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Problems and countermeasures of coastline protection and utilization in China

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ABSTRACT

The coastline serves as a space carrier of marine economic development in coastal areas, and is an important platform for protecting marine environments and maintaining ecological balance. The integral components of a natural coastline have important ecological functions. In addition to the excessive economic development in China's coastal areas since the 1990s, other problems have occurred such as: a sharp decrease in natural coast due to the artificialization of mainland coastline, inefficient utilization of coastline resources by unplanned projects, weak legal enforcement by an imperfect management system, and impaired coastal functional value. By analyzing problems arising from the protection and utilization of China's coastline in the past 30 years, this paper reviews the relevant policies and regulations in China's marine administration. These issues are approached from the perspectives of an ecosystem, refined management of marine resources, scientific planning and natural coastline protection. The results indicate an improvement in the ecological environment through the introduction of multiple management systems. For instance, the natural coastline of China is currently decreasing at a rate slower than in 2008, and has a stable retention rate. Additionally, the over-exploitation of coastline has been curbed with a scientific and rational allocation of coastline resources; ecological problems such as coastal erosion, beach and coastal wetland degradation have been improved. The introduction of relevant policies, including, “Regulations on the Management of Coastline Protection and Utilization” fundamentally changed the passive decentralized management model. An initial institutional system that is in line with the protection and utilization status of China's coastline has been formed. Simultaneously, all levels of China's marine management departments are exploring and improving the coastline management system. Ultimately, this will provide valuable experience and practice in the protection and utilization of coastline for coastal countries across the world.

1. Introduction

Coastlines are hosts to marine development and are also an important platform for protecting the environment and maintaining the ecological balance of the coastal zone. Coastlines have been developing for hundreds of years (Airoldi et al., 2005). Much of Australia's coastline is reclaimed for agriculture or urbanization, while a seawall (or revetment) is formed on the periphery. This artificial coastline is used to protect the enclosing areas from storm surges, coastal erosion, and other marine disasters (Chapman and Underwood, 2011). More than half of the natural coastline in Japan (Koike, 1996), the United States (Davis et al., 2002; Chapman and Bulleri, 2003; Bozek and Burdick, 2005), Australia (Chapman, 2003; Bulleri, 2005; Bulleri et al., 2005; Bulleri and Chapman, 2010), and Europe (Bacchiocchi and Airoldi, 2003; Airoldi et al., 2005) are replaced by seawalls and other forms of artificial coastline, which creates a series of ecological problems. Most coastal countries take the coastline into their coastal management (Clark, 1996; Belfiore, 2000; Barragán, 2003), and the solutions to these problems depend on the coordination among departments at different administrative levels. (Ngoile and Linden, 1997; Fabbri, 1998; Salmona and Verardi, 2001; Garcia, 2002).

As of 2016, China's Gross Ocean Product (GOP) was USD $1061.9 billion (computed at 1:6.64, the exchange rate of Chinese currency, the renminbi (RMB) against the US dollar in 2016), an increase of 6.8% over the previous year, which accounted for 9.5% of the national Gross Domestic Product (GDP) (SOA, 2017). According to the growth rate, this figure will continue to increase. Other coastal countries are also experiencing similar situations. Specifically, the contradiction between coastal protection and development is becoming increasingly prominent given offshore development intensity, the expanding proportion of hardened

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mainland coastline, the declining natural coast, and the shrinking coastline resources. Some eco-environmental problems have occurred, along with the rapid economic and social development in Chinese coastal areas (damage to coastal functions, destruction of landscape and ecological functions, and lack of beach access for the public).

To address these problems, Chinese marine administrative departments have conducted research, formulated relevant policies, and put them into effect. On March 31, 2017, the State Oceanic Administration released the "Regulations on the Management of Coastline Protection and Utilization" (hereinafter referred to as Regulations). The introduction of "Regulations" is of great significance since it is the first systematic sectoral regulation for coastline protection and utilization in China. The "Regulations" stipulate that the State Oceanic Administration shall take charge of the guidance, coordination, and supervision of coastline protection and utilization. The coastal provincial governments shall be responsible for the supervision and management in their respective administrative areas, and shall meet the target of natural coastline retention rate. Therefore, it is crucial to analyze the problems arising from the protection and utilization of China's coastline in the past 30 years, and evaluate the effect of relevant policies formulated by China's marine administration. It is also necessary to explore the management system in line with China's current economic and social development to that of other coastal countries.

2. Review of China's coastline

As of 2012, the total length of China's mainland coastline is 19,048 kilometers (see Fig. 1). Guangdong Province, the longest, at 4006 kilometers, accounts for 21% of the total (Guan and A, 2013). Table 1 shows the length of coastline for each coastal province in China. The ratio of artificial coastline to total mainland coastline is 60.97% in China (Guan and A, 2013). The percentage of artificial coastline in Tianjin, Jiangsu, Shanghai and Liaoning Provinces is an alarming 70% (see Fig. 2).

Natural coastline refers to that which the interaction between land and sea has not been obviously influenced by artificial structures, whose original shore and swash zone are mostly preserved with original sandy, muddy, bedrock, or biological coastline, as well as with natural morphological and ecological functions after remediation. The majority of the bedrock coast is distributed along the southern end of Liaodong Peninsula, Jiaodong Peninsula in Shandong Province, Lianyungang City in Jiangsu Province and Hangzhou Bay in Zhejiang Province; sandy coasts are mainly distributed in Liaoning, the northern and central parts of Hebei Province, Lianyungang City in Jiangsu Province, Weihai and Yantai in Shandong Peninsula, southern part of Fujian, eastern and western part of Guangdong, southern Guangxi and some estuaries of the Pearl River; and muddy coasts are found in the Yangtze River estuary, the Pearl River estuary, the Yellow River Delta, the Haihe River estuary, the Yalu River estuary as well as in western Guangdong, Jiangsu, Shandong, Hebei and Liaoning. Moreover, in China's tropical and subtropical region, marine organisms play an important role in shaping the coast and forming biological coastline, such as coral reefs and mangrove forests. The coral reefs are distributed along the coasts of Hainan Island and Leizhou Peninsula, while the mangrove forests are found on the coasts of Fujian, Qinzhou Bay in Guangxi, Leizhou Peninsula in Guangdong, Dianbai County, Yangjiang and coastal Hainan.

3. Major problems of China's coastline

3.1. Rapid artificialization trend

Based on analysis of satellite remote sensing images, China's natural coastline is decreasing year by year. From 1990 to 2010, the natural coastline decreased by 2385 km, with an average annual reduction of 120 km, while the artificial coastline increased by 2992 km, with 150 km as the average annual increase (Gao et al., 2013). As of 2014, the retention rate of the natural coastline was less than 33% (Hou et al., 2016). However, the reduction rate of the natural coastline has lessened since 2010 and the retention rate of the natural coastline is more stable (see Fig. 3). According to SOA's monitoring result, the fishery-related coastline occupies the largest proportion among all sea use activities, accounting for 55.2%. Succeedingly, the coastline used for reclamation is 12.4%, and the coastline for transportation and industry is 9.8% and 7.4%, respectively. The coastline designations in recent years have witnessed more coastline being hardened for port construction, land preparation projects, and coastal industry. Due to the sharp decrease of coastline space, marine economy must confront a shortage of resources. Therefore, it is urgent that the natural coastline be appropriately protected and developed.

3.2. Low resource use efficiency

As mentioned earlier, among the approved coastal projects, the fishery-related coastline occupies the largest proportion, while the high-yield port transportation and coastal industry proportions are lower. Although aquaculture is the longest, its output value is low, with few benefits. That is, the occupied coastline is long, but the resource utilization level is low, and the phenomenon of irrational coastline occupation is critical. Moreover, it has posed pressure on surrounding marine environment, resulting in a sharp reduction in natural coastal wetlands (Xia and Xu, 2013), and therefore, a lack of functional benefits. Consequently, it is urgent to strengthen the review and demonstration of the waterfront, so as to improve the efficiency of the projects.

3.3. Imperfect management system

Before introducing the "Regulations," laws on the protection and utilization of the coastline were not established in China, and there was a deficiency of overall planning for the protection, development, and renovation of coastline. Coastline protection had no pertinence or hierarchy, and failed to form a unified and effective differentiated management model. Since there was no unified and standardized system, the natural coastline's hierarchical and classified protection contained errors. Due to insufficient policies and weak enforcement, coordination among the coastline management departments was inadequate. Furthermore, the contradictions among fishery, salt industry, transportation, land, city planning, environmental protection, tourism and other sea use activities were relatively prominent. Inevitably, the existing laws concerning the coastline are weak in pertinence and lack a comprehensively coordinated management system.

3.4. Impaired coastal function value

There are 8252 species of coastal wetland organisms in China (He, 2008). Among them, the total nitrogen and phosphorus removed by degradation in the natural reed wetlands of Liaodong Bay reaches 7632 tons and 360 tons respectively, corresponding to 8% and 2% of the total amount of marine pollution discharged from land (Qu et al., 2000). For a long time, the overexploitation of Chinese coastline, including coastal protection engineering (seawall, revetment, dike, etc.), coastal port engineering (docks and breakwater), and sea reclamation (reclamation seawall, revetment, dike reclamation, etc.), not only caused the artificialization of a majority of natural coastline, but also had a negative impact on coastal ecosystem environments and seawater hydrodynamics. The main effects are as follows: first, it causes coastal erosion or siltation; second, it alters the filtration and self-purification of gulf pollutants, resulting in insufficient gulf water exchange capacity and water quality deterioration; third, reclamation and other related projects destroy the natural coastline and directly occupy coastal wetlands, bays, estuaries and other ecological space, resulting in the loss of biodiversity; and lastly, natural beach, landscape, vegetation, wetland and