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OAJRC Environmental Science, 2024, 5(2), 47-52
https://www.hillpublisher.com/journals/oajrces/
ISSN Online: 2632-2331

Safety Evaluation of Marine Biodiversity in Beibu Gulf Region of Guangxi Based on PSR Model

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How to cite this paper: Yongzong Ge, Yuping Xu, Shangjun Lin. (2024). Safety Evaluation of Marine Biodiversity in Beibu Gulf Region of Guangxi Based on PSR Model. *OAJRC Environmental Science*, 5(2), 47-52.
DOI: 10.26855/oajrces.2024.06.003

Received: July 21, 2024
Accepted: August 17, 2024
Published: September 14, 2024

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Abstract

This paper analyzes the current state of marine biodiversity in the Beibu Gulf of Guangxi from three perspectives: marine genetic diversity, species diversity, and ecosystem diversity. It defines the concept of marine biodiversity safety and establishes evaluation criteria for assessing the degree of marine biodiversity safety. Utilizing environmental and socio-economic development data from the Beibu Gulf region between 2014 and 2020, 20 evaluation indicators were selected across three categories: pressure, state, and response. This framework was used to construct an evaluation index system for assessing the marine biodiversity safety degree in the Beibu Gulf region of Guangxi. The Pressure-State-Response (PSR) model was employed to empirically analyze and evaluate the marine biodiversity safety degree in this area. The assessment results indicated that the marine biodiversity safety index for the Guangxi Beibu Gulf region was 0.4444, 0.4960, 0.5321, 0.4835, 0.5385, 0.6145, and 0.6661, respectively. This safety index demonstrated an upward trend and currently indicates a basic safety state. Finally, in light of the numerous challenges facing marine biodiversity in the Guangxi Beibu Gulf region, countermeasures and recommendations were proposed in three areas: standard formulation, environmental protection, and the establishment of a lifelong accountability system for resource and environmental damage. These suggestions aim to provide a reference for decision-making in biodiversity protection and management in the Guangxi Beibu Gulf region.

Keywords

PSR model, Beibu Gulf region, Marine biodiversity, Safety degree evaluation

1. Research background

As the cradle of life on earth, the ocean has nurtured a large number of organisms, and the ocean has nurtured about 87% of the earth's biomass with an area of about 71% of the earth, which is an important treasure house of biodiversity. Marine biodiversity has many functions, such as resource supply, cultural services, and climate regulation, and is an important basis for the survival and development of human society. In 2015, The State Council issued the Notice on the Pilot Program of Issuing and Compiling the Balance Sheet of Natural Resources. Many scholars suggested standardizing government management by surveying biomass and establishing a lifelong investigation system for resource and environmental damage. Therefore, the survey of Marine species and quantity has become an important task of Marine resource balance sheet management, which also makes the assessment of Marine biodiversity get more attention.

Since the 20th century, scholars at home and abroad have begun to study biodiversity, including species, heredity, and ecosystems. In terms of ecosystem, scholars respectively found an "inverted U-shaped" relationship between per capita income and the destruction of tropical rainforest biological species and the damage to Marine biodiversity [1, 2]. In terms of species, scholars adopted a negative binomial regression model and found that there was a positive linear relationship between economic growth and fish species threat [3]. Endangered species showed an "inverted U-shaped" trend with the increase in per capita income [4].

In China, the value of Marine biodiversity in Pingtan, Fujian Province through the method of conditional value be assessed [5]. The relationship between the level of economic development and the inflection point of China's Marine environment by selecting four indicators, such as the proportion of sub-health of typical Marine ecosystems and the area of sea with water quality worse than the fourth type be studied [6]. Marine biodiversity in the Qingdao Sea area by constructing a safety evaluation system for Marine biodiversity from three aspects: pressure, state, and corresponding. The results showed that the overall safety level of Marine biodiversity in the Qingdao sea area was not high and there was a risk of destruction by human factors [7].

2. Research object

The Beibu Gulf of Guangxi is a new important area of Marine research in China. It is rich in Marine biological resources and has various Marine ecosystems such as mangroves, coral reefs, and seaweed beds. However, with the rapid economic development in recent years, human production and life, and the development and construction of coastal areas, Marine ecosystems and Marine biodiversity are facing increasing threats.

2.1 Status of Marine genetic diversity in Beibu Gulf of Guangxi

The sum of all kinds of genetic information in Marine organisms is the genetic diversity of Marine organisms. Research on the genetic diversity of Marine organisms can reveal the origin and evolution of Marine organisms. In recent years, Marine researchers in Guangxi have used cell markers and molecular markers to study the genetic diversity of Marine organisms in Beibu Gulf of Guangxi, and have made a series of achievements.

2.2 Status of Marine species diversity in Beibu Gulf of Guangxi

At present, more than 1,500 kinds of Marine organisms have been recorded in Beibu Gulf of Guangxi, both subtropical and tropical types, including more than 500 kinds of fish, more than 200 kinds of shrimp, more than 330 kinds of shellfish, more than 190 kinds of crabs, nearly 140 kinds of phytoplankton, 130 kinds of zooplankton, which is one of the most diverse Marine areas in China. In the last 10 years, many scholars have carried out Marine biological resources observation in spring and autumn and achieved fruitful results [8]. In this paper, the main species composition of Marine organisms in the Beibu Gulf region of Guangxi was obtained by means of literature inquiry, expert consultation, and relevant data inquiry.

2.3 Status of Marine ecosystem diversity in Beibu Gulf of Guangxi

Ecosystem diversity refers to the diversity of habitats, biomes, and ecological processes in the biosphere and the extremely wide diversity of changes in habitats, biomes, and ecological processes in the ecosystem. Guangxi Beibu Gulf region is close to the Beibu Gulf, the coastline is 1628.59 km, the sea area is about 128,000 km2, belongs to the subtropical monsoon climate. There are many kinds of Marine ecosystems in Beibu Gulf of Guangxi, such as the estuarine ecosystem, mangrove ecosystem, coral reef ecosystem, and seagrass bed ecosystem.

3. Research method

3.1 Selection of evaluation index

The safety degree of Marine biodiversity is the objective degree to which Marine biodiversity is composed of all Marine species, their genetic variation within species, and the Marine living environment is prevented from being in a dangerous state. Generally speaking, the higher the level of Marine biodiversity, the more stable the Marine ecosystem, and the higher the safety of Marine biodiversity. Therefore, in accordance with the internationally recognized assessment methods of resources and environment, this paper selects the corresponding indicators from the three aspects of pressure, state, and response [9], so as to establish the Marine biodiversity safety evaluation model and reveal the Marine biodiversity safety status in the Beibu Gulf region of Guangxi.

3.1.1 Pressure index

The pressure index refers to the impact of human production and life on Marine resources and the environment. According to the actual situation of economic and social development and ecological environment in Beibu Gulf region of Guangxi as well as the availability of data, eight related evaluation indicators were set, including the number of permanent residents, the number of tourists, the discharge of industrial wastewater, the discharge of ammonia nitrogen of wastewater pollutants, the chemical oxygen content of wastewater pollutants, the amount of fertilizer used, the volume of water transportation and the amount of seawater products caught

3.1.2 Status indicator

State indicators are indicators that can reflect the status quo of Marine biodiversity security, which can show the status of the environment and resources, including the status quo of biodiversity and ecosystem. By reading relevant literature and combining

the availability of data, six related evaluation indexes were set, including total fishery economic output value, number of red tide discoveries, cumulative area of red tide, mariculture area, average diversity index of phytoplankton and average diversity index of zooplankton.

3.1.3 Response index

Response index refers to the index of active measures taken by human beings to solve resource and environmental problems and improve the safety of Marine biodiversity. According to the availability of relevant research and data, this paper sets six response indicators, namely, the amount of harmless treatment of domestic waste, the general public budget expenditure (energy conservation and environmental protection), the total amount of urban sewage treatment, the personnel of Marine scientific research institutions, the comprehensive utilization rate of general industrial solid waste, and the sewage treatment rate.

3.2 Data processing

In this paper, the initial data of the Marine biodiversity safety evaluation index system in the Beibu Gulf region of Guangxi were obtained by consulting relevant data. However, due to the dimensional disunity among the evaluation indicators, dimensionless processing is carried out on the indicator data, linear transformation is carried out on the initial data through the deviation normalization method, and the result value of the transformation is mapped to [0, 1]. The linear transformation function is as follows.

Positive correlation indicators, the greater the value indicates the greater the safety of biodiversity, such as the average diversity index of zooplankton, general public budget expenditure (energy conservation and environmental protection), etc. Standardized methods:

$$\chi^* = \frac{x-min}{\max-min} \tag{1}$$

Negative correlation indicators, the larger the value, the smaller the security of biodiversity, such as the number of seawater products caught, the number of tourists, and other pressure indicators, standardized methods:

$$Y = 1 - \frac{x-min}{\max-min} \tag{2}$$

where max indicates the maximum value of the data. min is the minimum value of data. The data processing results are shown in Table 1.

Table 1. Summary of marine biodiversity safety assessment indicators in the Beibu Gulf region of Guangxi

Index	2014	2015	2016	2017	2018	2019	2020
The number of permanent residents	1.0000	0.8835	0.7628	0.6315	0.5264	0.4282	0.0000
Number of tourists	1.0000	0.9249	0.7987	0.6199	0.3555	0.0000	0.3121
Industrial wastewater discharge	0.0000	0.1762	1.0000	0.7699	0.9494	0.6374	0.7696
Effluent pollutant ammonia nitrogen discharge	0.0000	0.0163	0.5509	0.4911	0.4242	0.7121	1.0000
Chemical oxygen content of wastewater pollutants	0.0000	0.0399	0.9722	0.9824	0.9757	0.9879	1.0000
Fertilizer use	0.0000	0.2432	0.3191	0.5745	0.8754	1.0000	0.6024
Water freight volume	1.0000	0.8087	0.7135	0.5067	0.0408	0.0985	0.0000
The amount of marine products caught	0.0085	0.0000	0.0537	0.2457	0.5534	0.6025	1.0000
Total output value of fishery economy	0.7149	0.5808	1.0000	0.1832	0.0000	0.1547	0.2949
Number of red tide sightings	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000
Cumulative area of red tide	1.0000	1.0000	0.8347	0.0000	1.0000	1.0000	1.0000
Mariculture area	0.0978	0.0000	0.0369	1.0000	0.8972	0.6497	0.3425
Average phytoplankton diversity index	0.0000	1.0000	1.0000	0.7383	0.7168	0.6910	0.8292
Average zooplankton diversity index	1.0000	0.0000	0.2769	0.5538	0.4577	0.4577	0.4577
Harmless disposal capacity of domestic waste	0.0000	0.0861	0.2508	0.1621	0.5870	1.0000	0.9351

Table 1 Continued

General public budget expenditure	0.1909	0.3794	0.0000	0.0146	0.2923	0.4882	1.0000
Urban sewage treatment capacity	0.0000	0.2650	0.4607	0.6471	0.7969	0.9467	1.0000
Marine scientist	0.8882	1.0000	0.2599	0.2599	0.0000	0.1732	0.1444
General industrial solid waste comprehensive utilization rate	0.9804	1.0000	0.8220	0.5671	0.6277	0.0000	0.4208
Sewage treatment rate	0.0000	0.4744	0.7459	0.8170	0.8187	0.9546	1.0000

3.3 Index evaluation calculation

With reference to relevant studies, the standard deviation weighting method in the objective weighting method was adopted to assign weights to various evaluation indicators, so as to obtain the normalized weights of Marine biodiversity safety evaluation indicators in the Beibu Gulf region of Guangxi [10]. The specific calculation steps are as follows. The results are shown in Table 2.

Table 2. Normalized weight of marine biodiversity safety evaluation index in Beibu Gulf region of Guangxi

Classification index layer	Concrete index layer	Comprehensive evaluation index weight
Pressure index	The number of permanent residents	0.0438
	Number of tourists	0.0482
	Industrial wastewater discharge	0.0505
	Effluent pollutant ammonia nitrogen discharge	0.0473
	Chemical oxygen emission of wastewater pollutants	0.0620
	Fertilizer use	0.0467
	Water freight volume	0.0537
	The amount of Marine products caught	0.0501
Status indicator	Total output value of fishery economy	0.0472
	Number of red tide sightings	0.0705
	Cumulative area of red tide	0.0491
	Mariculture area	0.0551
	Average phytoplankton diversity index	0.0446
	Average zooplankton diversity index	0.0397
Response index	Harmless disposal capacity of domestic waste	0.0541
	General public budget expenditure	0.0452
	Total amount of urban sewage treatment	0.0485
	Personnel of Marine scientific research institutions	0.0514
	General industrial solid waste comprehensive utilization rate	0.0463
	Sewage treatment rate	0.0458

3.4 Safety classification criteria for Marine biodiversity

In this paper, the safety degree of Marine biodiversity is divided into five levels according to the equal-distance method [11]. The safety degree of Marine biodiversity in Beibei Bay of Guangxi is measured by the level of the safety degree index of Marine biodiversity. The closer the safety degree index is to 1, the higher the safety degree is. The closer the safety index is to 0, the lower the safety level is. Each level has the following characteristics (see Table 3).

Table 3. Safety classification criteria for Marine biodiversity

Safety of Marine biodiversity	Safety index of Marine biodiversity	The state of Marine life
Safety	OMSI > 0.8	Marine biodiversity is under less pressure; Species are very rich, ecosystems are rich, and diverse, and have stable structure and function. Marine biodiversity is in a very safe state.
Basic safety	0.6 < OMSI < 0.8	Low pressure on Marine biodiversity; The species are abundant and the ecosystem types are diverse and stable. Marine biodiversity is in a relatively safe state.
Critical safety	0.4 < OMSI < 0.6	Marine biodiversity is under moderate pressure; The species richness is average, the ecosystem is relatively simple, and the safety of Marine biodiversity is at an average level.
Unsafety	0.2 < OMSI < 0.4	Marine biodiversity is under great pressure. Biodiversity is at a low level and the ability of ecosystems to repair themselves is low. Marine biodiversity is in a precarious state.
Danger	OMSI < 0.2	Marine biodiversity is under great pressure; Species richness is small, biodiversity is at a very low level, and ecosystems are severely degraded. Marine biodiversity is in a precarious state.

4. Research result

4.1 Result

This study calculated the Marine biodiversity security index of Guangxi Beibu Gulf by analyzing various indicators such as the status of Marine biodiversity, threats faced by Marine biodiversity, and countermeasures taken by human beings, and using data that can reflect the economic, social and environmental resources status of Guangxi Beibu Gulf region (see Table 4). The specific calculation formula is:

$$OMSI = \sum C_i P_i \tag{3}$$

Where: represents the normalized weight value of evaluation index i; It represents the normalized standard value of the i evaluation index, and the sum of the product of the two is the Marine biodiversity safety index of the current year, and it is used to evaluate the Marine biodiversity safety of the Beibei Bay area of Guangxi in the current year.

Table 4. Safety assessment of Marine biodiversity in Beibu Gulf of Guangxi

Year	2014	2015	2016	2017	2018	2019	2020
Marine Biodiversity Index OMSI	0.4444	0.4960	0.5321	0.4835	0.5385	0.6145	0.6661
Safety grade	Critical safety	Critical safety	Critical safety	Critical safety	Critical safety	Basic safety	Basic safety

4.2 Basic analysis

According to the analysis of each index, it can be found that the ammonia nitrogen discharge of wastewater pollutants, the chemical oxygen content of wastewater pollutants, the amount of fertilizer used and the amount of seawater products caught in the pressure index show an obvious downward trend. Among the status indicators, zooplankton diversity and phytoplankton diversity showed a phenomenon of first rising and then small fluctuation. All the response indicators in the evaluation system show a steady upward trend, which indicates that the government and people in the Beibu Gulf region have adopted more active measures to strengthen environmental protection and pollution control.

5. Conclusion and suggestion

5.1 Conclusion

5.1.1 The Marine biodiversity in Beibu Gulf of Guangxi has reached the basic safety state

Although the Marine biodiversity in the Beibu Gulf area of Guangxi is on the rise and has reached the basic security state, it is still at a relatively low level of basic security. At present, the Marine ecosystem health of the Guangxi Beibu Gulf region still needs continuous attention.

5.1.2 The effect of the policy has been remarkable, and the residents' awareness of Marine protection has been continuously enhanced

A series of measures taken by the Guangxi Beibu Gulf government to protect Marine biodiversity have achieved remarkable

results. The safety degree of Marine biodiversity has reached the basic safety range, the response index has been continuously improved, and the residents' awareness of Marine protection has been continuously enhanced.

5.2 Suggestion

In order to ensure that the safety of Marine biodiversity in Beibu Gulf of Guangxi continues to improve steadily, the government can strengthen the protection of Marine Biodiversity and the Marine ecosystem from three aspects: formulating Marine biosafety evaluation standards, reducing pollutants in the sea and establishing lifelong responsibility investigation system.

5.2.1 To formulate and continuously improve the safety evaluation standards of Marine biodiversity

At present, there is still a lack of unified standards for the safety evaluation of Marine biodiversity, and the relevant scholars have some differences in the research results due to the differences in the evaluation indicators selected in the study of Marine organisms in the same area. Therefore, the development and continuous improvement of Marine biodiversity safety evaluation criteria can provide a standard for relevant scholars to study.

5.2.2 Reduce land-based pollutants into the sea, and strengthen environmental protection knowledge publicity

The local government should continue to strengthen financial support and administrative supervision, on the one hand, the use of various pollution treatment equipment to improve the proportion of sewage and various garbage harmless treatment, on the other hand, strengthen the supervision of the private discharge of pollutants near the sea, in order to reduce the land pollutants into the sea as much as possible.

5.2.3 A lifelong liability system for Marine environmental damage has been established

Establishing a lifelong accountability system for Marine environmental damage can not only avoid officials' inaction in Marine environmental protection but also avoid the possibility of damaging resources and the environment in pursuit of short-term economic interests and personal achievement

Funding

This study was supported by the Beibu Gulf Marine Development Research Center project (BHZKY202007) and the Beibu Gulf University high-level talent research project (23KYQD15).

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