Development Trends, Environmental and Ecological Impacts, and Policy Recommendations for Bohai Sea Reclamation: Postprint

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Abstract

In recent years, China' s coastal areas have been undergoing a new phase of large-scale reclamation driven by rapid industrialization and urbanization. The Bohai Rim, characterized by a long history and large scale of reclamation, has become the focal region of coastal reclamation in China. Due to reclamation and estuarine delta growth, the area of the Bohai Sea has shrunk by 0.57×10 km² since the 1940s, with a shrinkage rate exceeding 82 km²/a; since 2000, the shrinkage rate has further increased to 141 km²/a. The length and proportion of natural coastline in the Bohai Sea have also declined sharply, decreasing from 1397 km in 1990 to 561 km in 2014, with its proportion of the total coastline length dropping from 54.92% to 16.18%. Coastal reclamation has caused various hazards, such as: changes in oceanic tidal waves and hydrodynamic conditions, alterations in nearshore and offshore sedimentary environments and submarine topography, exacerbation of nearshore water environment and sediment pollution, loss of tidal flat wetland area and decline in ecological functions, damage to benthic organism habitats and community destruction, encroachment upon and destruction of fishery resources ("three grounds and one corridor" : spawning, feeding, and overwintering grounds, and migration corridors), intensification of coastal zone natural disaster risks, induction of economic and social system risks, and adverse impacts on industrial and economic development, etc.

Based on an analysis of the current status and issues in the supervision and management of coastal reclamation in China, policy recommendations are proposed: reform and optimize the coastal reclamation management system, establish land-sea coordination and linkage mechanisms, and improve laws and regulations; strictly implement the ecological red line system, control the scale and speed of coastal reclamation, and promote and optimize the construction of protected areas; conduct environmental and ecological restoration and reconstruction in reclaimed areas and their surrounding waters; strengthen su-

pervision and intensive, optimized utilization of newly added land resources in reclaimed areas; enhance the construction of basic observation systems and vigorously promote the development of scientific research; promote participation of the public, stakeholders, and non-governmental organizations in the protection of coastal wetlands.

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Abstract

In recent years, a new round of large-scale coastal reclamation activities, driven by rapid industrialization and urbanization, has been carried out across China' s coastal areas. The Bohai Sea, with its long history of extensive reclamation, has become the region with the most intensive reclamation activities in China. Due to sea reclamation and estuarine delta growth, the area of the Bohai Sea has shrunk by 0.57×10 km^2 since the 1940s, with shrinking rates exceeding 82 km^2/a and reaching as high as 141 km^2/a since 2000. The natural coastline of the Bohai Sea decreased sharply from 1397 km in 1990 to 561 km in 2014, and its proportion dropped from 54.92% to 16.18%.

Large-scale reclamation may cause multiple hazards and declines in ecological functions, including changes in ocean hydrodynamics, nearshore and offshore topographical and morphological changes, coastal water and sediment pollution, tidal wetland damage, benthic habitat and community destruction, degradation of spawning and nursery grounds, aggravation of natural disasters and social system risks in coastal areas, and declines in industrial and economic development. Based on analysis of the status quo and problems in reclamation management and policies in China, the following policy recommendations are

suggested: reform and optimize the reclamation management system; establish a land-sea coordination mechanism; improve laws and regulations; strictly implement the ecological red line system; control the scale and speed of reclamation; promote and optimize the construction of protected areas; carry out environmental and ecological restoration in reclaimed areas and surrounding waters; strengthen supervision and intensive optimization of newly added land resources from reclamation; enhance basic observation system construction; vigorously promote scientific research development; and encourage participation of the general public, stakeholders, and non-governmental organizations in coastal wetland conservation.

Keywords: Bohai Sea; sea reclamation; environmental impacts; supervision and management; policy recommendations; ecological restoration

1. Characteristics of Bohai Sea Reclamation

Based on topographic maps, satellite imagery, and extensive field investigations, we adopted the mean high tide line as the shoreline definition to analyze multi-temporal mainland coastline data [1-3]. This analysis reveals the characteristics of Bohai Sea reclamation.

1.1 Changes in Bohai Sea Area

Since the 1940s, the Bohai Sea area has shrunk by 0.57×10 km², with an average reduction rate of 82.06 km²/a, representing a 7.06% decrease. Since 2000, the shrinkage rate has reached 141 km²/a. The primary causes of this area reduction are estuarine delta development and human reclamation activities. The islands in the Bohai Sea have also undergone significant changes, with island area changes occurring in two phases: a dramatic decrease during the first phase (1940s-1990s), mainly due to reclamation processes that expanded land area and engulfed some nearshore islands (area decreased from 461.10 km² to 93.84 km²); and a growth phase after 1990, characterized by island area reclamation and artificial island construction, with island area reaching 153.04 km² by 2014.

Table 1 shows the area change characteristics of the Bohai Sea since the 1940s. The sea area (total area minus island area) decreased by 0.54×10 km², with a reduction proportion of 6.72% and an average reduction rate of 77.66 km²/a.

The hotspot areas of coastal change in the Bohai Sea include seven main regions: (1) The Dalian municipal district and Wafangdian coast, including Jinzhou Bay and Fuzhou Bay, characterized by reclamation processes and the land-connection of nearshore islands; (2) The Shuangtaizi River estuary, mainly featuring estuarine delta erosion and deposition changes; (3) The Daling River mouth; (4) The Tangshan coast, characterized by tidal flat development and reclamation for ports and harbor industries; (5) The Tianjin coast, featuring

estuary modification, tidal flat development, reclamation for ports and harbor industries, and providing space for urban development; (6) The Yellow River Delta, showing complex patterns resulting from estuarine delta development, coastal erosion, and other factors; and (7) The southern coast of Laizhou Bay, primarily characterized by reclamation for salt production and aquaculture.

Among these hotspot areas, the Yellow River Delta and Liao River estuary were initially dominated by natural hydrological processes but have seen human activity factors gradually increase and become dominant. The other five hotspot areas have been primarily influenced and driven by human activities throughout. The hotspot areas distributed in the western and southwestern parts of the Bohai Sea, particularly the Yellow River Delta, show the most significant changes in coastline and rapid land-sea transformation, playing a dominant role in the morphological changes of the entire Bohai Sea. Although severe coastal erosion exists in some local areas, human activity factors have become the dominant influence.

1.2 Coastline Changes in Bohai Sea

Considering the impact of shoreline fractal characteristics on the comparability of shoreline extraction results from different periods, we analyzed results extracted from Landsat TM/ETM+/OLI satellite imagery since 1990. The total length of the Bohai Sea coastline has been steadily increasing: from 2545 km in 1990 to 3467 km in 2014. This increase is mainly due to Yellow River Delta growth and changes in reclamation methods. As the total coastline length increases, the length of natural coastline has continuously decreased from 1397 km to 561 km, and its proportion has declined more rapidly from 54.92% to 16.18%, sequentially decreasing to 59.86%, 39.99%, 19.49%, and 16.18% in 2000, 2005, 2010, and 2014, respectively.

Changes in the length proportions of different coastline types well reflect the phased characteristics of reclamation [Figure 1: see original paper]. Before the 1940s, when human impact on coastal zones was relatively simple—focused on resource acquisition and disaster defense—the coastline was dominated by natural shorelines with small proportions of artificial shorelines, mostly salt pond embankments. By the 1990s, the proportion of artificial shorelines approached 60%, and their structural types began to diversify, with significant increases in the lengths and proportions of salt pond embankments and protective dikes, but the most substantial increase was in aquaculture embankments. This reflects how economic development and improved living standards created higher demands for dietary structure among urban and rural residents. In recent years, a very significant feature has been the decreasing proportion of salt pond embankments, while the lengths and proportions of port and dock shorelines, aquaculture embankments, and reclamation shorelines have increased. This structural change demonstrates the significant impact of industrial transformation during industrialization and urbanization on coastal zone resources and environment.

2. Impacts of Large-Scale Reclamation on Environment, Ecology, and Socioeconomic Development

Large-scale reclamation is a basic approach to expanding space toward the ocean under the background of increasingly acute land resource shortages during industrialization and urbanization. While providing large amounts of new land resources and development space in the short term, numerous facts and studies have proven that the negative impacts of reclamation on coastal environment and ecology are long-term and difficult to estimate. The Bohai Sea is a semi-enclosed inland sea, making the hazards caused by large-scale reclamation even more prominent.

2.1 Changes in Marine Tidal, Wave, and Hydrodynamic Conditions

Large-scale reclamation directly alters coastal structure and tidal current movement, changing hydrodynamic conditions such as water flow and waves. For estuaries, reclamation narrows river channels, intensifies tidal wave deformation, and reduces maximum ebb current velocity and ebb tidal discharge. Reclamation activities directly alter the hydrodynamics of bays, reducing water' s sediment-carrying capacity, accelerating bay siltation, and consequently causing beach changes [4]. Reclamation activities in the Moksipo coastal zone of Korea' s Yeongsan River estuary led to reduced tidal water level and aggravated flood disasters during typhoons [5]. Numerical wave modeling analysis of wave element changes in Bohai Bay' s Caofeidian, Tianjin Port, and Huanghua Port areas shows that effective wave height decreased after construction, with particularly significant reductions in harbor basins and tidal channels [6]. Based on Bohai Sea hydrodynamic models simulating the impact of intensive sea use on tides, shoreline changes have caused the semidiurnal tide amphidromic point near the Yellow River port to gradually shift southeastward, reduced semidiurnal tide amplitude in Laizhou Bay, and enhanced amplitude in the three major bays [7]. Simulations of tidal current and wind wave characteristics before and after Bohai Bay reclamation projects show that sediment concentration distribution tends to decrease under normal dynamic conditions, decrease in nearshore areas under strong dynamic conditions, and increase in waters in front of structures [8]. Using numerical simulation methods to predict impacts of reclamation projects in the Yellow River estuary and Laizhou Bay from four aspects—tidal level, current velocity, wave, and suspended sediment concentration—the study found that in waters sheltered by projects, effective wave height decreases, sediment-carrying capacity reduces, and suspended sediment concentration near projects also decreases [9].

2.2 Changes in Nearshore and Offshore Sedimentary Environment and Submarine Topography

Reclamation directly changes sediment types and characteristics in adjacent sea areas. Originally fine-grained sediment areas dominated by tidal action become mixed coarse and fine sediments with poor sorting. Frequency curves show irregular multi-peak patterns, and some areas even completely cover fine-grained sediments with local coarse-grained sediments [10]. Dredging areas severely alter submarine geomorphology, causing new seabed and coastal erosion or siltation. The 1984 reclamation project in Seosan Bay on Korea' s west coast built a 13 km seawall, causing significant changes in low tidal flat sedimentation processes [11]. Studies on sedimentation in northern Liaodong Bay show that human activity is an important factor changing and reshaping the modern sedimentary pattern of northern Liaodong Bay. Reclamation reshapes coastal morphology and spatial distribution patterns, limiting the ability of coastal shallow areas to participate in modern sedimentation and indirectly affecting changes in sedimentation rates and the enrichment and diffusion of heavy metal elements [12]. Studies on the impact of large-scale offshore artificial island construction in Longkou on surface sediments show dynamic differentiation of clastic minerals. Long-term implementation of large-scale reclamation projects has obvious transport effects on sediments with particle sizes smaller than 4Φ, but smaller effects on transporting sediments larger than 4Φ [13]. Analysis of grain size and clay mineral composition and distribution characteristics of surface sediments in the Caofeidian nearshore area shows that long-term reclamation implementation has more obvious impacts on the distribution of finer particles in surface sediments. The distribution characteristics of kaolinite and chlorite are closely related to hydrodynamic changes caused by reclamation [14].

2.3 Deterioration of Nearshore Water and Sediment Environment

Reclamation projects reduce sea area water exchange capacity and pollutant self-purification capacity. Activities such as aquaculture, port terminals, and harbor industries formed by reclamation increase pollutant discharge. The combination of these two effects causes continuous deterioration of nearshore water and sediment environments. Studies on distribution characteristics and formation mechanisms of hypoxic zones in Bohai Sea bottom waters show that hypoxic zones have north-south dual-center structures. Seasonal stratification of seawater and its blocking effect on dissolved oxygen are key physical mechanisms for hypoxic zone formation, which is essentially consistent with the dual-center cold water structure. The emergence of hypoxic zones is the result and concentrated manifestation of drastic changes in the Bohai Sea ecosystem [15]. Arsenic content is relatively high in bottom sediments of northern Liaodong Bay shallow sea areas, with high-value areas distributed in Jinzhou Bay and nearby areas. Bottom sediment pollution in Jinzhou Bay is mainly caused by frequent reclamation activities and land-source pollutant discharge [16]. Studies on heavy metal pollution caused by reclamation in Bohai Bay show that Cu, Cd, and

Pb contents in 2014 sediments were higher than in 2005, with heavy metal pollution becoming more severe. High-value areas of Cu, Zn, and Cd are mainly concentrated in nearshore estuaries and central and southern Bohai Bay [17]. Evaluations of ecological impacts of intensive sea use found that habitat quality comprehensive indices in western and southern nearshore areas of Laizhou Bay are lower than in central and eastern areas, with the main pollution factor being inorganic nitrogen, whose content has exceeded Class I marine water quality standards [18]. Evaluations of heavy metal pollution and potential ecological hazards in Caofeidian reclamation areas show that average contents of seven heavy metals in surface sediments near reclamation areas are higher than background values of heavy metals in Bohai Bay sediments. Cd is the main polluting element with strong ecological hazards [19].

2.4 Loss of Tidal Wetland Area and Decline of Ecological Functions

Reclamation projects occupy large areas of coastal tidal wetlands, completely changing their natural attributes and causing the basic disappearance of their ecological service functions. Tidal flats and estuaries are critical habitats for various fish spawning and migration, migratory bird feeding, and rare flora and fauna growth. Reclamation leads to wetland biological population reduction, even near extinction, completely changing ecosystem structure and seriously degrading ecological service functions. Large-scale reclamation in Dalian caused nearshore wetland loss, ecosystem degradation, and biodiversity reduction [20]. The Caofeidian reclamation project occupies tidal wetlands, causing annual ecological service function losses of 1.02×10 yuan in climate regulation, air and water quality regulation, and other services [21]. Studies on wetland ecosystem service value loss caused by reclamation in Weifang' s northern coastal area show losses of 1.8×10 yuan, with unit area loss of 2.15×10 yuan $\cdot$ hm $^{2}\cdot$ a ^{1} [22]. Research on the impact of reclamation activities on coastal wetland vegetation organic carbon content in the Yellow River Delta found that reclamation activities changed key environmental factors for vegetation growth, resulting in relatively single vegetation types and changes in vegetation element ratios. The intensity of reclamation activities over 20 years has exceeded the bearing capacity of the Yellow River Delta wetland ecosystem, especially in areas with strong reclamation activities such as Dongying Port and Wuhaozhuang [23], showing an increasing trend [24].

2.5 Damage to Nearshore Benthic Habitats and Communities

Reclamation projects cause drastic changes in nearshore substrate conditions and benthic living conditions through marine soil extraction and burial processes, leading to benthic habitat loss and fragmentation, deteriorated benthic environment, reduced benthic organisms, changed community structure, and decreased biodiversity. Analysis of the environmental and ecological impacts of suspended solids generated by reclamation in Dalian' s Lingshui Bay found that changes in seabed sediments and seawater quality affected the ma-

rine ecosystem, with numerous benthic plankton experiencing migration, death, or even extinction due to changes in habitat and breeding environments [25]. Reclamation-induced environmental changes have significant impacts on macrobenthic community structure in Bohai Bay nearshore areas. Reclamation is not conducive to mollusks and crustaceans, and changes in habitat elements such as nearshore shallow seas lead to reduced species numbers and diversity [26]. Reclamation projects have prominent impacts on marine biological resources such as fish eggs and larvae. Manila clams show vertical migration behavior after being buried, and juvenile fish sensitivity to suspended solids gradually increases. With increased burial depth, mortality gradually increases, and with prolonged suspended solids exposure time, reclamation intensifies benthic habitat loss, reduces biological species diversity, and decreases average biomass and abundance. Benthic habitat loss and fragmentation cause significant changes in macrobenthos distribution patterns [27-28].

2.6 Severe Occupation and Destruction of Marine Fishery Resources

Marine fishery resources are an important foundation for the sustainable development of China' s marine economy. Large-scale reclamation occupies and destroys "spawning grounds, nursery grounds, feeding grounds, and migration channels" (三场一通道), which are listed alongside overfishing and climate change as main causes of fishery resource degradation [29]. The impacts of large-scale reclamation on marine fishery resources are mainly manifested in: permanent changes in marine attributes caused by construction, leading to water quality decline, benthic habitat loss, and reduced biodiversity and productivity; significant changes in physical field conditions such as hydrodynamics and salinity, causing shrinkage or complete disappearance of basic conditions for fishery resource spawning grounds, overwintering grounds, and migration channels; reduced tidal prism and deteriorated water exchange capacity; high-concentration suspended particle diffusion fields causing damage to fish eggs and larvae; and changed material cycling processes due to hydrodynamic and sedimentary environmental changes. The Caofeidian reclamation project has huge impacts on coastal tidal currents and sea currents, especially blocking shallow tidal channels and dramatically changing surrounding topography and sediment erosion/deposition, causing coastal environmental, ecological, and resource damage, and even significantly affecting material transport and fish migration throughout the Bohai Sea [30-31]. Reclamation increases suspended matter content in nearshore waters, forcing some fishing and aquaculture industries to stop, seriously affecting local fishermen' s economy and livelihood, and causing fishery resource degradation due to declining water environmental quality. Local fishery development space faces unprecedented transfer pressure [32].

2.7 Adverse Impacts on Marine Economic Industries such as Aquaculture and Tourism

Scientific and rational reclamation can provide substantial land resources for coastal economic and social development, meet the development needs of ports and harbor industries, and provide space for aquaculture and salt production, thereby creating new economic growth points and promoting healthy, sustainable regional economic development [33]. However, disorderly reclamation has many drawbacks, causing huge impacts on traditional industries and new economy development, particularly marine aquaculture, salt industry, marine transportation, and marine tourism. Reclamation occupies aquaculture and salt production spaces, and changes in hydrodynamic conditions and waste discharge lead to increased suspended solids concentration, degraded water and benthic environment quality, and sharp reductions in plankton, seriously affecting aquaculture yield and salt production water intake environment [34]. Reclamation is generally distributed in nearshore waters and shallow sea areas at estuary entrances, which are often regions with prominent shipping functions. Reclamation alters marine hydrodynamic conditions, significantly reduces tidal prism, causes sediment siltation in bays and estuary entrances, affects navigation of shipping vessels, and leads to port siltation, impairing waterway functions and causing port functional and economic losses, even forcing selection of new ports [35].

2.8 Increased Coastal Natural Disaster Risks and Induced Economic-Social System Risks

Reclamation leads to intensified coastal and marine natural disaster risks, enhanced ecological environment vulnerability, and decreased resource-environment carrying capacity. Reclamation changes marine hydrodynamic conditions, causes sediment siltation, reduces wave dissipation capacity in nearshore shallow areas, intensifies the destructive effects of marine disasters such as storm surges, and directly impacts nearshore protection projects [36]. Increased suspended solids and eutrophication substances in water lead to frequent ecological disasters such as harmful algae and jellyfish, deteriorating water environment in surrounding sea areas and threatening marine biodiversity and ecosystem health. Reclamation breaks the balance of sea-land interdependence, hindering coordinated development between sea and land. The transformation of 曲折的自然岸线变为平直的人工岸线 (winding natural coastlines into straight artificial ones), reduced bay and estuary areas, occupation and destruction of coastal natural wetlands, blocked river entrances, destroyed animal feeding grounds, and affected flood discharge alter groundwater circulation characteristics [37]. Many valuable coastal tourism resources disappear, and high heavy metal content and other toxic substances accumulate in shellfish, bioaccumulating through food chains and posing significant health risks to humans. Reclamation causes loss of marine resource values, intensifies conflicts among different stakeholders, and easily creates

social instability factors [38]. Many fishermen can no longer engage in marine fishery production, resulting in significantly reduced income. When surplus labor is not properly resettled and transferred, disagreements over property rights often arise, easily intensifying social conflicts at certain levels. Marine resource management involves multiple government departments, and conflicts and contradictions between departmental interests and jurisdictions can easily trigger inter-departmental and inter-regional conflicts.

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3. Current Status and Problems in China' s Reclamation Supervision and Management

The development of Bohai Sea reclamation and its environmental and ecological impacts are a microcosm of China' s coastal areas. Over recent decades, China has gradually strengthened reclamation supervision, promulgated the "Maritime Area Use Management Law" in 2002, and continuously promoted marine functional zoning and marine protected area construction, reflecting certain achievements in reclamation supervision and management. However, compared with the increasingly intense development trend and its adverse impacts on coastal environmental ecology and economic and social development, obvious deficiencies still exist.

3.1 Unclear Administrative Management Subjects, Confused Responsibilities, and Prominent Multi-Head Management Problems

China' s current coastal zone and marine administrative management system is a multi-department, multi-level system. In terms of reclamation approval, supervision, and management, it involves the State Oceanic Administration, Ministry of Land and Resources, Ministry of Environmental Protection, State Forestry Administration, Ministry of Agriculture, and their subordinate institutions at provincial, municipal, and county levels. Approval and management generally follow the principle of hierarchical decentralized management, but functions overlap between different management departments. At the national level, multiple departments simultaneously accept authorization and leadership from the State Council, with different goals and principles between different levels. Provincial governments are responsible for macro guidance and management of provincial tidal flat resources, while the State Council directly authorizes provincial governments to develop, utilize, and protect coastal tidal flat resources. Municipal and county governments are responsible for development, construction, and management within their jurisdictions. Functional overlap and the hierarchical decentralized management principle are not conducive to centralized management and effective protection of coastal tidal flat wetlands and are institutional causes of increasingly intense large-scale reclamation in China.

3.2 Imperfect Laws and Regulations, Lack of Targeted and Strong Legal Supervision and Policy Constraints

The "Maritime Area Use Management Law" ended China's long history of unregulated sea use, and reclamation management work has gradually strengthened. However, relevant supporting laws and regulations are not perfect. Reclamation planning authority is dispersed among coastal provincial government departments. There is a lack of unified national-level master plans, overall principles, and overall reclamation planning for tidal flat resource development and protection. Insufficient basic monitoring and scientific research also constrain the scientific nature, comprehensiveness, and authority of marine functional zoning. The natural attributes and ecological values of sea areas have long been seriously underestimated. Tidal flat and sea area development, use, and compensation fees have not been established on the basis of ecosystem functions and services, placing marine environment and ecosystems in a state of overdevelopment and 透支性开发 (exploitative development). Functional overlap among management departments is also reflected in conflicts and contradictions between the "Marine Environmental Protection Law," "Land Administration Law," and other laws, with contradictions and conflicts existing between local and central laws and regulations.

3.3 Absence of Reclamation Ecological Compensation Mechanisms and Post-Effect Assessment Systems

Marine ecological compensation refers to the payment of corresponding fees by marine users or beneficiaries to marine resource owners or those who have paid for marine ecological environmental protection during the legal utilization of marine resources. Its purpose is to support and encourage marine ecological environmental protection rather than blindly seeking economic benefits from the ocean. China has not yet established a reasonable and effective marine ecological compensation mechanism. Compared with the economic benefits brought by reclamation development and the resulting environmental and ecological service losses, reclamation compensation fees have long been low, objectively indulging reclamation development behavior. The impacts of reclamation on environment and ecology are long-term and phased, making long-term tracking and dynamic evaluation difficult. However, China faces insufficient long-term monitoring data and lagging basic research levels, which hinder the improvement of reclamation engineering measures and the implementation of environmental and ecological restoration work in project areas and their impact zones.

3.4 Unreasonable Development and Utilization of Newly Added Land Resources from Reclamation, Administrative Management Gaps and Vacancy Periods

The boundaries between marine and land administrative management for reclamation processes and newly added land resources have not been clearly demarcated, and coordination mechanisms have not yet been formed. Newly added

land resources from reclamation lack effective legal supervision and policy constraints. The economic development momentum in newly reclaimed areas is insufficient, and administrative management gaps and vacancy periods exist. The "8·12" major fire and explosion accident at Ruihai International Logistics Co., Ltd.' s dangerous goods warehouse in Tianjin Port, Binhai New Area, Tianjin, in 2015, with direct economic losses of 6.866 billion yuan, was partly caused by reclamation. Although Tianjin New Port, built through reclamation, had been transferred to Tianjin' s management, various departments illegally entrusted multiple administrative functions to Tianjin Port Group Company, creating an internal relationship between safety supervision and enterprise operation. The administrative management gaps and lack of effective supervision mechanisms in reclamation areas are important lessons from the Tianjin Port accident [39].

3.5 Lack of Efficient and Intensive Utilization Mechanisms for Newly Added Land Resources from Reclamation, Prominent Resource Idleness and Waste Problems

Administrative department segmentation and missing laws and regulations have led to and exacerbated blind, disorderly, and excessive reclamation in coastal areas. Reclamation project justification is insufficient, and phenomena such as long-term idleness and unclear actual demand for newly added land resources from reclamation are widespread. Projects are implemented quickly with short approval cycles, but administrative policies for sea area use right cancellation, land survey registration and confirmation, land use right transfer, and subsequent supervision and inspection are blank and disconnected. The coordination and linkage mechanisms between marine and land administrative management are not in place, leading to widespread and even prominent problems of long-term idleness and waste of newly added land that cannot be developed on schedule or is developed with low efficiency.

3.6 Insufficient Monitoring Data and Lagging Scientific Research, Difficult to Meet Reclamation Supervision and Ecological Restoration Needs

China' s marine scientific research history is relatively short, lacking long-term observation and monitoring data. Lagging basic research development makes it difficult to meet the needs of reclamation planning, engineering scheme formulation, environmental effect assessment, ecological damage assessment, ecological compensation standard calculation and compensation policy formulation, and post-effect assessment of reclamation projects. This seriously constrains the scientific nature of reclamation supervision and management work and hinders the implementation of ecological restoration work in reclamation project areas and their impact zones.

3.7 Insufficient Participation of the Public and Stakeholders

Low participation rates and insignificant participation effectiveness of the public and stakeholders in natural resource development, utilization, and supervision and management are common problems. This is partly because local management departments and reclamation implementers ignore rights granted to the public in existing laws and regulations, encroaching on rights and opportunities of the masses and stakeholders. It is also due to inadequate publicity of laws and regulations, with public awareness and legal consciousness, as well as stakeholders' awareness of safeguarding their own interests, needing improvement.

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4. Policies and Recommendations

Based on the above analysis, we propose policy recommendations for future reclamation supervision and management.

4.1 Reform and Optimize Reclamation Management System, Establish Land-Sea Coordination and Linkage Mechanisms

The focus should be on strengthening national-level overall planning and macro-control of reclamation, emphasizing that local-level reclamation planning must comply with national-level overall planning principles and objectives. Reform the existing multi-department, multi-level management system, clarify land-sea administrative divisions in reclamation supervision, and establish land-sea coordination and linkage mechanisms throughout all levels and departments to eliminate administrative gaps and vacancy periods in reclamation management. Establish a comprehensive coastal zone management committee to formulate and introduce comprehensive "Coastal Zone Management Law" from the perspectives of policy and regulation formulation and improvement, reclamation planning and approval, coastal zone red line demarcation, and coastal zone ecological restoration, eliminating loopholes in comprehensive coastal zone management and reclamation supervision from legal and policy levels.

4.2 Strictly Implement Ecological Red Line System, Control Reclamation Scale and Speed, Promote and Optimize Protected Area Construction

In 2016, the State Oceanic Administration issued "Several Opinions on Establishing the Bohai Sea Marine Ecological Red Line System," proposing clear targets for natural coastline retention rate, marine ecological red line area proportion, land-source direct discharge pollutant compliance rate, and seawater quality compliance rate. In 2017, the General Office of the State Council issued the "Wetland Protection and Restoration System Plan," implementing total wetland area control, with national wetland area not less than 8×10 hm^2 (including 7×10 hm^2 of natural wetlands), new wetland area of 3×10 hm^2, and

wetland protection rate increased to over 50% by 2020. The "Coastline Protection and Utilization Management Method" incorporates coastlines into marine ecological red line management, requiring national natural coastline retention rate not less than 35% by 2020. For current and future periods, we recommend further emphasizing the following goals and measures: First, ensure scientific demarcation of red line areas and formulate supporting policies and supervision measures. Second, ensure scientific demarcation of protected areas, focusing on areas with prominent or important ecosystem functions and services, and establish new protected areas and optimize existing ones. Third, draw on the U.S. "Wetland Mitigation Banking" and "Conservation Easement" systems for application in China' s tidal flat wetland and natural coastline protection.

4.3 Carry Out Environmental and Ecological Restoration and Reconstruction in Reclaimed Areas and Surrounding Waters

Adhering to the principle of natural recovery supplemented by artificial restoration, increase financial support at all levels to promote environmental and ecological restoration and reconstruction in reclamation areas and surrounding waters. Prioritize restoration of nationally and locally important wetlands with severe fragmentation and degraded ecological functions. Take pollution cleanup, natural wetland and coastline restoration, maintenance and restoration of land-sea ecological connectivity, marine environment restoration, wetland vegetation restoration, and coastal zone ecological disaster prevention as important goals. Gradually restore coastal tidal flat wetland ecological functions and maintain healthy wetland ecosystems. Key targets in the Bohai Sea region should include estuarine wetland protection and restoration, "spawning grounds, nursery grounds, feeding grounds, and migration channels" (三场一通道) protection and restoration, seagrass bed habitat protection and restoration, marine hypoxic zone environment restoration, oil pollution prevention, and harmful algae and jellyfish disaster prevention.

4.4 Strengthen Supervision and Intensive Optimization of Newly Added Land Resources in Reclaimed Areas

Sea area use rights and land use rights have been regulated in the "Maritime Area Use Management Law" and "Land Administration Law," respectively. Further promoting seamless legal connection between sea area use rights and land use rights is key to strengthening supervision of newly added land resources in reclaimed areas and promoting their intensive optimization. We recommend improving existing policy and regulation systems from the perspectives of property rights attribution, paid use systems, and handling of illegally reclaimed land in reclamation areas. Add methods for connecting various systems in the "Maritime Area Use Management Law," eliminate conflicts and gaps between legal norms, and achieve seamless connection between sea area use rights and land use rights.

4.5 Strengthen Basic Observation System Construction and Vigorously Promote Scientific Research Development

Focus on basic observation, monitoring, and scientific research from the perspectives of marine environment and marine disasters. Establish coastal zone and marine basic observation and monitoring technology systems characterized by wide coverage, multiple elements, high frequency, automation, and multiple platforms. Form three-dimensional comprehensive observation and monitoring networks. Establish observation data management and sharing policy systems and technical systems. Increase investment in basic research and promote multidisciplinary basic research development. Through observation system construction and scientific research development, provide reliable basic data and solid scientific and technological support for reclamation planning, engineering scheme design, environmental impact assessment, real-time monitoring of environmental and ecological effects during reclamation, post-effect assessment, ecological restoration in reclamation areas and adjacent areas, and reclamation ecological compensation.

4.6 Promote Broad Participation of the Public, Stakeholders, and Non-Governmental Organizations

Focus on strengthening the following work: enhance publicity of coastal zone and marine-related laws and regulations, policies, and basic knowledge to improve public awareness, legal consciousness, and stakeholders' awareness of safeguarding their own interests; establish public participation mechanisms throughout the entire process of reclamation project approval, implementation, and supervision, including project approval hearings and public notice systems; introduce policies and measures to encourage non-governmental organizations at home and abroad, such as Wetlands International and World Wide Fund for Nature, to actively participate in coastal zone resource and environmental management-related affairs.

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Note: Figure translations are in progress. See original paper for figures.