Quantitative Evaluation of Artificial Interference Intensity on Coastline——A Case Study of Haizhou Bay in China

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Abstract. Based on the two characteristics of the sensitivity nature of coastline to the artificial interference and the intensity of the human activity interference, this paper constructs an evaluation model of artificial interference intensity on coastline, and takes the Haizhou Bay of China as an example for analysis. The results show that the coastline of Haizhou Bay is 77.75 km long and the coastal areas are affected by human development activities to varying degrees. The lengths of the middle section of high level, medium-high level, medium level, medium-low level and low level interferences are 18.13km, 11.12km, 17.15km, 28.31km, and 3.04km respectively. The high level interference and medium-high level interference shore sections are mainly distributed in the three coastal areas of Lanshangang district, Binhai new town of Ganyu district, and Binhai new town of Lianyun district. Meanwhile, the effectively recognizing the intensity of interference received from coastlines, which can provide the basis for the implementation of more scientific and efficient coastal protection management.

1.Introduction

The coastline is the dividing line between oceans and land. The IUGS（International Union of Geological Sciences）has made the coastline one of 27 global geological indicators[1,2]. Under natural conditions, the coastline is constantly evolving and developing under the regional geological structure background and its spatial location and geomorphological evolution characteristics are influenced and controlled by hydrodynamic and geomorphic evolution and development. The coastal zone has abundant resources and superior location conditions, making it a gathering place for human activities. As a link connecting the ocean and land, the coastline is an important cornerstone for the spatial advantage of coastal space resources and an important space for development and utilization of various coastal activities. Human activities such as port construction, coastal towns and fishery aquaculture have changed the characteristics of coastal landforms to a certain extent, which have affected the evolution of the coastline. In recent decades, the development of coastal zones has continued to be active. It is of great significance to understand objectively the impact of human activity interferences on the evolution and development of coastlines, to use coastline resources intensively and efficiently, as well as to protect coastline resources scientifically and reasonably. Coastal changes in different research areas conducted by scholars[3-5] reflect that the evolution of coastlines in different regions from the perspective of spatial-temporal evolution of coastline locations. Artificial landforms play an important role in the evolution of modern coastlines. In terms of the effects of environmental and environmental interferences on human activities in coastal areas, many scholars have started from the intertwined characteristics of the marine and terrestrial eco-environments of the coastal zone, focusing on the sensitivity and vulnerability of the coastal resource environment, and the types and characteristics of the development and utilization of coastal resources and environment, thus analysing the impact characteristics of human development activities on coastal

resources and environmental[6-8]. Based on the analysis of the sensitivity nature of the coastline and the characteristics of the use of the activity interference force[9-11], taking Haizhou Bay as an example, we applied the Delphi method and spatial analysis techniques to construct an evaluation model of the artificial interference intensity on the coastline, which comprehensively analyses the intensity and spatial distribution of artificial interferences in the coastline of Haizhou Bay.

2.Research area

The research area is located on the west coast of China's South Yellow Sea, starting from Lanshantou in Rizhao City and south to East West Island in the range of 34.76°N-35.12°N and 119.19°E-119.46°E. The area is a typical arc-shaped shoreline bay, located in the transition zone of East Asian subtropical-warm temperate zone. It possesses typical ecosystems such as shrimp germplasm resources protection zone and bay ecosystem protection zone. There are many rivers such as the Xiuzhen river, the Zhewang river, the Longwang river, the Xingzhuang river, the Qingkou river, and the Linhong river that flow into the sea on the western coast. Meanwhile, coastal rocks, sand, silt, and other coastal landforms develop along the coast. Besides, the development of coastal zones is active and there are various types of utilization such as ports, towns, tourism, and fishery. Coastal areas adjacent to the city from north to south are Lanshan district of Rizhao city, Ganyu district and Lian yun district of Lianyungang city.

3.Material and method

3.1 Data

The data sources include remote sensing image data, on-site survey data, and sea area using management data. The remote sensing image uses the Landsat OLI remote sensing image as the data source at the climax and low tide in the study area in 2017. The image includes 9 bands, the spatial resolution of the bands 1-7 and 9 is 30 meters, and the spatial resolution of the band 8 is 15 meters. The image width is 185x185km. Also, field surveys are conducted to obtain information on typical surface features and development activities in coastal areas. Based on the sea area using management data, the information on the development and utilization of submarine fisheries and other subsurface waters is obtained. Besides, the ENVI5.3 software platform is used for remote sensing image geometry correction and band fusion pre-processing, and the spatial information such as coastlines and development activities are discriminated based on the remote sensing interpretation markers.

3.2 Method

3.2.1 The analysis of coastline sensitivity

Coastline sensitivity refers to the sensitivity nature of the coastline to interferences in human activity, which is mainly determined by the composition of the coastal sediments and the dynamics of coastal evolution in the regional dynamic landscape environment. According to the characteristics of coastal sediment types and coastline stability, a coastline sensitivity index model is established. The formula is as follows:

$$S_i = \frac{W_i}{B_i} \tag{1}$$

In the formula, S_i refers to the sensitivity index of coastline i, B_i refers to the coastal sediment type coefficient of coastline i, and W_i refers to the coastline stability coefficient of coastline i. According to the existing coastal studies, the coastal sediment types are classified into four types: argillaceous, gravel, limestone, and other matrix materials in terms of the bottom and their lithologic characteristics by the Delphi method. So, the B_i values are 2.0, 1.7, 1.2, and 1.0, respectively. At the same time, coastline stability factors are classified into five categories: strong siltation, weak siltation, relatively stable, weak erosion, and strong erosion according to the evolution of the coast. So, the W_i values are 2, 1.5, 1.0, 0.75, and 0.5, respectively by the long-term coastline transition distance representation.

3.2.2 Interference analysis of coastal development

Coastal development interference refers to the degree of interference to the nature of the coastline by coastal human development activities. Different coastal development and utilization types have different degrees of change in the nature of coastal zones, and development interferences are mainly determined by the type of coastal development and the intensity of interference power. According to the utilization types of coastline adjacent coasts and coastal zones and the integrity characteristics of coastline intertidal zones, a model of coastal development interference force is established. The formula is as follows:

$$P_i = (FL_i \times DFL_i + FS_i \times DFS_i) \div T_i \quad (2)$$
$$T_i = \frac{DD_i}{DL_i} \quad (3)$$

In the formula, P_i refers to the coastal development interference force index of coastline i; T_i refers to the intertidal integrality coefficient of shore segment i [12]; FL_i refers to the adjacent land use type stress coefficient of shore segment i; FS_i refers to the adjacent sea area utilization type stress coefficient of shore i. DFL_i and DFS_i are the distance attenuation coefficients for terrestrial stress and sea area stress, respectively [13]. T_i is calculated based on the spatial distance relationship between the artificial embankment line, the average tidal high-tide line, and the mean tidal low-tide water line; DD_i is the distance between the artificial embankment line and the mean tidal low-tide water line; DL_i is the distance between the average high tide and high tide line and the mean low tide and low tide line with no artificial interference. According to the actual research, the coastline stress coefficients of different types of human use activities are determined. Land use types are classified into four types: industrial and mining enterprises, urban land, agricultural and fishery lands, and ecological wetlands. The FL_i values are 1, 0.8, 0.5, and 0.15, respectively. The impact of the sea direction on the shoreline mainly comes from the interference and destruction of regional dynamic geomorphology by the offshore engineering project. At the same time, according to the utilization mode, the direction of the sea area is divided into land reclamation, sea use for structures, sea use for sea, and open sea use. The FS_i values are 1, 0.8, 0.6, and 0.15, respectively.

3.2.3 Quantitative evaluation of artificial interference intensity

The intensity of artificial interference on the coastline is affected by the sensitivity of the natural attributes of the coastline to the artificial interference and the intensity of human activity interference in the region. In order to quantitatively assess the intensity of artificial interference on the coastline and effectively identify the interference characteristics of human activities on the natural attributes of the coastline, we established a quantitative assessment model for artificial interference intensity on the coastline. The formula is as follows:

$$CA_i = S_i * P_i \quad (4)$$

In the formula, CA_i refers to the artificial interference intensity of the shoreline i; S_i refers to the coastline sensitivity index of coastline i; P_i refers to the coast development interference power index of coastline i. The greater the CA_i value of the artificial intensity of the coastline interference, the greater the artificial interference intensity. Considering the value range of coastline sensitivity index and coastal development interference force index, the coastline artificial interference intensity is divided into five levels, low-level interference ($\leq$0.5), medium-low level interference (0.5 to 1), and medium interference (1~2), medium-high interference (2~5), high-interference (>5).

4. Results and analysis

4.1 The characteristics of coastline sensitivity

The total length of the coastline of Haizhou Bay is 77.75km, and the overall shape is an arc concave toward the west. There are three types of coastal sediments: bedrock, gravel, and mud. The three coasts are generally from north to south with a gravel-to-mud transition due to the dynamic and geomorphic environment of Haizhou Bay[14]. Among them, there are 12.34km of base rock, 18.43km

of gravel, and 46.98km of mud. The stability characteristics of the coastline are generally stable and silting. The spatial distribution of the northern coast is mainly stable, and the southern part is dominated by silt growth. The siltation intensity is the strongest at the southern end of the Haizhou Bay. The stability section is 47.44km, and the deposition type is 30.31km. Combining the characteristics of coastal sediment types and coastline stability, we evaluate the sensitivity of Haizhou Bay coastline. The areas with high level sensitivity are concentrated in the Lanshantou section and the Longwang estuary-Xishu section. The coast along the Lanshantou is a high-sensitivity sensitive bank with a length of about 9.30km; the northern side of the Xiuzhen river estuary to the shore of the Longwang river estuary is a low-sensitivity bank with a length of about 27.27km; the Longwang estuary and the Qingkou estuary are medium-sensitivity shores with a length of about 12.14 km; Qingkou estuary to the west side of the Xida embankment is a high-sensitivity coastal section with a length of about 21.21km; Xida embankment to the north side of the east-west island is a low-sensitivity section with a length of about 7.8km.

4.2 The characteristics coastal development interference
The major coastal zone development activities in the Haizhou Bay area include port shipping, port industry, coastal towns, and mariculture. In the northern part of Haizhou Bay, there are Lanshangang district of Rizhao Port and Ganyungang district of Lianyungang port. The south is the famous coastal city -Lianyungang.The southern mainland coastline of Haizhou Bay is connected between Xida embankment the East-West island. The coastal area adjacent to the land area continuously distributes the pond culture area from north to south. The ponds on the two sides of the Linhong estuary have the widest range of aquaculture, and the width of contiguous ponds can reach 4km or more. The adjacent sea areas are mainly harbor shipping areas and marine aquaculture areas. Coastal towns from north to south include Lanshan district, Zhewang town, Shiqiao town, Haitou town, Ganyu district, and Lianyun district. According to the utilization types of shoreline adjacent sea areas and coastal zones and the integrity characteristics of the intertidal zone, the coastal development interferences are evaluated. The entire coast of Haizhou Bay has been disturbed by development and utilization.The high level interference shore sections are mainly distributed in the Lanshantou, Xingzhuang-Qingkou estuary, Linhong estuary -Xishu, and the north side of the East-West island, with a total length of 29.54km. However,the distribution of medium level interference force and low level interference force shorelines is relatively scattered, with total lengths of 16.37km and 31.84km, respectively.

4.3 Quantitative analysis of interference intensity
Considering the dual effect of the sensitivity of the natural property of the coastline on the artificial interference and the intensity of the human activity interference, we quantitatively evaluate the intensity of artificial interference on the coastline. The artificial interference intensity index of the Haizhou Bay coastline is between 0 and 10.0. The entire coast has been disturbed by human development activities to varying degrees, and the spatial differentiation of artificial interference intensity is significant. The spatial statistical analysis shows that the high level interference shores are concentrated in the shore section of Lanshantou and Linhong estuary-Xishu, with a total length of 18.13km; the medium-high level interference coastline is distributed in 3 bank sections include the mouth of Xingzhuang estuary - Qingkou estuary, the south side of Linhong estuary and Xishu with a total length of 11.12km; the medium level interference bank sections are located on 7 bank sections include the south side of Lanshantou, north side of Zhewang estuary, south side of Hankou estuary, both sides of Longwang estuary, north side of Xingzhuang estuary, Qingkou estuary - Linhong estuary, and north side of East-West island with a total length of of 17.15km; the medium-low level interference banks are distributed on 5 bank sections include both sides of the Xiuzhen estuary, Zhewang estuary -Hankou estuary, the south side of the Hankou estuary-the north side of the Longwang estuary, south side of the Longwang estuary-north side of the Xingzhuang estuary, and Xida embankment with a total length of of 28.31km; the low level interference section is only distributed on Xishu bank section with a length of 3.04km.

5.Conclusion and discussion

Based on the dual effect that the sensitivity of the natural attributes of the coastline to the artificial interference and the intensity of human activity interference, we constructed a widely used coastline artificial interference intensity evaluation model, which took Haizhou Bay in China as an example. This method comprehensively considers the material composition of the coastline itself and the characteristics of stable natural attributes, and the interference of the development activity of the coastal land and sea areas in two diretions. The comprehensive assessment of the artificial interference intensity on the coastline is conducive to assessing the characteristics of human activity interference intensity under different shore section attribute characteristics. Meanwhile, effective screening of coastlines with strong interference and high sensitivity can provide a basis for more scientific and efficient coastline protection and management. The coastline of Haizhou Bay is 77.75km long. In terms of coastline artificial interference intensity evaluation, which is built on coastline sensitivity and human interference intensity, the coastal areas are affected by human development activities to varying degrees. The lengths of the middle section of high level, medium-high level, medium level, medium-low level and low level interferences are 18.13km, 11.12km, 17.15km, 28.31km, and 3.04km respectively.

The high level interference and medium-high interference shore sections are mainly distributed in the three towns development shores of Lanshan district, Ganyu district, and Lianyun district. Among them, the development of the coastal zone along the coast of Lanshan district is dominated by port industry and urban construction, and the development of urban construction space is mainly for the coastal section of Ganyu district and Lianyun district.

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