Study on the Influence of Land Reclamation of Tianjin Port Free Trade Zone on Hydrodynamic Environment

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Abstract. According to the reclamation process of Tianjin port free trade zone, the monitoring data of Marine hydrology, Marine hydrology, topography and Marine environment monitoring data were collected before and after the reclamation of nearshore zone. Through data comparison and numerical simulation, the changes of nearshore flow field and the topography of the sea area before and after reclamation are analyzed. It is found that the reclamation of Tianjin port free trade zone has great influence on the nearshore flow field, which leads to the change of the nearshore geomorphology.

Keywords: Sea Reclamation · Hydrodynamic Force · Submarine Topography

1 Introduction

With the acceleration of urbanization in coastal areas, land resources are increasingly scarce. Through reclamation, human beings expand the living and development space for coastal areas [1]. It is reported that after the founding of New China, the country experienced four large-scale land reclamation [2]. In the 21st century, the momentum of sustained and rapid economic and social development in coastal areas continues unabated. In 2003, the Outline of the National Plan for Marine Economic Development was promulgated, which divided China's coastal zones and adjacent sea areas into 11 comprehensive Marine economic zones. The trend of urbanization, industrialization and population agglomeration has been further accelerated. The shortage of land resources and the prominent contradiction in land use have become the key factors restricting economic development. In this context, a land reclamation boom has been set off in coastal areas, with the main purpose of building industrial development zones, coastal tourism areas, new towns and large-scale infrastructure, and alleviating the contradiction between the shortage of urban land and the shortage of land for investment and development.

Large-scale reclamation activities not only bring economic benefits, but also bring huge negative impact on coastal wetland environment, resulting in wetland area shrinking, natural shoreline sharp reduction, and damage to Marine and terrestrial ecosystems

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[3]. Since the 18th CPC National Congress, the CPC Central Committee and The State Council have attached great importance to Marine ecological protection and the control of reclamation, requiring strict control of the adverse impact of reclamation activities on the Marine ecological environment.

2 Reclamation Process of Tianjin Port Free Trade Zone

Tianjin coast belongs to silt coast, shallow water depth, wide beach, no natural deep water shoreline resources. The expansion of the port in history and the recent construction of port-neighboring industrial estate are accompanied by large-scale land reclamation activities. The reclamation of land along the coast of Tianjin can also be divided into four phases: sporadic reclamation period from 2003; In 2004, it entered the moderate reclamation phase; In 2010, it entered the period of massive reclamation, and the outer boundary of land creation was basically completed in that year. After 2014, there was almost no new reclamation [4].

Tianjin port free trade zone (harbor area) is located in the south of Tianjin Port main port area, north of the Nangang industrial zone. The reclamation process in this area is mainly divided into two areas: (1) North area construction officially began in 2003; (2) Central area officially developed and constructed in 2007; At the end of 2010, North area and central area were merged into Lingang Economic Zone. By the end of 2017, this area integrated into one functional zone as Tianjin port free trade zone.

Reclamation activities in the area began in 2003 and were basically completed by the end of 2013. The period from 2006 to 2013 was the peak of reclamation construction in this area. The reclamation process is shown in Fig. 1.

3 Analysis of Hydrodynamic Environmental Impact

The hydrodynamic investigation data in 2006, 2008 and 2013 were selected to review and analysis hydrodynamic environment. Through comparison, it can be seen that:

(1) After the overall reclamation construction, the overall flow direction of the sea current in this area changes slightly — from the general WNW-ESE before the construction to NW-SE.
(2) The average flow velocity of rising and falling tides at each point before the construction is 0.27 m/s and 0.25 m/s respectively, and the average measured flow velocity in the engineering process is generally less than 0.3 m/s. After the reclamation construction, the rising tide is 0.40 –0.55 m/s. The variation of the flat velocity increases slightly.

The two-dimensional numerical model MIKE21 FM developed by the Danish Institute of Hydraulics was used to study the influence of tidal flow field movement in the sea area. The hydrodynamic monitoring data in 2013 was taken as the hydrodynamic calculation data, and the hydrodynamic changes before and after the reclamation were compared and analyzed. The flow field distribution of surge and fall at the completion of reclamation is shown in Fig. 2, and the variation of velocity is shown in Fig. 3.

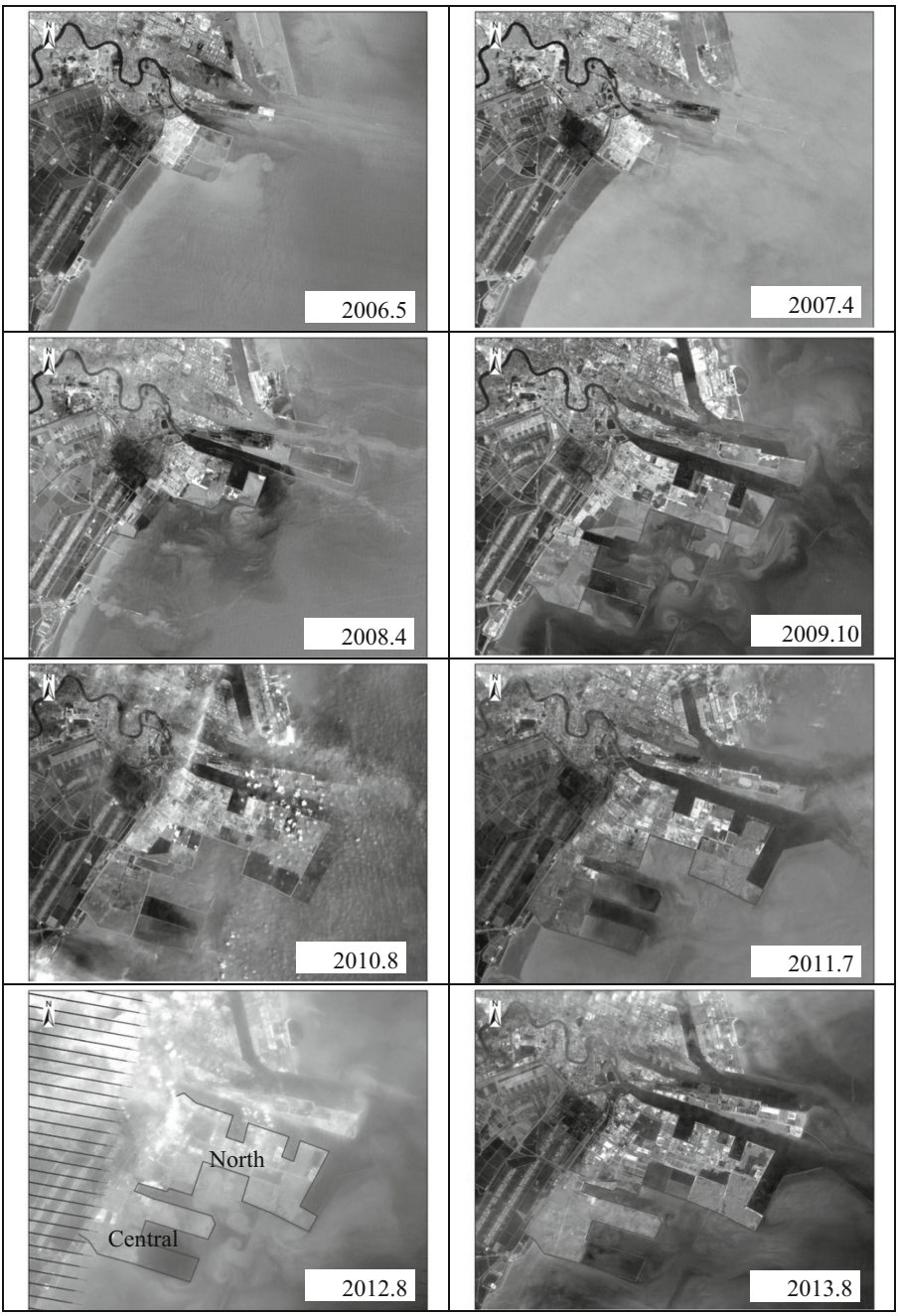

Fig. 1. Satellite images of reclamation changes of Tianjin Port Free Trade Zone from 2006 to 2013

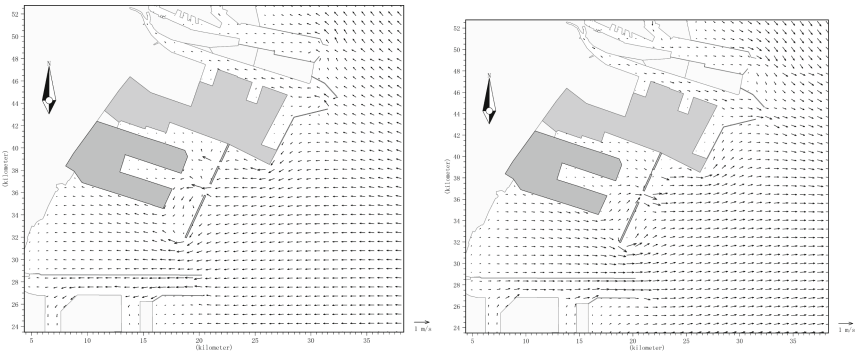

Fig 2. Flow field distribution after regional reclamation

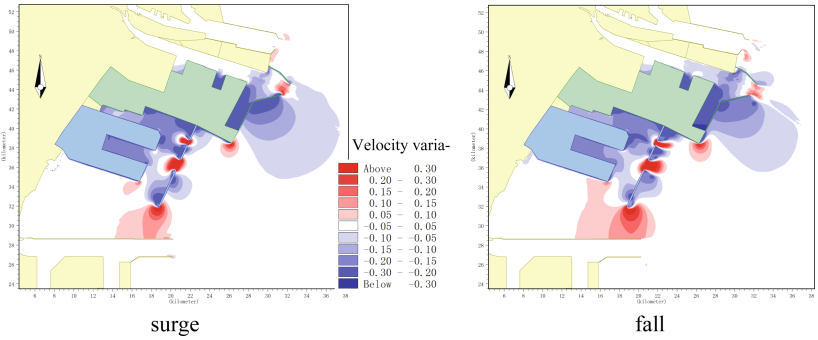

Fig. 3. Contour map of velocity variation after regional reclamation

During the surge, the velocity off the sea to the east of the whole reclamation area of the Tianjin Port free Trade area decreases, and the amplitude of the impact also decreases gradually as the influence area expands outward fan- shaped. The velocity of the breakwater near the east of the north area decreases by 0.4–0.5 m/s at most; the maximum distance between the range with a reduction greater than 0.05 m/s and the reclamation area is about 10.3km; The range with a reduction greater than 0.1 m/s has a maximum distance of 5.5km from the reclamation area. The velocity in the interior and west of the reclamation area also decreased, When the reduction amplitude is greater than 0.05 m/s, it can reach the port pool water area of Nangang Industrial Zone. The flow velocity increased by 0.1/s at the east entrance of the reclamation area, the southeast corner of the reclamation area and the sea area between the breakwater and the Nangang Industrial zone. The velocity in the entrance also increased. At the moment of fall, the change trend of velocity caused by reclamation is similar to that at the moment of surge, but the range and range of change are slightly different.

It can be seen from the comparison results of the flow field vector diagram that after reclamation the tide flow changed from the onshore flow into flow along the edge of the reclamation area. The north area is blocked by the outer breakwater, and the water

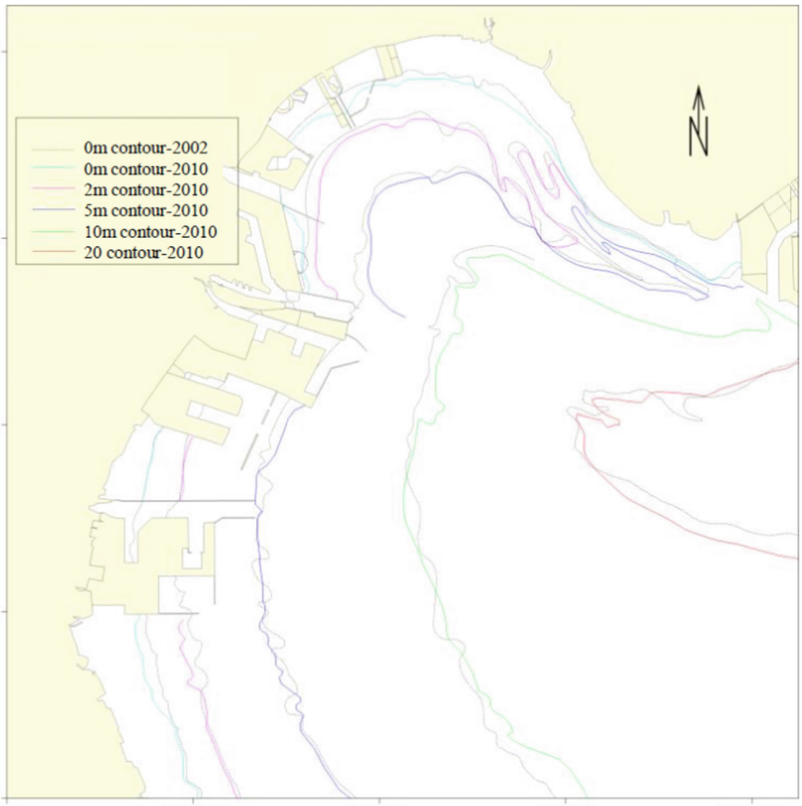

Fig. 4. Contour map of reclaimed area from 2002 to 2010

flows to the southeast, between the reclamation and the Nangang Industrial Zone. The reclamation caused significant deflection of the flow direction within about 6km outside area.

4 Analysis of Landform Changes

Land reclamation has changed the scouring and silting environment near the project in this area. According to the comparative analysis results, after large-scale reclamation, the silt strength decreases at the southeast corner of the area and at the entrance of the north area due to the increase of flow velocity. The silt strength increase in the east of the east breakwater and north of the north breakwater as the flow rate decreases.

Comparative analysis was made of the pre-reclamation, mid-reclamation and post-reclamation charts and the bathymetric data in 2002 and 2010, as shown in Fig. 4. The evolution of sea bed near the reclamation area has the following characteristics.

(1) In the north of Tianjin Sea area, the 0m contour to 20m contour has different degrees of outward migration, with the maximum outward migration of 1000m, located near the beach of Tianjin Dongjiang Port Area.

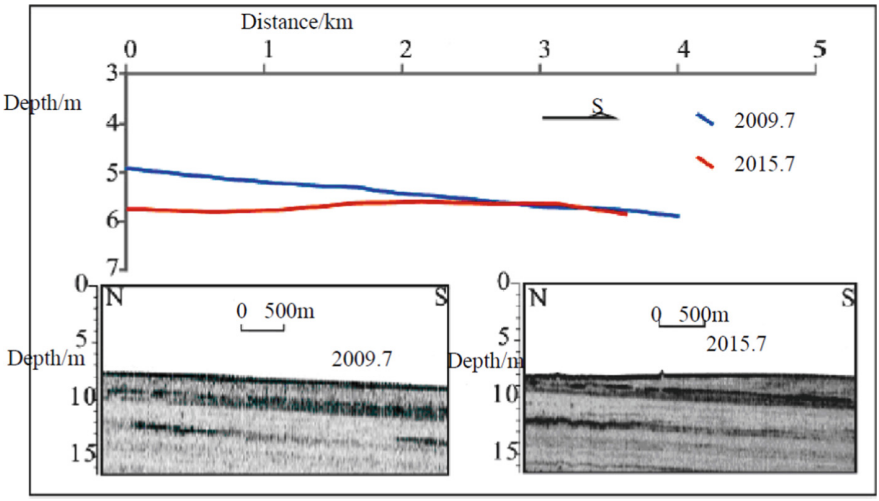

Fig. 5. Monitoring results of water depth and scour and silt on the southeast side of the outer barrier of Tianjin port free trade zone

(2) In the central part of Tianjin sea area, 0m contour, 2m contour and 5m contour are basically consistent and maintain stability. The 10m contour shows the trend of outward shift in the north and retreat to shore in the south. The 20m contour receded ashore.
(3) In the south of Tianjin Sea area, the 0m contour to 5m contour receding to shore is relatively obvious within 5km from Nangang Industrial Zone. The 20m contour is moving outward.

The water depth measurement data on the southeast side of the outer barrier of Tianjin port free trade zone in 2009 and 2015 were used for analysis [6]. As shown in Fig. 5, it can be seen that The survey section direction is NW-SE, the length is about 4km. The water depth gradually increases to the east, in 2009, the depth of water was 4.9 –5.0m. Six years later, in 2015, this section suffered significant submarine erosion, the water depth becomes 5.8 –5.9m, and the submarine slope slowed down significantly, from 0.28‰ to 0.03‰, which was almost horizontal.

To sum up, large-scale reclamation has significantly changed the topography and geomorphology of offshore waters. Large-scale reclamation also changes the offshore flow field, changes the regional balance of scour and silt.

5 Conclusion

This paper reviews and analyzes the impacts of the reclamation process of Tianjin port free trade zone on Marine hydrodynamic forces, Marine topography and geomorphology and Marine environment, summarizes the Marine hydrological monitoring data before, during and after the reclamation, and gives the changing trend of Marine hydrological

conditions and environmental conditions during the reclamation process. The research results are as follows:

(1) The large-scale reclamation of Tianjin port free trade zone changes the offshore flow field, resulting in significant changes in the landform of the offshore sea area.
(2) In the sea area of Tianjin port free trade zone, 0m contour, 2m contour and 5m contour are basically consistent and maintain stability; The 10m contour shows the trend of outward shift in the north and retreat to shore in the south. The 20m contour receded ashore.
(3) The contrast between the survey sections of the southeast side of the outer barrier and the coast line shows that the sea floor slope has slowed down significantly.

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