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Study on the variation of seagrass population in Coastal waters of Khanh Hoa Province, Vietnam

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Abstract—Khanh Hoa is among of a few coastal provinces where seagrasses are very abundant and form the large meadows in littoral zones, bays, lagoons. It is possible to consider that the coastal waters of Khanh Hoa has the most diverse of seagrass composition among areas of Vietnam.

The investigation of seagrass beds in Khanh Hoa province (1996–1997) recorded 9 species of seagrasses , some of which were very interesting because of their large distribution areas, high density and biomass.

Study on the variation of density, above ground biomass, leaf growth rate and leaf production of *Enhalus acoroides* and *Thalassia hemprichii* at two stations My Giang (Vanphong bay) and Dong Ba Thin (Camranh bay) were conducted two times per month in two years 1998, 1999.

At My Giang station: the mean values of density and leaf production of *E. acoroides* were highest in September: 144±5 shoots/m^2 and 5.96±0.3 gDW/m^2/day, above ground biomass and leaf growth rate were highest in April 158±2 gDW/m^2 and 1.57±0.2 cm/day (March). The density of *T. hemprichii* was highest in May: 1050±30 shoots/m^2, biomass was highest in October: 148±10 gDW/m^2, leaf growth rate and leaf production were highest in September: 0.66±0.02 cm/day and 5.55±0.3 gDW/m^2/day.

At Dong Ba Thin station: the mean values of density of *E. acoroides* was highest in November: 120±10 shoots/m^2. The above ground biomass, leaf growth rate and leaf production were highest in September. The mean values were 383±15gDW/m^2, 1.8±0.2 cm/day and 5.24±0.4 gDW/m^2/day respectively. The density, biomass, leaf growth rate and leaf production of T. hemprichii were also highest in September, the mean values were 420±30 shoots/m^2, 110±10 gDW/m^2, 0.66±0.05 cm/day and 3.79±0.2 gDW/m^2/day respectively.

The studied results showed that the variation of density, above ground biomass, leaf growth rate and leaf production of seagrass beds depend on seasons in year and the environmental conditions. These values were often high in dry, sunny season (March–October) and often low in the rainy season (November–January). During the low tide (May–August) seagrass beds were exposed to the air that caused the decrease of density, biomass, leaf growth rate and leaf production of seagrasses.

Key words: biomass, coverage, density, degradation, leaf growth rate, leaf production, seagrass beds, species composition, structure, variation

Introduction

Seagrasses form dense submerged vegetation. It produces a great quantity of organic materials and offers an available substrate for epiphytic algae and sessile fauna. It also provides a suitable habitat, nursely ground with plenty of food for marine life(Kikuchi T. et al. 1977).

In Vietnam seagrass beds occur in many coastal areas from the North to the South, the results of investigation recorded 14 species of seagrasses, among them 9 species were found out in the coastal waters of Khanh Hoa (Nguyen, H. D., Pham, H. T., Nguyen, X. H. and Nguyen, T.L., 1997). The dominant species are *Enhalus acoroides*, *Thalassia hemprichii*, they have high density and biomass. At Vanphong and Camranh bay they form a thick meadows and occupy a large areas up to some hundreds of hectares (according to the researched results in 1998 and 1999). Study on the variation of density, above ground biomass, leaf growth rate and leaf production of seagrass beds at My Giang (Van Phong Bay) and Dong Ba Thin (Cam Ranh Bay) in the coastal waters of Khanh Hoa in order to contribute for finding out about the causes affected the variation of structure of the seagrass population. Apart from that, this study help increasing our knowledge on the ecological role of seagrass beds in the coastal waters of Khanh Hoa.

Materials and Methods

This paper based on the results of the project entitled "Study on seagrass beds in the Khanh Hoa province" from 1996 to 1997 and the project "Study on the biodiversity of seagarss ecosystem in Khanh Hoa province" from 1998 to 1999 (Ministry of Science, Technology and Environment) and the results of study on the degradation of seagrass beds in the coastal waters of Khanh Hoa in 2001 and 2002. The methods used are those outlined in "Survey manual for tropical marine resources, seagrass communities", edited by S. English, C. Wilkinson and V. Baker (ASEAN- AUSTRALIA 1994) and "Seagrass research methods" edited by R. C. Philips and C. P. McRoy (UNESCO, Paris 1990). The studied sites for study on the variation of two dominant seagrass species *Enhalus acoroides* and *Thalassia hemprichii* were located at My Giang (Vanphong bay) (12°28′30″N–109°17′30″E) and at Dong Ba Thin (Camranh bay) (12°01′00″N–109°12′00″E). Carried out study 2 times per month at each station by using the quadrat 0.25 m^2 (50 cm×50 cm) for sampling and calculating the density, biomass and coverage of seagrasses on each transect (Fig. 1).

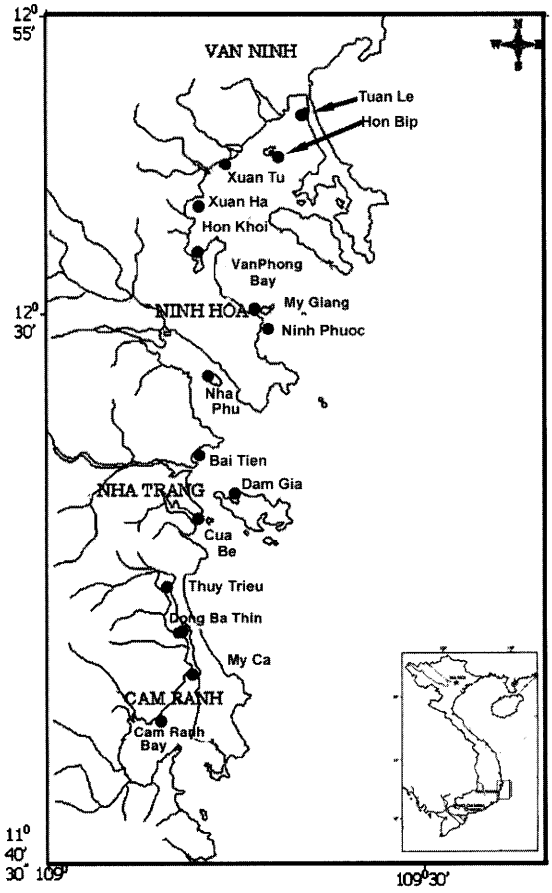

Fig. 1. Map showing the studied stations in the coastal waters of Khanh Hoa province.

Results

1. Status of some concentrated seagrass distribution areas in the coastal waters of Khanh Hoa

The investigated results showed that there are nine species in six genera belonging to two families of seagrasses were found out along the coastal waters of Khanh Hoa, those are:

Family Hydrocharitaceae Jussieu

1. *Enhalus acoroides* (L.f.) Royle
2. *Thalassia hemprichii* (Ehrenb.) Aschers.
3. *Halophila ovalis* (R. Br.) Hook
4. *Halophila beccarii* Aschers.
5. *Halophila minor* (Zollinger) den Hartog

Family Cymodoceaceae Taylor

6. *Cymodocea serrulata* (R. Br.) Aschers. & Magnus
7. *Cymodocea rotundata* Ehrenb. & Hemprich ex Aschers.
8. *Halodule uninervis* (Forsk.) Aschers.
9. *Ruppia maritima* Linnaeus

The density, coverage and biomass of some concentrated distributions of seagrass beds in the coastal waters of Khanh Hoa province were studied and showed in the Table 1.

2. Variation of Enhalus acoroides and Thalassia hemprichii at MyGiang and Dong BaThin stations

Among the areas which had the concentrated distribution of seagrass beds in the coastal waters of Khanh Hoa province, we choose 2 stations My Giang (Van Phong bay) and Dong Ba Thin (Camranh bay) for our studies on the variation of seagrass population.

Some environmental parameters of the studied stations such as: temperature, salinity, Secchi disk transparency of sea-water were calculated simultaneously (Fig. 2)

The most dominant species *Enhalus acoroides* and *Thalassia hemprichii* and form a large meadows at these stations were chosen the object for our studies.

The density, biomass, leaf growth rate, and leaf production of these seagrass species were studied from June 1998 to June 1999. The results showed that these values are often high in dry, sunny season (March–October) and often low in the rainy season (November–January).During the low tide (May–August), seagrass beds are exposed to the air that caused for the decrease of density, biomass, leaf growth rate and leaf production of seagrasses.

a. My Giang (Vanphong bay): This station situated near the mouth of Vanphong bay with the sand, sand muddy and sand reef substrates, the transparency of sea-water is clear, the salinity is stable all year round. These seagrass bed are influenced by the environmental conditions of the open sea.

The studied results showed that the density of E. acoroides ranges from 108±2–144±4 shoots/m^2 (the mean

Table 1. Density, coverage and biomass of Seagrass beds in the coastal waters of Khanh Hoa.

Study areas	Time	Species	Coverage (%)	Density (shoots/m^2)	Biomass (g.DW./m^2)	Substrate type
Xuan Tu, Xuan Ha	April 1996	*E. acoroides*	40–60	59	346	
(Van Ninh, Khanh Hoa)		*T. hemprichiii*	30–80	108	43	Sand, Mud.
		H. minor	50	4808		Muddy sand
		H. uninervis	20	2236		
Bip island	April 1996	*E. acoroides*	20	20–45	50–111	Muddy sand,
(Vanphong bay,Khanh Hoa)						Sand /reef
Tuan Le (Van Ninh)	May 1996	*E. acoroides*	10	36	112	Sand, Sand/reef
						Sand, Mud
Hon Khoi (Ninh Hoa)	April 1996	*T. hemprichii*	45	224–320	120–148	Muddy sand,
		E. acoroides	15–40	20–60	32–162	Sand/reef
My Giang (Ninh Phuoc)	July 1997	*T. hemprichii*	40–70	188–800		
		E. acoroides	30–80	68–116		
		C. rotundata	20–80	732		
		C. serrulata	5–70	650		
		H. ovalis	5–20	1400–7600		
		H. uninervis	5–30	2600–4100		
Ninh Phuoc (Ninh Hoa)	May 1996	*T. hemprichii*	30–60	450–1300	42–91	Sand/reef
		C. rotundata	20	1500		
		H. uninervis	20	4550		
Nha Phu lagoon (Ninh Hoa)	July 1996	*T. hemprichii*	10–40	360–458		Muddy sand,
		E. acoroides	10–30	30–42		Sand/reef
		H. uninervis	10–30			
Bai Tien-Honchong (Nhatrang)	July 1996	*T. hemprichii*	40–75	690–962	211–326	Sand/reef
Cuabe-Songlo (Nhatrang)	July 1996	*T. hemprichii*	20–30	292		Sand, Muddy sand
		C. rotundata	10	615		
		H. ovalis	30–60	3804		
		H. uninervis	30–70	6880		
Thuy Trieu lagoon	June 1996	*H. uninervis*	50–80	11625	165	Mud, Muddy sand
		H.ovalis	30–80	12700	100	
		E.acoroides	50	60	366	
Camranh Bay	June 1996	*E. acoroides*	20–70	50–90	149–298	Mud
		T. hemprichii	30–50	118–316	100–110	Muddy sand
		H. uninervis	20–70	6000–9300		
		H. minor	20–70	5700–18100		

values 124), the leaf production ranges from 3.17±0.2–5.96±0.3 gDW/m^2/day (the mean values 4.31), the above ground biomass ranges from 105±2–158±2 gDW/m^2 (the mean values 135) and the leaf growth rate ranges from 1.02±0.1–1.57±0.2 cm/day (the mean values 1.22)

The density of *T. hemprichii* ranges from 600±20–1050±30 shoots/m^2 (the mean values 854 shoots/m^2) the highest values in May, the leaf production ranges from 3.27±0.1–5.55±0.2 gDW/m^2/day (the mean values 4.31), the above ground biomass ranges from 68±6–149±10 gDW/m^2 (the mean values 113), the highest values in October and the leaf growth rate ranges from 0.45±0.01–0.66±0.03 cm/day (the mean values 0.57) in November and December 1998 because of the troubled sea-water, sampling were not carried out (Figs. 3–4).

b. Dong Ba Thin (Camranh bay): This station situated in Camranh bay with the muddy sand or sand mud substrates, the transparency of sea-water was low in year round, the salinity varies depend on the rainy season in year round. These seagrass beds were influenced by the environmental characteristic conditions of the lagoon.

The studied results showed that the density of *E. acoroides* ranges from 55±10–120±15 shoots/m^2 (the mean values 90 shoots/m^2), the leaf production ranges from 0.53±0.8–5.24±0.4 gDW/m^2/day (the mean values 2.33), the above ground biomass ranges from 46±20–383±15 gDW/m^2 (the mean values 165) and the leaf growth rate ranges from 0.53±0.1–1.80±0.3 cm/day (the mean values 1.16).

Thalassia hemprichii was decomposed from December to February at Dong Ba Thin because of the reduction of the salinity (down to 10‰). The density of *T. hemprichii* ranges from 48±15–420±30 shoots/m^2 (the mean values 200 shoots/m^2) the highest values in September, the leaf production ranges from 0.49±0.1–3.79±0.3 gDW/m^2/day (the mean values 1.14), the above ground biomass ranges from

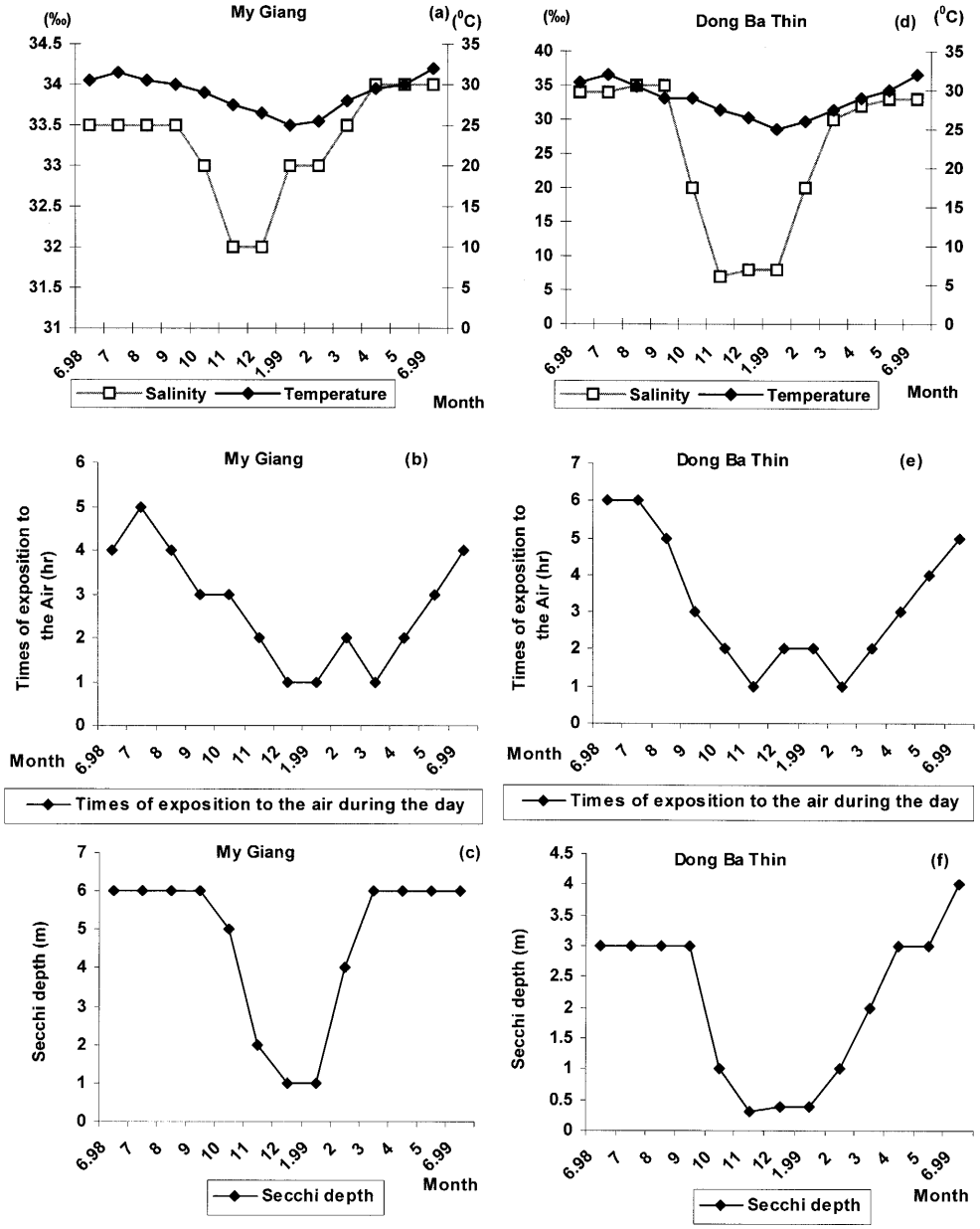

Fig. 2. Seasonality in environmental factors: (a) Salinity (‰) and water temperature (°C); (b) Times of exposition to the air during the day (h); (c) Secchi disk transparency (m).

13±4–110±10 gDW/m^2 (the mean values 39), the highest values in September and the leaf growth rate ranges from 0.36±0.05–0.66±0.05 cm/day (the mean values 0.28) (Figs. 5–6).

3. Variation of the areas of seagrass beds

a. Variation of the distributed areas:

According to the investigated results in 1996–1997, the areas of seagrass concentrated distribution in Khanh Hoa coastal waters were: Vanphong bay, Nhatrang bay, Thuytrieu lagoon and Camranh bay. In general, seagrass beds distributed in the shallow waters along the coast from littoral zone to 10 meter in depth, but they had most abundant distribution from the infralittoral zone to some meters in depth where the substrates are muddy sand, sand mud or sand reef. In the littoral zone along the islands or bay with the sand mud or sand reef substrates, the species *Thalassia hemprichii* had dominant distribution, In Camranh bay (with the muddy sand substrate) *Enhalus acoroides* was dominant. In Vanphong bay the big seagrass beds normally were mixed from 5 to 7 species of seagrasses (Tuan Le, Hon Khoi, My Giang).

Untill now most of the seagrass beds in the coastal waters of Khanh Hoa have been degraded seriously because of the impact of the human (Tuan Le, My Giang, Ninh Tinh, Thuytrieu lagoon, Camranh bay) some areas were devastating completely (Camthanh, Camranh bay). The distributed areas of seagrasses were degradated rapidly from 1235 ha in 1997–1998 down to 795 ha in 2002. (Table 2)

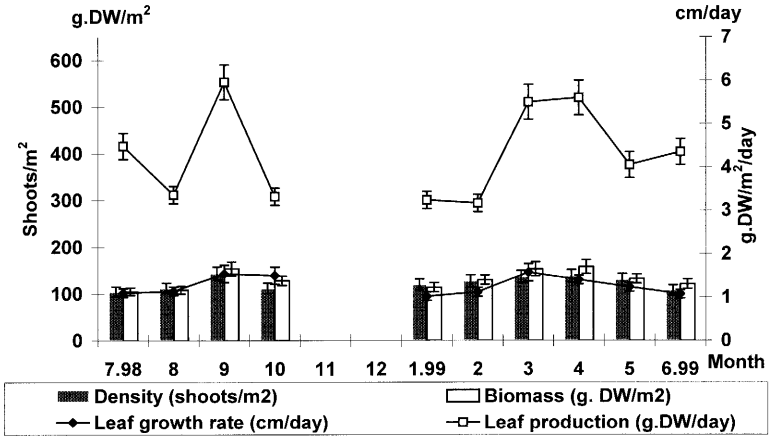

Fig. 3. Variation of density, biomass, leaf growth rate and leaf production of *Enhalus acoroides* at My Giang (Vanphong bay).

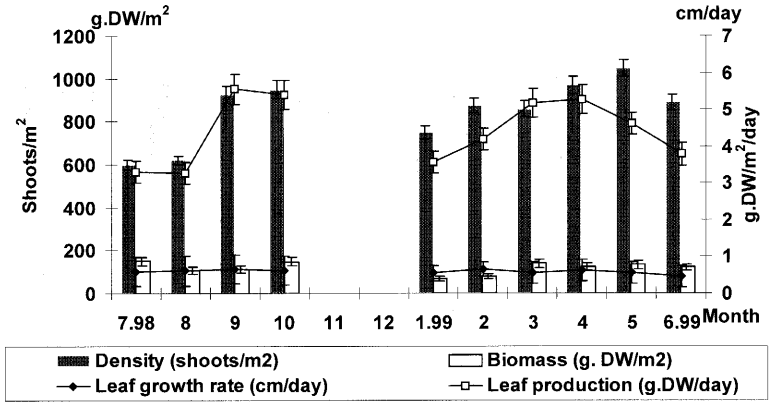

Fig. 4. Variation of density, biomass, leaf growth rate and leaf production of *Thalassia hemprichii* at My Giang (Vanphong bay).

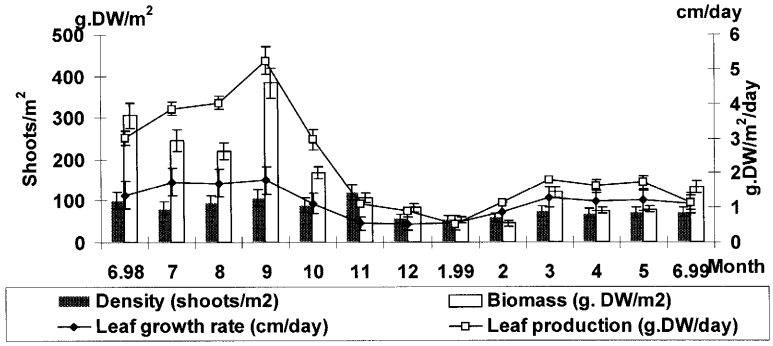

Fig. 5. Variation of density, biomass, leaf growth rate and leaf production of *Enhalus acoroides* at Dong ba Thin (Camranh bay).

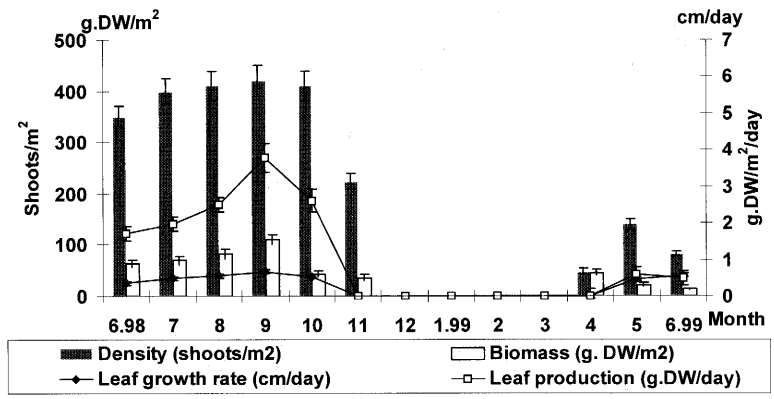

Fig. 6. Variation of density, biomass, leaf growth rate and leaf production of *Thalassia hemprichii* at Dong ba Thin (Camranh bay).

Table 2. Variation of the distributed areas of seagrass beds in coastal waters of Khanh Hoa province.

Studied sites	Distributed areas (1997,1998) (ha)	Distributed areas (2001, 2002) (ha)	Species composition (dominant order)	% degraded distributed areas of seagrasses
Tuan Le (Vanphong bay)	120	100	Ea, Cr, Th, Hu, Ho, Hm	16, 67
Hon Bip (Vanphong bay)	10	10	Ea, Th	0
Xuan Tu,Xuan Ha (Vanphong bay)	70	30	Ea, Th, Ho, Hm, Cr	57, 14
Hon Khoi(Vanphong bay)	100	40	Ea, Cr, Th, Hu, Ho	60
My Giang, Ninh Tinh (Vanphong bay)	80	20	Ea, Th, Cr, Cs, Ho, Hm, Hu	75
Nha Phu lagoon	20	20	Ea, Th, Ho, Hm, Hb, Hu, Rm	0
Bai Tien, HonChong (Nhatrang bay)	10	8	Th, Ho, Hm,	20
Dam Gia (Nhatrang bay)	10	10	Ea, Th, Hu, Cr, Ho, Hm	0
Song Lo (Nhatrang bay)	8	6	Ea, Th, Cr, Hu, Ho	25
Cua Be (Nhatrang bay)	7	1	Hu, Cr, Ea, Ho	85, 71
Thuy Trieu lagoon	500	350	Ea, Th, Hu, Ho, Hm	30
Camranh bay	300	200	Ea, Th, Ho, Hu	33, 33

(Ea: *Enhalus acoroides*, Th: *Thalassia hemprichii*, Cr: *Cymodocea rotundata*, Cs: *Cymodocea serrulata*, Hu: *Halodule uninervis*, Ho: *Halophila ovalis*, Hm: *Halophila minor*)

b. Causes of variation of the seagrass areas

Studied results showed that during the period 1996–2002, seagrass beds in the coastal waters of Khanh Hoa province were loss or reduced up to 30% of the distribution areas.

The loss of seagrass areas has been caused by:

- Extensive shrimp farming.
- Fishing in seagrass beds, push net or trawling by fishermen.
- Exploit dead coral and shell in coastal zone.
- Sedimentation.
- Typhoon, flood.
- A degradation in water quality, waste water discharge from shrimp ponds, eutrophication from rivers.
- Especially, by demand of food for Lobter cages, some destroyed fishing ways by digging for Mollusc, Lingula sp., trawling are main causes of seagrass loss in shallow water.

Conclusions

From the studied results at Dong Ba Thin and My Giang stations, coastal waters of Khanh Hoa, we realized that the variation of density, above ground biomass, growth rate and leaf production of the seagrass beds depend on seasons and the environmental conditions. These values were often high in dry, sunny season (March–October) and often low in the rainy season (November–January). During the low tide (May–August) Seagrass beds were exposed to the air that caused the decrease of density, biomass, leaf growth rate and leaf production of seagrasses. The seagrass beds living in the lagoon (Dong Ba Thin station) were also influenced clearly by the fresh waters in the rainy season and the flood (from October 1998 to January 1999, It happened the flood at this station in this time and caused the seagrass beds seriously decomposed, especially for the *Thalassia hemprichii*).

At My Giang station which situated near the sea, the salinity of seawaters was few variant around year, for this reason the seagrass beds were not influenced by the reduction of the salinity. The reduction of density, biomass, growth rate and leaf production were influenced clearly by the troubled seawaters in November and December.

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