

Spatial-temporal analysis of coastline changes around Bohai Sea based on remote sensing in recent 20a

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ABSTRACT

This study examined the dynamic changes of the Bohai Sea coastline in recent 20 years through spatial-temporal analysis using combined data from remote sensing and GIS technology. Three standard false color remote sensing images derived from visual interpretation and the vectorization from artificial methods are adopted to complete the extraction of the Bohai Sea coastline information. The results show that the Bohai Sea coastline has an increasing trend from 1990 to 2010, especially with the fastest growth during 2000 to 2010. The coastlines along the Liaoning and Shandong Provinces generally had a growing trend, while the shoreline along the Beijing-Tianjin-Hebei region changes most rapidly. These analyses have suggested that human influence is the key factor in causing the significant changes of the Bohai Sea coastlines in recent years.

Keywords: Bohai Sea, coastline, remote sensing, GIS

1. INTRODUCTION

In recent years, the Bohai Sea Rim Area has become one of the most important economic development regions in China. Rapid growth of economy urbanization and industrialization has gradually increased the deprivation of land resources in the Bohai Sea region. Examining the accurate situation of coastline changes is of the great significance for the sustainable development and environmental protection for the Bohai Sea coastal region.

Numerous studies generally focused on two aspects in analyzing the coastline changes. One part of studies tended to qualitatively examine the drivers, status, influence, remediation countermeasures for the coastline changes. The others attempted to combine the remote sensing and GIS technology to quantitatively study the coastline features. However, the former lacks real-time and accurate information, while the latter is more limited in the provinces, and thus lacks of inter-regional comparisons. More importantly, quantitative investigations and inter-regional studies for the coastline changes are currently rare for the Bohai Sea region. By integrating the remote sensing and GIS techniques, therefore, this

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study accurately extracts information on the spatial-temporal changes of the Bohai Sea coastline in past two decades in order to better understand the actual situation of coastline variations.

2. STUDY AREAS

The Bohai Sea Rim region covers a full ring around the Bohai Sea coastal region and partial contains the Yellow Sea in the Northeast China, including the Beijing city, Tianjin city, Hebei, Shandong and Liaoning provinces shown in Figure 1. In this paper, we divided this entire area into 3 parts: Liaoning, Jingjinji(Beijing-Tianjin-Hebei),Shandong for further study. The Bohai Sea Rim region has the vast sea with long and winding coastlines. Its east side lies in the mouth of the Yalu River, and its west side is along the administrative boundary of Shandong and Jiangsu provinces. Important harbours in the North China are in this region, such as Dalian, Qinhuangdao, Tianjin, Yantai, and Qingdao. Since the 21st century, with the development of Tianjin Binhai New Area and other major strategies, the Bohai Sea region has become a strategic focus of the country's economic development.

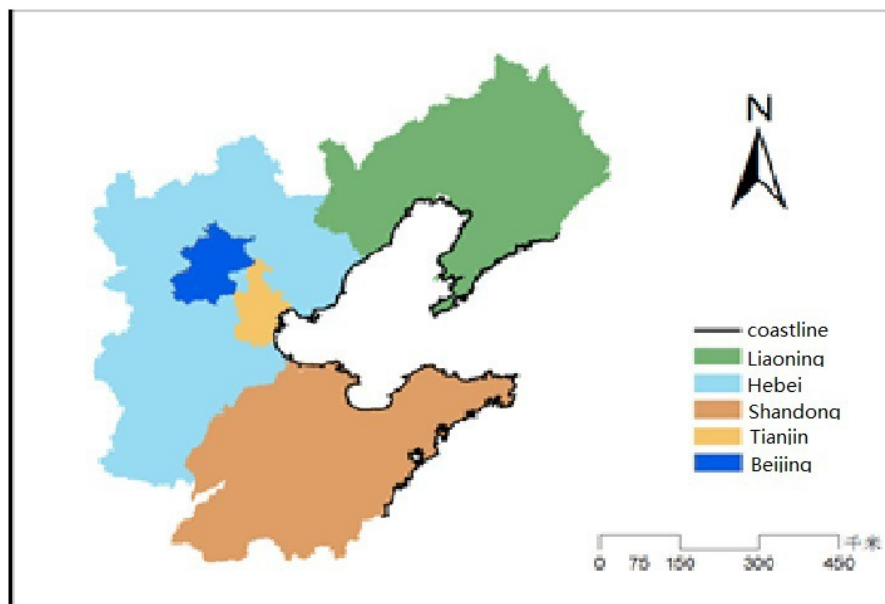


Fig. 1 Bohai Sea Rim location

3. DATA SOURCE

Remote sensing data is an important source of information for studying coastline changes. Disparate kinds of remote sensing data have different characteristics. The remote sensing data for this study is from the Chinese Academy of Sciences database with sunny cloudless conditions, including the Bohai Sea region Landsat TM (Thematic Mapper, TM) images in 1990, 2000 and Landsat ETM+ (Enhanced Thematic Mapper, ETM+) images in 2010.

This paper also used vector data of Chinese administrative division, including provincial, city and county administrative boundaries, station points, roads, water and other layers. Other field data are derived from the survey data, reports and literatures.

4. RESEARCH METHOD

In mapping, the definitions of coastline differ in geography, economics and politics based on the different research purposes^[1-3]. This study focuses short time period during 1990 to 2010, and the effects of natural factors on coastline changes are relatively small. Since the 21st century, in order to promote the rapid development of the Bohai Sea region's economy, human has done a large scale transformation on coastal zone. The construction of the new shore, docks, levees and other artificial form of architectures and other natural features are the extracting standards.

ENVI software was used in this study for stitching and processing the remote sensing images. Complete geometric correction using the cubic convolution interpolation method is applied to the images. Using a dark pixel atmospheric correction, the image brightness is improved in dynamic range and enhanced contrast and also the image quality is improved as well^[4]. Both artificial and natural coasts have sharp contrasts with coastal seawater and fishpond in the 432-band RGB image on a standard TM false color composite image. Therefore, in this study, visual interpretation and manual vectorization method for extracting shoreline change are used in ARCGIS platform. Also the Google Earth software is used to avoid false positives when extracting the coastline. Typical coastline interpretation signs are shown in Figure 2.

After the coastline extraction was completed, we obtained the overall changes of coastline length in the Bohai Sea Rim region for 1990, 2000 and 2010. The coastline of the Bohai Sea and administrative circles vector charts overlay, coastline length variation can be derived in Liaoning, Beijing, Tianjin, Shandong and adjacent regions.



Fig. 2 Coastline interpretation signs

5. RESULTS AND ANALYSIS

5.1 Coastline change process analysis

In this paper, we used remote sensing images to extract the length of the coastline as well as the range of its change over the Bohai Sea Rim region in 1990, 2000 and 2010. According to the image information and related data, the paper examined the changing process of coastlines and the potential causes. Results from the extraction are shown in Figure 3.

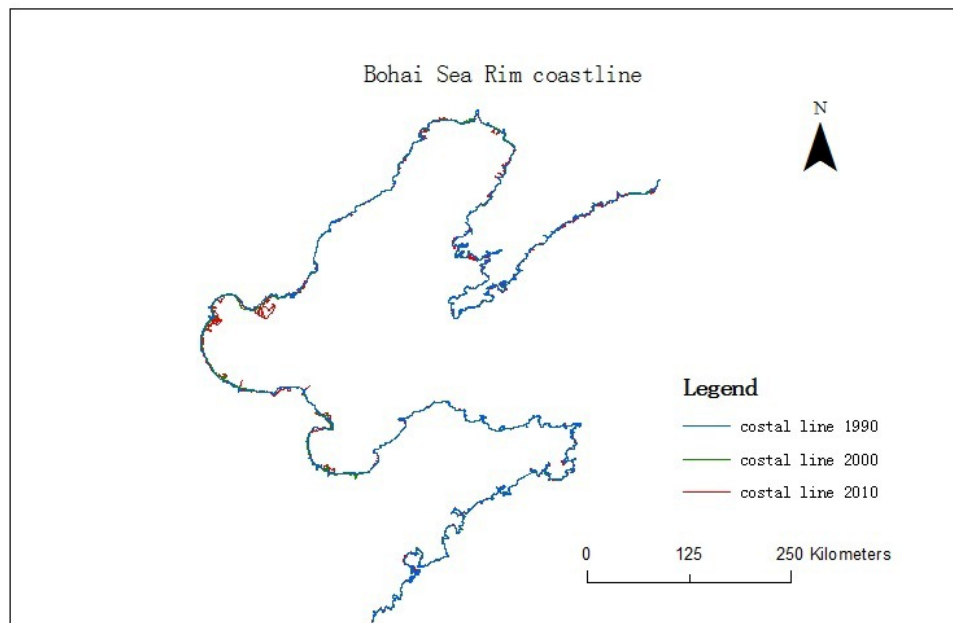


Fig. 3 Bohai Sea Rim coastline

In 1990, the total length of Bohai Sea Rim coastline was 5014.12 km, where Liaoning Province was 2035.04 km, Jingjinji area was 386.76 km and Shandong Province had 2592.32 km. In 2000, the total length of the coastline of Bohai Sea Rim was 5247.93 km, in which Liaoning Province had 2112.47 km, Jingjinji area was 478.33 km and Shandong Province had 2675.13 km. In 2010, the total length of the Bohai Sea Rim coastline became 5836.94 km, in which 2246.21 km for Liaoning Province, 811.05 km for Jingjinji area and 2779.68 km for Shandong Province. In the former 10a, the Bohai Sea Rim coastline increased 233.81 km, with the growth rate of 23.38 km/a. Jingjinji area has the maximum growth of 91.57 km, with the growth rate reaching 9.16 km/a, as shown in Table 1. In the latter 10a, the Bohai Sea Rim coastline grew 589.01km, with the growth rate of 58.9 km/a, while the Jingjinji area increased most rapidly for 332.72 km, with the growth rate of 33.27 km/a, as shown in Table 2.

Table 1 From 1990 to 2000 Bohai Sea Rim coastline change table

Region	1990 (km)	2000 (km)	Length (km)	Growth rate (km/a)
Liaoning	2035.04	2112.47	77.43	7.74
Jingjinji	386.76	478.33	91.57	9.16
Shandong	2592.32	2657.13	64.81	6.48
Total	5014.12	5247.93	233.81	23.38

Table 2 From 2000 to 2010 Bohai Sea Rim coastline change table

Region	2000 (km)	2010 (km)	Length (km)	Growth rate (km/a)
Liaoning	2112.47	2246.21	133.74	13.37
Jingjinji	478.33	811.05	332.72	33.27
Shandong	2657.13	2779.68	122.55	12.26
Total	5247.93	5836.94	589.01	58.90

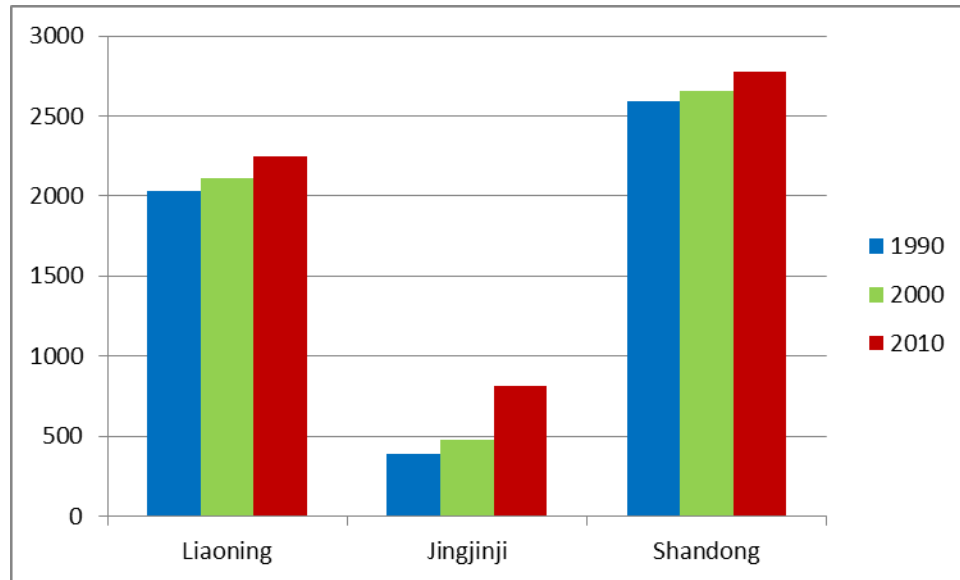


Fig. 4 1990 ~ 2010 Bohai Sea Rim coastline change

In summary, from 1990 to 2010 Bohai Sea Rim coastline clearly showed a growing trend. Overall, the coastline had rapidly advanced towards the ocean. Compared Table 1 with Table 2, it shows that from 1990 to 2000 the Bohai Sea Rim coastline increased relatively slowly, while from 2000 to 2010 the increase rate was becoming faster. Figure 4 shows that from 1990 to 2010, the Jingjinji region had the sharpest coastline changes, while the changes of coastlines along the Liaoning and Shandong Provinces were relatively flat.

5.2 Causes analysis for coastline change

Shoreline change causes can be summarized into two main causes: natural and human factors. Natural factors include sea-level rise caused by global warming, rivers, large waves erosion of coastal areas, and estuarine sediment accumulation, etc. Human factors mainly include artificial-reclamation-built-towns, coastal aquaculture, and construction of piers, etc^[5-8]. We can select the range of large areas of coastline changes by adopting the ARCGIS attribute selection function, and do more analysis by combining with remote sensing images and local survey data.

The length of Tangshan Caofeidian coastline was 33.37 km in 2000, and was 163.68 km in 2010. Total growth is 130.31km within 10 years, accounting for 39.22% of growth in the entire length of the coastline along the Jingjinji

region. It indicates that the Jingjinji region is the one with the greatest changes of coastlines. The comparison shown in Figure 5 between two remote sensing images for this area suggested that the large-scale construction of deep-water harbor and port industrial park are the major cause for this dramatic change of coastline.

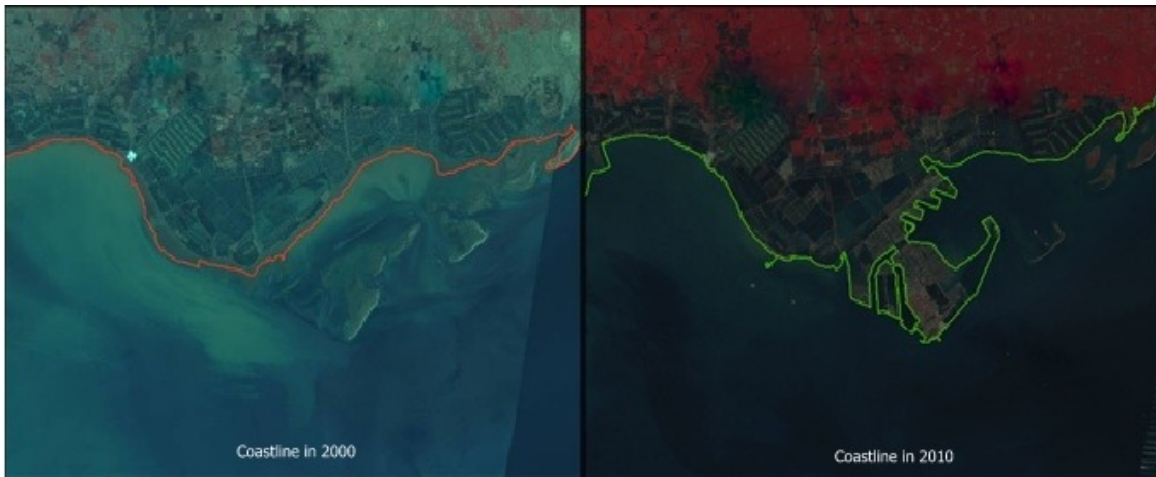


Fig. 5 Coastline change in Caofeidian region

Using the same way we can find more places where coastline changes were mainly caused by human factors, such as Daliaohe River near Yingkou City, Tianjin Binhai New Area, Jiaozhou Bay, Laoting County, Tangshan City, Qingdao City, etc. From the analysis, it is suggested that the port construction, fishing facilities and the construction of solar salt field are the most important reasons for the Bohai Sea Rim coastline changes. Compared with these impacts of human activities, natural variations, such as estuaries siltation and erosion of the coastlines, generally had relatively small effects ^[9]. Meanwhile, given that the 20-year study period is short, natural factors affecting the coastline change is relatively weak. Therefore, results suggested that the human factor is the key cause for the Bohai Sea Rim coastline changes within the recent two decades.

6. CONCLUSIONS

In this paper, we extracted the Bohai Sea region coastline information and analyzed the spatial-temporal evolution of coastline changes within the recent 20 years, by using three remote sensing images, remote sensing and GIS technology, and the Google Earth and EXCEL software. Results show that from 1990 to 2010, the Bohai Sea coastline showed a growing trend, particularly during 2000 to 2010 there was the fastest growth. The Jingjinji region had the most rapid shoreline change, and the ocean coastlines along the Liaoning and Shandong Provinces also showed an increasing trend. Human factors like port construction, fishing facilities and the construction of solar salt field are key causes for the Bohai Sea Rim coastline changes within the recent two decades.

7. ACKNOWLEDGEMENTS

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