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Marine Resources Carrying Capacity Index based on Metrological Test of "Tail Effect" of Marine Resources

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Abstract: Although the concept of ocean carrying capacity is advanced, its development is at the initial stage of exploration. The development period is short and it is not really mature. It is inevitable that many problems will arise. At present, the research on bearing capacity(BC) is mostly about some elements within the land, such as resources and environment. However, few studies have been carried out on the BC of marine related elements, and even fewer quantitative studies have been carried out. Therefore, this paper designs and evaluates the index system of marine resources(MR) carrying capacity by measuring the "tail effect" of MR. This paper discusses the construction of the MR carrying capacity evaluation index system, studies and analyzes the measurement and test method of the "tail effect" of MR, and then applies it to the design and evaluation of the MR carrying capacity index system. Finally, the effectiveness of the method proposed in this paper is verified through experimental analysis, which is of great significance for the establishment of a scientific and reasonable evaluation index system in the future.

1. Introduction

The marine system is a comprehensive system, which is composed of different ecological systems such as society, economy and nature. These different systems have corresponding functions, and they are related to each other, and they also constrain each other. For the social system, the main constraints it faces are population, social structure, etc; For the natural ecosystem, it should not only ensure its own coordination, but also provide corresponding resources and good environment for economic development; The resource system should maintain its own sustainability; The environmental system shall ensure that its self-healing ability is not damaged. In addition, economic development will inevitably promote social progress, which will enable the ecological system to be reasonably used and well protected. This paper is based on the MT method

of "tail effect" of MR. The index system of MR carrying capacity is designed and evaluated.

Many scholars at home and abroad have studied and analyzed the design and evaluation of the MR carrying capacity index system based on the MT of the "tail effect" of MR. Many studies focus on evaluating the BC of single factor. According to the situation of the study area, ghouali A and other scholars have constructed a series of index systems affecting the change of BC, such as shoreline stability, coastal sediment dynamics, land use, beach quality, and estimated the BC of the Indian Coast [1]; Gabbar h a et al. Took the South Sea area of Brazil as the research object, comprehensively measured its carrying capacity for marine fishing and carried out ecological simulation in the process of research, and finally came to the following conclusion: there is a certain risk that the output of marine fishing and fishery in this sea area will shrink in the future, so they also put forward targeted policy suggestions [2]; Rodriguez a R and others collected the resource loss data of 17 countries in an all-round way, and realized the calculation and analysis of the resource bearing situation on this basis [3].

The key to MR carrying capacity evaluation is to establish a scientific and reasonable evaluation index system, and the selection of evaluation index is directly related to the accuracy of the final evaluation. Therefore, this paper puts forward the MT method of "tail effect" of MR, analyzes and studies it, applies it to the design and evaluation of MR carrying capacity index system, and verifies the feasibility of the method proposed in this paper for the establishment of MR carrying capacity evaluation system through experimental analysis [4-5].

2. Design and Evaluation of MR Carrying Capacity Index System

2.1. Construction of MR Carrying Capacity Evaluation Index System

2.1.1. Foundation for Establishment of Evaluation Index System

The evaluation index system of marine resource carrying capacity is not created out of thin air. It is based on the index system of marine resource carrying capacity and obtained after modification and improvement [6-7]. The indicator system of marine resource carrying capacity is established on the basis of economics, environmental science, resources science and oceanography, using analytic hierarchy process, referring to the resource carrying capacity system of the road area, referring to the statistical data in the China Ocean statistical yearbook over the years and consulting relevant experts.

2.1.2. Construction Principles of Evaluation Index System

In this paper, the multi index evaluation method, which is commonly used in the analysis and research of BC, is used to construct a system that can evaluate the comprehensive BC of the system. In the process of gradual development, mankind will develop and use various resources from the ocean, and will discharge many pollutants into the sea. The utilization of resources and environmental pollution will have an impact on the balance of the marine ecosystem that cannot be ignored. The marine system will continue to adjust and recover based on its own ecological elasticity, and the marine system will be affected in various ways in the process of human activities, Finally, the relationship involved in it becomes more complex, and the scale of the whole system also expands greatly [8-9]. Therefore, the marine system has a very significant complexity, which requires the use of a composite evaluation system when evaluating its BC, so that more accurate results can be obtained [10-11].

Selection principle of indicator construction: each indicator designed in the evaluation process has certain connection and systematicness, so the evaluation system itself is an organic combination

of all aspects, and its specific composition can directly determine the accuracy of the results. Taking the theory of carrying capacity as the theoretical guidance and based on the coupling theory of MR ecological environment social economy, the evaluation system should meet the following requirements:

Scientific principle: in order to make the indicators involved in the system have scientific positioning and obtain more accurate results, the system should be built on the basis of following the scientific principle [12]. The indicators involved should be as comprehensive as possible and can truly reflect the actual situation of economy and resources. The data calculation method of the index is true and reliable, and the statistical calculation method and finally make the research results scientific. It can objectively and truly reflect the state of marine comprehensive BC in the study area [13].

Systematic principle: since the comprehensive marine carrying capacity is the final product of the interaction between many different factors such as economic and social development and MR and environment, the evaluation should be comprehensive. The content of each aspect of the evaluation index system subsystem is controlled and affected by different factors. The selection of evaluation indexes should be based on the system concept. The indexes can reveal the development law of BC from multiple angles, levels and comprehensively, and comprehensively display various different characteristics of the whole system, so as to make the whole system more comprehensive and scientific [14-15].

Hierarchy principle: the marine system formed by organic combination of different elements is highly complex and large-scale, and is composed of subsystems such as resource system, environmental system and social economy. Therefore, the evaluation index system of ocean BC must have the characteristics of hierarchy. The index system of ocean BC includes at least three levels, such as target level, element level and index level. The higher the level of indicators, the more comprehensive they are [16-17].

Dynamic principle: the BC of the ocean is always in the process of regular change, and also changes in time and space. The evaluation system should not only analyze its static change, but also reflect its development and other dynamic aspects. The indicators involved in the system should also be dynamic and quantifiable, so that the overall evaluation system can be dynamic.

Feasibility principle: whether the evaluation can be carried out smoothly will be affected by three aspects: first, whether the selected method is reasonable, second, the relevant data section used is unscientific, and third, the relevant indicators involved are not quantifiable. Therefore, the indicators involved in the system should be relevant but not repetitive. At the same time, the authenticity, scientificity and accessibility should also be considered in data statistics and analysis [18].

2.2. Evaluation Index System of MR Carrying Capacity

Based on the index system of MR carrying capacity, and following the six principles of evaluation index, the evaluation index system of MR carrying capacity is determined by using qualitative and quantitative methods. As shown in Table 1.

According to the specific meaning of marine comprehensive BC, combined with the application of state space method in the research of marine comprehensive BC, after selecting some indicators, the selected results are displayed to professionals, and corresponding adjustments are made according to their opinions. The finally determined indicators are social economy, MR and ecological environment. The indicator layer mainly includes specific indicators such as population density, output value of marine industry, wastewater discharge and environmental protection investment.

Table 1. Evaluation index system of MR carrying capacity

Target layer	Level I indicator	Secondary indicators	Level III indicators
Evaluation of MR carrying capacity	Supply function of MR	Marine living resources	Marine fishery output
			Crustacean production
			Algal production
		Marine non living resources and service resources	Offshore crude oil production in coastal areas
			Offshore natural gas production in coastal areas
			Sea salt production in coastal areas
			Number of production terminals
			Number of star rated hotels in coastal areas
	Economic function of MR	Total marine economy	Gross marine production
			Added value of major marine industries
		Marine economic structure	Growth rate of marine gross domestic product
			Proportion of marine tertiary industry

3. Design and Evaluation of MR Carrying Capacity Index System based on MT of "Tail Effect" of MR

3.1. Metrological Inspection of "Tail Effect" of MR

If the MR are infinite, under the mode of balanced and stable growth, the MR and the labor force grow synchronously. The growth rate is s, that is, q (T) = NQ (T). The average marine economic output growth rate per unit labor force is:

$$\bar{g}_{Y/L}^{bgp} = \frac{(g+n)\delta + n\beta + \beta n - n}{1-\beta} \tag{1}$$

Among them, it means that there is no constraint on MR, and the "tail effect" of MR on marine economic growth is:

$$Drag = \bar{g}_{Y/L}^{bgp} - g_{Y/L}^{bgp} = \frac{\eta(b+n)}{1-\beta} \tag{2}$$

The "tail effect" of MR varies with the elastic coefficient of MR η Labor force growth rate n and capital elasticity coefficient β And increases with the increase of.

3.2. Weighting Method of MR BC Index

The data is obtained from relevant statistical data, and the data is highly objective. The entropy method is adopted. Entropy weight method is to determine the weight according to the idea of the variability of evaluation indicators, and accurately calculate the information entropy corresponding to the evaluation indicators. If there is a relatively large value, it can be judged that the evaluation indicators have a relatively large degree of variation based on this, which can significantly affect the evaluation object, and there is also a relatively large weight. In this research, we mainly use the following formula to calculate the entropy value of the evaluation index:

Establishment of evaluation matrix: first, we need to standardize the index factors. At this time, the main method we use is the range method. Mij is usually expressed as an evaluation index in the matrix.

Calculate the proportion of index mij:

$$K_{ij} = \left[\frac{H_{ij}}{\sum_{i=1}^{h} H_{ij}} \right] \tag{3}$$

Calculate the information entropy of indicators:

$$F_{ij} = -Z \times \sum_{i=1}^{n} K_{ij} \times In\left(K_{ij}\right) \tag{4}$$

Z is a constant, z =; Determine the utility value BJ of the indicator. The greater the utility value, the greater the indicator weight; Calculate the entropy weight method weight HJ of the jth index.

$$H_j = B_j / \sum_{j=1}^{n} B_j \tag{5}$$

3.3. Weighting of BC Index

According to the established index system, 12 experts and scholars in marine and environmental fields were invited to evaluate and compare the indexes, and 10 evaluation forms were recovered. Firstly, analyze, screen and test whether the judgment matrix of each expert can pass the consistency test. It can be found that they are all less than 0.1 through the test, so all judgment matrices are reserved. Secondly, the arithmetic mean value of each score in the expert judgment matrix of the effective questionnaire can be counted. After the above series of operations, the comprehensive judgment matrix can also be obtained. The comprehensive judgment matrix is obtained and the consistency index of the matrix is checked again. In this way, the relatively reasonable weight distribution can be realized.

The entropy method is used to calculate the weight, and the information entropy and weight of each index are calculated and determined according to the dimensionless data processing results. The final results are shown in Table 2 and figure 1.

The comprehensive weight is the comprehensive subjective and objective weight to obtain the final weight. By effectively integrating the advantages of the two weighting methods, the evaluation index can reflect the impact of the evaluation object to a large extent, and the rationality is also effectively improved.

Table 2. Comparison of weighted data of comprehensive BC index

Indicator layer	Entropy weight method	AHP weigh	Comprehensive weight
Offshore and coastal wetland area	0.0597	0.0515	0.0530
Per capita sea area	0.0234	0.0411	0.0380
Port throughput	0.0316	0.0355	0.0348
Mariculture quantity	0.0632	0.0481	0.0507
Marine catch	0.0330	0.0578	0.0535
Mariculture area	0.0416	0.0397	0.0400
Marine economic density	0.0290	0.0236	0.0246

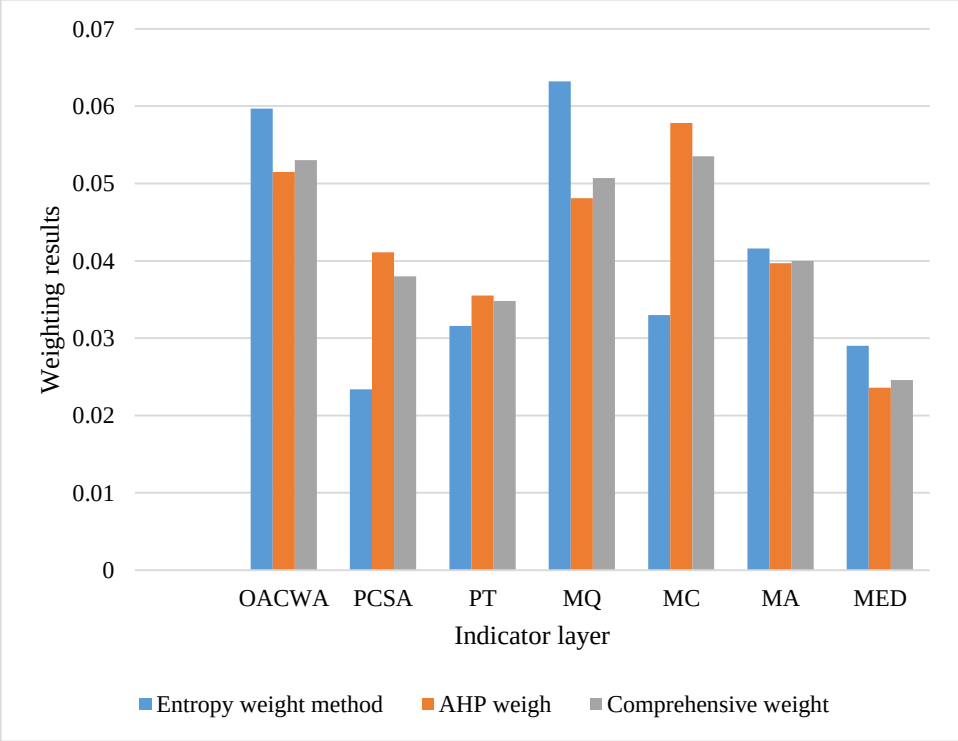

Figure 1. Weighted results of comprehensive BC index

4. Experimental Test and Analysis of MR Carrying Capacity Index System based on MT of "Tail Effect" of MR

At present, there is no detailed study on the classification of MR BC within the ideal value. Therefore, according to the method of land BC classification in relevant literature, after appropriate adjustment, the MR BC is divided into three sections, which are $\geqslant$ 0.50, 0.50-0.35 and $\leqslant$ 0.35, corresponding to three levels in turn, and the characteristics of each level are described.

The score range of no less than 0.50 is grade I, characterized by abundant marine living resources, full development of non living resources and service resources, rapid development of marine economy, less marine pollution, low incidence of marine disasters, and large investment in marine environmental protection; The score range between 0.50 and 0.35 is grade II. The characteristics are described as follows: marine living resources are general, non living resources and service resources have been developed to a certain extent, marine economic development is general, marine pollution and marine disasters are serious, and marine environmental protection has been invested; The score range of no more than 0.35 is grade III, characterized by the depletion of

marine living resources, the lack of effective development of non living resources and service resources, the slow development of marine economy, serious marine pollution, frequent marine disasters, and serious lack of marine environmental protection.

The change trend analysis of marine resource carrying capacity is shown in Table 3 and Figure 2, which shows the change trend of the scores of marine resource carrying capacity in China in the past six years.

Table 3. Data table of China's MR carrying capacity

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
BC score	0.302	0.41	0.512	0.313	0.46	0.644
SD model predictive value	0.752	0.734	0.723	0.715	0.712	0.707
linear prediction	0.3	0.412	0.423	0.468	0.503	0.532

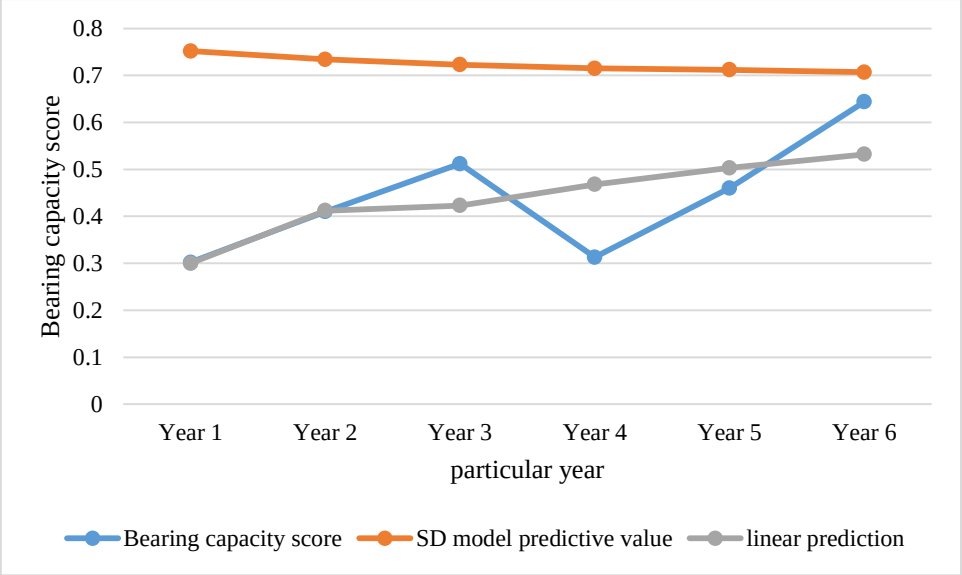

Figure 2. Change trend of China's MR carrying capacity in recent 6 years

From the above table and figure, it can be concluded that according to the classification of MR carrying capacity, the MR carrying capacity score in the first three years is lower than 0.35, which is at the third level, indicating that China's MR carrying capacity is weak in the past two years, the MR are in the state of unsustainable development, the marine living resources are sharply reduced, and the marine pollution and disasters are more than those in other years. In the last three years, the marine resource carrying capacity scores are between 0.50-0.35, which is in the second level, indicating that China's marine resource carrying capacity has been improved in these two years. The investment in marine environmental protection has increased, the marine pollution has decreased, the marine living resources have remained stable, the non living resources and service resources have been developed to a certain extent, and the marine economy has increased significantly. In the third year, the MR carrying capacity score was 0.511, which was the first level, mainly because the MR remained good in this year; In the last year, the marine resource carrying capacity score was

0.644, ranking the first level. It was the year with the best marine BC in the past six years, indicating that China's marine resource carrying capacity developed rapidly in all aspects in this year.

The gray line segment in the above figure is a linear prediction of China's marine resource carrying capacity in the coming years. It can be found from this line that China's marine resource carrying capacity is still rising in the future years, but the rising speed may slow down with the increase of marine resource carrying capacity, and finally a more reasonable, stable and sustainable marine resource carrying capacity will be achieved.

5. Conclusion

In this paper, the research on MR carrying capacity evaluation has achieved some research results, but there are still many shortcomings, and there are still a lot of research needs to be carried out further. This paper mainly uses the MT method of "tail effect" of MR to evaluate the carrying capacity of MR. However, the research on MR carrying capacity covers different disciplines including MR, environment and human system, and its research also draws on the methods and means of many disciplines. There is an urgent need to strengthen the cross integration research with marine economy, marine management and other disciplines. How to combine the quantitative analysis with the qualitative analysis is the direction of further research in the future. In the future research, we can select several years to compare the changes of MR carrying capacity of coastal provinces, so as to improve the evaluation of MR carrying capacity.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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