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Marine Resource Carrying Capacity Evaluation from the Perspective of Marine Resource Segmentation and Protection

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Abstract: In recent years, with the expansion of the scale of marine development and utilization, and the lack of awareness and measures for marine ecological environmental protection in the early days, my country's marine environment is facing a huge threat, and people have gradually begun to pay attention to how to develop the ocean rationally and sustainably. The proposal and development of the concept of carrying capacity (CC) provides a new entry point for evaluating the health of marine ecosystems. This paper mainly studies the evaluation of the CC of marine resources (MR) from the perspective of the segmentation and protection of MRs. Based on the construction of a scientific and perfect MR monitoring system, this paper uses the achievements of information technology to carry out dynamic analysis and evaluation of MRs carrying conditions; adopts the method of sensitivity analysis to simplify the evaluation index system of MRs carrying conditions, and then combines The ability to monitor MRs is screened. Experiments show that the coefficient of variation of the coupling coordination degree between marine economic efficiency and MRs and environmental CC is between 0.15 and 0.21, showing a stable trend overall, indicating that the degree of difference in coupling coordination between coastal regions is high.

1. Introduction

With the rapid development of modern information technology and Internet technology, people's production and lifestyle are gradually changing to informatization and networking. The rational development and utilization of MRs is an important guarantee for a country or region to achieve sustainable development, and the carrying status of MRs is an important indicator reflecting the sustainable development and utilization of MRs [1-2].

In a related study, Ghouali et al. studied variable-price fisheries models to assess the possible impact of the establishment of marine protected areas (MPAs) and locations where fishing is prohibited on fish stocks and fisheries [3]. Research shows that marine protected areas can positively impact the recovery of depleted fish stocks by disrupting catastrophic equilibrium and maintaining only a globally asymptotically stable positive equilibrium. Ibrahim proposed a Gordon-Schaefer bioeconomic model with non-constant fishing capacity and nonlinear cost [4] to study the impact of unregulated (IUU) fishing on the population size of Ghana's marine fisheries. A static equilibrium reference point for the model is established and discussed. Bifurcation analysis of the modified Schaefer model shows that there is a transcritical bifurcation point if the model structure is unstable. The necessary conditions of the model are investigated by using the Pontryagin maximal principle, and the sufficient conditions to ensure the existence and uniqueness of the optimal system are established.

Most of the traditional methods for evaluating the carrying status of MRs are ex-post evaluations, which are insufficient in terms of scientificity, timeliness and operability. It is urgent to adapt to the needs of the new era. On the basis of building a scientific and perfect MRs monitoring system, use information the dynamic analysis and evaluation of MRs carrying status based on chemical technological achievements has important practical significance for the sustainable development and utilization of MRs [5-6]. This paper starts from the division and protection of MRs, and conducts research on the evaluation of MRs CC. On the basis of constructing a scientific and perfect MR monitoring system, use the achievements of information technology to carry out dynamic analysis and evaluation of MR carrying status; adopt the method of sensitivity analysis to simplify the evaluation index system of MRs carrying status, and then combine the MRs carrying status evaluation index system. Resource monitoring capabilities are screened.

2. Design Research

2.1. There are Problems

(1) Problems exist in the informatization construction of MRs management in my country

With the continuous deepening of MR management informatization construction and related research in various parts of our country, some problems have gradually been exposed. In terms of MRs informatization construction, because my country does not have a mature and perfect MRs monitoring and management system, the level of economic and social development in various regions is uneven, resulting in uneven MRs informatization construction levels, and the quality and performance of marine monitoring equipment is insufficient. , there is no unified MR monitoring system and system platform, and the information exchange between them cannot be achieved, resulting in the phenomenon of information "island": In addition, the application of MR monitoring systems is generally less, and the system platform has a single function [7-8].

(2) Problems exist in the analysis and research of MRs monitoring data

In terms of analysis and processing of MRs monitoring information, it is the current research hotspot of scholars at home and abroad to explore the method of processing abnormal values of MRs monitoring data. my country's water administrative departments and related institutions are also gradually exploring and practicing. The characteristics of traditional statistical data are not the same, and the existing related data processing and analysis methods are relatively few, which cannot meet the information and processing of various types of complex monitoring data. A scientific and unified MR monitoring system is the foundation of MR informatization management. Scientific and timely MR management decision-making is inseparable from accurate and reliable MR monitoring information. How to improve the MR informatization monitoring and management system and apply it to MR optimization Configuration and management deserve further research and thinking [9-10].

(3) Problems existing in the evaluation of MRs carrying status

At present, the evaluation index system of MRs carrying status mostly includes three aspects: MR system, economic and social system and aquatic ecosystem. The evaluation index is relatively systematic and comprehensive, but it inevitably leads to the problems of a large number of indicators and complicated calculation. It is impossible to comprehensively evaluate the carrying status of MRs. The evaluation methods of MR carrying status are not yet mature and unified, and the current mainstream evaluation methods have certain limitations and defects, which need to be analyzed and discussed in combination with the specific situation of the evaluation. As far as the time scale of evaluation is concerned, the static evaluation of MRs carrying status is mostly carried out in "years". The evaluation results are lagging behind and lack timeliness, which makes it difficult to guide the protection and management of MRs at that stage.

2.2. Factors Affecting the CC of MRs and Environment

The environmental CC of MRs is related to natural resources and environmental conditions, social economy and culture, and human marine development activities, as well as some factors (evaluation methods, evaluation indicators, etc.) [11-12]. Mainly include:

(1) Natural factors

Location, resources, environment, etc. are all natural factors. In terms of MRs (fisheries, tourism resources, energy, natural resources, etc.), it is reflected in the quantity, quality and utilization of resources. Regarding the marine environment, it is mainly reflected in the intensity and quality of the marine environment.

(2) Human factors

The pressure on ecosystems caused by human activities and the regulation of CC are the two main aspects of anthropogenic factors. The magnitude of the pressure is related to the population base, structure and economic development. In the long history of rapid human development, it is also closely related to the pollution of the marine environment and the destruction of the marine ecosystem. The rest also includes the CC of the ocean, which is influenced by local marine culture, living standards, usage patterns and government decisions.

(3) Subjective factors

Today, there is no consensus on how to explore CC, and different evaluation methods and indicators, as well as different operation methods, will produce different research results.

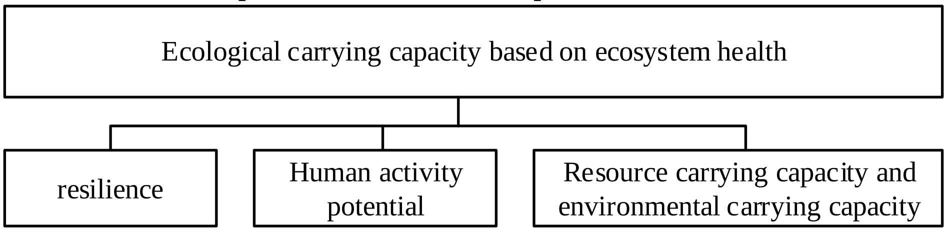

Figure 1. Ecological CC components

2.3. Principles of Index Selection

The MRECC evaluation index system is to scientifically measure the CC of MRs and environments at different scales to the population and the total amount of human social and economic activities. It serves the implementation of sustainable development strategies. The two are both related and different. From the perspective of use, the composition of the indicator system should not be too complicated, and each specific indicator should have good availability and operability, especially the qualitative indicators, which must be quantified [13-14]. In the process of constructing a set of indicators system, some general principles are generally followed as follows:

(1) Scientific principles

The scientific principle means that the index system must be able to reflect the concept of sustainable development, and at the same time include the degree of goal realization. The established index system meets the requirements of scientificity and rationality, which is the basis for further research.

(2) The principle of operability

If the operability of the indicators is not considered when establishing the indicator system, it will be difficult to be applied in practical applications, thus losing the meaning of research. Therefore, it is necessary to select some relatively easy-to-obtain data and indicators that can ensure accuracy for research, and should be able to well reflect the CC of MRs and environment.

(3) Hierarchical principle

Since the marine system is a very complex and huge system, this huge system can be divided into many subsystems, and these subsystems can also be divided into smaller subsystems. The index should follow the principle of hierarchy, so as to conform to the basic characteristics of the ocean. Generally speaking, the construction of the evaluation index system of MRs and environmental CC consists of 3-4 layers of indicators.

(4) Completeness principle

This principle requires that the index system to be constructed covers a wide range of contents, and can comprehensively reflect the contents of different subsystems at various levels in the marine human-earth system, as well as the way, strength and direction of the interaction between various elements. This requires that when constructing the index system, it is necessary to examine whether the MRs have been used reasonably, whether the ecosystem is healthy, and whether the social environment follows the principle of sustainable development [15-16].

(5) Dynamic principle

The basic characteristics of the ocean include dynamism, so the evaluation index system used to describe the CC and carrying status of the sea area should take this characteristic into consideration, and select the appropriate index based on the status of the marine system at different stages of development and the future development trend of the marine system.

2.4. Evaluation Indicators

The MR carrying status is a comprehensive index that is mutually restricted and influenced by the MR system, the economic and social system, and the ecosystem. The selection of its evaluation index needs to be comprehensively considered, combined with the monitoring level of MRs, and the complex relationship between the various systems. , the comprehensive evaluation of MRs carrying status. In this paper, the method of sensitivity analysis is used to simplify the evaluation index system of MRs carrying status, and then combined with the monitoring ability of MRs to screen [17-18].

(1) Calculation of index sensitivity

In order to quantitatively evaluate the sensitivity of MR carrying status to the changes of each evaluation index, the sensitivity coefficient was calculated, and the index was screened according to the sensitivity coefficient. The formula for calculating the sensitivity coefficient is as follows:

$$\beta = \frac{(I_{t+1} - I_t)/I_t}{(L_{t+1} - L_t)/L_t} \tag{1}$$

Among them: β is the sensitivity coefficient, the larger the β value, the higher the sensitivity of the index; It and It+l are the MR CC in different time periods; Lt and Lt+1 are the evaluation index values in different time periods.

(2) Vector modulo method

In formula (1), It and It+l are the quantitative values of MR CC, and the vector model method is used to quantitatively evaluate MR CC. The principle of the vector modulo method is as follows: Assuming that there are m different horizontal years, there are m corresponding CC evaluation values, set as Ej (i=1, 2, ..., m), and each evaluation value Ej includes n specific values. The components determined by the evaluation index, namely:

$$E_j = (E_{1j}, E_{2j}, \mathrm{K}\ , E_{nj}) \tag{2}$$

Normalized to get:

$$E_j = (E_{1j}, E_{2j}, \mathrm{K}\ , E_{nj}) \tag{3}$$

in:

$$E_j = \frac{E_{ij}}{\sum_{j=1}^{m} E_{ij}} (i = 1,2,\Lambda\ , n)(j = 1,2,\Lambda\ , m) \tag{4}$$

Then, the j-th CC evaluation value can be represented by the normalized vector modulus, namely:

$$|E_j| = (\sum_{i=1}^{n} (w_{ij} E_{ij})^2)^{\frac{1}{2}} \tag{5}$$

Among them wi. is the weight of the i-th index of the j-th CC.

3. Experimental Study

3.1. Construction of indicator system

(1) Construction process

The selection of indicators and the construction of the indicator system generally include the following four steps:

1) Determine the object to be assessed and the purpose of the assessment, and select the direction of the assessment according to the purpose of the assessment;

2) Preliminarily establish an indicator system framework according to the evaluation object and evaluation purpose;

3) Further screen the indicator system, and complete refinement, screening and induction on the basis of the initially established indicator system;

4) Optimize the structure of the constructed index system.

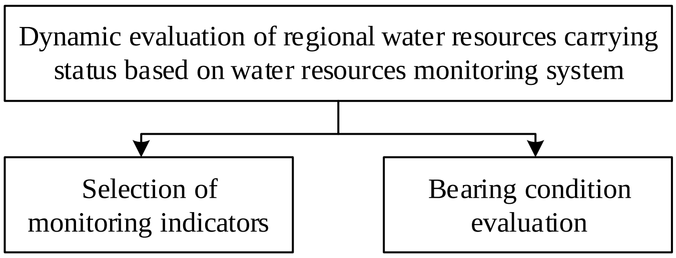

Figure 2. Evaluation process

(2) Specific indicators

According to the characteristics of MRs and environment, starting from the four target levels of resource CC, environmental CC, ecosystem services and human activity potential, and from the specificity, objectivity, credibility and repeatability of indicators, management relevance, sensitivity , controllability, measurability, comprehensiveness, importance and other 9 aspects, according to the selection experiment method and expert evaluation method, the following potential indicators that may affect the safety of MRs and environment are screened out as the corresponding three-level indicators:

1) Resource CC index. It mainly reflects the supply capacity of the ocean as a resource, and mainly includes two types of three-level indicators, biological resources and geographic resources. The changes in biological resources are characterized by two indicators: offshore fishing intensity and offshore aquaculture intensity; geographic resources use coastline development intensity. and sea area development intensity to characterize.

2) Environmental CC index. It mainly reflects the pollution-absorbing capacity of the marine environment and the self-recovery capacity of the environment. The water quality, sediment and biomass quality in environmental monitoring were used as three-level indicators.

3) Ecosystem service indicators. It mainly reflects the service functions of marine ecosystems, including three three-level indicators: ecosystem integrity, ecosystem structure changes, and ecosystem functions.

4) Indicators of human activity potential. It mainly reflects changes in natural MRs and environment caused by human activities, and mainly adopts management choices as three-level indicators.

According to the three-level indicators proposed above, an index system framework for evaluating ocean health is established: first-level indicators (MRs and environmental CC) - second-level indicators (resource CC, environmental CC, ecosystem services, and human activity potential) - three-level indicators. As shown

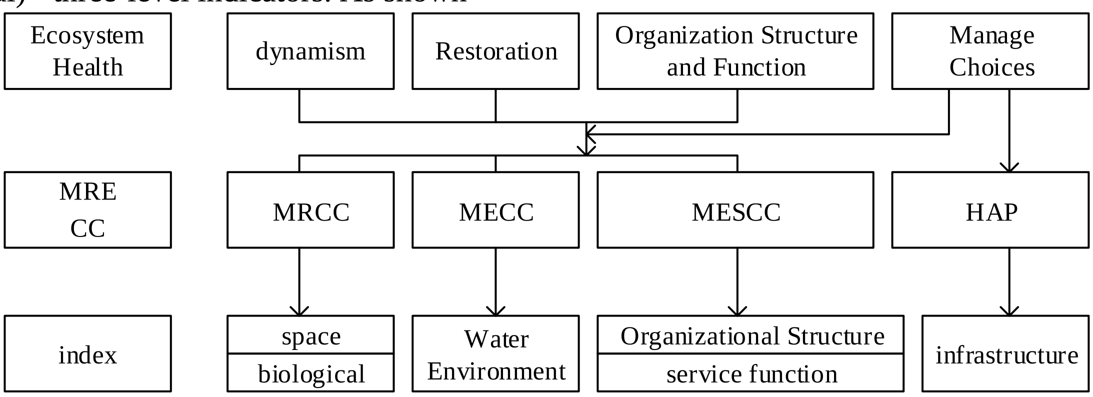

Figure 3. Framework diagram of MRECC indicator system

3.2. Marine Ecological Carrying Status

(1) Marine ecological comprehensive carrying index (E2)

The individual evaluation results of the zooplankton index and the macrobenthos index are weighted and averaged to obtain the marine ecological comprehensive carrying index (E2). The calculation formula is as follows:

$$E_2 = \frac{E_{2-F} + E_{2-B}}{2} \tag{6}$$

When E2⩾2.5, the marine ecological comprehensive carrying index can be loaded; when E2 is between 1.5-2.5, it is critical overload; when E2<1.5, it is overload.

(2) The carrying status of marine ecological disasters (E3)

The frequency of internal red tides was used to evaluate marine ecological disasters. Taking the average value of red tides in the past ten years as the base value, according to the comparison between the frequency of marine red tides in the evaluation year and the average value of many years, the marine ecological disaster level (E3) is obtained. The calculation formula is as follows:

$$E_3 = \frac{I}{I_A} \times 100\% \tag{7}$$

In the formula: I is the frequency of marine red tides in the evaluation year; IA is the average value of the past ten years. When E3<80%, the evaluation result is loadable; when 120%>E3⩾80%, the evaluation result is critical overload; when E3⩾120%, the evaluation result is overload.

Since the units of the evaluation indicators are not uniform and cannot be compared in size, it is necessary to deal with the different dimensions and the obvious differences in quantity between the original indicator data before calculation.

human potential

Humans transform and intervene in natural sea areas through science, management and other related activities, changing the CC of resources and environment, which can be specifically characterized by indicators such as environmental protection investment, scientific research and technical service investment.

(3) Calculation formula of MRs and environmental CC

The calculation method of CC in this study is as follows:

$$MRECC = \sum_{i=1}^{m} Z_i W_i \tag{8}$$

Among them, MRECC refers to MRs and environmental CC, Zi is the standardized index value, and Wi is the weight of each index.

4. Experiment Analysis

4.1. The Relationship between Ocean Health and MRs and Environmental CC

Ocean health means that the entire marine ecosystem of the ocean has no adverse reactions and can develop stably and sustainably. In other words, ocean health can be defined as marine ecosystems that show vitality. A healthy marine ecosystem is productive and capable of maintaining human services. Ocean health, as a metaphor, is a great way to use it to evaluate whether marine ecosystems are at their best. The environmental CC of MRs is a way of reflecting the health of the ocean, and the level of CC is directly related to the level of ocean health. According to the determined health level, the corresponding warning level is formulated, as shown in Table 1.

Table 1. Classification of early warning levels of resource and environmental CC based on ocean health

Health level	Health status	Warning level	Warning status	Alert level color
I	Very healthy	I	No police	Green
Ii	Healthy	Ii	Light police	Blue
Iii	Sub-health	Iii	Central police	Yellow
Iv	Unhealthy	Iv	Serious police	Orange
V	Sick	V	Giant police	Red

4.2. Discussion on The Application of The Indicator System

According to the MRECC monitoring and early warning index system constructed in this study, the selection experiment method (CE) is used to carry out the adaptive actual screening of the MRs and environmental CC indicators of the sea area. According to the basic principles of CE, the construction process of MRECC early warning indicators is as follows:

(1) Screening of potential early warning indicators

According to the characteristics of MRs and environment, and based on the index system constructed in this study, starting from four target layers: resource CC, environmental CC, ecosystem services and human activity potential, 35 potential impacts on MRs and environment in sea areas were selected. Potential safety indicators are used as early warning potential indicators, and these indicators are issued to various researchers from the specificity, objectivity, credibility and repeatability, management relevance, sensitivity, controllability, measurability, comprehensiveness, and importance of indicators. 9 aspects, including sex, were scored, and the overall score of each potential early warning indicator was further analyzed. A total of 24 questionnaires were sent out, and 21 valid questionnaires were returned. After synthesizing the questionnaires, 12 indicators with relatively high importance were obtained as alternative indicators.

(2) Secondary screening of early warning indicators

Based on the evaluation table for the selection of potential early warning indicators of resource and environmental CC constructed above, the study selects 12 indicators with relatively high importance as alternative indicators, and assigns them from two aspects of importance and satisfaction. secondary filter. The following table shows the results of the survey on the importance and satisfaction of potential early warning indicators of resource and environmental CC after the secondary screening of experts.

Table 2. Importance of MRECC potential early warning indicators and expert satisfaction evaluation table Importance satisfaction

target layer	Potential Indicator	average value	standard deviation	average value	standard deviation
MECC	Eutrophication Index	5.8	1.2	6.3	2.7
	water quality	8.8	1.2	7.3	2.1
	garbage density	7.0	1.4	5.3	1.0
	Sediment quality	5.5	2.8	6.7	1.9
	biomass mass	6.2	1.9	7.0	0.6
MRCC	Shoreline development intensity	8.7	1.5	6.3	1.9
	Sea area development intensity	8.7	0.8	6.2	2.3

	Natural wetland retention rate	7.7	2.0	5.3	2.1
	fishery production	7.7	2.0	4.3	1.9
MEsCC	total biomass	6.3	1.5	7.0	0.6
HAP	Marine environmental protection investment as a percentage of GDP	7.0	1.7	7.7	0.5
	Sewage outlet compliance rate	6.3	0.8	6.5	1.5

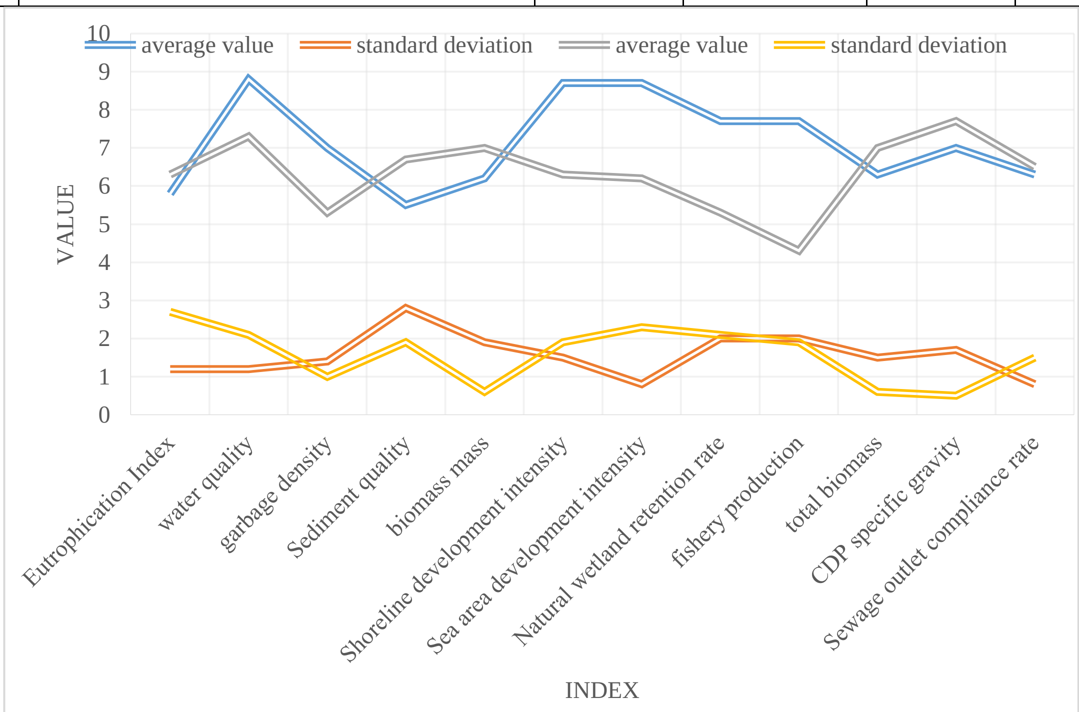

Figure 4. Analysis of the importance of MRECC potential early warning indicators and expert satisfaction

4.3. Coefficient of Variation Analysis of Coupling Degree

The coefficient of variation is a measure of the degree of variation that occurs between data. In order to obtain the change degree of the difference between the MRs and environmental CC and the coupling degree of marine economic efficiency in 10 years, the calculation formula is as follows:

$$v = \frac{\sqrt{\frac{\sum_{i=1}^{n}(x-\bar{x})^2}{n}}}{\bar{x}} \tag{9}$$

Xi represents the coupling coordination degree value of the two; X represents the average coupling degree; n represents the number of units in the study.

It can be seen from the figure that the coefficient of variation of the coupling coordination degree between marine economic efficiency and MRs and environmental CC is between 0.15 and 0.21, showing a stable trend in general, indicating that the degree of difference in the coupling coordination between coastal regions is high. From the perspective of time series, the variation of the coefficient of variation can be divided into two stages. The first four years showed a downward trend, and the coupling coordination between the two generally increased. From 5 to 8 years, the value of the coefficient of variation turned around and rose, and the coordination difference showed an increasing trend. In the past two years, the coefficient of variation has grown the fastest and fluctuated the most, indicating that the gap between the coupling coordination degree has increased, and then gradually became smooth.

5. Conclusion

The ocean is an indispensable space carrier for human survival and development. It extends the scope of human living space and contains extremely rich energy. The development of human society cannot be separated from the ocean. Based on the research of domestic and foreign scholars on the evaluation index system of MRs carrying status, this paper summarizes the current mainstream MRs carrying status evaluation index system including three subsystems of MRs, economic society and ecology. Each subsystem contains many evaluation indicators. Each index comprehensively affects the carrying status of MRs. In this paper, the evaluation indicators of MRs carrying status are preliminarily determined based on frequency statistics, expert consultation and other methods. However, due to the large number and complex types of indicators, statistical indicators cannot be obtained in real time, and it is difficult to meet the needs of dynamic evaluation of MRs carrying status. In this paper, the method of sensitivity analysis is used to simplify the evaluation index system of MRs carrying status, and then combined with the monitoring ability of MRs to screen.

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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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