Songklanakarin J. Sci. Technol.
32 (5), 497-504, Sep. - Oct. 2010

Songklanakarin Journal
of Science and Technology

http://www.sjst.psu.ac.th

Original Article

Seasonal variations in seagrass percentage cover and biomass at Koh Tha Rai, Nakhon Si Thammarat Province, Gulf of Thailand

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Received 18 March 2009; Accepted 3 September 2010

Abstract

Seasonal variations in seagrass percentage cover and biomass at Koh Tha Rai, Nakhon Si Thammarat Province, Gulf of Thailand, were investigated between July 2006 - July 2008 using *SeagrassNet* protocol. The SeagrassNet protocol is a standard method for monitoring seagrass worldwide, and Koh Tha Rai is among the first few places using such protocol in Thailand. The standard protocol such as *SeagrassNet* allows comparisons of findings among various sites worldwide. Five species of seagrass found at Koh Tha Rai : *Enhalus acoroides* (L.f.) Royle*, Cymodocea rotundata* Asch. & Schweinf.*, Thalassia hemprichii* (Ehrenb.)Asch.*, Halophila ovalis* (R.Br.) Hook.f. and *Halodule uninervis* (Forssk.) Asch. *E. acoroides* covered the largest area, while *C. rotundata* covered only a small area. Most seagrass showed seasonal variations both in percentage cover and biomass. There were also variations in above and below ground biomass as well as in the sediment. There was a decline of seagrass with increasing of sedimentation in a sheltered site. This study provides a systematic monitoring of seagrass in Thailand, which is still limited.

Keywords: seagrass, SeagrassNet, monitoring, Koh Tha Rai, Thailand

1. Introduction

Seagrasses are marine flowering plants that form an important coastal habitat world wide. They often occur in vast meadows which provide nurseries, shelter, and food for a variety of commercially, recreationally and ecologically important species. Twelve genera and 60 species have been reported worldwide (Short *et al*., 2007). There are 16 species from Southeast Asia (Fortes, 1990), 12 of which are reported in Thailand (Lewmanomont *et al*., 1996). There are more than 14.9 km^2 (Poovachiranon *et al*., 2006) in Thailand, 5.5 km^2 in the Gulf of Thailand and 9.4 km^2 in the Andaman Sea. Seagrasses are known to support many endangered species such as turtles and dugongs (Nakaoka and Aioi, 1999; Nakanishi *et al*., 2006; Adulyanukosol and Poovachiranon 2006).

The ecological roles of seagrasses are very important. They filter estuarine and coastal waters of nutrients, contaminants and sediments, and are closely linked to other communities such as coral reefs and mangroves (Nybakken, 2001). Moreover, they provide habitats for a wide variety of marine organisms (Nakaoka and Toyohara, 2000; Kwak and Klumpp, 2004). The relatively high rate of primary production in seagrasses drives detritus-based food chains, which helps to support many of these organisms (Adam and King, 1995). To date, the study of seagrass in Thailand is still very limited compared to studies of coral reef and mangrove ecosystems (Satumanatpan *et al*., 2000).

A sharp decline of seagrass is reported from various places around the world (Orth *et al*., 2006); in the Americas (Short *et al*., 2006); in the Mediterranean (Calleja *et al*., 2007); in Sweden (Baden *et al*., 2003); and in Malaysia

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(Freeman *et al*., 2008). In the Southeast Asian region including Thailand, coastal development, over fishing and aquaculture are known to negatively affect seagrass beds (Satumanatpan and Plathong, 2003). Increase of sediment in the water column due to coastal runoff, deforestation and erosion can cause dramatic changes and damage to seagrass and other marine communities (e.g. Airoldi *et al*., 1996; Duarte, 2001). Furthermore, global climate changes will also influence photosynthesis and, consequently, productivity of seagrasses, (Short and Neckless, 1999), thus changing the seagrass ecosystem.

Seagrass study in Thailand was first reported over a hundred years ago by Ostenfeld (1902). Since these, there have been more than 141 seagrass studies in Thailand on various topics such as dugong, associated animals, ecology, taxonomy, species lists, distribution, biochemistry, surveys, management and conservation, and research methods. Associated animal and ecological studies are the most common and taxonomy the least studied topic. Most of the reports were from various departments of natural resources or fisheries, but scientific research has been carried out by foreign scientists, as for example, Nakaoka *et al.* (1999; 2002; 2004; 2007); a few under the SE Asian water, but mostly in the Philippines (e.g. Terrados *et al*., 1998; Durate *et al*., 2000; Agawin *et al*., 2001; Kamp-Nielsen *et al*., 2002; Lacap *et al*., 2002). Recently, there have been scientific publications by Thai scientists, namely, Tuntiprapas et al. (2008), Prathep *et al*. (2008), Rattnachot *et al*. (2008). It is worth noting that there has been little focus on the plants themselves, which are important for conservation and management.

2. Materials and Methods

The seagrass monitoring program, was carried out in Had Khanom-Mu Koh Thalay Tai National Park, Nakon Si Thammarat province, Thailand (9°19'20" N, 99°46'80" E). It is a 0.22 km^2 seagrass bed and the only one in the province. The site is close to the mainland.

The protocol for seagrass monitoring is the same throughout the world and is based on a statistically valid and peer-reviewed sampling scheme (Burdick and Kendrick, 2001). We adapted the SeagrassNet protocol in order to deal with tides, turbidity and the weather. Although field collections were not carried out as specified by the protocol, the complete protocol can be found in Short *et al.* (2006). Two sites were established, the first on a sheltered bay which has a fine grain sediment bottom. The second site is sheltered on the other side of the bay with a sandy substrate. A site consists of three fixed parallel 50 m cross transects, their midpoints on a transect seaward, perpendicular to the shore (Figure 1). Quarterly sampling was done at twelve 0.25 m^2 quadrats placed at random locations along the cross transects. Species composition was measured along the cross transects and seagrass abundance was determined by measurements of cover. Seagrass percent cover by species was visually estimated per each quadrat using photos. Biomass was collected with a 0.0035 m^2 core outside each quadrat at least 5 m distance from the quadrat but in an area of the same seagrass species and cover. The sediments were washed from the core samples and analyzed. Plant material was separated into leaves, stems and root/rhizome. Epiphytes were scraped from the leaves. All plant parts were rinsed in fresh water, dried at 60° for 24 h until constant weight was achieved, and then weighed. The study was carried out between July 2006 - July 2008.

2.1 Statistical analyses

SPSS version 13.0 for Windows was used to analyze data; significance level of 95% were used. Because all data

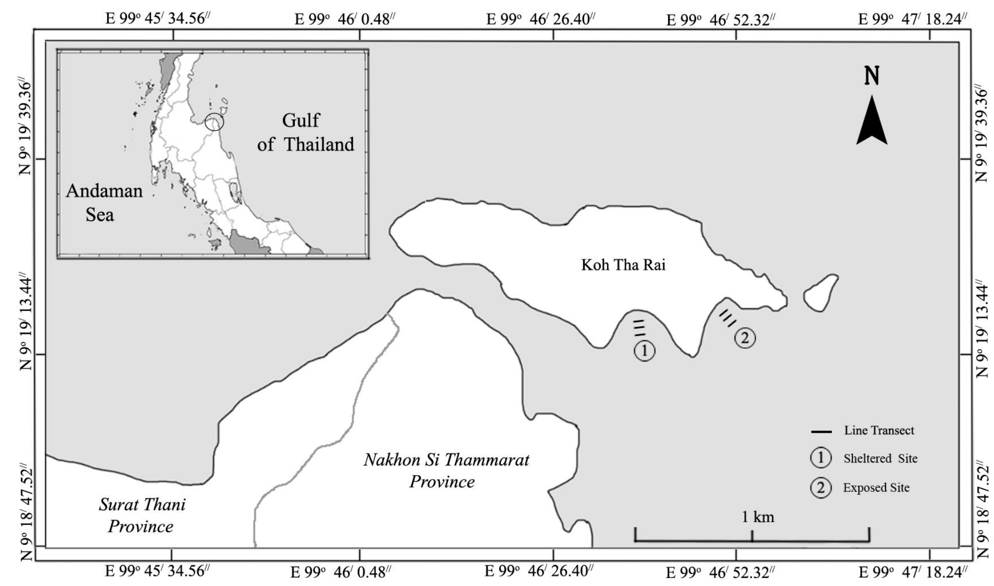

Figure 1. Line transect placement following SeagrassNet protocol at Koh Tha Rai, Nakhon Si Thammarat Province, Gulf of Thailand.

(and data transformed with Log(x+1) and square root) had a non-normal distribution as tested with Shapiro-Wilk Test, the non- parametric Kruskal Wallis Test was used to test for differences in percent coverage, biomass and sediment among lines. The Friedman Test was employed to test the difference of each month. The two independent samples Mann-Whitney nonparametric test was used to test the difference in both percent coverage and biomass in 2006 between sand and mud sites.

3. Results

3.1 Seagrass monitoring

1) Site 1 (Sheltered Site) VS Site 2 (Exposed site)

Four species of seagrass were found at Site 1: *Enhalus acoroides, Cymodocea rotundata, Thalassia hemprichii and Halodule uninervis*. The study was first set up for 2 monitoring sites in July 2006. There was no significant difference in total coverage between the two sites (Table 1A; Figure 2A). The highest coverage was from *E. acoroides* at 16.50% ± 6.13% at the sheltered site with a muddy soft bottom. *C. rotundata* was only found at this site. The total biomass and above ground and below ground biomass were not significantly different between sites (Table 1B; Figure 2B). The sediment was then much greater on the sheltered site, with mud more than 50 cm thick. Seagrass, therefore, could not be further assessed. *E. acoroides* survived throughout our study, but the other seagrass species were covered by mud.

2) Coverage

At Site 2, 4 species of seagrass were found in June 2007: *Enhalus acoroides, Halophila ovalis, Thalassia hemprichii and Halodule uninervis*. *H. ovalis was* not found in June 2006. There were variations in total coverage of seagrasses at Koh Tha Rai among months but not among distances from the shore (Table 2, Figure 3A). The highest coverage was found in September 2007, 25.69% ± 5.45% (Mean ± S.E.). However, each species showed differences in coverage among lines (Table 2; Figure 3B). *E. acoroides* covered the largest area at the site due to its large plant size, found at the lower shore. The highest coverage was found on line C (offshore) during September 2007, 35.42% ± 5.76%. *T. hemprichii* covered a greater area on the upper shore; the highest coverage was 15.42% ± 6.38% on line A (nearshore).

3) Biomass

There were variations in total biomass, above ground biomass, below ground biomass and above ground: below ground biomass ratio among lines, but not among months except in April 2008, when there was greater above ground than below ground biomass. (Table 3; Figure 4A). The highest total biomass was found on line C during July 2006, 654.04±173.99 dry wt/m^2; the highest biomass of above and below ground were also found in the same month, the highest above ground was 225.02±53.13 dry wt/m^2; and the highest below ground was 429.02±125.02 dry wt/m^2 respectively. There was significant difference in above: below ground biomass during April 2008 compared with the months. The highest above ground was found on line A, 92.75±42.84 dry wt/m^2 and the highest below ground was 78.12±25.27 dry wt/m^2 respectively (Figure 4B).

4) Sediment

There were no significant differences in sediment size among lines and months (P>0.05). The percentage weight of

Table 1. Coverage (A) and biomass(B) of seagrasses between sand and mud site in July 2006. Significant effect is shown in bold.

(A)

	Sand	Mud	*P-Value*
Total coverage (%)	13.3±4.47.0	19.0±12.2	0.599
Enhalus acoroides (%)	9.1±4.54	16.5±6.13	0.253
Thalassia hemprichii (%)	2.9±1.64	2.3±1.08	0.383
Halodule uninervis (%)	0.9±0.48	0.1±0.14	**0.050**
Cymodocea rutundata (%)	0.00±0.00	0.03±0.03	0.317

(B)

	Sand	Mud	*P-Value*
Total biomass (g dry wt/ m^2)	259.06±99.607	641.18±273.616	0.174
Above ground biomass(g dry wt/ m^2)	93.3±33.151	191.59±72.884	0.204
Belowground biomass (g dry wt/ m^2)	165.742±66.461	449.59±208.819	0.204

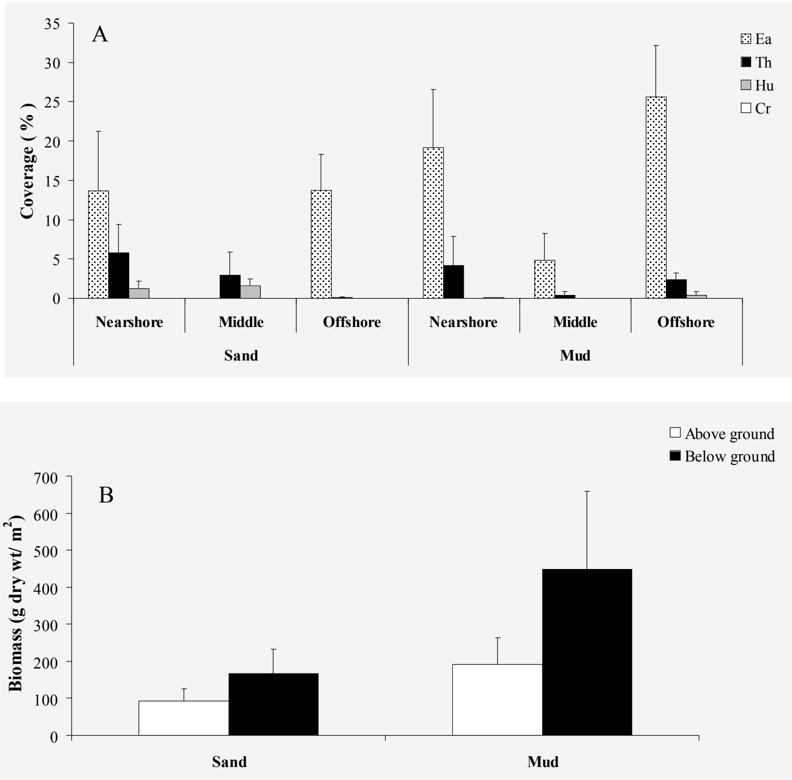

Figure 2 Coverage (A) and biomass(B) of seagrasses between mud (site 1) and sand (site 2) site at Koh Tha Rai on July 2006.

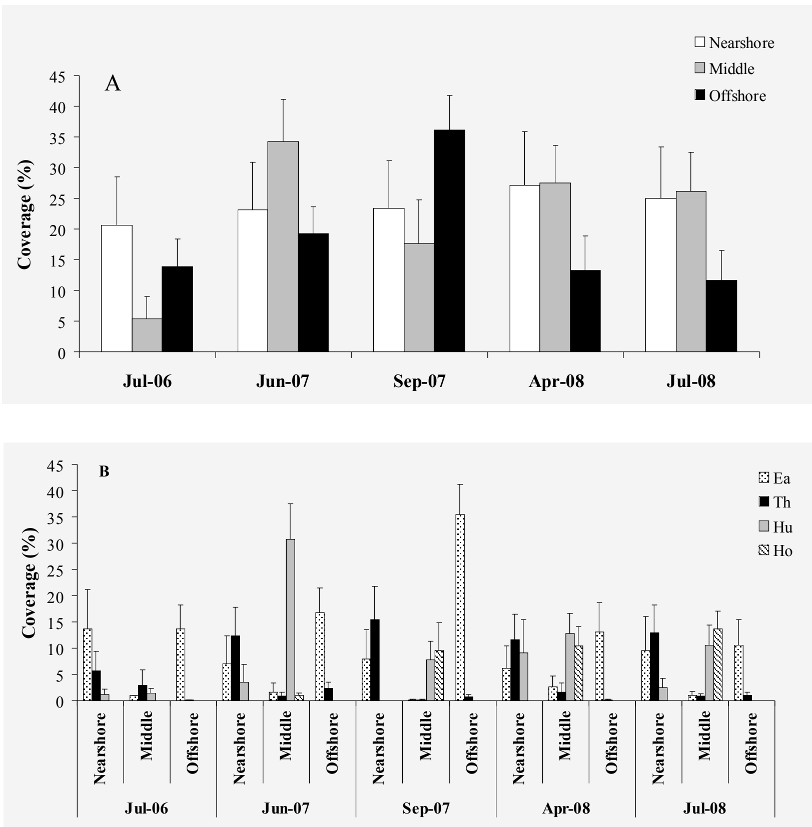

Figure 3. Coverage of each line (A) and each species (B) of seagrasses during July 2006 – July 2008, site 2 at Koh Tha Rai.

Table 2. Summary of seagrasses coverage during July 2006 to July 2008. Significant effects are shown in bold.

	χ^2	*df*	*P-value*
Total Coverage			
Month	10.825	4	**0.029**
Line	0.439	2	0.803
Enhalus acoroides			
Month	6.849	4	0.144
Line	56.262	2	**0.000**
Thalassia hemprichii			
Month	6.302	4	0.178
Line	23.148	2	**0.000**
Halodule uninervis			
Month	20.980	4	**0.000**
Line	66.786	2	**0.000**
Halophila ovalis			
Month	22.783	4	**0.000**
Line	68.066	2	**0.000**

sediment showed similar patterns throughout the study (Figure 5). The grain size of <125 μm sediment was the most abundant at 42.85% ± 9.75% and only very small percentage of <63 μm sediment was found. However, we observed greater sediment on the other side of the bay, where we were unable to monitor after June 2007.

Table 3. Summary of seagrass biomass during July 2006 to July 2008. Significant effects are shown in bold.

	χ^2	*df*	*P-value*
Total biomass			
Month	4.504	4	0.342
Line	18.049	2	**0.000**
Above ground biomass			
Month	2.896	4	0.575
Line	16.23	2	**0.000**
Below ground biomass			
Month	6.57	4	0.160
Line	16.469	2	**0.000**
Ab:Be biomass			
Month	11.348	4	**0.023**
Line	6.217	2	**0.045**

4. Discussion

Seagrass research in Thailand is urgently needed. There have been few studies on this ecosystem, which has been ranked amongst the most valuable ecosystems in the

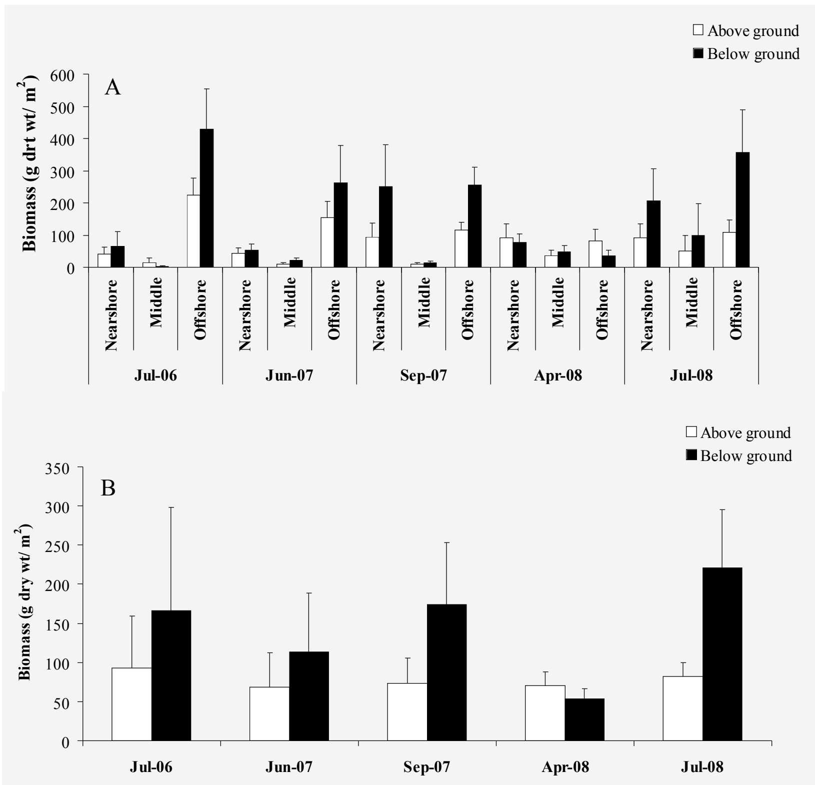

Figure 4. Biomass of each line (A) and each species (B) of seagrasses during July 2006 – July 2008, site 2 at Koh Tha Rai.

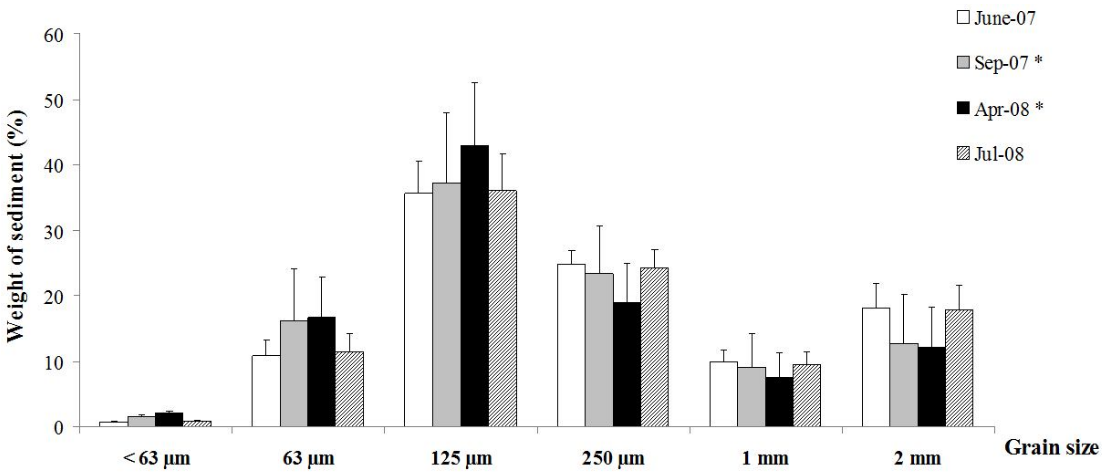

Figure 5. Grain size composition during July 2006 – July 2008, site 2 at Koh Tha Rai.

world. This assessment is based on the value-added services they provide, estimated at 19,004 US$/ha/year; almost 10 times greater than coral reef ecosystems (Costanaza *et al.*, 1997). The sharp decline of seagrass in various places around the world (Orth, *et al.*, 2006), especially in SE Asia (Terrados *et al.* 1998; Freeman *et al.*, 2008), is motivation for increasing research. The results from this study help shape future research not only on seagrass biology, ecology and ecosystems but also on the seagrass restoration.

There was a sharp decline of seagrass at Site 1, the sheltered site. It was covered with fine mud 50 cm deep after the first 3 months of the study. The increase of sediment, appears to come from a nearby development project and from the clearing of mangroves for prawn farming. These are common disturbances in the SE Asian regions and developing countries (Satumanatpan and Plathong, 2003; Green and Short, 2003). *SeagrassNet* would help to not only document seagrass populations but also provide baseline information for further research, conservation and management. *SeagrassNet* has been successful and has provided useful information in various regions both in the Americas and in SE Asia (Short *et al.*, 2006; Freeman *et al.*, 2008). There are now 8 *SeagrassNet* sites established in Thailand both in the Gulf of Thailand and in the Andaman sea. The monitoring program helps us to understand the trends of seagrass populations in Thailand and to be part of *Global Seagrass Study Network*.

Seagrass species have shown differences in distribution patterns. *Thalassia* is more dominant on the upper shore, where larger sized sediment was observed. *Enhalus* is dominant on the deeper sites, perhaps because of the larger size of the plant, which is submerged most of the time. *Halophila ovalis* and *Halodule uninervis* are more dominant mid-shore. Study of the competition among species, physical parameters and sediment type would allow us to understand more on the vertical distribution of seagrasses, and the information of distribution pattern would provide useful information for seagrass transplantation and restoration.

The cover of seagrass found at the site is considered small compared to that along the coast of the Andaman Sea (Poovachiranon *et al.*, 2006). However, even so, it supports a great diversity of associated animals (Tuntiprapas *et al.*, 2008). We have also observed increased sedimentation and a change of particle sizes and topography, together with the die-off of the above ground biomass during the low tide in summer months. However, there is no decline of total cover and biomass at Site 2, seagrass survived a harsh environment. Recent study has also shown that climate change would be less likely to have an influence on the seagrass (Björk *et al.*,2008). Further study is needed since it is a new area of research and different species of seagrass might behave differently and different bioregions might be affected differently. Despite the seasonal die-off of the above ground biomass during summer months, there was an increase of seagrass coverage at Tha Ria after 2 years. We have promoted the importance of seagrass to the local community and nearby school, which has an increased awareness of the local conservation groups. Buoys have been put around the seagrass beds. The local community has become aware and helps protect the seagrasses. A slight increase of seagrass has been observed.

There was no difference in total biomass at the site, but there were differences at different distances from the shore. There was greater below ground biomass at the lower shore. This might be because of larger rhizome accumulation throughout the years, which has not been removed or damaged. The above ground part, however, could have been damaged and died off in the dry season and also it could have been snapped off and washed up during the monsoon season. During the dry season, seagrasses seem to have suffered more than during the monsoon, thus decreasing both the above ground and below ground biomass. Such disturbance could reduce the coverage of seagrasses and thus limit biomass. There is slightly less biomass of seagrass found in this study compared to the others (Duarte and Chiscano, 1999). Seagrass is known to accumulate greater carbon in the global ocean, and processes a significant component of the marine carbon budget (Duatre and Cebrián, 1996). Therefore, it would be important to have further study on the seagrass carbon budget under the changing environment since there is an increase of CO_2 in the atmosphere, which might cause an imbalance and increase the carbon in the seawater.

Acknowledgement

We are indebted to Professor Frederick T. Short for helping with the equipment, training and protocols. Professor Larry B. Liddle helped with manuscript improvement. Special thanks are extended to the Seaweed & Seagrass Research Unit Team for the field assistance. This work was supported by TRF/BIOTEC Special program for Biodiversity Research and Training grant BRT R_149021, TOTAL E&P Thailand and TOTAL Foundation of France; and BRT R-351003, TOTAL E&P Thailand and TOTAL Foundation of France.

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