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An Examination of the Suitability of Sea Area for Tourism and Recreation Based on Principal Component Analysis

Binyong Li¹, Quanming Wang¹, Zhichen Liu², Xiaolu Huang¹* and Binbin Wang³

¹ Academy of Sea-Area Management Policy and Technology, National Marine Environmental Monitoring Center, NMEMC, Dalian, 116023, China
² Navigation College, Dalian Maritime University, Dalian, 116021, China
³ Institute of Economic and Social Development, Dongbei University of Finance and Economics, Dalian, 116025, China

*Corresponding author’s e-mail: xlhuang_gis@hotmail.com

Abstract. Eleven evaluation factors from four aspects, namely, resources, environment, economy, and location are selected in this study. Principal component analysis and geographic information system (GIS) technology are used to examine the spatial distribution characteristics of sea area suitability for tourism and recreation from the grid scale. Results show that the principal component analysis method can 1) extract four potential comprehensive indexes (i.e., principal components) by comprehensively analyzing the information of numerous influencing factors of sea area suitability for tourism and recreation, 2) calculate the comprehensive score by using the principal component information, and 3) evaluate sea area suitability for tourism and recreation. The evaluation results can provide reference and support for not only the selection of sea area for tourism and recreation but also the rationality demonstration of marine projects.

1. Introduction

With the development of China's marine economy, the coastal regional tourism shows a fast growing trend. The “Building the Marine Economy” policy was first proposed in 2012 in the 18th National Congress of the Communist Party of China. In 2013, the policy was designated as “Marine Tourism Year of China” by the China National Tourism Administration, which provides an opportunity and impetus for the development of local marine tourism industry. Coastal tourism in major coastal areas, bays, and islands has demonstrated an explosive growth with the coming of leisure time and support of national policies. China's coastal tourism industry achieved an added value 10,874 billion yuan in 2015, which is equivalent to an increase of 11.4% over the previous year, which has become an important growth point for driving marine economy [1]. Coastal tourism, which is a double-edged sword, influences the destruction and protection of coastal ecological environment with the increasing intensities of coastal tourism development. Therefore, the rational allocation of coastal tourism resources and the development of coastal tourism industry according to local conditions have become important research topics in coastal tourism resource development, environmental protection, and economic development.

Decision making for the development of coastal tourism industry should be based on the suitability research of coastal tourism resource development, which is aimed at guiding people to undertake development in accordance with the suitable inner direction of different regions, and it can improve
the socio-economic and ecological value of coastal tourism and ensure the rational utilization of
marine tourism resources being of great significance. Literature on coastal tourism and sea area
suitability for tourism and recreation has received increasing attention from domestic and international
scholars. Avissar N G [2] sets up a model to study the suitability of the beach. Navickas V et al. [3]
evaluate coastal tourism resources from the aspects of nature, biology, human utilization, and
influence. Guo Chuan [6] and other domestic scholars assess the spatial competition situation of
tourism resources from the aspect of coastline type. Wang Jiping et al. [5] evaluate the quality of
tourism environment in Lianyungang City, Jiangsu Province. Ji Houde et al. [6] conduct systematic
research on island tourism planning and development according to island tourism resources. Cui
Zhenyu [7], Zhu Zhengtao [8], Wang Chusheng [9], and Chen Chunhua et al. [10] also conduct
correlational studies on the distribution of coastal area tourism industry, environmental carrying
capacity of tourism, marine ecological suitability, and sea area evaluation of tourism and recreation,
respectively. The existing literature on the suitability of coastal tourism mainly focus on the coastal
area of land territory, whereas studies on the sea area are few. Appraisals of sea area suitability for
tourism and recreation in different areas also primarily concentrate on the perspective of line or point
tourist resources, such as the beach, coastline, and island. Only a few studies, however, have been
conducted on the surface distribution of sea area suitability for tourism and recreation in near shore
regions.

Coastal tourism resources involve a multidimensional system composed of many factors. The
current research methods chiefly select multifaceted indexes, such as natural endowments, socio-
economic conditions, development potential, and accessibility conditions of coastal tourism resources
to build an evaluation index system for evaluation. Due to the huge number of indexes and potential
 correlations among them, it is imperative to explore a method for scientific and reasonable evaluation
of sea area suitability for tourism and recreation in the development and protection of coastal tourism
resources. Principal component analysis (PCA) can effectively reduce the dimension of input data,
remove the correlation between the data, and replaces the original multi-dimensional variables with
the few aggregative variables. PCA can ascertain the small number of factors that reflect their internal
relations and play a leading role from the factors that originally have a complex but interrelated
relationship [11]. Hence, the study attempts to select an evaluation index from the four aspects of
resources, environment, economy, and location, and uses the PCA method to appraise the suitability of
the sea area in Liaoning coastal waters. This approach can test a convenient and feasible index
selection method of sea area for tourism and recreation. At the same time, the evaluation results can
provide reference for the layout and selection of this sea area.

2. Material and research method

2.1. Areas and data sources

Liaoning Province is located in the south of Northeast China on the boundary of the Yellow Sea and
Bohai Sea. The total length of the coastline of the mainland is 2110 kilometers and the province
consists of 633 islands. Liaoning is rich in coastal tourism resources, especially in coastal wetland
landscape resources, natural bathing beaches, and island tourism resources. At present, Six coastal
tourism belts have been built through the Liaoning coast, which take Dalian as the center and take
Dandong and Huludao as the two wings [12].

This study refers to the selection and division scope of the functional zones of sea area for tourism
and recreation in Marine Functional Zoning of Liaoning Province (2011–2020). The distribution
situations of the sea area for tourism and recreation area confirmed by the national marine dynamic
monitoring and management system and based on the accessibility of the evaluation index. The buffer
area of 10 kilometre to the seaward side of the continental coastline is selected as study area. Dalian
Changhai County is not included in the scope of the study given the particularity of island tourism
resources.
Related data and information mainly come from the Liaoning Statistic Yearbook and China Ports Yearbook from 2013 to 2015, Report on the Delimitation of the Marine Ecological Red Line in Liaoning Province (Bohai Sea Area), Regionalization of the Marine Ecological Red Line in Liaoning province (Yellow Sea), spatial distribution map of current sea area utilization status (1:100,000), sea isobath data, and the data confirmed by the National Marine Dynamic Monitoring and Management System. To match the data year in the statistic yearbook, the comprehensive monitoring data of marine water quality in Liaoning province from 2012 to 2014 are selected as the marine water quality data. Data on marine disasters, including storm surge, sea ice, and red tide in the last 30 years in the Liaoning coastal area are chosen to provide a comprehensive and objective reflection of the risk of marine disasters and the feasibility of developing coastal tourism in different sea areas of Liaoning Province.

2.2. Research Method

2.2.1. Selection and calculation of evaluation factors. Eleven evaluation factors from four aspects of resources, environment, economy, and location are selected to evaluate the suitability of sea area for tourism and recreation

Resource condition includes five evaluation factors of water depth condition, comprehensive index of tourist area level, coastline length, coastal type, and confirmed quantity of the sea area for tourism. The comprehensive index of tourist area level reflects the attraction of tourism resources to tourists. The index takes as judgment object the highest-level tourist attractions in the county where the evaluation unit is located and uses the characteristic assignment method to assign points directly. For example, the highest level of tourist attractions is at the international level, then the assignment is 1. The national 4A level assignment is 0.9, the national 3A level assignment is 0.8, the national 2A level assignment is 0.6, the national 1A level assigns 0.4 points. The other levels are 0.2 points. Water depth condition, coastline length, and coastal type denote the difference of tourism resources endowment, which are extracted according to sea isobath and the spatial distribution map of current sea area utilization status. The confirmed quantity of the sea area for tourism indicates the current development situation of the sea area for tourism and recreation of the evaluation unit. The data were obtained from the current data verified by the National Marine Dynamic Monitoring and Management System.

Environmental conditions include two evaluation factors: seawater quality and quality of marine disasters. After interpolating and rasterizing the comprehensive monitoring data of marine water quality in Liaoning Province from 2012 to 2014, the mean value of three-year water quality is taken to obtain data on seawater quality. Marine disasters include three evaluation indexes of storm surge, sea ice, and red tide. The data derived from marine disaster data in the coastal area of Liaoning over the past 30 years. The hazard degree of different disasters is delimited by using the frequency and area of marine disasters in the past 30 years. The characteristic assignment method is adopted to assign points. For example, the assignment of no disaster area is 1, the low risk area is 0.8, and the lower risk area is 0.6. A higher risk area obtains 0.4 points, whereas a high-risk area gains 0.2 points.

Location conditions can evaluate the quality of traffic convenience and accessibility of different grid units and include two evaluation factors: offshore distance and traffic developed index. Offshore distance refers to the distance between the grid unit and the nearest shoreline calculated by the ArcGIS 10.2. The traffic developed index takes the railways, highways, ports, and airports adjacent to the land area as evaluation factors and assigns the points with reference to the characteristic assignment method which has been Li Wenjun et al. proposed [13].

Economic conditions include two evaluation factors of per capita GDP and economic benefit of sea-related tourism. Per capita GDP can indicate the economic development level of the areas adjacent to land territory. The sea-related economic benefit signifies the coastal tourism development degree [14], which includes tourism total revenue and total tourist arrivals as two evaluation indicators. The related data of per capita GDP and economic benefit of sea-related tourism are obtained by averaging the years of the statistical data in the Liaoning Statistic Yearbook from 2013 to 2015.
The weight of each calculation index in all evaluation factors is determined using Delphi method \cite{15}. The standardized index value [Formulas (3) and (4) for the standardization method] is combined and the score of the evaluation factor is calculated and obtained (see table 1).

The final evaluation unit of this study is a grid unit of 1 kilometre x 1 kilometre. The scores of each evaluation factor are counted on that grid unit using Zone Statistics statistical method.

2.2.2. Principal component analysis. PCA \cite{16} is a technique of dimension reduction process, which classifies original variables into a few comprehensive indexes. This process requires fewer comprehensive indexes to replace the original variable indexes. These comprehensive indexes can reflect as much information as possible while being independent of one another. Data must be standardized in order to solve dimensional problems among indexes. PCA is performed using the SPSS software platform, such that the principal component and the load amount are extracted and the final score is ascertained for each sample. The mathematical models for PCA are given as:

\[
F_m = a_{1m}X_1 + a_{2m}X_2 + ... + a_{pm}X_p
\]

\[
F = W_1F_1 + W_2F_2 + ... + W_mF_m
\]

In the formula, F is the synthesis score. \(F_m\) is the score of the Mth principal component. \(W_i\) is the weight of the Mth principal component, that is, the contribution rate of each principal component factor; \(a_{1m}, a_{2m}, ..., a_{pm}\) is the score coefficient of the Mth principal component. \(X_1, X_2, ..., X_p\) is the raw data of standard deviation after standardization.

| Influence Factors | Evaluation Factors | Evaluation Indexes                        | Algorithm               |
|-------------------|--------------------|-------------------------------------------|-------------------------|
| Resource Conditions | Water depth condition | Sea water depth data                       | Range Method            |
|                    | Comprehensive index of tourist area level | Highest level of regional attractions | Characteristic Assignment Method |
|                   | Shoreline length   | Shoreline length                          | Range Method            |
|                   | Coastal type       | Coastal type                              | Characteristic Assignment Method |
|                   | Quantity of the sea area for tourism and recreation confirmed | Quantity of the sea area for tourism and recreation confirmed | Range Method |
|                   | Quality of seawater quality | Water quality data                        | Range Method            |
| Environmental Conditions | Marine disaster | Storm surge, sea ice, red tide prone areas | Characteristic Assignment Method |
|                   | Offshore distance  | Offshore distance                         | Range Method            |
| Locational Conditions | Traffic developed index | Railway and high-speed with or without passenger transport scale of airport and port | Characteristic Assignment Method |
|                   | Per capita GDP     | Per capita GDP                            | Range Method            |
| Economic Conditions | Economic benefits of sea-related tourism | Coastal tourism total output value Coastal tourism revenue | Range Method Range Method |
2.2.3. Standardization of Index. The evaluation factors of sea suitability for tourism and entertainment are not comparable in terms of measurement units or grading values. Hence, the evaluation indexes must be standardized. Range method and characteristic assignment method are adopted respectively for quantitative and qualitative indexes to standardize the values between 0 and 1.

a) Range method. The relationship between evaluation index and sea area suitability for tourism and recreation is positive or negative. A positive relationship indicates that the higher the evaluation index value the higher the suitability. A negative relationship suggests that the smaller the evaluation index, the higher the suitability. To facilitate comprehensive analysis, a negative direction index is rendered positive to ensure the consistency of the action direction of index. The positive and negative indexes are calculated by different standardized formulas [17]:

1) Standardization formula of positive evaluation index:

\[ F_{ij} = \left( X_{ij} - X_{\text{min}} \right) \left( X_{\text{max}} - X_{\text{min}} \right) \]

2) Standardization formula of negative evaluation index:

\[ F_{ij} = \left( X_{\text{max}} - X_{ij} \right) \left( X_{\text{max}} - X_{\text{min}} \right) \]

In the formula, \( X_{ij} \) is the jth actual value of ith evaluation unit. \( X_{\text{max}} \) is the maximum value of the corresponding index of each evaluation unit. \( X_{\text{min}} \) is the minimum value of the corresponding index of each evaluation unit. \( F_{ij} \) is the standardized value calculated from the jth index of the ith evaluation unit.

b) Assigning method according to characteristic value. Qualitative indexes can be graded and scored according to the influence degrees of each factor on sea area for recreation before they are proceeding to the next calculation.

3. Results and discussion

3.1. PCA of the evaluation index of sea suitability for tourism and recreation

The evaluation factors are processed using SPSS 20.0 statistical software. Bartlett’s sphericity test and KMO statistical measurement are applied to determine the feasibility of PCA. Bartlett’s sphericity is employed to check the correlation between variables. The test result is \( \text{Sig} = 0.000 \), which is less than the significant level of 0.05. Thus, the original hypothesis of Bartlett sphericity is rejected. The KMO statistical measurement is higher than 0.5 with the value of 0.786, which mean that the method of PCA is applicable. The eigenvalues and cumulative contribution rates of each principal component are obtained through PCA. The PCA results of the evaluation factors of sea area suitability for tourism and recreation are shown in table 2. The cumulative contribution rate of variance reaches 80.32% for the first four principal components. This finding shows that this rate contains 80.32% of the total amount of information, which can better reflect the characteristics of other indexes. Therefore, the first four principal components are selected for further analysis.

Principal component load matrix is obtained by varimax rotation method (see table 3). The four principal components contain the load capacity situation of the original variables information. Each load capacity represents the correlation coefficient between the principal component and the corresponding variable. The greater the coefficient is, the more information the principal component contains and the more it can reflect the characteristics of the corresponding index. The first principal component of this analysis has larger load capacity on seawater depth, seawater quality, and sea-related tourism economic benefits, which mainly reflects the impact of tourism resources quality on the sea area suitability for tourism and recreation. Natural environmental conditions, which include seawater depth and seawater quality, directly affect the comfort and landscape effect of tourism and recreation, thereby influencing the value of tourism resources.

The economic benefits of sea-related tourism can better reflect tourism income and indirectly indicate the attractions of local tourism resources. The second principal component has a significant load capacity on per capita GDP, which mainly reflects the influence of development potential on the
sea area suitability for tourism and recreation. Per capita GDP indicates the local economic development level and its support and drive effect on the development of tourism in local sea area.

Traffic accessibility and marine disasters account for a large proportion of the third principal component, which mainly reflects the impact of the accessibility and safety of tourist destinations on the sea area suitability for tourism and recreation. Traffic condition is an important factor for tourism development, which not only affects the attraction of the local area to the tourists, but also influences the accessibility of tourists. By contrast, marine disasters, especially red tide and sea ice, often have a considerable impact on tourism safety and recreation.

The fourth principal component has larger load capacity on the quantity of sea area confirmed for tourism and recreation, which mainly reflects the influence of scale effect of tourism development on sea area for tourism and recreation. For the region wherein the sea area for tourism and recreation has begun to take shape, the construction of the scenic spots develops rapidly and the attractions of the tourists will further increase given the improvement of the conditions of foreign-related transportation and basic service facilities\textsuperscript{[18]}.

The principal components can be generalized as the four principal factors of tourism resource quality, development potential, accessibility and safety of tourist destination, and the scale effect of tourism development.

| Principle Component | Eigenvalues | Contribution Rates (%) | Cumulative Contribution Rates (%) |
|---------------------|-------------|------------------------|----------------------------------|
| 1                   | 3.947       | 43.852                 | 43.852                           |
| 2                   | 1.439       | 15.994                 | 59.846                           |
| 3                   | 1.184       | 10.936                 | 70.781                           |
| 4                   | 0.959       | 9.539                  | 80.320                           |
| 5                   | 0.688       | 5.420                  | 85.740                           |
| 6                   | 0.477       | 5.301                  | 91.042                           |
| 7                   | 0.385       | 4.282                  | 95.323                           |
| 8                   | 0.337       | 3.747                  | 99.070                           |
| 9                   | 0.084       | 0.930                  | 100.00                           |

Table 3. Principal component loading matrix after rotation.

| Index               | First Principal Component | Second Principal Component | Third Principal Component | Fourth Principal Component |
|---------------------|---------------------------|----------------------------|---------------------------|---------------------------|
| Water depth         | -0.814                    | 0.071                      | 0.045                     | -0.033                    |
| Marine disaster     | -0.102                    | -0.15                     | -0.661                    | 0.089                     |
| Per capita GDP      | 0.321                     | 0.685                      | 0.260                     | -0.196                    |
| Seawater quality    | 0.735                     | -0.108                     | 0.090                     | -0.003                    |
Traffic accessibility 0.099 0.139 0.746 -0.141
Economic benefit of sea-related tourism 0.799 0.457 0.203 0.033
Quantity of the sea area for tourism and recreation confirmed 0.46 -0.055 -0.086 0.816

3.2. Spatial distribution of sea area suitability for tourism and recreation

The spatial distribution map of sea suitability for tourism and entertainment based on different principal components can be obtained through the geographic information system software ArcGIS 10.2 (figure 1).

The first principal component represents nearly 50% information of the original 11 indexes. The spatial layout can preliminarily describes the spatial distribution of sea area suitability for tourism and recreation. As shown in figure 1 (a), sea areas with high suitability (most suitable and more suitable) are mainly distributed in the coastal waters of Dandong Yiquan Town and Gushan Town, the coastal waters from Dalian Zhuanghe Qingduizi Bay to the Biliu River, the coastal waters from the Jinzhou Dengsha River to the eastern part of Lvshun Tieshan Town in Dalian, the coastal waters of Jinzhou Bay, the near shore waters from Dalian Wafangdian Xianyu Bay to Yingkou Moon Bay, the seaside from Dalian Wafangdian Xianyu Bay to Huludao Xingcheng City, and the sea area of Zhimao Bay in Suizhong County. Sea areas with low suitability (less suitable and unsuitable) are mainly distributed in Liaodong Bay. According to the ecological red line protection requirements, such as the Liaoning Dandong Yalu River Estuary Wetland National Nature Reserve and the Liaoning Dalian Spotted Seal National Nature Reserve, are under strict control in terms of development and utilization. Therefore, they are classified as unsuitable sea areas for tourism development. Sea area suitability for tourism and recreation generally shows a decreasing tendency from coast to sea, especially in the coastal waters of the Bohai Sea. This finding is closely related to the fact that the first principal component mainly reflects information on seawater depth, seawater quality, and economic benefit of sea-related tourism. Variations of the indexes including seawater depth and water quality with the increase of offshore distance are significant in the coastal waters of the Bohai Sea but not obvious in the Yellow Sea. Thus, for the sea area suitability for tourism and recreation in different sea areas, the reflection degree differs even with the same evaluation index.

In the spatial distribution of sea area suitability for tourism and recreation reflected by the second principal component, as shown in figure 1 (b). Areas with high suitability are mainly located in the regions such as Dalian Zhuanghe Qingduizi Bay; the coastal waters along the areas of Dalian Jinshitan, Dayao Bay, Xiaoyao Bay, Dalian Bay, Bangchui Island, and Xiaopingdao; the coastal water of Jinzhou Bay; the coastal waters from Dalian Wafangdian Dagouzui to Yingkou Laobian District; and the sea areas of Huludao Xingcheng City and Binhai in Suizhong county. Areas with low suitability are mainly distributed in the western coastal water of Dalian Zhuanghe Heidao, the coastal water of Dalian Pulandian Pikou County, the western and eastern coastal waters of Laotieshan in Lvshunkou District, Liaodong Bay, and ecological red line areas, which include Liaoning Dandong Yalu River Estuary Wetland National Nature Reserve and the Liaoning Dalian Spotted Seal National Nature Reserve. The spatial distribution of sea area suitability for tourism and recreation described by this principal component is significantly influenced by the regional economic development level. The patch area in the spatial layout is relatively large and complete.

In the spatial distribution of sea area suitability for tourism and recreation reflected by the third principal component, as shown in figure 1 (c). Areas with high suitability are mainly distributed in the coastal waters from the Dandong Bodhisattva Temple Town to the Pikou streets; the coastal waters of Dalian, such as Lvshunkou District, Ganjingzi Yingchengzi Town, Fuzhou Bay, and Changxing Island; the near shore waters from Wafangdian Xianyu Bay to Yingkou Laobian District; as well as Huludao coastal waters. Areas with low suitability are mainly distributed in regions including Liaodong Bay,
the coastal waters from Dalian Pulandian Pikou to Jinzhou Dengshahe, the ecological red line areas, such as the Liaoning Dandong Yalu River Estuary Wetland National Nature Reserve and Liaoning Dalian Spotted Seal National Nature Reserve. The areas of Liaodong Bay Top are seriously affected by sea ice. The sea areas on both sides of the Dalian Bohai Sea and Yellow Sea are considerably affected by storm surge. In terms of spatial distribution, the suitability of most other sea areas for tourism and recreation is high.

In the spatial distribution of sea area suitability for tourism and recreation reflected by the fourth principal component, as shown in figure 1 (d). Areas with high suitability are mainly located in the coastal water of Dandong Donggang City; the coastal waters of Dalian such as Zhuanghe City, Jinzhou District, Ganjingzi District, Xigang District, Shahekou District, Lvshunkou District, and Wafangdian District; the coastal waters of Yingkou such as Bayuquan District, Gaizhou City, and Laobian District; the near shore area of Panjin Panshan County; the coastal water of Jinzhou Binhai New District; the coastal waters of Huludao including Lianshan District, Longgang District, and Xingcheng City. Areas with low suitability are mainly distributed in Liaodong Bay; the coastal waters from Dalian Wafangdian Dagouzi zu to Yingkou Gaizhou Xianren Island; the offshore areas of Huludao such as Lianshan District, Longgang District, and Xingcheng City; and ecological red line areas, such as the Liaoning Dandong Yalu River Estuary Wetland National Nature Reserve and Liaoning Dalian Spotted Seal National Nature Reserve. As the confirmed sea areas for tourism and recreation in the coastal waters of Huludao Xingcheng District, Yingkou Bayuquan District, and Dalian City are relatively concentrated, the suitability of the sea area for tourism and recreation in the corresponding sea areas is reflected more detailed.

![Figure 1. Spatial distribution of different principal components.](image)

### 3.3. Comprehensive evaluation of sea area suitability for tourism and recreation
Numerous factors affect sea area suitability for tourism and recreation. Four principal components are obtained through the SPSS PCA. These factors effectively reflect the suitability of the sea area for tourism and recreation. A comprehensive evaluation model of sea area suitability for tourism and recreation is determined as follows:

\[ Y = 0.575Y_1 + 0.1Y_2 + 0.15Y_3 + 0.175Y_4 \]  

(5)

In the formula, \( Y \) is the comprehensive score of sea area suitability for tourism and recreation, \( Y_1 \) is the tourism resource quality, \( Y_2 \) is development potential, \( Y_3 \) is the accessibility and safety of tourism destination, and \( Y_4 \) represents the scale effect of tourism development. The final spatial distribution of sea area suitability for tourism and recreation in Liaoning Province is obtained through this evaluation model (see figure 2). Among them, the most suitable sea area for tourism and recreation is 1963.43 square kilometers, the more suitable sea area is 2444.21 square kilometers, the suitable sea area is 1249.40 square kilometers, the less suitable area is 1297.76 square kilometers, and the unsuitable area is 2784.86 square kilometers. The most and more suitable areas are located in the coastal waters from Dalian Zhuanghe Qinghuizi Bay and Zhuanghe Gali Island westward to Pulandian Pikou County; the near shore waters of Dalian Jinzhou District, Ganjingzi District, Xigang District, Shahekou District, and Wafangdian City; the coastal waters from Dalian Wafangdian Taiping Bay to Yingkou Gaizhou Xianren Island; as well as the coastal waters of Huludao Xingcheng City and Suizhong County. The less suitable and unsuitable areas are mainly distributed in the near shore water of Liaodong Bay Top, the coastal waters from Yingkou Port to Laobian District, the coastal waters from Dalian Wafangdian Hongshizui to Taiping Bay and Dalian Bay, as well as ecological red line areas, such as the Liaoning Dandong Yalu River Estuary Wetland National Nature Reserve and Liaoning Dalian Spotted Seal National Nature Reserve.

4. Conclusions
A comprehensive evaluation of sea area suitability for tourism and recreation in Liaoning Province is conducted in this study using GIS spatial analysis technology by adopting PCA. The main conclusions are as follows. (1) PCA can extract the potential comprehensive index (i.e., principal component) by comprehensively analyzing the numerous evaluation factor information of sea area suitability for tourism and recreation, calculating comprehensive scores using principal component information, and evaluating sea area suitability for tourism and recreation. This approach can provide methodological reference for selecting the evaluation index and evaluating the suitability of the sea area for tourism and recreation in a simple and reasonable way. (2) The confirmed spatial distribution results of sea area suitability for tourism and recreation obtained using the ArcGIS platform and PCA can be used as research basis for optimizing the distribution of the sea area for tourism and recreation in coastal areas.
of Liaoning Province. This finding can also provide theoretical basis for realizing the coordinated development of industry distribution of sea area for tourism and regional economy in coastal areas. (3) This study demonstrates that the same evaluation index has different degrees of reflection on the suitability of tourism development in various sea areas. The accuracy of the description for the suitability of tourism development also differs. Therefore, the follow-up study must integrate the characteristics of different sea areas to select indexes that can reflect the spatial heterogeneity of sea areas and further improve the evaluation index system. (4) The PCA used in this study played a significant role of dimension reduction in eliminating the correlation between the numerous evaluation indexes of sea area suitability for tourism and recreation. However, PCA remains unsatisfactory when the index is normally standardized and the principal component is weighted to construct a comprehensive evaluation function. Hence, succeeding investigations can aim to combine PCA with other methods, such as the genetic algorithm and the neural network, to further optimize the research results.

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