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Main seagrass beds and threats to their habitats in the coastal sea of South China

HUANG Xiaoping[1], HUANG Liangmin[1], LI Yinghong[1], XU Zhanzhou[1], FONG C W[2], HUANG Daojian[1], HAN Qiuying[1], HUANG Hui[1], TAN Yehui[1] & LIU Sheng[1]

1. LED, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China;
2. Environmental Resource Management Company of Hong Kong, Hong Kong, China

Correspondence should be addressed to Huang Xiaoping (email: xphuang@scsio.ac.cn)

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Abstract The distribution, species, biomass, productivity of main seagrasses and their suffered main threats are introduced and discussed in this paper based on the field surveys in the offshore areas of Guangdong, Guangxi and Hainan provinces. The seagrass beds distributed mainly in Liusha Bay, Donghai Island and Hailing Island of Guangdong Province; Hepu and Pearl Bay of Guangxi Zhuang Autonomous Region; Li'an Bay, Xincun Bay, Longwan Bay and Sanya Bay of Hainan Province and so on. The total area of seagrass beds in the coastal sea of South China is about 2400 ha. There are about 8 species, such as *Halophila ovalis*, *Halodule uninervis*, *Halophila beccarii*, *Zostera japonica*, *Enhalus acoroides*, *Thalassia hemperichii*, *Ruppia martime* and *Cymodocea rotundata*. These seagrasses have high biomass and productivity. However, they are subjected to some threats resulting from artificial and natural factors, especially anthropogenic causes, such as culture of shrimps and fishes, shellfish collection, fishing by means of poisons, electric power and explosives as well as trawling, artificial pollution, dredging channels, and typhoons natural disaster.

Keywords: seagrass, distribution, ecological character, threats, South China.

The seagrass is the only epigeal angiosperms, which fructifies and germinates under the seawater. There are about 50 species of seagrass belonging to 12 genera in the world, and more than 20 species in South China Sea[1)]. Seagrasses distribute widely in the coastal areas of temperate zone and tropical zone, and they are frequently and seriously disturbed by natural and artificial factors. The seagrasses prefer living in inshore lagoons, estuaries and bays with slow current. Mangrove, coral reef and seagrass bed are the three typical marine ecosystems in tropical and semi-tropical zones. The seagrass bed is one of the most productive marine ecosystems in the biosphere[1]. Seagrasses are very important in the marine ecological environment, such as improving shallow seawater quality, being the direct food resource of many creatures, providing important habitat and concealment for many creatures, and a natural barrier resisting against wave and tide and thus protecting the coast. The roots of seagrasses are able to utilize abundant nutrients in the sediments, which generally cannot be utilized by other primary producers in this ecosystem. Seagrasses are productive and form a large carbon storehouse. The carbonaceous nutrients are usually foods for vegetarian such as sea turtle, birds and marine mammal in tropical zone. Oddment food chain is usually regarded as the main energy flowing pathway of seagrasses.

One of the hot points for seagrass researches is to take carbon as research objective and to study its flowing process in the ecosystem of the food net in the seagrass beds[2—4]. The stable isotope method instead of traditional analytical method, namely analysis of the internal substances in the alimentary canals, is used to study nutrient classes and the flowing of substances and energy in the ecosystems because of the limitations of several factors, such as too small consumers, difficult discrimination of the primary producers and too complex intermediate processes of the food nets. N isotope analysis is normally used to determine the nutrient position of marine organisms in the food net in seagrass bed.

According to the international research results, the seagrass beds are now subject to artificial threats although they possess very high economic value[5]. The effects resulting from offshore environmental pollution on seagrass are especially and widely concerned by the researchers. Estuaries and bays admit a lot of nutrients from human activities and these nutrients produce bad effects on the structure and functions of the seagrass ecosystem[6—8]. Eutrophication leads directly to a large

1) UNEP. Seagrass in the South China Sea. UNEP/GEF/SCS Technical Publication No. 3. 2004, 1－12.

reproduction of plankton and epiphytic algae on seagrasses, thus reducing light flux of water body and dissolved oxygen contents due to decomposition of the algae. All these give a serious effect on the living and reproduction of seagrasses. There are some researches on heavy metals pollution of seagrass ecosystem[9]. Prang *et al*. studied enrichment of heavy metals by seagrasses and effects of heavy metals on physiological functions of seagrasses in Australia[9], indicating that the harmful level of trace heavy metals on seagrasses depends on the endurance capacity of the seagrasses against heavy metals and their own characters. Different species of seagrasses have different enrichment capacity for different heavy metals. Catriona *et al*. evaluated the impacts of three herbicides (Atrazine, Diuron and Irgarol 1051) with their lethal concentrations on *Zostera* by means of photosynthesis activity (measured by fluorescent character of chlorophyll a and the pigment concentration in photosynthesis, at the same time, compared the impacts of seawater with the same concentrations of the herbicides on the seagrass living in a laboratory and in the field and their recovery capacity[10].

There are few researches on seagrass in China. Over twenty years ago, Yang *et al.* analysed theoretically the character of geographic distribution of seagrass, but did not deal with the concrete distributing location, species and biological characteristics of seagrass in China[11—13]. There was little information about the geographic distribution, species number, density, productivity, biodiversity, habitat diversification, ecological function and economic value of seagrass in China. People have little knowledge about the importance of seagrass in the marine ecosystem and are short of consciousness on seagrass protection and the ecological niche, and especially are short of management for seagrass conservation. In this study, based on field surveys, the geographic distribution, species, biomass, productivity, characteristic of main ecological niche of seagrasses and their suffered threats in South China were studied, so as to lay foundation for the further study on seagrass in China, and provide scientific basis for the protection and management of seagrass beds.

1 Sources of data

On the basis of many correlative data, reports, satellitic photographs and environmental information, the field surveys on the main seagrass beds in Guangdong, Hainan and Guangxi provinces were conducted in September and October, 2002 and in July, 2003. According to the growth habits of seagrasses and specific coastal environmental characters in South China, field surveys were conducted along the coasts where there might be seagrass beds. The surveys were conducted during low tide of the spring tide, so that seagrasses could be most probably found. A diving survey was conducted on the coasts with visible seagrass chipping and the intertidal zones with found seagrass. The concrete distribution scopes of seagrasses were confirmed by GPS, and specimens were collected to confirm the species of seagrasses according to the method recommended by international seagrasses researchers[14,15]. The biomasses of seagrasses in some main seagrass beds were surveyed by means of the method recommended by ref. [14]. In these surveys, three to five representative sections (from the coast toward the sea) in the surveyed seagrass beds were chosen, and the parallel space between two sections was about 100 m, and the space between the sampling spots in each section is about 50 m. Four sampling quadrate frames in 50 cm ×50 cm were set near each sampling spot to collect all parts of seagrasses (including roots, rhizome and leaves) in every sample frame. The wet weights of the seagrasses were measured after cleaning the collected seagrasses and drying their surfaces naturally. Then, their dry weights were measured after airing the seagrass in the laboratory, drying them at 80 ℃ in the oven until the weights were constant. In the mid of October, 2002, the productivity of main seagrass leaves was measured every 46—48 h using the marking method and field measuring[14,15]. At the same time, the inhabited environment and the present threats to the main seagrass beds were surveyed on the field and then analysed.

In the last twenty years, the scientists in Hong Kong have done some researches on the seagrass distributing sporadically in Hong Kong. Correlative data were collected and coordinated in this study in order to perfect the data of seagrass in South China.

2 Distribution and species of seagrasses

2.1 Seagrass beds in Guangdong

Seagrass beds in Guangdong Province distribute in Liusha Bay in Leizhou Peninsula, Donghai Island in Zhanjiang and Hailing Island in Yangjiang, etc. The area of seagrass bed in Liusha Bay is about 900 ha, and the main species of seagrass are *Halophila ovalis* and *Halodule uninervis*, each distributing relatively inde-

pendently. *Halophila ovalis* is the dominant species accounting for more than 98% of the whole area of the seagrass beds in consecutive distribution. The area of seagrass bed in Donghai Island is about 9 ha, and the species is *Halophila beccarii*. The area of seagrass bed in Hailing Island is about 1ha, and the species is *Halophila ovalis*.

2.2 Seagrass beds in Guangxi

Seagrass beds in Guangxi Zhuang Autonomous Region distribute mainly in the sea areas near Hepu and Pearl Bay. The seagrass bed in Hepu distributes mainly in Tieshan Bay and the southwest of Yingluo Bay, and the total area is about 540 ha, occurring in 8 pieces with each area from 20 to 250 ha. The bottom material is fine sand. The main species of seagrass in Hepu are *Halophila ovalis* and *Zostera japonica* as well as a little *Halodule uninervis* and *Halophila beccarii*. The dominant species is *Halophila ovalis*. The main species of seagrass in Pearl Bay is *Zostera japonica*, and a little *Halophila beccarii*. The total area is about 150 ha.

2.3 Seagrass beds in Hainan

Seagrass beds in Hainan Province distribute in Li'an Bay, Xincun Bay, Longwan Bay and Sanya Bay, etc. The seagrass bed in Li'an Bay with an area of 320 ha distributes at the sea area in 0—3 m water deep around the lagoon. The bottom material is sand-mud. The species of seagrass are *Enhalus acoroides*, *Thalassia hemperichii, Cymodocea rotundata, Halophila ovalis* and *Halodule uninervis*, etc. The dominant species is *Enhalus acoroides* and the total distribution area of *Halophila ovalis* and *Halodule uninervis* is less than 10%. In Xincun Bay, seagrass bed with area about 200 ha distributes mainly in the south of the lagoon, and the bottom material is sand-mud. The main species of seagrass are *Enhalus acoroides*, *Thalassia hemperichii, Cymodocea rotundata*, *Halodule uninervis*, etc. The dominant species is *Enhalus acoroides*, but the total area of *Halodule uninervis* is less than 8%. In Longwan Bay, seagrass bed with area about 350 ha distributes in belts at the inner sides of coral reef platform, and the bottom material is fine sand. The main species of seagrass are *Thalassia hemperichii, Enhalus acoroides* and *Halophila ovalis*. In Sanya Bay, the main species are *Thalassia hemperichii* and *Enhalus acoroides*, and the area of the seagrass bed is about 1ha. The bottom material is fine sand.

2.4 Seagrass beds in Hong Kong

In Hong Kong, the main species are *Zostera japonica*, *Halophila*, *Halophila beccarii* and *Ruppia maritima*[16]. The seagrass beds in small areas distribute mainly in the sea area of Shenzhen Bay and Dapeng Bay, and the bottom material is mainly mud-sand.

The location, area and species of seagrasses of the above-mentioned main seagrass beds are listed in Table 1, and concrete distributing locations are shown in Fig. 1.

3 Biomass and productivity of seagrasses

3.1 Biomass of seagrasses

The results of survey on the biomass of main species of seagrass in Li'an Bay, Xincun Bay, Hepu and Pearl Bay are listed in Table 2. The biomasses (dry weight) of *Halophila ovalis* and *Halodule uninervis*

Table 1 Area and species of seagrasses in South China

Region	Seagrass bed	Area (ha)	Seagrass species
Guangdong	Liusha Bay	900	*Halophila ovalis*, *Halodule uninervis*
	Donghai Island	9	*Halophila beccarii*
	Hailing Island	1	*Halophila ovalis*
Guangxi	Hepu	540	*Halophila ovalis*, *Zostera japonica*, *Halodule uninervis*, *Halophila beccarii*
	Pearl Bay	150	*Zostera japonica*, *Halophila beccarii*
Hainan	Li'an Bay	320	*Enhalus acoroides*, *Thalassia hemperichii*, *Cymodocea rotundata, Halophila ovalis*, *Halodule uninervis*
	Xincun Bay	200	*Enhalus acoroides*, *Thalassia hemperichii*, *Cymodocea rotundata*, *Halodule uninervis*,
	Longwan Bay	350	*Enhalus acoroides*, *Thalassia hemperichii*, *Halophila ovalis*
	Sanya Bay	1	*Enhalus acoroides*, *Thalassia hemperichii*
Hong Kong[16]	Shenzhen Bay	—	*Zostera japonica*, *Halophila ovalis*
	Dapeng Bay	—	*Halophila beccarii*, *Ruppia maritime*

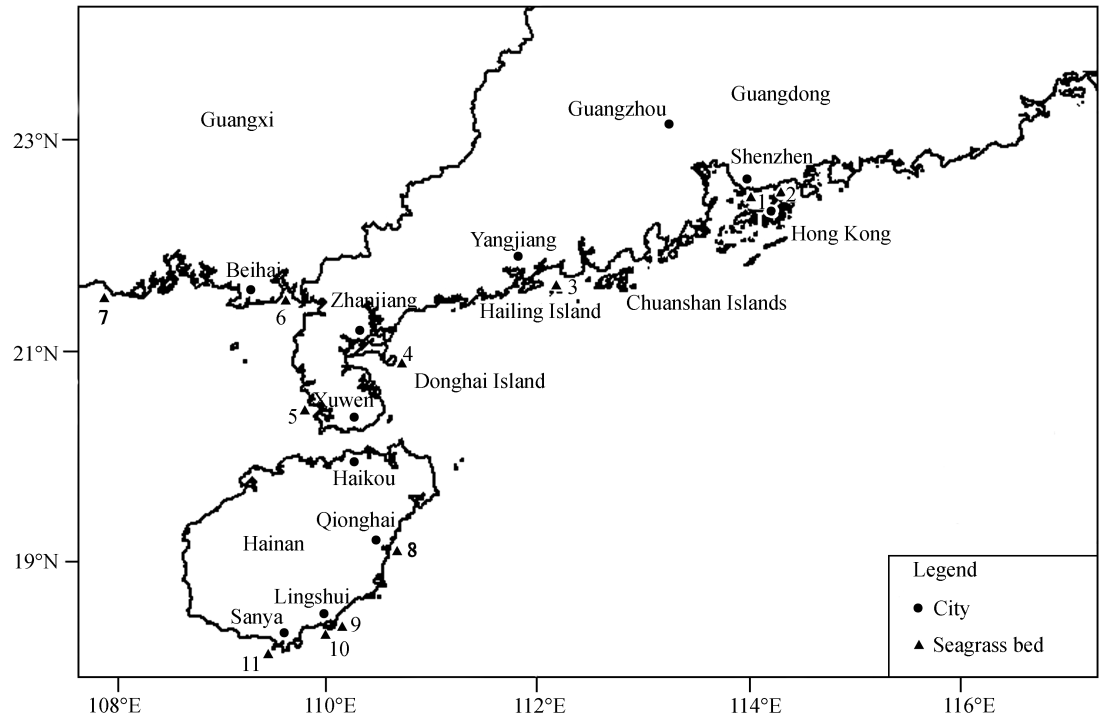

Fig. 1. Geographic distribution of seagrass beds in South China. 1, Dapeng Bay seagrass bed; 2, Shenzhen Bay seagrass bed; 3, Hailing Island seagrass bed; 4, Donghai Island seagrass bed; 5, Liusha Bay seagrass bed; 6, Hepu seagrass bed; 7, Pearl Bay seagrass bed; 8, Longwan Bay seagrass bed; 9, Li'an Bay seagrass bed ; 10, Xincun Bay seagrass bed ; 11, Sanya Bay seagrass bed.

Table 2 Biomass of main seagrass species

Seagrass bed	Survey time	Species	Wet weight (g/m^2)	Dry weight (g/m^2)	Wet weight/ dry weight
Liusha Bay	Oct. 2002	*Halophila ovalis*	189.5	25.7	7.4
		Halodule uninervis	92.7	18.8	5.1
Li'an Bay	Oct. 2002	*Enhalus acoroides*	4660.0	1094.8	4.3
		Thalassia hemperichii	11357.0	1146.8	9.9
		Cymodocea rotundata	2041.0	365.3	5.9
		Halodule uninervis	990.0	225.3	4.4
		Halophila ovalis	416.0	52.8	7.9
Xincun Bay	Oct. 2002	*Enhalus acoroides*	7112.0	1932.0	3.7
		Thalassia hemperichii	6563.0	818.8	8.0
		Cymodocea rotundata	3537.0	658.4	5.4
Hepu	Jul. 2003	*Halophila ovalis*	1965.0	25.5	7.7
Pearl Bay	Jul. 2003	*Zostera japonica*	449.0	66.4	6.8

are relatively low, amounting to 18.8—225.3 g/m^2, while those (dry weight) of *Enhalus acoroides* and *Thalassia hemperichii* are relatively high, amounting to 818.8—1932.0 g/m^2. As to the ratio of wet weight to dry weight of all seagrass species, *Enhalus acoroides* is the lowest, amounting to 3.7—4.3, while that of *Thalassia hemperichii* is the highest, amounting to 8.0—9.9.

3.2 Productivity of seagrasses

The leaves productivity and shoot density of main seagrasses in Liusha Bay and Li'an Bay are listed in Table 3. Of all the species investigated, the shoot density of *Halophila ovalis* in Liusha Bay is the highest, amounting to 5958 shoots/m^2, while that of *Enhalus acoroides* in Li'an Bay is the lowest, amounting to 66 shoots/m^2. In Li'an Bay, the leaves productivity of *Thalassia hemperichii* is the highest, amounting to 4073.011 mg/m^2/d, while that of *Enhalus acoroides* is the lowest, only 913.810 mg/m^2/d.

Table 3 Shoot density and leaves productivity of main seagrass species

Seagrass bed	Survey time	Species	Shoot density (shoots/m^2)	Shoot productivity (mg/shoot/h)	Leaves productivity (mg/m^2/d)
Liusha Bay	Oct. 2002	*Halophila beccarii*	5958	0.011424	1633.541
		Enhalus acoroides	66	0.576900	913.810
Li'an Bay	Oct. 2002	*Thalassia hemperichii*	1508	0.112539	4073.011
		Cymodocea rotundata	2027	0.059692	2903.896

4 Characteristics of representative biology species in main seagrass beds

In the tropical and semi-tropical zones, seagrass beds always distribute near coral reef and mangrove. Seagrass beds, mangrove and coral reef distribute from shallow to deep area of the coast in order. Brief analysis on the characteristics of representative biology species in four main seagrass beds investigated is as follows.

4.1 Hepu seagrass bed

Hepu seagrass bed close to Shankou National Natural Reserve for Mangrove distributes mainly in the extending-to-sea area of mangrove. The *Halophila ovalisi* is favorite food of Dugong, which is vulnerable to extinction on the IUCN redlist. Now, the majority of the seagrass bed is a part of the National Natural Reserve for Dugong. Besides Dugong, there are five species of prawn (i.e. *Penaeus penicillatus* Alcock, *Penaeus* (*Marsupenaeus*) *japonicus* Bate, *Metapenaeus burkeroadi* Kudo, *Metapenaeus ensis* (de Haan) and *Metapenaeus affinis* H. Mine-Edwards), two species of siganid (i.e. *Siganus oramin* (Bloch et Valenciennes) and *Siganus fuscescens* Houttuyn), three species of urchin (i.e. *Langanum depressum* Lesson, *Temnopleurus reevesii* Gray and *Arachnoides placenta* Linnaeus), four species of holothurian (i.e. *Holothuria* (*Meleatyla) martensii* Semper, *Pentacta anceps* Selenka, *Holothuria scabra* Jaeger and *Opheodesome sp*.) and two species of starfish (i.e. *Astropecten kagoshimensis* de Lovizl and *Astropecten monacanthus* Sladen).

4.2 Liusha seagrass bed

There are mangrove and coral reef distributing sporadically near Liusha seagrass bed in Guangdong Province. There are five species of prawn (i.e. *Metapenaeus joyneri* Miers, *Penaeus (Marsupenaeus) japonicus* Bate, *Penaeus (P.) semisulcatus* de Haan, *Metapenaeus ensis* de Haan and *Parapenaeopsis hardwickii* Miers), one species of siganid (*Siganus oramin* Bloch et Valenciennes), one species of urchin (*Langanum depressum* Lesson), one species of starfish (*Archaster typicus* Müller et Troschel) and one species of holothurian (*Holothuria* (*Meleatyla*) *martensii* Semper).

4.3 Li'an seagrass bed

There are mangrove and coral reef distributing sporadically near Li'an seagrass bed in Hainan Province, too. There are four species of prawn (i.e. *Metapenaeus ensis* de Haan, *Penaeus (P.) semisulcatus* de Haan, *Penaeus (Marsupenaeus) japonius* Bate and *Metapenaeus joyneri* (Miers)), one species of holothurian (i.e. *Euapta godefforyi* (Semper)), one species of siganid (*Siganmus oramin* Bloch et Valenciennes), one species of starfish (*Archaster typicus* Müller et Troschel) and one species of urchin (*Diadema setosum* Leske).

4.4 Xincun seagrass bed

There are mangrove and coral reef distributing near Xincun seagrass bed, of which, coral species are rather rich with record up to 53[17]. There are four species of prawn (i.e. *Metapenaeus joyneri* (Miers), *Penaeus* (*Marsupenaeus*) *japonicus* Bate, *Penaeus (P.) semisulcatus* de Haan and *Metapenaeus ensis* de Haan), one species of siganid (*Siganmus oramin* (Bloch et Valenciennes)), one species of starfish (*Archaster typicus* Müller et Troschel), one species of holothurian (*Holothuria leucospilota* (Brandt)) and one species of urchin (*Salmaciella dussumieri* (L. agassiz)).

5 Threats to seagrass beds

According to the survey, the seagrass beds in South China are facing serious threats, because people neglect the importance of seagrass beds. The concrete situation is analyzed as follows.

5.1 Building shrimp ponds and breeding aquatic in seawater

In recent ten years, shrimps culture has been blooming in the coastal area of South China, and sea reclamation for culturing shrimps is the main form. A large area of seagrass bed in intertidal zone has been changed into shrimp ponds, and the seagrass bed has been destroyed destructively. This phenomenon occurs universally in

Liusha Bay and Hailing Island in Guangdong, Pearl Bay in Guangxi and Li'an Bay in Hainan.

Culturing shellfishes (such as oysters and pearl shells) and large algae in the seagrass beds and their neighboring sea areas can destroy seagrass obviously. About 100 ha shellfishes culturing area in Hepu seagrass bed in Guangxi made the seagrasses in the culture area die out. This kind of shellfish culture exists in a large area in Liusha Bay seagrass bed, too. *Eucheuma* are cultured in a large area in seagrass beds in Li'an Bay and Xincun Bay in Hainan. In this way, the photosynthesis of seagrasses decreases, thus affecting the growth of seagrass.

5.2 Fishing by netting and trawling

In the seagrass bed where fish resource is quite abundant, local people catch fishes by setting lots of nets during the alternation of flood tide and ebb tide. Some activities, such as piling and trampling on seagrasses while working, affect the growth of seagrasses.

Trawling destroyes seagrass quite seriously. In Hepu sea area, there are more than 400 trawling boats working in the shallow sea areas with water depth less than 10 m. Trawling operation pulls out the roots of seagrasses in pieces, thus destroying the seagrasses destructively.

5.3 Catching shrimps and fishes by poisons, electric power and explosives

Prawn is the main fishery resource in seagrass beds. During ebb tide, numbers of fishermen catch fishes by poisons and electric power, which destroys the seagrass seriously. This phenomenon is very universal in seagrass beds in the coastal area of South China, especially in Liusha Bay in Guangdong Province. Fishing by exploding is also prominent, which threatens seagrass seriously.

5.4 Digging and raking shells

Digging *Sipunculus nudus Linnaeuses*, *Phascolosoma esculentaes* and shells is universal in most of the seagrass beds in the coastal area of South China. In Hepu of Guangxi and Liusha seagrass bed of Guangdong, hundreds of people, including children, dig shellfishes and rake shells, which is one of the economical incomes of local people. The digging shellfishes and raking shells pull out the roots of seagrasses and thus destroy the seagrasses destructively, and loosen the sand and mud of beaches and make them flow and cover the seagrasses, and thus affect the normal growth of seagrasses.

5.5 Artificial pollution and dredging channels

Pollutants from land and sea cause increasing contents of un-degradable organic materials, nutrition and suspended substance (SS), and thus destroy the inhabited conditions of seagrasses. For example, many restaurants located in a tour site near Xincun Bay seagrass bed discharge a great deal of kitchen waste into the sea and thus increase greatly contents of organic materials, SS, and so on, changing the living environment of seagrasses.

Dredging channels affects the seagrasses greatly, because the seagrasses in the construction areas may be deracinated and the seagrasses in the non-construction areas may be covered by the increasing SS in the water because of dredging channels, thus affecting their photosynthesis. The phenomenon occurs in Hepu seagrass bed in Guangxi.

5.6 Typhoon

The storm tide, storm waves caused by typhoon pull up the roots of seagrasses or cover seagrasses with sands stirred up by waves, which destroys seagrass resource. For example, a typhoon in September, 2002 destroyed the seagrass bed in Hepu of Guangxi seriously, and the seagrass bed did not recover until three months later since the typhoon.

As seen from the above analysis, the seagrass beds in the coastal areas of South China are destroyed mainly by artificial factors. But the degradation of seagrass beds in Australia was mainly caused by the decreased light absorption of seagrasses and increased turbidity caused by suspended particulates and the re-suspended sand in the water, in this way, the dimming of light in water affects photosynthesis of seagrass[18].

6 Summary

(1) The seagrass is abundant in the coastal areas in South China, and there are about 8 species of seagrasses. The area of seagrass beds is about 2400 ha.

(2) Although the biomasses of seagrasses are changeable in a large range, they have generally higher biomasses. The biomass (dry weight) of *Halophila ovalis* is relatively low, amounting to 18.8—225.3 g/m^2, while biomasses (dry weight) of *Enhalus acoroides* and *Thalassia hemperichii* are relatively high, amounting to

818.8—1932.0 g/m^2.

(3) Leaves productivity of main species of seagrasses is quite high. The leaf productivity of *Thalassia hemperichii* is the highest, amounting to 4073.011 mg/m^2/d, while that of *Enhalus acoroides* is the lowest, amounting to 913.810 mg/m^2/d.

(4) In South China, many seagrass beds distribute near either coral reef or mangrove. At the same time, the seagrass beds possess abundant representive biology species such as prawn, holothurian, echinoid, starfish and siganids.

(5) The inhabited environments of the seagrass beds are facing many threats, such as shrimp ponds construction, aquaculture in seawater, fishing by nets, explosives, poisons and electric power, digging shellfishes and raking shells, trawling, artificial pollution, dredging channels as well as typhoon.

(6) At present, there are just a few researches on seagrass in China, and people have a superficial knowledge about seagrass resource and its ecological function and economic value, so it is necessary to strengthen research on seagrasses and at the same time to heighten the government departments and the public's understanding on the importance of seagrasses in marine ecosystem and the consciousness of seagrass conservation.

(7) The following researches should be carried out in the seagrass research in China: ① finding out the real conditions of seagrass resources, ② studying the impacts of human activities and global changes on seagrass beds, ③ carrying out the study of biodiversity and ecological functions of seagrass beds and, ④ carrying out study of conservation biology for seagrass bed.

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