

The distribution of seagrass meadows and dugong feeding trails in the dry season around Talibong Island, Trang Province, Thailand

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ABSTRACT

To study feeding selectiveness of dugongs, community structure of seagrass meadows and distribution of dugong feeding trails were investigated around Talibong Island, Thailand, during the dry season 2005. The dominant species in this area were; *Halophila ovalis*, *Cymodocea serrulata*, *Cymodocea rotundata*, *Enhalus acoroides*. *H. ovalis* dominated in shallow areas mainly on tidelands and in deep areas, *E. acoroides* dominated areas that received the strongest influence of drift sand, such as shallow offshore sides of the seagrass meadows, or waterways. Along coastal sides of *E. acoroides* communities, the comparatively calm inner sides were dominated by *C. serrulata* and *C. rotundata*. Among those seagrass meadows, concentration of dugong feeding trails were observed at *H. ovalis* communities in tidelands, therefore dugongs selectively feed on *H. ovalis* at tidelands in this study site during dry season.

KEYWORDS: *Dugong dugon*, *Halophila ovalis*, dugong feeding trails, dry season, seagrass meadow, Thailand

INTRODUCTION

Dugongs (*Dugong dugon*, Müller) occur in the tropical and subtropical sea areas of the Indo-Pacific Ocean (Nishiwaki and Marsh, 1985), and are a rare species as the IUCN Red List classified dugong as vulnerable. However neither proper protection nor management has been given to dugongs as a result of insufficient amount of ecological knowledge.

In studies of dugong feeding ecology, several reported on analysis of stomach contents, fecal samples, and mouth samples (Heinsohn and Birch, 1972; Lipkin, 1975; Johnstone and Hudson, 1981; Marsh et al., 1982; Erftemeijer et al., 1993; Preen, 1995; Adulyanukosol, 2001; André et al., 2005), as well as field observation of dugong feeding trails (Aragones, 1994; De Iongh et al., 1995; De Iongh et al., 1997; Kasuya, 1999; Mukai et al., 2000; Nakanishi et al., 2005), which clarified that they feed on seagrasses. Anderson (1994) and Preen and Marsh (1995) reported the importance of seagrass meadows as their feeding grounds. Although in these reports, it is not clear about feeding selectiveness of dugong, Aragones (1994) and De Iongh et al. (1995) suggested dugong feeding behavior may change depending on seasons, weather, tides, and seasonal seagrass growth conditions. Also at this study area, Nakanishi et al. (2005) pointed out dugong's feeding selectiveness may be connected with seagrass species,

its amount, and seasonal seagrass growth condition at each feeding region, or differences on dugong feeding preference itself, so that accumulation of ecological knowledge of dugong feeding is an issue. Therefore, the authors collected data on distributional structure of seagrass meadows and dugong feeding trails around Talibong Island, Trang Province, Thailand, during the dry-season, and gained knowledge on dugong feeding behavior. The results are presented below.

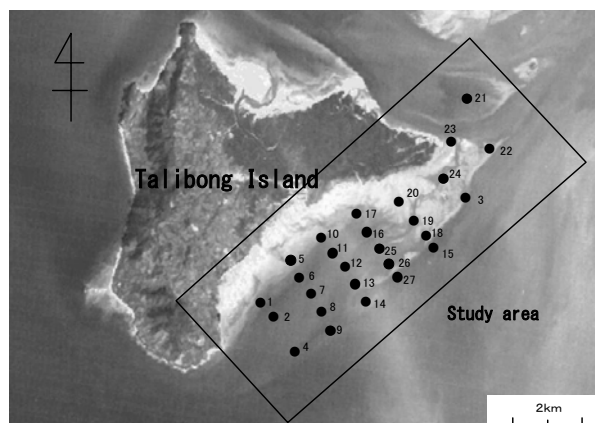


Fig.1 Map of the study area around Talibong Island, Thailand. Closed circles indicate study sites in the seagrass meadow.

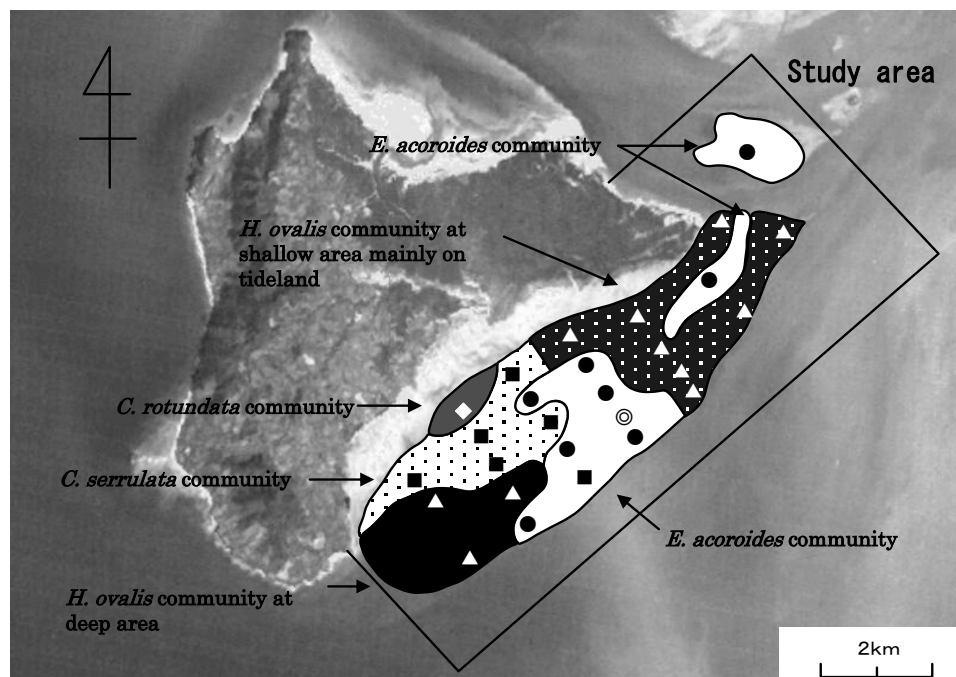


Fig.2 Distribution of seagrass communities and dominant species in each study site. Opened triangles indicate site where *Halophila ovalis* dominated. Closed circles indicate site where *Enhalus acoroides* dominated. Closed squares indicate site where *Cymodocea serrulata* dominated. Opened diamond indicates site where *Cymodocea rotundata* dominated. Double circle indicates site where *Thalassia hemprichii* dominated.

MATERIALS AND METHODS

Study area

In Thailand, dugongs have been found along the coastlines of the Gulf of Thailand and the Andaman Sea (Adulyanukosol, 2000). The largest group of dugong inhabits the waters around Talibong Island, in Trang Province (Adulyanukosol et al., 1997; Adulyanukosol and Chantrapornsyl, 1999; Adulyanukosol, 2000; Hines et al., 2005), where the largest seagrass meadows in Thai waters are also located (Chansang and Poovachiranon, 1994; Poovachiranon, 2000). Nakanishi et al. (2005) and Nakanishi et al. (submitted) found that species composition of seagrass meadows around Talibong Island, consist of 11 species of seagrasses; *Enhalus acoroides*, *Halophila beccarii*, *Halophila decipiens*, *Halophila ovalis*, *Halophila minor*, *Thalassia hemprichii*, *Cymodocea serrulata*, *Cymodocea rotundata*, *Halodule pinifolia*, *Halodule uninervis*, and *Syringodium isoetifolium*, and reported dugongs were using those seagrass meadows as their feeding grounds.

Methods

Observations were made by SCUBA divers from 27th of February to 3rd of March 2005. We observed seagrass conditions and dugong feeding trails in 27 study sites which were randomly placed around Talibong Island (Fig.1).

For seagrass condition, at each study site, three 50cm quadrats were randomly set within a

circle of 5m radius, and seagrass species, its coverage, and water depth (the water depth compared to Mean Sea Level (MSL)) within quadrats were recorded. Data obtained from three quadrats at each study site was averaged. We analyzed it for seagrass community structure with aspects of species composition and water depth.

We measured the leaf length of each 30 *H. ovalis* at depths shallower than, and deeper than -0.5m and compared them.

For dugong feeding trails, 50m lines parallel to the coast line were laid down at each study site, and the number of dugong feeding trails on the line were counted. We observed grazed seagrass species, as well as the most grazed seagrass species judging from surrounding seagrass composition at places where dugong feeding trails were found.

RESULTS

Distributional structure

A total of nine seagrass species were found at these study sites; *Enhalus acoroides*, *Halophila beccarii*, *Halophila ovalis*, *Thalassia hemprichii*, *Cymodocea serrulata*, *Cymodocea rotundata*, *Halodule pinifolia*, *Halodule uninervis*, and *Syringodium isoetifolium* (Table 1). Classifying the data obtained at each study site by species composition and water-depth showed mainly five zones; *E. acoroides*, *C. serrulata*, *C. rotundata*, "*H. ovalis* at shallow areas mainly on tidelands", and "*H. ovalis* at deep areas" zones (Fig.2). Characteristics of distribution of seagrass

Table 1. Water depth, seagrass growth condition and the number of dugong feeding trails in each study site. Water depth was expressed as height compared to Mean Sea Level (MSL). *, The most consumed seagrass species at each study site. (), Other consumed seagrass species at each study site. ■, Seagrass species where dugong feeding trails were observed.

Division of seagrass community	<i>E. acoroides</i>												<i>C. serrulata</i>					
	9	11	13	14	16	21	24	25	26	27	1	6	7	10	12			
Study site																		
Water depth (m)	-2.2	-1.9	-1.2	-0.5	-1.0	-0.3	+0.6	-0.3	+0.6	-0.3	+0.3	-1.5	-1.0	+0.6	-0.6			
Total coverage of seagrasses (%)	10	15	25	15	25	20	10	25	35	30	40	50	25	60	40			
<i>Enhalus acoroides</i>	10	15	25		25	20	10	25	+	30	10							
<i>Halophila beccarii</i>																		
<i>Halophila ovalis</i>	+			5					15		15	20	5					
<i>Thalassia hemprichii</i>									20									
<i>Cymodocea serrulata</i>				10							15	30	20	50	40*			
<i>Cymodocea rotundata</i>									+					10				
<i>Halodule pinifolia</i>																		
<i>Halodule uninervis</i>									+									
<i>Syringodium isoetifolium</i>									+									
Total number of dugong feeding trails	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1			

Division of seagrass community	<i>C. rotundata</i>	<i>H. ovalis</i> at deep sites				<i>H. ovalis</i> at shallow sites											
		2	4	8	3	15	17	18	19	20	22	23					
Study site	5																
Water depth (m)	+0.9	-1.6	-2.4	-0.7	+1.3	+0.5	+1.3	+1.3	+1.2	+1.1	+0.9	+0.9					
Total coverage of seagrasses (%)	40	35	20	5	45	45	40	40	50	55	30	25					
<i>Enhalus acoroides</i>						5	+	+			+	+					
<i>Halophila beccarii</i>									(20)								
<i>Halophila ovalis</i>	10	30*	15	+	45*	20*	20	40*	30*	35*	30*	25					
<i>Thalassia hemprichii</i>						15	20	+									
<i>Cymodocea serrulata</i>		(5)	+			(5)				20							
<i>Cymodocea rotundata</i>	30				+		+					+					
<i>Halodule pinifolia</i>			+	+													
<i>Halodule uninervis</i>		+	+	+		+											
<i>Syringodium isoetifolium</i>						+											
Total number of dugong feeding trails	0	12	0	0	8	2	0	1	3	8	12	0					

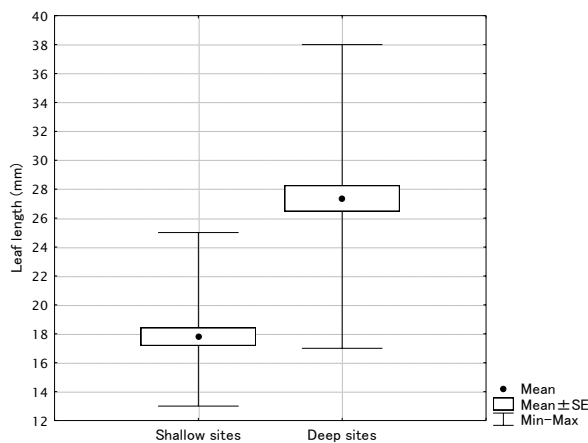


Fig.3 Leaf length of *Halophila ovalis* at depths shallower than, and deeper than -0.5m.

meadows were; large-sized *E. acoroides* dominated in the areas that received strong influence of drift sand, such as boundary areas at offshore sides of the seagrass meadows or waterways (depth of -2.2 to +0.6m), with coverage of 10 to 30%. Although site 14 and site 26 belong to *E. acoroides* dominant zone, other seagrass species dominated at these sites. As discussed in the next section “Interspecies relationship”, those sites were located at areas surrounding the zone, or at unoccupied spaces among *E. acoroides*. *C. serrulata* dominated along coastal side of *E. acoroides* dominant zone, comparatively calm inner seagrass meadow areas (depth of -1.5 to +0.6m) with coverage of 15 to 50%. *C. rotundata* dominated along coastal side of *C. serrulata* dominant zone (depth of +0.9m) with coverage of 30%. *H. ovalis* dominated at shallow areas (depth of +0.5 to +1.3m) mainly on tidelands, and at deep areas (depth of -2.4 to -0.7m) in the seagrass meadows, the coverage of *H. ovalis* were 20 to 45%, and less than 5% to 30%, respectively. The average of leaf length of *H. ovalis* at deeper than -0.5m depth was 27 ± 5 mm, whilst at shallower than -0.5m depth was 18 ± 3 mm (Fig.3). The leaf length of *H. ovalis* at depths deeper than -0.5m was significantly longer than that at depths shallower than -0.5m (Mann-Whitney U-Test, $p < 0.05$).

Interspecies relationship

Comparing coverage of each site in detail (Table 1), at sites with high coverage of *E. acoroides*, 15 to 35% (site 11, 13, 16, 21, 25, 27), almost none of the other seagrass species grew. In these areas, other seagrass species grew only at unoccupied spaces among *E. acoroides* or surrounding areas. At sites with high coverage of *C. serrulata*, 40 to 50% (site 10, 12), *H. ovalis* did not grow together, but at sites with low coverage, 15 to 30% (site 1, 6, 7), *H. ovalis* grew together. In the field, the same interspecies relationship was observed between *C. rotundata* and *H. ovalis*. On the other hand, at the sites with high

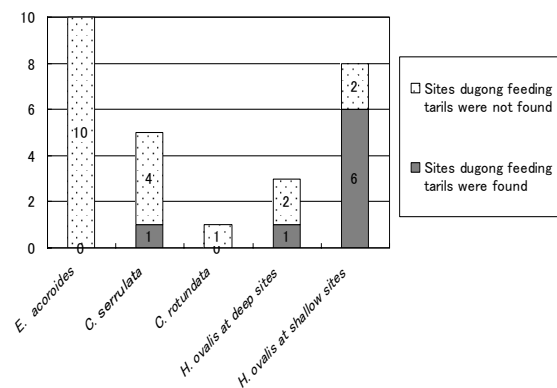


Fig.4 Number of sites where dugong feeding trails were found and sites where trails were not found in each seagrass zone

coverage of *Halophila* species, 40 to 50% (site 3, 18, 19), almost no other seagrass species could be found, even if it could, only with low coverage, less than 5%.

Dugong feeding trails

Dugong feeding trails were found at one of five sites within *C. serrulata* zone, one of three sites within *H. ovalis* zone at deep areas, and six of eight sites within *H. ovalis* zone at shallow areas mainly on tidelands (Table 1). Dugong feeding trails were not found at *E. acoroides* and *C. rotundata* zones. Seven of the eight sites observed with them were in *H. ovalis* zones and among those, six sites were in *H. ovalis* zone at shallow areas, especially showing concentration in *H. ovalis* zone at tidelands (Fig.4). The average number of dugong feeding trails of each site in each seagrass zone was 0.2 in *C. serrulata* zone, 4 in *H. ovalis* zone at deep areas, and 4.3 in *H. ovalis* zone at shallow areas (Fig.5). The average number of dugong feeding trails in *H. ovalis* zone at shallow areas was not significantly different from that at deep areas (t-Test, $p > 0.05$), but it was significantly different from that in *C. serrulata* zone (t-Test, $p < 0.05$). Therefore, dugong feeding trails were concentrated in *H. ovalis* zone.

DISCUSSION

Community structure of seagrasses meadows

Community structure of seagrass meadows changes depending on species interaction and environmental factors such as water depth, salinity, turbidity, substrate, light, and drift sand (Young and Kirkman, 1975; Dredge et al., 1977; Walker, 1989; Hemminga and Durate, 2000). In particular communities that are exposed to periodical drift sand and current are always in a state of local loss and regeneration, resulting in a characteristic patchy landscape (Den Hartog, 1971), the condition of seagrass meadows fluctuates depending on frequency and magnitude of physical disturbances it receives (Duarte, 1991b). Water depth tolerance of seagrasses differs

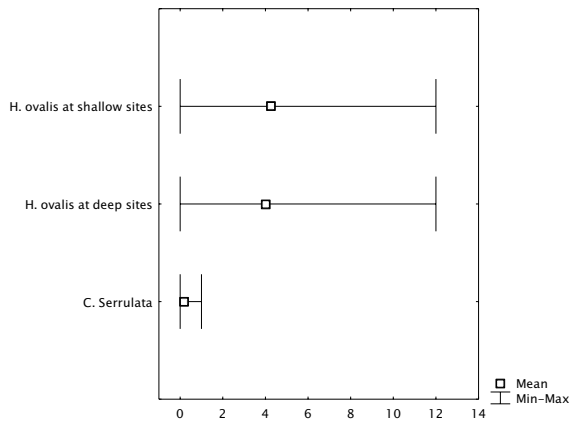


Fig.5 Average number of dugong feeding trails confirmed in each site with maximum and minimum number

for every species (Walker, 1989; Toma, 1999). As drift sand and water depth were considered to be a main factor for determining seagrass community structure, distributional structure of seagrass meadows in this study area were organized with water depth and magnitude of drift sand disturbance; offshore side where it receives strong influence of drift sand, and coastal side with less drift sand (Fig.6). The seagrass meadows in this area could be grouped in five distributional zones.

First of all, shallow areas mainly on tidelands were dominated by *H. ovalis*. Among seagrasses, *Halophila* species are very tolerant of high temperature and intense light (Walker, 1989). On tidelands, *Halophila* species are able to resist exposure to air and desiccation, as their leaves lay flat on the sediment surface (Hemminga and Durate, 2000), it is known that *Halophila* species are well adapted to tideland environment (Birch and Birch, 1984; Walker, 1989; Hemminga and Durate, 2000). In our observation, *Halophila* species were avoiding exposure to air and desiccation using this method on tideland during low tide, and monospecific *H. ovalis* communities were often observed at places that were exposed completely at low tide. Although other seagrass species were observed at the tideland as well, they occurred less and chiefly in slight depressions which retain water at low tide. Blighted leaf from desiccation were often seen. Therefore, on the tidelands, seagrass species other than *Halophila* species could not develop communities due to exposure to air and desiccation. Thus *Halophila ovalis* dominated on the tidelands.

On the other hand, *H. ovalis*, *C. serrulata*, *H. uninervis*, and *H. pinifolia* were observed at deep area of seagrass meadows. *H. ovalis* was the dominant species among these. The deepest depth

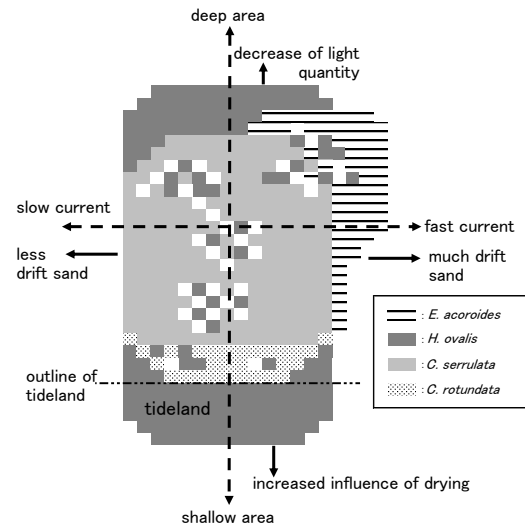


Fig.6 Schematic view of seagrass community structure in this study area, relation to drift sand and water depth.

was -2.4m at this area and light that was important for photosynthesis decreased. Since this area was facing offshore, it was receiving occasional sediment disturbances from waves of strong trade-winds as well as influence of drift sand during rainy seasons, though it was not as much as shallow offshore sides of the seagrass meadows (-2.2 to +0.6m depth), which will be described later. Among seagrasses observed in this area, *H. ovalis*, *H. uninervis*, and *H. pinifolia* are smaller seagrasses. Such smaller seagrass species elongate faster and spread in two dimensions at a greater rate than larger seagrass species do (Hemminga and Durate, 2000). Due to this character, smaller seagrass species are considered to play a pioneer role (Duarte, 1991a; Duarte et al., 1997). Therefore, in this area, it was hard for slow growing larger seagrass species to sustain its communities against occasional disturbances during rainy seasons. As a result, the fastest grower of all seagrasses (Preen, 1995; Yamamuro and Chirapart, 2005), *H. ovalis* dominated in this area. As *H. ovalis* at deep areas has longer leaves than *H. ovalis* at shallow areas, it is possible that *H. ovalis* at deep areas adapted to low light environment by changing its morphology; with longer leaves to receive more light. In addition, we thought this difference of morphology was not related to difference of grazing pressure of dugong, as grazing pressure of dugongs was lower in deep areas than shallow, which will be described later, and because of sympatric occurrence of those two types around -0.5m depth.

Shallow offshore sides (-2.2 to +0.6m depth) and waterways receive the strongest influence of drift sand in the seagrass meadows. At these areas, *E. acoroides* dominant communities were observed. *E. acoroides* is most suitable species for bearing drift sand because it has a thick and long rhizome that

supports its body structure (Toma, 1999) and tolerates heavy sedimentation (Terrados et al., 1997). At these areas, other seagrass species than *E. acoroides* were found in small amounts, but limited to surrounding areas of *E. acoroides* communities or unoccupied spaces among *E. acoroides* where influences of drift sand were lessened. Therefore, it appeared the areas were unsuitable for other seagrass species to grow due to influence of drift sand.

C. serrulata and *C. rotundata* dominated the area along coastal sides of *E. acoroides* communities. Toma (1999) pointed out stabilization of sediment is significant for growth of *C. serrulata* and *C. rotundata* grows at places without direct exposure to waves. In our research, those two seagrasses were observed at calm areas where waves from offshore and influence of drift sand were lessened by *E. acoroides* communities, and hence resulted in *C. serrulata* and *C. rotundata* dominance. Although *H. ovalis* were found at these areas, as the coverage of *C. serrulata* and *C. rotundata* increased, the coverage of *H. ovalis* decreased. Nakaoka and Izumi (2000) implied that the growth of *H. ovalis* became slower when *T. hemprichii*, a larger seagrass than *H. ovalis*, grew surrounding *H. ovalis* communities, compared to the case without *T. hemprichii* growing around it. Thus it is considered that *H. ovalis* lost the interspecies competition due to dominance of larger seagrass species than *H. ovalis*. In such places, distribution of *H. ovalis* will be limited to boundary areas and unoccupied spaces of the larger seagrass communities.

Usages of seagrass meadows by dugongs

The present situation for feeding selectiveness of dugongs is unclear as several authors reported contrary results; Wake (1975) and Marsh et al. (1982) reported no feeding selectiveness of dugongs based on the analysis of stomach contents, but Gohar (1957), Heinsohn and Birch (1972), and Lipkin (1975) reported presence of feeding selectiveness. In field observation of dugong feeding trails, Kasuya et al. (1999) reported they could not identify dugong feeding selectiveness on seagrasses, but De Iongh et al. (1995), Nakanishi et al. (2005), and Yamamuro and Chirapart (2005) reported presence of feeding selectiveness.

In our research, judging from the distribution and number, dugong feeding trails were heavily concentrated in *H. ovalis* communities at shallow sites mainly on tidelands (Fig.4, Fig.5). It is more advantageous and efficient for dugongs to feed at deeper seagrass communities which do not become exposed at low tides. In addition, *E. acoroides*, *C. serrulata*, and *C. rotundata* were other dominant species than *H. ovalis* in the seagrass meadows, these seagrasses were bigger and the quantity of these seagrass resources available for dugongs in a unit area was more than that of *H. ovalis*. When

considering only feeding efficiency, consuming larger-sized *E. acoroides*, *C. serrulata*, or *C. rotundata* must be more efficient. However dugong feeding trails were concentrated in shallow *H. ovalis* communities in this research (Fig.4, Fig.5). Additionally, in this study area, Nakanishi et al. (2005) reported that dugong feeding trails were concentrated in *H. ovalis* communities of tidelands during the dry season in 2004. Therefore, we concluded that dugongs selectively feed on *H. ovalis* communities at shallow areas mainly on tidelands during the dry season in this study area. Although *H. ovalis* communities were also observed at deep areas in these seagrass meadows, its leaves were bigger than that in shallow areas mainly on tidelands, and seagrass species other than *H. ovalis* often grow together in deep *H. ovalis* communities. These two differences may be caused by feeding preference of dugongs towards monospecific *H. ovalis* communities at shallow areas mainly on tidelands. To date, studies of dugong feeding behavior by the field observation of dugong feeding trails, reported several different results. De Iongh et al. (1995) reported feeding preference of dugongs towards *H. uninervis* at seagrass meadows that were dominated by three seagrass species; *H. uninervis*, *C. rotundata*, and *T. hemprichii*. Kasuya et al. (1999) could not be clear about dugong feeding selection at seagrass meadows in which seven seagrass species grew together, and Yamamuro and Chirapart (2005) reported that dugongs selectively feed on *H. ovalis* in research of tideland. The reason for those different results may be caused by bias of the main flora of seagrass meadows and water depth of study sites. Therefore it is necessary to accumulate and organize knowledge of community structure of seagrass meadows and distribution of dugong feeding trails.

In our research, dugong feeding trails were observed at *H. beccarii*, *C. serrulata* and *H. ovalis* (Table 1), but not at *E. acoroides*. Nakanishi (2005) also reported that dugong grazing scars at *E. acoroides* communities in this study area had not been observed during the dry season 2004. Nakanishi (submitted) found only two dugong grazing scars at nine *E. acoroides* communities in this area during the dry season 2005. Aragonés (1994) reported that more dugong feeding trails were observed at communities of smaller seagrasses than *E. acoroides*, such as *H. ovalis*, *H. uninervis*, *C. serrulata*, *C. rotundata*, *S. isoetifolium*, *T. hemprichii*, in the Philippines. Thus, we concluded that there is less possibility for dugong feeding selection towards *E. acoroides*.

During 1997 to 1999, Adulyanukosol (2001) analyzed stomach contents of six dugongs that accidentally drowned in the surrounding area, and confirmed that dugongs fed dominantly on other seagrass species than *H. ovalis*. This indicates involvement of available seagrass species, amount of seagrasses, seasonal growth condition of seagrasses

at their habitat, or dugong feeding preference itself. Hence it is necessary to study these in the wet season as well, to clarify feeding behavior of dugongs in this area.

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