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"Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand"

NATIONAL REPORTS
on
Seagrass in the South China Sea

"Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand"

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Cover Photo: *Lingula unguis* in a seagrass bed of Koh Kong Province, Cambodia. Photo by Mr. Kim Sour.

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Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand

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NATIONAL REPORT

on

Seagrass in the South China Sea

CAMBODIA

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1. INTRODUCTION

Cambodia's shoreline is 435km long and includes the two provinces of Koh Kong and Kampot, and the two municipalities of Sihanoukville and Kep. The seaward boundary has been defined as the outer limit of the Exclusive Economic Zone (EEZ, 55,600sq. kilometres) (Nelson, 1999) but the landward boundary has not yet been defined. Cambodia's coastal and marine areas contain a diverse range of habitats and other living resources. Compared to neighbouring countries, these habitats and resources remain relatively intact, providing important nursery and feeding areas for a variety of species, especially those of significance to marine capture fisheries.

From a functional perspective, Cambodia's coastal zone is comprised of two inter-related systems, ecological and socio-economic systems. The ecological system includes the physical, chemical and biological parametres that provide natural resources, sequester pollutants and offer fundamental life-support functions (e.g. clean air and water) for humans and other living organisms. The socio-economic system is largely dependent upon the many functions and products of the ecological system.

Seagrass beds are critical habitats that support a diverse range of resident and migratory species, including some considered to be endangered and vulnerable. Since the 1972 Stockholm Conference on the Human Environment, an over-riding concern in the protection of the marine environment has been that of pollution. However, notwithstanding a number of regional action plans and conventions that have since been developed and implemented for the management of marine pollution, the quality of the marine environment has declined over the last thirty years (Miles, 1999).

The objectives of this report are to:

- Review past and ongoing research activities seagrass in Cambodia, including information relating to geographical location, physical and biological attributes, environmental state, social dependence and use, and economic valuation;
- Review past and ongoing seagrass-related programmes of concerned Ministries and NGOs, including comments regarding programme needs, priorities, and costs and benefits;
- Provide information about seagrass management, highlighting efforts in the economic valuation of seagrass goods and services carried out by concerned institutions;
- Discuss socio-economic and other influences on seagrass programme implementation in Cambodia;
- Discuss institutional requirements for the management of seagrasses within Cambodia's EEZ; and
- Provide baseline results from research and monitoring activities recently conducted in Cambodia.

2. REVIEW OF NATIONAL DATA AND INFORMATION

Very little research has been conducted on the status of fish stocks, the success of current management arrangements, and the impact of fishing on the marine environment. Most research has been funded by government and relevant organisations.

2.1 The Importance of Seagrasses to Humans and the Marine Ecosystem

The majority of seagrass studies in Cambodia have focused on ecosystem and management issues, hence, socio-economic information relevant to these resources is scarce. However, there are some reports detailing the importance of seagrass ecosystems to Cambodians. According to Tana and Chamnan (1995) one species (Khmer name *Smao Prayong*) is eaten by Dugong (*Dugong dugon*).

Cambodia's marine fisheries depend significantly on seagrass ecosystems. A large number of seagrass dependent fish and shrimp species are highly valuable in both domestic and international markets, and are subject to high levels of legal and illegal fishing effort. The collection of invertebrates by fishers using snorkel and mask is also popular in inshore seagrass areas.

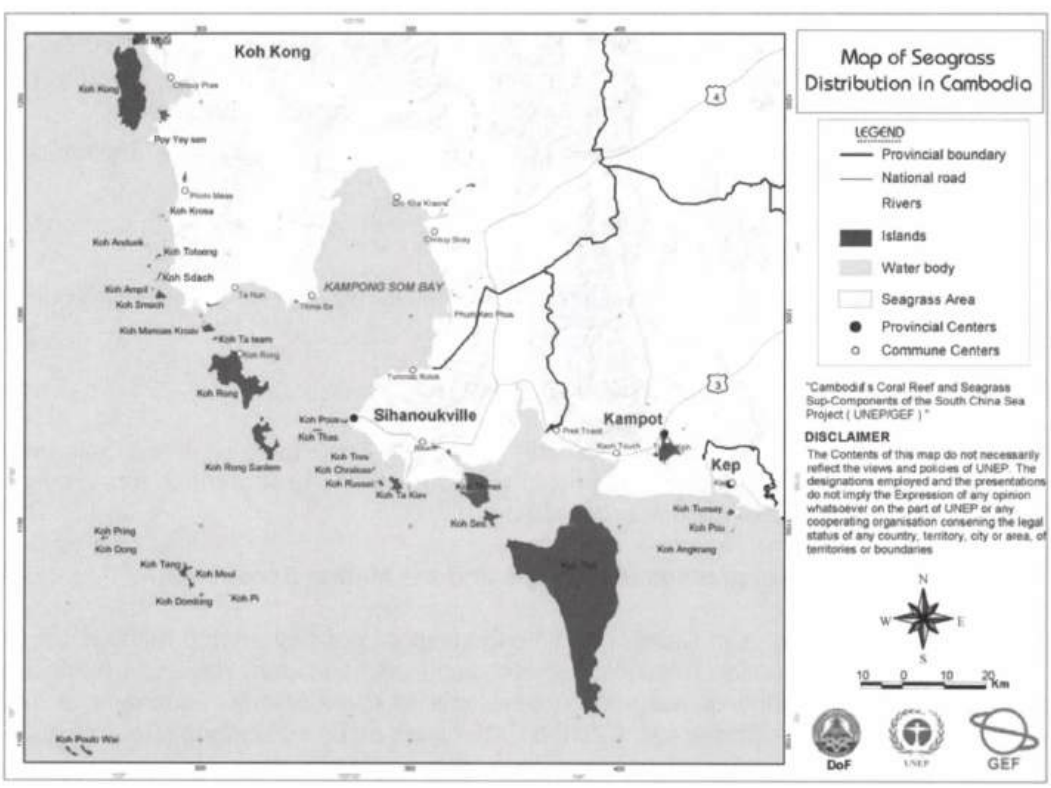
According to statistics of the Department of Fisheries, 42,000 to 45,000 tonnes of marine fish and invertebrates are harvested from Cambodia's marine waters every year. However, some observers estimate that actual landings could be 10 to 20 times higher than the reported figure. The overall representation of seagrass-dependent fish species in marine landings is unknown, but is most likely high.

2.2 Geographic Distribution of Seagrass

Seagrasses can be found in most shallow water areas of Cambodia's coastal zone. Recent surveys provide information about the location of significant areas of seagrass (Figure 1). However, the composition of seagrass species and variation in their distribution and abundance over time are largely unknown.

Extensive beds occur in waters adjacent to Kampot Province and Kep Municipality, with seagrass and/or mixed seagrass and *Caulerpa* beds found along the entire coast to the Cambodia-Viet Nam border (Ethirmannasingam, 1996 in Nelson, 1999). According to district fisheries officials, large areas of seagrass once occurred in Kampong Som Bay, although as a result of high intensity trawling and push netting, seagrass distribution and abundance has diminished significantly in this area. A limited survey conducted by Ethirmannasingam (1996) identified the presence of seagrass between mainland Cambodia and Koh Kong Island.

Seagrass habitats in Cambodia can be divided into two main types: extensive seagrass meadows along the mainland, and patches of seagrasses inter-mixed with corals around islands (Ethirmannasingam, 1996 in Nelson, 1999). Much of the muddy coast of Kampot Province supports seagrass beds, including extensive patchy beds near the river mouth at Kampot town and very large beds east of Koh Tunsay. Inshore seagrass beds are mixed stands of several species, while offshore, *Enhalus acoroides* occurs in extensive beds. Small seagrass beds have been observed in waters adjacent to Koh Rong and Koh Rong Sanlem (Wetland International Asia-Pacific and Lower Mekong Basin Program, 2001).



Source: DoF, 2004 a.

Figure 1 Map of seagrass distribution in Cambodia

A survey conducted by Fishery Department officials in 2004 using GPS found that the total area of seagrass in Cambodia's waters is 32,492ha (DoF, 2004 b). The seagrass area at Kampot covers 25,240ha, and can be divided into three meadows. The first, extending from Prek Trapeang Ampil to Prek Kdat, has an area of 1,795ha; the second, extending from Prek Kdat to Prek Koh Torch (Kilometre 12) covers 380ha; and the third, 23,065ha, starts at Prek Koh Torch and extends to Kep Town. Seagrass beds typically occur in water depths of 3 to 4m, with salinity ranging from 25ppt to 30ppt, and most seagrass areas have been damaged by trawl and push net fishing. This damage results from the fact that, despite a ban on trawling in water less than 20m depth, this law is not enforced.

2.3 Physical/Chemical Characteristics

Information about the environmental factors influencing seagrass distribution and abundance in Cambodia is lacking. However, preliminary sea surface and air temperature, sedimentation, depth, turbidity, and visibility data have recently been gathered. Generally, visibility is low to very low in areas where most seagrass beds are situated, especially during the rainy season. The substrate is typically muddy, although some areas are characterised by a mixture of sand and mud substrate types.

2.4 Biological Aspects

2.4.1 Seagrass

Seagrass play an important role for marine animals, including dugongs and green turtles, and provide habitat for many commercially important fish and crustacean species. They also maintain water quality by absorbing nutrients and stabilising sediments (Short *et al*, 2001). A total of nine species of seagrass have been reported from Cambodia's coastal waters by the Kampot Working Group (2002) as follows:

- *Thalassia hemprichii,*
- *Halodule uninervis,*
- *Enhalus acoroides,*
- *Halophila decipiens,*
- *Cymodocea serrulata,*
- *Halodule pinifolia,*
- *Cymodocea rotundata,*
- *Syringodium isoetifolium,* and
- *Halophila ovalis*

2.4.2 Associated Marine Biota

The exact number of seagrass associated species is unknown. Many economically important species of fish and crustacean are associated with seagrass habitats and use these areas for spawning, nursing grounds, as well as feeding. The shallow water seagrass beds occur on soft sediments. In these areas, shrimp and demersal fish species, squid and cuttlefish, slipper lobster and mantis shrimps are found amongst seagrass (Ing, 2003).

2.4.3 Marine Endangered Species

Many groups of marine living resources are under threat from human activities and natural phenomena and some species of fish, reptiles, marine mammals and corals are becoming endangered. Based on a review conducted for the fisheries component of UNEP/GEF South China Sea Project, there are 12 species of marine mammals and 5 species of sea turtle in Cambodia's marine waters (Ing, 2003). According to Tana (1995) there are three species of marine mammals along the Cambodian coastline that are accidentally caught by gill nets and shrimp trawlers in the seagrass beds of Sihanoukville and Kampot Bay, i.e., Irrawady dolphin (*Orcaella brevirostris*), Spinner dolphin (*Stenella longirostris*) and dugong. Most species of marine mammals are assumed to be vulnerable, endangered or critically endangered, either locally or globally and therefore conservation of these species is a high priority of the Department of Fisheries.

2.5 Threats to Seagrass

Seagrasses are threatened by destructive fishing practices particularly demersal trawling, push netting, and other active fishing gears that damage seagrass and disturb sediments (Tana, 1995). Fisheries landings from seagrass areas have recently declined, leading to stakeholder concerns about the effects of trawling in these areas. Decline in water quality associated with agricultural use of fertilisers and pesticides, and increased erosion from unsustainable logging practices also threaten seagrass. Fertilisers can encourage the growth of algae that out-compete seagrass or epiphytic algae that reduce the ability of seagrass to photosynthesise, often leading to dieback. Erosion from poor land use can result in increased water turbidity which reduces the quantity of sunlight reaching seagrass plants, diminishing the photosynthetic capacity of the plants.

2.6 Causal Chain Analysis, Including Constraints in Addressing Threats

Cambodia's national coral reef and seagrass committee has convened numerous meetings at the national level aimed at reviewing local and national threats to seagrass. Causal chain analyses have been conducted to identify the causes of the five key threats to coral reefs and seagrasses in Cambodia. These key threats include:

- Sedimentation,
- Unsustainable fishing practices,
- Seaweed farming on seagrass beds,
- New settlements near seagrass areas, and
- Unsustainable development in coastal areas.

Owing to the comparatively short coastline of Cambodia, the causes of degradation of seagrass beds are similar in all areas. A series of flow charts have been prepared to highlight threats to seagrass at the local and national levels. The example provided in Figure 2 is based on information for Kampot Province.

These flow charts begin with the main threat at the top and then detail the root causes of these threats. In response to the causes, a series of intervention measures have been identified that are located at the base of the flow chart.

Seagrass and coral reef areas are thought to respond to key threats in a similar manner. However, trawling and push net fishing is thought to be more damaging to seagrass, whilst cyanide and dynamite fishing are more serious threats to coral reef areas.

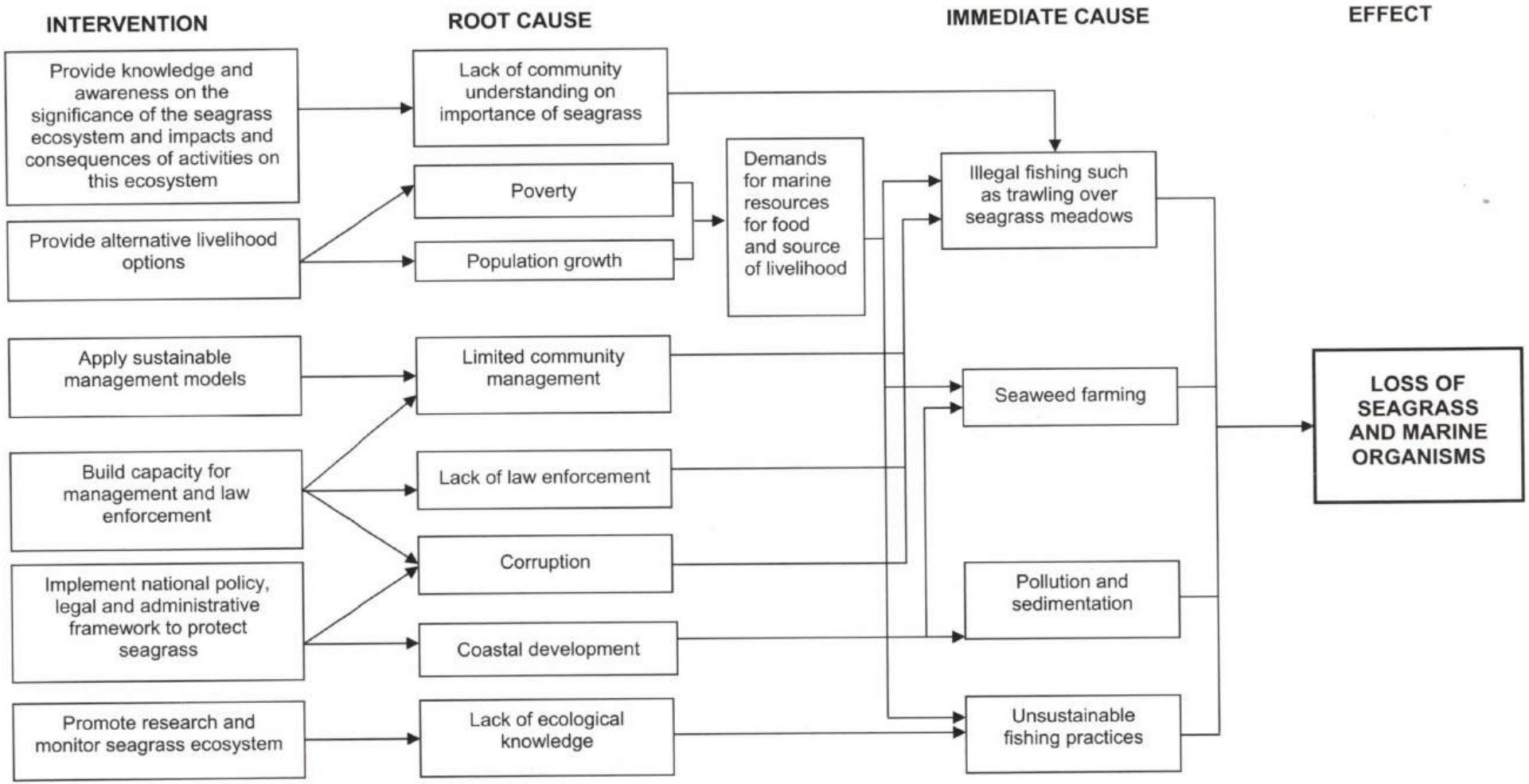


Figure 2 Causal chain analysis of threats to seagrass in Cambodia.

3. SOCIO-ECONOMIC SITUATION WITHIN COASTAL AREAS

The development of Cambodia's coastal zone continues to occur at a rapid pace, fueling concerns regarding the unsustainable use of natural resources in the coastal zone. The status of many coastal and marine resources is however, largely unknown.

This section aims to review information about the economic value of coral reefs and seagrasses in Cambodia. Issues in the management of seagrasses and coral reefs, including the socio-economic circumstances of coastal communities, problems at the operational management level, and institutional frameworks will be discussed.

3.1 Population Size and Composition

The population census conducted in March 1998 (the first census in 36 years) showed a population of 11.4 million, with approximately 85% living in rural areas.

As can be seen in Table 1, populations ranged from 28,677 in Kep to 527,904 in Kampot Province. The national average household size was found to be 5.2, which is slightly higher than the average household size of 5.0 in Kampot province, but lower than Koh Kong (5.3), Sihanoukville (5.5), and Kep (5.3). Women represent 52.1% of the population in Kampot; 48.8% in Koh Kong; 50.6% in Sihanoukville; and 51.1% in Kep (Ministry of Planning, 1999).

On a provincial basis, the proportion of female-headed households ranged from 22.5% to 26.8%. In coastal areas, 24.8% of households were headed by females; however, this is lower than the national average (Ministry of Planning, 1999).

The average population density in Cambodia is 64 persons per km^2, but the density in Koh Kong is considerably lower at 12 persons per km^2 compared with Kampot (108) and the municipalities of Sihanoukville (179) and Kep (85). Table 1 and Figure 3 highlight the population size and density of Cambodia and its coastal areas.

Table 1 Population size and density of Cambodia and its coastal areas.

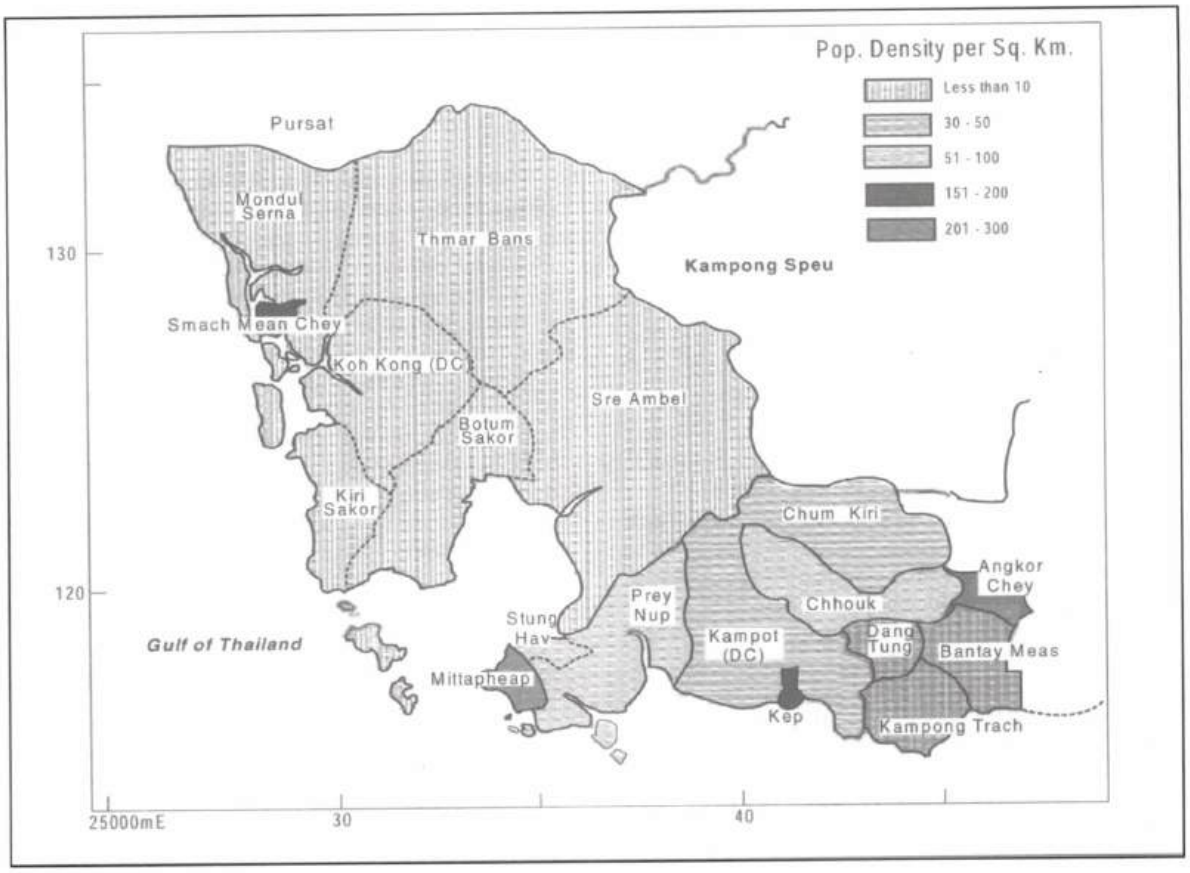
Location	Areas (Km^2)	Population	Women (% of total)	Density (/km^2)
Cambodia	181,035	11,426,223	51.8	64
Kampot	4873	527,904	52.1	108
Koh Kong	11160	131,912	48.7	12
Sihanoukville	868	155,376	50.5	179
Kep	336	28,677	51.0	85

Source: Ministry of Planning, 1999.

Cambodia's population is growing at an estimated annual rate of 2.4% (Ministry of Planning, 1999). The population is mostly comprised of people of Khmer decent (90%) and the main ethnic groups are the Cham, Vietnamese, and Chinese and others from different hill tribe groups. It is estimated that 95% of the population speak the Khmer language. The main religion in Cambodia is Theravada Buddhism, while the Cham are Muslim. There are no estimates of the distribution of ethnic groups in coastal areas. Village studies carried out by ECZM project showed that the proportion of Cham people on at least part of the coastline is relatively high.

3.2 Occupation

There is a scarcity of clear information about the occupations of Cambodia's coastal people. However, the ECZM project conducted a review of socio-economic circumstances observed in coastal areas of Cambodia. It identified that most households depended on several occupations and sources of income, but fishing was the main occupation in six villages of Sihanoukville, six villages of Kampot, five villages of Koh Kong, and three villages of Kep. This study also indicated that most villagers also farm rice for family consumption (Carl Bro International, 1999).



Source: ICLARM, 2001.

Figure 3 Population densities in the coastal zone of Cambodia (1996-1997).

3.3 Migration

There was considerable rural to urban migration in the years immediately following the 1993 elections, as villagers searched for better employment opportunities in the largely urban private sector generated by the influx of international development assistance. Village studies carried out by the ECZM project indicated that the present migration into and out of most coastal areas is limited. The migration into the coastal areas of Koh Kong province has, however, been substantial over the last 20 years. Table 2 highlights the migration by reason and by gender.

Table 2 Reasons for migration into Cambodia's coastal zone by reason and gender.

Reason for migration	Both Sex (%)	Males (%)	Females (%)
Total	100	100	100
Transfer work	11.0	15.2	3.2
To search for employment	31.0	29.6	15.6
Education	2.5	2.8	1.6
Married	11.4	12.2	9.3
Family moved	53.9	28.9	56.2
Natural calamities	2.7	2.6	3.0
Return after replacement	6.0	5.3	6.1
Other reasons	5.2	3.6	5.1

Source: Ministry of Planning, 1999.

3.4 Education

According to the 1998 census, 61.2% of Cambodia's literate population had not completed primary education. In Kampot, Koh Kong, Sihanoukville, and Kep, the percentage of the population yet to have completed education at a primary level was 65.9%, 58%, 56% and 68%, respectively. A small percentage (1.45%) of Cambodia's literate coastal population had acquired literacy without formal education and passing any grade or class. Cambodia is very much an oral society and letters are rarely used to provide news to relatives or friends. Villagers in rural areas rarely have access to newspapers, books, or any other written materials.

Recent studies show that gender disparity in education is greatest among the poor, but it is also significant among the richest 20% of the population. Boys and girls have fairly similar school enrolment rates until the age of 10; by 15 years of age, male enrolment is 50% greater than that of girls, and by 18 years of age, male enrolment rates are nearly three times as large as female enrolment rates. This means that initially, parents send both their sons and daughters to school, but take the girls out of school earlier than the boys. Household survey data suggest that more than 60% of children drop out of school because they have to help the family with household and market work. Furthermore, parents are often reluctant to send their girls to secondary school as they would be required to travel long distances or stay away from home (Ministry of Planning, 1999).

3.5 Household Income

According to a socio-economic survey conducted by the Ministry of Planning in 1999 (Ministry of Planning, 1999), the subsistence agricultural sector dominates both total employment and incomes, and there is a relatively small proportion of the population in wage employment. Nationally, earnings from self-employment were estimated at 241,990 Riels (US$63.43) per household per month, or 60% of the total monthly household income (Table 3). Income from wage employment amounted to 83,687 Riels (US$21.94) or 20% of total income, or one-third the value of earnings from self-employment. The contribution from all other sources of income, which consisted of rental income, interest received transfers, and imputed value of house rents etc., was about the same as that of wage employment.

In Phnom Penh, the main source of household income was wage employment contributing 35% of total income, a share that is marginally higher than the contribution from other income sources. In the case of Phnom Penh, income from the three main sources was nearly equal. In the rural sector, however, self-employment income contributed over 70% of household income, with wage employment contributing less than one sixth of the household income. In monetary terms, income from wage employment amounted to only 48,442 Riels (US$12.70) per household per month. The relative contributions from these three sources in the other urban areas were the same as for Cambodia as a whole, although the numerical value of household income in the urban areas is more than 160% of the value of household incomes in the rural sector (Ministry of Planning, 1999).

Table 3 Average monthly household income by main source of income by stratum in Cambodia during 1999 (Riel).

Main Sources of Income	Cambodia		Phnom Penh		Other Urban		Rural	
	Value	%	Value	%	Value	%	Value	%
Total Income	403,334	100	1,139,553	100	515,027	100	314,247	100
Self-Employment Income	241,990	60	345,340	30.3	298,509	58.0	224,352	71.4
Income from Wage Employment	83,687	20.7	397,463	34.9	109,609	21.3	48,442	15.4
Other Income	77,657	19.3	396,750	34.8	106,909	20.8	41,452	13.2

Source: Ministry of Planning, 1999.

The 1999 survey conducted by the Ministry of Planning estimated the average monthly household income of the country to be 403,334 Riels (US$105.72). There were large differences in the sectoral distribution of household incomes; the households in Phnom Penh on average received 1,139,553 Riels (US$298.70) per month, which declined to 515,027 Riels in other urban areas and to 314,247 Riels (US$82.37) per month in the rural sector. Thus, the average income of households in Phnom Penh was 262% higher than that of rural households, which depended mainly on farm incomes. The

differentials in household income were less marked among the ecological zones, rising from 319,211 Riels per month in the less developed Plateau and Mountain zone to 452,023 Riels (an increase of 41.6%) in the Plains zone that contains the capital city and several provincial towns with urban populations (Ministry of Planning, 1999).

The average *per capita* income of Cambodia was 79,355 Riels (US$20.80) per month (Ministry of Planning, 1999). Thus, the annual *per capita* income received by households amounted to US$249.60. The average *per capita* monthly income of all ecological zones, other than that of the Plains zone was lower than the national average. The differentials between the Tonle Sap zone, which had the lowest *per capita* income, and the Plains zone, which had the highest, was less than 30%. The *per capita* income of households in the Tonle Sap areas has dipped below that of the Plateau and Mountain zone as the average household size in Tonle Sap is higher than that of the Plateau and Mountain zone.

The survey also indicated that the average income per person per month in the coastal zone is US$19.50. The level is higher than that in the Tonle Sap zone (US$17.80) and mountain zone (US$18.21), but is lower than in the plain (US$23.09).

3.6 General Socio-economic Problems

Lack of rice and other food: Many informants in socio-economic studies mentioned lack of rice for several months each year as a major problem. Some also mentioned the lack of other types of food as a problem. Most households had a small plot of land where they grew rice for household consumption. However, most of the plots were small, which meant that the villagers had to purchase and/or borrow rice for part of the year. Other reasons for lack of rice and other food were bad weather and insect attacks. The two most commonly suggested solutions to this problem were for an outside organisation to provide food and seeds/seedlings for different fruit trees. The provision of more land was suggested in some villages.

Lack of water during the dry season: The main sources of water in most villages are dug wells and ponds. However, most households lack water during several months of the dry season when they either collect water from streams, springs, or ponds up to 5km from their houses or purchase water at relatively high prices. The survey conducted by CZM/DANIDA (Nelson, 1999) suggested that an outside organisation should construct more dug wells and/or ponds in villages.

Lack of schools, paths, and health facilities: Some children do not attend school because of the distance to the school and/or because they have to look after younger siblings, help with household work, farming, fishing, and other work. Many villagers identify the lack of schools and facilities, as well as an insufficient number of teachers, as a major problem and suggest the construction of a school in the village. Construction of proper paths and repair of paths is also considered a priority by many villagers for easier access to markets, schools, and other facilities. Lack of hospitals/clinics is another problem, especially for poor households who cannot afford to travel to hospitals or clinics far from their village.

Lack of capital for productive use: Many households mentioned the lack of capital to invest in fishing, farming, and other equipment as a major impediment to an improvement in their living standards. Often villagers are forced to sell their products to the traders at low prices in lieu of paying interest on loans. Other households borrow money from rich neighbours and other moneylenders at interests of up to 150% per month. Provision of long-term loans with no or low interest is seen as the solution to this problem. Villagers also suggested establishing a fishing association to be responsible for the extension of loans.

Decline in fish catch: The living standards of people are reputed to have declined over recent years. The main reasons for this are a significant reduction in availability of natural resources, especially marine fishery resources, due to the use of trawlers in shallow water, the use of modern fishing equipment like motorised push nets, a substantial increase in the number of fishers and boats, use of dynamite in rocky and coral areas, and the destruction of mangroves in order to establish salt pans or shrimp farms (Sihanoukville Coral Reef Working Group, 1999). Villagers have suggested that the use of illegal fishing equipment and methods be controlled, and that seagrasses, coral reefs, and mangrove be protected and rehabilitated to aid the resolution of this problem. Some villagers have suggested that a mangrove protection group be established.

Lack of mechanisms for participation in decision-making: The participation of villagers in decision-making is virtually non-existent. The only mechanism for villagers to express their views is through the village leader to the commune leader and district authorities. If the district does not wish to take action on their views there is no process of appeal. In some instances, this has led to rioting and destruction of private property.

Fishing conflicts: Small-scale, trawl, and motorised push net fishers are in conflict over access to inshore areas and fish resources. Trawls often destroy small-scale fishing gear and large commercial operators typically do not pay compensation to local fishers. Small-scale fishers cannot claim compensation as trawling is banned in most inshore areas and the crews of such vessels are usually under the protection of high-ranking military, police, or government officials. Push net fishing is believed to be highly destructive of habitats such as seagrass and may take large catches of juveniles when used inshore.

4. INSTITUTIONAL ARRANGEMENTS AND NATIONAL LEGISLATION

4.1 Roles and Responsibilities in Coastal Zone Management

There are a number of government bodies in Cambodia with responsibility for coastal zone management. The main ministries include the Ministry of Agriculture, Fisheries and Forestry (MAFF), the Ministry of Industry, Mines and Energy (MIME), the Ministry of Tourism (MT), the Ministry of Public Works and Transport (MPWT), the Ministry of Rural Development (MRD), the Ministry of Women's Affairs, the Ministry of Planning, and the Ministry of Environment. Additionally, there are a number of existing ministerial committees with responsibility for certain key issues. The two of significance in the coastal zone are the National Committee for Land Management, Urbanisation and Construction and the Committee on Land Tenure. Also of relevance to the coastal zone is the Cambodian Development Council, which is the body responsible for the management of foreign investments, including both private business and donor investments.

A National Steering Committee chaired by the Minister of Environment, with representatives from other institutions and ministries with a stake in the coastal zone, oversees Coastal Zone Management in Cambodia (see below).

National Steering Committee

Minister	Ministry of Environment (Chair)
Under-Secretary of State	Ministry of Agriculture, Fisheries and Forestry
Under-Secretary of State	Ministry of Tourism
Under-Secretary of State	Ministry of Industry, Mines and Energy
Governor	Kampot Province
Governor	Kep Municipality
Governor	Sihanoukville Municipality
Governor	Koh Kong Province
Representative	Cambodian Development Council
Representative	Ministry of Public Works and Transport
Representative	Ministry of Rural Development
Chief	Coastal Co-ordination Unit
Representatives	NGO and other donor projects in the Coastal Zone

Day-to-day management of coastal resource and their use is the responsibility of the Ministry of Agriculture, Forestry and Fisheries, particularly the Department of Fisheries (Nelson, 1999). There are fisheries personnel at district and provincial levels responsible for patrolling and managing commercial and medium scale fisheries. They also monitor and protect critical fisheries habitats such as mangroves, seagrasses, and coral reefs.

The mandate of the Ministry of Environment overlaps with that of the Ministry of Agriculture, Forestry and Fisheries to a certain extent. The Ministry of Environment is responsible for the management of protected areas and for overseeing environmental protection. This includes protection of coral reefs, seagrasses, and mangroves, particularly when they occur in a protected area. This overlap does not seem to be problematic for managers on the ground, but requires legal clarification.

Ministry of Industry, Mines and Energy is responsible for management of industrial operations, including licensing and regulation of salt farming, oil and gas exploration, mining, quarrying and cement production, brewing, garment and shoe manufacturing, and small-scale industries such as iron-mongery and cabinet-making.

Ministry of Public Works and Transport is responsible for management of the Port of Sihanoukville, the ferries that run between Sihanoukville, Koh Sdach, Sre Ambel and Koh Kong, development of infrastructure, sewage and waste disposal, and main roads (not rural roads that are the responsibility of the Ministry of Rural Development).

Ministry of Rural Development is primarily responsible for assistance to the rural areas of the country. The Ministry and its provincial and district offices are responsible for rural water supply (wells), roads, community development, primary health care, credit schemes, small-scale irrigation and other community-level initiatives for furthering the welfare of rural communities.

Ministry of Tourism promotes and develops tourism in Cambodia, including all aspects of planning, legislation, and policy.

The provincial governors are highly influential in provincial areas. They control the budgets of provincial sectoral departments. It is very unclear how decision-making powers are divided between provincial and national decision-makers. It may depend on the personal power of the provincial governor compared with officials at the central government level. A draft Environmental Impact Assessment (EIA) Sub-decree is currently before the National Assembly (Nelson, 1999). This law will require all coastal developments to pass an EIA administered by the Ministry of Environment.

There is currently no mechanism for coordinating the operational activities of the different ministries in the coastal zone. In the future, coastal management may be managed through the National Steering Committee or through the Coastal Co-ordinating Unit of the Ministry of Environment, which is now trying to build its capacity through improvements to its facilities and equipment.

4.2 Management Policies and Guidelines

Broad guidelines for environmental management were outlined in the First 5-Year Socio-Economic Development Plan (1996 to 2000), which states clearly that the country lacks a coherent management structure for the sustainable use of the available natural resources. The plan identified seven key environmental issues, among which degradation of the coastal zone was included. The plan also indicates that coastal zone planning and local zoning and development plans should be developed for the coastal region. Local area management plans should target specific types of anticipated activities, such as aquaculture development, oil and gas production, or tourism resort development. The Ministry of Environment in conjunction with the Ministry of Public Works and Transport and the National Committee for Land Management, Urbanisation and Construction should conduct this planning.

The medium term goals of the government with respect to coastal zone management include:

- The development of a preliminary coastal zone master plan with delineation and zoning of critical sections of the coast;
- The development of local area management plans for areas of intensified activity;
- Definition of the institutional mechanisms for implementation of the plans; and
- Provision of local infrastructure and services. Regulatory surveillance by MoE, development of local institutions for the provision and maintenance of infrastructure, and compliance with environmental criteria and surveillance.

Other national policies with respect to CZM include the fisheries policy, or more specifically, the management of the marine fisheries in the country. The main points in this policy include:

- The creation of job opportunities and improved livelihoods for local communities;
- Equity in access to and distribution of benefits within the fisheries sector;
- The encouragement of integration of fisheries management within overall rural development in fishing communities;
- The extension of institutional responsibilities of fisheries management to the communities; and
- The enhancement of protection and sustainable use of the fisheries resources of Cambodia.

Industrial sector policy is also significant to coastal areas in that it can play a key role in determining whether coastal developments are undertaken in an environmentally-friendly manner or not. The main elements of the existing industrial policy include:

- Encouragement of industrial development that ensures political, economic and social stability;
- The development of an industrial base for the country that will maximise the use of existing natural resources, attract foreign investment, and promote technology transfer and human resource development;
- Provision of support to the Ministry of Education in the development of vocational training;
- Increased effectiveness, competitiveness, and modernisation in the free market economy;
- The creation of special economic zones to facilitate new industrial foundations;
- The social and economic development of the country through industries, value-added natural resource exploitation, sustainable economic development and job opportunities;
- Development of a petroleum training institute; and
- Development of agro-manufacturing and food processing industries.

Key policy initiatives within the tourism sector include:

- Increased foreign exchange earnings;
- Increased investment in all aspects of tourism;
- Employment creation;
- Increased regional development;
- Enhancement and preservation of national heritage; and
- Development and conservation of the physical and environmental resources in the coastal areas.

Of critical importance to CZM on environmental policy:

- The implementation of all national policy and programmes relating to the environment
- The protection of the environment from all economic development
- Conservation through the creation of protected areas
- The development of laws and sub-decrees with respect to environmental management, conservation, and protection
- The strengthening of existing laws and sub-decrees with respect to environmental management, conservation, and protection
- The preparation and implementation of national and regional environmental action plans through coordinating functions
- Ensuring sustainable development.

In addition to these general policy statements about the environment, the National Environmental Action Plan (NEAP) provides clearer guidance on specific policy issues. This plan was adopted by the Council of Ministers in 1997 and is meant to provide strategic guidance on key issues. It was developed through a participatory process.

The main points of concern to the coastal sector in the NEAP include the section addressing coastal fisheries management, biodiversity, and protected areas as they relate to coastal areas, energy development, and urban waste management.

Although most ministries have policies to cover their area of responsibility, it must be noted that in most cases these policies are extremely broad, do not reflect the reality of the capacity of the ministry in question to implement them, and may not reflect the legal situation.

5. MANAGEMENT PERSPECTIVES–THE DEVELOPMENT OF A NATIONAL SEAGRASS ACTION PLAN

The goal of the National Action Plan for Coral Reef and Seagrass Management in Cambodia is to protect and manage coral reefs and seagrasses to promote the balance between utilisation and conservation and ensure that the benefits of this sustainable use contribute to the reduction of poverty and improve the quality of life for all Cambodia.

Mission:

- To maintain coral reef and seagrass diversity and production through the protection of ecosystem integrity.
- To manage human activities and utilise coral reef and seagrass resources in a way that preserves the ability of these ecosystems to sustain and improve quality of life for Cambodians.
- To ensure that the benefits coming from the sustainable use of these resources contributes to poverty reduction and food security.

Aims and Objectives:

Awareness of the important roles, functions, and economic values of coral reef and seagrass ecosystems is low among most Cambodians. As a result, these ecosystems have been poorly studied and information about their contribution to quality of life in Cambodia is scarce. This makes the task of developing policies and plans for resource management difficult.

Important aspects in the management and utilisation of coral reef and seagrass resources include: conduct scientific research and monitoring; apply national policy, legal, and administrative frameworks; enhance public awareness, communication and educational programmes; build and maintain human capacity; and apply the management system. To achieve this goal, the National Action Plan has the following objectives:

a. Implement National Policy, Legal, and Administrative Frameworks.
b. Establish management models to ensure sustainable use of coral reefs and seagrass.
c. Establish research and monitoring facilities to monitor coral reef and seagrass status to support conservation and management.
d. Build cross-sectoral capacity for sustainable coral reef and seagrass management at national and local levels.
e. Increase awareness within communities of the ecological roles and economical values of coral reef and seagrass to realise the balance between utilisation and conservation of these resources.
f. Create financial sustainability and improve economic status of coastal communities.

6. CONCLUSION AND RECOMMENDATIONS

Based on a review of existing research results it is clear that Cambodia's inshore seagrasses are threatened by increasing human pressures. This pressure comes from a variety of activities, including foraging on seagrass beds, the use of trawl or motorised push nets by commercial fishers, and a wide range of natural events and human activities within the coastal zone.

The review of income levels in coastal areas indicates that most people are poor and rely on fishing as a primary source of income and food. Due to socio-economic circumstances, including low levels of general education in most coastal areas, some fishers employ destructive fishing methods and many glean seagrass beds for a variety of food and ornamental organisms.

There is still a lack of clear policies and regulations for seagrass management in Cambodia. The responsibilities of the Department of Fisheries and Department of Environment (DoE) overlap in all coastal provinces. This has created confusion amongst departmental staff about their roles and responsibilities in the management of these ecosystems.

This review highlights a need for research into the ecology and management of seagrasses in Cambodia's coastal zone. It is generally recommended that the following actions be carried out.

- Biological research on seagrass should be conducted throughout Cambodia's EEZ.
- Socio-economics surveys should be used to improve understanding of the value of the goods and services provided by seagrass ecosystems.
- Capacity of Cambodian marine scientists and managers should be developed.
- Public awareness and education programmes should be implemented at the community level. More attention must be paid to the development of farmer and fisher knowledge about the role seagrass ecosystems play in the maintenance of their livelihoods and food security.
- Policies and/or sub-decrees for coral reef and seagrass conservation and management should be developed and implemented as soon as is practicable.

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NATIONAL REPORT

on

Seagrass in the South China Sea

CHINA

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1. INTRODUCTION

Seagrasses are one of the most important ecosystems in the South China Sea (SCS). There are more than 50 species of seagrass in the world, with more than 20 species in the South China Sea. They are one of the three typical ecosystems of shallow seas. Seagrass can purify and improve water quality by means of decreasing suspended matter, absorbing excessive nutrients, and improving clarity of water. They provide habitats for many kinds of animals and act as a spawning field for various marine organisms, providing a valuable nursery for commercially important fish and crustaceans. Their dense roots can stabilise sediments and provide a natural seashore barrier against waves and tides. Additionally, seagrass beds play an important role in the C, N and P cycles (Fortes, 1998).

The importance of seagrasses has been poorly recognised for a long time, which has led to their worldwide depletion. There are many reasons for seagrass loss. However, effects of human activities, such as pollution, eutrophication, and sedimentation and land reclamation have played a major role.

In China, there are few research reports on seagrasses. The main reports include "The comprehensive investigation of the national shore and resources of beaches", "The comprehensive investigation of resources of national islands", and "The comprehensive investigation of Nansha Islands and its vicinity of sea regions". Currently, "The investigation of the ecosystems of the national shore" is being conducted. Other related research includes "The plant record of Nansha Islands and its vicinity inlands", "The plant record of the inshore islands of Hainan and Guangdong", "The comprehensive report on resources of islands of Guangdong", "The comprehensive investigation of the resources of Pearl River estuary's shore and beach", "The species and distribution of marine biology in China", and "The China plant record". There are some journal articles about seagrass in the South China Sea, including "Names and distributions of the plants in the South China Sea and its shore" (Singapore), "The primary studies about the distribution, productivity, structure, and function of seagrass in China", "Studies on the ecosystem of seagrass in China", "Studies on the geography of seagrass in China", "Studies on the classification of seagrass systems", "Conservation and management of Hong Kong seagrasses", "The research status about seagrass zoology in Hong Kong", and "Seasonal cycles of growth and reproduction in the seagrass *Zostera japonica* in Hong Kong".

Following publication of the research report entitled "Reversing Environmental Degradation Trends in the South China Sea and Gulf of Thailand – A Dissertation on the Seagrasses of China", a comprehensive programme was initiated to identify the species, distribution and environmental conditions of seagrasses in the South China Sea. This involved a field survey of the bays and estuaries of Guangdong, Guangxi, Hainan Island, and Hong Kong, including meetings with management organisations, fishers, residents, experts, and the analysis information obtained. The five seagrass beds of Liusha, Hepu, Pearl Bay, Li'an, and Xincun were chosen for the study. These beds have a diverse range of species and are easily managed and protected. The survey results include the physical, chemical, and the socio-economic environment of the seagrass beds, as well as seagrass biology and ecology (species, dwelling density, biomass, productivity, seagrass diversity, and rare species). Following this study, the Hepu and Li'an, seagrass beds were adopted as sites for scientific research on seagrass ecosystems in order to promote and advance research on the seagrass ecosystems in China. The aim was to establish a seagrass management system for China, and to promote seagrass protection and management. It is hoped that the above-mentioned work will reverse seagrass degradation trends in China's waters and the wider South China Sea area.

2. REVIEW OF NATIONAL DATA AND INFORMATION

Information was gathered from five seagrass beds located at Hepu, Pearl Bay (Guangxi), Liusha (Guangdong), Li'an, and Xincun (Hainan).

2.1 Geographical Distribution

Seagrass beds in Guangdong Province are located in Liusha Bay on the Leizhou Peninsula, Donghai Island in Zhanjiang, and Hailing Island in Yangjiang. The seagrass beds in Liusha Bay are continuous, with little or no space unoccupied by seagrass; *Halophila ovalis* covers more than 98% of the seagrass bed area.

In Guangxi, seagrasses are located in Hepu and Pearl Bay. The total area of seagrass in this area is 540ha, which is comprised of eight sites, namely Dianzhousha, Xialongwei, Beimu Salt-Field, Yingluo Bay, Danshuikou in Shatian, Shanliaojiuhejingdi, Gaoshatou, and the foot of Ronggen Hill. The area of seagrass at each site ranges from 20ha to 250ha. The substrate is predominantly composed of silt.

Seagrass beds in Hainan Province are located in Li'an Bay, Xincun Bay, Long Bay, and Sanya Bay. In Li'an Bay, seagrass is distributed around the lagoon in soft sediments *Enhalus acoroides* is the dominant species, whilst the total area of *Halophila ovalis* and *Halodule uninervis* accounts for less than 10% of the total seagrass area. In Xincun Bay, seagrass are most common in southern areas of the lagoon, and the most common seagrass species in the area is *Enhalus acoroides*. The total area of *Halodule uninervis* at this site is less than 8%. In Long Bay, seagrasses were observed in areas on the landward side of coral reefs, where the seafloor is mostly silt sand. The geographical distribution of seagrass beds on the South China Sea coast of China is highlighted in Table 1 and Figure 1.

Table 1 Geographical distribution of seagrass in the coastal waters of southern China.

Province	Seagrass bed name	Area (ha.)	Coordinate	Seagrass species
Guangdong	Liusha Bay seagrass bed, Guangdong	900	N20°26.75′ E109°57.83′	*Halophila ovalis*, *Halodule uninervis*
	Donghai Island seagrass bed, Zhanjiang	9	N 21°4.8′ E 110°18.6′	*Halophila beccarii*
	Hailing Island seagrass bed, Guangdong	1	N 21°38.4′ E111°52.2′	*Halophila ovalis*
Guangxi	Hepu seagrass bed, Guangxi	540	N 21°28.5′ E109°40.2′	*Halophila ovalis*, *Halodule uninervis*, *Zostera japonica*, *Halophila beccarii*
	Pearl Bay seagrass bed, Guangdong	150	N 21°36.1′ E108°12.7′	*Zostera japonica*, *Halophila beccarii*
Hainan	Li'an seagrass bed, Hainan	320	N 18°29.1′ E110°3.8′	*Enhalus acoroides*, *Thalassia hemperichii*, *Cymodocea rotundata*, *Halophila ovalis*, *Halodule uninervis*
	Xincun Bay seagrass bed, Hainan	200	N 18°24.1′ E 109°58.2′	*Enhalus acoroides*, *Thalassia hemperichii*, *Cymodocea rotundata*, *Halodule uninervis*
	Long Bay seagrass bed, Hainan	350	N 19°15.6′ E 110°39.0′	*Enhalus acoroides*, *Thalassia hemperichii* *Halophila ovalis*
	Sanya seagrass bed, Hainan	1	N 18°24.4′ E 109°22.2′	*Enhalus acoroides*, *Thalassia hemperichii*
Hong Kong (Fong, 1999)	Shenzhen Bay seagrass bed	--	N 18°28.2′ E 114°6′	*Zostera japonica*, *Halophila ovalis*
	Dapeng Bay seagrass bed	--	N 22°31.8′ E 114°16.2′	*Halophila beccarii*, *Ruppia maritime*

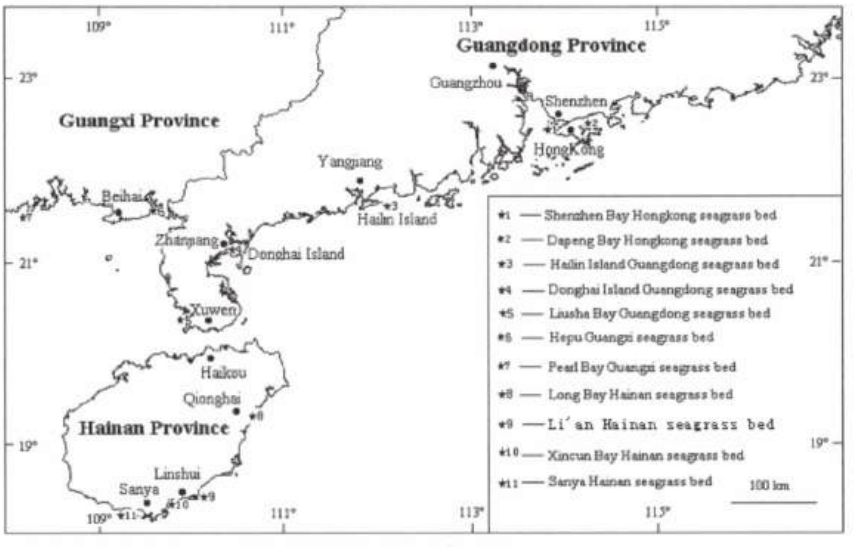

Figure 1 Seagrass distribution in the coastal waters of southern China.

2.2 Physical and Chemical Conditions

2.2.1 Hepu Seagrass Bed, Guangxi

2.2.1.1 Topography, Landform and Seafloor Type

The seagrass bed and the surrounding seafloor possess a complicated topography with deep troughs and sand ridges, belonging to a coastal region with a strong current (Forestry Survey and Design Institution of Guangxi, 2002; Chinese Bay Records Compilation Committee, 12th fascicule, 1993). Tidal currents and waves seriously erode the coast. The main topographical features of the area are tidal shoals, deep troughs caused by tidal currents, sand ridges, and seafloor plains.

Tidal shoals are located along the coasts of Shatian, Shaweinan, Wuninan and Yingluo Port. The shoals are normally 1 to 1.5km wide, although they are 4km wide at Shaweinan and Wuninan. They can be divided into sandy beach, silty beach, and sandy silt beach according to their sediment compositions. Sandy beaches extend from Shatian to Wuni. Sandy silt beach is observed in the low-tide zone of Shawei and Dianzhousha, mid to low-tide zones of Danshuikou, Yingluo Bay, and Beimu Salt-Works, and sub-tide zones on the western side of Gaoshatou and Wangliusha. Mangrove beach is observed in Yingluo Bay and the high-tide zone of the Dandou Sea. Seafloor plains are observed in the mouth of Tieshan Bay, where water depth is more than 10m. The seafloor is smooth and wide, and the sediments are composed mainly of sandy silt.

2.2.1.2 Sediment Characteristics

There are five sediment types in the seagrass beds at Hepu: coarse sand, medium size coarse sand, medium sized fine sand, fine sand, and clay sand. Sediments at this site are mainly fine-medium size, and are distributed on both sides of deep troughs in Tieshan Bay. Sediments are mostly yellow or brown colour, and are comprised mainly of shellfish detritus and whole shellfish. Intertidal beaches from the mouth of the Dandou Sea to the southeast side of Shatian Bay and to the western coast of the Beimu Salt-Works are comprised of sand (88.4-99.5%), gravel (2.83%), and silt (0.34%).

Soft sediments are primarily observed at the high-tide zone and on tidal current sand ridges from Wuni to Shatian. They are grey or greyish yellow in colour, and comprised mainly of fine sand and plant detritus. Sand, gravel, and silt account for 90.54%, 1%, and 1.6%, respectively, and contains a high quantity of shellfish detritus and live shellfish. The seafloor of the intertidal to nearshore zones of Yingluo Bay and Shatian Bay are comprised mostly of soft sediments. Sediments in this area are comprised of medium-fine grained sand (85%), coarse sand and fine gravel (10%), and clay (5%). This mix of sediments appears to be highly suitable for seagrass growth.

2.2.1.3 Weather and Climate

Air temperatures of the surveyed area are characterised by a temperature difference of only 13.8°C. Average air temperature in the Hepu is 22.9°C, while the highest and lowest temperatures recorded are 38.2°C and 1.5°C, respectively. There are no frosts and average rainfall is 1573.4mm. The rainfall in a summer half year, and a winter half year, accounts on average for 83.4% and 16.6% of the rainfall in the whole year, respectively. There are on average 144 rainy days per year at Hepu. There is typically less rainfall and fewer rainy days a year in Hepu than in other coastal areas of Guangxi.

The yearly average number of hours with clear sky and sunshine is 1,766.7, with an average sunshine frequency of 39.2% between dusk and dawn. The month with most sunshine is July (215.1 hours), and the month with the least is February (63.6 hours). The maximum and minimum relative humidity is 84.5% (March to April) and 71.6% (November), respectively. Yearly average relative humidity is 79.9%. The maximum and minimum evaporation capacities are 210.1mm (July) and 85.1mm (February). Yearly average evaporation capacity is 124.3mm.

2.2.1.4 Ocean Hydrology

The highest high tide level is 4.33m and the lowest low tide level is -2.75m. Average high and low tide level is 1.62m and -0.91m, respectively. The average tide range is 2.53m, with a maximum of 6.25m. The site is characterised of large tidal ranges. Tidal range is most significant during summer. Due to the influence of land, tidal range decreases gradually from the mouth of bay to the inner bay. The duration of flood ebb tides differ, with flood tides typically being longer than ebb tides. The average period between high tides and low tides are 6.10 and 12.41 hours, respectively.

The direction of the tidal current is the same as the direction of the deep trough in the surveyed area. The current at the mouth of the bay is NNE during flood tide and SSW during ebb tide. However, at the top of the bay it is NNW during flood tide and SSE during ebb tide. The maximum velocity of the flood tide current is about 60cm/s, approximately 2 to 4 hours before the high tide. The maximum ebb tide velocity is 70cm/s, appearing 4 to 6 hours after high tide. Velocity at the surface layer is about 10cm/s faster than that observed at the bottom layer, although their directions are the same. The tide in the surveyed area is characterised by an alternating current. The velocity of the residual current is smaller in the surveyed area, with greatest speeds observed at the mouth of the bay. The surface layer's velocity is 13cm/s in winter and 10.3cm/s in summer, and does not exceed 10cm/s in other regions.

From the middle of the bay to the top of the bay, the direction of the residual current is SSW in summer and WNW in winter. From the mouth of the bay to offshore waters, the direction of the residual current is SSW in summer and W or SE in winter. Current directions of surface layers change remarkably, with opposite current directions occurring in a few areas, especially where the direction of the surface layer is 180° opposite to that of the bottom layer current.

According to weather statistics, the prevailing and stronger wind comes from the north. Similarly, the strongest and prevailing waves in the area come from the north. The prevailing waves from September to March are from the north, but are primarily from the SW to SE from April to August. The maximum wave height at the mouth of Tieshan Bay is 3.2m from the S to SSW direction. The minimum wave height is 0.65m from the NE to ENE. In the inner of the bay, the maximum wave height is 3.41m from the S to SSW. The minimum wave height is 0.18m, from the N to NNE. At the mouth of Tieshan Bay, the average maximum and minimum wave periods are 6.4s and 2.9s, respectively, from the S to SSW and NE to ENE, respectively. In the inner of the bay, the average maximum and minimum wave periods are 6.7s and 1.5s, respectively, and from the S to SSW and the N to NNE, respectively.

According to statistical data, the annual average seawater temperature is 23.49°C. The extreme highest temperature is 34.4°C (15 July 1969), and the extreme lowest temperature is 8.4°C (5 February 1969) in the inner of the bay. Seawater temperature is higher in summer than in winter. The highest average seawater temperatures occur during July (29.45°C) and August (29.21°C). The lowest seawater temperatures occur during January (15.65°C) and February (15.91°C). Seawater temperature rises from March to June at approximately 3.34°C/month. It declines from August to January, and has been observed to drop at 4.99°C/month during November and December.

Seawater salinity is higher in offshore areas than those inshore. Salinity ranges from 26 to 31% at the mouth of the bay and 20 to 28% at the top of the bay. The main factors that influence salinity are rainfall and inshore surface waters. Average salinity in summer (22%) is lower than in other seasons, largely due to high rainfall. Maximum and minimum salinity is observed during maximum high tides or minimum low tides, respectively. Salinity ranges are larger in surface layers than bottom layers.

2.2.1.5 Quality of Seawater

Seawater quality in seagrass areas is highlighted in Table 2. The monitoring results indicated that the seawater quality in Yingluo Bay aligned with the first grade seawater quality standards. In Tieshan Bay, all parametres, except DO and oils, aligned with primary standards of seawater quality.

Table 2 Seawater quality of seagrass areas in Hepu, Guangxi Unit: mg/L (except for pH and salinity).

Item	Maximum	Minimum	Average	Standard of Evaluation	Overproof Percentage (%)
pH	8.14	7.98	8.06	7.8-8.5	0
Salinity %	30.1	23.5	28.4	-	-
Suspended substance	19	4	12	-	-
Dissolved oxygen	8.4	5.8	7.0	6.0	11.6
Active phosphate	0.007	0.0005d	0.005	0.015	0
Inorganic nitrogen	0.155	0.010	0.036	0.20	0
COD	1.38	0.25	0.64	2.0	0
BOD	1.0d	1.0d	1	1.0	0
Oils	0.10	0.025d	0.04	0.05	25.0
Cu	0.008	0.0005d	0.001	0.005	8.3
Pb	0.0012	0.0003	0.0005	0.001	8.3
Cd	0.0005d	0.0005d	0.0005	0.001	0
Hg	0.00007	0.00002d	0.00003	0.00005	8.3
As	0.0085	0.0008	0.0050	0.020	0
Total Cr	0.005	0.002d	0.002	0.005	0

Remark: *data with "d" in the table indicates that it is half of the detection limit.*

2.2.2 Li'an Seagrass Bed

2.2.2.1 Landform and Sediment Type

The geomorphology of the seafloor is simple in Li'an Bay. Essentially, it is a shallow sea lagoon with a maximum depth of 7.4 metres (Chinese Bay Records Compilation Committee, 11th fascicule, 1993). Bottom sediments are mainly silt in inshore areas and sand at the bay mouth.

2.2.2.2 Weather and Climate

Air temperature is high throughout the year in Li'an Bay, the minimum air temperature observed is 5°C, while the average air temperature is 19°C in January (Chinese Bay Records Compilation Committee, 11th fascicule, 1993). There are no frosts or cold fogs, and the area receives plentiful rainfall from a long rainy season. However, typhoons occur frequently, causing heavy rainstorms and variable weather and climate conditions.

The average air temperatures during winter and summer are 24.7°C and 37°C, respectively. The maximum and minimum temperatures occur in July and January, respectively. There are many continuous rainy days, normally more than 5 days each month, and more than 20 days in August and September. Yearly rainfall amounts to 1653.54mm. There are 7.5 days per year on average that record a rainfall of more than 50mm.

There are only a few days with fog each year. Although fog appears every month, it occurs only for short durations. The average sunshine is 7 hours each day. Yearly mean wind speed is 2.4m/s in the bay. The maximum wind speed is 28m/s, occurring in November from the ENE direction. The maximum yearly mean wind speed is 3.4m/s. Gales with a speed greater or equal to eighth grade occur mainly from July to November. The prevailing wind direction is from the north in winter and from the south in summer.

A northeast gale with speed of more than 30m/s occurs, couple with a storm tide, whenever a typhoon lands. There are more than 80 days with thunderstorms each year.

2.2.2.3 Marine Hydrology

Li'an Bay is located at the southeast of Hainan Island. The tide is caused by the Pacific wave passing through Bashi Channel, and it is an irregular mixed tide that tends to mainly be diurnal. About seven days in half a month experience a diurnal tide, and the other days are in irregular semi-diurnal tide. During the diurnal tide period, both high tide and low tide appear once, the flood lasts 15 hours and ebb lasts 9 hours. The maximum and mean tidal range is 1.55m and 0.68m, respectively. The maximum and minimum tide level is 1.89m and 0.21m, respectively, and the yearly mean range is only 1.68m.

The tidal current at Li'an is an alternating mixed tidal current, but mainly diurnal tide, and flows along the coastline in a northerly direction during the flood tide and to the south during the ebb tide.

Mean seawater temperature outside the mouth of Li'an Bay is 23.85°C in April and 30.2°C in August. Annual mean salinity of Li'an bay is 33.9%, with 33.52% in April and 34.08% in August.

2.2.2.4 Water Quality

All the values of water quality parametres do not exceed first class Chinese Sea water quality standards (Table 3). Water quality in this area is good.

Table 3 Water quality of Li'an Bay (mg/L).

Item	Cu	Pb	Cd	Hg	As	DIN	DIP
Concentration	0.0005	0.00008	0.0005	0.00005	0.0032	0.005	0.009
Evaluation standard (first class)	0.005	0.001	0.001	0.00005	0.020	0.20	0.015

2.2.3 Xincun Seagrass Bed, Hainan

2.2.3.1 Landform and Sediment Type

The seabed of Xincun Bay is featureless. It is a shallow lagoon basin, mainly including troughs eroded by tidal currents, a tide current delta, and an underwater plain.

2.2.3.2 Weather and Climate

Climatic conditions at Xincun Bay are almost identical to those of Li'an Bay described above.

2.2.3.3 Marine Hydrology

Xincun bay has the same tide type as that at Li'an Bay. It is not repeated here. No information about tidal currents at Xincun Bay is available, although limited observations have been taken from 3 stations at the mouth. The ocean current at these sites is an alternating mixed tidal current, but mainly of a diurnal tide. The current flows along the coastline. It flows easterly during the flood tide and westerly during the ebb tide.

The current speed on the northern side of the bay mouth is faster during flood tide than during ebb tide. The maximum flood and ebb speeds in surface layers are 120 to 130cm/s and 90 to 110cm/s, respectively. The maximum ebb and flood speed on the southern side of the bay mouth are 100cm/s and 55cm/s, respectively. Current speed during ebb tide is larger than that during flood tide, with the range being 10 to 16cm/s.

Residual current of the sea area concerned is generally minimal, although is larger in southern parts of the bay than its northern and central parts. Its direction is ES in the north of the bay, S to ES in the mid-bay, and W in the south of the bay. The speed of the residual current is 9 to 17cm/s north of the bay mouth, 4 to 9cm/s in mid-bay areas, and 11 to 26cm/s in southern bay areas.

Northeast gales and breezes prevail in the area. However, due to geographical conditions and the aspect of the bay mouth, gales inside the bay cannot produce larger waves. Swells from the south occur inside the bay after large waves at sea enter the bay. The highest and longest waves are all from the south. The maximum wave height is 2.2m, occurring in July or August. The annual average wave height is 0.4m.

At the intertidal zone of Xincun Bay, average water temperature is 26.25°C in October and 30°C in March. At the external sea area of the bay mouth, average seawater temperature is 23.75°C in April

and 30°C in August. Average salinity in Xincun Bay is 33.74%, ranging from 33.52% in April to 34.08% in August.

2.2.3.4 Seawater and Sediment Quality

Seawater quality is highlighted in Table 4. The field survey result indicates that the sea water quality of Xincun Bay is good comparing to the Chinese Sea water quality standard (first class).

Table 4 Water quality in Xincun Bay.

Items / Time	DO (mg/L)	COD (mg/L)	Total Hg (μg/L)	Cu (μg/L)	Cd (μg/L)
October	6.93	1.58	0.0075	19	0.3
March	7.34	0.84	--	1.7	1.7
Evaluation standard (first class)	>6.0	2.0	0.05	5.0	1.0

Sediment quality data is highlighted in Table 5. Concentrations of sulfide, Hg, and DDT are high comparing to the first class of Chinese Marine sediment quality, which may be caused by the sewage and the usage of pesticide in agriculture.

Table 5 Sediment quality of Xincun Bay (mg/kg).

Item	Hg	Cu	Pb	Zn	Cd	DDT	Sulfide	As	Cr	Oils
Concentration	0.021	16.0	26.0	97.0	0.08	0.0028	573	8.97	68.0	21.3
Evaluation standard (first class)	0.20	35.0	60.0	150.0	0.50	0.02	300.0	20.0	80.0	500.0

2.2.4 Liusha Seagrass Bed, Guangdong

2.2.4.1 Weather and Climate

The area is located to the south of the Tropic of Cancer and is characterised by long periods of sunshine and strong radiation, a long summer and no winter, and high air temperatures throughout the year. Wind direction varies on a seasonal basis in response to the effects of the monsoon current.

The annually average air temperature is about 23°C. The monthly maximum air temperature is 28.5°C in July, and the minimum temperature is above 15.5°C in January and February. Not less than 350 days have a daily average air temperature of more than 10°C.

The total yearly rainfall amounts to 1,300 to 1,500mm, of which about 90% occurs from April to October. Total sunshine is 2,200 hours a year. Annual sun radiant energy amounts to 1,293kW·h/m^2. The sun radiant energy may be 150kW·h/m^2 in August.

There are obvious seasonal changes in wind direction. The prevalent winds are from the northeast and east in winter (October to March), and from the southeast to east and south in summer (May to August). Yearly average wind speed is approximately 5.0m/s. There are approximately 15 days of gales a year.

Tropical cyclones influence ocean areas from May to November, especially from July to September. There are 1 to 3 (sometimes 4) tropical cyclones from July to September. Rainfall mostly occurs in summer because of the influence of the monsoon.

2.2.4.2 Marine Hydrology

The tide of Liusha Bay is caused by the Pacific tidal current as it passes through Bashi Channel, which then flows into the South China Sea. It is an irregular semidiurnal tide. It is characterised by two flood tides and two ebb tides in a day. The average tidal range is 2.0 to 2.5m, and the maximum tide range is more than 5.0m. The tidal range between monthly maximum and minimum averages is 0.15 to 0.20m. The tide range is maximal during the syzygial tide.

The ocean current of the area is driven by a semidiurnal tide. It alternates its direction from NW to S during the year. Maximum current velocity ranges from 18 to 108cm/s.

Prevailing wind direction is southeast in spring, and the direction of the residual current is northwest. The residual current is stronger in the surface layer than in the bottom layer. Residual currents are southerly in the surface layer and northerly in the bottom layer. The speed of the residual current, it is 7.7 to 19.7cm/s in the surface layer, and 4.2 to 7.9cm/s in the bottom layer.

The dominating wave is a storm wave. Its direction is SE from May to August, ENE from October to March, and E from April to September. The swell has the same direction as that of the storm wave. The wave direction is mainly ENE, accounting for 20.8% of waves throughout the year, followed by SE, which accounts for 17.1%.

Yearly average wave height is 0.9m. It changes noticeably with the seasons. Average wave height is 0.6 to 0.7m from May to August, and 1.0 to 1.2m from October to March. The maximum and minimum monthly average wave heights occur in November and August, respectively. Average wave period is 3.6 seconds. The annual variation of average wave periods shows the same trend as that of the average wave height. The average period ranges from 3.2 to 3.3s in summer, and from 3.7 to 4.1s in winter. The monthly average maximum and minimum periods occur in November and August, respectively.

Suspended silt and sand comes from river conveyed sands, sea area conveyed sands, and coast conveyed sands. The Jian River, one of the largest rivers in the west of Guangdong Province, pours into this sea area and is the main source of silt and sand. Wave action lifts sands from the sandy coast and bottom sand piles.

Seawater temperature is 25.25°C at the surface layer and 22°C at the bottom layer in spring. In autumn, distribution of seawater temperature is homogeneous at the surface and bottom layers. It is 26.07°C to 26.97°C in the surface layer, and 26.01°C to 26.82°C in the bottom layer. Seawater temperature changes slowly, with the lowest seawater temperature in February and the highest seawater temperatures in July and August. The highest seawater temperature is 34.6°C, and the lowest is 11.9°C.

Seawater salinity is 30.51 to 31.84% in the surface layer, and 30.61 to 31.06% in the bottom layer in spring. Surface and below seawater salinities are 26.03 to 28.83%, and 26.73 to 29.35%, respectively, in autumn. There are two highs and two lows of yearly salinity variation, the first high appears in January to February and the second high appears in July to August. The first low appears in June and the second low appears in September to October. All of these changes are relative to seawater evaporation and rainfall. The highest and lowest salinity is 34.44% and 10.72%, respectively.

2.2.4.3 Seawater and Sediment Quality

In spring, concentration of DO is 7.33 to 8.50mg/L at the surface layer and 6.92 to 8.39mg/L at the bottom layer. In autumn, it is 6.54 to 7.32mg/L at the surface layer and 6.36 to 7.32mg/L at the bottom layer. Concentrations of DO and oxygen saturation are 0.19mg/L and 3%, respectively, in spring, and are 0.19mg/L and 3%, respectively, in autumn. Vertical variation is low.

In spring, pH ranges from 8.14 to 8.21mg/L at the surface layer, and 8.13 to 8.22mg/L at the bottom layer. In autumn, pH ranges from 8.13 to 8.32mg/L at the surface layer, and 8.14 to 8.33mg/L at the bottom layer. The average concentration of active PO_4^{3-}-P is 0.50μmol/L in spring and 0.84μmol/L in autumn. Concentration of PO_4^{3-}-P is higher at the surface layer than at the bottom layer in spring, but is the opposite in autumn.

The range of concentrations of NO_3^--N is 0.00 to 1.50μmol/L at the surface layer, and 0.00 to 2.81μmol/L at the bottom layer in spring. It is 0.40 to 4.03μmol/L at the surface layer, and 0.03 to 3.43μmol/L at the bottom layer in autumn. Most of the sediment quality parametres are lower than first class of Chinese Marine sediment quality except Hg, Cd, and organic matters.

2.3 Biological Resources of Seagrass

2.3.1 Seagrass Resources

Marine plants are primary producers and form an elementary part of the food chain. These plants perform photosynthesis to produce energy that drives detritus-based food chains, and is consumed directly by grazing animals such as fish, turtles, and dugongs.

Seagrass, mangrove swamps and coral reefs are ecological systems with high biodiversity and productivity. However, seagrass ecosystems have been neglected in most parts of the world, including China. Only in recent years have seagrass beds been regarded as important marine ecosystems that provide a range of essential goods and services. Many species rely solely or partly on seagrass for food and protection, and further degradation of seagrass areas will likely cause further declines in the distribution and abundance of marine animals.

2.3.1.1 Hepu, Guangxi

The species and growth characteristics of seagrass

The two main species observed in this area are *Halodule uninervis* (Potamogetonaceae) and *Halophila ovalis* (Hydrocharitoceae). *Zostera japonica* (Potamogetonaceae) was discovered in an intertidal area of Shanliao in June 2001.

There are at least four species living between Yingluo Bay and Yingpan. These are *Halodule uninervis, Halophila ovalis, Halophila beccarii,* and *Zostera japonica.*

Halodule uninervis and *Halophila ovalis* exhibit different growth characteristics. *Halodule uninervis* grows throughout the year without clear seasonal changes. Its rhizome root system buries firmly in sandy substrates, with leaves shooting regularly. The growth of *Halodule uninervis* flourishes from March to April. At this time, pairs of leaves are visible over bottom sands, but *Halodule uninervis* is buried under the sand at most other times. *Halophila ovalis* sprouts from November to February and flourishes from March to June. During this time, its shape is clearly observable. It is difficult to locate *Halophila ovalis* after July because of its dying and yellow leaves. Its leaves gradually become yellow from July to October until the roots begin to sprout and grow from November.

Halodule uninervis and *Halophila ovalis* grow on intertidal beaches from the middle to low tidal zone, and are occasionally located on muddy subtidal substrates. Both species form single-species beds, although are capable of forming a part of a multispecies bed. *Halophila ovalis* can sprout and grow in areas of subtidal zones to a depth of 5 metres, whilst *Halodule uninervis* is rarely observed in the subtidal zone. Both of them become submerged during flood tides (Oceanology Institution of Guangxi, 1987).

The growth characteristics of *Zostera japonica* in this region are unclear, highlighting a need for more research work in this area. The distribution of seagrasses in Hepu, Guangxi is highlighted in Figure 2.

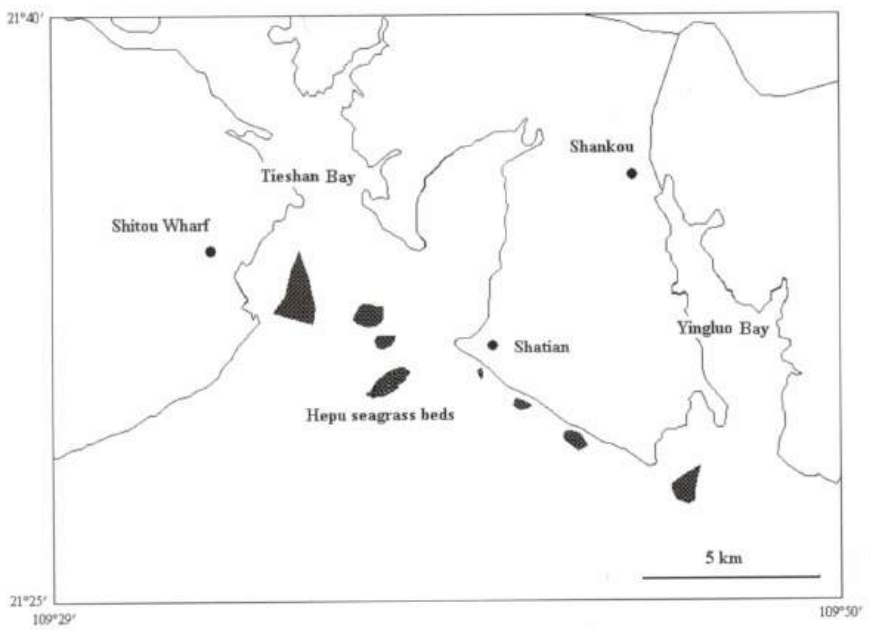

Figure 2 Seagrass distribution in Hepu, Guangxi.

Generally, seagrass growth is most rapid during spring and summer, with larger beds being observed during these times. Table 6 shows the seagrass growth variation by seasons in Hepu.

Table 6 Annual variation of seagrass area in eight sites of Hepu, Guangxi (hectares).

Survey time / Seagrass bed name	1987 (Spring)	1994 (Autumn)	1999 (Winter)	2000 (Summer)	2001 (Summer)	2002 (Spring)	2002 (Summer)
Dianzhousha	200.0	20.0	13.3	133.3	14.3	27.8	96.9
Beimu Salt-Field	46.7	16.7	10.0	30.0	5.3	62.0	239.5
Yingluo Bay	66.7	133.3	33.3	12.0	0.1	49.3	Unclear
Outdoor of Yingluo Bay	Unclear	133.3	1.3	20.0	3.3	Unclear	96.7
Danshuikou	Unclear	46.7	2.7	2.0	0.1	8.7	18.5
Shanliaojiuhejingdi	Unclear	26.7	13.3	33.3	193.0	51.4	59.9
Gaoshatou	Unclear	33.3	13.3	133.3	0.2	Unclear	Unclear
Foot of Ronggen Hill	-	-	-	-	13.3	3.4	27.6
Total		**410.0**	**87.3**	**364.0**	**229.6**	**202.6**	**539.1**

At Dianzhousha, 23 *Halophila ovalis* samples of 50cm × 50cm area were collected. Average wet weight of each sample was 202g/m^2, biomass was 25.5g/m^2, average dwelling density was 1,385 shoots/m^2, and the coverage was 79.5%.

2.3.1.2 Pearl Port, Guangxi

The average biomass was 66.4g/m^2, average cover was 52.2%, and average dwelling density was 1940 shoots/m^2. Seagrass distribution of Pearl Bay is shown in Figure 3.

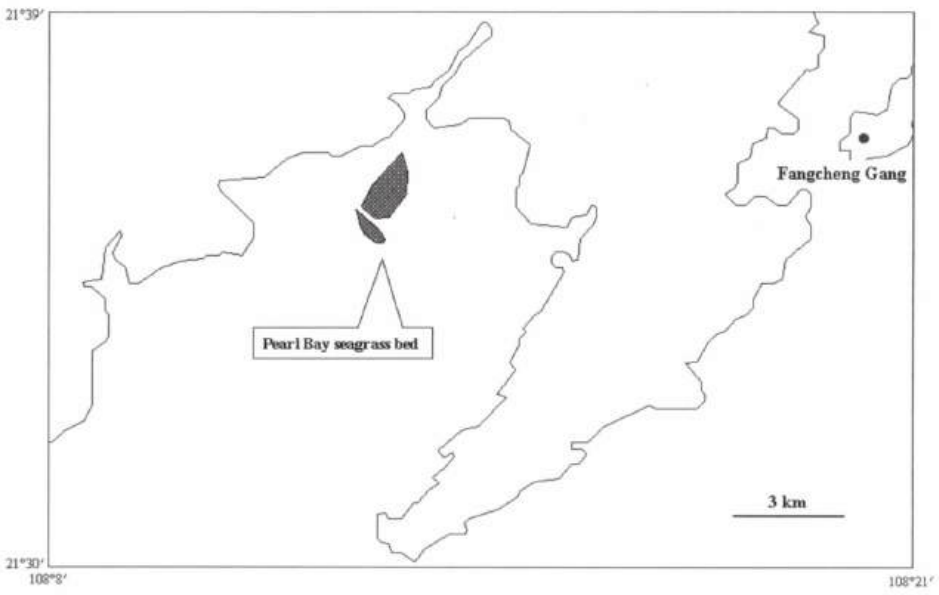

Figure 3 The distribution of seagrass in Pearl Port.

2.3.1.3 Li'an, Hainan

The distribution of seagrass in Li'an is shown in Figure 4 and listed in Table 7.

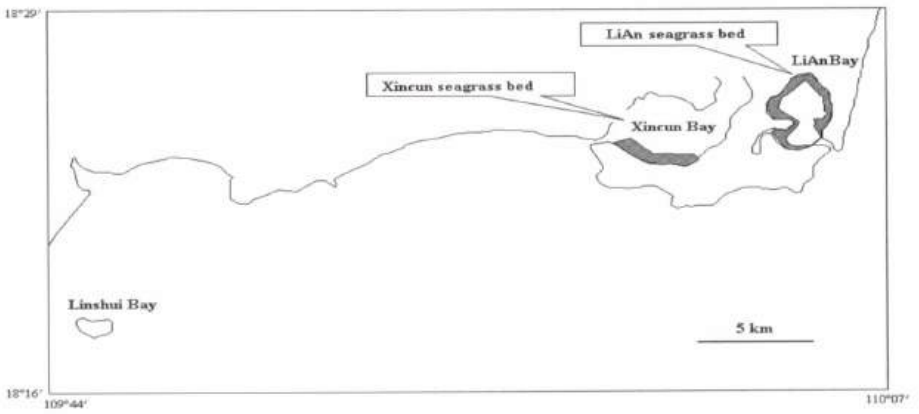

Figure 4 The distribution of seagrass at Li'an and Xincun.

Table 7 Biomass and productivity of seagrasses in Li'an.

Species	Biomass (g/m^2)	Wet Weight (g/m^2)	Dwelling Density ($shoots/m^2$)	Shoots Productivity (mg/shoot/hr)	Seagrass Productivity ($mg/m^2/d$)	Percentage of Seagrass (%)	Average Productivity ($mg/m^2/d$)
Enhalus acoroides	1,094.8	4,660	66	0.5769	913.810	25%	2,466.717
Thalassia hemperichii	1,146.8	11,357	1,508	0.112539	4,073.011	30%	
Cymodocea rotundata	365.3	2,041	2,027	0.059692	2,903.896	35%	
Halodule uninervis	225.3	900	--	--	--	7%	
Halophila ovalis	52.8	416	--	--	--	3%	

2.3.1.4 Xincun, Hainan

Four species of seagrass were observed in Xincun, namely *Enhalus acoroides, Thalassia hemperichii, Cymodocea rotundata,* and *Halodule uninervis.* Five samples were collected for *Enhalus acoroides, Halodule uninervis,* and *Cymodocea rotundata.* Table 8 summarises the results.

Table 8 Biomass and productivity of seagrasses in Xincun.

Species	*Enhalus acoroides*	*Thalassia hemperichii*	*Cymodocea rotundata*
Biomass (g/m^2)	1,934.4	816.0	652.8
Dwelling density ($shoots/m^2$)	112	1024	2491
Shoot productivity (mg/shoot/hr)	0.5769	0.112539	0.059692
Seagrass productivity ($mg/m^2/d$)	1,550.7	2,765.8	3,568.6
Percentage in seagrass bed	30%	20%	40%

2.3.1.5 Liusha, Guangdong

The two species of *Halophila ovalis* and *Halodule uninervis* were observed at this site. The total area of seagrass beds was 900ha at E 109°57'6"- N 20°26'6" (Figure 5). *Halophila ovalis* grew densely, while *Halodule uninervis* was relative sparse. There was an abundance of seagrass-associated marine animals.

Fifteen samples of *Halophila ovalis* were taken from single species areas, while two samples of *Halophila ovalis* and *Halodule uninervis* were obtained from mixed species beds. The average biomass and the wet weights of *Halophila ovalis* were $25.7g/m^2$ and $189.5g/m^2$, respectively. Its productivity was 0.011424mg/shoot/hr. The productivity of *Halophila ovalis* was $1,633.541mg/m^2/d$. The proportion of *Halophila ovalis* in the seagrass bed was 98%. The average productivity of the seagrass bed was $1,600mg/m^2/d$, and the biomass and the wet weights of *Halodule uninervis* were $18.8g/m^2$ and $92.7g/m^2$, respectively.

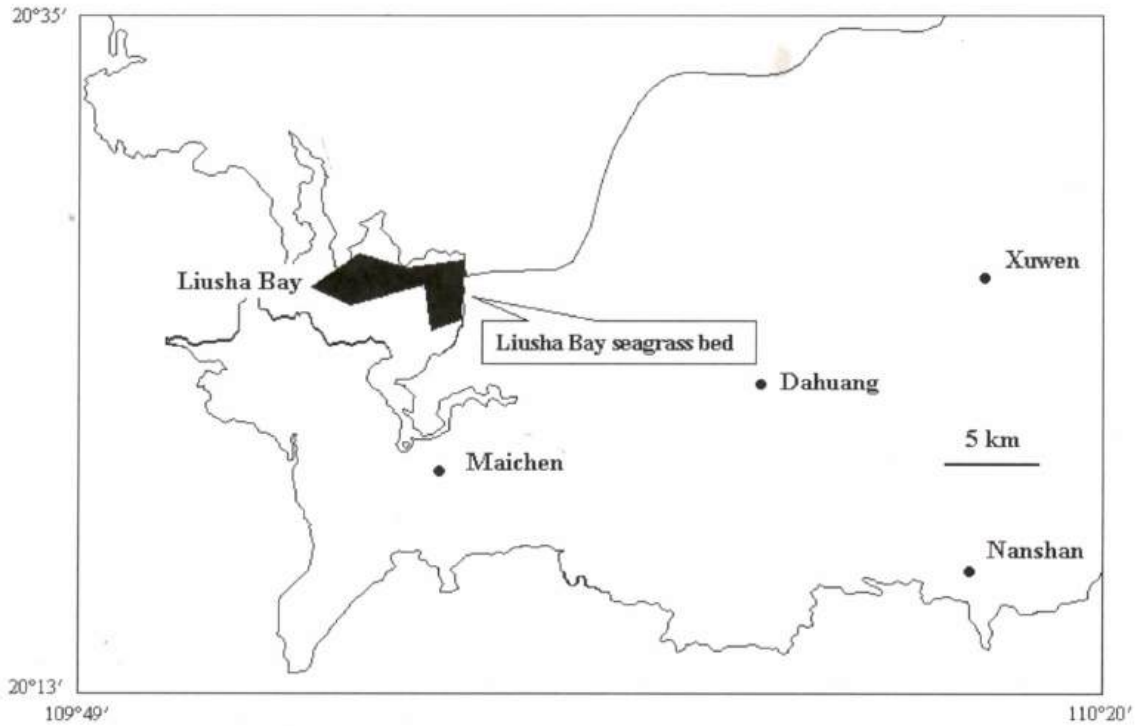

Figure 5 Distribution of seagrasses at Liusha.

2.3.2 *Marine Biota in Seagrass Beds*

2.3.2.1 Hepu, Guangxi

Mud-dwelling Benthos

The average biomass of mud-dwelling benthos in seagrass beds at Hepu was 70.20g/m^2, and the average dwelling density was 223.2ind/m^2. Table 9 shows the biota in seagrass beds of Hepu.

Table 9 Marine biota in seagrass beds at Hepu, Guangxi.

Type	Dwelling density (ind/m^2)	Species	Distribution	Remark
Prawn	2.0	*Penaeus penicillatus, Penaeus japonicus, Metapeenaeus burkeroadi, M. affinis, Metapenaeus ensis*	--	--
Gastropod	200	*Cerithidea cingalata, Thais gradadta, Nerita japonica, Turriteila bacillum*	--	--
Sipunculus	5	--	Widely distributed in sandy intertidal zone	Another name is sandworms
Phascolosoma esciilenta	--	--	Distributed in the sand-mud intertidal zone, especially in mangroves	Another name is niding, which is one of the important fishing organisms of coastal people as well as sand worms.
Pinctata martens	2.68	--	--	The distribution of dominant species significantly reduced due to overfishing since 1964
Meretrix meretrix	--	--	Inhabit sandy or mud-sandy beaches in the intertidal zones or shallow waters below tidal zones	--
Other organisms	--	*Astropecten kagoshimensis, Siganus oramin, Sparus macrocephalus*	--	--

Molluscs had the highest biomass of the mud-dwelling benthos, accounting for 77.2%. The proportional total biomass for other species was 7.9% for polychaetes, 6.4% for echinoderms, 5.4% for coelenterates, 1.7% for crustaceans, 0.5% for others, 0.4% for chordate, and 0.3% for *Siphonsoma*.

There are 60 species of mud-dwelling benthos in seagrass beds in Hepu, of which 24 species are polychaetes and 23 are molluscs. Analysis of species dominance indicates that the dominant mud-dwelling benthos species are *Haploscoloplos elongates, Notomastus latericeus, Notomastus aberans, Periglypta reticulate, Moerella rutila,* and *Branchiostoma belcheri.*

A certain amount of *Branchiostoma belcheri* appears in the mud-dwelling samples of the Hepu seagrass beds. The biomass and dwelling density of *Branchiostoma belcheri* in the Hepu seagrass ranged from 0.12 to 0.96g/m^2 and 8 to 44ind/m^2, respectively. Analyses indicate that the average biodiversity index of mud-dwelling benthos in Hepu seagrass beds was 3.07. The average species evenness was 0.77.

Trawl Net Benthos

The average biomass of trawl net benthos was 0.162g/m^2, while the average dwelling density was 0.055ind/m^2. For trawl net sites, molluscs, and crustaceans or coelenterates, molluscs and crustaceans had the highest dwelling densities.

There were 28 different species of benthos retained in trawl nets used in seagrass beds at Hepu, of which 22 were species of trawl net benthos and 6 species of qualitative samples. Based on the number of species of each group, molluscs and crustaceans were the main groups retained in trawl nets operated over the Dianzhousha seagrass bed. *Balanus reticulatus, Thais mutabilis, Talonostrea talonata, Archaster typicus, Scapharca gubernaculum*, and *Siphopatella walshi* dominated the trawl net benthos.

Biodiversity Index and Evenness

Special concern should be given to prawn, siganids, starfish, echinoid, and holothurian living in the seagrass beds. Nine species of prawn, holothurian, starfish, and echinoid were obtained from Hepu seagrass beds by different sampling methods. The results are as follows: two species of holothurian in frame sampling samples, and four species of holothurian, starfish, and echinoid in trawling samples. The nine benthic species were *Metapenaeus ensis, Metapenaeus intermedius, Penaeus (Marsupenaeus) japonicus, Pentacta anceps, Phyrella fragilis, Holothuria scabra, Astropecten monacanthus, Archaster typicus*, and *Arachnoides placenta.*

The biomass of samples by different sampling method changes remarkably. The biomass of samples from quadrat and transect sampling is usually higher than that of the trawl sampling method. There are seven families, nine orders, and nine species of mangrove in the survey area. Mangroves are mainly observed adjacent to the beaches of Yingluo Port, the Dandou Sea, Laoya Port-Eqingdun, Hetangling, and north of the Beimu Salt-flat. The largest areas of mangroves are present at Yingluo Port (220ha) and along the coast of the Dandou Sea (510ha). The other areas contain mangrove areas from 30 to several hundred hectares.

Rare Marine Animals

Eight species belonging to two orders of four families have been observed, including *Dugong dugong, Souca chinensis, Delphinus delphis, Neophocaena phocaenoides, Balaenptera edeni, Balaen potera, Tursiops truncates*, and *Lagenorhynchus obliquidens.*

2.3.2.2 Pearl Port

The average biomass and dwelling density of benthos in seagrass beds at Pearl Port was 118.81g/m^2 and 397.8ind/m^2, respectively. The proportional contribution of molluscs to total benthic biomass was 93.4% and 4.2% for echinoderms, 1.7% for crustaceans, and 0.3% for polychaetes and fish. Survey results indicate that there were 32 benthic species in seagrass areas of Pearl Port, 16 of which were molluscs, 8 were crustaceans, and 5 were polychaetes. *Clithon oualaniensis*, *Batillaria zonalis*, and *Certhidea cingulata* were the dominant species. The average biodiversity index and species evenness were 2.47 and 0.67, respectively.

2.3.2.3 Li'an

Mud-dwelling Benthos

The biomass and dwelling density of mud-dwelling benthos at different seagrass beds is shown in Table 10.

Table 10 Biomass (g/m^2) and dwelling density (ind/m^2) of mud-dwelling benthos in Li'an seagrass beds.

Seagrass species	*Halodule uninervis*	*Cymodocea rotundata*	*Halophila ovalis*	*Thalassia hemprichii*	*Enhalus acoroides*
Biomass	775.10	480.24	559.91	736.80	1,730.9
Dwelling density	3,360	2,080	2,144	2,092	1,912

Analysis of species composition identified 24 species, of which five species were polychaetes, 17 species of mollusc, one species of brachiopoda (*Lingula anatine)*, and 1 species of fish. Although the dominant species varied by seagrass bed, the most prevalent species were *Cerithidea cingulate*, *Dasybranchus caducus*, *Batillaria zonalis*, and *Pyramidella ventricosa*. Other important but less abundant species include *Pillucina pisidia*, *Clypemorus trailli*, *Clithon oualaniensis*, *Cerithidea microptera*, *Modiolus phillippinarum, Marphysa sanguinea, Otopleura auriscati,* and *Neritina violacea*. The diversity index and measure of evenness in seagrass areas of Li'an is presented in Table 11.

Table 11 Diversity index and measure of evenness of mud-dwelling benthos in seagrass areas of Li'an.

Seagrass species	*Halodule uninervis*	*Cymodocea rotundata*	*Halophila ovalis*	*Thalassia hemprichii*	*Enhalus acoroides*
Diversity index	1.89	2.08	2.16	2.34	2.26
Evenness	0.55	0.68	0.62	0.82	0.75

Trawl Net Benthos

Average biomass was 0.168g/m^2 during the daytime and 0.069g/m^2 at night. The average dwelling density was 0.010ind/m^2 in the daytime and 0.008ind/m^2 at night. There were only two groups of trawl net benthos: fish and crustacean. Only fish were caught in the daytime, although both fish and crustacean were caught at night. Much larger quantities of fish than crustacean were caught at night. Average fish biomass was 0.17g/m^2 during the day at each station, and the biomass of crustacean and fish at night was 0.008g/m^2 (11.6%) and 0.061g/m^2 (88.4%), respectively.

Average fish dwelling density was 0.010ind/m^2 during the daytime. Dwelling density of crustacean and fish at night was 0.002ind/m^2 (7.7%) and 0.024ind/m^2 (92.3%), respectively. Analysis of species composition identified 24 species, including 4 crustaceans and 20 fish. The crustaceans were all shrimp, including *Metapenaeus ensis*, *Penaeus semisulcatus, Penaeus japonicus*, and *Alpheus japonicus*. They were caught at night.

For fish, *Siganmus oramin* was retained in 4 of 6 trawl shots during the day, and 1 of 4 trawl shots at night, were caught. This species dominated catches, with observed biomass ranging from 0.002 to 0.22g/m^2, and a dwelling density from 0.0004 to 0.003ind/m^2.

The average biodiversity index was 2.19 during the day and 1.79 at night. The average evenness was 0.97 during the day and 0.75 at night. The average biodiversity index and average evenness in the daytime were slightly higher than those at night.

Qualitative sampling was also conducted for some groups. 23 species were caught, of which 11 species were bivalve mollusc, 8 species were pleopod mollusc, one species of crab, *Euapta godefforyi*, and *Diadema setosum*. The other groups are listed in the annex.

A large number of *Archaster typicus* inhabit a small seagrass bed (200m^2) in the area. Its biomass and dwelling density range from 1.2 to 6.4g/m^2 and 0.15 to 1.1ind/m^2, respectively.

2.3.2.4 Xincun, Hainan

A survey of benthos and shrimp in the Xincun seagrass bed area was conducted with quadrat and trawl sampling methods from 17 to 18 October 2002 (Ronald and McRoy, 1990; English *et al,* 1997). Qualitative sampling also took place.

Mud-dwelling Benthos

The biomass of mud-dwelling benthos collected from areas of *Enhalus acoroides*, *Cymodocea rotundata*, and *Thalassia hemprichii* amounted to 393.92g/m^2, 275.20g/m^2, and 191.20g/m^2, respectively. The dwelling density of mud-dwelling benthos collected in *Cymodocea rotundata* and *Enhalus acoroides* areas amounted to 1488ind/m^2 and 1408ind/m^2, respectively. Both of the latter are higher than the dwelling density (592ind/m^2) of benthos collected in areas of *Thalassia hemprichiis*.

Polychaetes, molluscs, and echinoderms were sampled in the seagrass areas of Xincun. Although the groups varied by seagrass type, molluscs dominated the benthic community. Mollusc biomass amounted to 94.2%, 75%, and 58.6% of mud-dwelling benthos collected from *Cymodocea rotundata, Thalassia hemprichiis*, and *Enhalus acoroides* sampling sites, respectively.

Molluscs had the highest dwelling density, amounting to 98.9%, 91.9%, and 93.2% of mud-dwelling benthos captured from *Cymodocea rotundata, Thalassia hemprichiis* and *Enhalus acoroides* sampling sites, respectively.

Analysis of species composition identified 10 species, of which three species were polychaetes, six species were molluscs, and one species was fish. Four species of mud-dwelling benthos were collected in *Cymodocea rotundata* areas and 6 species were collected from both *Thalassia hemprichii* and *Enhalus acoroides* areas.

The mollusc *Pillucina pisidia* is the most dominant species of all mud-dwelling benthos collected from areas of *Cymodocea rotundata, Thalassia hemprichii,* and *Enhalus acoroides*, both in terms of biomass and dwelling density. *Disbranches caducus* is the dominant polychaete species collected from areas of *Enhalus acoroides* (Table 12).

Table 12 Main species of benthos and their relative proportions (%) in seagrass beds of Xincun, Hainan.

Species	Item	*Cymodocea rotundata*	*Thalassia hemprichii*	*Enhalus acoroides*
Pillucina pisidia	Biomass (%)	91.9	57.8	51.9
	Density (%)	96.8	81.8	90.9
Disbranches caducus	Biomass (%)			39
	Density (%)			4.5

The biodiversity index of this area ranges from 0.26 to 1.12. The evenness of the Xincun area was 1.12 in *Cymodocea rotundata* beds, 0.62 in *Thalassia hemprichii* beds, and 0.26 in *Thalassia hemprichii* beds.

Trawl Net Benthos

The average biomass was 0.069g/m^2 and the average dwelling density was 0.007ind/m^2.

Trawl net benthos was composed of species of mollusc, crustacean, echinoderm, and fish. The biomass of benthic groups was 0.064 g/m^2 for fish, 0.0003g/m^2 for crustacean, 0.001g/m^2 for mollusc, and 0.0007g/m^2 for echinoderm. Dwelling density was 0.0047ind/m^2 for fish, 0.0017ind/m^2 for crustacean, 0.0003ind/m^2 for mollusc, and 0.0003ind/m^2 for echinoderm.

Twenty-one species were identified, including one species of mollusc, three species of crustacean, one species of echinoderm and sixteen species of fish. There are five dominant species in trawl net benthos, including the fish *Ambassis kopsil*, *Ctenogobius criniger*, *Tripterygion etheostoma*, and *Parascorpaena picta*, and the mollusc *Turbo cornutus*. The average biodiversity of the trawl net benthos was 2.44. The average evenness of the sampling stations was 0.82.

Special attention was given to penaeus. The catch of penaeus species from the *Enhalus acoroides* area was higher than that observed in the other smaller seagrass beds of the Xincun area. This aligns with the experiences and observations of local fishers.

Three species of penaeus were caught in the Xincun area. They are *Metapenaeus joyneri*, *Penaeus* (*Marsupenaeus*) *japonicus*, and *Penaeus* (*P.*) *semisulcatus* de Haan.

2.3.2.5 Liusha, Guangdong

Mud-dwelling Benthos

The average biomass and dwelling density of mud-dwelling benthos was 118.81g/m^2 and 388.8ind/m^2, respectively. The mud-dwelling benthos was composed of polychaetes, molluscs, and crustaceans. Molluscs dominated with an average biomass 97.08g/m^2 or 81.7% of total biomass. The biomass of polychaetes and crustaceans was 10.14g/m^2 (8.5%) and 11.58g/m^2 (9.8%), respectively.

The dwelling density was 272.0ind/m^2 for polychaetes (70.2%), 105.6ind/m^2 for molluscs (27.2%), and 11.2ind/m^2 for crustaceans (2.9%).

33 species were identified, including 14 species of both molluscs and polychaetes, and five species of crustaceans. Main species were *Diopatra variabilis*, *Marphysa depressa*, *Leonnates decipiens*, *Lumbrineris heteropoda*, *Solen grandis*, *Gafrarium divaricatum*, *Ciece scripta*, *Laternula* (*L.*) *marilina*, and *Mitrella bella*. Analysis of species dominance identified five dominant species.

Based on observations taken along a 200m transect, the biomass and density of the echinoderm *Archaster typicus* was 0.95g/m^2 and 0.03ind/m^2, respectively. Average biodiversity index and evenness were 2.70 and 0.85, respectively.

Trawl Net Benthos

Average biomass and average dwelling density were 0.010g/m^2 and 0.015ind/m^2, respectively. Molluscs, crustaceans, and fish were the main benthic groups in this area. Biomass of crustaceans was 0.0084g/m^{2}n (56.1%), 0.0035g/m^2 (23.4%) for fish, and 0.00306g/m^2 (20.5%) for molluscs. The dwelling density of the benthos was 0.0092ind/m^2 (62.7%) for crustaceans, 0.0049ind/m^2 (33.4%) for molluscs, and 0.0006ind/m^2 (3.9%) for fish.

36 species were identified, including 19 species of molluscs, 11 species of crustaceans, and 7 species of fish. *Siganus oramin* had a biomass and dwelling density of 0.002g/m^2 and 0.0002ind/m^2, respectively. The main species were *Drupa margariticola*, *Vexillum ornatum coccinium*, *Trachycardium carinatum*, *Gafrarium pectinatum*, *Metapenaeus ensis*, and *Diogenidae investigatoris*. Dominant index results showed that there were 5 dominant species. Average biodiversity and average evenness of trawl net benthos was 2.03 and 0.66, respectively.

2.3.3 Marine Endangered Species

Dugong dugon (Forestry Survey and Design Institution of Guangxi, 2002)

Dugong dugon is a rare and endangered sea animal and is listed as a national first class protected organism. Sea channels are present in the National nature reserves for *Dugong dugon* in Hepu (Guangxi), and the favourite food of *Dugong dugon, Halophila ovalis, and Halodule uninervis*, grow on the beach adjacent to the sea channels. The temperature and salinity of seawater in this region are very suitable for the growth of *Dugong dugon*, Hepu conservation zone is one of major habitats for *Dugong dugon*, although it is now rare in the region.

Dugong dugon are observed mainly in Northern Bay, including the coastal waters of Guangxi, waters west of Leizhou Peninsula, Guangdong, and that west of Hainan Island (Forestry Survey and Design Institution of Guangxi, 2002). The major habitat of *Dugong dugon* is the sea area of Shatian, Hepu (Guangxi). It belongs to the same species from Sumatra. They inhabit waters less than 20m deep. Feeding mostly occurs during the evening, when they move into seagrass areas with the flood tide.

Dugong feeding is seasonal, due to seasonal fluctuations in seagrass growth. They take *Halophila ovalis* in July to October. They take both *Halophila ovalis* and *Halophila uninervis* in other seasons. In the typhoon season, *Halodule* in the mid-tide zone is typically covered in sand and mud, so they take *Halophila* growing in the low-tide zone that is not significantly influenced by the typhoon.

Shatian waters are the main habitat of dugong in this area. Historically, dugongs were abundant in this area. From 1991 to June 1994, 51 individuals were observed in Shatian waters, while four were present in waters adjacent to the city of Beihai. It is worth mentioning that no dugongs were observed in the waters of YingPan-Beimu Salt-Fields from 1991 to June 1994. Human activities and environmental changes may have influenced their habitat and food sources in this area, forcing dugong to migrate to eastern waters.

Fishers worshiped dugong and believed that they were 'spirit fish', so fishing of dugong did not occur before 1958. A specific team was organised by the Shatian community to fish for dugong in 1958. 216 individuals were caught from 1958 to 1962.

Since the prohibition of catching dugong in 1976, no fishing for this species has occurred. However, human activities including the unlawful use of explosives in fishing are having a serious impact on dugong resources.

Chelonia mydas and Hippocampus kuda
A record indicated that there were *Chelonia mydas* and *Hippocampus kuda* in the Hepu seagrass bed of Guangxi Province.

2.4 Threats to Seagrass

2.4.1 Threats to the Main Seagrass Areas in China

2.4.1.1 Hepu Seagrass Beds, Guangxi

Aquaculture and Fishing activities
About 100ha of seagrass areas are being utilised for cage culture of seafood. As a result, seagrass in the breeding areas has been destroyed. Aquaculture can be destructive to seagrass.

Fishing is a traditional source of income for the local people. Trawl and electro-fishing is popular in the seagrass areas with more than 2,000 people fishing every day. Over 400 trawl-fishing vessels work in areas with water depths less than 10 metres; including Dianzhousha shoal and Gaoshatou shoal at Shatian Town and Yingluo Bay in Shankou Town. Besides fishing, digging *Sipunculus nudus*, *Linnaeuses* spp., *Phascolosoma esculentaes*, and shellfish are considered as threats to seagrass. Activities such as staking and trampling can destroy seagrass.

Natural factors

The storm tides and waves caused by typhoons, and the west-south waves caused by the west-south gales, disturb seagrass roots or smother shoots with sediments. Under these conditions, seagrass consuming snails tend to reproduce rapidly.

2.4.1.2 Liusha Seagrass Beds, Guangdong

Excessive aquaculture and fishing
The reclamation of a large area of coastal waters occurred for the culturing of shrimp. This project, which was supported by the local government as a revenue producing enterprise, destroyed seagrass beds in the area. The abundance of *Halophila ovalis* has declined due to cage, shellfish, and seaweed culture.

Trawling and digging for shellfishes is widespread in Liusha Bay. During the ebb tide, many people trample the seagrass to dig for shellfish. Some fishers use explosives, electricity, and/or poisons in fishing. These human activities can seriously affect seagrasses and the environment upon which they depend.

Pollution
Human-induced pollution of all types can significantly influence the distribution abundance of seagrass.

2.4.1.3 Li'an Seagrass Beds, Hainan

Reclaimed coastal areas for shrimp ponds, and densely placed stakes and piles for culturing *Eucheuma muricatum,* can destroy or inhibit seagrass growth. During the ebb tide, many people trample the seagrasses to dig for shellfish. Use of explosives, electro-fishing, and/or poisons in fishing represents a key threat to seagrasses.

2.4.1.4 Xincun Seagrass Beds, Hainan

The overexploitation is similar to that at Liusha and Li'an seagrass beds.

Xincun Port is a tourist location. Many tourism restaurants and fishers houses are built over the water, leading to discharge of untreated domestic and organic sewage into the sea. This greatly increases organic and suspended matter in the water that changes the growth environment of seagrass beds.

2.4.1.5 Seagrass Beds of Hong Kong

The high temperatures in this area can affect the germination of seeds. The macroalgae *Enteromorpha sp.* and *Ulva sp.*, and the epiphytic algae *Sphacelaria sp.* and *Acrochaetium robustum*, may reduce light availability for photosynthesis and limit the rate of gaseous exchange by *Zostera japonica.*

Demand for land by the industrial economy and housing in Hong Kong has not only degraded environmental conditions for local seagrasses, but also threatens their survival. The new international airport is a typical example. Reclamation and construction works for the airport increased sediment loads of coastal waters, creating an immediate threat to populations of *Zostera japonica* and *Halophila ovalis.*

2.4.2 Causal Chain Analysis of Threats

Results of causal chain analysis are shown in Figure 6.

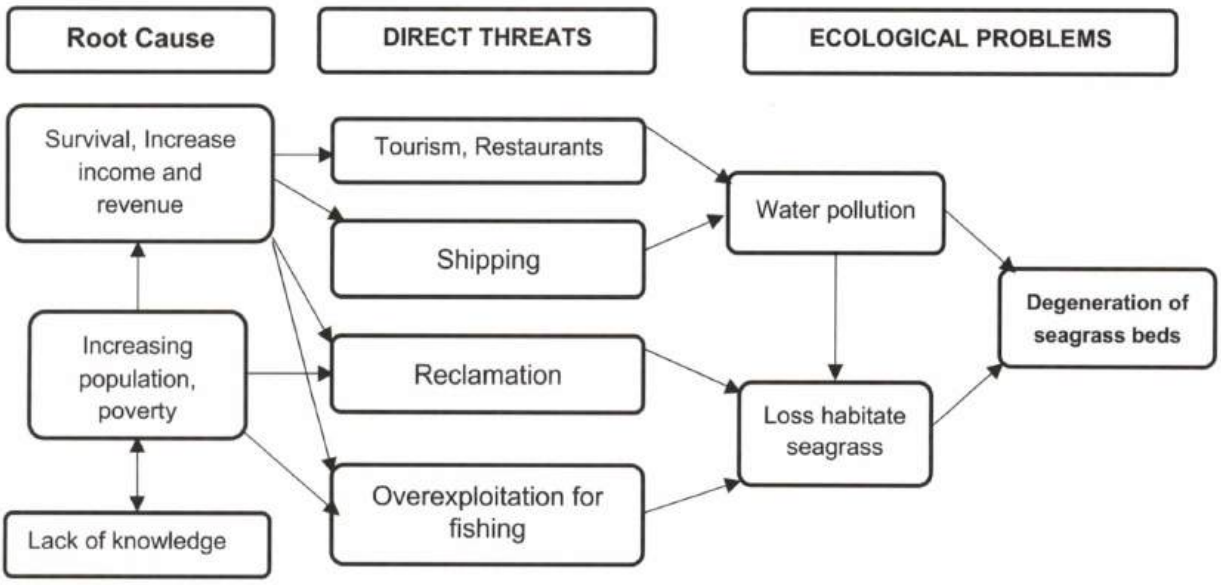

Figure 6 Causal chain analysis of the degradation of the seagrass beds in southern China.

3. ECONOMIC VALUATION

3.1 Economic Valuation of Main Seagrass Beds

In the above paragraphs, the ecosystem service value of the Hepu seagrass beds is calculated from three aspects, which include nine indexes. Summing up the calculation results of all the specific indexes, the ecosystem service value of Hepu seagrass bed reaches a value of US$39,352/ha/a, in which direct economic value is US$3,695/ha/a and indirect economic value is US$27,689/ha/a. Indirect economic value is 7.5 times direct economic value. At the same time, the non-use value is US$5,968/ha/a, which is in the proportion of 15% to the total economic value. The valuation results for each seagrass good and service are shown in Table 13.

Table 13 Economic value of ecosystem goods and services of Hepu seagrass bed.

Uses	Value (US$/ha/a)
Feed raw stuff	550
Handicraft	462
Cosmetic	832
Fishery	939
Aquaculture	912
Nursing ground	8,496
Coastline protection	191
Purification of water	19,002
Non-use value	5,968
Total	**37,352**

3.2 Economic Valuation of the Li'an Seagrass Beds

In the above paragraphs, the value of seagrass ecosystem goods and services are estimated for Li'an. These estimates are based on three aspects, including nine indexes. The ecosystem service value of Li'an seagrass bed is US$32,309/ha/a, in which direct economic value is US$6,444/ha/a, and indirect economic value is US$21,019/ha/a. Indirect economic value is 3.26 times that of the direct economic value. At the same time, the non-use value is US$4,846/ha/a, which is 15% of the total economic value. The valuation results of all the service values are shown in Table 14.

Table 14 Economic value of seagrass areas of Li'an.

Uses	Value (US$/ha/a)
Feed raw stuff	724
Handicraft	1086
Cosmetic	603
Fishery	638
Aquaculture	3,393
Nursing ground	1,817
Coastline protection	201
Purification of water	19,002
Non-used value	4,846
Total	**32,310**

4. LEGAL SYSTEM AND ADMINISTRATION OFFICES

4.1 Legal System

4.1.1 National Laws

4.1.1.1 Marine Environment Protection Law

The "Marine Environment Protection Law of the People's Republic of China" was adopted by the 13th Meeting of the Standing Committee of the 9th National People's Congress in 1999. The 11th article of this law stipulates, *"Units or individuals who dump pollutants directly into the sea must pay for their actions according to related regulations"*. The 73rd article stipulates, *"Units or individuals who discharge excess waste into sea must remedy the actions in a definite time and pay a fee for pollutant discharge under the supervision of related departments"*. This new law was expanded from 8 chapters and 48 articles to 10 chapters 98 articles, adding the "Marine Ecology Protection Law" and a total discharge amount control system in order to strengthen disciplinary sanctions, specialise legal responsibility, and added contents related to international treaties. It is undoubtedly good for resolving the marine problem and enforcing the sustainable development plan. The second countrywide marine pollution baseline survey in 1998 indicated that the Chinese offshore pollution problem is serious, that the environmental quality aspects of sea areas are worsening, and nearshore biological resources are degraded because of water pollution and overfishing. Article 10, Chapter 10 of the new law stipulates clearly that the State Council and coastal local governments should implement effective measures to protect mangrove swamps, coral reefs, wetlands, islands, bays, estuaries, important fishery areas, other representative and typical marine ecosystems, natural zones inhabited with some rare and endangered species, and waters inhabited by marine organisms of high economical value. Sites of marine natural history, high amenity value, and of scientific and cultural value are especially significant.

The law also stipulates that the State Council and the coastal provincial governments should plan and establish marine nature reserves, seawater treatment, and coastal defence projects according to local requirements. Regulations mentioned above embody the Chinese principles of strengthening environment protection, reasonable utilisation and development of marine resources, and placing the protection and conservation of ecosystems and their environments in the same important position. The revised marine environmental law stipulates not only the obligation of units and individuals to protect marine ecology, but also the punishment measures for violators. Violators who destroy marine ecosystems, such as mangrove swamps and coral reefs, marine fishery resources, and marine nature reserves should rehabilitate the areas damaged by pollution in a definite time and pay a pollutant discharge fee from 10,000 to 100,000 RMB.

4.1.1.2 Administrative Law of Sea Area Usage

The "Administrative Law of Sea Area Usage" was instituted on 1 January 2002. This law aims to strengthen the administration of marine usage, guarantee proprietary rights of state sea areas, define the legal rights of marine users, and to promote the reasonable development and sustainable use of marine regions. Individuals and units can use marine areas only after possessing the legal rights for marine region usage. The time limits for rights of marine region usage are specified in the law: marine aquaculture 15 years, shipbreaking 20 years, tourism or entertainment 25 years, salt industry and mining industry 30 years, public enterprises 40 years, and construction projects such as ports and boatyards 50 years. Individuals and units may apply to the marine administrative departments of the coastal provinces, autonomous regions, and municipalities directly under the Central Government for the rights of marine region use. The state is required to manage activities that may change the natural properties of the marine environments, such as land reclamation. The marine management information system was established by the state to monitor usage of marine regions. Individuals and units utilising marine areas must pay a fee according to the relative regulations issued by the Central Government. All these measures strengthen the management of marine resources and benefit seagrass areas. We consider that some measures on protection of marine ecosystems should be added as future amendments, including the protection of seagrass beds.

4.1.1.3 The Fisheries Law of the People's Republic of China

The "Fisheries Law of the People's Republic of China", adopted at the 14th Meeting of the Standing Committee of the National People's Congress on 20 January 1986, stipulates that:

"It shall be prohibited to use explosives and poisons in fishing, to fish in prohibited fishing areas and during closed seasons and to fish with fishing gears and methods banned by the fishery authority or to use fishing nets with meshes smaller than the minimum prescribed sizes". It also states that *"It is forbidden to reclaim land from lakes. Coastal beaches can't be enclosed without approval of a people's government at or above the country level. No one should be allowed to reclaim land from water areas used as a major seedling base and aquaculture ground".* These stipulations provide a foundation for the protection of seagrass ecosystems.

4.1.2 Laws and Regulations

4.1.2.1 National laws and regulations

(1) Regulations of the People's Republic of China on Administration of Waste Dumping in the Ocean

The "Regulations of the People's Republic of China on Administration of Waste Dumping in the Ocean" is an ordinance related to the "Environmental Protection Law of China". The ordinance strengthens the management of waste dumping in the ocean and the protection of seagrass beds.

(2) Regulations of the People's Republic of China on Administration for Prevention and Control of Marine Environmental Pollution by Coastal Engineering

The "Regulations of the People's Republic of China on Administration for Prevention and Control of Marine Environmental Pollution by Coastal Engineering" were adopted at the 61st Meeting of the State Department on 25 May 1990. No provision for the protection of seagrass was included. We consider that a specific provision for seagrass protection should be added in the subsequent revision.

(3) Regulations of the People's Republic of China on Administration for Prevention and Control of Marine Environmental Pollution by Terrigenous Pollutants

The "Regulations of the People's Republic of China on Administration for Prevention and Control of Marine Environmental Pollution by Terrigenous Pollutants" was adopted at the 61st Meeting of the State Council on 25 May 1990. This regulation emphasises the protection of marine nature reserves, which is closely related to the protection of seagrass.

4.1.2.2 Local laws and regulations

(1) Guangdong Province

The government of the Guangdong Province has issued some relevant regulations, such as "Management Measures of Guangdong Province for Usage of Sea Areas" (1996), "Decision on the Modification of 'Management Measures of Guangdong Province for Usage of Sea Areas'", "Standard of the Guangdong Province for the Using Fee of Sea Areas", "Environmental Functional Distribution of Regions along Offshore Areas in the Guangdong Province" (1999), "Implementation Rules of the Guangdong Province for the Fishery Management" (1990), "Decision of the Standing Committee of the Guangdong People's Congress on the Construction of the Man-made Reefs to Protect Marine Resources and Environment" (2001), "Management Measures of the Guangdong Province for the Protection of the Aquaculture at Shallow Beach" (1994).

(2) Guangxi Zhuang Autonomous Region

The government of the Guangxi Zhuang Autonomous Region has issued the following regulations: "Implementation Measures of the Guangxi Zhuangzu Autonomous Region for Fishery Administration", "Administrative Measures of the Guangxi Zhuangzu Autonomous Region for the Use of Sea Areas" (1997), "Administrative Measures of the Guangxi Zhuangzu Autonomous Region for the Young Aquatic Products", and "Administrative Provisions of the Guangxi Zhuangzu Autonomous Region for the Protection of Aquatic Wildlife". Some counties and cities have also instituted some provisions, such as "Standard of the Qinzhou City for the Collection of the Using Fee of Sea Areas", "Provisions of the Beihai City on the Administration of the Use Fee of Sea Areas", "Working Scheme of the Fangcheng District on the Registration of the Use of Sea Areas", "Administrative Measures of Hepu County for the Use of Sea Areas for Aquatic Breeding" (the Hepu County).

(3) Hainan Province

The Administration Office of Ocean and Fishery of the Hainan Province has instituted relevant laws and regulations: "Administrative Provisions of the Hainan Province on the Demonstration of Feasibility of the Use of Sea Areas (interim)", "Working Guideline of the Hainan Province on the Demonstration of Feasibility of the Use of Sea Areas (interim)" (1998), "Provisions of the Hainan Province on the Management of the Project Files of the Use of Sea Areas (interim)" (1998), "Working System of the Approval of the Use of Sea Areas" (1998). In September 1998, the People's Congress of the Hainan Province issued "Provisions of the Hainan Province on the Protection of Mangrove". Some counties and cities have also instituted some provisions, such as "Administration Provisions of the Haikou City on the Use of Sea Areas" (1998), "Interim Administration Measures of the Saya City on the Use of Sea Areas" (1992), "Implementation Measures of the Dongfang City on the Use of Sea Areas" (1997).

4.1.3 Programme

4.1.3.1 National Plan for Marine Development

The relevant departments of the central and coastal area governments identified 3,663 marine functional regions, including development and utilisation zones, control and protection zones, nature reserves, special function zones, and reserved zones from 1989 to 1995. Those plans provided a scientific foundation for administrators and the people to use oceans wisely, including the protection of seagrass.

4.1.3.2 Classifying Principle and Type of Marine Nature Reserves

The "Classifying Principle and Type of Marine Reserves" is effective from 1 April 1999. In the national standard, marine reserves were classified into 3 classes and 16 types. "Seagrass beds" is one of the 10 types of marine and coastal natural ecosystems. Section 4.4.3, Monitoring and Evaluation of Protected Objects, listed the major management targets for seagrass ecosystems as plant coverage, thickness, categories, benthic biodiversity, and community structure of seagrass beds.

4.1.3.3 Technical Guidelines for the Division of Marine Functional Zoning

The GB-17108-1997 National Standard of "Technical Guidelines for the Division of Marine Functional Zoning" was issued on 12 November 1997, and entered into force on 1 May 1998. The types of marine nature reserves include coral reefs, mangrove swamps, wetland, and other types of ecosystems exclusive of seagrass beds.

4.1.3.4 Emergency Programme for Oil Spills

To prevent marine pollution from ships and ports, all kinds of ships drew up the "Emergency Programme for Oil Spills" and were equipped with oil-water separators in accordance with the relevant stipulations. All ports have constructed facilities to accept and handle oily wastewater. This equipment can treat 3.7 million tonnes of oil-polluted wastewater from vessels up to 42,000 tonnes. These programmes prevent oil pollution of seagrass beds.

4.1.3.5 China Ocean Agenda 21 Century

The "China Ocean Agenda 21 Century" was prepared in 1996. It brought forward a sustainable development strategy for the Chinese marine project. It effectively establishes the nation's marine rights and interests, making good use of marine resources, protecting the marine eco-environment, and realises that the sustainable usage of marine resources and the marine environment are harmonious marine undertakings. Protecting the marine environment with an understanding of the importance of sustainable usage of marine resources and the marine environment are closely related to the protection of seagrass.

4.1.3.6 Action Plan of China for the Conservation of Biodiversity

The "Action Plan of China for the Conservation of Biodiversity" was issued in 1994. It is the principal document guiding the conservation of biodiversity action in China. It lists threats to the different biological resources, including marine resources and their ecological systems, and the causes of those threats. It proposed the general objective, the specific objectives and the actual measures to carry out the "Action Plan for the Conservation of Biodiversity".

4.2 Administrative Authority

The relevant administrative departments for seagrass are shown in Figure 7.

4.2.1 National Administrative Authority

The relevant administrative bodies responsible for the protection of seagrass are the State Environmental Protection Administration, State Ocean Administration, and the Fishery Administration of the Ministry of Agriculture.

4.2.1.1 State Environmental Protection Administration

Its main responsibilities are as follows:

- To formulate the national policy, laws and administrative regulations for environmental protection, to undertake the environmental impact assessments of major economic and technological policies, develop planning and key economic development plans, to formulate national environmental protection plans; to formulate and supervise the implementation of the national plan for pollution control and ecological conservation, in key ecological conservation regions and water source conservation zones, and to organise the zoning of environmental functions in different regions;
- To organise the supervision, coordination and monitoring of the protection of the marine environment, to supervise environmental protection in the exploitation and utilisation of natural resources, to guide and supervise important eco-environmental construction engineering as well as the recovery of destroyed ecology, to supervise and examine environmental protection in the development of natural resources, tourist attractions and forest parks, as well as the protection of biodiversity conservation and wild animals and plants;
- To guide and coordinate the solutions to major environmental problems involving different departments, localities, regions and river basins; investigate and deal with major accidents causing environmental pollution and ecological damage; be responsible for the monitoring and management of the environment and the administrative inspection of environmental protection;

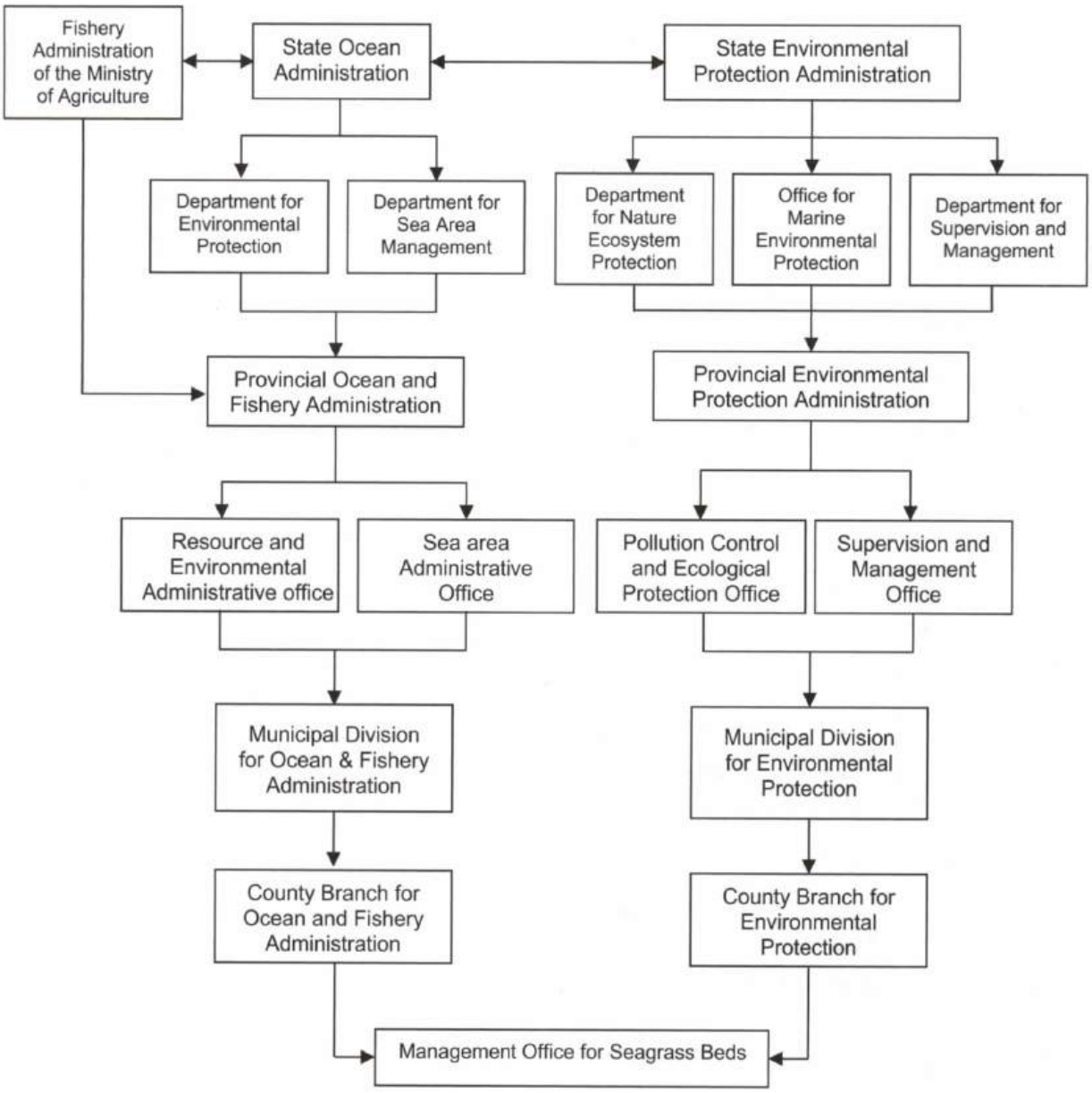

Figure 7 Government Departments involved in seagrass management in China.

- To formulate the national standards for environmental quality and pollutants emission discharge and organise their implementation; to organise the compilation and submission of the national report on environmental quality; and to participate in the national plan for sustainable development.

4.2.1.2 State Ocean Administration

The State Ocean Administration's main responsibilities are as follows:

- To formulate the fundamental laws, administrative regulations and policies on the ocean; to formulate oceanic functional zoning, development programmes for oceanic science and technology and the strategy of developing oceans by science and technology; to manage the fundamental data of oceans in our country; to undertake the statistics of the oceanic economy and the social development;

- To supervise and manage the use of the sea zone (including the coastlines); to issue licenses for sea area use; to implement the system of paid use of sea areas; to manage the laying of submarine cables and pipelines; to undertake the demarcation of sea areas;

- To formulate the programmes, standards and criteria for oceanic environmental protection and renovation; to formulate the control system and standards for pollutant emission and discharge into the ocean; to supervise the terrigenous pollutants discharging into the ocean according to the national standards; to be in charge of preventing environmental pollution caused by the exploitation and development of marine petroleum, the dumping of wastes from oceanic construction activities; to manage the investigation, monitoring, supervision and assessment of the oceanic environment; to supervise protection for biodiversity of the oceanic eco-environment and to supervise and protect the oceanic nature reserves and the special protective areas; to examine and approve the reports of environmental impact assessments for coastal or oceanic construction projects which are to be built, rebuilt or extended;
- To manage "The China Marine Surveillance"; to conduct cruising surveillance; to locate and punish those undertaking illegal activities; and
- To organise fundamental and comprehensive surveys of the ocean, conduct oceanic science and technology and relevant hi-technology research; to manage the public service systems, such as forecasting and alarm systems for oceanic observation, monitoring and disasters; synthetical information and standard gauge; to issue forecasts and alarms of oceanic disaster and oceanic environment forecast (exclusive of the weather forecast and alarm); to manage the survey of the polar region and ocean.

4.2.1.3 Fishery Administration of the Ministry of Agriculture

The Ministry of Agriculture's main responsibilities are as follows;

- To study and formulate agricultural and rural economic development strategies and medium-term and long-term development programmes; to implement them after approval; to formulate, carry out and supervise the agricultural exploitation programmes;
- To formulate agricultural resource zoning and the sustainable development of ecoagriculture and agriculture; to guide the exploitation and utilisation of farmland, fishery water areas, grasslands, the arable beaches and wetlands, and the renewable rural resources; to guide, protection and manage the species resources of agriculture; to protect the ecological environment of fishery areas and aquatic wildlife; to safeguard the fishery rights and interests of our country; to exercise the power of inspection of fishing boats and supervise the fishery management and fishing ports standing for the State; and
- To formulate development programmes and relevant policies for scientific research and education in agriculture, to spread the use of technology; to carry out the strategy of developing agriculture by science and education; to choose and implement the important scientific research projects and technology promotion projects and to guide agricultural education and the development of occupational skills.

The responsibilities of the Fishery Bureau under the Ministry of Agriculture are: to study and propose ideas and suggestions on the strategies and programmes for fishery development, measures for developing technology, relevant laws regulations and policies and to organise their implementation; to formulate and implement the policies, measures and programmes for the protection and reasonable use of fishery resources, protection of the ecological environment of the fishery areas and their aquatic wildlife.

4.2.2 Local Management Organisations

Among the local management organisations, the departments of environmental protection, agriculture, marine and aquatic products have a close relationship with the protection of the ecological environment and biodiversity in seagrass beds. However, the administrative organisations at the provincial level differ from province to province. In Guangdong Province, the departments of the ocean and aquatic products have been combined as the Department of Ocean and Aquatic Products, while in Guangxi Zhuang Autonomous Region and the Hainan Province, these two departments are separated. In Hainan, the departments of the environmental protection and land and resources management have been united as the Department of Land Environment and Resources, while in Guangxi and Guangdong, the Environmental Protection Bureaus are independent administrations. Their functions are similar to those of the national administrative authority.

4.3 Discussion

4.3.1 Effectiveness of Overall Laws and Regulations for Protection of the Marine Environment

China pays much attention to marine environmental protection, and has gradually established the organs and legal system in support of this. The concepts of marine protection, environmental awareness and legal enforcement have been strongly strengthened for the Chinese people. The development of marine environmental protection is an ongoing process.

Many laws and regulations relative to the protection of seagrass habitats have been issued and implemented. The "Law of the People's Republic of China on Marine Environmental Protection" was approved by the NPC Standing Committee in 1982 and was modified in 1999, in which many articles being relative to the protection of seagrass are included in the law.

In addition, many regulations and standards concerning marine environmental protection have been issued by national environmental protection administration and local governments, such as fishery water quality standard, seawater quality standard, comprehensive discharge standard of wastewater, discharge standard of wastes from ships, discharge standard of industrial wastes from ships, and discharge standard of oily wastewater from marine oil development industry. All of these laws, regulations and rules have formed a legal framework for marine environmental protection.

4.3.2 Existing Problems and Suggestions

(1) The laws and regulations mentioned above are directly or indirectly good for protection of the seagrass ecosystem. However, whilst they do not propose special policies and measures for the protection of seagrass, they play a small role in their protection. If we conduct more research into the importance of seagrass to the oceanic ecosystem, then the related department may strengthen the administration and protection of seagrass. As a result, seagrass protection measures will also be added to the regulations and laws. Perhaps integrated regulations concerning the protection of seagrass may be produced in the near future.

(2) Although there are many laws and regulations that are relative to the protection of the marine environment, those laws and regulations are not well coordinated, leading to some regions and objects which cannot be protected effectively. We suggest that the departments who construct laws and regulations should work together to ensure the efficient integration of them all.

(3) The local residents know and understand little about the corrective laws and regulations because of a lack of available information about them. This also makes enforcement of the laws and regulations difficult. We suggest that the relative departments increase advertising and education about the laws and regulations considerably, so that the people will know, understand and abide by them.

(4) Insufficient manpower, equipment and funding obstruct the enforcement of the above laws and regulations. We suggest that the nation strengthen legislation and strictly enforce the law in order to assure effective implementation of the laws and regulations.

Table 15 illustrates the national legislations of seagrass in China.

Table 15 Table of national legislation related to seagrass.

Legislation (Year)	Title	Description	Level of Implementation (national, provincial, district, local, traditional)/ Implementing Agency	Target (ecosystem, seagrass ecosystem)	Constraints	Remarks
2002	Rules of Monitoring techniques for Marine reserves – general provisions	Seagrass was listed as one of the protected targets, and the monitoring parametres of "seagrass ecosystem" are plants coverage, thickness, categories, benthic biodiversity, and community structure.	-Level: national -Imp. agencies: State Oceanic Administration of China	Protection of the following ecosystems: estuaries and offshore, intertidal, seagrass bed, coral reefs, mangrove swamps, islands marine rare and endangered species ecosystem		Execution
1996	Ordinance for Environmental Impact Assessment	Necessary ecological assessment for all established seagrass beds with important habitats	-Level: provincial -Imp. agencies: Department of fishery protection Hong Kong	Protection of seagrass bed ecosystems	Ecological assessment for all proposed developments projects affecting seagrass in order to minimise threat to local seagrass communities all established seagrass beds	Execution
1996	China Ocean Agenda 21 Century	A sustainable development strategy for China's marine programmes, to realise the sustainable utilisation of marine resources and marine environment	-Level: national -Imp. agencies: The State Council of China	To effectively safeguard the state's marine rights and interests, rationally develop and utilise marine resources, give positive protection to the marine eco-environment		Execution
1982	Law of the People's Republic of China on Administration for Marine Environmental Protection	Protect marine environment and resources, maintain ecological balance, prevent marine pollution, safeguard human health, and promote the development of marine planning	-Level: national -Imp. agencies: The environmental protection department under the State Council of China	Protection of mangrove swamps, coral reefs, wetlands, islands, bays, estuaries, important fishery water areas, and some other representative and typical natural ecosystems, as well as the areas with rare and endangered species as well as with natural historical remains and special significance	It stipulates the obligation of units and individuals for protection of marine environment and the punish measures for violators.	Execution
2002	Law on administration of sea region usage	Promote rational development and sustainable use of sea region	-Level: national -Imp. agencies: The State Council of China	Strengthen administration of sea region usage and guarantee the legal rights of sea region users	Prohibit all use of sea regions without permission	Execution
1986	Fisheries Law of China	Enhance protection, development and reasonable utilisation of fishery resources; develop artificial aquaculture	-Level: national -Imp. agencies: The department of fishery administration under the State Council of China	-Protection of fishery resources -Protection of fishery workers' lawful rights and interests -Development of fishery production	Prohibit use of explosives and poisons in fishing, fishing at prohibited fishing areas and during closed seasons, fishing with gear and methods banned by the fishery authority or fishing nets with meshes smaller than defined minimum sizes, and reclamation land from lakes	
1990	Regulations on the prevention and control of marine environmental pollution by coastal engineering	Strengthen environmental protection of coastal engineering	-Level: national -Imp. Agencies: The environmental protection department under the State Council of China	Protection of marine environment	Prohibit all engineering which demolished mangrove swamps and coral reefs	

Table 15 *cont.* Table of national legislation related to seagrass.

Legislation (Year)	Title	Description	Level of Implementation (national, provincial, district, local, traditional)/ Implementing Agency	Target (ecosystem, seagrass ecosystem)	Constraints	Remarks
1985	Regulations on administration for prevention of marine pollution from wastes dumping and other materials	Support implementation of The Marine Environmental Protection Law of China	-Level: national -Imp. agencies: State Oceanic Administration of China	Keep the balance of ecosystems, protect marine resources and promote development of marine	Prevent wastes dumping from pollution of oceans	
1996	Regulations of Guangdong Province for Administration of Sea Areas	Strengthen administration of sea area, use and develop sea resources soundly, protect marine environment, accelerate development of marine economy	-level: provincial -Imp. agencies: oceanic service of provincial government in Guangdong Province	Protect ecosystems of coral reefs, mangrove swamps, marine rare and endangered species, maritime nature reserves and integrated and typical marine ecosystems	-Industrial, traffic, communication and petrochemical engineering construction items - Wastes dumping to oceans -Protection of fishery, salt industry, and tourism	
1999	Environmental Functional Zoning along Inshore Areas of Guangdong Province	Protect and improve marine environment of Guangdong Province, prevent pollution of marine environment, and ensure sustainable development of marine resources	-level: provincial -Imp. agencies: Guangdong Province Environment Protection Bureau	-Rare marine resources -Fish laying eggs area		
1990	Implementing Measures of Guangdong Province for Fishery Management	Supervise and manage fishery actions	-level: provincial -Imp. agencies: Fishery Administration Department of Guangdong Province	Protect fishery and inhabited environment	Electrifying fish, poisoning fish, bastard fishing gears, trawling are all prohibited.	
1994	Management Measures of the Guangdong Province for Protection of Aquatic Breeding on Shallow Beach	Strengthen protection of aquatic breeding and use management of shallow beach of Guangdong Province	-level: provincial -Imp. agencies: Fishery Administration Department of Guangdong Province	Protect fishery, boost development of aquatic breeding in Guangdong Province		
1997	Administrative Measures of the Guangxi Zhuangzu Autonomous Region for the Use of Sea Areas	Strengthen comprehensive management of sea area, promote unitary benefit of society, economy, and environment	-level: provincial -Imp. agencies: oceanic service of provincial government of the Guangxi Zhuangzu Autonomous Region	The management of sea usage belong to oceanic service of provincial government of the Guangxi Zhuangzu Autonomous Region		
2001	Administrative Provisions of Hainan Province on Demonstration of Feasibility of the Use of Sea Areas	Exploit and use sea area rationally, maintain legal rights of sea area users	-level: provincial -Imp. agencies: oceanic service of provincial government of the Hainan Province	Standardise usage of sea area	The following action should be prohibited: -Action destroying marine resources, environment, nature sights, and ecosystem balance; -Action has bad influence to coast engineering.	

5. RECOMMENDATIONS

5.1 Problems in the Management of Seagrass

People do not understand the importance of protecting the marine environment, especially the concept of biodiversity. The administrative departments of government pay much attention to the development of resources but often neglect protection of the environment. Protection of the ecosystem has not been carefully thought out in some development plans and activities. In addition, the people are generally not aware of environmental protection.

Species diversity and balance of the ecosystem are in danger because of the excessive development of resources in seagrass beds. This results from many actions, such as trawling, illegal fishing, and reclamation for shrimp farming. At the same time, the habitats of seagrass are seriously threatened because of the acceleration of industrialisation and urbanisation, as well as inadequate facilities for environmental protection. Heavy terrigenous pollutants result in a decline of nearshore environmental quality, threatening seagrasses.

The governments have insufficient resources and funding to protect and effectively manage the marine eco-environment. The marine environments of seagrass beds have been often destroyed. The resources of the seagrass beds such as seagrass, *Dugong dugon*, Indo-Pacific Humpback Dolphins, *Sousa chinensis*, and mangroves have been destroyed or affected in some way. Biodiversity is declining.

There is a small amount of research on the seagrass ecosystem in China. The administrative departments cannot obtain accurate, timely and broad information from the insufficient resources of books, literature, and data about seagrass.

The existing information cannot be managed accurately because there is no special database about seagrass. Additionally, the newly obtained information is not updated immediately, which leads to the loss and waste of the information resources.

5.2 Prospect of Seagrass Management

The activities of humans have harmed the marine environment of seagrass beds. If no precautionary measures or protection are brought into effect, the living environment of seagrass will continuously worsen with the further acceleration of urbanisation and industrialisation around the seagrass beds. This will also endanger rare mammals such as Dugong dugon.

5.2.1 Legislation and Administration

Although there are no specific laws and regulations for managing seagrass beds, some laws and regulations are indirectly related to the sea and its environment. For example, "Law of the People's Republic of China on Marine Environmental Protection", "Law of the Utilisation of Sea Area", and the "Programme for the Protection of Marine Biodiversity in China". However, the laws cannot protect seagrass and its living environment effectively. In order to strengthen the protection and management of seagrass, more attention should be paid to research on seagrass, and the managing departments should recognise the importance of seagrasses. At the same time, protective measures for seagrass should be added to the laws and regulations.

Only some provisions in the national laws and regulations about the environment and the utilisation of the sea area are related to the protection of seagrass and its living environment.

These laws cannot be translated into actual management because the conservation zones of seagrass and its habitats are too large and have many special natural characteristics. In view of the urgency and complexity of seagrass protection and the weakness of legislation, it is necessary to establish Regulations on Administration for Seagrass Protection, in order to make the protection of seagrass legally enforceable. The laws about seagrass should be advertised widely in the society. The environmental protection department and marine management department should strictly execute the regulations and strengthen the management of seagrass.

5.2.2 Active Marketing and Education

It is necessary to advertise and popularise the knowledge of protection of marine biodiversity, and boost public consciousness of natural protection of the ocean by means of movies, TV programmes, videos, publications, posters, seminars, and exhibitions. The advertising and education should first be carried out in schools to instil in the youth consciousness of environmental protection. The advertising and education must focus on the coastal fishers in the conservation region to heighten their consciousness of protection and law, so that they will actively participate in the protection of seagrass.

The government should carry out public consultation for the policy, plans and rule of law, listen to views of stakeholders, attract the public to participate in actual management, and strengthen and consolidate the public foundation for environmental protection.

5.2.3 Construction of the Seagrass Management Department

No specific management department for seagrass exists in China. The management of seagrass is rather backward because of a lack of capital and regulations related to seagrass management. It is necessary to strengthen the construction and management of the administration department, including the construction of the administrative organs, equipment, facilities, and expertise, including training of a group of qualified managers.

5.2.4 Prevention of Sea Area Pollution from Terrigenous and Oceanic Matters

In order to protect the marine environment, pollution from aquaculture and fishing in the seagrass beds must be reduced. Development around the seagrass beds will influence the marine environment and it is necessary to use scientific approaches to assess the environmental capacity of a sea area and ensure that pollution is treated and discharged in accordance with the standards. It is necessary for new projects to carry out environmental impact assessments and insist on the triple bottom line concept to harmonise local development speed and scale by economic measures, to renovate the technology and improve the equipment of enterprises by means of the development of science and technology, and the adoption of clean production technology, and to strictly control dismantling of ships and to effectively supervise waste discharged from ships. In order to control the action of discharging wastes into the sea at will, the permit system for discharging pollutants and wastes dumping should be implemented.

5.2.5 Deep Research on Seagrass and Training for Researchers in this Field

It is necessary to support and encourage scientific research on seagrass, to strengthen international academic exchange, study advanced theory and experimental techniques, and train new researchers in the seagrass field. Consideration should be given to including seagrass into the teaching at universities so that it can be researched professionally. It is necessary to place seagrass in importance with coral reefs and mangrove ecosystems, to encourage the researchers to report their research process and results as soon as possible in order for them to be studied and used by other researchers.

5.2.6 Database of Seagrass

It is necessary to collect, save, and update regularly, the existing data and information of seagrass ecosystems in order to share the resource of seagrass, and reduce loss and waste of the data. A website should be constructed to make it easy for researchers to exchange ideas and communicate with each other. An information database for seagrass should be compiled in order to save and update the information regularly, and to ensure the integrity and accuracy of the information.

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ANNEX 1

Catalogue of associated species in different sites.

HEPU	PEARL BAY	LI'AN	XINCUN	LIUSHA
Mud-dwelling Benthos	**Mud-dwelling Benthos and Qualitative Sampling**	**Mud-dwelling Benthos**	**Mud-dwelling Benthos**	**Mud-dwelling Benthos**
1. Spogia	1. *Perineries vancaurina*	1. *Leonnates persica*	1. *Haploscoloplos elongatus* (Johnson)	1. *Eulalia*
2. Actinidae	2. *Haploscolplos elongatus*	2. *Haploscoloplos elongatus*	2. *Dasybranchus caducus* (Grube)	2. *Ceratonereis anchylochaeta*
3. Phyllodocidae	3. *Heteromastus latericeus* Sars	3. *Dasybranchus caducus*	3. *Ophelia acuminata* Oersted	3. *Leonnates decipiens*
4. *Sigalon* sp.	4. *Heteromastus* cf. *aberans* Day	4. *Marphysa sanguinea*	4. *Modiolus* (M.) phillippinarum (Hanley)	4. *Leonnates persica* Wesenberg
5. *Leonnates* sp.	5. *Onuphis eremita* Audouin et M.Edwards	5. *Lumbrineris heteropoda*	5. *Pillucina pisidia* (Dunker)	5. *Glycera alba*
6. *Paraleonnates uschkovi* Chlebovitsch	6. *Scapharca cornea*	6. *Modiolus (M.) phillippinarum*	6. *Nitidotellina minuta* (Lischke)	6. *Aglaophamus Viet Namensis*
7. *Glycera alba*	7. *Talonostrea talonata* Spnon	7. *Pillucina pisidia*	7. Natica arachnoidea (Gmelin)	7. *Haploscoloplos elongatus*
8. *Glycara convoluta* Keferstein	8. *Fragum carinatum*	8. *Gafrarium pectinatum*	8. *Pyramidella ventricosa* Guerin	8. *Polydora*
9. *Glycara* sp.	9. *Merisca diaphana*	9. *Moerella phillippinarum*	9. *Otopleura auriscati* (Holten)	9. *Haploscoloplos elongatus*
10. *Goniada* sp.	10. *Moerella iridescens*	10. *Nerita (Theliostyla) albicilla*	10. *Corythoichthys fasciatus* (Gray)	10. *Polyophthalmus pictus*
11. *Haploscoloplos elongatus* (Johnson)	11. *Clausinella isabellina*	11. *Neritina (Dostia) violacea*	**Trawl Net Benthos**	11. *Diopatra variabilis*
12. *Notomastus latericeus* Sars	12. *Dosinia (Phacosoma) truncate* sp.nov.	12. *Clithon oualaniensis*	1. *Turbo cornutus* Solander	12. *Marphysa sanguinea*
13. *Notomastus* cf. *aberans* Day	13. *Laternula (Exolaternula) marilina*	13. *Batillaria cumingi*	2. *Chirona tenuis* Hoek	13. *Marphysa depressa*
14. *Euchymene annandalei* Souther	14. *Clithon oualaniensis*	14. *Batillaria zonalis*	3. *Thalamita danae* Stimpson	14. *Lumbrineris heteropoda*
15. *Euchymene lombricoides* (Quatrefeges)	15. *Nerita (Ritena) yoldii* Recluz	15. *Cerithidea cingulata*	4. *Thalamita stephensoni* Crosnier	15. *Pillucina pisidia*
16. *Ophelia acuminata* Oersted	16. *Stenothyra glabar* A.Adams	16. *Cerithidea microptera*	5. *Archaster typicus*	16. *Cadella*
17. *Polyophthalmus pictus* Dujardin	17. *Certhidea cingulata*	17. *Clypemorus trailli*	6. *Allanetta bleeker* (Gunther)	17. *Moerella iridescens*
18. *Diopatrs chilenis* Quatrefages	18. *Certhidea rhizophorarum* A.Adams	18. *Calyptrea morbida*	7. *Centriscus scutus* (Linnaeus)	18. *Nitidotellina iridella*
19. *Onuphis eremita* Audouin et M. Edwards	19. *Certhidea* sp.	19. *Thais echinata*	8. *Ambassis kopsi* Bleeker	19. *Solen grandis*
20. *Eunice indica Kinnerg*	20. *Batillaria zonalis*	20. *Columbella turturina*	9. *Gerres macrosoma* Bleeker	20. *Gafrarium pectinatum*
21. *Marphysa belli* Audouin et M. Edwards	21. *Nassarius dealbatus*	21. *Pyramidella ventricosa*	10. *Lutjanus kasmira* (Forkal)	21. *Gafrarium divaricatum*
22. *Lumbrineris heteropoda* (Marenzella)	22. *Euraphia withersi*	22. *Otopleura auriscati*	11. *Halichoeres leparensis* (Bleeker)	22. *Ciece scripta*
23. *Arabella iricolor* (Montagu)	23. *Metapenaeus ensis*	23. *Lingula anatina*	12. *Leptoscarus vaigiensis* (Quoy et Gaimard)	23. *Marcia hiantina*
24. *Owenia fusformis* Delle Chiaje	24. *Alpheus* sp.	24. *Archaster typicus*	13. *Parapercis cylindrica* (Bloch)	24. *Laternula* (*L.*) marilina
25. *Terebellides stroemii* Sars	25. *Camptandrium sexdentatum* Stimpson	**Trawl net benthos**	14. *Tripterygion etheostoma* Jordanet Snyder	25. *Strombus urceus*
26. *Phalacrostemma* sp.	26. *Acmaeopleura* sp.	1. *Metapenaeus ensis*	15. *Dasson* sp.	26. *Mitrella bella*
27. Polychaeta	27. *Hemigrapsus sinensis* Rathbun	2. *Penaeus (P.) semisulcatus*	16. *Leptoscarus Acentrogobius ornatus* (Ruppell)	27. *Nassarius dealbatus*
28. *Siphonsoma* sp.	28. *Metaplax longipes* Stimpson	3. *Penaeus (Marsupenaeus)*	17. *Ctenogobius criniger* (Cuvier et Valenciennes)	28. *Pyramidella ventricosa*
29. *Barbatia decussata* (Sowerby)	29. Diogenidae	4. *Alpheus japonicus*	18. *Pardachirus xenicus* Matsubara et Ochiai	29. *Balanus reticulatus*

ANNEX 1 *cont.* **Catalogue of associated species in different sites.**

HEPU	PEARL BAY	LI'AN	XINCUN	LIUSHA
30. *Scapharca gubernaculum* (Reeve)	30. *Opheodesome grisea*	5. *Chanos chanos*	19. *Parascorpaena picta* (Cuvier et Valenciennes)	30. *Metapenaeus ensis*
31. *Modiolus* (M.) *philippinarum* (Hanley)	31. *Syngnathus djarong* Bleeker	6. *Allanetta bleekeri*	20. *Hypodytes indicus* (Day)	31. *Alpheus*
32. *Talonostrea talonata* Spnon	32. Gobiidae	7. *Sphyraena jello*	21. *Stephanolepis cirrhifer* (Temminck et Schlegel)	32. *Thalamita admete*
33. *Fragum carinatum* (Lynge)	**Qualitative Sampling**	8. *Hemiramphus quoyi*		33. *Camptandrium*
34. *Mactra* (*M.*) *A21* Philippi	33. *Trichomusculus subsulcatus*	9. *Osteomugil ophuyseni*	**Qualitative Sampling**	**Trawl Net Benthos**
35. *Merisca diaphana* (Deshayes)	34. *Clausinella isabellina*	10. *Ellochelon vaigiensis*	22. *Chlorostoma nigerrima* (Gmelin)	1. *Cerithidea cingulata*
36. *Moerella rutila* (Dunker)	35. *Nassarius dealbatus*	11. *Apogon amboinensis*	23. *Peristernia nassatula* (Lamarck)	2. *Clypemorus bifasciatus*
37. *Nitidotellina iridella* (Martens)	36. *Tachylleus* sp.	12. *Sillago maculata*	24. *Salmacis dussumieri* (L. agassiz)	3. *Drupa margariticola*
38. *Macoma* (*Psammacoma*) *candida* (Lamarck)	37. *Metapenaeus ensis*	13. *Caranx* (*C.*) *sexfasciatus*	25. *Holothuria leucospilota* (Brandt)	4. *Vexillum vulpeculum*
39. *Asaphis dichotoma* (Anton)	38. *Metapenaeus intermedius*	14. *Gerres filamentosus*	26. *Syngnathus cyanospilus* Bleeker	5. *Vexillum ornatum coccinium*
40. *Solen grandis* Dunker	39. *Penaeus* (*Marsupenaeus*) *japonicus* Bate	15. *Gerres licidus*	27. *Apogon kiensis* Jordan et Snyder	6. *Nassarius* (*Reticunassa*) *festivus*
41. *Trapezium* sp.	40. *Penaeus* (*Fenneropenaeus*) *penicillatus* Alcock	16. *Gerres macrosoma*	28. *Chorinemus hainanensis* Chu et Cheng	7. *Nassarius* (*Zeuxis*) *hepaticus*
42. *Moerella rutila* (Dunker)	41. *Halimede ochtodes*	17. *Lutjanus fulviflamma*	29. *Gerres lucidus* Cuvcier	8. *Scapharca gubernaculum*
43. *Periglypta reticulate* (Linnaeus)	42. *Mictyris longicarpus* Latreille	18. *Lethrinus haematopterus*	30. *Therapon thraps* (Cuvier et Valenciennes)	9. *Placuna* (*P.*) *placenta*
44. *Clausinella isabellina* (Philippi)	43. *Macrophthalmus* (*M.*) *dilatum*	19. *Therapon thraps*	31. *Upeneus luzonius* Jordan et Seale	10. *Trachycardium carinatum*
45. *Turritella bacillum* Kiener	44. *Macrophthalmus* (*Mareotis*) *definitus* Adams et White	20. *Therapon jarbua*	32. *Upeneus tragula* Richardson	11. *Merisca perplexa*
46. *Certhidea cingulata* (Gmelin)	45. *Metopograpsus quadridentatus* Stimpson	21. *Siganmus oramin*	33. *Sillaga maculata* Quoy et Gaimard	12. *Nitidotellina minuta*
47. *Thais mutabilis* (Link)	46. *Metaplax elegans*	22. *Acentrogobius ornatus*	34. *Sillago sihama* (Forskal)	13. *Nitidotellina iridella*
48. *Mitrella bella* (Reeve)	47. *Cloridopsis scorpio*	23. *Paramonacanthus*	35. *Callionymus richardsoni* Bleeker	14. *Solen grandis*
49. Pyramidellidae	48. *Pentacta anceps*	24. *Stephanolepis cirrhifer*	36. *Siganus oramin* (Bloch et Valenciennes)	15. *Circe tumefacta*
50. *Bullacta exarata* (Philippi)	49. *Protankyra pseudo-digitata*	**Others**		16. *Circe*
51. Caridea	50. *Siganus fuscescens*	25. *Septifer bilocularis*		17. *Gafrarium pectinatum*
52. *Phalangipus* sp.	51. *Periphthalmus cantonensis*	26. *Modiolus auriculatus*		18. *Anomalodiscus squamosus*
53. *Portunus* sp.	52. *Scartelaos viridis*	27. *Pinctada martensi*		19. *Laternula* (*Exolaternula*) *truncata*
54. *Charybdis* sp.		28. *Dendostrea crenulifera*		20. *Penaeus* (*Marsupenaeus*)
55. *Metaplax longipes* Stimpson		29. *Trachycardium flavum*		21. *Penaeus* (*P.*) *semisulcatus*
56. *Balanus reticulatus* Utinomi		30. *Pitar* (P.) *sulfurea*		22. *Metapenaeus joyneri*
57. *Holothuria scabra* Jaeger		31. *Gafrarium pectinatum*		23. *Metapenaeus ensis*
58. *Phyrella fragilis* (Ohshima)		32. *Gafrarium divaricatum*		24. *Parapenaeopsis hadwickii*
59. *Branchiostoma belcheri* (Gray)		33. *Circe scripta*		25. *Alpheus japonicus*
Trawl Net Benthos and Qualitative Sampling		34. *Circe tuimegacta*		26. *Portunus trituberculatus*
1. Spongia		35. *Tapes literata*		27. *Charybdis japonica*
2. Actinidae		36. *Trochus maculatus*		28. *Thalamita danae*
3. *Scapharca gubernaculum* (Reeve)		37. *Strombus urceus*		29. *Pilumnopeus eucratoides*

ANNEX 1 *cont.* Catalogue of associated species in different sites.

HEPU	PEARL BAY	LI'AN	XINCUN	LIUSHA
4. *Chlamys* (*Mimachlamys*) *nobolis* (Reeve)		38. *Erosaria erosa*		30. *Diogenidae*
5. *Talonostrea talonata* Spnon		39. *Moneteria* (*M.*) *moneta*		31. *Sillago sihama*
6. *Siphopatella walshi* (Reeve)		40. *Moneteria annulus*		32. *Johnius belengeri*
7. *Turritella bacillum* Kiener		41. *Mauritia* (*Arabica*) *arabica*		33. *Argyrosomus argentatus*
8. *Thais mutabilis* (Link)		42. *Columbella varians*		34. *Gerres lucidus*
9. Sepiolidae		43. *Bulla orientalis*		35. Siganmus oramin
10. *Balanus reticulatus* Utinomi		44. *Calappa hepatica*		36. *Acentrogobius caninus*
11. Diogenidae		45. *Euapta godefforyi*		37. *Solen ovata*
12. *Porcellana* sp.		46. *Archaster typicus*		**Shrimp from Electro-fishing**
13. *Cryptopodia gronicata* (Fabricius)		47. *Diadema setosum*		1. *Metapenaeus ensis*
14. *Portunus pelagicus* (Linnaeus)				2. *Metapenaeus joyneri*
15. *Charybdis japonica* (A.Milne-Edwards)				3. *Penaeus* (*Marsupenaeus*) *japonicus*
16. *Pentacta anceps* (Selenka)				4. *Penaeus* (*P.*) *semisulcatus*
17. *Astropecten monacanthus* Sladen				**In addition List**
18. *Archaster typicus*				1. *Archaster typicus*
19. *Arachnoides placenta* (Linnaeus)				
20. *Apogon quadrifasciatus* Cuvier et Valenciennes				
21. *Elates ransonneti* (Steindachner)				
22. *Zebrias zebra* (Bloch)				
23. *Paphia* (*Paratapes*) *undulata* (Born)				
24. *Metapenaeus ensis* (de Haan)				
25. *Metapenaeus intermedius* (Kishinouye)				
26. *Penaeus* (*Marsupenaeus*) *japonicus* Bate				
27. *Philyra olivacea* Rathbun				
28. *Thalamita sima* H.Milne-Edwards				