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ANALYSIS OF RECENT COASTLINE EVOLUTION DUE TO MARINE RECLAMATION PROJECTS IN THE QINZHOU BAY

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ABSTRACT

Intense marine reclamation activities bring obvious benefits, meanwhile, these activities also influence the coastal natural formation, hydrodynamic processes and water environment etc. In order to investigate the exact influence in the Qinzhou Bay brought by marine reclamation behaviors in recent years, based on the remote sensing image data in the Qinzhou Bay in 2006, 2008, 2009, 2012 and 2014, with the help of GIS and RS software, the thesis interprets Qinzhou Bay coastline and artificial reclamation by man-machine interaction and makes quantitative analysis in the Qinzhou Bay coast evolution recently. The results show: (1) Qinzhou Bay coastal morphology change degree was strong in 2006 - 2012 and the coastline changed greatly. Originally part of the natural shore segments which had twists and turns were gradually filled into artificial coast, the coast constantly advanced to the sea, coastline became regular and straight; (2) The change degree of coastline was relatively small in 2006-2008, the average artificial coastline increased 8.86 km/a, the average artificial reclamation area was 20.79 km^2 /a; in 2008-2012, the change range of coastline was the greatest, coastline changed most severely, the average artificial coastline increased 16.07 km/a, the average artificial reclamation area was 58.52 km^2 /a; however, in 2012-2014, coastline change degree relatively slowed, the average artificial coastline increased 4.04 km per year, the average artificial reclamation area was 3.464 km^2 /a. (3) Compared to the studies of predecessors, the innovation of this paper is that it is the first to carry out the detailed research on coastline evolution caused by reclamation engineerings of the Qinzhou Bay, then formed the change results on coastline that caused by intense human activities in the Qinzhou Bay, provided the area of the marine environment protection with full and accurate data.

Keywords: Qinzhou Bay; marine reclamation; remote sensing; geospatial analysis; coastline evolution

INTRODUCTION

Coastal zone is an important part of the ocean and the key area of ocean space which is useable The seawall, artificial island, harbor wharf, sea reclamation works etc., which were built for developing and utilizing were called coastal engineering. marine reclamations and other coastal engineering artificially can effectively alleviate the contradiction between people and land in the coastal zones, but also will cause harmful interference to the marine natural ecological environment. With the rapid development of regional social economy in our country, the acceleration of the modern urbanization and the modern industrialization pace, in order to expand their own survival and development space, people will naturally ask for development space from marine, so the contradictory problem between people and the land will become more prominent. From the beginning of the founding of the PRC to the end of the 20th century, marine reclamation in coastal areas was a total of about

1.1×104 km^2, the average reclamation area is 210-220 km^2 /a; in 2000 - 2005, the marine reclamation is near 300 km^2 /a; however, in 2006 - 2010, this number increased to 700 km^2 /a. These large-scale reclamation activities have made the length of coastline in China shortened by 2000 km than the early days of the founding of PRC [1]. The intense human activities bring obvious benefits to our country; at the same time, also influence on coast natural formation, hydrodynamic processes and water environment etc., like these problems that have emerged, led to quality reduction of coastal ecological environment, intertidal wetlands disappeared, ovipositor sites of offshore fish were buried and damaged, biodiversity was greatly reduced, variation of tide and tidal wave caused by the flow direction changed by near shore ocean currents , along with self-purification capacity decreased on the coast and others.

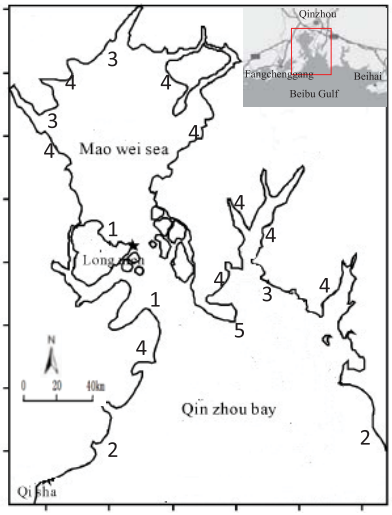

Fig. 1 Study area location and coastline distribution map

Beibu Gulf is located in the southwest coast of China, with an area of about 130 thousand km^2. Coastal cities include Beihai, Qinzhou, Fangchenggang City of Guangxi and Zhanjiang-an important city in western Guangdong etc., which are relatively less developed coastal areas. In recent years, with the establishment of China - ASEAN Free Trade Area, the Beibu Bay Economic Zone rose for national strategy, "one axis two wings" M type regional cooperative strategic concept of Guangxi Zhuang Autonomous Region Party committee proposed, an unprecedented high tide of opening and development occurs frequently in Beibu Gulf (Guangxi) economic zone, a batch of major industrial projects centrally settled in Beihai, Qinzhou, coast of Fangchenggang City. Due to reclamation cost far less than that of land acquisition, most of these projects selected reclamation. After comparing with Zhenzhu Harbor area in Beibu Gulf area, Fangchenggang City area, Qinzhou Bay, Beihai and Tieshan port and other sea areas and analyzed, Ge Zhenpeng, Dai Zhijun [2] and other scholars thought that these areas had utilized shorelines to make reclamation to different degrees, and recently the coast by human reclamation changed most greatly was in the Qinzhou Bay. In order to get more representative research data, this study intends to select Qinzhou as the research object, because it is positioned as the industrial center city of coastal port by Guangxi, which is characterized in that the port and industrial lands were mostly formed by artificial reclamation and the speed and scale of reclamation was unprecedented. Since January 2008, the country formally approved the implementation of Guangxi Beibu Gulf Economic Zone Development Plan. Until to 2012, in less than 5 years, Qinzhou grabed opportunity, , created 40 acres reclamation in a day, built a floor "Qinzhou speed" in seven days in Qinzhou, made10 million tons petrochemical enterprises, million tons paper-making enterprises, 10 square kilometers bonded port area, 55 square kilometers in China-Malaysia industrial park and other projects have settled in Qinzhou. Qinzhou has reclamation and did big industry in common with most coastal cities, is a typical new industrial city asking for lands from marine with rapid development, has a general character that represents the research field that artificial reclamation change coastal morphology. It shows that the coastal people claim development space from marine for their life and development,. This study uses TM and ETM high resolution remote sensing image in different periods, analyzes Qinzhou Bay coastline morphology changes, and draws a conclusion that the influence of regional reclamation and other coastal engineering on the gulf natural shoreline morphology.

CURRENT CONDITION OF THE STUDY AREA

The Qinzhou Bay in the middle of coastal top of northern gulf in Guangxi (Figure 1), consists of the inner bay (Maowei Sea), outer bay (Qinzhou Bay) and the tidal inlet connecting with two bays (Bay neck). There, numerous islands, narrow in the middle, both ends are broad, East, west and north are surrounded by low mountains and hills.The Qinjiang River and Maoling River input in the north and to the south is the Beibu Bay. it is a semi-enclosed natural bay. The harbor entrance width of Qinzhou bay is 29km in west-east direction and 39 km in north-sourth direction. The bay area is 380 km^2, where the shoal area is about 200 km^2. According to the lithology along the coast in Qinzhou Bay, hydrodynamic conditions, shoreline stability and other factors, combined with field survey, the coastal morphology can be roughly divided into the following several types (Correspond with the number marked in Figure1): (1) bed rock cape coastal morphology, mainly distributed in the narrow bay neck area between outer bay and inner bay, the terrain is extremely patched. mountains and low hills directly face sea, winding coastline and numerous branching streams, sea islands scattered, is a typical hilly Liman coast, such coastline is 175.38 km (account for 52.2% [3]); (2) The sandy coastal morphology, mainly distributed on both sides of the Qinzhou bay, is formed by external force, especially by sorting sediment of wave after sea level tends to be stable, the sand coast was generally far away from mountainous region,

mainly grew from the wave shadow that piles up behind the monadnock and bench terrace, also called a tombolo, coastal erosion morphology and accumulation morphology alternately distributes, promontory of monadnock or bench terrace raised up to sea, bay is concave, such coastline was 32.2 km (account for 9.58%) [3]; (3) muddy coast morphology, mainly distributed in delta plain coastline of inner Maowei bay top, belongs to the Qinjiang River - Maoling River Delta complex delta region, riverbed inlets cover densely, coastline cuts fragments, shoal and tidal flat are wide, coastline seaward, tidal flat well develops, such coastline is 49.62km (Account for 14.76%) [3]; (4) biological coast morphology, mainly distribute in the north and northwest of the Maowei Sea and the Jingu River, and also distribute disjunctively in the Longmen Islands (the central Gulf), is composed by the mangrove, such coastline is about 100 km[3]; (5) Artificial shoreline morphology includes port construction, road construction around Sea, land reclamation, coast protection and artificial coastal engineering shoreline of all kinds, shoreline morphology is regular, appear to be flat.

THE SOURCE AND PROCESSING OF DATA

In order to study the influence of Qinzhou Bay reclamation project on the shoreline morphology, we selected the remote sensing images in 2006, 2008, 2009 and 2012 and 2014, which were the most intense period of time of opening-up and development of the Beibu Gulf Economic Zone as the main data source [4], and combined with the "2008-2025 Qinzhou City Overall Planning Graph", investigate different change characteristics of coastline caused by reclamation engineering in the Qinzhou Bay in near future and next 10 years. Remote sensing image data come from China geographic spatial data cloud (http://www.gscloud.cn/) website, the spatial resolution is 30 m, and the spatial coordinates system is GWS-84. The shooting time of TM image in 2006 was October 30th, cloud cover was 1.0, the image quality was good; shooting time of TM image in 2008 was November 20th, cloud cover was 0.03, the image quality was better; shooting time of TM image in 2009 was November 23rd, cloud cover was 0.04, the image quality is also very satisfied; shooting time of ETM image in 2012 was October 22nd, cloud cover was 24.65, cover area of cloud was not within the study area, had no effect on the image quality in the study area; shooting time of ETM image in 2014 was October 12th, cloud cover was 20.53, cloud cover area was not in the study area. The study area had no effect on the image quality; after obtaining remote sensing images, the main application of ArcGIS10.0, ERDAS9.0, ENVI5.0 and other GIS software and remote sensing image processing software did a pretreatment about shadowgraph, including geometric correction, atmospheric correction, image band fusion, image cutting and other images in the study area. Interpretation is mainly to make water and land divide, with the help of ENVI5.0, combined with the field survey, in the interpretation process.

Geometric correction is to enable remote sensing images have the same projection and coordinate system, influenced by earth curvature and rotation and other factors, resulting that pixels on the image would produce a certain distortion between coordinates in the image coordinate system and map coordinates system [5] and to obtain precise coordinates on remote sensing image where each pixel correspond with ground target, need to do geometric correction. We adopt the land use planning database as a reference in central city, Shabu Town, Qinzhou, in image, choose typical features and artificial buildings with clear location identification mark (such as road intersection, river intersection point, building boundary, etc.) as a reference point, complete image geometric correction in the geometric correction module of ERDAS9.0.

Image band fusion is to enhance the remote sensing image processing, in order to make the remote sensing images can provide more categories and higher classification accuracy, synthesize the characteristics of the land sat bands and the combination contrast between different bands and research achievements of the predecessors, this thesis selects 5, 4, 3 band combination. The false color image complexed by 3 bands is close to the true color, land features are easy to identify, and the boundary is clearly visible.

COASTLINE EXTRACTION

Coastline is one of the elements of coastal geomorphology, and many researchers have put forward their own views and opinions on the coastline according to their research. Many researchers believe that the coastline is the boundary between the ocean and the land, that is, the boundary between water level of mean high tide and land, because it is relatively easy to locate in the field or make photography interpretation [6, 7]. The determined coastline in this paper is based on the water edge, which is interpreting by remote sensing, to determine coastline of study area after tide level correction.

Water edge extraction

There are many kinds of methods to extract water edge, including by visual interpretation, density slicing or edge extraction for single band image and multi-band classification extraction etc. [8]. In the process of extracting coastline, extracting water edge line is a very important step. Different coastal types make their different characteristics. We mainly study the influence of reclamation on the Qinzhou Bay coastline morphology changes, so the coastal types are rock coast and artificial coast will be taken into consideration. In the remote sensing image, the Bedrock Coast and the artificial coast have very obvious boundaries of water and land. According to the reflectance characteristics of water spectrum to select water pixel to make a analysis from the image, and determine average spectral curves of water pixel, make average spectral curve of water pixel as central criterion, if the target pixel spectrum falls within the average spectral curves of water pixel, it is determined to be water, otherwise land [9].

TIDE LEVEL CORRECTION

Because the coastline is affected by the tide, the water edge extracted from the image map is not the defined coastline; it is just the instantaneous water edge when taking the pictures of satellite. According to the definition of coastline (coastline is the dividing line between the ocean and land, namely boundary between mean high tide of sea water tide and land). Understandably, the probability is very small that image shooting is just the mean high tide line, therefore, to get real coastline need to make tide of water edge correction to the mean high tide line. Tide corrections are generally based on the tide height of satellite imaging time, mean high tide level and coast slope and other information to calculate horizontal distance between instantaneous waterline and high-water line, so as to determine the shoreline position [10]. In this paper average monthly maximum tidal range and average monthly minimum tidal range in the study area of Longmen tide station in 2009 were collected, according to tide correction principle; we can get the adjusted distance 4.04 m from water edge to the coastline in 2009. Due to the data at the Longmen tide gauge station in other years cannot be collected, we cannot calculate in 2006, 2008, 2012 and 2014. due to 2009 was in the middle of 2006 and 2014, the correction in 2009 can be regarded as the average year. For lack of original data, the 4.04m obtained using tidal level in Longmen gauge was applied in the other years. Actually, our interesting region is far away from wide shoals. Here, no significant variation of water-land boundary exists. The usage of '4.04m' is acceptable, and the average correction distance from water edge to coastline was 4.04 m in 2006 to 2014.

RESULTS ANALYSIS

Through super positions of interpretation results of five satellite remote sensing image, it can be seen that: in 2006-2008 shoreline change of the Qinzhou Bay was significantly complex, during these two years, new lans emerge continuously; while in 2008 – 2009, the Qinzhou Bay coastline changed rapidly, through 2009 - 2012 coastline change moved close to the level maintained in 2014, that is, reclamation area has tended to be relatively stable, but according to the Qinzhou City 2008-2025 Qinzhou Overall Planning, Qinzhou Bay coastline, in the next 10 years, Qinzhou Bay will continue to change along with the current trend, but will not change too intensely.

ANALYSIS OF COASTAL MORPHOLOGICAL CHANGES IN QINZHOU BAY

From the point of overall change space, the Qinzhou Bay Coastal morphology change rate was relatively great, bedrocks and biological mud coastline on both sides of the entrance of the Jingu River almost disappeared, new coast and part of the natural bank segments all turned into artificial coasts, coast continue to advace seaward, many originally winding coast were gradually filled, coastlines became increasingly flat.

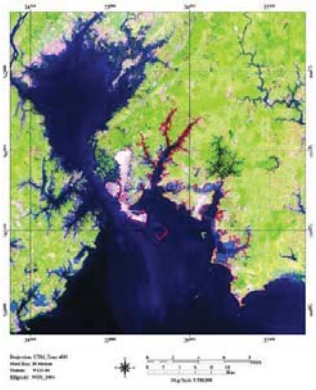

Fig. 1-1 *coastlines in 2006*

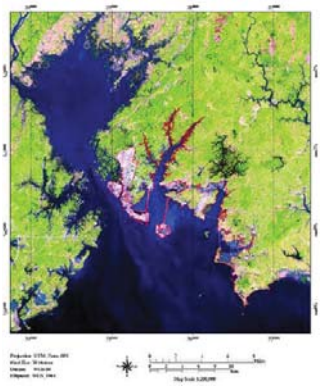

Fig. 1-2 *coastlines in 2008*

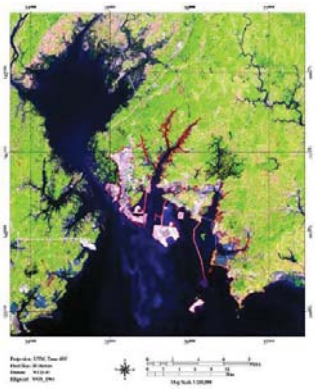

Fig. 1-3 *coastlines in 2009*

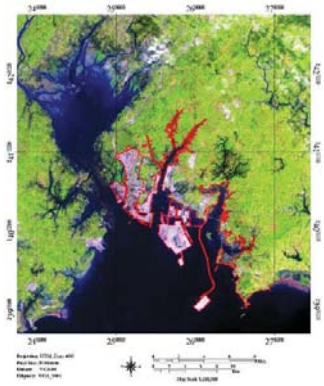

Fig. 1-4 *coastlines in 2012*

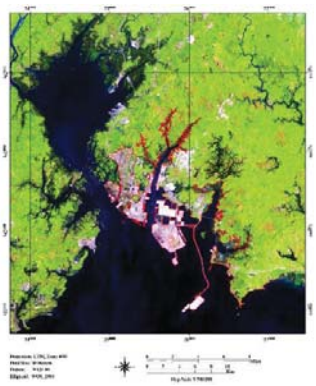

Fig. 1-5 *coastlines in 2014*

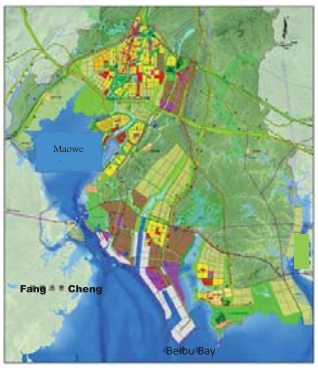

Fig. 2 *Qinzhou overall planning(2008-2025)*

Coastal morphological changes in Qinzhou port area

In October 2006, the coastline in the Qinzhou Port only had wing angles, which toward the Gulf, land form was a shaped hook , forming an inner sound, coastlines with twists and turns, close to natural status; at this time, artificial coastline morphology changed slightly (Figure 1-1). Compared with images in November 2008, in the Qinzhou port a sea embankment was built up from bay wing to north-south direction, the inner zone were encircled and coastal morphology became aciform (Figure 1-2). From the image in November 2009, it can be seen that from 2006 to 2009, Qinzhou port "hook-shaped" bay wing topography has become a small peninsula in bursting into the sea, inner Harbors became land (Figure 1-3), bedrock-typed natural meandering coastline was surrounded by regular and straight artificial coastline, so shoreline space form changed, and during this 3 years, due to artificial reclamation, land area increased 1.81 km^2; in contrast with images in 2009-2012, the Qinzhou port coastline morphological changed little during this period, the Qinzhou port "hook-shaped" Bay coasts and the original bedrock shoreline merged to form a complete zone plate artificial land area (figure 1-4). While during the period of 4 years, due to the artificial reclamation project continued to expand, land area of the Qinzhou port increased 4.52 km^2. Until to 2014, in Qinzhou port, artificial reclamation was fully completed, coastline completely changed into artificial coastline.

Coastal morphological changes in Qinzhou Free Trade Zone

From satellite images in October 2006, the present position of the Qinzhou Bonded Port was in the sea (Figure 1-1). Therefore, the Qinzhou Bonded Port Shoreline changes greatly in Qinzhou Bay, because it is in the depths of the ocean added an artificial coastal engineering without foundation. From (Figure 1-2) can be seen by November 2008, at an approximately pentagonal bonded port area had landed in the boundless ocean, from the east coast of theJingu estuary as a starting point, a long 3.48 km cross-sea road was built from north to south connected to the land in the sea, and at that time, The Sandun island was a dot that cannot be seen in satellite imagine. However, satellite image In November 2009 displayed, the bonded port area of 6.95 km^2 was basically formed in the sea (Figure 1-3), and a cross-sea road was built to connect it, and at the same time, The Sandun island had greatly changed. It is developed from scratch in the sea, and directly emerged a rectangular artificial island with 1.33 km^2, and built 10.05 km long cross-sea road connected with land. In contrast with satellite images in October 2012, it can be found that the main artificial land of Qinzhou Bonded Zone and the Sandun island in the sea changed little, only filled lands between the bonded area land and Makouling coastline to connect lands in bonded area with landmass into a piece, formed a second delta artificial peninsula corresponding with the Qinzhou Port. According to the evolution trend and combined with the Qinzhou City Master Plan (Figure

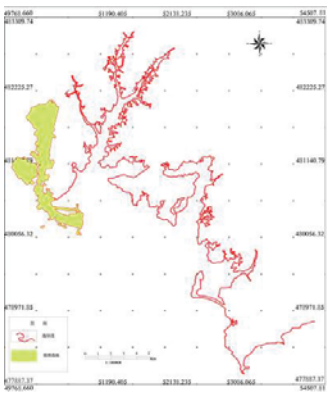

Fig. 3-1 *Coastlines In 2006*

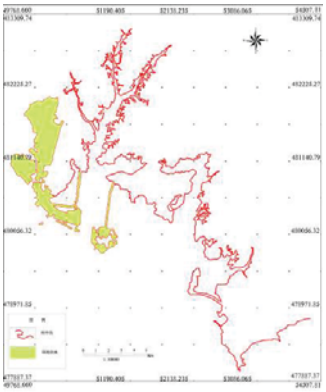

Fig. 3-2 *Coastlines In 2008*

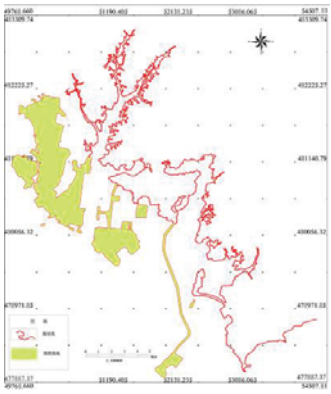

Fig. 3-3 *Coastlines In 2009*

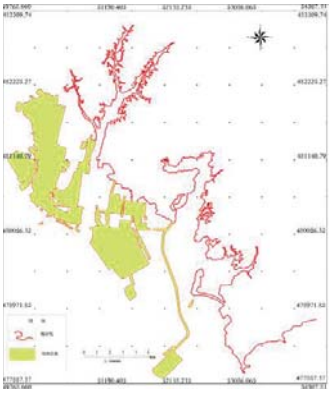

Fig. 3-4 *Coastlines In 2012*

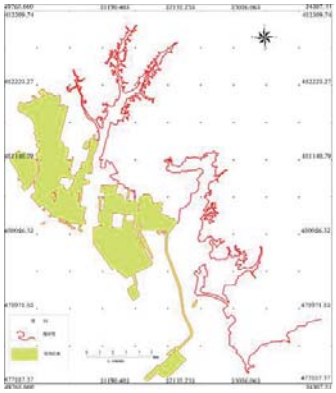

Fig. 3-5 *Coastlines In 2014*

2), we can see that in the next 10 years (2025) the Qinzhou Gulf coastal morphology changes might occur centrally in the sundun island and bonded port area, a peninsula land might emerge between them.

COASTAL SHORELINE CHANGES IN QINZHOU BAY

According to the satellite image data, the period of time related to this study are 2006 - 2008 - 2009 - 2012-2014 and the coastline changes in tte Qinzhou Gulf in next 10 years (2025). As for the Qinzhou Gulf Coastline changes before 2006, HuangGu[6], Zhou Xiangjun [5], MaYanli [11], Ge Zhenpeng [2] et al. combined with related discourse of the Beibu Gulf coastline changes, this paper will not repeat them. In this paper, the focus is set on the influence of the Qinzhou Bay reclamation project on the other coastline during 2006 to 2014 and the next 10 years.

From the Interpretation results it can be seen that : In 2006-2008, the Qinzhou Bay coastline change greatly, in 2006, it was 137.01 km^2, while in 2008, it was 178.59 km^2, within 2 years, new coastal areas emerged continuously , increased 41.58 km^2, with an average increase of 20.79 km^2/a (Figure 3-1 to 3-2), and artificial coastline length increased 17.72 km, the artificial coastline increased 8.86 km/a; in 2008-2009, the Qinzhou Bay coastline changed rapidly, in 2009, reached 301.20 km^2, annual growth was 122.61 km^2 (Figure 3-3), compared with coastal land areas in 2006, it increased 164.19 km^2, and compared with artificial coastline in 2008, it increased by 36.74 km, compared with 2006, it increased 54.46km; during 2009-2012, in the Qinzhou Bay, coastline variation was still relatively severe. it was 458.89 km^2 in 2012, the annual growth was 37.16 km^2 (Figure 3-4), compared with 2006, it increased 321.88 km^2 land area; while compared with the artificial shoreline in 2006, it increased 82.01 km; compared with 2009, increased 27.55 km, from 2009 to 2012, the annual average of artificial shoreline was 9.18 km, in 2012-2014 the Qinzhou Bay coastline variation was relatively slowly, 528.17 km2 in 2014, increased 69.28 km2, annual growth was 34.64 km^2 (figure 3-4), and compared with the coastal land areas in 2006, increased 391.16 km^2, compared with artificial shoreline length in 2006, it increased 90.09 km, compared with 2012, it increased 8.08 km; During the period of 2012-2014 an average annual increase in artificial shoreline was 4.04 km; from the Qinzhou City shoreline planning figure in 2025(Figure 2), and the coastal land area increased by 2401 km^2 related to that of 2006, an annual increase was about 88 km^2, compared with the coastal land area in 2015, it increased approximately 1149 km^2.

In summary, the Qinzhou Bay shoreline change degree was little in 2006-2008, in 2008-2012, it speed up, changed most dramatically, and in 2012-2014, it changed slowly, within the next 10 years from 2014 to 2025, growth will become relatively slow.

DISCUSSION

From the Qinzhou Bay coastal morphology and analysis of coastline evolution, the 6 years from 2006 to 2012 is the fastest time in the Qinzhou Bay coastal morphological changes. Because in May 2008, the State Council formally approved the establishment of the Qinzhou Bonded Port Area and Qinzhou began by blowing sand reclamation was conduced in the construction of the bonded zone. From May to November in 2008, in less than six months of the founding of bonded area, a land of 2.6 km^2(Figure 3-2) was filled out, which created a "Qinzhou speed" by blowing sand reclamation projects. With this reclamation rate, by September 2009, increased land area had expanded 2-3 more times (Figure 3-3). And before 2008 The Sandun island was just a sea land with a sanatorium in Xiniujiao, in 2009, a large oil project was started in the Sundun island,an meanwhile land reclamation began. Until to August 2010, the area has increased to about 2 km^2, and a road of 50m width and about 10.05 km length which connect to with the coast was built. In addition to the Qinzhou port for the implementing capacity expansion to do the reclamation project, made relatively calm and clean original ecology shallow bay in Qinzhou Bay become into the most violent regions of human activities in Beibu Gulf in recent years.

The influence of Qinzhou Bay reclamation project on Qinzhou Bay environmental was significent, mainly manifested in (1) the natural shoreline shape is changed, seawater power in the bay area was affected, so made flow velocity increase 0 - 0.2 m/s on the west and east side of the project area [12], although effectively reduce the sediment deposition in the port area, but will lead to an insufficient amount of sediment supply in Qinzhou Bay and may cause that northeast seacoast in Qinzhou Bay Sea would be exacerbated by seawater. (2) change the actual capacity of Qinzhou Bay seawater, admissible water volume was significantly reduced, in 2012 Qinzhou Bay water volume was decreased about 2.21% than in 2008[13], made Maowei Sea level elevation, gentle flow, causing that pollutants brought by the Dafeng River, MaoLing River and Qinjiang River were not easy to spread and degrade. (3) coastal industrial and port construction, especially oil, paper-making and other industries, will bring pollution to the atmosphere of the Qinzhou Bay and seawater, including discharge of sewage, production waste, garbage, transport ship pollution and others to the gulf (4) influences on the Qinzhou Bay biological community, Qinzhou Port reclamation engineering dumped and buried shallow sea beach and low-lying shrimp ponds, seriously damage to the environment for the survival of costal life and some mangroves and amphibians may thus became extinct. (5) seawater tidal current field and tidal volume were changed, the direction of the flow field was changed due to the new shoreline in the eastern and South project area, the flow direction changed significantly, caused a decline in tidal volume in the bay, tidal volume of bay body in the Qinzhou Bay was reduced by 3934.38 * $104m^3$ and accounted for total tidal volume of about 2% in the Qinzhou Bay [8].

CONCLUSION

The thesis uses remote sensing images in a total of five periods, including 2006, 2008, 2009 and 2012 and 2014, combined with ArcGIS10.0, ERDAS9.0, ENVI5.0 and other GIS soft-wares and RS image processing software, interpret coastline by way of man-machine interaction, and makes quantitative analysis on Qinzhou Bay Coastal morphology and coastline dynamic changes, the main conclusions are as follows:

1. During 2006-2012, Qinzhou Bay Coastal morphology change degree strongly, the bedrock and sludge biological mud shoreline on both sides of entrance of the JinGu River almost disappeared, new coasts and part of the original bank sections all turned into artificial coast types, coast continued to seaward, many originally winding coasts with twists and turns were gradually filled, shoreline became increasingly flat.
2. In 2006 - 2012, Qinzhou Bay coastline changes greatly, but in 2006-2008 shoreline changed to a lesser extent; In 2008-2012, the tolerance of increase or decrease were biggest and shoreline change was most severe; while in 2012-2014 speed was relatively slow; in the next 10 years from 2014 to 2025, growth rate will become relatively flat.
3. The reason of Qinzhou Bay coastal change is mainly attributed to the reclamation engineering caused by the regional economic development. The influence of reclamation project on environment is rather large.

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