Spatial distinction analysis on marine ranch development potential in coastal areas of China

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Abstract. According to the 14th Five-Year Plan and the outline of 2035 long-term goals, a modern marine industrial system should be built, the layout of green offshore aquaculture should be optimized, and marine ranching should be built. The research on the construction of marine ranching can provide new ideas for sustainable ecological fishery and inject new vitality into the development of marine industry. In the future, the construction of marine ranching will be a vast world. In this paper, from the perspective of geography, the GC-TOPSIS method combined with the entropy weight TOPSIS method and the grey correlation method were used to construct 22 evaluation index systems to estimate the development potential of marine ranching construction in ten coastal provinces and municipalities of China from 2011 to 2016. The results showed that the overall development potential of marine ranching in ten provinces and urban areas had regional differences (north, central and south), and the differences in the north and south regions were obvious. The regional differences in the central coastal areas of China were not significant, and the development potentials of marine ranching in ten provinces and urban areas were all medium. The development potential of four criteria layers of marine ranching in ten coastal provinces and regions of China is different in space, and the development potential of marine ranching in the same region is unbalanced in all aspects of the criteria layers. To estimate the development potential of marine ranching in China's ten coastal provinces and regions provides scientific support for the sustainable development of ecological fisheries, and has practical application value for the scientific planning of marine ranching and the selection of demonstration areas.

1. Introduction

In recent years, people's predatory fishing of marine fishery resources, as well as the high density of fishing cultivation in the seaside, has led to the deterioration of the ecological environment in the coastal waters and the damage of fishery resources. This situation seriously affects the development of China's offshore marine fishery, and also has a negative impact on the sustainable development of marine biological industry [1]. In order to solve the above problems, we need to vigorously carry out research on the development potential of marine ranching construction, ensure the steady and sustainable growth of aquatic resources, improve fish production, maintain the dynamic balance of marine ecosystem, and provide support for the realization of sustainable ecological fisheries.

Marine ranching is a kind of artificial fishing ground set up by people to cultivate fish resources seedlings in a controlled sea area and manage and detect their growth process in order to ensure the increase of production and the sustainable and stable growth of aquatic resources. The development
potential refers to the development potential of an industry in various aspects in the future [2–4]. Similarly, the development potential of marine ranching refers to the development potential of marine ranching in various aspects in the future. In 2019, Academician Ding Dewen pointed out that the construction of marine ranches is not only a technical problem, but also an academic problem, as well as a governmental system problem. We will encourage "government guidance" and "government support", make the government functions more market-oriented, and explore new models for the use of the sea. Five academic problems of the artificial ecosystem construction, habitat construction, behavior control, natural enemy disease control and environmental coordination should be solved. In the existing literature, Shen Weiteng, Hu Qiuguang et al. [5] and Xu Hanxiang, Wang Weiding et al. [6] studied marine ranching mainly in the aspect of construction suitability (mainly in the literature of site selection). Liu Lixin, Liu Jin et al. [7]; Wang Yanfeng, Hu Qiwei et al. [8]; Huang Jianqing, Chen Pimao et al. [9] and Ma Huan, Qin Chuanxin et al. [10] studied marine ranches mainly from the perspective of efficiency evaluation. Du Xiaoyan, Wu Xiaoping et al. [11]; Qu Huayong, Chen Yong et al. [12], and Sun Shuxian et al. [13] mainly studied the connotation of the construction of modern marine ranching. There are more qualitative methods than quantitative ones, and the quantitative methods are mostly from the perspective of biology, while few quantitative methods are used from the perspective of geography. The research on the development potential of marine ranching construction is less mature than that on the development potential of other marine industries.

This paper, mainly through the potential resources and potential benefits, the industrial economic base, ecological potential and marine science and technology talent potential, these four aspects of 22 indicators, from the perspective of quantitative geography reflection of the development of future marine ranching construction potential size, estimates the construction development potential in ten provinces along China's coast during 2011–2016 to measure ocean ranch. The calculation results were compared and analyzed to provide a certain reference for scientific planning of marine ranching.

2. Data sources and research methods

2.1. The data source
People's Republic of China on the 12th five-year plan for national economic and social development program (2011) proposed to accelerate the development of marine economy, so this article of each index data in the year beginning from 2011, sea area is small, and the Shanghai fisheries development space is very limited, there will not be in Shanghai and join the measure, this study did not include Hong Kong, Macao and Taiwan regions. The data are mainly obtained from 2012–2017 China Fishery Statistical Yearbook, China Marine Statistical Yearbook and the statistical yearbook of Liaoning, Hebei, Tianjin, Shandong and other 10 provinces and municipalities. The Engel coefficient of fishermen in this index system is the ratio of the total expenditure to the food expenditure of fishermen's families. The rate of sewage treatment into the sea is obtained indirectly through direct discharge of massive amount of sewage and total discharge of industrial wastewater.

2.2. The research methods
In order to measure the development potential of marine ranching construction more accurately, this paper selects an objective weighting method, namely, the entropy weight method, which can reflect the real and reasonable information of indicators. The TOPSIS method is a kind of a sorting method that approximates to the ideal solution. It is a sorting method based on the proximity of the finite evaluation objects to the ideal goal, which is to evaluate the relative merits of the existing objects. The grey correlation method is a method to measure the degree of correlation among factors according to the degree of similarity or dissimilarity between the development trend of factors, which is also called "grey correlation degree". The GC-TOPSIS method is a new method combining the grey correlation method and the TOPSIS method, and its measurement results are better than those of single methods such as the grey correlation method and the TOPSIS method [23]. The GC-TOPSIS calculation steps are as follows:
Index weight calculation

\[ w_j = \frac{d_j}{\sum_{i=1}^{m} d_j}, \]  

(1)

where \( w_j \) indicates the index weight, and \( d_j \) indicates the redundancy.

So you multiply the weight times the normalized matrix and you get the weighted normalized matrix. Calculate the relative progress of the GC-TOPSIS synthesis.

\[ GC_j^+ = \delta_1 D_j^- + \delta_2 S_j^+ \]

\[ GC_j^- = \delta_1 D_j^- + \delta_2 S_j^- \]

\[ GC_j = \frac{GC_j^+}{(GC_j^+ + GC_j^-)} \]

(2)

where \( S_j^+ \) 、 \( S_j^- \) are the positive and negative ideal solutions, \( D_j^+ \) 、 \( D_j^- \) are Euclidean distances of the positive and negative ideal solutions, \( \delta_1 = \delta_2 = 0.5 \) and \( GC_j \) are comprehensive progress.

3. Results analysis

3.1. Weight analysis based on the entropy weight method

The weight of each index was calculated according to the steps of the entropy weight method, as shown in Table 1. The weight value of the index is the contribution degree of the index to the development potential of marine ranching construction. Therefore, in the development process of marine ranching, the influence of various indicators on the development potential of marine ranching can be explained by analyzing the weight of indicators.

Further observation of the criterion layer shows that the weight of the resource and benefit potential is 27.29 %, the weight of the industrial economic foundation potential is 22.64 %, the weight of the ecological potential is 18.33 %, and the weight of marine science and technology talent potential is the highest, reaching 31.73 %. Science and technology talents are the important power to regional economic development, and are also the important power of marine ranching construction potential support conditions, which in the process of marine ranching construction should always adhere to the "relying on science and education" strategy. The full implementation of the thought of science and technology is the first productive force, and adhering to the education for this, the science and technology and education are in the important position of economic and social development.

3.2. Spatial difference analysis based on the GC-TOPSIS comprehensive relative progress

The development potential of the four criteria layers of marine ranching construction in ten coastal provinces and urban areas of China has regional differences, and the advantages of the development potential of marine ranching construction in different provinces and urban areas are different. See Figure 1.

(1) The top three provinces in terms of resources and benefits potential of marine ranching construction and development. Shandong province. As can be seen in Figure 1 (a), there are significant differences between the north and south regions. In the north, there are excellent Shandong province, good Liaoning Province, and poor Hebei Province and Tianjin City, whose average comprehensive proximity score is 0.501, indicating good development potential of overall resources and benefits. In the south, Guangdong, Guangxi and Hainan provinces are in the good, middle and poor grades, and their average comprehensive proximity score is 0.498, indicating good development potential of overall resources and benefits. However, three central provinces are in the middle grade, and the development potential level of the central region is the same. The average comprehensive proximity score of the central region is 0.494, and the development potential of the overall resources and benefits is poor.
Table 1. Index system of the development potential of marine ranching construction

| System layer               | Indicator layer                                                  |
|----------------------------|------------------------------------------------------------------|
| Resource and benefit       | Area of nearshore and coastal wetlands (0.0460)                  |
|                            | Sea water breeding area (0.0451)                                 |
|                            | To determine the area of the sea (0.0450)                        |
|                            | Marine fry number (0.0453)                                      |
|                            | Fisherman's Engel coefficient (0.0463)                           |
|                            | Number of people employed in the fishing industry (0.0452)      |
|                            | National level aquatic product original quantity of improved seed farm (0.0455) |
| Underlying potential of    | Marine fishing yield (0.0453)                                    |
| industrial economy         | Mariculture yield (0.0449)                                      |
|                            | Cargo throughput of port (0.0450)                                |
|                            | Added value of marine and related industries in coastal areas (0.0457) |
|                            | Rate of sewage treatment into the sea (0.0458)                   |
| Ecological potential       | Number of national marine nature reserves (0.0467)              |
|                            | Number of protected marine and coastal ecosystems (0.0457)      |
|                            | Number of national aquatic germplasm resources protected areas (0.0451) |
|                            | Number of scientific and technological personnel in marine research institutions (0.0458) |
|                            | Number of research and development personnel in marine research institutions (0.0454) |
|                            | Expenditure of internal funds of marine research and development institutions (0.0451) |
| Marine science and technology talent potential | Number of research and development projects of marine scientific research institutions (0.0454) |
|                            | There are professional points for doctoral students majoring in marine science (0.0452) |
|                            | Set professional points for Marine postgraduate students (0.0451) |
|                            | The number of professional points of marine undergraduate graduate students is set (0.0453) |

(2) Shandong, Hebei, Guangdong and Jiangsu provinces ranked the top in the industrial economic foundation potential of marine ranching construction and development. Hebei and Jiangsu provinces are at the forefront with the added value of marine and related industries in their coastal areas and a sound industrial chain foundation. Zhejiang, Liaoning and Guangxi provinces are at a medium level in terms of marine ranching industry base, as shown in Figure 1 (b). Zhejiang and Guangxi provinces have an average development level of each indicator based on industrial economy, while Liaoning Province has good industrial economy foundation, but most enterprises in the province are state-owned enterprises, with bloated system and insufficient development vitality. No matter the three provinces and cities in the north are in excellent, good, medium and poor grades, respectively, their average comprehensive proximity score is 0.507, indicating that the underlying potential of the overall industrial economy is good. The average comprehensive proximity score of the three central provinces was 0.501, which was generally good. The average comprehensive proximity score of the three southern provinces is 0.493, and the overall potential of industrial economic foundation is poor, indicating that there is a significant regional difference between the north and south central regions.

(3) Ecological potential of marine ranching construction and development. The ranking of provinces from high to low is as follows: Shandong, Fujian, Zhejiang, Liaoning, Jiangsu, Guangdong, Tianjin, Hebei, Guangxi and Hainan. There is a big regional difference in the north and south central regions.
Shandong Province in the north is in the excellent grade, Liaoning Province is in the middle grade, and Hebei Province and Tianjin city are in the poor grade. Located in the Bohai Bay, near the three provinces and one city of shallow water depth, vulnerable to pollution, self-purification ability is weak, in terms of seawater quality keep more difficult than other regions, but can still have topped in Shandong Province. It further suggests that the government's policy of ecological value guidance effect is significant, its comprehensive close to scoring average of 0.499, the overall ecological potential is good. The ecological development potential of marine ranching in Jiangsu, Zhejiang and Fujian provinces located in the central region is medium, good and good respectively, and the average comprehensive proximity score is 0.5. The overall ecological potential of marine ranching in the central region is good, with little regional difference. On the other hand, the ecological potentials of Guangdong, Guangxi and Hainan provinces in the south showed a gradual decline, and were medium, poor and poor respectively, as shown in Figure 1 (c). On the whole, the average comprehensive proximity score of ecological potential in the southern region was 0.477, which was the lowest among the three regions.

Figure 1. Spatial distribution map of four development potentials of marine ranching in the criterion layer
The spatial distribution of marine science and technology talent potential for the construction and development of marine ranching in various provinces and regions is shown in Figure 1 (d). Shandong and Jiangsu ranked first and second, with a high number of ocean-related universities and researchers and the government's emphasis on cultivating relevant talents. The northern region has a large internal difference and uneven internal development potential, but its average comprehensive proximity score is 0.543, which is generally good. In addition to Shandong Province, which is excellent, Liaoning Province and Tianjin city are in the medium grade, and Hebei Province is at a poor level of development. The ecological development potential of marine ranching in Jiangsu, Zhejiang, and Fujian provinces located in the central region is in the good, poor, and poor grades respectively, and the average comprehensive proximity score is 0.54, indicating that the overall potential of marine science and technology talents in the central region is good, and the regional difference is obvious. However, the spatial distribution of marine science and technology talent potential in Guangdong, Guangxi, and Hainan provinces in the south is the same as that of the ecological potential, showing a state of gradual decline, with the level of medium, poor, and poor, respectively. In general, the average comprehensive proximity score is 0.489, indicating that the three southern provinces have poor talent potential in marine science and technology. In the future construction of marine ranching, emphasis should be given to the cultivation of marine-related talents. High-quality talents are the source of future innovative construction and development of marine ranching.

4. Conclusion

In this paper, the GC-TOPSIS method combined with the entropy weight TOPSIS method and grey correlation method were used to construct 22 evaluation index systems from four aspects of the resource and benefit potential, industrial economic foundation potential, ecological potential and marine science and technology talent potential, and to estimate the development potential of marine ranching construction in ten coastal provinces and urban areas of China from 2011 to 2016. It provides a new method and results reference for the research on the development potential of marine ranching construction. The conclusions are as follows:

(1) In the weight analysis of the criterion layer, the marine science and technology talent potential has the highest weight, followed by the resource and benefit potential, industrial economic foundation potential and ecological potential. The top three indexes of the index layer weight are the number of national marine nature reserves under ecological potential, the fisherman's Engel coefficient under the resource and benefit potential, and the area of nearshore and coastal wetlands.

(2) There are regional differences in the overall development potential of marine ranching construction in China's ten coastal provinces and cities. The development potential of the marine ranching criterion layer in ten coastal provinces and urban areas of China has regional differences in space, and the internal differences of each region in the north and south are obvious, and the development potential of marine ranching construction in the same region is unbalanced in all aspects. The potential resources and potential benefits, industrial economic base, ecological potential and marine science and technology talent potential basis is better than that of the central north, central is superior to the south, in the future development of the oceanic ranching construction area should pay attention to complementing each other, pay attention to the development of the relevant scientific and technological personnel, the accumulation of industrial economic base, and the ecological protection, comprehensive improving of the development potential.

On the whole, after decades of development, marine ranching has achieved large-scale output in Shandong, Guangdong, Zhejiang, Liaoning and other coastal provinces. However, the construction of marine ranching in China is still at the primary stage of the artificial reef construction and proliferation and release. Based on the geographical perspective, this paper conducted a qualitative and quantitative study on the spatial and temporal differences of the development potential of marine ranching in China, so as to objectively and reasonably clarify its future development context and potential, which can provide scientific guidance for various regions to formulate relevant plans and policies and promote the
realization of high-quality development goals of fishery. At present, the research on the development potential of marine ranching construction is not mature, and the relevant research is still lacking, which should be paid enough attention. How to formulate targeted and operational development strategies according to the development potential and actual development of marine ranching construction in different regions, and promote the high-quality development of fishery, will become a topic requiring in-depth research in the future. In addition, there are various factors affecting the development potential of marine ranching construction, but this paper only selected 22 indicators from four aspects: resource and benefit potential, industrial economic foundation potential, ecological potential and marine science and technology talent potential. In the future, a more systematic index system can be constructed to carry out research by adding qualitative analysis from the aspects of government guidance and other aspects by integrating various factors. Marine ranching, as an emerging marine industry, provides a new path for the transformation and upgrading of fishery, and has a promising future.

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