Ecological development of coastal wetland in north coast of Hangzhou Bay of Shanghai

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Abstract. Taking the north coast of Hangzhou Bay of Shanghai as an example, this paper studies the ecological development model of coastal wetland under the combination of the time background and environmental conditions. In this paper, the coastal wetlands in north coast of Hangzhou Bay of Shanghai were divided into 4 types according to needs, including tourism park, tidal flat reservoir, reed tidal flat wetlands, muddy coastal wetlands. Through the use of case studies, the cases of similar site conditions or environmental issues were summarized, so as to be 4 types of coastal wetlands to find more suitable ecological development measures to provide reference for decision makers and builders.

1. Introduction
The coastal wetland is located in the interlaced zone of ocean and land. Its complex geographical location determines its special habitat environment and is one of the most productive ecosystems in the world. According to statistics, China’s coastline spans 18,000km along the north-south coast, of which the coastal wetland area is about 5.941 million hectares, up to 10% of the national land area[1]. With the acceleration of globalization, all countries have focused their attention on the development of coastal resources. As a country with a large population, especially in the eastern coastal region, it is currently facing an important dilemma in social reform and economic development, so the development of blue resources has become the top priority of development measures[2]. Population and economic migration to the coast, artificial introduction of alien species, aquaculture, wastewater discharge, and unreasonable planning and layout have led to the shrinking of coastal wetland resources, environmental pollution and even collapse. Ocean ecosystem is facing many challenges and is gradually losing its ecological functions such as provide habitat, species maintenance, water quality. Since the 1950s, coastal wetlands have lost up to 2 million hectares due to changes in the natural environment and human activities (mostly attributed to human activities), accounting for 50% of the total area of coastal wetlands[3]. Whether the ecological protection and development can be balanced and the important functions of the coastal wetland ecosystem can be demonstrated has become an urgent and urgent task in coastal areas.

As a pioneer in reform and opening up, Shanghai is an international metropolis which has played a pioneering role in the ecological development and restoration of the coastal zone. Shanghai has successively issued ocean relevant documents such as "Shanghai Land Use Master Plan (2016-2040) for review", “Shanghai Marine Ecological Red Line Delineation Plan”, “13th Five-Year Shanghai Marine Ecological Environment Restoration Plan (Report)”, it can be seen that Shanghai’s efforts to improve the quality of the marine environment and protect marine ecology. Facing such situations, society should respond to the call for the construction of marine ecological civilization, follow the...
relevant positioning of higher-level planning and policies, and think about the ecological development of the coastal wetland in the north coast of Hangzhou Bay of Shanghai to form a comprehensive ecological development system in Shanghai.

2. Concept of coastal wetland
Understanding the concept of coastal wetlands is the scientific basis for further research, and the key issue in the theoretical system of coastal wetlands. After a long period of exploration and development of the discipline, academia have made differentiated definitions of coastal wetlands according to research needs such as "Ramsar" international wetland protection convention and the "China Wetland Classification and Grading Standards" formulated by the China Environmental Health Commission have both defined the concept of coastal wetlands[4]. Although many scholars have studied the definition of coastal wetlands, there is currently no standard and uniform definition of coastal wetlands[3]. This article combines the classification of Shanghai coastal wetlands in the "Shanghai Coastline Survey Statistical Report" which containing muddy (estuary) coastal wetlands, reed tidal flat wetlands, sandy tidal wetlands, artificial wetlands (paddy fields, aquaculture ponds, tidal flat reservoirs and salt fields) and research needs to define the coastal wetland in the north coast of Hangzhou Bay as follows: the area from the outside of the seawall to the outer edge of the large seaweed growing area, whether it is an artificial wetland (tourism park, tidal flat reservoir) or a natural wetland (upper tide reed tidal flat wetlands, intertidal muddy coastal wetlands, and estuary wetlands connected to the outflow river basin).

3. Overview of the coastal wetland in north coast of Hangzhou Bay of Shanghai

3.1. Coastal wetland distribution in north coast of Hangzhou Bay of Shanghai
The north coast of Hangzhou Bay of Shanghai in this study starts from the Nanhuizui landmark in the north to the boundary point of the Jinsiniang Bridge in the Shanghai-Zhejiang land area, Which include Dishuihu Port, Luchao Port, Zhonggang Port, Nammen Port, Jinhui Port, Nanzhu Port, Longquan Port 8 estuaries (sluices), totaling 90.62km ("Shanghai Coastline Survey Statistics Report"), showing a concave curved coast form. According to the definition of coastal wetlands in this study, field distribution of coastal wetlands and types in north coast of Hangzhou Bay was investigated(figure 1).

Figure 1. Types and distribution map of coastal wetlands in the north coast of Hangzhou Bay.
3.2. Site conditions of coastal wetland in north coast of Hangzhou Bay of Shanghai

3.2.1. Strong Tide River Bay. The Hangzhou Bay is connected to the East China Sea and has a trumpet shape with a maximum tidal range of 7.5m\(^5\). The tide is reciprocating in the east-west direction, and the period of rising and falling tides continues to be long which average high tide lasted about 5h25min and average ebb tide lasted around 7h\(^6\). The runoff is weak that the near-shore velocity is weak than the far-shore, with Jinhui Port as the boundary, the east of Jinhui Port is a silting state, the west of Jinhui Port is a scouring state, and storm surges such as heavy rain and typhoons in summer make plants along the line extremely vulnerable.

3.2.2. Mucky shore. The main incoming sand in the Hangzhou Bay is suspended sand, and the amount of sand is affected by three factors: the incoming sand from the Yangtze River, local tidal characteristics, and seasonal events such as wind and waves, but the most important factor is the incoming sand from the Yangtze River\(^7\). As a result, wetlands along the tidal flat continue to accumulate and develop into new land.

3.2.3. Dual ecosystems where brackish water meets. Hangzhou Bay is the intersection of the Yangtze River, Qiantang River, and the open sea. It is affected by both the freshwater ecosystem and the saltwater ecosystem. It is rich in species and is a place for spawning of many plankton and fish. There are low-salinity populations near the shore, high-salinity populations in the offshore, freshwater populations, and estuary brackish water populations.

3.2.4. Important "transit station" for bird migration. It is the middle end of migratory bird migration in East Asia / Australia, and the main migration site of the black-billed gull what is the world's rare and endangered bird\(^8\).

3.3. Problems of coastal wetland in north coast of Hangzhou Bay of Shanghai

Based on the analysis of the site conditions in north coast of Hangzhou Bay of Shanghai, We found some problems. Firstly, in the face of the Yangtze River and Qiantang River entering the sea, the sediment and the impact of tidal sand movement from the area caused a lot of suspended solids (SS) in the offshore water. Secondly, human activities have caused serious damage to coastal wetlands. For example, there are many organic pollutants such as N, P from endogenous water have caused red tide due to eutrophication; some factories directly discharge wastewater into the sea without treatment have caused the biomass reduce, then harmful substances in heavy metals which have increased and continued to accumulate that flow through the food chain will eventually cause life and health threats to higher animals and even humans: the reason of Minamata disease in which many people died in Kyushu, Japan is mercury-containing substances which are industrially excluded in the water body exceed the standard. Thirdly, coastal docks, ports, etc. will cause oil pollution under unconscious conditions which is difficult to be degraded and will survive on the animals and plants in the sea. Finally, as a typical coastal estuary wetland, coastal wetland on the northern shore of Hangzhou Bay is eroded by seawater, and the soil has a heavy alkaline structure that is difficult to maintain plant production.

4. Conception of ecological development in north coast of Hangzhou Bay of Shanghai

4.1. Case study

Through online inquiry, field visits, literature review, etc., research other cases in Hangzhou Bay and other coastal wetland construction practice cases for similar environmental problems or site conditions, including domestic Liaoning, Tianjin, Hebei, Shandong, Jiangsu, Shanghai, Guangdong and Fujian 15 cases; 9 cases from Sweden, Australia, Canada, the United States, Turkey, Singapore, and Malaysia,
providing a reference model for the benign development of coastal wetlands in north coast of Hangzhou Bay of Shanghai (Table 1).

Table 1. Case study.

| China Province | Name                                        | Main strategies for ecological development |
|----------------|---------------------------------------------|---------------------------------------------|
| Liaoning       | Panjin Coastal Wetland                      | Ecological engineering for coastal restoration in coastal tourist areas |
|                | Lingang Economic Zone                       | Ecological landscape effects                |
| Tianjin        | Ecological wetland                          | Reclamation project for ecological restoration and reconstruction of vegetation and large benthic organisms |
|                | Ecological Engineering for coastal restoration in coastal tourist areas | Belt park along the embankment and seaside that makes full use of the original resources for environmental improvement and ecological restoration |
|                | Ecological Restoration of the Old Seawall in Sino-Singapore Eco-City | Multiple ecological restoration methods to restore bird and plant habitats |
|                | Qinhuangdao Coastal Landscape Belt          | Construction of landform consolidation + soil improvement and salt control + selection of suitable plants + cultivation and management of innovative mucky coast ecological restoration model |
| Shandong       | Beidaihe Coastal Wetland                    | A full-featured blue tourism and health center, a coastal cultural hub where the city and the natural environment are harmonious |
|                | Blue Silicon Valley Coastal Park in Jimo District, Qingdao | Improve road and green space systems and enhance regional benefits |
|                | Coastal Space in Qianhai District, Qingdao | Typical exemplary coastal zones of ecological restoration types and methods by zone |
| Jiangsu        | Yancheng, Jiangsu                           | Estuary coastal wetlands dominated by bird habitat restoration |
| Shanghai       | Dongtan Wetland                             | The memory point formed by the characteristic landmark sculpture setting |
|                | Nanhuizui Guanhai Park                      | Ecological and cultural features of estuarine coastal wetlands |
| Guangdong      | Nansha Wetland                              | Adopting the spatial layout pattern of "core area-buffer zone-production service area" ecological sensitivity level to form a reclamation coastal wetland |
|                | Xinhui Yinhu Bay Wetland                    | Zoning by ecological sensitivity level, a collection of natural resources such as water features, hot springs, vegetation, wetlands, and bays |
|                | Shenzhen Bay Coastal Leisure Belt           |                                             |

| Other Country | Name                                       | Main strategies for ecological development |
|---------------|--------------------------------------------|---------------------------------------------|
| Sweden        | Hornsbergs Strandpark coastal strip view   | Urban leisure and sports coast zone created with new technology "floating island wharf" |
| Australia     | Darling Harbour, Sydney                    | Public landmarks by industrial zones         |
| Canada        | Port of Toronto                            | Commercial, leisure, cultural port area      |
| United States | Coastal Marina District, Long Beach, California | Relationship between the city's business district and its coastal areas |
|               | Seattle Marina Coast                       | New coastal reform area combining biological habitat protection and public recreation |
|               |                                             | To achieve a seamless connection between cities and coastal areas, reshape urban coastal interfaces, bring together public spaces and social and economic centers |
| Turkey        | Luanda Bay Marina                          | Central Bay that makes full use of the waterfront advantage |
| Singapore     | Gardens by the Bay                         | To create various activities and highlights the value |
4.2. Conception of ecological development in typical lots

4.2.1. Reed tidal flat wetland + intertidal silt coastal wetland. This section of the coast has a fast sediment deposition rate and a large tidal flat area. The shoal vegetation includes the Spartina alterniflora community and the Scirpus trilobata community, and common egrets inhabit in Nanhuizui. With reference to examples such as the coastal zone of Luanda Bay, the coast of the southern forest city, Dongtang Wetland Park, Qinhuangdao Coastal Landscape Belt, Seattle Coast Zone, etc., combined with own environmental conditions, the concept of ecological development includes creating a perfect transportation system, protecting biological habitats, and setting up point-like views bird platforms, adding colorful leaf trees and connecting the surrounding green space park ecosystem (figure 2).

4.2.2. Reed tidal flat wetland. Affected by the accelerating embankment in recent years, the shoal has good stability. The shoal has been planted along the inner coast of the embankment, there are vegetation such as reed and Spartina alternatus. But the intertidal zone is periodically invaded by high salt water and benthic organisms, which dominated by offshore salt species and relatively few freshwater species. Based on the development of biological habitat protection and coastal wetland, referring to the examples such as Luanda Bay Coastal Zone, Qinhuangdao Coastal Landscape Belt, Panjin Coastal Wetland, Qingdao Qianhai District Coastal Space, Beidaihe Coastal Wetland, etc., combined with own environmental conditions, the concept of ecological development includes creating and improving the transportation system, protecting biological habitats, respecting the laws of marine movements, and introducing auxiliary science-based wooden planks (figure 3).
4.2.3. Tourist park. The existing artificial which are typical coastal tourist activity areas to focus on the construction of the central vibrant coastline, referring to the examples such as Luanda Bay Coastal Belt, Seattle Coastal Coast, Singapore's Gardens by the Bay, Nanhuizui Seaview Park, Jimo District Blue Silicon Valley Coastal Park etc., combined with own environmental conditions, the concept of ecological development includes creating and improving the transportation system, planning coastal greening system, improving leisure facilities along the route, providing communication gathering squares, using ecological staircase sea walls to eliminate height differences and introducing activities (figure 4).

4.2.4. Tidal flat reservoir. keep status quo (figure 5).
5. Conclusion
Under studying the basic environmental conditions of north coast of Hangzhou Bay of Shanghai and a large number of cases, in addition choosing typical and mature case construction measures and construction experience as a reference, ecological development of Hangzhou Bay is putted forward. This is only a preliminary idea in a big time that embarrassing situation between the overall poor environmental conditions of the Hangzhou Bay and Shanghai's construction of a marine center city. In the overall thinking, the preliminary idea of improving the quality of the near shore environment and revitalizing the value of the area must be further explored in order to obtain practice, so as to serve as an example of ecological development for decision makers and builders.

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