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## Dugong (*Dugong dugon*) and seagrass in Thailand: present status and future challenges

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### ABSTRACT

Dugong and seagrass research in Thailand has been principally conducted by Phuket Marine Biological Center (PMBC), Department of Marine and Coastal Resources (DMCR). The first stranded dugong was reported in 1979. The interview surveys with villagers and aerial surveys for dugong population were started in 1993 and 1997, respectively. Several research topics were documented on dugong, both the biological and chemical aspects, and including the management plan. Seagrass surveys had been originally conducted in 1988 particularly in the Andaman sea coast and seagrass surveys in the Gulf of Thailand have been recently performed. Seagrass data-based information of PMBC was officially available in 2004. Although, the diversity of only 12 seagrass species have been reported in Thai waters, the seagrass beds have been shown to play an important role as the nursery ground of economically important species. We have reviewed the recent status and future research of dugong and seagrass in Thailand according to the following items: population, genetic divergence and threats; dugong behavior, feeding habit and acoustic survey; heavy metal and organotin compounds concentration; status of seagrass; marine organisms in seagrass beds; future challenges; and conservation and management.

**Keywords:** Dugong, seagrass, Andaman Sea, Gulf of Thailand, conservation, management

### INTRODUCTION

Dugong (*Dugong dugon*) is the only true herbivorous marine mammal member of Family Dugongidae, Order Sirenia (Nishiwaki and Marsh, 1995). Dugongs are rare and restricted only to some areas along both coastlines of Thailand, the Andaman Sea and the Gulf of Thailand (Nateekanjanalarp and Sudara, 1992a, 1992b; Chantrapornsyl and Adulyanukosol, 1994; Adulyanukosol, 1995, 1999, 2000, 2004; Adulyanukosol et al., 1997; Hines 2000; Hines and Adulyanukosol, 2001; Hines et al., 2003, 2004, 2005a, 2005b). Phuket Marine Biological Center (PMBC) got the first information of dugong in 1979 (Boonprakob et al., 1984) and further studies on dugong behavior in captivity were done made by Adulyanukosol and Patiyasevi (1994), Boonyanate (1994); and Adulyanukosol et al. (2004b). Information on the history of dugongs, local beliefs, and the use of dugong body parts in Thailand has been obtained from interviews with local people along both coastlines since 1993 (Adulyanukosol, 1999, 2004). An aerial survey for dugong population was first conducted by the Department of Royal Forestry in 1993 (Aueng et al., 1993). PMBC has performed aerial surveys since 1997 (Adulyanukosol et al., 1997; Adulyanukosol, 2000; Hines 2000; Hines and Adulyanukosol, 2001; Hines et al., 2003, 2004, 2005a). The interviews with villagers and aerial surveys have still continued on both

coastlines, the Andaman Sea and the Gulf of Thailand. Age determination of 12 dugongs (6 males and 6 females) ranged from 1-43 years old (Adulyanukosol et al., 1998). Effects of grazing and disturbance by dugong on seagrass ecosystems were studied by some researchers *i.e.* Nakaoka et al. (2002) and Mukai et al. (1999).

Seagrass beds are essential to ecosystems in the Indo-Pacific region and considered to play an important role in sustaining the abundance of either commercial fish or crustaceans in near-shore fisheries or marine endangered species *i.e.* dugong, dolphin, and sea turtle. In the earlier period, seagrass in Thailand was found only in 5 species (Den Hartog, 1970). Then Poovachiranon (1988) provided initial basic information on seagrass beds in Phang-nga Bay, Andaman Sea. The distribution and composition of seagrass communities on both coastlines has been well documented by some researchers in recent years (Chansang et al., 1989; Sudara et al., 1989, 1992; Lewmanomont et al., 1991, 1996; Aryuthaka et al., 1992; Aryuthaka and Poovachiranon, 1994; Mananansab and Ingsawang, 1997; Sinanan and Boonprakob, 1997; Supanwanid et al., 1997). Seagrass surveys had been originally conducted in 1988, particularly in the Andaman coast while surveys in the Gulf of Thailand have been recently intensively performed in 2003 (Poovachiranon, 1988;

Poovachiranon et al., 1994; Poovachiranon and Adulyanukosol, 1999; Poovachiranon et al., 2006). Ground surveys of seagrass were conducted by the transect method to estimate the seagrass distribution and coverage area (Changsang and Poovachiranon, 1994; Poovachiranon and Chansang, 1994). Community based participation on dugong and seagrass have been recently established in some areas of Andaman coast.

This report shows the current status of dugong and seagrass in Thai waters including the need for future research and management planning. Principal information has mostly been based on the outcome of PMBC, Department of Marine and Coastal Resources (DMCR) and the collaboration project since 1988.

## RESULTS

### Present Status of Dugong

#### Population, genetic divergence and threats

Dugongs are distributed along the coast of the Andaman Sea in 6 provinces; Rangong, Phang-nga, Phuket, Krabi, Trang and Satun. In the Gulf of Thailand there are very few dugongs which are scattered in small numbers. Aerial surveys of dugong in the Gulf have been conducted only in some specific areas in recent years *i.e.* Rayong, Chanthaburi, Trat, Surat Thani Provinces. Nevertheless dugongs were found alive and dead in other provinces too such as Chonburi, Chumphon, and Pattani Provinces (Adulyanukosol, 2004; Fig 1).

The dugong population in Thai waters is estimated about 250 dugongs; 200 dugongs in the Andaman Sea and 50 dugongs in the Gulf (Adulyanukosol, 2007; Adulyanukosol and Thongsukdee, 2005, 2006). The largest dugong population in Thai waters (123 animals in 2001) was found around Talibong to Muk Islands, Trang Province (Adulyanukosol et al., 1997; Adulyanukosol, 2000; Hines 2001, Hines et al., 2005a, 2005b). It may be the highest population of dugong in Southeast Asia regions (Adulyanukosol, 2004, Hines et al., 2005a). General distribution of dugongs (sighting and stranding records) including seagrass beds is available in Fig. 1.

Since 2003 PMBC has been in cooperation with San Jose University, America to study the genetics of Thai dugongs. The first result from mt-DNA analysis showed no significant genetic differentiation between the dugong populations of the Andaman and the Gulf (Palmer, 2004). We are continuing further studies on microsatellite DNA of dugong samples and we hope to get new information of the genetics of Thai dugong.

In Thailand, we believed that there was no dugong hunting after launching the Fisheries Acts of B.E. 2490 (1947) (Adulyanukosol, 1999, 2004, 2007; Saranakomkul, 2002). The deaths of dugongs were

mainly caused by incidentally entanglement in various kinds of fishing gear particularly gill nets, sting ray net, long line for sting ray, stake trap (set net), and trawler. Three cases were caused by boat strikes and one case was from shark attack (Adulyanukosol, 1999, 2004).

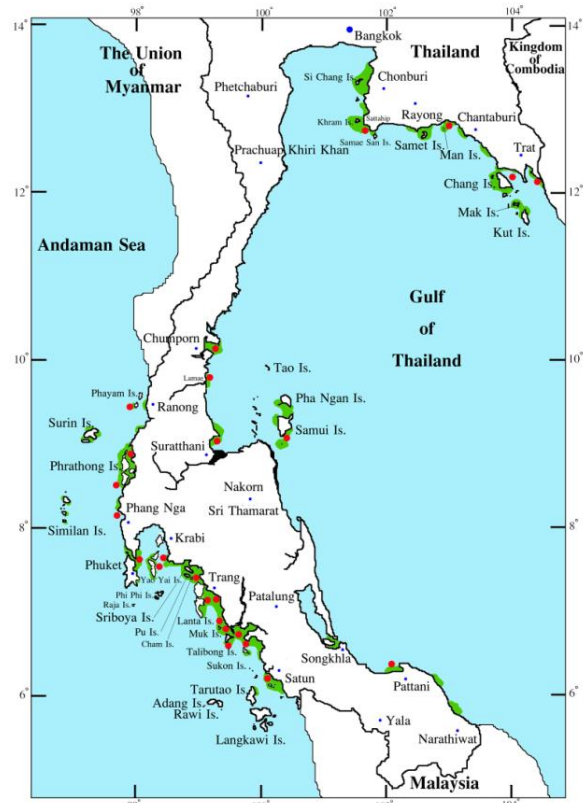


Fig. 1. Map of coastlines of Thailand showing the distribution of dugong (solid circle) and seagrass (grey patch) (modified from Adulyanukosol, 2004)

### Dugong behavior, feeding habit and acoustic survey

The feeding trails of dugong were confirmed mostly on *Halophila ovalis* meadows in various places along the Andaman coast (Adulyanukosol et al., 2003; Mukai et al., 1999). Some feeding trails were observed on *Halophila beccarii* bed at Thungka Bay, Chumphon Province (Natawadee Nokgate, personal communication). However dugong feeding scars were newly observed on *Enhalus acoroides* meadow at Talibong Island, (Yohiei Nakanishi, personal communication) and some feeding trails were also noticed on *Cymodocea serrulata* meadow in Krabi and Trang Provinces (authors, unpublished data). The analysis of 12 stomach contents of dugongs found a mixture of in total 9 seagrass species, ranging from 2-6 species in each stomach sample. They were *Halophila ovalis*, *Halophila descipiens*, *Halodule uninervis*, *Halodule pinnifolia*, *Thalassia hemprichii*, *Cymodocea*

*rotundata*, *Cymodocea serrulata*, *Enhalus acoroides* and *Syringodium isoetifolium*. The large proportion of seagrass species found in stomach contents were apparently the dominant species found in the seagrass area nearby the places where the stranded dugongs were collected (Adulyanukosol, et al., 2001, 2004a).

In addition, feeding behavior of wild dugongs monitored by a passive acoustical method was carried out at Talibong Island. Feeding sounds were only detected at night, implying diurnal differences in the feeding behavior of the studied dugong population. Differences in periodicity of feeding sounds suggested that two or more individuals were in the acoustically observable area. Two differences in feeding sounds were from grazing activities on *Enhalus acoroides* (a hard and long leaf blade seagrass) and *Halophila ovalis* (a soft and tiny leaf seagrass) (Tsutsumi et al., 2006). However all aggregate feeding activities of dugongs have been observed in daytime during aerial surveys for dugong population since 1997 (Adulyanukosol, 2004; Adulyanukosol and Thongsukdee, 2005, 2006; Adulyanukosol et al., 1997, 2007, Hines et al., 2005).

Mating behaviors, aggregate feeding and parental care have been observed in the seagrass beds as well (Adulyanukosol and Thongsukdee, 2005, 2006; Adulyanukosol et al., 2007). The mating patterns have been described under 5 categories; Following, Approaching and Stimulating, Pairing, Mounting, and Separating. Cow-calf pairings including small to large groups (3-10 individuals in each) were commonly seen aggregate feeding on seagrass beds. Cow appeared to play with or train the young calf in shallow areas of seagrass bed as well (Adulyanukosol, et al., 2007).

To understand the behavior of wild dugongs is very valuable information for the implementation of the conservation and management of dugong and seagrass resources. The Dugong Biological Survey Project (DBS) has been conducted in collaboration between Japanese researchers (Kyoto University in chief) and PMBC in 2003 to 2006 and the project will be continued until 2009. DBS has carried out the research on dugong and seagrass at Talibong Island. Dugong Acoustic Survey is one of the highlighted research topics under DBS. Vocalizing dugongs were localized using an array of stereo-underwater-recording systems. The results from earlier Dugong acoustic surveys showed that the center frequency of dugong calls ranged from 3-8 kHz, and the duration of the calls was classified roughly in two: 100-500 ms and over around 1000 ms. Vocalization intervals were classified in two patterns: 0-5 s and about over 20 s between each call. Further information is available in Ichikawa et al. (2003, 2004, 2005, and 2006) and Tsutsumi et al. (2006).

#### *Heavy metal and organotin compounds concentration*

PMBC has collaborated with Burapha University and Chulalongkorn University in Thailand including Japanese researchers to study heavy metal and organotin compounds in marine mammals' tissues. So far the preliminary results have showed the following information.

The analysis of heavy metal accumulated in tissues from 10 stranded dugongs found that the maximum concentration of mercury (Hg), cadmium (Cd), zinc (Zn), lead (Pb), copper (Cu), and arsenic (As) accumulated in dugong tissues were; 3.173, 20.77, 1001.7, 8.56, 438.2, and 5.87  $\mu\text{g/g}$ , respectively. The highest concentration of Hg, Cd, Zn, and Cu were found in the liver while the highest value of Pb was found in the kidney and the highest As value was in lung tissue (Phadungsakchayakul et al., 2003; Panutrakul and Adulyanukosol, 2006). To determine the relationship among dugong, seagrass food and sediments, further studies will be conducted on the heavy metal in the seagrass food and sediments.

Harino, et al. (2007) measured the concentrations of butyltin (BT) and phenyltin (PT) compounds in organs and tissues of dugongs. They found that the concentrations of BTs and PTs were in the range of 14-14,468 and <1-30  $\mu\text{g/kg}$  (detection frequency: 79%), respectively. Although concentrations of BTs in dugongs were higher than reported concentrations in cetaceans and pinnipeds, PTs were lower in dugongs. The concentration of BTs in the liver was the highest among all the tissues and organs tested. Dibutyltin (DBT) or monobutyltin (MBT) were found to be the dominant compounds among the BTs. The distribution in the body of PTs was not clear because of the lower levels of this compound. TPT was the dominant compound among PTs. No significant differences in BT or PT concentrations were observed between the Andaman Sea and the Gulf ( $p < 0.05$ ). The concentrations of BTs and PTs in the livers of dugongs had decreased between 1998 and 2002, suggesting a decrease in OT concentrations in the surrounding environment.

#### *Present Status of Seagrasses*

##### *Status of seagrass*

Twelve species of seagrass representing 7 genera of 2 families have been reported through both coastlines of the Andaman Sea and the Gulf of Thailand. There are *Halophila ovalis*, *Halophila minor*, *Halophila decipiens*, *Halophila beccarii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halodule uninervis*, *Halodule pinifolia*, *Enhalus acoroides*, *Thalassia hemprichii*, *Syringodium isoetifolium* and *Ruppia maritima* (Sudara et al., 1989; Aryutthaka et al., 1992; Aryutthaka and Poovachiranon, 1994; Changsang and Poovachiranon,

1994; Lewmanomont et al., 1991, 1996; Poovachiranon et al., 2006). All species are found in both seas, except *R. maritima* is not reported in the Andaman coast. The total coverage area is 14,937 ha; 9,448 ha in the Andaman and 5,489 ha in the Gulf (Poovachiranon et al., 2006, Table 1). In general the status of seagrass in the Andaman coast is: 40% in good condition, 30% in fair, and 10% poor (Changsang and Poovachiranon, 1994; Poovachiranon et al., 2006). In the Gulf, seagrasses show seasonal changes in the species and distribution particularly in Rayong and Nakhon Si Thammarat Provinces (Table 1).

The largest area of seagrass including the highest diversity of 11 seagrass species is located at Talibong Island, Trang Province (Changsang and Poovachiranon, 1994; Poovachiranon et al., 2006, Fig.1). The seagrass beds around Talibong Island and

Muk Island are the most important feeding ground, nursery ground and reproduction area of dugongs. An aerial survey method is one of the practical techniques for seagrass survey where the coastal lines are dotted with islands and characterized by mangroves, river mouths, and beaches (Poovachiranon and Adulyanukosol, 1999).

In general the seagrass beds in the Andaman Sea coast are more abundant than those of the Gulf. The degradations of seagrass beds are mainly caused by human impacts such as sedimentation from coastal construction, fishery and illegal fishing. Seasonal changes caused by monsoons occurred in some areas. A summary of the status of seagrass and its coverage is shown in Table 1.

Table 1. The status and coverage of seagrass in each province in Thailand in 2006. (modified from Poovachiranon et al., 2006, na = not available)

Province	Area (ha)	Status	Remarks (cause of degradation, seasonal change)
<i>Gulf of Thailand</i>			
Trat	644	fair	Monsoon
Chanthaburi	2,704	good	Fishery, shrimp farm, increasing of coastal community
Rayong	6048	fair	Fishery, waste from houses, sediment, cruising of tourist boat, seasonal change
Chonburi	96	degraded	Construction of a retaining wall, pier and house in Sattahip Bay
Petchaburi	28.8	in reservoir	na
Prachuap Khiri Khan	3.2	natural	na
Chumphon	172.8	degraded	Sediment and water waste from aquaculture, crude oil survey
Surat Thani	1,708.8	fair	Sediment from shrimp farm, aquaculture and coastal development
Nakhon Si Thammarat	7.2	natural	Seasonal change
Phatthalung	73.6	natural	na
Songkhla	54.88	natural	na
Pattani	83.2	degraded	Coastal development, industry along the river, waste from industry, fisheries (push net and trawl)
Narathiwat	12.16	natural	na
Total	5,489		
<i>Andaman Sea</i>			
Ranong	150.4	degraded & natural	High sediment from river mouth
Phang-nga	2536	good	Seasonal change, fisheries (trawl, push net), tsunami
Phuket	612.8	fair & degraded	Sediment from land, fisheries (trawl, push net), water waste from shrimp farm, tsunami
Krabi	2,507.2	fair	Seasonal change, sediment from land, push net
Trang	3,366.4	fair	Push nets, beach encircle net, sediment from land, tsunami
Satun	275.2	fair	na
Total	9,448		
Grand total	14,937		

#### *Marine organisms in seagrass beds*

One hundred and forty nine fish species belonging to 51 families have been reported in the Andaman seagrass beds; *Siganus*, *Atherinomorus* and *Leiognathus* were the dominant genera (Sattapoomin and Poovachiranon, 1997). A total of 38 species of fishes were found in seagrass beds at Kung Krabaen, Chataburi Province and Samui and Pha-ngan Islands, Surat Thani Province, in the Gulf (Sudara et al., 1992). *Siganidae* was the most abundant in seagrass beds studied in Thailand (Sudara et al., 1992; Janekitkarn and Monkolprasit, 1994).

The polychaete worms, molluscs and crustaceans are the dominant fauna. The echinoderms, sipunculids, and nemerteans are also commonly found in the seagrass beds. They include economic species such as conchs (*Strombus canarium*), clams (*Scapharca inaequivalvis*), swimming crabs (*Portunus sanquiolatus* and *Portunus pelagicus*), mud crabs (*Scylla serrata*), penaeid shrimp (*Penaeus semisulcatus*, *Penaeus merguensis*, *Metapenaeus ensis* and *Metapenaeus moyebi*), mantis shrimp (*Orloquilla nepa*), and sea cucumber (*Holothuria scaba*). Most of them are in juvenile and subadult stages. (Poovachiranon et al., 1994). Very little research has been made on fauna in the seagrass beds. Currently the relationship between seagrass biodiversity and infauna free-living nematode communities has been investigated by Somerfield et al (2002).

Seagrass beds are shelter, nursery ground and feeding ground for marine animals, particularly fishes and crustaceans. Dugongs (*Dugong dugon*) and sea turtles also utilize the seagrass beds as their feeding grounds. The number of these animals has decreased in many areas of Thailand both in the Andaman Sea and in the Gulf of Thailand. Most dugongs were found feeding in seagrass beds. Furthermore other marine endangered species found in seagrass beds are bottlenose dolphins (*Tursiops aduncus*), Indo-Pacific hump-backed dolphin (*Sausa chinensis*), Irrawaddy dolphins (*Orrcaella brevirostris*), and sea turtles. Green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*), were also observed in seagrass beds and adjacent areas (Adulyanukosol et al., 1997, 1999; Adulyanukosol and Thangsukdee, 2005, 2006).

#### *Future Challenges*

The ranges of the dugongs extend over a vast area in which all causes of anthropogenic mortality cannot be prevented (Marsh et al. 2002). Although a high level of protection in areas that support large numbers of dugongs was previously recommended, recent conservation actions implemented on smaller scales may not be sufficient to ensure the sustainability of

dugong populations (Marsh et al. 2002, 2004; Gales et al. 2004; Sheppard et al. 2006). When developing strategies for dugong conservation, the dugong population of any one bay should be considered not as an isolated entity but as a fluctuating component of a spatially dynamic metapopulation (Sheppard et al. 2006).

Thai waters particularly in Trang Province possibly contain the largest dugong population in Southeast Asia regions. Groups of dugongs along the Andaman Sea coast could possibly be mixed, with any number of animals migrating from one area to another (Hines et al. 2005b). In order to conserve this population and to declare the protected area for dugongs, more understanding of dugong behavior and movement or migration patterns is required. To obtain this information, the study of movement behaviors by fitting with satellite PTTs and/or GPS transmitters, and strengthening the aerial survey in large scale areas are the priority research areas needed in near future.

Diversity and seasonal anatomical changes of seagrasses has been reported in both sea sides, the Andaman and the Gulf (Meesawat et al., 1999; Potchana Boonyanate, personal communication). Seasonal anatomical change in seagrass species has been reported in *Halodule uninervis* and *Halodule pinifolia* (Meesawat et al., 1999). Some seagrass species have many varieties *i.e.* the number of transverse veins in *Halophila* spp, the variety of the tip and width of the *Halodule* leaves. There are still unproved studies on the taxonomy of some species particularly *Halophila* spp. and *Halodule* spp. (Waycott et al., 2004; John Kuo, personal communication). Waycott et al (2004) have grouped the *Halophila* spp. as *Halophila* complex and *Halodule* spp. as *Halodule* complex. Cooperation is needed among countries to digest the knowledge or it is necessary to study deeper in the genetic field to update the classification of these seagrass groups. Man-made perturbations such as push-net fishing and siltation (from coastal development) are believed to be responsible for degraded seagrass beds in many areas under investigation (Chansang and Poovachiranon, 1994; Poovachiranon and Adulyanukosol, 1999). The degraded seagrass beds that have a high potential to recover should be restored. Meanwhile methodologies of restoration in degraded seagrass beds are under careful investigation.

Generally the coastal areas of Thailand are turbid waters which makes the seagrass survey difficult. Therefore in sub-tidal zones down to 10 m depth it may be necessary to use high technology underwater video cameras for seagrass survey. This method was recently demonstrated by the French scientists in 2006 at PMBC. New seagrass beds at about 10 m depth in

turbid areas at the southeast Phuket Island were discovered by this methodology (Poovachiranon, unpublished data). In order to achieve sustainable seagrass management, not only biological-based research but also economic-based research is required. It is very hard to evaluate the economic value of marine flora and fauna particularly the seagrass habitat. However Vithayaveroj (2003) recently reported the net benefit of fishery from seagrass beds was about 2-6 million baht/year. Seagrass data-based information was formally available in 2004 at PMBC website ([www.pmbc.go.th](http://www.pmbc.go.th)).

DMCR has set a policy for the community based participation on marine and coastal resources management particularly mangrove, coral reef, seagrass and marine endangered species. In the near future local people will do much to contribute to conserve their natural resources and to understand how important the sustainable uses are. In addition, integrated management of dugong and seagrass were successful in Thailand because of the cooperation among various institutions *i.e.* universities, National Park, Wildlife and Plant Department, Department of Fisheries, and NGOs. Productive research in the region and among the regions (*i.e.* Cambodia, Vietnam, Japan, France, and America) is under cooperation.

#### *Conservation and Management*

Awareness and education materials of dugong and seagrass have been produced regularly by many sectors *i.e.* PMBC, universities, schools, and NGOs. Since 1995, PMBC has published and distributed at least 4 types of posters, brochures, dugong book, seagrass book, and 2 versions of dugong cartoon books including 7 types of t-shirts, dugong casts, dugong key holder etc. These kinds of materials are the tools to educate people and to make them aware of the conservation.

Attempts to establish the Dugong and Seagrass National Action Plans have been moving ahead since 2002 (Adulyanukosol, 2004, Adulyanukosol et al., 2005). The Action Plan for Seagrass of the Gulf of Thailand has been already launched in 2004 (see UNEP, 2004). The National Action Plan for Seagrass for both coastlines, the Andaman Sea and the Gulf, under the cooperation between DMCR and Mahidol University is planned to be complete in 2007. Although the Dugong National Action Plan has been drafted under the co-operation between WCS (Wildlife Conservation Society, Thailand) and DMCR in 2004, the attempt to make it complete is still going on (Adulyanukosol et al., 2005). Furthermore, DMCR with cooperation of the Australian Government had held two meetings on Dugong Conservation and Management in Bangkok in August 2005 and in May 2006. In total 31

countries had participated in the meetings. The basic principles of the Memorandum of Understanding (MoU) on this issue are not legally binding. The first meeting for signature of this MoU was already held in United Arab Emirates during 28-31 October 2007. In this meeting 7 countries (Australia, Myanmar, France, United Arab Emirates, Eritrea, Madagascar, and Tanzania) have already signed the MoU. After most countries where dugongs distribute have adopted the MoU, the conservation and management of dugongs and their habitats will be stronger between the regions and over dugong's ranges.

Furthermore after the tsunami struck the Andaman Sea coast of Thailand on 26 December 2005, rapid assessments on marine ecosystems (mangrove, coral reef, seagrass, marine endangered species and water quality) were conducted in the beginning of January 2006. Seagrass beds received little damage from the tsunami. About 72% (57.6 km<sup>2</sup>) of the total seagrass area along the Andaman Sea coast was inspected post tsunami, of this only 5% had been affected. A number of sea turtles and marine mammals were affected by the tsunami. At least 37 turtles were washed ashore mostly along the west coast of Phangnga. A dugong and a hump-backed dolphin have been saved and released back to the wild (DMCR, 2005). After the tsunami event, local people along the Andaman coast have realized that the natural resources particularly mangrove and seagrass can help in protecting the seashore and make less damage on their property and life from natural disaster.

Promotions for conservation including educational materials were widely provided from various sectors *i.e.* PMBC, universities (Kasetsart University, Burapha University, Mahidol University, Princes of Songkhla University), NGOs (Yadfon Association, WWF). As above mentioned, dugong and seagrass research in Thailand is focused within this decade, it is hard to complete all research needed for conservation and management plan within a short time. However we should get many good results from the cooperation among government offices (*i.e.* universities, Department of Fisheries, National Parks, Wildlife and Plant Department, Royal Forestry Department), NGOs (Yadfon Association, WWF, Andaman Project), and local communities including collaboration within the regional level (*i.e.* Cambodia, Vietnam, Philippines, and Malaysia) and international level (*i.e.* Japan, France, and America).

Meetings and training on dugong and seagrass conservation were held in many provinces along both coastlines. Notably the education materials and exhibitions have been produced continually since the beginning of the project in order to educate people at different levels (teacher, student, officer, villager etc.)

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The various kinds of education and campaign materials are; brochures, books, leaflets, posters, short articles, t-shirts, mobile exhibitions. Research combined with education is the key of our success in conservation of dugong and seagrass in Thailand.

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