

Seagrass mapping in East Bintan coastal area, Riau Archipelago, Indonesia

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Abstract—Sea-truthing based on Satellite Image Data recorded at 28th April 2000 by Landsat 7 with sensor ETM+ was carried out in September 2004 to map the extend of seagrass of East Bintan coastal area. Due to the ability in penetrate through water depth, only bands with the wave length of 1 (0.45–0.52 μm), 2 (0.53–0.60 μm) and 3 (0.61–0.69 μm) were used for image analysis purpose. Approximately 2,093.66 ha total of seagrass was estimated in the area of study. The widest area of seagrass was recorded in the northern part of East Bintan, Tanjung Berakit i.e ± 847.29 ha with percent coverage ranged between 46 to 56%. It was found that 10 of 13 species of Indonesian seagrass exist in. They are namely, *Cymodocea rotundata*, *C. serrulata*, *Enhalus acoroides*, *Halodule pinifolia*, *H. uninervis*, *Halophila ovalis*, *H. spinulosa*, *Syringodium isoetifolium*, *Thalassia hemprichii* and *Thalassodendron ciliatum*. The most dominant species in the area is *Thalassodendron ciliatum*. The existence of *Halophila spinulosa* is noteworthy, since In Indonesia, this species is considered to be rare. Beside in this location, it existence was only reported in Kuta Bay, Lombok (Kiswara 1994). In East Bintan coastal area, it was found only in Tanjung Berakit with very low percent coverage (<5%) and patchy distribution.

Key words: seagrass mapping, East Bintan, *Thalassodendron ciliatum*, dominant species, *Halophila spinulosa*, rare species, Landsat 7 with ETM+, band 1,2 and 3

Introduction

Seagrass meadow is well recognized as one of the important marine ecosystem in the coastal zone (den Hartog 1970, Fortes 1989, Philips R. C. and Menez 1988). It serves high quantity of nutrient contribution to the surrounding waters (McRoy and Goering 1974) (The major functions of seagrass are namely stabilizing and holding bottom sediment (Dawes 1981), slowing water current and retarding the wave action (den Hartog 1976, den Hartog 1977). Seagrass meadow also provide shelter and food source for other marine organisms (Azis and Soegiarto 1994, Kikuchi and Peres 1977, Moosa and Aswandy 1994, Ogden J. C. 1980). Currently, there are 12 species of seagrass from 7 genera reported in Indonesia (Kuriandewa et al. 2003). This is comparable to other countries in the region.

For having so many islands and long coastal areas, it was roughly estimated that approximately 30,000 km² of seagrasses cover Indonesian Archipelago (loc cit.). However, reliable data of such information is inadequately available, since former and recent seagrass researches rarely measured the extent of seagrass intentionally, they mainly focused on the biology of seagrass and it associated biota (Hutomo, Kiswara and Azkab 1988). Seagrass extent was mostly measured using rough estimation technique. Considering to the very extensive area to be studied, for obtaining precise information of Indonesian seagrass coverage, it is favorable to use

remote sensing technique as alternative tool. Although, satellite data image is relatively expensive, this technique, so far, is proven to be practically dependable for certain purpose e.g. underwater object such as coral and seagrass (Hashim et al. 2001). Respond to this matter and to provide descriptive information for proposed management of seagrass ecosystem, mapping of seagrass using remote sensing technique has been carried out in Bintan Island, Riau Archipelago province in the late of June 2003.

Bintan Island is located in the south-east of Singapore, and the east direction of Batam Island. The study-site is located in the eastern part of Bintan Island, precisely in the 0°5'27" Introduction North and 104°38'39" East (Fig. 1a & 1b). It takes only less than 2 hours by boat to reach this location from Singapore. The windy season (North Wind Season) usually starts from September to February. Salinity is generally ranged between 28–29‰. The brief demography and current use patterns of the area are as follows:

Low population density; most of civilians are farmers and artisanal fishers; some others are employees of marine resort.

The area is allocated for marine tourism (Anonymous 2000), as well as general marine activities such as harbor, mariculture, etc.

The adjacent marine area is allocated for sand mining concession.



Fig. 1a.

Methods

Satellite image recorded in 29 June 2000 by LANDSAT 7 with sensor ETM+ (Fig. 3), was used to guide the estimation of seagrass distribution and area extent. Study was carried out along the coastal area of Eastern Part of Bintan in 21st until 30th June 2003. Since there is a gap between recording date and time of study, it was assumed that there was only insignificant change of seagrass density and area extent during 3 years period.

Image data was analyzed using the following procedures:

1. **Pre-survey analysis.** Satellite image is classified using unsupervised classification. It produces map that will

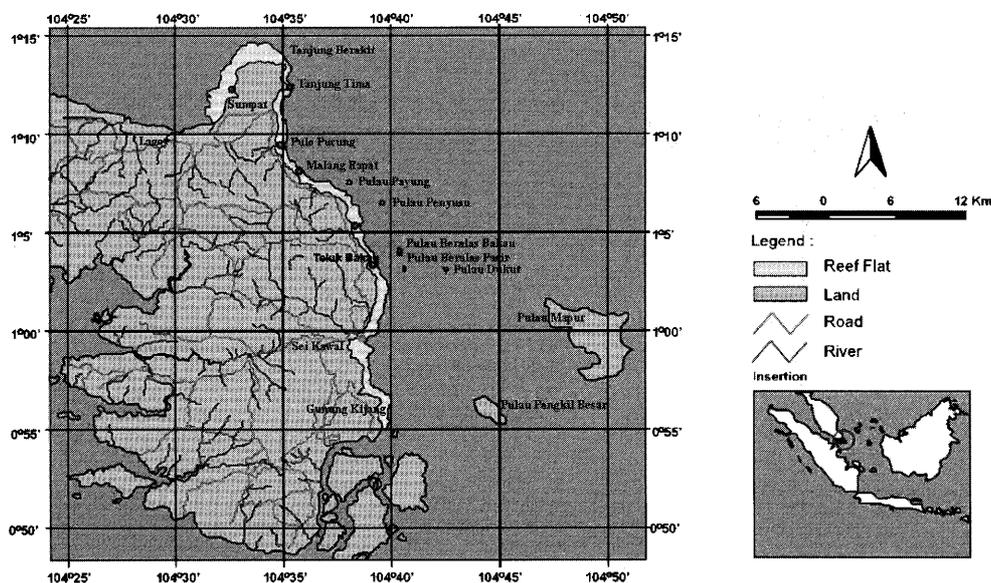


Fig. 1b. Map of East Bintan Island.

BINTAN ISLAND

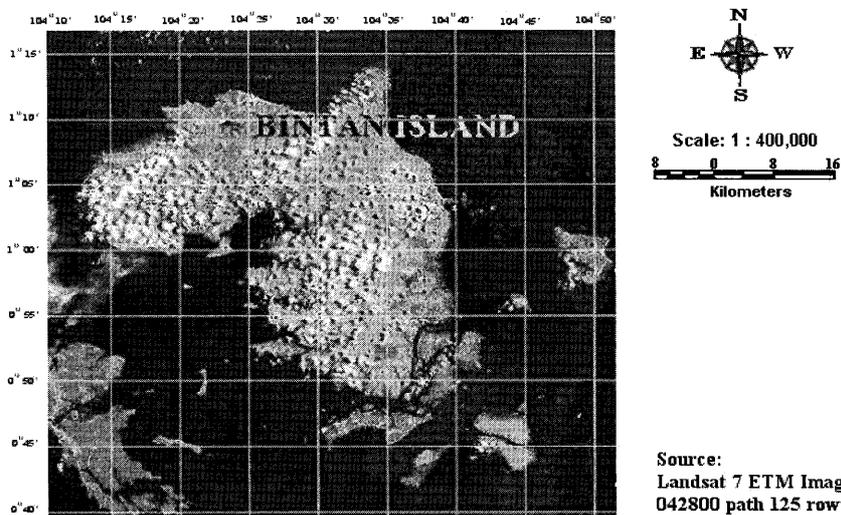


Fig. 2. Image of Bintan Island of Landsat 7 ETM Image 042800 path 125 row 59.

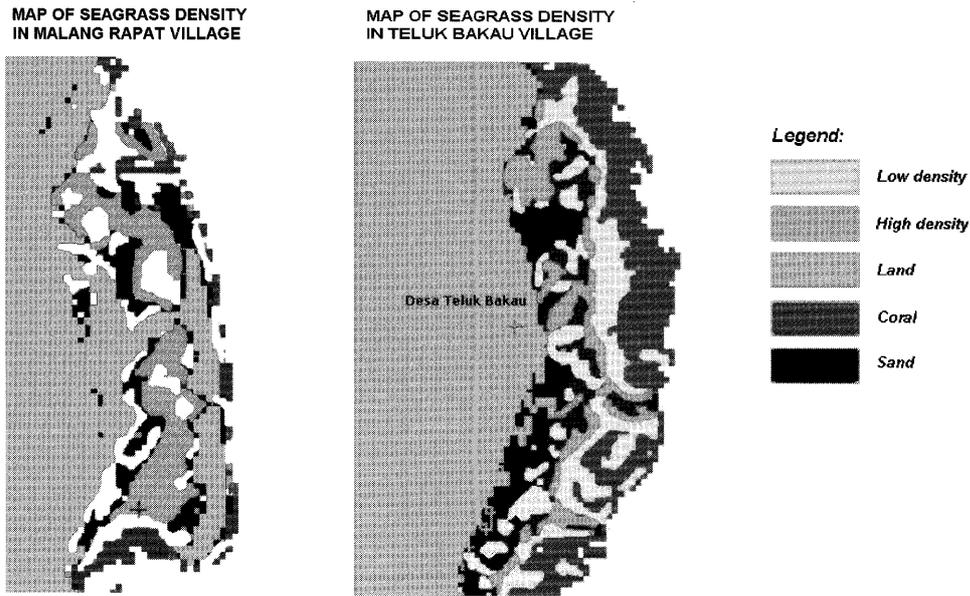


Fig. 3. Map of seagrass density in Malang Rapat Village.

Fig. 4. Map of seagrass density in Teluk Bakau Village.

be used as basic guidance to decide the observation points. These fixed positions will be visited for sea truth purpose.

2. **Sea truth.** The purpose of this procedure is to observe the existing condition of seagrass and other observation target on the designated sites as decided in the pre-survey. Data of seagrass species, density, percent coverage and geographic position was recorded during surveillance. Small boat, scuba gears, Garmin (GPS), 50×50 cm frame, diving knife and roll tape meter was used for such purpose. The result will be matched for correcting the unsupervised classification map using certain analysis as describe in the next procedure.

3. **Post-survey analysis.** For having the capability to penetrate through deeper water only visible bands, with specific range of wave length i.e. band 1 (0.45–0.52 μm), band 2 (0.53–0.60 μm) and band 3 (0.61–0.69 μm) were analyzed. The analysis was using software i.e. Arc View 3.2 with extension image analysis 1.1 and ErMapper 5.5 version. The analysis was consists of water line (sand), mixed ecosystem (sand-coral-sargassum), seagrass and coral digitations. The digitations of each object were done manually in the monitor screen (on screen digitizing).

Results and Discussion

As resulted from the image analysis, there were approximately 2093.66 ha of seagrass estimated along the coastal waters range from Teluk Bakau until Tanjung Berakit Village. There are 10 species were found in the study areas i.e. *Cymodocea rotundata*, *C. serrulata*, *Enhalus acoroides*, *Halophila ovalis*, *H. spinulosa*, *Halodule pinifolia*, *H. uninervis*, *Syringodium isoetifolium*, *Thalassia hemprichii* and *Thalassodendron ciliatum*. The density of the whole area of

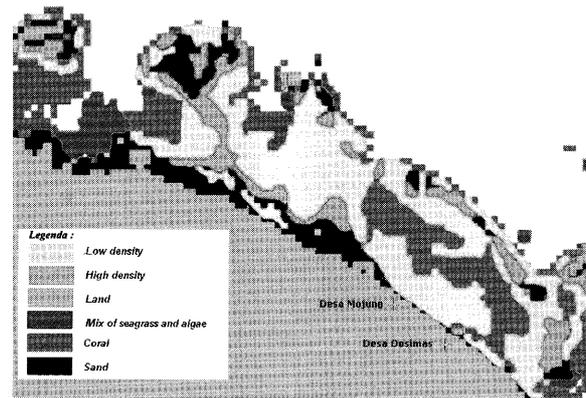


Fig. 5. Map of seagrass density in Tanjung Berakit Village.

seagrass is shown in Figs. 3, 4 and 5. These figures were resulted from the analysis and interpretation from data of sea-truthing as listed in Table 1. The existing condition of the study areas describes as follows.

Sei Kawal. Coastal water in this area received fresh water input from Kawal River. This river plays very important role, since this river mouth is used as traditional port by local fishermen and is treated as fish trading area. In this area, mangrove vegetation was estimated around (203.84 ha). The seagrass area was wider than that of mangroves (Fig. 6). It was spread around 364.41 ha. Coral zone was approximated 13.8 ha and the area of mixed of sand, coral and sargassum 5.06 ha (Table 2 & Fig. 6) Seagrasses exist sporadically from the area close to the beach line (± 10 to 30 meters) and spread until the reef slope. Namely 9 species of seagrasses were found i.e. *Cymodocea rotundata*, *C. serrulata*, *Enhalus acoroides*, *Halophila ovalis*, *Halodule pinifolia*, *H. uninervis*, *Syringodium isoetifolium*, *Thalassia*

Table 1. Detail of sea-truth in East Bintan coastal water.

Location	Position	Time	Sal (%)	Ked. (m)	Species	Notes	
Traveller lodge to	1.07007 104.64728	10.51	31	1.8	Ho, Th, Hp, Tc	beach	
	1.07019 104.64919	11.07	30	3.2	Coral	reef flat	
Sei Kawal	1.06829 104.65196	11.15	33	14.3	Sand	reef slope	
	1.06398 104.65177	11.25	32	1.72	Tc, Cs	beach	
	1.0638 104.65441	11.35	31	14.2	Sand	reef flat	
	1.06028 104.65298	11.5	34, 36	1.33	Th, Ho, Cr, Hp, Ea	beach	
	1.05944 104.65484	11.55	30, 31	12.11	Sand	reef flat	
	1.05704 104.65325	12.05	32, 33	1.4	Ea, Tc, Th, Cr, Ho, Si	beach	
	1.05732 104.65489	12.53	31	4.6	sand, coral	reef flat	
	1.05324 104.65297	13.07	35, 36	1	Ea	beach	
	1.05311 104.65539	13.2	34	1	Si, Ea, Tc	reef flat	
	1.05316 104.65739	13.3	32, 33	3.02	sand, coral	reef slope	
	1.05023 104.65686	13.37	30, 31, 32	0.9	Si, Ea, Tc, Th, Cs	beach	
		104.65871	13.5	32	1.53	Tc, Cs	reef slope (dense)
	1.04723 104.65729	14	32, 34	0.9	Ea, Th, Si, Cr, Cs	beach (dense)	
	Teluk Bakau	1.04535 104.66119	14.15	33	1.42	Tc, Ea	reef slope (dense)
1.04137 104.65917		14.34	33	1.42	Ea, Th, Cs	beach	
1.036 104.66498		14.5	31, 32	1.35	Tc	reef slope	
1.03282 104.65866		15.3	31	0.55	Ea, Th, Cr	reef slope	
1.0308 104.66031		15.4	31	0.68	Ea, Th	reef flat	
1.02791 104.65765		15.45	32	0.53	Cs, Cr	reef slope	
1.02739 104.66058		15.53	31, 32	0.91	Si, Th, Tc	reef flat	
1.02259 104.65998		10.55	31, 32	1.3	Cr, Si, Hu, Cs, Th	reef slope	
1.01602 104.65445		11.1	33	1	Sand	beach	
1.00461 104.65524		11.35	32	0.92	Th, Cs, Tc, Si, Ea	reef flat	
0.99928 104.6509		12	—	0.5	sand, coral	beach	
0.99409 104.64834		12.1	28, 29	0.91	Ea, Cr, Th	reef flat	
0.98206 104.64419		12.4	31, 33, 34	0.98	Th, Cr	reef flat	
1.0808 104.64221		09.20	32, 31	2.2	coral, sand, sargasum	beach	
1.08551 104.63932		09.38	32	1.57	Cs, Th, Si	beach	
1.11083 104.63413		10.40	32, 33	1.13	Hu, Th, Si, Ea	beach, Ea (50%)	
1.11453 104.62638		11.0	—	0.6	Sandy	beach	
1.11658 104.62386		11.0	32	1.0	Hp, Th, Ea	beach, Th (30–40%)	
1.11825 104.61982		—	—	—	Sandy	reef flat (ds.pucung)	
1.1186 104.61853		—	—	—	sandy, coral	reef flat (ds.pucung)	
1.12032 104.61376		11.22	32	1.71	Si, Th, Ea, Cs, Cr, Hu	beach, Th (100%)	
1.12517 104.60559		—	—	—	Ea, Th, Sargassum	seagrass extensive	
1.12587 104.60496		—	—	—	seagrass, reef flat, sand	—	
1.14345 104.58677	11.38	—	—	Sand	trikora		
1.15299 104.58288	13.50	30	1.0	coral, Th	beach		
1.16115 104.58026	—	—	—	Sargasum	tengah		
Mengkurus	1.16115 104.58026	14.15	32, 33, 34	1.25	Hu, Si	tengah	
	—	10.0	—	—	Ea, Si, Cr, Th, Cs, Hu	Ea (p 103–116 cm), Th (31 cm) Tegakan 5–7 batang/0.25 m ²	
	1.110831 104.63295	11.0	—	—	Ea, Th		
	1.113 104.62936	—	—	—	Seagrass		
	1.11538 104.62577	—	—	—	Sand		
	1.11949 104.61699	—	—	—	Sand		
	Pucung	1.07195 104.64524	11.2	—	—	Cr, Si, Hu, CS	
		1.07099 104.6456	—	—	—	coral, sargasum	
		1.0711 104.64651	—	—	—	Seagrass	
		1.07087 104.64701	—	—	—	Sand	

Table 1. (Continued)

Location	Position		Time	Sal (‰)	Ked. (m)	Species	Notes
Tanjung Timah	1.05732	104.65375	—	—	—	Ea	
	1.05596	104.65197	—	—	—	Th	
	1.05533	104.65428	—	—	—	Seagrass	
	1.05552	104.6551	14.20	—	4.0	Tc	reef slope, Tc (100%)
	1.05565	104.65594	—	—	—	Tc	reef slope
Desa Berakit	1.05355	104.65716	—	—	—	—	reef slope
	1.21125	104.54668	09.30	—	—	—	beach
	1.21053	104.54047	09.35	31, 32	2.03	Ea	tengah
	1.20293	104.54317	13.40	31	1.02	Ea	tengah, Ea (100%), p 75, 102, 130 cm
	1.21058	104.53891	14.00	32	2.0	Tc, Ho, Th, Ea, Si, Cr, Cs, Hu	mid part Ea p 77 cm, Tc p 22 cm
	1.21066	104.54102	14.35	31	0.85	Halophila spinulosa	beach
	1.21045	104.54145	—	—	—	Halophila spinulosa	beach

Note: Hu=*Halodule uninervis*, Ho=*Halophila ovalis*, Hp=*Halodule pinifolia*, Hs=*Halophila spinulosa*, Cs=*Cymodocea serrulata*, Cr=*Cymodocea rotundata*, Si=*Syringodium isoetifolium*, Ea=*Enhalus acoroides*, Th=*Thalassia hemprichii*, Tc=*Thalassodendron ciliatum*.

Table 2. Zonation in coastal water of East Bintan.

No	Zonation	Seagrass Extent (ha)							Total
		Sei kawal	Teluk Bakau	Mengkurus	Mlng. Rapat	Pulau Pucung	Tanjung Tima	Tanjung Berakit	
1	Sand	—	—	—	—	—	—	—	—
2	Mix (s,c,sg)	5.06	14.14	27.26	66.14	25.93	29.4	61.51	229.44
3	Seagrass	364.41	147.02	271.73	323.59	69.1	70.52	847.29	2.093.66
4	Coral	8.34	13.8	1.75	16.77	13.71	4.25	12.46	71.08
	Jumlah	377.81	174.96	300.74	406.5	108.74	104.17	921.26	

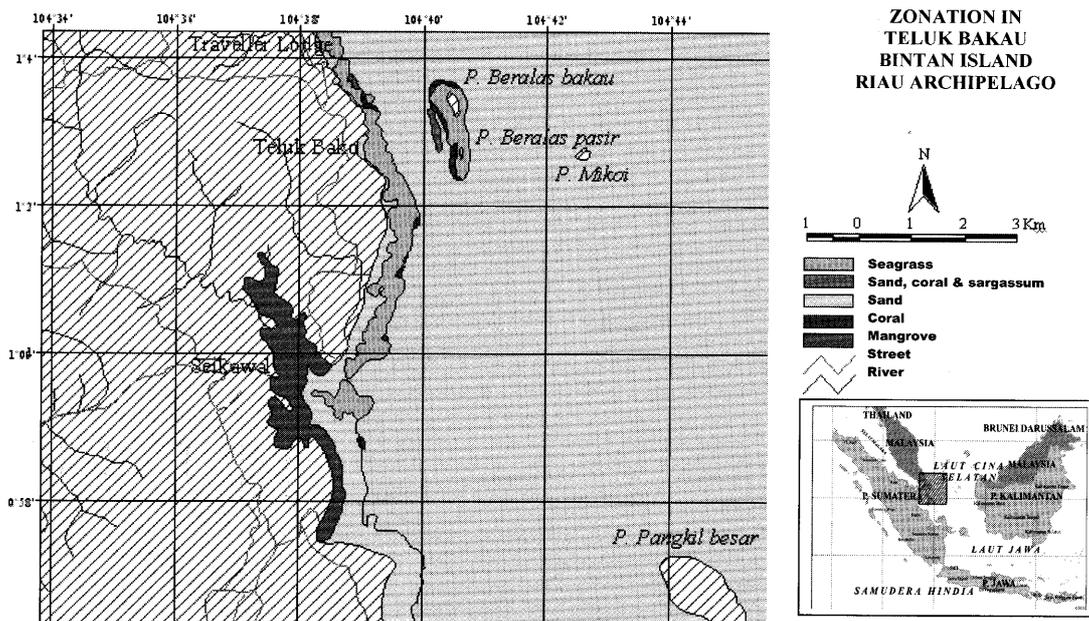


Fig. 6.

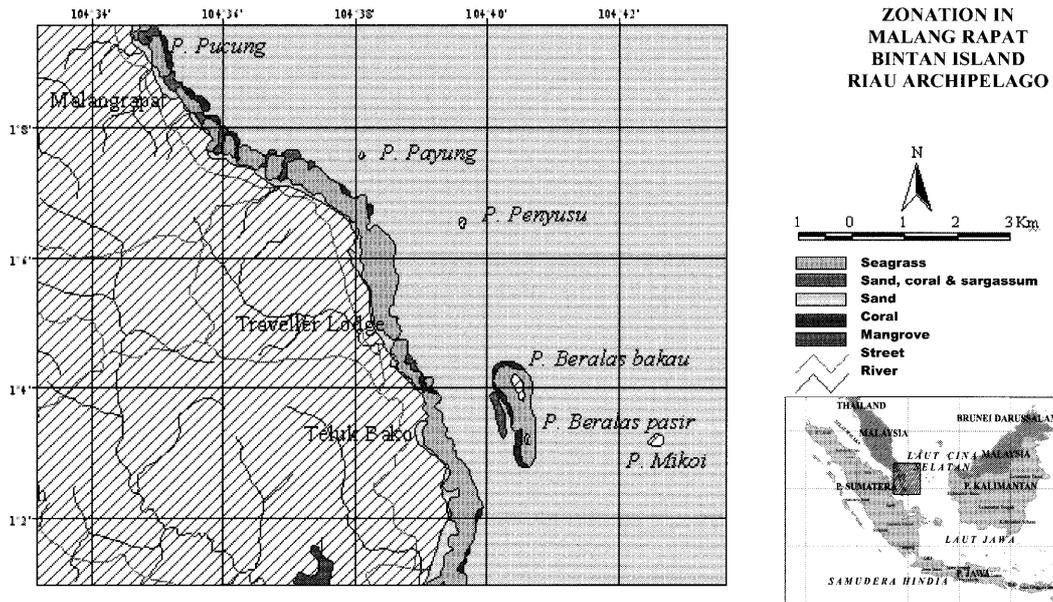


Fig. 7.

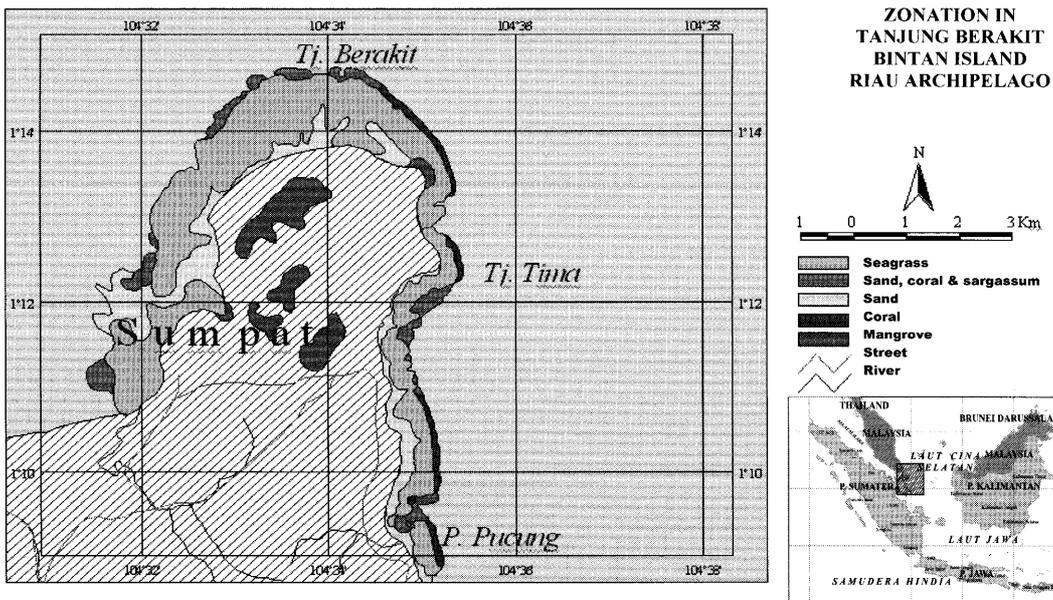


Fig. 8.

hemprichii and *Thalassodendron ciliatum*. The percent coverage ranged between 15 to 60%. It was dominated by *Thalassodendron ciliatum* in the subtidal and by *Cymodocea rotundata* in the intertidal water. Seagrass substrate in the area close to the beach line consists of fine sand mixed with little mud.

Teluk Bakau. Teluk Bakau consists of Dusun Mengkurus and Dusun Teluk Bakau. The beach vegetation in this area was dominated by coconut trees and barringtonians. The beach substrate is fine sand with creamy color. There was not much domestic waste in the beach since only little domestic area in this village. In Dusun Mengkurus waters seagrass

area covered +271.73 ha, mixed of sand, sargassum and coral covered +27.76 ha and coral area of coral was estimated only 13.8 ha (Fig. 3). Commonly, seagrasses started to be seen in the area about 30 to 50 meters. The species of seagrass were similar with those of Sei Kawal.

Extensive, mixed vegetation of seagrass was recorded in Dusun Teluk Bakau. There were 9 species of seagrasses documented (Table 3). *Enhalus acoroides* appeared foremost in shallow water around 20 to 100 meters from the beach line. Bottom sediment of this area mostly muddy fine sand. The thick of sediment is around 20 to 35 cm depth. Although find also in the shallow water about 30 to 50 meters near the beach line, in Teluk Bakau, *Thalassodendron ciliatum* mostly

Table 3. Seagrass distribution in coastal water of East Bintan.

Parameter	Teluk			Malang Rapat	Pulau Pucung	Tanjung Timah	Tanjung Berakit
	Sei Kawal	Bakau	Mengkurus				
A Beach morphology	Slope	Slope	Slope	Slightly slope	Slope	Slope	Slope
B Beach vegetation	Mangrove	Barringtonian & coconut	Mangrove & coconut				
C Human settlement	×	×	×	×	—	×	×
D Fresh water inflow	River	—	—	Creek	Creek	—	Creek
E Type of seagrass substrate							
Carbonate sediment	×	×	×	×	×	×	×
Terrigenous (silicate)	×	—	—	×	—	—	×
F Seagrass area (ha)	364.41	147.02	271.73	323.59	69.1	70.52	847.29
G Seagrass coverage (%)	15–60	30–90	60–90	40–90	50–90	45–70	30–80
H Recorded species	9	9	9	8	9	6	10
<u>Hydrocharitaceae</u>							
1 <i>Enhalus acoroides</i> (Ea)	Dense	fair	Fair	Dense	Fair	Fair	Dense
2 <i>Halophila decipiens</i> (Hd)	—	—	—	—	—	—	—
3 <i>Halophila minor</i> (Hm)	—	—	—	—	—	—	—
4 <i>Halophila ovalis</i> (Ho)	Rare	Very rare	Rare	Very rare	Rare	—	Rare
5 <i>Halophila spinulosa</i> (Hs)	—	—	—	—	—	—	Rare
6 <i>Thalassia hemprichii</i> (Th)	Fair	Fair	Dense	Fair	Fair	Fair	Dense
<u>Cymodoceaceae</u>							
7 <i>Cymodocea rotundata</i> (Cr)	Fair	Fair	Dense	Dense	Fair	Rare	Dense
8 <i>Cymodocea serrulata</i> (Cs)	Fair	Rare	Dense	Fair	Fair	Rare	Dense
9 <i>Halodule pinifolia</i> (Hp)	Rare	Rare	Rare	—	Rare	—	Rare
10 <i>Halodule uninervis</i> (Hu)	Rare	Rare	—	Rare	Rare	Rare	Rare
11 <i>Syringodium isoetifolium</i> (Si)	Fair	Fair	Rare	Dense	Fair	Fair	Dense
12 <i>Thalassodendron ciliatum</i> (Tc)	Very dense	Very dense	Dense	Dense	Very dense	—	Dense
I Dominant Species	(Tc)	(Ea) & (Tc)	(Th) & (Tc)	(Ea)	(Tc)	(Ea)	(Ea) & (Tc)

distribute in the deeper water area especially close to the reef slope. The coverage of this species reached more than 95%.

Malang Rapat. Survey in Malang Rapat Village was carried out in and Dusun Malang Rapat Dusun Pulau Pucung and Dusun Tanjung Timah. The beach is relatively narrow in Dusun Pulau Pucung. It was only less than 10 meter in the lowest tide, since the beach angle relatively steep. There was no domestic place in this area except some resort with poor sewage system. Beach vegetation was dominated by mangroves and coconut in certain part. Seagrass densely distribute at about 150 to 200 meter from the beach line. In some of shallow areas *Syringodium isoetifolium*, *Cymodocea rotundata* and *Thalassia hemprichii* appeared in monospecific vegetation but only in patchy form with narrow area of less than 0.5 ha. The percent coverage of these species was more than 80% each. The recorded seagrass species were similar with those in Teluk Bakau and Sei Kawal except for *Halodule pinifolia*. Zonation of seagrass; mixed of sand, sargassum and coral; and coral was estimated 69.1 ha, 25.93 ha and 13.71 ha consecutively (Table 2 and Fig. 4). *Cymodocea rotundata* considered to be the most common seagrass in this area.

Dusun Tanjung Timah water is located in the northern

part of Malang Rapat Village. Unlike in Dusun Pulau Pucung, there is no mangrove in this area. The bottom substrate is mostly dead coral, coarse sand and volcanic rock. Seagrass coverage was estimated around 70.52 ha and dominated by *Enhalus acoroides* in the intertidal zone. It occurs denser in the shallower water with muddy and thicker substrate. The coverage of seagrass was range between 45 to 70%. Only 6 species of seagrass were recorded in this area (Table 3). *Halophila ovalis*, *Halodule pinifolia* and *Thalassodendron ciliatum* were not found in Tanjung Timah

Tanjung Berakit. Mangrove with coverage of 158.4, grow densely in the west part of Tanjung Berakit coastal water. The most common species is *Rhizophora mucronata*. Seagrass of *Enhalus acoroides* sparsely occur in monospecific vegetation form close to the mangrove area with percent coverage range between 25 to 45%. Bottom sediment consists of fine sand and mud with slightly the same composition. In the mid part of intertidal zone, seagrass meadow with mix vegetation growth densely and cover extensive area. Percent coverage ranges between 30–80%. Namely 2 species of seagrass occur dominantly i.e. *Thalassodendron ciliatum* and *Enhalus acoroides* (Tabel 3). In this mixed vegetation of seagrass, the rare species of seagrass in Indonesia *Halophila*

spinulosa was found in very sparse density and in patchy distribution. This finding is considered being the most important result of this study, since the last documented of this species was only in Kuta Bay, Lombok (Kiswara 1994).

The coverage of seagrass in Tanjung Berakit relatively high compare to those in the other study sites (see Table 2.). The occurrence of *Thalassodendron ciliatum* in the subtidal zone along the East Bintan coast especially close to the reef edge, demonstrates the role of seagrass protecting the reef slope from natural degradation with retarding the energy of wave action. The beaching detritus of seagrass was so abundant drifted along the beach line. With natural process, decomposition, it will serve huge quantity of nutrient to the surrounding waters.

Conclusions

1. Seagrass coverage of East Bintan coastal waters approximately 2093.66 hectares.

2. Namely ten species of seagrass were recorded *i.e.* *Cymodocea rotundata*, *C. serrulata*, *Enhalus acoroides*, *Halodule pinifolia*, *H. uninervis*, *Halophila ovalis*, *H. spinulosa*, *Syringodium isoetifolium*, *Thalassia hemprichii* and *Thalassodendron ciliatum*.

3. The most dominant species in the area is *Thalassodendron ciliatum* occur mostly in the reef edges. The second rank is *Enhalus acoroides* which distribute in the intertidal zone with thicker sediment.

4. Tanjung Berakit water is recorded as the widest area (847.29 ha) and the highest diversity of seagrass in East Bintan. (10 species).

5. *Halophila spinulosa* is the rarest species found in the East Bintan and only occurs in Tanjung Berakit

6. The use of remote sensing technique is in actual fact very practical to obtain the map of seagrass.

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