Chapter 4 Ecosystem Issues and Policy Options Addressing Sustainable Development of China's Ocean and Coast

4.1 The Importance of Sustainable Development for China's Ocean and Coasts

The next 10-20 years will be a key phase for China's strategic development and a critical period of rapid industrialization and urbanization. It also offers a chance to modify and perfect the country's development patterns. The international and domestic situations that China now faces are profoundly different than those of just a few years ago. Now, not only does China have to respond to the global challenges of financial crises and climate change, it also has to resolve increasingly serious domestic resource shortages and environmental issues in order to regain a pattern of sustainable development. Furthermore, faced with a depletion of land-based resources, the knowledgeable development of the ocean and coasts becomes an essential step on the path toward the sustainable development of the Chinese economy.

4.1.1 Oceans-The Basis for China's Sustainable Development

China is an important coastal country with a continental coastline of more than 18 000 km. It possesses 6 900 islands[1] having an area of more than 500 m^2. China has a claimed jurisdictional sea area [2,3,4,5] of 3.0 million km^2 including 380 000 km^2 of territorial seas. The ocean, coasts, and offshore marine environments are therefore an important piece of the

[1] The National People's Congress Standing Committee legislation working team, Explanation of Sea Island Protection Law of China. 2010, China Law Press, p.165, 182.

[2] Data source: National Statistics Administration. Chinese Statistical Year Book-2008. Beijing: Chinese Statistics Press.

[3] China Institute for Marine Affairs (CIMA). Chinese Ocean Development Report-2010. Beijing: Chinese Ocean Press.

[4] For comparison, China's land area is 9.6 million km^2.

[5] Yang Jinsen, Collection of China Marine Strategy Papers. 2006, Ocean Press, p.271.

challenge for the sustainable development of China. The wealth of natural marine resources and the enormous value of marine ecosystem services are — and must continue to be an important contributor to the nation's socio-economic development.

Box 4-1 Marine Biological Diversity

China's marine jurisdiction includes: temperate, subtropical and tropical climatic zones crossing 38 degrees of latitude. There are 20 000 species residing in these zones including 14% of the world's fish species, 43% of the mangrove species, 14% of the cephalopods, and 33% of the Indo-west Pacific region's coral reef species. For example: there are 1 140 species in the Yellow Sea and Bohai Sea; 4 167 in the East China Sea; and 5 613 in the South China Sea.

China's offshore and coastal environment provides an array of resources for peoples' livelihoods, including biological resources, minerals, pathways for transportation, locations for port development, and tourism assets. It is estimated that the ocean supplies more than 20% of the nation's animal sources of protein; 23% of its oil and 29% of its natural gas reserves[6]; as well as providing pleasing locations for recreation. Apart from direct economic values, China's ocean and coastal environments offer countless habitats that contain a wealth of biological and genetic diversity, along with providing ecosystem services such as nutrient recycling, detoxification and shoreline protection. Further, the ocean also plays a key role in carbon sequestration, regulating the water cycle and climate, and is a major source of oxygen. These services are vital for human survival and development.

Box 4-2 Ecosystem Services and Functions

Scientists recognize four categories of ecosystem services: provisioning services such as food and water; regulating services such as the regulation of climate, floods, coastal erosion, drought and disease; cultural services such as recreational, spiritual, and religious benefits; and supporting services such as nutrient cycling and photosynthesis. Some key benefits provided by the ecosystem services of functioning marine systems include healthy seafood, clean beaches, stable fisheries, abundant wildlife, and vibrant coastal communities.

[6] See Footnote 5.

4.1.2 Marine Economy as a Driving Force for China's Socio-Economic Development

Since the 1990s, China has included the development of marine resources as an important theme within the nation's development strategy and has used the development of the marine economy as a major vehicle to help revive China's economy. China is placing increasing importance on marine resources, environmental protection, marine management, and marine industries – allowing marine development to become one of the fastest growing sectors of the Chinese economy.

In the 21st century, the contribution of the marine sector to regional economic development has grown increasingly prominent. In 2008, total marine revenue[7] reached 2.97 trillion *yuan*, accounting for 9.87% of the national GDP and 15.8% of the coastal provinces GDP[8].

This rapid development of the marine economy has promoted employment in coastal areas. The workforce in marine-related industries has expanded from 21.1 million people in 2001 to 32.2 million people in 2008, accounting for 4.15% of the total national workforce and 10.3% of the coastal workforce in 2008[9].

Box 4-3 Marine Economy

Since 2001 there has been a 15% annual growth rate in marine revenues and marine industries. In 2008, the total marine revenue reached 2.97 trillion *yuan*, accounting for 9.87% of the national GDP and 15.8% of the coastal GDP. The main (principal) marine industries' 2008 revenues were 1.74 trillion *yuan*, accounting for 5.7% of the national GDP. By 2020, these main marine industries are projected to have revenues of 5.34 trillion *yuan*, accounting for 7.03% of the national GDP.

More importantly, the Chinese economy is currently highly dependent on an open global marine economy as China houses five of the world's 10 largest container ports. Nineteen percent of the world's bulk goods are shipped to China and 22% of the world's containers transporting exports come from China. China's merchant vessels are found in more than 1 200 ports internationally, and together they form an import-export economic structure that is utterly dependent on the world's oceans.

---

[7] Total Marine Revenue includes: marine tertiary industries; marine secondary industries; and marine primary industries. Ref. Statistical Bulletin of China's Marine Economy in 2008; SOA.

[8] Statistical Bulletin of China's Marine Economy (2001-2009); SOA.

[9] See Footnote 5.

In the past 30 years of Chinese economic reform, the structure of marine industries has undergone profound changes. Where marine salt and fisheries were once the leading industries, now the five most important (main) players are: marine transportation; marine tourism; fisheries; offshore oil and gas; and shipbuilding. Other industry sector players including marine energy, seawater resources, marine engineering, biopharmaceuticals, and marine science and education are now also playing an important supporting role. The five main marine industries contributed about 91% of the marine primary industry revenues in 2008[10].

Table 4-1 National Marine Primary Industry Revenue and its Ratio to National GDP [11]

[Trillions *yuan*]

	Rate of Increase [Year]	2008	2011	2012	2013	2014	2015	2016	2018	2020
Total National Marine Industry Revenue	10%	1.735 1	2.262 7	2.489 0	2.737 9	3.011 7	3.312 8	3.644 1	4.409 4	5.335 3
GDP	8%	30.067	37.875 8	40.905 8	44.178 3	47.712 6	51.529 6	55.651 9	64.912 4	75.713 8
GDP% Ratio		5.7	5.97	6.08	6.19	6.31	6.42	6.55	6.79	7.05

Projections show that by 2020, the revenue generated by the Chinese marine primary industries will reach 5.34 trillion *yuan* accounting for 7% of the projected national GDP. One should note that this represents an expected 100% growth in the sector during the next decade.

4.1.3 Sustainable Development of the Ocean and Coasts: Pillars to Support and Secure Coastal Development

In the 30 years following the Chinese economic reform, China's opening-up policy has evolved from establishing special economic zones — including some southeastern coastal cities — to a multi-dimensional approach that includes many regions. Yet due to their advantageous locations, rich marine resources and policy strategies, China's coastal areas are seeing an increasing concentration of industrial and broader economic activity. Currently, China has formed a coastal ribbon of high economic development, which has brought with it population density and urbanization.

From 2001 to 2008, the total GDP of the 11 coastal administrations increased by an

[10] See Footnote 5.

[11] China Institute for Marine Affairs (CIMA). Chinese Ocean Development Report-2010. Beijing: Chinese Ocean Press. Page 226. Note: Predicted values are for marine primary industries only.

annual rate of 10% reaching 19.47 trillion *yuan* or 57% of the total national GDP. The coastal population is currently 554 million. Though China's coastal area constitutes only 13% of its total landmass, more than 40% of the Chinese population now lives in this area. The region is responsible for 90% of China's imports and exports[12].

Coastal areas are now also heading into a new stage of industrialization. Local governments of coastal administrations are introducing a full range of supporting policies and measures, creating an upsurge of marine-related development. At the same time, in response to the global financial crisis, the Central Government has introduced a series of important policies some of which aim to satisfy domestic land demand and to ensure economic growth and the adjustment of infrastructure to suit future development expectations.

In 2009, China introduced several key industrial revitalization plans for steel production, shipbuilding, automobile and equipment manufacturing, and the result has been significant restructuring. Looking at long-term development, there will continue to be large-scale relocation of petrochemical, steel, shipbuilding, and thermal and nuclear power industries into coastal areas, making the continuing industrialization and urbanization of these regions inevitable. In the new industrial development of coastal areas, the five main industries will be: heavy industries, ports and logistics, shipbuilding and marine engineering, modernized fisheries, and marine tourism – all of which are expected to undergo rapid change. These major developments are obviously linked with the ocean and coasts and will require ongoing access to marine areas and resources to fuel their progress.

Projections suggest that by the year 2020, the GDP from coastal areas will experience a 2.5 fold increase from 2008 figures and will reach 47 trillion *yuan*, goals that have been set in order to achieve a moderately well off society. According to Chinese demographic research, the national population will reach 1.45 billion people by the mid-2020s and 1.5 billion by 2030. In 2020 and 2030[13], the coastal areas' population will grow to 700 million and then 840 million people. At the same time, the industrialization of these coastal areas will require new adjustments and the redistribution of marine spatial resources. Total shoreline occupied by harbours may increase from 600 km to more than 1 000 km; coastal industries and urban development may require sea reclamation of more than 5 000 km^2; port construction, ship building and marine tourism industries will all need to expand their marine space; and modernized fisheries industries will need to develop seaward towards deeper waters. Marine space is one of the main elements in supporting sustainable economic development in the future, and therefore ecosystem functions must be considered when analyzing the ca-

[12] See Footnote 5.

[13] Jiang, Z.H., Xu, K.D. and Song, J. 2006. Research Report on National Population Development Strategy, Beijing.

pacity of marine spatial resources to accommodate projected development needs.

Box 4-4 Coastal Population
By 2020 China's coastal population is expected to grow to 700 million; and, by 2030 it is expected to be 840 million. It is currently 554 million.

4.2 Historical Background of China's Sustainable Development Policy

In 1996, sustainable development officially became one of China's basic development strategies. It evolved from originally being a scientific consensus into being an important element of Government policy and operational programming. China's Ocean Agenda 21 proposed the background, aims, and priority areas for the sustainable development of marine areas. Since the implementation of Agenda 21, the sustainable development of China's ocean and coasts has seen an almost 15-year history, which coincides with the period of transition in China's economic and social development. The terms 'a moderately well-off society', 'harmonious society', 'environmentally friendly' and 'resource-saving society', and 'ecological civilization' are now all continuously employed at the highest levels of government, shaping progress and defining China's sustainable development. Also China is signing and joining many environmental treaties and conventions such as the GPA etc.. The process by which China is sustainably developing its marine areas is seeing continuous improvement, and there is a growing capacity for truly sustainable development of the ocean and coasts.

Box 4-5 GPA – Marine
The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities is a long-standing UNEP led initiative to assist States to protect their marine environment from land-based sources of pollutants. It addresses pollutants such as sewage, heavy metals, hydrocarbons, radioactive waste, litter, nutrient over-enrichment, and the physical alteration and destruction of critical habitats.

4.2.1 Strategy and Planning for the Sustainable Development of the Ocean and Coasts

In 1996 and 1998 respectively, the China Ocean Agenda 21 and the White Paper. 'The Development of China's Marine Programs' were published, together forming the foundation for a sustainable development strategy for China's ocean and coasts and for a national marine policy. With the arrival of the 21st century, the government has shifted even more of its focus onto marine development.

China's program outline of the 10th Five Year Plan of the National Economy and Social Development, passed in 2001, was the first high-level national development strategy to mention the ocean and coasts. It did so in the following statement: 'Strengthen research on marine resources, development, protection and management, improve research on the utilization of marine resources and develop marine industries; and increase the usage of marine areas and protect national maritime interests'. The State Council released the National Marine Economic Development Plan in 2003, proposing key tasks such as developing the marine economy and protecting marine ecological habitats.

In 2006, the 11th Five Year Plan of the National Economy and Social Development of China was endorsed during the Fourth Session of the 10th National People's Congress. This marks the first time an individual chapter was dedicated to the ocean. It proposed strengthening marine awareness, protecting national maritime interests, protecting marine habitats, developing marine resources, implementing marine integrated management and promoting the development of the marine economy. It also outlined the rational use, protection and development of marine resources. The ocean being listed and placed in an important chapter in the national development strategy plan was a significant step towards the promotion of the sustainable development of China's marine industries. In January 2008, the State Council published the 'Planning Outline of National Marine Program Development,' which now lays out specific requirements regarding the aims and goals of protecting marine ecological habitats.

In 2002, the endorsed report of the 16th National Congress of the Communist Party of China proposed: 'The Implementation of Marine Development.' This marks the first appearance of the term 'ocean' in a National Congress report. In 2007, the 17th National Congress of the Communist Party of China clearly indicated 'Development of Marine Industries.' General Secretary Hu Jintao particularly emphasized the nation's intention to develop marine industries during his visit to Shandong, and he placed emphasis on the utilization of marine resources based on sound science and the nurturing of marine industries. The 12th Five Year Plan, which is being prepared currently by the State Council, is expected to place

ocean activities and marine resources at the same level as energy strategies, emphasizing the importance of the ocean and coasts in current national planning strategies.

As a conclusion, against a backdrop of socio-economic development and a determination to further implement proper scientific concepts, China's policies, laws and legislation regarding the sustainable development of the ocean and coasts are continuously improving. Though various phases of action plans allow sustainable development principles to be incorporated into marine industry plans and government-related policies, the emphasis on both the development of marine resources and the protection of ecological habitats means that marine environmental management and land-based pollution control need to be clearly integrated. The main focus must be on the protection of offshore marine environmental resources and further expanding development opportunities towards the open ocean by finding and creating new resources in deeper waters. On the other hand, marine management has evolved from single departmental administrative controls into an integrated management approach considering a combination of legal, economic, technical and the necessary administrative responsibilities. Various regions are now increasingly practicing ocean and coastal management using ecological systems as the basis for decision-making.

4.2.2 China's Actions on Ocean and Coastal Management

China's ocean and coasts are among the most intensely used marine areas on the planet and have made an extraordinary contribution to the nation's dramatic economic development during the past half-century. They have helped to transform China into a truly global marine transportation nation complete with modern shipbuilding industries and competitive harbours and ports. Those same waters support fisheries and innovative mariculture industries that lead the world.

This report generally focuses on the deteriorating environmental conditions of China's ocean and coasts and offers insights into why changes have occurred and what needs to be done to improve the situation. One should not, however, mistakenly conclude that China is currently standing still and not attempting to correct matters. The truth is that China has already achieved much in ocean management and is well positioned to achieve sustainable development of its ocean and coasts.

For example, it has only been in the last couple of years that leading ocean management nations have adopted marine spatial planning as a key tool in their arsenal for implementing marine area-based management, but China has been working with the idea for nearly two decades and implemented their own initial marine functional zoning scheme in 2002.

Fisheries nations recognize that seasonal closures are an important tool for the conser-

vation of fisheries resources and the consequential sustainability of their fishing industries. Many nations successfully implement these closure strategies across single species and selective areas but China has been boldly implementing full summer closures across all species at sub-national regional levels since 1995[14,15].

To aid decision making, some advanced ocean management nations have been undertaking statistical surveys of their marine-related activities for the last decade or so on various time scales. But here again China is a leading nation and has been producing a detailed statistical analysis of the economic value of their marine related activities annually.

Integrated coastal zone management (ICZM) is being implemented currently in many nations at the local level. The southern city of Xiamen initiated China's first ICZM programme in 1997[16]. Xiamen has created an ICZM model characterized by 'legislation first, centralized coordination, scientific support, integrated legal enforcement, funding guarantee, and public participation'[17]. This successful model is regarded as an ICZM demonstration site not only for East Asian countries but also for countries around the world. There are more than 20 local ICZM initiatives in China at present.

Box 4-6 ICZM

Integrated Coastal Zone Management is intended to bring together the management of the river basin to coastal sea linkages and the larger coastal and marine ecosystems, thereby putting the concept of ecosystem-based management into practice. An effective ICZM program will minimize multiple use conflicts; protect lives and properties from natural and man-made disasters; protect and conserve habitats and biodiversity; ensure the sustainable use of freshwater resources; and ensure food security for the coastal population. There are more than 20 local ICZM initiatives in China at present.

There are many other examples that can be added to this list of accomplishments China has successfully implemented ahead of other nations. However, these aforementioned (and other) examples have not been without their challenges and problems along the way. Often, China has moved ahead too quickly without a full understanding of the scientific conse-

[14] A reference of summer closures: Sherman K. & Tang Q. et al. 2005. A global movement toward an ecosystem approach to management of marine resources. Marine Ecology Progress Series, 300: 275-279.

[15] A decade of summer ban fishing in China, edited by Bureau of Fisheries, Ministry of Agriculture, China.

[16] Chua Thia-Eng; Dynamics of ICM: Practical Applications in Sustainable Coastal Development in East Asia. Manila: PEMSEA. 2008.

[17] The Third Ocean Institute and Xiamen University. The Strategic Action Plan of Ecosystem Based Jiulong River Watershed and Xiamen Bay Management. 2009.

quences and without a sufficient appreciation of the longer-term environmental transactional costs. One of the aims of this report is to suggest how China can improve its environmental management of these important activities.

China's legal system for the sustainable development of the ocean and coasts.

Since the Marine Environment Protection Law was passed in 1982, the Chinese government has implemented a series of additional pieces of legislation to promote the sustainable development of the ocean and coasts as well as the conservation of marine habitats. By the beginning of the 21st century, the Chinese government had already set up a relatively complete marine legal system and supporting legislation and regulations. The set-up and implementation of these laws and regulations has sped up the progress of the protection of the marine environment, marine management, and has also accelerated ecological restoration within China, effectively promoting the sustainable development of the ocean and coasts. However, challenges remain for the implementation of such legislation, and for the engagement of authorities and the full uptake of a wide range of responsibilities, including, for example, the necessary regulations and enforcement.

A number of crucial pieces of legislation now guide activity and provide a context for future policy decisions:

(1) The Marine Environmental Protection Law of the People's Republic of China (formulated in 1982, revised in 1999) is China's fundamental law for the protection of the marine environment and establishes the basic principles of protecting marine resources, preventing pollution, maintaining ecological balance, securing human health, and promoting sustainable socio-economic development. Within the Chinese legal system of marine environmental protection, the first category is generic and it is applicable to all marine environmental protection-related activities, which include: monitoring and management, pollution control, marine spatial planning, emergency response to major marine pollution incidents, marine protected areas, and the damage liability system. The second category is for the management of specific cases, namely supporting legislation for the implementation of the 'Marine Environment Protection Law', including: pollution prevention from shipping, offshore oil and gas exploration, marine dumping, prevention of pollution from ship dismantling, the building of coastal infrastructure and marine engineering works, and the prevention of land-based pollution.

(2) The Law on the Administration of the Use of Sea Areas. Before the 1980s, although various marine activities were restricted to certain marine areas, in principal, there was no corresponding legislation on the use of sea areas. In May 1993, the Ministry of Finance and the State Oceanic Administration jointly published the Law on the Administration of the Use of Sea Areas. The legislation, which received the endorsement of the State Council, clearly pro-

poses the establishment of 'maritime licensing' and payment for the use of sea areas, contributing to the initial establishment of the administration of the use of sea areas. The Law on the Administration of the Use of Sea Areas was passed in 2001 and officially put into force in 2002, marking the formal establishment of the management system for the use of sea areas. The basic sea area management regime includes a functional zoning system, and a sea area use payment system and property use rights system. China has completed the development of a national, provincial, municipal and county-level zoning scheme for coastal waters and a usage charge standard that is the basis of sea area management. Of some concern, however, is the fact that the current zoning scheme gives priority to social development over ecosystem protection needs.

(3) The Law for Island Protection. Under vigorous promotion by the National People's Congress, 'The Law of the People's Republic of China for Island Protection' was adopted during the 12th session of the 11th National People's Congress Standing Committee in 2009. The Island Protection Law consists of five key elements including: an island conservation plan; the protection of island ecological habitats; ownership of uninhabited islands; the protection of special islands; and the monitoring and control of island use. The legislation explicitly indicates the duties of all levels of government administrations for marine management regarding the protection and development of islands. Its introduction symbolizes the legalization of China's management, protection and development of islands.

(4) The Fisheries Law of the People's Republic of China covers all fisheries-related activities including marine fisheries. This law was adopted in 1986, and revised twice – in 2000 and 2004. In 1987, the Ministry of Agriculture released the Fisheries Law implementation guidelines which outline rights and management processes regarding the exploitation of fisheries resources. They also set specific rules regarding aquaculture, fisheries, and the enhancement and protection of fishery resources. The law established a system of harvesting permits and seed stock permits for aquaculture; determined allowable catch and a licensing system for the fisheries industry. The law also provided for permits for high seas fishing and fishing in waters under the juridisdictions of other countries; limited fishing areas, times, fishing methods and tools; the enhancement of fishery resources and conservation systems (fishery resources protection fee system, fishing ban, and restriction measures), and determined closed areas and seasons for fishing. State and Local authorities within the purview of the legislation also issued a number of supporting regulations and implementation measures.

4.2.3 The Status and Problems of Marine Management

4.2.3.1 The current status of marine management

Since the 1950s, China's marine management system has gone through significant de-

velopment and change. It has evolved from the management of individual industries to the combined management of industries and the marine environment, and finally, after decades of progress, China is gradually shaping an integrated ocean management system. In 2008, the State Council gave the State Oceanic Administration (SOA) the new task of focusing their work more on strategic marine research and the coordination of marine affairs, on top of their responsibility for marine management and administration. There are about ten other departments that are involved in marine-related affairs, including the Ministry of Environmental Protection, Ministry of Agriculture (Fisheries), Ministry of Land and Resources, Ministry of Communications (Transport), Ministry of Water Resources and the State Forestry Administration as well as provincial, state, county, and local government agencies.

Marine-related State administrations are obliged to implement management controls on marine-related activities under their jurisdiction according to the current legal system, which includes the 'Environmental Protection Law' and the 'Marine Environment Protection Law' and other supporting legislation. The SOA and other marine-related administrations have developed a series of provincial and national plans for the conservation of marine biological diversity and ecological habitats. The enlisting of marine habitats into national socio-economic development plans has increased the effectiveness of the overall management of the marine environment. With regard to marine spatial use, three systems related to marine spatial planning are in effect: marine tenure, rights to resources, and the paid usage of the sea. Each is implemented according to the 'Law on the Administration of the Use of Sea Areas.' Management of Islands – the planning and protection of island ecological habitats, ownership of uninhabited islands and the protection and monitoring of special islands – is conducted according to the 'Island Protection Law'. The Ministry of Agriculture and several levels of local governments carry out the management of fisheries and marine biological resources under the 'Fisheries Law' and other marine biological resources legislation.

It is in the nature of environmental issues that they do not respect administrative boundaries, therefore various government administrations are exploring new co-management arrangements for land, estuarine, coastal, and sea area activities to better address marine environmental issues. For example, on the 2nd March 2010, the Ministry of Environmental Protection and the SOA signed an agreement that signifies China's formation of a new environmental protection system for coastal land and seas. According to the agreement, both parties will strengthen communication and collaboration in nine areas, including monitoring nitrogen, phosphorus, petroleum and heavy metal pollution in key sea areas. The Ministry of Environmental Protection has already initiated environmental impact assessments for key strategic developments in the areas around the Bohai Sea, the economic zone on the western

coast of the Taiwan Straits and in the Beibu Gulf economic rim.

4.2.3.2 The problems of marine management

Even though the legal system in China dealing with marine resource management is already relatively comprehensive, the planning system is steadily improving and, among other things has established four levels of enforcement at national, provincial, local and municipal levels, thus shaping the capacity to manage marine habitats within territorial waters. However, several structural flaws remain at the governmental and industry-focused marine management levels, some of which are described below.

Firstly, marine management systems are not effectively marine-focused and need better internal coordination. China's marine management is, for the most part, handled by departments primarily responsible for land-based resource management, therefore China's administrative decision making is greatly influenced by the natural resources and industry development sectors. This fragmented system of development-minded management has resulted in the serious loss of marine resources and ecosystem functions and services, and is not conducive to the integrated management needed specifically to secure the protection of marine ecosystems as a whole. Accordingly, the management of marine resources and the implementation of environmental management continues being carried out through a stove-pipe management approach, where departments responsible for such things as ocean space, transportation, agriculture, oil & gas, and tourism manage both the land and marine functions and where there is a lack of coordination within agencies and between agencies on such important matters as joint law enforcement. This lack of coordination extends even between different governments (national, provincial, local) and different departments at the State level, and is an obstacle to the implementation of integrated marine management. There is currently no coordinated whole-of-government approach to marine management in China.

Box 4-7 Conflicting Marine Environmental Governance

The responsibility for China's marine and coastal environmental protection is scattered across different administrations of the Central government and coastal local governments. There is no single agency providing a whole-of-government coordinated approach for the sustainable development of China's marine territory. The responsibilities of the various departments are governed by different uncoordinated legislation, therefore causing many overlaps and conflicts of functions. There is an urgent need to create a high-level administration to oversee and coordinate the sustainable development of China's ocean and coastal activities.

Secondly, even though China has an adequate suite of marine legislation, the overall system lacks comprehensiveness, particularly when it comes to a coordinated approach to marine environmental protection. The existing series of marine-related laws and legislation are aimed at supporting development, industry protection, and the management of specific individual marine resources. They overlook other resources and industries, and there is a clear lack of a coordinated National Marine Strategy to provide guidance to policy makers. On the other hand, while the content and structure of many pieces of legislation emphasize shared high level marine protection issues, they lack *specific* solutions to the range of different regional problems that arise. The existing legislation cannot adapt to the needs of a modern integrated marine management system, especially with regard to region-specific marine environmental management challenges.

For example, China has joined the International Convention on Civil Liability for Oil Pollution Damage (1992), but due to the lack of domestic oil spill-related legislation on the criteria of assessing ecological impacts and compensation standards and claims, even though many oil spill incidents have caused serious damage to the environment and ecological habitats, they cannot be legally compensated for. In particular, vessels that carry less than 2000 tonnes of oil are not included in this convention, and there are no laws within China that regulate these vessels. Many oil spill incidents are caused by small-scale oil tankers, and they inflict serious damage on marine ecosystems. Another similar cause of the continued degradation of marine environments in China is the lack of policy to control non-point sources of marine pollution from agricultural activities.

At the same time, many marine environmental protection laws in China are concerned with the general *principles* of marine protection and lack specific necessary legal mechanisms and procedures; they provide inadequate basis for supervision, monitoring, reporting, assessment, and corresponding punitive measures. The result is poor implementation of environmental laws.

Thirdly, there is a lack of policy guidance coupling integrated marine management with river basin management. Currently, China has set up many pollution prevention and control projects within national, local and basin-wide areas; examples include the Huai River Water Pollution Control and Planning, and the Bohai Sea Blue Sky and Clear Water Projects. These sorts of projects are mainly 5-year water environmental management plans. However, for technical, economic and policy reasons, if these plans do not allow the connection between resource management and land use planning, they cannot be integrated within the nation's socio-economic development plans, making it difficult to achieve water environment goals and standards. Even after more than 10 years of com-

prehensive integrated treatment and the significant investment of financial resources, the water quality in the Huai River basin, Bohai Sea, Taihu Lake, and the Dianchi Lake is still not improved.

At the time of the development and implementation of integrated watershed management projects, many integrated marine and coastal management projects were also being developed at the national and provincial levels. An important issue is whether or not the linkage between river basins and adjacent marine waters was even considered. It is difficult to link various marine management initiatives at the scale of ocean, coasts, estuaries, and watersheds, with land-based management that is normally under the jurisdiction of local administrations. Fragmented area management models lead to problems in coordinating resource and environmental management systems. Hence, there is a lack of integrated river-basin-to-marine-management strategic planning.

There is as well the vital need for a coordination mechanism between marine management and the Chinese economy. For example, local governments responsible for managing coastal areas have developed their own individual economic development plans and there is a clear trend toward the rapid development of heavy industries all along the coasts. Even though there are environmental impact assessment requirements, these only give consideration to single projects and do not currently consider the cumulative impacts of numerous projects in a single area. There is a lack of integration between policies on the protection of the marine environment and localised economic development.

Finally, there is a lack of information-sharing mechanisms. On one hand, the nation's monitoring and data systems cannot satisfy the full needs for environmental protection because the monitoring standards are inadequate and enforcement is poor. On the other hand, there are many departments who monitor the environmental parameters of marine, river basin, and coastal pathways, including for environmental protection, marine quality, water quantity, fisheries stock assessments, and marine works. However, different departments use different monitoring standards and therefore generate different statistics. In some cases, conflicting situations arise, and therefore monitoring results are not readily shared among departments. Conflicting data pose a great threat to the development of an adequate marine management system. Overlapping work between monitoring agencies, and the lack of transparency of the data, cause a waste of resources and clearly contribute to poor decision making at the end of the day.

Box 4-8 Agricultural Pollution

Pollution from agriculture is one of the main environmental problems in China. The current river basin management practiced by China mainly focuses on point-source pollution with non-point source emissions being neglected. Even the new 2008 PRC Law on the Prevention and Control of Water Pollution does not include any specific regulations, standards or monitoring criteria for agricultural non-point source emissions. The highest discharged pollutants are from agricultural sources (44%), domestic sources (37%), and industrial sources (19%). These include: chemical oxygen demand, ammonia nitrogen, total nitrogen, total phosphorus, petroleum products, volatile phenols, and heavy metals.

4.3 The Ecological Challenges of the Sustainable Development of China's Ocean and Coasts

China's marine ecological habitats have distinctive regional characteristics and localized endemic species. Ecological health is highly dependent on coastal habitats, and ecosystems and biological diversity are particularly vulnerable. Due to the rapid development of marine industries and the coastal economy during the past three decades, coastal ecosystems and their habitats have been under significant threat and have deteriorated. Even though the Chinese government has given marine conservation high priority — including with measures to *prevent* the deterioration of marine environments — existing marine legislation remains much weaker than similar terrestrial environmental conservation legislation. Since the end of the 1970s, the health of coastal environments in China has weakened and ecosystems have suffered, which is a serious threat to the sustainable development of China's ocean and coasts. Moreover, as rapid development in coastal areas continues, the effort to ensure the sustainable development of the ocean and coasts will encounter many new risks and threats.

4.3.1 The Current Status of Chinese Coastal Environments

Since the beginning of the 1980s, profound changes have taken place in the type, scale, structure and nature of marine environmental problems. The four major issues are: the environment, the ecology, marine hazards, and shortage of natural resources. And though these four categories are conceptually quite straightforward, in reality they intertwine in ways that are unique to the Chinese situation, and they exert a compounded effect that is unlike common marine environmental issues familiar to most developed countries.

4.3.1.1 Serious pollution of coastal marine environments

In recent years, the degree of pollution within China's offshore waters remains high, with the area of polluted coastal waters increasing. In 2009 for example, polluted offshore waters covered approximately 147 000 km^2 [18], which accounts for over half of China's total coastal marine areas[19]. Polluted areas are mainly concentrated in large estuaries and bays, including Liaodong Bay, Bohai Bay, Laizhou Bay, Jiaozhou Bay, Xiangshan Harbour, Changjiang Delta, Hangzhou Bay and the Zhujiang River Estuary. Limited waste treatment has placed great pressure on the marine environment. The previously mentioned areas are largely the most developed coastal areas within China, and the developmental strategy of 'treatment after pollution' is one of the main reasons for the serious environmental problems.

Currently, the major marine pollutants include inorganic nitrogen, phosphate, and oil – where the main pathways are from land-based sources. Wastewater contains many persistent organic pollutants (POPs) such as polycyclic aromatic hydrocarbons, organochlorine pesticides, polychlorinated biphenyls and heavy metals that are occasionally detected. These POPs all pose a major threat to food safety and human health.

4.3.1.2 Damage to the health of marine ecosystems

Pollution, large-scale reclamation, and the invasion of exotic aquatic species have caused significant damage in coastal wetlands and the decline of biological diversity resulting in the degradation of coastal marine habitats. Monitoring results from 2009 show that China's healthy, sub-healthy and unhealthy coastal systems constitute 24%, 52% and 24% of total coastal waters respectively[20]. According to preliminary analysis, China has lost 57% of its coastal wetlands, 73% of its mangroves, and 80% of its coral reefs since the 1950s. Two-thirds of the coasts are under the threat of coastal erosion and the reduction of marine biological diversity. Moreover, populations of endangered species are facing serious declines.

Box 4-9 Ecological Disasters

Since the 1990s, ecological disasters caused by red tides, green tides and jellyfish blooms have been frequently recorded in China's seas, which provide an alarm on the overall health of marine ecosystems. The frequency and scale of red tides significantly increased since the late 1990s. The area of a single red tide can reach thousands of km^2. A large-scale green tide occurred

[18] SOA. Bulletin of China Ocean Environmental Quality (2001-2009).

[19] The coastal marine area is measured from the high water mark seaward to the ten-metre depth contour. This area quoted also includes internal waters (Bohai Sea for example).

[20] See Footnote 21.

for the first time in 2007, and has reappeared every year thereafter. The affected area of a green tide has reached tens of thousands of km^2. Since 2000, the biomass of giant jellyfish has been increasing and since these ingest large amounts of zooplankton, they rob fish of their food supply.

4.3.1.3 Increasing prevalence of marine hazards

The main environmental problems experienced in Chinese coastal waters include eutrophication, harmful algal blooms (HAB), coastal erosion, salt-water intrusion, and oil spills. Compared to the 1990s, the problem of HABs has become more serious both in terms of frequency and the size of the areas affected. From 2001-2009, the average occurrence of HABs was 79 annually, with the area affected reaching 16 300 km^2. The recorded HAB events and accumulated areas affected by HAB are now 3.4 times more than during the 1990s[21]. From historical statistics, there is a trend for HAB occurrence to be spreading from local to regional waters. Large-scale green tides occurred in consecutive years — 2008 and 2009 — causing direct economic losses of near 2 billion *yuan*. An HAB in the Yellow Sea raised global concerns due to its threatening of the Olympic sailing competitions in 2008.

As China moves from being an oil-exporting country to an oil-importing country, there is a corresponding increase in the volume of oil imports. Currently, China's volume of offshore oil shipments places it third globally after the USA and Japan. The annual growth rate of domestic oil output is 10 million tonnes. With the increase of oil transportation volume and the number of vessels involved, the risk of ship accidents has also increased and China's seas could become more prone to oil spill accidents. According to statistics provided by the Ministry of Communications, there were a total of 2 635 oil spill incidents from 1973-2006[22]. At the same time, the increase in offshore oil and gas exploitation has further increased the risk of oil spill incidents. The pipeline burst and resulting large volumes of oil spilled into the sea in Dalian in 2010 caused great ecological damage[23].

4.3.1.4 Decline of inshore marine fishery resources

Historically under-utilized, China's inshore marine fishery resources are now being over-exploited. Since the 1960s, the number and horsepower of fishing vessels has steadily increased, and fishing technologies have modernized and grown ever more efficient. In the mid-1970s, fishery catches reached three million tonnes. The harvest of traditional targeted species such as large and small yellow croaker dramatically decreased, while catches of lower quality fish species increased. Through the mid-1980s, catches rose an

---

[21] See Footnote 21.

[22] http://finance.qq.com/a/20070706/000458.htm

[23] http://www.cnr.cn/china/newszh/yaowen/201007/t20100719_506752529.html

average of 20% each year, and the main targeted species shifted to small sized pelagic fishes such as anchovies, mackerels, and scads which eventually constituted more than 60% of the total catch[24,25]. The accelerating harvest and a lack of systematic fisheries management then also combined with a loss of fishery habitats and the destruction of nursery and breeding grounds to create a decline in the offshore fishery resources evident today.

Box 4-10 Aquaculture

China has been the world's top producer of aquatic products since 1990, and is the only country where aquaculture production is greater than its wild capture fishing yield. In 2009, aquatic production was slightly more than 51 million tonnes, with more than half coming from aquaculture among which the dominant products were: fish, crustaceans, mollusks, seaweeds, and echinoderms.

4.3.2 Marine Ecological and Environmental Problems – An Increasingly Urgent Threat

4.3.2.1 Serious land-based pollution and the continuing deterioration of the marine environment

Land-based pollutants that are produced by human activities and then released into the marine environment through direct emissions such as river runoff and atmospheric deposition significantly impact marine environmental quality. Therefore, the control of land-based pollutants is of utmost importance to protection of the marine environment and the sustainable development of the oceans and coasts around the world. Since the establishment of the Global Program of Action by UNEP in 1995, the protection of marine environments from land-based pollution has been a common goal of more than 160 countries.

Land-based pollution is a key factor in the decline of conditions in China's ocean and coasts. For the past 10 years, the volume of pollutants carried by river discharge has steadily increased. River monitoring results for the period 2002-2007, show that pollutants carried to the sea by the major rivers (Changjiang River, Zhujiang River, Huanghe River, Minjiang River, Qiantang River and others) increased by 121.3% and reached up to 13.67 million

[24] Tang Q, 1993. The effect of long—term physical and biological perturbations of the Yellow Sea ecosystem. In *Large Marine Ecosystem: Stress Mitigation, and Sustainability*, pp.79-93. Ed. by K. Sherman, L. M. Alexander and B. O. Gold. AAAS Press, Washington, DC. USA.

[25] Jin X.S., Zhao X.Y., Meng T.X. 2005. The marine resources and habitat in the Yellow Sea and Bohai Sea. Beijing: Science Press.

tonnes in 2009. The Changjiang River and Zhujiang River contribute about 70% of China's total pollution run off into the sea[26].

In recent years, as efforts to control the point source pollution carried by rivers achieved some success, agricultural non-point source pollution was found to be a key contributor to increasing levels. The first national pollution census[27] shows that the chemical oxygen demand (COD) emitted from agricultural non-point source pollution reached about 13 million tonnes, which is 2.3 times the amount produced by industrial sources — indeed, in some watersheds, agricultural sources can outweigh industrial sources by as much as 5 times[28]. Pollutants transferred by rivers from agricultural and village sources affect the downstream coastal water quality and marine environment. Therefore, agricultural pollutants have become one of the more pronounced problems for the control of China's terrestrial and marine water pollution and this and other environmental problems in drainage areas should be addressed as soon as possible.

The nation's marine sewage discharge has declined from 13.63 million tonnes in 2005 to 8.36 million tonnes in 2008, a relatively dramatic decrease yet a total that still exceeds environmental quality standards[29]. The four major sea regions — the Bohai Sea, Yellow Sea, East China Sea, and South China Sea — all have high marine pollution discharge rates, on average exceeding the Integrated Wastewater Discharge Standard (GB 8978-1996) rate by 75%, with the highest being measured in the East China Sea where standards were surpassed by 92% in 2008. Looking at different oceanic regions, the Bohai Sea has a pronounced increasing trend in pollutant discharges; these are exerting great pressure on the marine environment.

Atmospheric deposition has become another of the most significant pathways for nutrient and heavy metal pollution entering the ocean, and densely populated coastal areas are particularly important sources of the nutrient loading (especially nitrogen). Excess nutrients have significant impacts on marine phytoplankton growth and development and in some serious cases cause HABs. According to a study, land-based soluble inorganic nitrogen is transferred to the western Yellow Sea mainly through atmospheric deposition, and the amount of ammonium nitrate has surpassed the amount deposited by streams[30,31]. Currently,

---

[26] See Footnote 21.

[27] The First National Pollution Census was done during October 2006 – July 2009. Ministry of Environmental Protection website

[28] The Bulletin of the First National Pollution Census. Ministry of Environmental Protection website

[29] See Footnote 21.

[30] Zhang J, Chen SZ, Yu ZG, Wang CS, Wu QM. Factors influencing changes in rain water composition from urban versus remote regions of the Yellow Sea. Journal of Geophysical Research, 1999, 104, 1631-1644

[31] Chung CS, Hong GH, Kim SH. Shore based observations on wet deposition of inorganic nutrients in the Korean Yellow Sea Coast. The Yellow Sea, 1998 (4): 30-39

China's monitoring of aerosols and rainfall is focused in specific cities and regions, but atmospheric deposition on marine environments is still at an early stage of research, lacking data from long-term and large-scale monitoring. Hence, there needs to be more in-depth research and monitoring work on the impacts of atmospheric deposition on oceans.

More than 70% of nutrients discharged into the sea are from land-based origins[32], and these and other sources of pollution being leached into the marine environment have led directly to a decline in marine water, sediment and biological quality. Beyond the obvious direct link to marine water quality, the volume of pollutants discharged into the sea has a direct connection to huge economic costs tied to marine fisheries, marine tourism, and human health and safety. Taking fisheries as an example, the average revenue loss caused by pollution reached 2.3% of total fisheries GDP[33,34]. Marine pollution also causes environmental degradation, the decline in biological diversity, and the loss of ecosystem services, each of which may be difficult to account for in monetary terms but is significant nonetheless.

It is expected that in reaching 2020, China's GDP will quadruple compared to 2000. Consequently, it is further expected that the amount of industrial and domestic wastewater and pollutants will reach double the 2003 figures as a baseline, and that the livestock industry will generate pollution nearing three times the 2003 levels. Coastal water pollution is predicted to grow much higher than the national average level (2-3 times)[35], placing tremendous pressure on offshore coastal environments.

4.3.2.2 Increased eutrophication of inshore waters, leading to significant ecological disasters

Eutrophication refers to 'a process of changing nutrient concentration and profile in seawater resulting from the enrichment of nutrients caused by anthropogenic activities, leading to further changes of the structure and function of marine ecosystems, and the degradation of their services and values'. As coastal population and production patterns and standards of living change, the amount of nutrient material discharged to the ocean also increases. Nutrient pollution caused by the large amount of nutrients deposited into the sea has become a global environmental problem. According to the recently published American and European coastal eutrophication evaluation results, 28% and 65% of the EU and USA seas

---

[32] Nengwang Chen, Huasheng Hong, Luoping Zhang, Wenzhi Cao. Nitrogen sources and exports in an agricultural watershed in southeast China. Biogeochemistry, 2008 (87): 169-179.

[33] Ministry of Agriculture-State Environmental Protection Administration. Bulletin of China's Fishery Ecological Environment, 2000-2008.

[34] Value of Fisheries GDP in 2009 was 594 billion *yuan*. China Fisheries News – May 2010.

[35] Cao Dong. Economy and Environment: China in 2020. Beijing: Chinese Environmental Science Press. 2009.

respectively experience varying degrees of coastal eutrophication[36,37].

Coastal eutrophication is an increasingly serious problem within Chinese waters, with the following key concerns: 1) The extent of sea area with eutrophication. Since 2000, more than 130 000 km^2 (nearly half of China's offshore coastal waters) have been found not to meet water quality standards. The source of the trouble is nitrogen (N) and phosphorus (P) overloading of coastal waters. 2) There exists a serious nutrient pollution problem within estuaries and bays. These include areas such as the Bohai Sea's Liaodong Bay, Bohai Bay and Laizhou Bay, the East China Sea's Changjiang River Estuary and Hangzhou Bay, as well as the South China Sea's Zhujiang River Estuary. 3) The nitrogen pollution in coastal waters is prominent. The average concentration of DIN in seawater exceeds the Grade-I level in most coastal provinces. In Shanghai and the Zhejiang province, the DIN concentration has exceeded the Grade-IV level for many years[38].

Box 4-11 Hypoxia

Coastal hypoxia is a low oxygen condition of inshore waters that occurs when oxygen levels fall below normal. It occurs when excess chemical nutrients run in from the land, e.g., from agriculture and sewage. Desirable marine and estuarine species, especially those in fisheries and aquaculture, are severely affected by hypoxia.

The trend for coastal nutrient pollution problems is upward, both in area affected and seriousness of the problem. From 2004-2009, sea areas with moderate eutrophication increased by 6%, those with severe eutrophication increased by 66%[39]. In turn, studies confirm that eutrophication is one of the main reasons for the increasing incidence of HABs globally.

Since the 1970s, there has been an increase in the frequency of HABs within Chinese waters, with a three-fold increase in the rate of occurrence every decade[40]. Algal blooms composed of Alexandrium, Karenia, Gymnodinium, Prorocentrum and other toxic and

---

[36] OSPAR Commission. 2003. OSPAR Integrated Report 2003 on the Eutrophication Status. London, U.K.: OSPAR.

[37] Bricker S., Longstaff B., Dennison W., Jones A., Boicourt K., Wicks C., Woerner J., 2007. Effects of nutrient enrichment in the nation's estuaries: A decade of change. NOAA Coastal Ocean Program Decision Analysis Series No. 26. Silver Spring, MD: National Center for Coastal Ocean Science. Online at: http://ccma.nos.noaa.gov/publications/eutroupdate/.

[38] See Footnote 21.

[39] Report on China's Environmental Quality. Ministry of Environmental Protection. Beijing: Chinese Environmental Science Press. 2009.

[40] Zhou M.J., Zhu M.Y., Zhang J., 2001, Status of Harmful Algal Blooms and Related Research Activities in China. Chinese Bulletin of Life Sciences, 13 (2): 54-59.

harmful dinoflagellates blooms continue to emerge[41]. The distribution and extent of harmful dinoflagellates blooms and the damage caused by them are all increasingly seriously. In 1999, the Bohai Sea area experienced a 6 000 km^2 HAB. Between the years 2000 and 2010, the East China Sea has experienced 10 000 km^2 large scale HABs every year. In 2005, Karenia blooms caused the death of large numbers of caged fishes in the coastal areas of Zhejiang Province, resulting in more than 10 million *yuan* in economic losses. In 2008, a large scale HAB affected the Yellow Sea, affecting 30 000 km^2 of sea and damaging a million tonnes of biological resources, causing a direct economic loss of 1.3 billion *yuan*. At the same time, the growing number of HABs exacerbates paralytic shellfish poisoning, posing a significant threat to human health and safety.

Hypoxia is another environmental problem closely related to eutrophication. Out of 415 sea areas that are affected by eutrophication, 163 areas are also experiencing hypoxia[42]. This serious lack of oxygen leads to the collapse of marine ecological systems and fisheries resources, resulting in the formation of dead zones. In recent years, bottom water hypoxia is increasingly evident in the areas surrounding the Changjiang River Estuary. From 1990 onwards, the probability of the occurrence of hypoxia in summer has increased by 90% and a wide extent of hypoxic zones has been observed[43, 44].

In addition to HAB and hypoxia, eutrophication also plays an important part in the proliferation of jellyfish and the decline of fisheries resources.

Under the driving force of coastal eutrophication, China's offshore coastal ecosystems are at a critical period of evolution. Given China's rapid economic development, increasing urbanization and energy consumption patterns, the problem of coastal eutrophication is certain to worsen in the future and will be one of the key challenges to China's marine environment. HABs and hypoxia will be more pronounced and will become a major threat to the health and sustainable development of the marine ecosystems within China.

4.3.2.3 Out of control large-scale sea enclosing and reclamation – weakening marine ecosystem services

The coastal areas of China have undergone four major sea enclosing and reclamation

---

[41] Wang B. D., 2006. Cultural Eutrophication in the Changjiang River Plume: History and Perspective. Estuarine Coastal and Shelf Science. 69(3-4): 471-477.

[42] Selman M., Greenhalgh S., Diaz R., Sugg Z., 2008. Eutrophication and Hypoxia in Coastal Areas: A Global Assessment of the State of Knowledge. WRI Police Note, Water Quality: Eutrophication and Hypoxia, No. 1.

[43] Science of China (D) 32(8)：686-694。Wei, H., He, Y., Li, Q., Liu, Z., Wang, H., 2007. Summer Hypoxia Adjacent to the Changjiang Estuary. Journal of Marine Systems. 69, 292-303.

[44] Wang B. D., 2009. Hydromorphological Mechanisms Leading to Hypoxia off the Changjiang Estuary. Marine Environmental Research, 67: 53-58.

phases since the founding of the Peoples Republic of China, including the last two decades, which have seen huge demand for the construction of cities, ports and industrial infrastructure. From 1990 to 2008, the total area of reclaimed land has increased from 8 241 km^2 to 13 380 km^2, an average increase of 285 km^2 annually[45]. According to incomplete statistics, as the new coastal development strategy unfurls, there will be a demand for a further 5 780 km^2 of sea to be reclaimed by the year 2020, which undoubtedly will create severe environmental impacts on coastal ecological environments.

The current sea enclosing and reclamation projects in China have the following characteristics: ① A change of the use of the land reclaimed from the sea. The reasons for the reclamation of land has changed from sea salt, agriculture, and aquaculture production into major developments of ports, harbours, coastal industries, and the development of cities. Therefore the economic gain from sea reclamation is dramatically increasing. ② The scale of sea enclosing and reclamation is increasing at a much faster pace of development. From 1990 to 2008, there was average sea reclamation of 285 km^2 annually, whereas it will be more than 500 km^2 per year from 2009 to 2020. These figures clearly illustrate an expansion in the scale and rate of reclamation activities. ③ Reclamation activities are mainly concentrated along the bays and estuaries of large coastal cities, and have enormous impact on the environment. ④ Most project design and evaluation is usually lacking; the approval period is short; the implementation of the reclamation is fast. ⑤ It is difficult to manage and monitor reclamation activities. Before the establishment of the Law on the Administration of the Use of Sea Areas in 2002, there was no regulation or monitoring or compensation involved in reclamation activities. Since the passing of that Law in January 2002, the management of sea reclamation activities has steadily improved, but the actual management and enforcement still faces many issues and problems.

Large-scale sea enclosing and reclamation has inflicted great damage on the Chinese marine ecological environment as a result of:

(1) The loss of coastal wetlands and ecological services. Coastal wetlands provide important and valuable ecosystem services such as the purification of water sources, detoxification, nutrient recycling, habitats crucial to biodiversity, regulation of atmospheric composition, and protection of the shoreline. Moreover, marine ecosystems, especially coastal wetlands, are important natural barriers against marine hazards such as flooding. The activities related to sea reclamation on coastal areas lead to a decline in coastal wetlands and a large-scale loss of those essential ecosystem services, and a diminished capacity of coast-

[45] Fu, Y.B., Cao, K., Wang, F. and Zhang, F.S. 2010. Preliminary study of the methods used to evaluate the potential impacts of sea reclamation. *Ocean Development and Management* 27 (1): 27-30.

lines to protect against marine hazards.

(2) The weakening of the carbon sequestration functions of the ocean and coastal wetlands influences. Oceans and coastal wetlands play an important role in the global carbon cycle. Sea reclamation affects large areas of the coasts and seas. The conversion of coastal wetlands into agricultural lands, urban areas and industrial lands will lead to the loss of areas for carbon sequestration and transform these places into carbon sources instead.

(3) The loss of habitats and feeding areas for birds. Since 1988, the reclamation activities in Shenzhen have destroyed large areas of mangrove forests, including 1.47 km^2 of mangroves in the Futian nature reserve, with a resulting decrease in the number of bird species from 87 (1992) to 47 (1998), a decline of 46%[46]. From 1956 to 1998, Shanghai Chongming Dongtan has experienced many phases of reclamation resulting in a total of 552 km^2 of reclaimed land. The reclamation activities have shrunk coastal wetlands and destroyed salt marshes. The living habitats of wetland birds have been destroyed and food sources have been removed. The winter populations of Eastern Curlew, Spotted Redshank and Mongolian Plover shrank between 1990 and 2001. From the winter of 1986 to the winter of 1989, the population of Tundra swans remained at a level of 3 000-3 500 but has steadily decreased in recent years. Only 51 were found during the winter of 2000/2001 in Dongtan[47].

(4) Decrease in the biological diversity of benthic species. Sea enclosing and reclamation work such as dredging and land filling causes dramatic changes to the marine environment, including the decline in benthic and community structural change. The development of the deepwater channel in the Changjiang River Estuary in 1998 caused a species diversity decrease of 87%, biomass decrease of 76% and a drop of 66% in average density, when monitoring results in May-June 2002 were compared with the baseline surveys from 1982-1983. In 2002-2004, 15 tonnes of benthic organisms were returned to the Changjiang River Estuary in restoration experiments after the construction of the north-south dike, although the diversity and biomass were raised, the community structure changed from crustacean to mollusks-dominated[48]. Sea enclosing and reclamation have also impacted Jiaozhou Bay, and intertidal species diversity has dropped from 154 in the 1960s to only 17 in the 1980s, leaving only 1 of the original 14 dominant species close to extinction[49].

---

[46] Xu, Y.G. and Li, S. 2002. The impact of urban construction and protective measures on the mangrove ecology and resources in Futian, Shenzhen. *Resources Industries* 3: 32-35.

[47] Ma ZJ, Jing K, Tang SM, Chen JK, Shorebirds in the Eastern Intertidal Areas of Chongming Island During the 2001 Northward Migration [J]. The Stilt. 2002 (41): 6-10.

[48] Zhen, X.Q., Chen, Y.J., Luo, M.B. and Wang, Y.L. 2006. Preliminary study on the restoration of benthos in the Yangtze River Estuary. *Journal of Agro-Environment Science* 2: 373-376.

[49] Liu, H.B. and Sun, L. 2008. Game analysis on the reclamation actions in Jiaozhou Bay and the protection countermeasures.

(5) Coastal landscape diversity damaged. After sea enclosing and reclamation is completed, artificial landscapes replace natural landscapes and valuable coastal and island landscape scenery and resources are damaged during the process. Currently, studies in Liaoning Province, Laizhou Bay in Shandong Province and other areas have gathered evidence of coastal wetland shrinkage, loss of wetland patches, decrease in wetland scenic diversity and evenness, and high rates of fragmentation and human disturbance. The loss of coastal landscape diversity has led to an increase in the vulnerability of ecological environments[50].

(6) Damage of fish habitats leads to unsustainable fishery resources. Most breeding and feeding habitats of fishes are in offshore shallow seas or estuaries, where most of China's sea enclosing and reclamation takes place. During large-scale sea enclosing and reclamation projects, the high concentration of suspended particles causes damage to fish eggs and juveniles. The destruction of breeding habitats causes difficulties in recruitment, which leads to negative impacts on the sustainable development of fishery resources. Reclamation projects also lead to a change in hydrological characteristics, affecting the migration of fishes, damaging the habitats of fishery populations, and causing a decline in fishery resources. For example, Fujian Mindong's Sandou Ao, Guangjing Yang, Minnan's Wuzhou Island, Green Island, and Tseung Kwan O are spawning areas of the large yellow croaker; Min and Jiulong Rivers are important areas for the juveniles and also for migrating adult ayu fish. Xinghua Bay, Meizhou Bay, Guanjing Yang and Xiamen Harbour are the main spawning areas of Japanese Spanish Mackerel. The various embankments for sea enclosures have transformed harbours and beaches into land and changed the coastal hydrology and sea bottom, all of which damages spawning, fishing and nursery areas and leads to a decline of fishery resources[51].

(7) Decline in water purification services, exacerbating coastal pollution. Large-scale sea enclosing and reclamation projects directly cause marine pollution through industrial wastes. The modification of coastlines and changes in the coastal hydrodynamic system weaken the resilience of the marine environment. In recent years, the increase in the occurrence of HABs in the western harbour of Xiamen can be correlated with the large-scale reclamation work around Xiamen Island. The reclamation activities around Hong Kong's Victoria harbour caused the accumulation of pollutants, exacerbating marine environmental pollution.

Ocean Development and Management 25 (6): 80-87.

[50] Han, Z.H., Li, J.D., Yan, H., Shen, T.Y.J. and Xu, C. 2010. Ecological safety analysis of the wetland of Liao River Delta based on landscape patterns. *Ecology and Environment* 19 (3): 701-705.

[51] Zhou, Y.H. 2004. Study on Fujian's tidal flatland reclamation using RS and GIS. Master Thesis, Fujian Normal University.

(8) Increased risk of marine disaster. Sea enclosing and land reclamation increases the risk of coastal land subsidence and coastal erosion, and weakens the ability of protection services for marine hazards.

4.3.2.4 Overexploitation of fisheries causing a decrease in the reproduction of resource population

The Fishery industry has contributed significantly to food safety and to the economic development of China. However, since bottom trawl is the principal fishing method and since exploitation of fisheries has surpassed stock-recovery ability, not only has the biomass of the fishery resource decreased dramatically, but so also have habitats been destroyed, resulting in the extinction of some commercially important species.

Overfishing has also caused biomass reduction of high-valued species and a decrease in body size (e.g., the average length of small yellow croaker decreased from 20cm in the 1970s to 10cm today). As well, scientists are concerned by observations of early maturation, and lowered trophic level. The catch of juveniles has increased, and the quality of catches decreased[52]. Also species extinction has meant that naturally dominant species are gone, biodiversity has decreased, and there has been a change of ecosystem structure and function that poses great difficulties for the restoration and sustainable development of marine fisheries [53, 54]. In addition, the discards and wastewater from fishing activity are harmful to the marine environment.

The development of mariculture has also had a significant impact on coastal and inshore marine ecosystems. Although the production of fed species, such as fish and shrimp, takes only 10% of the total mariculture production in China[55], they are the major source of pollution from mariculture. The feed for these species is composed mainly of trash fish or fishmeal, and its wide use may result in significant increase in N, P and organic wastes in the seawater[56]. Large-scale mariculture has posed severe stress on tidal and coastal ecosystems, resulting in the shift of habitats including wetland, seaweed bed and coral reefs, all of which has destroyed the spawning ground and habitat of some fishery species, and has had a nega-

---

[52] Zhang, B. and Tang, Q.S. 2004. Study on trophic level of important resource species at high trophic levels in the Bohai Sea, Yellow Sea and East China Sea. *Advances in Marine Science* 22 (4): 393-404.

[53] Jin, X.S. and Deng, J.Y. 2000. Variation in community structure of fishery resources and biodiversity in Laizhou Bay, Shangdong Province. *Biodiversity* 8 (1): 65-72.

[54] Tang, Q.S. 2006. Marine biological resources and habitats in China's exclusive economic zone. Beijing: Science Press.

[55] The Ministry of Agriculture, Bureau of Fisheries. China's Fishery Yearbook 1998 and 2009. Beijing: Chinese Agricultural Press.

[56] Cui. Y., Chen, B.J. and Chen, J.F. 2005. Evaluation of pollution caused by mariculture in the Yellow and Bohai Seas. *Chinese Journal of Applied Ecology* 16 (1): 180-185.

tive effect on the recovery of these fishery resources.

4.3.2.5 The proliferation of hydraulic engineering projects – impacts on estuarine environments

China has the largest number of large-scale hydro projects in the world. More than half of the world's large reservoirs (>15m in height) are found in China and these are mainly distributed around the Changjiang and Huanghe River basins. The construction of these projects has led to a dramatic decrease in river runoff and sediment load into the sea. The transported sediment from rivers decreased from 2 billion tonnes per year in the 1950-1970 periods to 3 to 4 million tonnes in the most recent decade, and that poses a serious threat to coastal environments. The Huanghe River, being one of the most important rivers historically in China, has decreased its sediment load by 87%. The Liaohe, Haihe and Luan Rivers have zero sediment transport into the sea and have experienced a 90% decline in runoff[57, 58, 59]. Although the rivers south of Haihe have not experienced such significant change in sediment load, the amount of sediment flux into the sea decreased dramatically, for instance, a 53% decline has been experienced in the Changjiang River[60, 61].

The decrease in river sediment leads to the erosion and retreat of deltas and coastal wetlands, and the decline in resources produces a dramatic change to the riverine ecological habitats. The Huanghe River delta experienced an annual *increase* of 23 km^2 during the 1980s, compared to an annual *erosion* of 1.5 km^2 since the end of the 20th century. This erosion phenomenon is also evident in the Changjiang River delta[62, 63]. There are a number of estuarine and coastal habitat ecological problems that are associated with the construction of large-scale hydraulic engineering projects, these include changes in structure and population of planktonic communities, a decline in biodiversity and primary production, and increase in

---

[57] Dai, S.B., Yang, S.L. Gao, A., Liu, Z., Li, P. and Li, M. 2007. Trend of sediment flux of main rivers in China in the past 50 years. *Journal of Sediment Research* 2: 49-58.

[58] Liu, C., Wang, J.Y. and Sui, J.Y. 2007. Analysis on variation of seagoing water and sediment load in main rivers of China. *Journal of Hydraulic Engineering* 12: 1444-1452.

[59] Yang, Z.S., Li, G.G., Wang, H.J., Hu, B.Q. and Cheng, Y.J. 2008. Variation of daily water and sediment discharge in the Yellow River lower reaches in the past 55 years and its response to the dam operation on its main stream. *Marine Geology & Quaternary Geology* 28 (6): 9-17.

[60] Dai, S.B., Yang, S.L. Gao, A., Liu, Z., Li, P. and Li, M. 2007. Trend of sediment flux of main rivers in China in the past 50 years. *Journal of Sediment Research* 2: 49-58.

[61] Liu, C., Wang, J.Y. and Sui, J.Y. 2007. Analysis on variation of seagoing water and sediment load in the main rivers of China. *Journal of Hydraulic Engineering* 12: 1444-1452.

[62] Yang, S. L., M. Li, S.B. Dai, Z. Liu., J. Zhang and P.X. Ding, 2006. Drastic decrease in sediment supply from the Yangtze River and its challenge to coastal wetland management. Geophysical Research Letters. Vol. 33, L06408, doi: 10.1029/2005GL02550.

[63] Li, P., Yang, S.L., Dai, S.B. and Zhang, W.X. 2007. Accretion/erosion of the Subaqueous Delta at the Yangtze Estuary in Recent 10 Years. *Acta Geographica Sinica* 62 (7): 707-716.

HABs, and the degradation and disappearance of fish spawning grounds and hatcheries. As these hydraulic projects continue to develop, the negative impacts on the ecological environment will be more pronounced.

However, there are key questions that remain unresolved concerning how the impacts on estuaries and coastal habitats caused by major hydraulic engineering projects interact with other influencing factors, such as climate change and human disturbances.

4.3.2.6 Sea level, temperature rise and ocean acidification as potential new threats

Climate change influences many well known aspects of the marine environment, including sea level, sea temperature and ocean acidification[64]. It is projected that changes to these will influence the health of the marine ecosystems and also the sustainable development of Chinese society. Due to the geography of coastal regions and the level of human activity there, the impacts of climate change will be more pronounced in these areas. In the past decades changes to sea levels have already been observed, and it is anticipated that future climate change will bring even more serious impacts.

In the past 30 years, China's sea level has risen at an average of 2.6 mm/year, higher than the global average[65, 66]. According to predictions, China's coastal sea level may increase from 80-130 mm in the next 30 years[67]. Areas that are particularly vulnerable include the Changjiang Delta, Zhujiang River Delta, Huanghe River Delta and coasts around the Beijing/Tianjin area. Sea level rise is a slow-occurring marine hazard, but the long-term accumulated effects may include increased flooding, coastal erosion, seawater intrusion, soil salinization and other marine hazards[68]. These represent a threat to the living environment of humans, and the most direct impact of sea level change will be coastal wetland, tropical coral reef and mangrove forest losses. There will also be valuable coastland lost within the most economically developed areas.

Monitoring results from the past few decades have shown an upward trend in sea surface temperatures of China's coastal waters, and the sea surface salinity levels are also changing. For example, the Yellow Sea's temperature rise of 1.4℃, makes it one of the regional seas with the highest increase globally[69]. Changes in sea surface temperatures have

---

64 IPCC, 2007: Climate Change: 2007 Integrated Report.

65 Lin, Y. 2010. The rate of sea level rise in China is higher than the global average rate. *Guangming Daily*. Available at: http://www.gmw.cn/content/2010-01/28/content_1045930.htm

66 According to 2007 China Sea Level Bulletin, the world average sea level rise at the same time was 1.7±0.5mm/per year. http://www.soa.gov.cn/soa/hygbml/hpmgb/seven/webinfo/2008/01/1271382651226473.htm

67 SOA 2010. Bulletin of China's Sea Level, 2009.

68 See Footnote 68.

69 In the recent twenty years, the world average SST has been in an upward trend, with temperature increase at about 0.13 degree

important impacts on Chinese marine ecosystem, such as resource distributional modifications, restoration of mangroves extended to the north, and the calcification of tropical coral reefs. Chinese marine fishes have clear geographical characteristics, which means that rising sea temperatures will lead to changes in their geographical distribution and community structure. At the same time, warmer sea waters will affect human society in many ways including socio-economically and through the food chain as changes to habitats of marine organisms impact the fisheries and aquaculture industries. Sea temperature change will also modify patterns of marine biological resource exploitation and lead to a loss of marine ecosystem functions and services.

As atmospheric CO_2 concentrations increase, the impacts of ocean acidification are also more significant. Ocean acidification will affect the bone formation, metabolism and life histories of calcified organisms, leading them to fail at interspecific and community competition. These effects, passed down the food chain, will affect the entire ecosystem community, functions and services. Ocean acidification poses an especially serious threat to tropical coral reefs already facing pressures from human population expansion and human activities associated with economic development. For example, ocean acidification has led to the degradation and decline of Chinese coral ecosystems and a corresponding decline in coral reef marine tourism opportunities. In addition, China, as the worlds number one provider of global fisheries production, including shellfish, shrimps and crabs, needs to be mindful that these organisms are easily affected by ocean acidification.

Box 4-12 Atmospheric CO_2 Absorption

Seaweeds can transform dissolved inorganic carbon into organic carbon by photosynthesis. Filter-feeding mollusks can also clear out particulate organic carbon by feeding activity and through the process of calcification a lot of carbon can be imbedded in their shells. In this way, a significant amount of carbon is removed from the seawater by the harvesting of mariculture products.

Coastal areas are generally the worlds most highly populated and economically developed areas. In China, the Changjiang Delta, the Zhujiang River Delta and the Bohai Sea area are the three most important economic zones. Coastal areas are China's principal locations for key industries and economic development projects along the coast have become the driving force for China's economy. A point to note is that these coastal areas are particularly

C/10 year period. Cited from IPCC AR4 report.

vulnerable to climate change, as sea level rise will lead to marine hazards, coastal erosion, seawater intrusion, and has led to serious impacts to the coastal economic and societal development. It is foreseen that sea level and temperature rise and ocean acidification are leading to an increased occurrence and degree of a variety of marine hazards in the future.

The need to adapt to the impacts of climate change is closely linked to China's economic development and the interests of the Chinese people. Currently, China's marine capacity to respond and adapte to climate change is inadequate to meet the forseeable challenges. In order to effectively decrease the impacts of climate change and to assure the sustainable development of the coastal economic zones, it is vital to understand the role and function of oceans in climate change adapation. As we move forward, China needs to establish integrated management and coordination mechanisms with which to handle the challenges of climate change; it needs to increase the capacity of coastal areas to adapt; it needs to strengthen basic research on air-sea interactions; it needs to establish a comprehensive monitoring network of the marine environment; and finally, it needs to put in place measures to increase the nations resilience to marine hazards.

4.3.3 The Bohai Sea-the Hotspot of Chinese Marine Environmental Problems

The Bohai Sea, China's only inland sea, has an area of 77 000 km^2. It is surrounded by what is already China's most important economic zone and is expected to continue growing at a higher rate than the other zones. In recent years, the Bohai Sea's ecological services and functions have deteriorated so badly that it has become the nation's most talked-about marine environmental problem region. Unlike other polluted sea-spaces in China, the Bohai Sea is a semi-enclosed shallow body whose natural flushing processes are weak.

The Bohai Sea is bordered by four of China's most populous coastal administrative regions and in addition to receiving the outflow of seven regional water systems, it is also the recipient of waters from distant catchment areas and therefore sees the effects of their land-based point and non-point sources of pollution. Domestic and international experts and scholars agree that the Bohai Sea is likely to become a 'Dead-Sea' if effective remediation measures are not adopted soon.

(1) Environmental pollution is still the main focus of the Bohai Sea's environmental problems and the area of polluted coastal water is increasing. The major marine pollutants include inorganic nitrogen, active phosphate and oil, all originating from land-based sources. Pollution in the Bohai Sea had historically resulted from petroleum or heavy metal industries, but others have joined these sources such as light industry, domestic waste, agriculture, and air pollution.

The principal river systems around the Bohai Sea include: the Huanghe, Haihe, Liaohe, Luanhe, Shuangtaizihe Rivers; the Liaodong Peninsula Rivers and Shandong Peninsula Rivers. These river systems bring in large amounts of inorganic nitrogen and active phosphate, leading to increasingly serious eutrophication within the Bohai Sea and resulting in changes to the community structure of phytoplankton and the subsequent occurrence of HABs.

The shellfish within Bohai Bay have higher organic pollutants, oil and heavy metal residues than anywhere else in the area. DDT, petroleum products, lead, cadmium, and arsenic pollute the coastal sediment, and these have exceeded the Grade I Quality Standard for Marine Sediment. Hexachlorocyclohexane and polychlorinated biphenyls have exceeded the Grade Ⅲ Quality Standard for Marine Sediment. The monitoring stations south of Bohai Bay have shown levels above the Grade I Quality Standard for Marine Sediment in cadmium and arsenic, and levels of lead have also exceeded Grade Ⅱ Quality Standards. The monitoring stations north of Bohai Bay show that petroleum products, cadmium and arsenic have also exceeded Grade I Quality Standards.

Box 4-13 Strategic Environmental Assessments

SEA examines the environmental, and increasingly also the social and economic impacts and dimensions of policies, plans, and programs and other strategic undertakings. The trend for SEA in the marine domain is Regional-SEA, a proactive and futures-oriented approach to ensure that planning and assessment for a marine region supports the most desired outcomes rather than the most likely ones and informs subsequent project-based environmental assessments and decision processes.

(2) The Bohai Sea's ecosystem faces being significantly compromised by pollution. There are major threats to the health of marine ecosystems; fisheries resources are depleted, and ecosystem support to marine economic development is declining. Monitoring results have indicated that ecosystems within the Bohai Sea have all been classified as sub-healthy or unhealthy in recent years. The rapid development of the Bohai region's economy and people's rising standard of living have contributed to an increased dependence on coastal wetland resources, but the leading coastal wetlands and associated biodiversity are damaged. Reclamation, pollution, and the high level of sedimentation and over-exploitation have also damaged important natural wetlands. The coastal wetland area is shrinking and there is a loss or weakening of ecological functions. These problems in turn cause the acceleration of coastal pollution. Coastal reclamation and damming prevents the migration of aquatic organisms to their spawning and feeding grounds and threatens the survival of species. Fish

farms with open systems also increase the risk of the invasion of exotic species. Marine pollution, habitat destruction, overfishing and inshore ecosystem structural changes are causing the decline of traditional fishing industries and biodiversity reduction in the Bohai Sea. Currently, certain species of the Bohai's traditional commercial fishes, such as hair tails, sea bream and herring, are locally extinct.

As the pace of economic development in the coastal areas around the Bohai Sea increases, so does the scale of sea enclosing and reclamation. In 2009 alone, approved land reclamation in the Bohai region was about 60 km^2 (the real reclamation was far larger than this number however). Due to exploitational activities such as sea reclamation projects, road works, salt fields and aquaculture ponds, the coastal wetlands of the Bohai Sea are being lost permanently, or have become artificial wetlands providing weakened ecosystem services. Degradation of so many wetland ecosystems means a loss of ecosystem services, and there is a close connection between the loss of wetland ecosystems and increasing coastal pollution on the one hand, and the decline of fisheries resources and biodiversity on the other.

Forty rivers feed the Bohai Sea and these are the main source of water for marine ecosystems. In recent years, with the intensification of land development and construction, various activities have begun using increasing amounts of the available water, and this combined with declining rainfall has led to the drying up of some rivers and a resulting decline in the amount of water discharged into the sea. Along with a decrease in quantity, water quality has also become poorer. Salinity in river mouths has risen, as has the salinity of the whole of the Bohai Sea. This effect is particularly pronounced in the estuaries where an increase in salinity means the loss or degradation of spawning areas. The incidence of saltwater intrusion has also increased and the Bohai Sea area now accounts for more than 90% of the nation's total saltwater intrusion.

(3) The increase in marine hazards in the Bohai Sea area in turn increases the risk of oil spill incidents and these must become a top priority for mitigation amongst the various marine environmental problems.

The Bohai Sea contains many ports, and at the same time is the strategic base of the nation's oil reserves. Currently, the Bohai Bay is the largest marine oil field in China. Up until 2009, a total of 23 marine gas fields, 1 932 oil wells and 175 oil platforms had been built/operated in the Bohai Sea. It is forecast that the infrastructure for the oil, gas and chemical industries will be increasing in this area. Oil transportation in the Bohai Sea will reach 210 million tonnes annually by 2020[70]. Such intensive oil transportation in the area

[70] National Development and Reform Commission. 2009. *The Environmental Action Plan on the Bohai Sea 2008-2020*. Available at: www.pc.dl.gov.cn/qiye/ShuiWuFile%5C 渤海环境保护总体规划.pdf

and oil exploration activities mean that the risk of oil spillage will increase significantly.

The environmental problems in the Bohai were formed from long-term accumulation and involve a wide range of government and user conflicts and there is a need for the implementation of an efficient and integrated method as a solution. First of all, the sources of environmental problems are widely dispersed, from the upstream end of the Huanghe River down to the coastal zones at the river mouth, these areas all share economic and environmental benefits, making this a typical shared open resource. For example, a study showed that 60% of the Bohai Sea's pollution does not come from the 13 coastal counties, and fully 40% came from provinces that are not surrounding the Bohai Sea (only three provinces surround this area). So clearly the control of marine pollution has to consider the difficulties of working across administrative boundaries.

Secondly, each of the four coastal jurisdictions surrounding the Bohai Sea has its own economic development plan, and these tend to favour the further development of heavy chemical industries in coastal areas. Such ambition is feasible judging from the perspective of individual projects, however the cumulative impact of all these industries must also be considered.

Thirdly, oversight of marine resources and implementation of environmental management are carried out through divisional management. Various departments such as marine, transportation, agriculture, oil and gas and tourism have equal functions, and there is a lack of coordination of joint law enforcement systems or mechanisms. The lack of coordination between different departments has become an obstacle to the implementation of integrated marine management, causing difficulty in solving marine environmental protection issues that cross regions and departments.

Finally, the national government's marine and basin management of the Bohai Sea area on the one hand, and local government management on the other, cannot be well incorporated. The result is that relevant plans and standards or statistics cannot be correlated, and in some cases, conflicts may also arise.

Box 4-14 Ecosystem-Based Management

There are many explanatory definitions for EBM – Lackey (1998) illustrates it as follows:

Seven core principles, or pillars, of ecosystem management define and bound the concept and provide operational meaning:

1. Ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end;

2. Ecosystem management is place-based and the boundaries of the place must be clearly and formally defined;

3. Ecosystem management should maintain ecosystems in the appropriate condition to achieve the desired social benefits;

4. Ecosystem management should take advantage of the ability of ecosystems to respond to a variety of stressors, natural and man-made, but all ecosystems have limited ability to accommodate stressors and maintain a desired state;

5. Ecosystem management may or may not result in emphasis on biological diversity;

6. The term *sustainability*, if used at all in ecosystem management, should be clearly defined — specifically, the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs; and

7. Scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public and private choice.

A definition of ecosystem management based on the seven pillars is:

'The application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period'.

As with all management paradigms, there is no 'right' decision but rather those decisions that appear to best respond to society's current and future needs as expressed through a decision-making process.

Lackey, R. 1998. Seven Pillars of Ecosystem Management. Landscape and Urban Planning. 40: 21-30.

4.4 Lessons Learned and Trends in International Marine Management

4.4.1 Practicing Ecosystem-Based Marine Management and Marine Spatial Planning

Ecosystem-based management (EBM) is one of the new tools being used in international strategic marine management. The use of EBM as the basis for integrated marine management has consensus from the national agencies of many countries (including China), and specialists and scholars. In July 2010, for example, the USA Interagency Oceans Policy Task Force[71] released their final report proposal for a national marine policy for the USA, and listed the implementation of EBM as one of its first priorities. Subsequently, President

[71] www.whitehouse.gov/administration/eop/ceq/initiatives/oceans

Obama signed an Executive Order to implement the proposal[72]. Canada, Australia, the UK and others have also taken similar steps to implement EBM. International bodies have also proposed a concept of dividing the global oceans into pan-ocean ecosystems known as "large marine ecosystems," as a means of integrating, for example, fisheries management in the open oceans, coastal seas, estuaries, and river basins. The technique is viewed as a way to encourage the collaboration of national, multi-national, and international agencies for the protection of these resources.

Box 4-15 Marine Spatial Planning

Similar to land use planning, MSP is a relatively new process which identifies sea areas most suitable for various types or classes of human activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives that have been prioritized by government. China was a world leader when it introduced MSP in 2002 however, with eight-years of experience it is now time for China to revisit its earlier zoning decisions and revise its MSP using sustainable development (rather than economic gains) as its foundational element.

Recently, marine spatial planning (MSP) has also evolved as a favoured new tool under integrated ocean management on the international scene. MSP uses ecosystem protection as a basis for strategically allocating space, and for regulating, managing and protecting multiple, cumulative and potentially conflicting uses of the oceans and coasts. At the moment, the UK, Germany and Australia have implemented marine spatial planning, whereas the European Union (EU) is about to start MSP in the North Sea. The US/NOAA ocean policy research report published in September 2009[73] states that MSP is an effective tool to advance EBM in ocean policy.

4.4.2 Implementing Regional Specific Environmental Management

To protect and restore the ecological environment of the Baltic Sea, the Baltic Nations signed The Convention for the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention-HELCOM) in 1974. The Helsinki convention is a good example of

[72] www.whitehouse.gov/the-press-office/executive-order-stewardship-ocean-our-coasts-and-great-lakes

[73] Lindholm, J. and R. Pavia (Eds). 2010. *Examples of ecosystem-based management in national marine sanctuaries: moving from theory to practice.* Marine Sanctuaries Conservation Series ONMS-10-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 33pp.

member nations agreeing to regulate their individual domestic behaviours in order to collectively improve the levels of pollution entering their shared waters. Other relevant experience includes: Laws Concerning Special Measures for Conservation of the Seta Inland Sea of Japan; the Barcelona Convention for the Mediterranean Sea; the Convention on the Protection of the Black Sea Against Pollution; and the 1983-2000 Chesapeake Bay Agreement of the USA, all of which are region-specific management agreements.

Experience has shown that setting up regional governance committees can ensure the effectiveness of regional multi-governmental agreements. The Baltic Sea experience indicated that strong political will and support from top government officials is necessary for successful environmental protection and management.

Box 4-16 No Net Loss

In Canada and some other nations a 'No Net Loss Policy' is one of the most important decision points within environmental impact assessments when considering approvals for marine and coastal works. The object of the policy is to achieve no net loss of habitat productive capacity by primarily avoiding any loss at the site of the proposed activity. In cases where this cannot be achieved, various levels of mitigation or compensation are invoked. In all cases, the proponent will fund whatever measures are agreed to, into the future.

4.4.3 Initiating an Ecological Compensation Scheme and Sustainable Financing System for Environmental Protection

The key to the successful implementation of an ocean or coastal management project is to have an effective and sustainable financing system. Since the issue of pollution management normally requires management across different administrative boundaries, areas to be managed have different financial capabilities and different economic development priorities, as well as varying levels of participation in environmental governance. However, downstream areas are the beneficiaries of environmental governance in upstream areas; hence, many nations and international organizations are attempting to establish financial mechanisms that are suitable for whole-of-basin environmental governance.

In addition to government-coordinated financial mechanisms for environmental protection, another important policy method for coastal jurisdictions such as in the USA and EU nations is regulating the use of economic leverage to control the interests of environmental stakeholders and to establish compensation and restoration systems for ecological damage.

Ecological compensation is an important aspect of environmental economics policy, its core element being to internalize the external cost of potential ecological damage and ecological protection when undertaking marine works. Internationally, this system has two forms of compensation: the first is monetary compensation, where monetary values of the damage to ecosystem services are used to gauge the compensation. The other is in-kind compensation, which includes re-creation of the impacted ecosystem or mitigation and restoration of damaged ecosystems. One of the main aims of ecological compensation is that human activities will not cause a net loss of naturally-occurring resources. The Habitats Directive of the EU specifies that damage caused by reclamation projects for example, must be compensated, and the compensation plan must be completed before the proposed reclamation project is approved. Canada for example has had a compensation scheme attached to its no-net-loss policy for fisheries habitat since the 1980s.

4.4.4 Coordination of Marine Environmental Protection and River Basin Integrated Management

Since the late 1990s, in order to prevent marine pollution caused by land-based activities, the international community has promoted a 'mountaintop-to-oceans' strategy for marine pollution prevention. This approach emphasizes the coupling of integrated marine management and river basin management, to facilitate coastal area and ocean space planning, and to develop mechanisms for resolving inter-regional and national marine pollution issues. At the same time, the international community has also paid more attention to new marine pollution issues, such as eutrophication and hypoxia in estuaries, floating garbage collection, noise pollution affecting marine mammal behaviour, coastal pathogens, and the prevention of environmental issues caused by aquaculture and so forth.

Box 4-17 Hilltops to Oceans

Water in streams, rivers, reservoirs and groundwater serves as a vector to transport pathogens, nutrients, sediments, heavy metals, persistent organic pollutants, and litter large distances, from the Hilltops to Oceans. Globally sewage remains the largest source of contamination by volume, although industrial and agricultural pollution, and increased sedimentation, also threaten the health and productivity of ocean and coastal resources. Through improvements made to China's sewage management in recent years, agricultural pollution is now the most significant source. For the most part, in China, transported sediment is at its lowest volume since measurement records began.

4.5 Conclusions

The ocean is an extremely important basis for the sustainable development of China's overall economy and the well being of its people. It is one form of the nation's valuable capital. The sustainable development of China's ocean and coasts faces a variety of ecological and environmental challenges. First, the complex nature of pollution in the offshore environment is worsening. Secondly, marine coastal habitats are degraded and ecosystems have undergone drastic changes, which makes this a critical moment to undertake protection and restoration. Thirdly, there is a high frequency of marine hazards, which represent ongoing threats to marine development. Lastly, the *primary* economic coastal zones are linked with many environmental problems, and represent a potential source of new challenges and threats to the upcoming and developing *secondary* economic coastal zones.

The environmental problems faced by coastal and marine ecosystems are fundamentally socio-economic problems and the solutions to these problems require integrative policies and strategies. The basic principle is to integrate marine development and environmental protection in accordance with the country's socio-economic development strategies, in order to achieve a balance between marine socio-economic developments and the utilization and preservation of environmental resources. Employing advanced international concepts, entire ecosystems should be viewed as the basis for research, decision-making and action, so that land, ocean and freshwater are treated as a whole, and so that socio-economic development of coastal and watershed regions is conducted in such as way as to encourage protection of marine/riverine ecosystems and sustainable land use. These concepts also support sustainable, safe and healthy marine usage. They encourage the development of new strategic industries to facilitate changes in marine economic growth. These concepts also suggest innovative management structures and systems that might include an authority that can oversee inter-departmental conflicts and interests, and that can support various linkages between governmental administrations at different levels so as to encourage the involvement and commitment of different interested bodies.

4.6 Policy Recommendations

4.6.1 Recommendation 1: Develop a National Strategy for the Sustainable Development of the Ocean and Coasts

The next 10-20 years is the key period during which China accelerates and fully develops into a moderately well off society, and reaches the peak number of its population, as well as the height of its industrialization and urbanization. Rapid development of the coastal areas, coupled with a lack of national planning or even a general development strategy, will make sustainable development of the ocean and coasts extremely challenging. We recommend the National Development and Reform Commission and other relevant government administrations, based on the evaluation of China's Ocean Agenda 21, study and formulate a new path for the sustainable development of China's ocean and coasts, and that they lay out the basic principles, policy directions, and strategic goals for the sustainable development of China's seas for the next 20 years. This macroscopic guideline should include listing priorities for the various aspects of the coastal regions' overall economic development, maritime economy development, marine environmental protection, and the care of resources. For guidance, one may wish to consult the Marine Policy Statement[74] approach currently being advanced by the UK Government and its Devolved Administrations, and the Obama Administration's recent Executive Order to implement the USA's National Oceans Policy.

Particular priority should be given in the Strategy to the following issues that need immediate and urgent attention:

(1) Land reclamation from the sea.

(2) Eutrophication caused by land sources including agriculture.

(3) Fisheries and aquaculture practices that damage ecosystems.

4.6.2 Recommendation 2: Create a National Oceans Council

Sustainable marine development requires integrated management of ocean and coastal activities. However, no single government administration can manage the complex and comprehensive nature of the associated problems. In the short term, it is not possible for China to centralize ocean management, thus it is likely that multiple agencies (and multiple jurisdictions) will continue to manage ocean and coastal affairs. Setting up an overall plan-

[74] See the 'Governance' report located in Annex Two of the Final Report for further details on the UK's Marine Policy State-

ning committee and a coordination mechanism between agencies will strengthen the existing system by ensuring the enforcement of agreements in policies, and will guarantee the effective execution of existing maritime laws and policies.

It is therefore recommended that a National Ocean Council be set up, led by a Vice-Premier of the State Council, with committee members selected from leaders of the relevant government administrations with marine-related responsibilities.

Due to the urgency of China's marine ecological issues, the Council's initial tasks are to:

(1) Develop the National Strategy;

(2) Strengthen communications between various government administrations; and

(3) Coordinate and direct multi-departmental, multi-industrial and multi-regional projects in ocean development.

At an early date the Council should also focus on the unique and pressing problems encountered in the Bohai Sea by:

(1) Coordinating major marine and coastal area development projects;

(2) Managing and monitoring the implementation of the various plans;

(3) Shepherding the development of a Bohai Sea Area Environmental Management Law; and

(4) Coordinating all development projects that may impact the Bohai Sea ecosystem.

4.6.3 Recommendation 3: Develop an Integrated Ocean Management Legal Framework

To resolve the ecological issues related to the sustainable development of China's ocean and coasts, the legal system and the administrative and economic policies have to be integrated. In the past, there was more emphasis on administrative measures, whereas in the future the implementation of legislation should be used as a foundation that can serve, for example, to strengthen law enforcement capabilities and to facilitate the greater use of economic instruments.

It is recommended that the National People's Congress and the State Council start studying and drafting a PRC Ocean Basic Law, which should govern the development of the ocean and coastal economy, protection of marine ecosystems, and the promotion of sustainable development. This law should embody the principles of ecosystem-based management. To further improve on the marine legal system and realistically push toward improved ma-

---

ment.

rine ecological protection we recommend the relevant government administrations start drafting a PRC Coastal Area Management Law and a PRC Bohai Sea Area Environmental Management Law.

4.6.4 Recommendation 4: Implement Ecosystem-Based Integrated Ocean and Coastal Management

Ecosystem-based management and the integrated management approach emphasize using natural ecosystems as the unit of management, and scholars and oceans management experts globally view this as the most effective solution to environmental and ecological issues. We therefore recommend the following actions be undertaken:

4.6.4.1 Action 1: Review marine spatial planning using ecosystem functional units as a basis for decision making

China is a world leader in setting up and implementing marine spatial planning. However, the country's early mapping work emphasized economic development opportunities as the basis for making decisions. Along with the influence of the national coastal area development strategy, this gave rise to new conflicts regarding marine space, resource use and ecological damage. Therefore China must now objectively evaluate marine space, resource availability, and capacity, and must revise the existing mapping based on protecting ecosystem functioning. We recommend that, in a newly revised marine spatial plan, attention be paid to international ocean zonation theories and methods. We further recommend implementing ecosystem functioning as the basic principle for decision making so as to prioritize and manage marine economic activities and reclamation undertakings in a manner that meets the goals of sustainable development.

4.6.4.2 Action 2: Set up a red line system for coastal reclamation

In the context of a new marine spatial plan, China needs to fully consider the multiple applications and ecological value of marine resources and the ecological impact of reclamation in setting up an operational red line system. We recommend the use of scientific information to rank potential areas for reclamation, and to locate sensitive and vulnerable areas and ecological checkpoints as a way of prioritizing areas of protection within the red line for reclamation. As a priority, establish a red line system for bays, estuaries, islands and shallow beaches.

4.6.4.3 Action 3: Set up a compensation system for marine ecosystem services

Using integrated environmental and economic measures the government should require the identification of costs for marine development works including the costs of potential damage to coastal ecosystems. Due to the uniqueness of marine ecosystems, there

is a need for a specialized compensation scheme to be developed. Such compensation is especially important with regard to large development projects, but should also address coastal reclamation, oil spills, damage to marine protected areas, and river basin-estuary-bay areas. There will also be a need to initiate ecological compensation research and to build a few case studies for evaluation and learning. The focus in the short-term should be on coastal reclamation projects, where every proposal for the use of ocean space should be accompanied by a compensation proposal to ensure that project approvals are not provided until adequate ecosystem compensation is included. Options include the use of in-kind compensation, economic compensation and other methods to compensate the loss of ecosystem services. The aim of the exercise is to practice a policy of 'No Net Loss' of productive habitat.

4.6.4.4 Action 4: Set up Marine Protected Area (MPA) networks

MPAs are an effective means to protect marine ecosystems and biodiversity. The Task Force recommends that China further strengthen its current set of MPAs and, by 2020, designate 5% of the area of China's ocean and coasts as MPAs. Also, identify new candidate MPAs that complement the existing MPAs and help to build towards having a representative network of MPAs for the protection of various types of ecosystems and rare and endangered species.

4.6.4.5 Action 5: Augment restoration and re-creation of damaged marine ecosystems

In the past decades many Chinese marine ecosystems have been damaged. It is recommended that China set up marine ecological restoration/re-creation pilot projects at biodiversity hotspots, sites impacted by exotic species, islands, and climate-sensitive areas to carry out typical ecological restoration work, so as to sustain marine biodiversity and increase resilience to natural disasters and climate change.

4.6.4.6 Action 6: encourage conservation and enhancement of marine biological resources

Set-up management systems for the conservation of marine biological resources in the context of ecosystem-based management by: developing sustainable capture fisheries to promote effective resource stewardship; increasing the regulation of coastal and inshore fisheries; setting up species-specific marine protected areas; protection, restoration and conservation of critical fisheries habitats and biodiversity; optimizing artificial reef and sea ranching activities; and by improving the efficiency of wild stock enhancement.

4.6.4.7 Action 7: Develop new methods of fisheries with lower carbon footprints

Improve aquatic ecosystems and encourage the development of environmentally friendly marine algae aquaculture. Also, promote polyculture systems and initiate shellfish-dominated aquaculture to lessen the carbon footprint of the fisheries industries.

4.6.5 Recommendation 5: Implement an Optimal Plan to Minimize the Negative Impacts of River Basins on the Ocean and Coasts

Land-based pollution and major hydraulic engineering projects have severe negative impacts on estuaries and coastal areas. To minimize these impacts, we recommend the following actions:

4.6.5.1 Action 1: Establish best practices for controlling river-basin-to-estuarine pollution

Pollution reduction involves massive costs. Different tributaries impact the estuaries and coasts in different ways. It is necessary to formulate well-devised plans that are adapted to different types of river basins and agricultural pollution pathways. The objective should be to minimize the cost incurred while balancing the scale and effectiveness of pollution reduction measures.

In the light of escalating eutrophication problems along China's coasts, priority should be given to controlling the nutrient concentrations of nitrogen, phosphates and COD in river systems. We recommend using total nitrogen concentration as a controlling factor, and using a mass-balance approach, based on the carrying capacity of the receiving estuaries, to set the guideline levels for land-based pollution. We also recommend a fair distribution of nitrogen release quotas in the regions along the river system, and recommend increasing the monitoring of total nitrogen and air quality to cut down eutrophication in coastal areas.

4.6.5.2 Action 2: Reinforce the regulating of flow and sediment discharges due to hydraulic engineering projects

It is suggested that — under the coordination of the National Ocean Council — the Ministry of Water Resources, River Basin Management Committees and Sea Area Management Administrations should implement a plan to regulate river water and sediment discharges, taking into consideration the amount of sediment needed to sustain deltas, the minimum water requirement by cities along the delta coasts, and the minimum water level required to sustain estuarine and coastal ecosystems.

4.6.6 Recommendation 6: Strengthen the Long-Term Monitoring and Forecasting for Terrestrial and Aquatic Ecosystems, and the related Fields of Science

Long-term and constant monitoring of the marine environment, together with in-depth studies of marine science, are the foundations for effective resolution of problems existing in marine ecosystems. It is suggested that:

4.6.6.1 Action 1

Under the coordination and guidance of the National Ocean Council, government administrations that are involved with the marine environment should work together to monitor the watershed, estuary and the sea as a unit, standardizing monitoring indices and technology, and establishing a unified monitoring system for the atmosphere, watershed, and oceanic/coastal areas. A platform for information exchange should be launched to promote data sharing.

4.6.6.2 Action 2

To prevent eutrophication in the coastal environment, it is suggested that the Ministry of Environmental Protection and the State Oceanic Administration collaborate in strengthening the utilization of NO_x as a monitoring and control index for the atmosphere in the near future, and that nutritional salts (total nitrogen and total phosphorus) be used as the corresponding index for river basins. To control the volume and quality of freshwater entering the sea and to protect the estuarine ecosystems, various governmental administrations such as the Ministry of Environmental Protection, the Ministry of Water Resources and the State Oceanic Administration should work together to monitor the watershed, estuary and sea as a single unit.

4.6.6.3 Action 3

In the near future, emphasis should be placed on developing integrated research for addressing scientific questions concerning river basin and marine ecosystems. Management of ecosystems can be supported by scientific knowledge i.e. a deeper understanding of the mechanisms behind marine ecology and coastal ecosystem services. As an example, research should be conducted on the effects of large-scale coastal reclamation and climate change on marine ecosystems. Close attention should be paid to coastal areas that are densely populated and have thriving economic activities. A coordinating body for monitoring the marine environment should be established, and should be responsible for an environmental monitoring network that conducts laboratory studies and field observations and carries out demonstrations on regional ecosystem recovery.

4.6.7 Recommendation 7: Enhance the Early Warning and Emergency Response System for Major Marine Pollution Incidents

There are increasing risks associated with marine development since many heavy industries in China are clustered around the coasts and the scale of petroleum transport and oil extraction has grown. For example, painful lessons are learnt from accidents such as the Gulf of Mexico oil spill in 2010 and the explosion of oil pipelines in Dalian also in 2010.

Therefore there is a need to follow the international framework for protection of marine ecological systems through prevention and early warning signals, and to establish a system of early warning and emergency response for severe marine pollution incidents. A subcommittee should be formed under the National Ocean Council to deal with emergency response for severe marine pollution cases, and to lead and coordinate the efforts of different government administrations. In addition, there is a need to build a reporting system for severe marine pollution events; to conduct environmental risk assessments evaluating potential risks; to organize a scheme to facilitate early warning and information exchange; to improve the regional emergency response system; to strengthen the supervision of organizations responsible for potential environmental risks; and to ensure the implementation of various emergency response measures.

4.6.8 Recommendation 8: Establish a Campaign to Promote Ocean Awareness and Public Participation

Various media should be employed to provide wide publicity and to educate the public about the importance of the ocean and coasts, and to thus induce them to be actively involved in safeguarding the marine environment. In the face of massive coastal developments, this will help to create an atmosphere of marine ecological systems protection in society. A platform to support and enhance public participation in decision-making processes concerning important ocean development projects should be established. This will permit and encourage more stakeholders to take part in policy decisions.