Analysis of stomach contents of dugongs (*Dugong dugon*) from Gulf of Thailand

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ABSTRACT
During October 1994-March 2001, six stomach samples of stranded dugongs were collected from 4 provinces in the Gulf of Thailand - 3 from Rayong Province, 1 from Chonburi province, 1 from Chumporn Province and 1 from Surat Thani Province. Based on the inspection of physio/morphological characters of leaves and epidermal cells, seagrass fragments were identified down to genus/species under stereo-and compound-microscopes. Five species of seagrass were found in the dugong stomachs, their biomass were determined in terms of dry weight. The percentage of dry weight of each genus/species found in the stomach contents was as follows: *Halophila* (*H. ovalis* and *H. decipiens)* 9.97-55.43%, *Halodule uninervis* 0-37.43%, *Thalassia hemprichii* 0-2.25%, and *Enhalus acoroides* 0-13.74%. The frequency of occurrence of seagrasses in the stomachs ranged from the maximum to the minimum as follow: *Halophila*, *Halodule*, *Enhalus* and *Thalassia*. In addition, rhizome (13.99-45.49%) and algae (3.33-16.41%) were found in all stomach samples.

KEYWORDS : stomach content, dugong, seagrass, biomass, Gulf of Thailand

INTRODUCTION

Dugongs (*Dugong dugon*) are the extent herbivorous marine mammal in the tropical-subtropical areas of the Indo-Pacific (Nishiwaki and Marsh, 1985). In Thailand, dugongs have been found along the coastlines of both the Gulf of Thailand and Andaman Sea. The largest group of dugongs inhabits around Talibong-Muk Islands, Trang Province (Aueng *et al.*, 1993; Adulyanukosol *et al.*, 1997; Hines and Adulyanukosol, 2001; Adulyanukosol, 2004). Dugongs are surviving by feeding on seagrasses (Hinsohn and Birch, 1972; Johnstone and Hudson, 1981; Marsh *et al.*, 1982; Erflemeijer *et al.*, 1993). There are a few studies on the precise composition of dugongs diet, however, they were inconclusive as to whether dugongs were selective in their grazing or not (Johnstone and Hudson, 1981). Heinsohn and Birch (1972) have reported that dugongs in Townsville area of Queensland fed exclusively on seagrass, selectively on *Cymodocea* spp. and *Halodule* spp. Heinsohn and Spain (1974) have recorded that brown algae, in addition to seagrasses, were eaten by dugongs due to the destruction of seagrass meadows by tropical cyclones. In addition, the dugongs occasionally fed on invertebrate, such as ascidians and polychaete, along with the seagrasses (Spain and Heinsohn, 1973; Lipkin, 1975; Marsh *et al.*, 1982; Preen, 1995, Adulyanukosol *et al.*, 2001). Johnstone and Hudson (1981) have found the leaf of *Avicenia marina* in a dugong's mouth as well. While Nair *et al.* (1975) have reported that the main food of the dugong in Mandapam, India was *Cymodocea serrulata*. Moreover, the dugongs at the Central Marine Fisheries Research Institute were fed with *C. serrulata* and *Halodule uninervis*. Adulyanukosol *et al*. (2001) have found 9 species of seagrass in the stomach samples from Trang province, Thailand, and 2 genera, *Halodule* and *Halophila*, were found in all stomach samples.

The purpose of this study is to determine the composition of food in the dugong stomachs and the relation of seagrasses found in the stomach to the species of seagrass in the catch area.

MATERIALS AND METHODS

Six stomach samples were collected from the dead dugongs during 1994-2001 from 4 provinces located in the Gulf of Thailand; 3 dugongs from Rayong Province and another 3 dugongs from Chonburi, Chumporn and Surat Thani Provinces (Fig. 1).

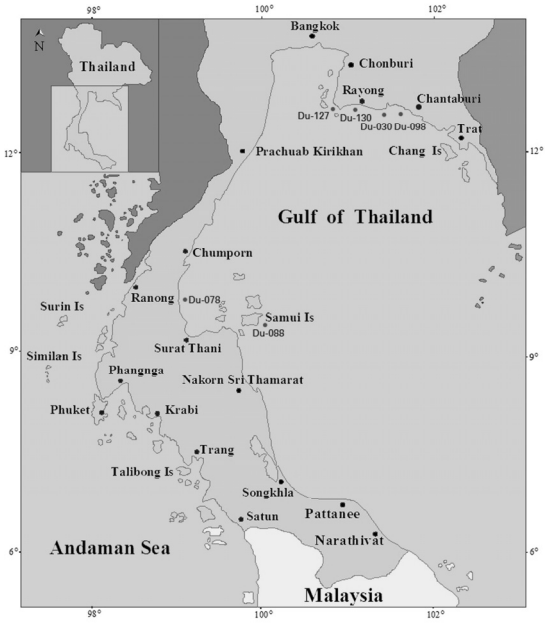

Figure 1. Map shows 4 areas where the specimens found.

After measuring external characteristics and weighing the dugong carcasses, the internal organs were inspected (measuring, weighing including parasite collecting). The measurements of the stomach samples were the maximum lateral diameter of the stomach through the esophagus, weight and pH in 3 regions of each stomach using pH paper (Fig. 2a). Then the stomach content was weighed and preserved in 10% formalin. After well mixing of each stomach content, 3 sub-samples, about 5 gm wet weight each, were inspected. Samples were identified down to genus/species under stereo-and compound-microscopes basing on physio/morphological characters of leaves and epidermal cells of seagrass fragments following the method of Channels and Morrissey (1981), Adulyanukosol *et al.* (2001) and Adulyanukosol and Poovachiranon (2003). *Halophila ovalis* and *H. decipiens* were group as "*Halophila*". There was no attempt to identify the rhizome and root of seagrass into species so they were grouped as "rhizome". Detritus, rotten seagrass fragments, and unidentified materials were grouped as "others". Algae were treated as a single species. Biomass of each genera/species of seagrasses was measured as well. General information of 6 specimens are given in Table 1.

Table 1. General information of the 6 dugongs in this study, stomach contents, and pH of the stomach including small and large intestines. (W=Width, L=Length, Wt=Weight, M=Male, F=Female, Sto =Stomach, Lat dia= lateral diameter, fd= food, Nemt= Nematode, Bd wt=Body weight, Si=Small intestine, Li=Large intestine, - = no information).

Number (ID-No)	Date	Locations	L (m)	Wt (kg)	Sex	Sto		%food/ Bd wt	Nemt (ind)	pH		
						Lat dia (cm)	fd (kg)			Sto	Si	Li
Ray-1 (Du-030)	7/10/94	Kew bay, Samet Is., Rayong	2.42	-	F	-	-	-	-	-	-	-
Ray-2 (Du-098)	15/10/98	Mannok Is., Klaeng, Rayong	2.14	180	M	24	2.0	1.11	55	3-7	7	8
Ray-3 (Du-130)	7/3/01	Pla beach, Ban Chang, Rayong	2.09	166	M	28	5.4	3.25	0	4-7	7	6
Chb-1 (Du-127)	13/6/00	Sattahip bay, Chonburi	1.09	27.8	F	10.1	0.3	1.08	0	3-5	7	7
Chp-1 (Du-078)	19/5/98	Bangman Bay, Lamae, Chumporn	2.31	151	F	27	0.7	0.46	160	-	-	-
Sut-1 (Du-088)	30/8/98	SE of Samui Is., Surat Thani	2.35	228	M	27	8.8	3.86	0	2-5	5	8

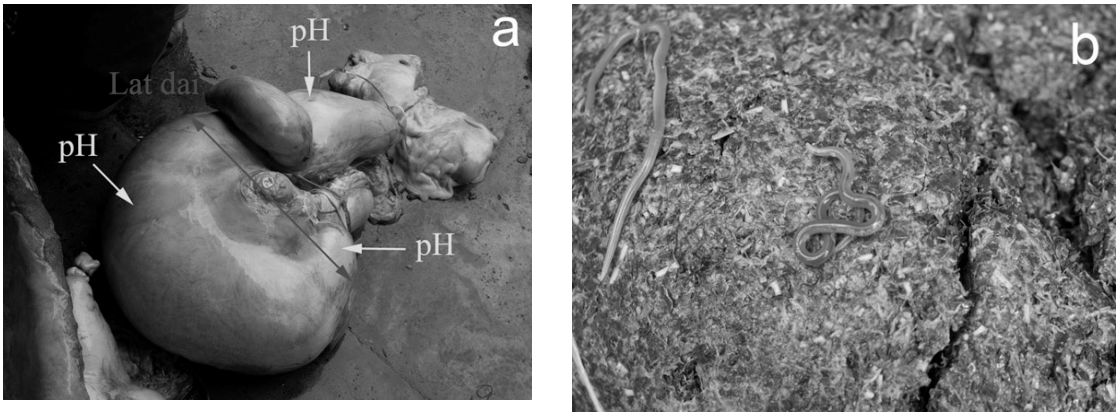

Figure 2. a) stomach of dugong shows the lateral diameter (Lat dai) and 3 regions of pH measurement, b) general feature of food in the dugong stomach, mainly seagrass fragments with yellowish brown color and the small picture shows the nematode, *Paradujardinia halichoris*, commonly found in the stomach of dugongs.

RESULT

In this study, 6 dugongs were 3 males and 3 females and the sizes of the dugong ranged from 1.09-2.42 m in length and 27.8-228 kg in weight (Table 1). The maximum lateral diameter of the stomach through the esophagus length ranged from 10.1-28 cm. In general, the food in the stomach samples was mainly seagrass fragments with yellowish brown color and dry (Fig 2b). Nevertheless, some mucus was observed in the food that attached to the sac wall. The percentage of food per body weight was between 0.46-3.86. The values of pH in the stomach, small intestine, and large intestine ranged from 2 to 7, 5 to 7, and 6 to 8, respectively. The nematode, *Paradujardinia halichoris* was found in Ray-2 and Chp-1; 55 and 160 individuals, respectively ((Table 1, Fig. 2b).

Frequency of occurrence

The frequency of occurrence of seagrasses in the stomachs ranged from the maximum to the minimum as follow: *Halophila*, *Halodule*, *Enhalus* and *Thalassia* (Fig. 3). *Halophila ovalis* and *H. decipiens* were found in all stomach samples (Fig. 4a and 4b). The different morphology of the tip of the leaves *Halodule uninervis* was found (Fig. 4c). Rhizome, algae and other materials were found in all stomachs as well. Large pieces of algae (about 2 cm in length) were observed in the food of Chb-1 and 2 major kinds of the algae found were *Sargassum* sp. and *Caulerpa maxicana* (Fig. 4d).

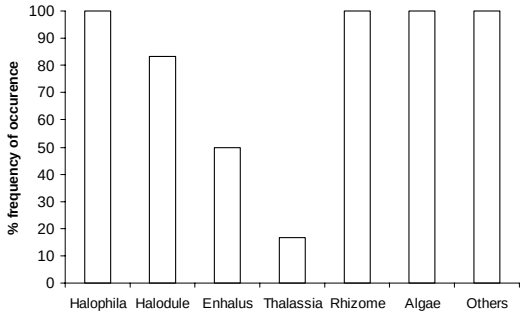

Figure 3. Percentage of the frequency of occurrence of 4 genera of seagrasses (*Halophila*, *Halodule*, *Enhalus* and *Thalassia*), rhizome, algae and others found in 6 stomach samples**.**

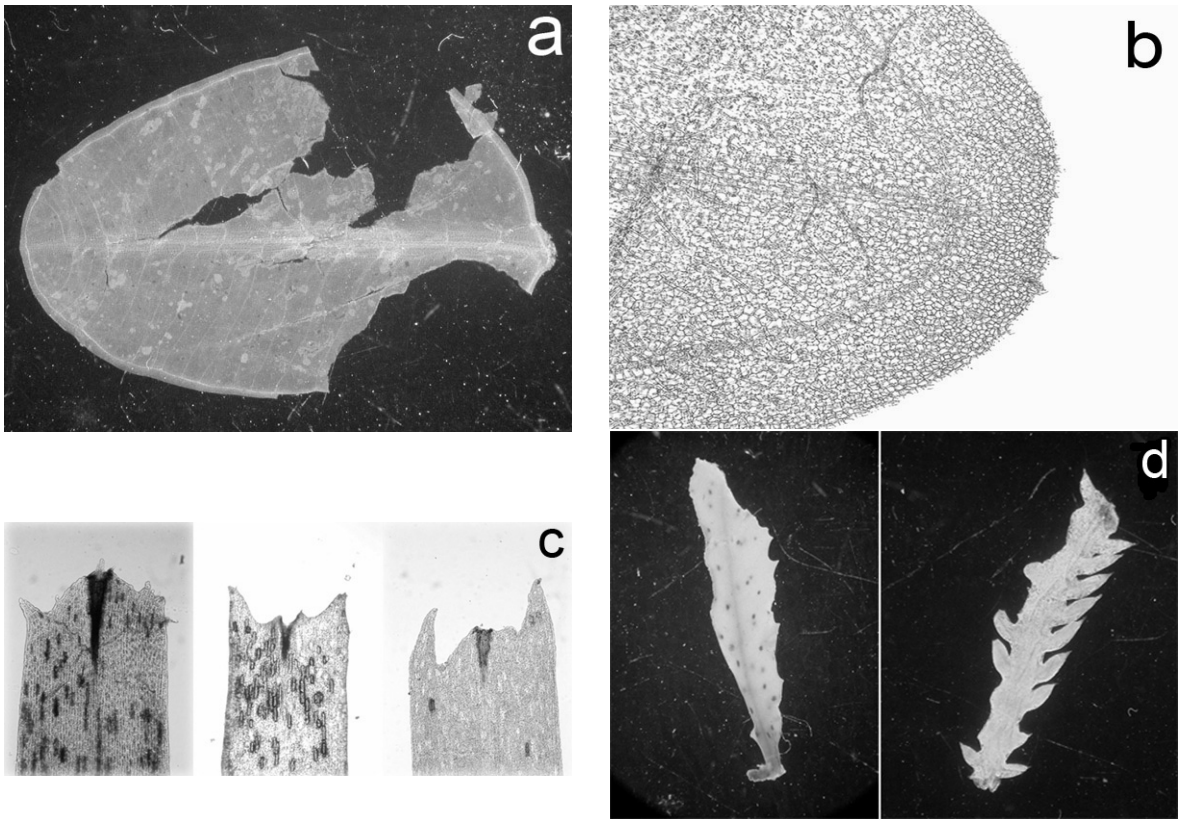

Figure 4. The samples from the stomach contents; a) leaf-fragment of *Halophila ovalis* with clear cross veins, b) epidermal cells of *Halophila decipiens* show hair on both sides of the leaf with fine tooth on the leaf margins c) different morphology of the tip of the leaves *Halodule uninervis*, d) the large pieces of *Sargassum* sp. (left) and *Caulerpa maxicana* found in stomach content of Chb-1 (right).

Biomass (dry weight) of each component

The average percentage of dry weight of each genus/species found in the stomach contents was as follow: *Halophila* (*H. ovalis* and *H. decipiens*) 9.97-55.43%, *Halodule uninervis*, 0-37.43%, *Thalassia hemprichii* 0-2.25%, and *Enhalus acoroides* 0-13.74%. In addition, rhizome (13.99-45.49%) and algae (3.33-16.41%) were found in all stomach samples. Focusing on genus *Halophila*, which was found in all stomachs; *H. ovalis* was found in the greater proportion (>80%) than *H. decipiens* in Ray-1 and Sut-1 while another 4 samples (Ray-2, Ray-3, Chb-1 and Chp-1) were on the contrary (Table 2).

Table 2. The percentage of average dry weight of seagrasses, rhizome, algae, and others found in the dugong stomachs (Sp.=Species, Ho=*Halophila ovalis*, Hd=*Halophila decipiens*, Hu=*Halodule uninervis*, Th=*Thalassia hemprichii*, Ea=*Enhalus acoroides*, Rhi=Rhizome, Alg=algae, Oth=Others, nf=not found, *=Ho>Hd, **=Hd>Ho)

Sp.	% Mean (S.D.)					
	Ray-1	**Ray-2**	**Ray-3**	**Chb-1**	**Chp-2**	**Sut-1**
Ho/ Hd	55.43 (6.87) *	31.31 (2.93) **	37.76 (2.47) **	9.97 (0.55) **	46.35 (3.82) **	23.23 (11.80) *
Hu	5.99 (2.33)	12.93 (1.03)	2.85 (3.44)	37.43 (1.21)	nf	17.85 (10.97)
En	13.74 (1.78)	nf	5.20 (0.35)	nf	nf	13.30 (2.23)
Th	nf	nf	nf	nf	nf	2.25 (3.89)
Rhi	13.99 (6.78)	38.63 (3.93)	45.49 (2.97)	42.63 (4.83)	30.25 (2.61)	32.88 (7.37)
Alg	3.33 (2.94)	10.68 (2.72)	3.4 (2.69)	7.46 (3.17)	16.41 (4.91)	7.15 (6.50)
Oth	7.51 (1.88)	6.45 (4.33)	5.29 (1.34)	2.51 (4.35)	6.99 (6.41)	3.34 (5.79)

DISCUSSION

Marsh *et al*. (1977) found that the pH of the contents of all regions of the main sac, of duodenal diverticula and of the proximal duodenum were 1-3, 5-6 and 4-7 for all dugongs tested, respectively. In this study, the pH in the stomach, small intestine, and large intestine ranged from 2 to 7, 5 to 7, and 6 to 8, respectively. Conspicuous infestations of nematode, *P. halichoris*, were observed in almost all stomachs of the dugongs examined, particularly the large infestation in the cardiac gland in both Thai dugong and Australian dugong. There was no sign of cellular reaction on the host tissue surrounding the nematode (Marsh *et al*., 1977; Adulyanukosol *et al.*, 2001). However, in this study *P. halichoris* was found in only 2 specimens (Ray-2 and Chp-1). Channels and Morrissey (1981) have mentioned that the digesta collected from the cardiac region of the main sac is the least digested, but we found no difference of the food in any region of the main sac. The results show relatively similar values in the amount of food per body weight between the dugongs in this study (0.46-3.86%) and those of Trang samples (0.41-3.35%) (Table 1; Adulyanukosol *et al.*, 2001). Although captive dugongs usually require food about 8-10% of their body weights (Kataoka *et al.*, 1995).

Table 3. The seagrass species distributed in the areas in which the 6 dugongs stranded and the seagrass species found in the specimens. Seagrass information referred from Lewmanomont *et al*. (1991), Nateekajanalap (1989), Aryuthaka and Poovachiranon (1994) and Potchana Boonyanate, personal communication. (Ho=*Halophila ovalis*, Hd=*H. decipiens*, Hm=*H. minor*, Hb=*H. beccarii*, Hu=*Halodule uninervis*, Th=*Thalassia hemprichii*, Ea=*Enhalus acoroides*, Rm=*Ruppia maritima*, RaY=Rayong Province, ChB=Chonburi Province, ChP=Chumporn Province, SuT=Surat Thani Province, x=seagrass in natural area, •=seagrass in stomach sample)

Species	RaY	Ray-			ChB	Chb-1	ChP	Chp-1	SuT	Sut-1
		1	2	3						
Ho	x	•	•	•		•		•	x	•
Hd	x	•	•	•	x	•	x	•	x	•
Hm	x				x					
Hb	x								x	
Hu	x	•	•	•		•			x	•
Hp	x									
Th									x	•
Ea			•	•			x		x	•
Rm					x					
Total	**6**	**3**	**4**	**4**	**3**	**3**	**2**	**2**	**6**	**5**

Remarks: Ho, Hb, Hd, Hp, Hu, Cs, Th, and Ea distribute in Trat Province; Hd, Hm, Hp, Hu and Ea distribute in Chantaburi Province.

The relationship between seagrass found in the stomach and surrounding habitat of stranding place

Two to five species of seagrass distributed in each province of the study areas (Table 3). The total of 5 species of seagrass were found in the stomachs (ranged from 1 to 5 species each specimen). If focusing on the locations in which the dugongs were stranded, we can consider the coast of the Gulf into 2 parts; eastern Gulf (Chonburi to Trat Provinces) and western Gulf (Petchaburi to Narathiwat Provinces) (Fig. 1). There are 6 species of seagrass distributed in Rayong coast.

Three dugongs (Ray-1, Ray-2 and Ray-3) from Rayong Province

Three dugongs coming from Rayong province (Ray-1, Ray-2 and Ray-3) have 4, 3 and 3 species of seagrass in the stomachs, respectively (Table 3). All seagrass species found in the stomachs of those dugongs from Rayong distribute in the coast of Rayong except *E. acoroides* which was found in the stomachs of Ray-1 and Ray-3. Considering the nearby area of Rayong in Chantaburi and Trat Provinces, 3 more species were found; *Cymodocea serrulata*, *Thalassia hemprichii* and *E. acoroides*. In this case, *E. acoroides* may distribute in some area of Rayong or the dugongs may feed on *E. acoroides* in Chantaburi or Trat during their travel. Although 2 species of *Halodule* (*H. pinifolia* and *H. uninervis*) distributed in Rayong, but only the tip of *H. uninervis* leaf was found. However, there might have *H. pinifolia* in the stomach contents because the epidermal cells of these two species are alike (Adulyanukosol *et al*., 2001). In general, the width of the leaf *H. uninervis* (0.25-3.5 mm) is wider than that of *H. pinifolia* (0.6-1.25 mm) (Hartog, 1970). Nevertheless, there is wide-leaf variety in *H. uninervis*; 0.25-0.35 mm in broad-leaf and less than 0.1 mm in narrow-leaf (Kuo and Hartog, 2001). Thus without leaf tip, it is hard to separate these two species (Adulyanukosol *et al*., 2001).

Chb-1, a calf from Chonburi Province

Three species of seagrasses, *H. decipiens*, *H. minor* and *Ruppia maritim*a, were recorded in Chonburi coast (Table 3). However it may not be necessary to focus on *R. maritima* because this species usually occurs in shrimp pond or brackish water area. The very young calf (Chb-1) fed on *H. ovalis*, *H. decipiens* and *H. uninervis.* Two species of its food (*H. ovais* and *H. uninervis*) was not found in the record of seagrass distribution in Chonburi. Perhaps these 2 species distribute in Chonburi waters or in the area close to Sattahip bay, where the dugong was stranded. One more remark, the large pieces of algae, *Sargassum* sp. and *Caulerpa maxicana* (about 2 cm long) were found in its stomach (Fig. 4d). Generally, algae in the dugong stomachs were found in the smaller fragments than the seagrass leaves (Adulyanukosol *et al.*, 2001). This is for the reason that the teeth of the calf did not grow very well including a restricted contact area of the teeth between upper and lower jaws when chewing.

Chp-1 from Chumporn Province

Only 2 species of seagrass (*H. decipiens* and *E. acoroides*) were reported in Chumporn Province and an only single genus of *Halophila* was found in the stomach of Chp-1. *Halophila* combined higher proportion of *H. decipiens* with little amount of *H. ovalis* (Table 2, 3). The high biomass of *Halophila* in Du-078 reached 76.6 % (leaves 46.35 plus rhizome 30.25, Table 2). Surprisingly, a lot of *H. decipiens* (> 80% of *Halophila* group) were found in the specimens from the Gulf, particularly in Du-098, 130, 127 and 078 which were from Rayong, Chonburi, and Chumporn (Table 2 and 3) but it was rarely found in Trang samples (Adulyanukosol *et al*., 2001). This species distributes in deep area of the Andaman Sea (Poovachiranon, 2000). Perhaps the distribution of this species in the Gulf is the same pattern as the Andaman. It is necessary to carry out more surveys of seagrass in deeper areas and remote islands of the Gulf.

Sut-1 from Surat Thani Province

Sut-1 stranded in the south of Samui Island, Surat Thani. Six species of seagrass are available in Surat Thani Province and 5 species of those seagrass, excluding *H. beccarii*, were found in the food of Sut-1. Mainly *Halophila* (*H. ovalis* > *H. decipiens*) was found and followed by *Halodule uninervis* (Table 2 and 3).

Johnstone and Hudson (1981) have reported that the type and abundance of seagrass species in the dugong may be related to the abundance, ecological distribution and energetic value of seagrass species in the catch area. While Adulyanukosol *et al.* (2001) have reported that the composition of seagrass found in dugong stomachs may relate to the composition presented in dugong feeding ground since the seagrass species making up a large proportion in the stomach contents were apparently the dominant species found in the seagrass area nearby the places where the stranded dugongs were collected. There are few studies on seagrasses in the Gulf of Thailand, particularly the abundance of each seagrass species in each location of our study areas. Therefore, it is hard to notify the relationship between the foods found in the stomachs and the seagrass species in the catch areas. Nevertheless, it seems all dugongs have fed mainly on the seagrasses available in the catch areas. Furthermore it is necessary to carry out more surveys of seagrass in the Gulf, especially the areas in which dugongs still exist. The seagrass information including dugong population assessment is very critically needed for establishment of Dugong and Seagrass Action Plan for Thailand.

ACKNOWLEDGEMENTS

We would like to say thank to all the people who supported the information and specimens of this study; Mr. Mickmin Charuchinda, Director of Eastern Marine and Coastal Resources Research Center (EMCOR), Rayong Province including Mr. Somchai Man-anansap, Mr. Ranawan Boonprakob and Mr. Potchana Boonyanate from EMCOR; Mr. Sombat Poovachiranon from PMBC, Ms. Rattima Kuruwanchareon from Institute of Marine Science, Burapha University, Chonburi Province; Ass. Prof. Chatcharee Kaewsuralikhit, Kasetsart University; Mr. Somphorn Meesangkaew, Deputy Director for Administration and Farms Affairs and Mr. Boonsin Jittapraphan, Deputy Director for Academic and Student Affairs, Maejo University at Chumporn Province; Mr. Virat Saengsod, Choksudarat-fishing port, Samui Island and Mr. Wittaya Sasithorn, Samui Snake Farm, Surat Thani province; Dr. Chatcharee Kaewsuralikhit from Kasetsart University for identification of algae and Dr. C. den Hartog for confirmation of *Halodule uninervis*; Ms. Palap Tiptus for editing the manuscript.

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