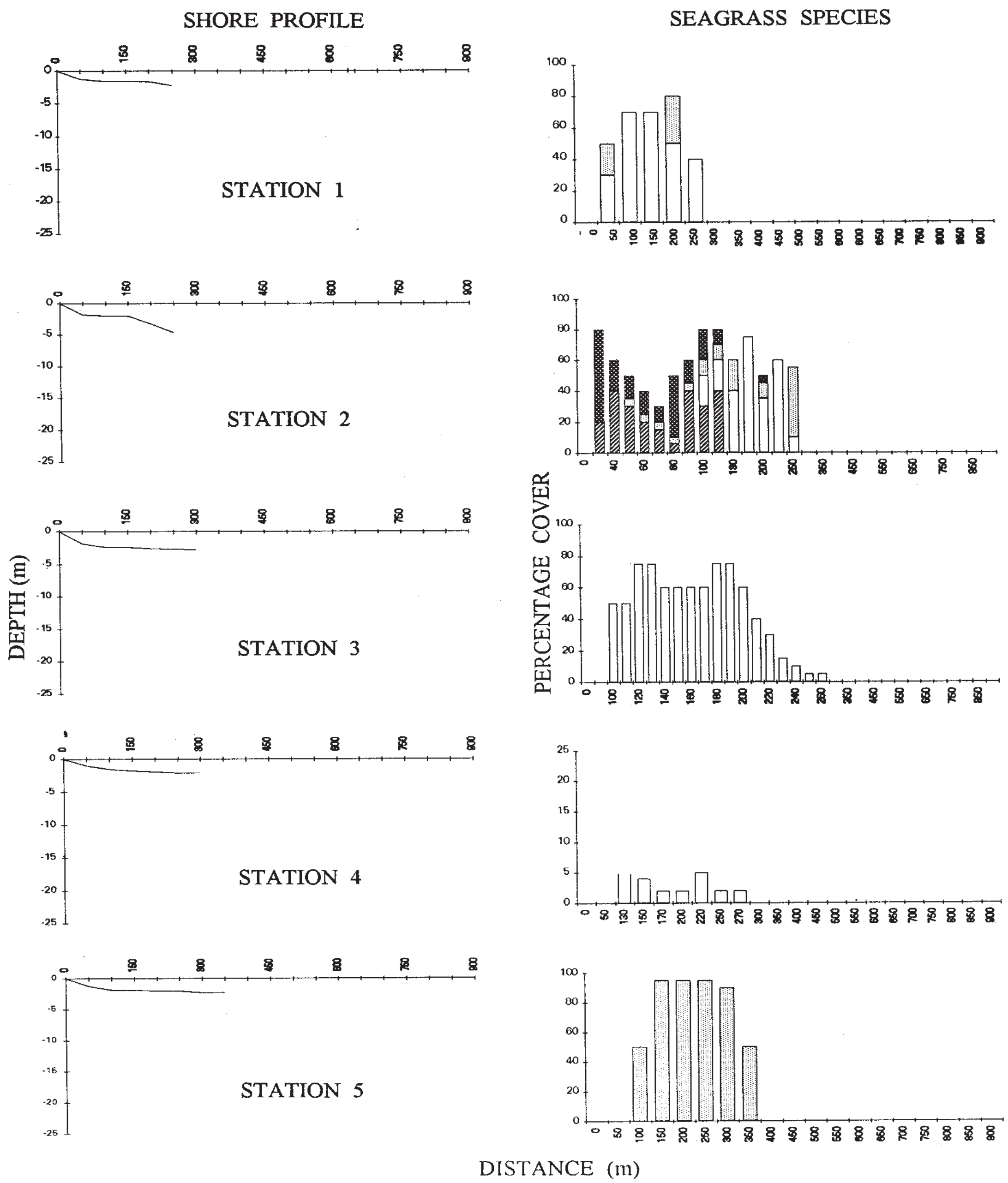
The individual transects

Mangrove associated grass beds are characterized by relatively narrow bands of grass bed adjacent to mangroves fringing bays or sheltered shorelines. The upper part of a grass bed is intertidal. Sediments are either homogeneously composed of very fine to medium sand, or non-homogeneous changing along the transect in offshore direction from very fine sand to fine sand or mud, or from fine sand to coarse sand.

Fig. 2 shows characteristic shore profiles and species composition expressed as the percentage seagrass cover of beds associated with mangrove communities. Each grass bed profile stretched 250-650 m and had different topography (slope) and substratum.

Station 1: 250 m transect. The grass bed started 50 m from the mangrove at 1.5 m depth. The edge of the bed reached a depth of 2.3 m at MHW. The bed was dominated by *Enhalus acoroides* occurring continuously to the end of the seagrass bed. *E. acoroides* had 70% coverage in the area between 100 and 150 m. Sparse patches of *Halophila ovalis* mixed with *E. acoroides* occurred at 50 and 200 m. The substrata were fine to very fine sand.

Station 2: 260 m transect. Seagrass covered approximately 60% of the area. The depth varied from 1.8 to 2.0 m in the upper part of the transect (50-100 m). From 100 m and seawards, the depth increased from 2-4.65 m at the end of transect . The vegetation was composed of mixed stands of *Cymodocea rotundata, Thalassia hemprichii* and *Halophila ovalis* in the 50-100 m interval. In the area between 100 and 260 m, the beds comprised *Enhalus acoroides, Cymodocea rotundata, Thalassia hemprichii* and *Halophila ovalis*. These species had coverage of 18.6, 17.9, 15 and 8.5%, respectively. Homogeneous, medium sand substratum dominated this grass bed.



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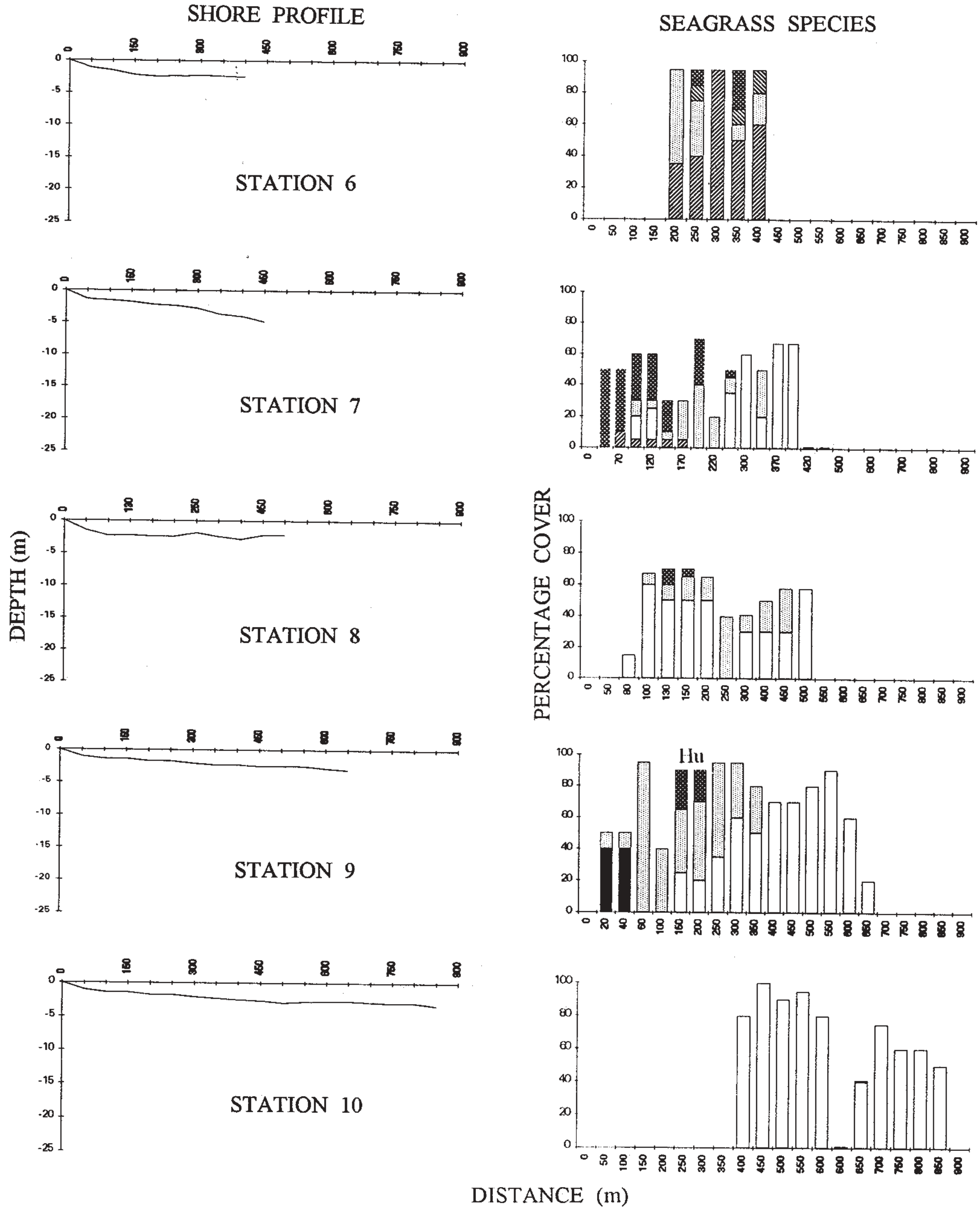

Figure 2. Mangrove-associated seagrass beds along the Andaman Sea coastShore profiles of 10 seagrass beds (left) and percentage cover (right). The following abbrivations has been used to show the percentage cover of individual species: ▨ = *Cymodocea rotundata*, □ = *Enhalus acoroides*, ■ = *Halophila beccarii*, ▩ = *Halophila ovalis*, ▧ = *Halodule pinifolia*, Hu = *Halodule uninervis*, and ▩ = *Thalassia hemprichii*.

Stations 3 & 4: 260-270 m transects. Seagrass beds of these stations were similar in terms of length, slope and species composition. Only one species, *Enhalus acoroides*, had a patchy occurrence in the upper and lower tidal zones at a maximum depth of 2.8 m (station 3). It was infrequent at station 4, where patches occurred at a maximum depth of 2.1 m. Seagrass coverage was 47.4% on very fine sand substratum in the area between 100 and 260 m at station 3. The coverage was 4% on very fine sand to muddy substratum in the area between 130 and 270 m at station 4.

Station 5: 350 m transect. A pure stand of *Halophila ovalis* stretched across the total transect from shallow water to the maximum depth of 2.3 m. Coverage ranged from 50-90% (mean 79.17%.). The substratum was fine sand.

Station 6: 400 m transect. Seagrass beds extended from the mangrove line and 200 m seawards to a water depth of 2.4 m. Depth increased to 2.5 m in the area between 200 and 400 m. *Cymodocea rotundata* was the most common species (56% coverage) followed by *Halophila ovalis* (25%), *Thalassia hemprichii* (7%), and *Halodule pinifolia* (7%). The substratum was fine sand.

Station 7: 470 m transect. *Thalassia hemprichii* was common in the upper part. Coverage was 20 to 50%. Water depth increased from 1.3 m to 1.8 m in the area between 50 and 200 m. *Thalassia hemprichii, Halophila ovalis, Cymodocea rotundata* and *Enhalus acoroides* were found in this area. Depth increased progressively to 4.8 m at MHW over the stretch from 200 m to the end of the transect. Seagrass occurred to the maximum depth of 4.8 m. *Halophila ovalis* grew in a mixed community with *Enhalus acoroides* and *Thalassia hemprichii.* The coverage of *Halophila ovalis* ranged from 1 to 40%. The coverage of *Cymodocea rotundata* ranged from 5-10% in the area between 70 and 170 m. *Enhalus acoroides* occurred in two areas: one zone between 100 and 120 m; the other one between 270 and 390 m. Coverage ranged from 15-67%. The substratum type changed from medium sand to coarse sand offshore.

Station 8: 500 m transect. Seagrasses were moderately abundant. Depth increased from 1.5-2.4 m in the area between 50 and 200 m, but decreased again to 1.8 m at 250 m, after which it increased to 2.8 m at 400 m. The depth decreased again at the outer edge of the seagrass bed. Patches of *Enhalus acoroides* and *Halophila ovalis* were distributed throughout the area. Patches of *Thalassia hemprichii* occurred in areas between 130 m and 150 m. The coverage varied accordingly: *Enhalus acoroides* (15-60%), *Halophila ovalis* (10-40%), and *Thalassia hemprichii* (5-10%). Substratum was homogeneous, medium sand.

Station 9: 640 m transect. Water depth increased gradually from 1.0 m to 3.0 m along the stretch from 50 m to the edge of the seagrass bed. In the upper tidal zone, approximately at 20-50 m, *Halophila beccarii* (40% coverage) occurred together with *Halophila ovalis*. Otherwise, the bed comprised abundant *Halophila ovalis* (10-95% coverage) until 350 m. *Halophila ovalis, Thalassia hemprichii, Enhalus acoroides* and *Halodule uninervis* were found in the area between 150 and 200 m. Further seawards, *Enhalus acoroides* became more abundant (20-90% coverage). Infrequent patches of *Enhalus acoroides* were noted further seawards from the outer edge of this seagrass bed. Substratum was a mixture of fine sand and very fine sand.

Station 10: 850 m transect. Depth increased from 1.5 m (at 50 m) to 3.3 m at the outer edge of the bed. A monospecific stand of *Enhalus acoroides* (73% coverage) began at 400 m and stretched to the end of the grass bed. However, a sparse stand of *Halophila ovalis* (1% coverage) occurred in the area between 600 and 650 m. Substratum was coarse sand in the upper intertidal and changed to medium sand in the upper subtidal zone.

Species coverage

The overall seagrass coverage was 62% leaving 38% of the area without vegetation. *Enhalus acoroides* was most abundant (34% coverage). *Halophila ovalis* covered 17% of the total area of grass beds while *Cymodocea rotundata* and *Thalassia hemprichii* covered 4 and 6%, respectively. The 3 species *Halophila beccarii, Halodule pinifolia*, and *Halodule uninervis* were rare in the mangrove-associated seagrass beds and covered 0.8, 0.7 and 0.2%, respectively.

Distribution of seagrasses and water depth

Chansang and Poovachiranon (1994) showed that depth distribution of seagrass species was correlated with secchi-depth for all types of grass beds in the Andaman Sea. *Halophila beccarii* was only found close to the mangrove edge in the upper tidal zone at a depth of 1 m (Fig. 3). The following 7 species occurred to the end of individual transects: *Halophila ovalis* and *Enhalus acoroides* from the intertidal zone to >4.0 m depth (sparse stands of *Halophila ovalis* at a maximum depth of 4.8 m). *E. acoroides* formed dense meadows in deeper water (maximum depth 4.7 m) but patches occurred in the intertidal. Patchy stands of *Halodule uninervis* occurred in the lower tidal zone (1.9 m). This species was not found deeper than 2.1 m. *Halodule pinifolia* occurred in shallow water at 2.4 m water depth. It was only found at one site (station 6). *Cymodocea rotundata* and *Thalassia hemprichii* were abundant in shallow water (maximum depth 3.3 m).

Mean total biomass

The lowest mean total biomass was 557 g w.w. m^{-2} (Station 5), and the highest one was 1941 g w.w.m^{-2} (Station 10) corresponding to 31.6 and 296.7 g d.w. m^{-2}, respectively (Fig. 4A). The mean biomass at station 4 was 247.3 g d.w. m^{-2}, while stations 7, 3, 9 and 2 had 105, 109.9, 132.1 and 172.3 g d.w.m^{-2}, respectively. The remaining sites had mean biomasses less than 100 g d.w. m^{-2}, *viz.*, station 5, 1, 6 and 8 with 31.6, 77.4, 97 and 97.3 g d.w. m^{-2}, respectively. Grass beds with high biomass were dominated by *Enhalus acoroides* which occurred in abundance at station 10 (Fig. 2). *E. acoroides* is the largest seagrass species recorded in the Indo-Pacific. Low biomass was found when small *Halophila ovalis* occurred in a pure stand, *e.g.*, at station 5.

Comparison of above-ground and below-ground biomass

Fig. 4 B&C show the mean total biomass per unit area of above-ground and below-ground biomass. Individual species of seagrass are listed in Table 1 which shows the mean biomass per unit area of leaves (above-ground biomass), roots, and rhizomes (below-ground biomass). The relative proportions of leaves, roots & rhizomes were calculated for individual species and grouped into the following three categories:

1. Relatively high above-ground, and low below-ground biomass

Halophila ovalis (total biomass 25.08 g d.w. m^{-2}). A relatively high above-ground biomass (56%) Rhizomes comprised 28%.

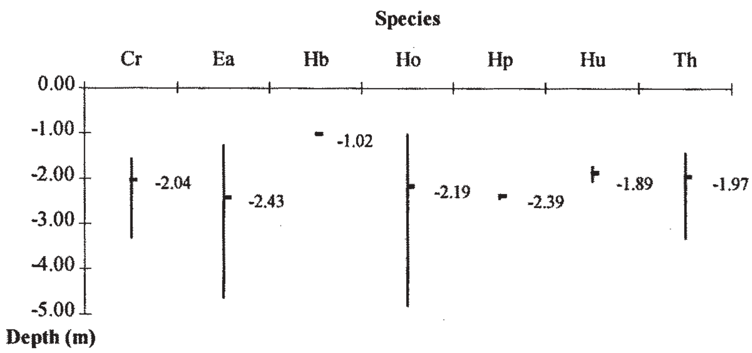

Figure 3. Mangrove-associated seagrass beds along the Andaman Sea coast. Encountered species of seagrass as a function of mean depth. Bars indicate depth range. Cr = *Cymodocea rotundata*, Ea = *Enhalus acoroides*, Hb = *Halophila beccarii*, Ho = *Halophila ovalis*, Hp = *Halodule pinifolia*, Hu = *Halodule uninervis*, and Th = *Thalassia hemprichii*.

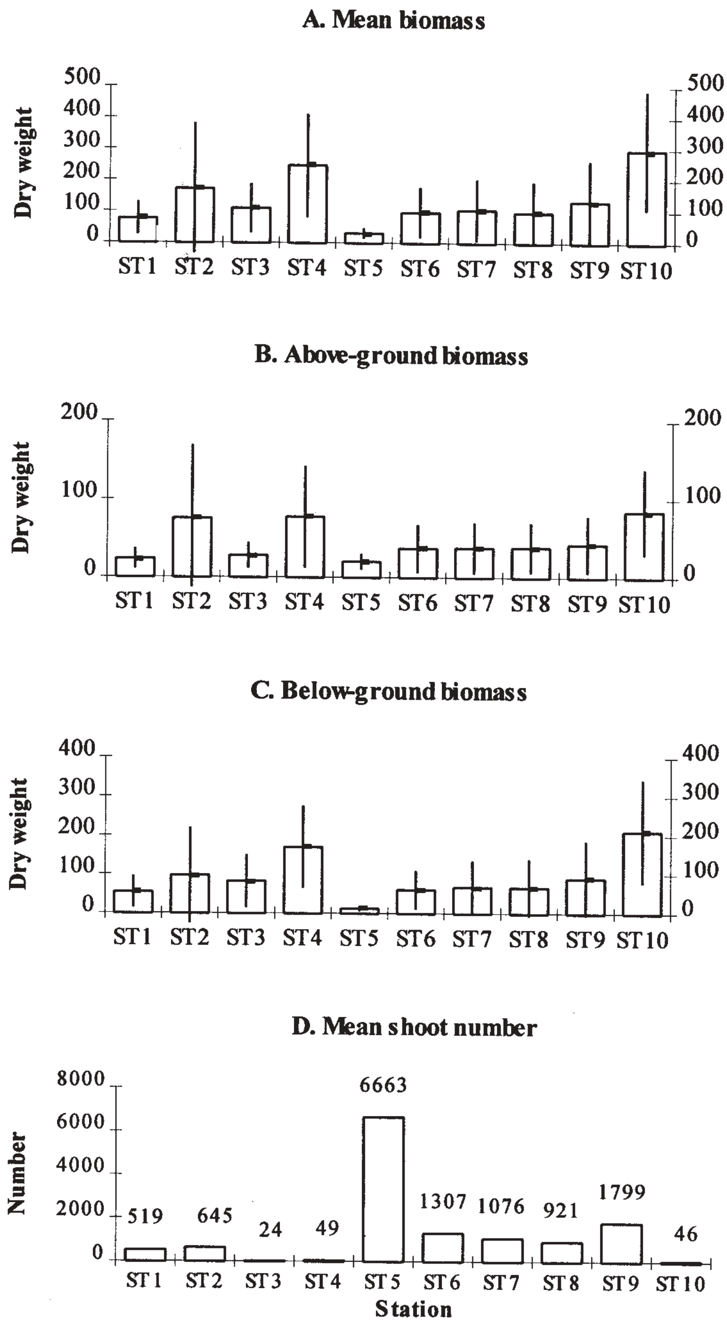

Figure 4. Mangrove-associated seagrass beds along the Andaman Sea coast. Estimates at station 1-10 (**A**) Mean total biomass ± SD (g d.w. m^{-2}). (**B**) Mean above-ground biomass± SD (g d.w. m^{-2}). (**C**) Mean below-ground biomass± SD (g d.w. m^{-2}). (**D**) Mean shoot number m^{-2}

2. Relatively low above-ground, and high below-ground biomass

Halodule pinifolia (total biomass 26.03 g d.w. m^{-2}) 22% above-ground biomass. Rhizomes dominated the below-ground biomass (48%). *Enhalus acoroides* (total biomass 196.62 g d.w. m^{-2}) 29% above-ground biomass. This species had the highest rhizome biomass (64%). *Halodule uninervis* (total biomass 2.97 g d.w. m^{-2}) 36% above-ground biomass. Rhizomes dominated the below-ground biomass (39%). *Halophila beccarii* (total biomass 13.67 g d.w. m^{-2}) 40% above-ground biomass. Rhizomes comprised 44 % of the total biomass.

3. Above-ground biomass relatively similar to below-ground biomass

Thalassia hemprichii (total biomass 239.77 g d.w. m^{-2}) 46% above-ground biomass. Below-ground biomass was dominated by roots (39%). This was in contrast to the other seagrasses where root biomass was low, relative to the biomass of rhizomes. *Cymodocea rotundata* (total biomass 94.2 g d.w. m^{-2}) 47% above-ground biomass. Rhizomes comprised 37%.

Shoot number

Fig. 4D shows the mean shoot number estimated per unit area for individual species of seagrass. The pure stand of *Halophila ovalis* at station 5 had a very high mean shoot number. Very low shoot densities were found at stations 3, 4, and 10 which comprised pure stands of *Enhalus acoroides*.

Table 1. Biomass (g d.w. m^{-2}) and ratio of leaf, root and rhizome of the species

Species	Biomass (g.dw.m^{-2})			Ratio
	Leaf	Root	Rhizome	Leaf: Root: Rhizome
Cymodocea rotundata	44.00	15.55	34.65	3:1:2
Enhalus acoroides	56.75	13.97	125.90	4:1:9
Halophila beccarii	5.44	2.16	6.07	3:1:3
Halophila ovalis	13.91	4.06	7.11	3:1:2
Halodule pinifolia	5.72	7.81	12.50	1:1:2
Halodule uninervis	1.07	0.73	1.17	1:1:2
Thalassia hemprichii	105.28	94.49	40.00	3:2:1

DISCUSSION

Depth distribution of seagrass species is limited by light availability (Fig. 3). Seagrass was only found in shallow (usually turbid) water adjacent to mangroves in the Andaman Sea. In comparison, beds were found at water depths >10 m along the north east Australian coast between Cape York and Hervey Bay (Lee Long *et al.*, 1993). This discrepancy is presumably due to differences in water transparency.

The present study showed sediment conditions ranging from mud to coarse sand. However, the muddy substratum at station 4 may reflect environmental disturbance since the site was located in a bay which was dredged for tin ore in 1980-1981. The coverage and biomass of seagrasses were also very low at this station. Pethpiroon (pers. comm.) visited the site during 1974-1975 and found luxurious growth of seagrass in that area. Apart from this station, most seagrasses were found in fine to medium sand substrata despite being adjacent to mangrove areas. *Enhalus acoroides* was the most common species in mangrove associated grass beds (Fig. 2). It occurred in 8 of 10 stations and had the highest coverage (34%). *Halophila ovalis* ranked second. It was found in 7 of 10 stations (16.5% coverage). These two species also had the widest range of depth distribution (Fig. 3) which implies that they can tolerate exposure at low tide.

The temperate seagrass *Zostera marina* displays considerable variation in above-ground (1-100 g d.w. m^{-2}) and below-ground (5-1600 g d.w. m^{-2}) biomasses. This wide range is caused by variation in environmental parameters as well as different sampling methods and design (Thayer *et al.*, 1984; Kenworthy and Thayer, 1984). Total biomass of seagrass ranged from 31.6 to 296.7 g d.w.m^{-2} in this study. The maximum biomass was low compared to Indonesia, where biomass ranged from 236.8 to 676 g d.w. m^{-2} (Azkab, 1991), and other parts of Asia with 2.1 to 862.7 g d.w. m^{-2} (Kiswara, 1992).

Above-ground mean biomass of *Enhalus acoroides* ranged from 23 to 86 g d.w. m^{-2} in this study (stations 3 and 10), which was similar to other studies in the region. Fortes (1992) found leaf biomass to be 10.60-85.23 g d.w. m^{-2} in *Enhalus acoroides*, and 0.18-25.41 g d.w. m^{-2} in *Thalassia hemprichii*. Coles *et al.* (1989) reported maximum above-ground biomass of 158.3 g d.w. m^{-2} in the Gulf of Carpentaria, and 99.6 g d.w. m^{-2} between Cape York and Cairns.

With the exception of *Thalassia hemprichii* the below-ground portion weighed more than the above-ground portion. It was especially pronounced in *Enhalus acoroides* and *Halodule spp.* which were the most common species. Thus the below-ground biomass constitutes a significant pool of organic matter which can contribute to nutrient cycles in the sediment.

In most of our surveys, variability was higher with leaf standing crop than with roots and rhizomes. We speculate that this is related to grazing, physical damage, non-lethal human disturbance, and that leaves have faster turnover rate than roots and rhizomes.

Thalassia hemprichii communities showed an epiphyte contribution of about 37% of the total annual mean net production (seagrass plus epiphyte) at one site, and 19% at another one in Papua New Guinea (Heijs, 1984). In comparison, only small amounts of macroalgae and ephiphytes were observed at seagrass beds in the Andaman Sea. We are unable to explain this difference. Further studies are needed on environmental parameters and ecological factors, such as the presence of grazers.

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