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Research on the Coordinated Development of Marine Economy and Marine Industrial Structure from the Perspective of Low-carbon Economy

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Abstract

There are few quantitative studies on marine low-carbon economy in my country. Research on the coordinated development of marine economy from the perspective of low-carbon economy and domestic marine industry structure has profound guiding significance for the sustainable development of marine economy. Based on the coupling coordination degree model, this paper constructs an index system to analyze the coordinated development of my country's marine low-carbon economy and marine industrial structure. The research results show that: 1. In terms of time, the timing of the coupling and interaction of the marine low-carbon economy and industrial structure in coastal areas of my country has basically shown a steady upward trend. After 2010, it has entered a state of coordination. 2. From a spatial perspective, there are obvious regional differences in the degree of coupling coordination among coastal provinces. The degree of coupling coordination in southern coastal areas is generally higher than that in northern coastal areas. At the same time, the degree of coupling coordination has a great relationship with the level of regional marine economic development.

Keywords

Low-carbon; marine economy; Industrial structure; Coupling coordination.

1. Introduction

The concept of a "low-carbon economy" first appeared in the UK government's energy white paper, Our Energy Future: Creating a Low-Carbon Economy. Low-carbon economy is an economic model based on low energy consumption, low pollution and low emissions[1]. Scientific research and observational data show that in the nearly 100 years since the Industrial Revolution, the global climate is changing with warming as the main feature. The main reason for this change is the large amount of greenhouse gases emitted by human activities, particularly in the process of industrialization in developed countries. Such global climate change has had a serious impact on economic and social development and human life.

In 2014, China made a low-carbon commitment to "plan CO2 emissions to peak around 2030". In 2016, the "13th Five-Year Plan" put forward a "green and low-carbon cycle" development, and plans to achieve my country's unit GDP by 2020. Carbon dioxide emissions are 40%-45% lower than in 2005. The development of marine economy plays a vital role in the development of low-carbon economy. The ocean has a rich blue carbon sink. The ocean carbon pool is 50 times that of the atmosphere and 20 times that of terrestrial ecosystems. More than half of the biological carbon or green carbon capture on the earth is done by marine organisms, not on land. Therefore, research on the coordinated development of marine industrial structure and marine economy from the perspective of low-carbon economy is of great practical significance for the comprehensive realization of the green development of the ocean.

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2. Literature Review

Chinese scholars' research on marine low-carbon economy mainly focuses on the theoretical level: Sun Jiatao (2010) discussed the development model of China's marine low-carbon economy and put forward relevant policy recommendations[2]. Qi Zhanhui et al. (2010) reviewed the main carbon sources and carbon sinks and the research progress of ocean carbon sequestration mechanisms, and discussed the key research directions for the development of carbon sink fisheries in the South China Sea[3]. Xu Donglan believes that blue carbon sinks are low-cost, technically feasible, and a variety of benefits for reducing carbon. It can not only improve the high-carbon environment, but also benefit the development of my country's blue economy, which can bring a "win-win" effect[4]. Li Hongying et al. (2011) used the coordinated development model to study the coordinated development of the marine economy and ecological environment in Zhejiang Province from the perspective of a low-carbon economy, and proposed countermeasures that are conducive to the low-carbon transition of the marine economy[5].

There is a close relationship between marine industrial structure and marine economic growth. The marine industry is the internal driving force that promotes marine economic growth. At the same time, the marine economic growth will conversely promote the continuous upgrading and optimization of marine industrial structure. To sum up, the marine industry structure and the marine economy are not two completely independent systems. The marine industry and the ocean, and the economy are two systems that cross each other and mutually promote the coupling and synergy between the two. However, there are few studies on the synergy between the two. Most of them only study the impact of the marine industrial structure on the marine economy, and ignore the synergy between the two. This study will start from the perspective of low-carbon economy, construct an evaluation index system, and use a coupling coordination model to discuss the mechanism of coupling and coordination between the marine industrial structure and the marine economy, with a view to providing guidance for the sustainable development of my country’s marine low-carbon economy significance.

3. Research Method

3.1. Coupling Coordination Degree Model

Coupling was originally a physical concept and refers to two or more (systems or motion forms that affect each other through various interactions. Coupling degree describes the degree of mutual influence of systems or elements. From the perspective of synergy Coupling，the role and the degree of coordination determine the order and structure of the system when it reaches the critical region, that is, the trend of the system from disorder to order[6].

Yueming Wu et al. (1996) established a coordination degree model based on the synergetics viewpoint, and Liu Yaobin et al. (2005) combined the meaning of coupling on this basis and promoted the construction of a coupled and coordinated development model. After that, they studied the socio-economic and ecological environment systems and widely used this model.

According to the coupling definition, suppose that the marine industry structure has m indicators (X_i) and the marine economy has n indicators (Y_j). Let the functions f(x) and f(y) be the comprehensive development index of forestry industry structure and the comprehensive development index of forestry economy.

3.1.1. Initialize the Data

Because this paper divides the original data into positive indicators and reverse indicators, the original data of each indicator has different dimensions, so the indicators need to be dimensionless and normalized.

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Processing of positive indicators: $Z\big|_i^x = \frac{x_i - \min x_i}{\max x_i - \min x_i}$ ..... (1)

Handling of negative indicators: $Z\big|_i^x = \frac{\max x_i - x_i}{\max x_i - \min x_i}$ ..... (2)

In the same way, the raw data of marine economic indicators is standardized to obtain $Z\big|_j^y$, (j=1,2……n)

3.1.2. Calculate the Comprehensive Development Index of Marine Economy and Marine Industry Structure

$$f(x) = \sum_{i=1}^{m} a_i Z_i^X, \quad \sum_{i=1}^{m} a_i = 1 \quad \text{.....} \quad (3)$$

$$f(y) = \sum_{i=1}^{n} b_j Z_j^Y, \quad \sum_{i=1}^{n} b_j = 1 \quad \text{.....} \quad (4)$$

In the above formulas (3) and (4), ai and b_j respectively represent the weights of the various indicators of the marine industry structure and the marine economy; f(x) represents the comprehensive development index of the marine low-carbon economy, and f(y) represents the marine industrial structure The comprehensive development index; the method of determining the weight mainly includes subjective assignment method and objective assignment method, and the analysis result of subjective assignment tends to be unstable. Since the entropy method has objective weighting characteristics, this study uses the entropy method to determine the weight of marine economic indicators and the weight of marine industry structure indicators[7].

3.1.3. Use Entropy Method to Determine Index Weight

Take the calculation of the index weight of the marine industry structure as an example, with m indexes and k years, the standardized data matrix is Z=z(ij)m*k

1. The same metrics as metrics

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{k} z_{ij}} \quad \text{.....} \quad (5)$$

2. Calculate the entropy value of the jth index

$$e_j = -k \sum_{i=1}^{k} p_{ij} \ln p_{ij}, k = \frac{1}{\ln k} \quad \text{.....} \quad (6)$$

3. Calculate the difference coefficient of the j-th index

$$d_j = 1 - e_j \quad \text{.....} \quad (7)$$

4. Determine the weight

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$$w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad \cdots\cdots \tag{8}$$

3.1.4. Calculate the Degree of Coupling

$$C = \left\{ f(x)g(x) / \left[\frac{f(x)+g(y)}{2} \right]^2 \right\}^k, k \geq 2 \quad \cdots\cdots \tag{9}$$

$C \in (0,1)$ represents the degree of coupling. The higher the degree of coupling, the higher the degree of mutual influence between the marine low-carbon economy and the marine industrial structure. k is the adjustment coefficient. This article only focuses on the composite system of marine low-carbon economy and industrial structure, so k=2.

3.1.5. Calculate Coordination

$$T = \alpha f(x) + \beta g(y) \quad \cdots\cdots \tag{10}$$

$$D = \sqrt{C \cdot T} \quad \cdots\cdots \tag{11}$$

Because two regions with the same degree of coupling may face different overall development levels. When the marine low-carbon economy and marine industrial structure are both at a low level of development, a higher degree of coupling can be obtained. Therefore, this paper introduces a model of coupling and coordination degree. In formulas (10) and (11), T is the comprehensive evaluation index of the marine low-carbon economy and marine industrial structure composite system. α and β represent the weights of the marine low-carbon economy and the comprehensive development level index of the marine industrial structure. In view of the two systems. Equally important, here α=β=0.5; D represents the degree of coupling and coordination of two composite systems. Obviously, the larger the value of D, the higher the degree of coupling and coordination, and the better the state of coordinated development between the two systems.

Table 1. Coupling coordinated development types and criteria

Coordination phase	Ranges	category	Coordination type
Antagonistic stage	0.000-0.099	Severe dysregulation	The lagging marine industry structure f(x)>f(y)
	0.100-0.199	Moderate dysregulation	
	0.200-0.399	Mild dysregulation	
Run-in stage	0.400-0.499	On the verge of dysfunctional recession	Marine low-carbon economy lagging f(x)<f(y)
	0.500-0.599	Barely coordinated development	
Coordination stage	0.600-0.699	Mildly coordinated development	Synchronization of marine industrial structure and marine low-carbon economy f(x)=f(y)
	0.700-0.799	Moderately coordinated development	
	0.800-1.000	Well-coordinated development	

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3.2. Construct An Evaluation Index System

In order to study the coupling and synergy between the marine industrial structure and the marine economy from a low-carbon perspective, this paper constructs an evaluation index system for the marine industrial structure and marine economy. Low-carbon economy is a sustainable development path characterized by low-carbonization. At present, there is no unified standard for the evaluation of marine low-carbon economy in the world. Therefore, this study refers to the sustainable development indicator system revised for the third time by UNCSD, and the following principles should be considered when constructing the indicator system: ①The indicators are concise and representative ②The availability of indicators is comparable among countries (economy); ③The choice of indicators is linked to policy objectives; ④The compatibility of socio-economic indicators and environmental indicators. Constructed an evaluation index to measure the marine low-carbon economy. Including low-carbon environmental indicators, low-carbon input indicators, low-carbon output indicators, three criterion levels[8]. Low-carbon resource indicators include sea area, industrial wastewater and waste discharge. The abundant carbon sinks owned by the ocean are the development of ocean low-carbon economy. In the key link, the amount of waste discharged reflects the quality of the marine environment, so it can be used as an indicator to measure the low-carbon environment. Low-carbon input and low-carbon output can measure a region's efforts towards a low-carbon economy. Low-carbon investment includes human investment, capital investment, and investment for ecological construction. Marine industry carbon productivity, marine industry output value and per capita output value of marine industry can effectively measure the low-carbon efficiency of a region. At present, my country's relevant agencies have released data on total energy consumption in coastal areas, but have not announced the total energy consumption of marine industries in coastal areas. According to the research ideas in References [9], the total output value of the coastal area marine industry accounts for the proportion of the coastal area's gross product value as the proportion of the coastal area's marine industry carbon emissions in the total coastal area's total carbon emissions, and the calculation formula for carbon emissions Total carbon emissions = total energy consumption * carbon emission coefficient [11] corresponding to each energy; carbon emissions from marine industry = sum of marine industry output * regional carbon emissions / regional production value; carbon productivity = regional output value / Regional carbon emissions, this study selects the sum of the carbon emissions of coal, oil, and natural gas to represent the regional carbon emissions. Per capita total output value of the marine industry = total output value of the marine industry / average annual population; marine labor productivity = total output value of the marine industry / average annual number of employees in the marine industry). According to the (Regulations on the Division of the Three Industries), my country's marine industry structure is divided into the first, second and third industries, and an evaluation index system is constructed in accordance with the connotation and definition of the marine industry structure.

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Table 2. The level of economic development is coupled with the coordinate evaluation index

Target layer	Criterion layer	Evaluation index	unit	Positive or negative
Economic development level indicator	Low-carbon environment	Confirm the area of the sea	hectares	+
		Industrial wastewater discharged directly into the sea	Million t	-
		General industrial solid waste dumping	t	-
	Low carbon investment	Sea-related employees	Ten thousand people	+
		Labor productivity	Ten thousand yuan/person	+
		Nature reserves	Square kilometer	+
	Low carbon output	The per capita output value of the marine industry	Ten thousand yuan/person	+
		The total output value of the marine industry as a proportion	%	+
		Carbon productivity in the marine industry	Ten thousand yuan/ton	+

Table 3. The index of coordinated evaluation of industrial structure coupling.

Target layer	Criterion layer	Evaluation index	unit	Positive or negative
Industrial structure index	the first industry	The proportion of the output value of the first industry to the marine industry	%	+
		The value added of the output value of the first industry	100 million	+
		The output value of the per capita first industry	Ten thousand yuan/person	+
	the secondary industry	The proportion of the output value of the secondary industry to the marine industry	%	+
		The value added of the output value of the secondary industry	100 million	+
		The output value of the per capita secondary industry	Ten thousand yuan/person	+
	the tertiary industry	The proportion of the output value of the tertiary industry to the marine industry	%	+
		The value added of the output value of the tertiary industry	100 million	+
		The output value of the per capita tertiary industry	Ten thousand yuan/person	+

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3.3. Data Sources

The data sources in this article are the "China Ocean Statistical Yearbook" and "China Energy Statistical Yearbook". The research area is set to 11 coastal areas in my country, including Liaoning, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Guangxi, Hainan. Since 2006, my country has made major adjustments to the accounting caliber of the marine economy. In order to ensure the consistency and comparability of the data, the data for the period 2007-2015 has been calculated with 2006 as the base year.

4. The Analysis of Space-time Differences Between the Marine Industrial Structure and the Coordinated Development of the Marine

4.1. Analysis on the Time Difference of Coordinated Development of Marine Industrial Structure and Marine Economy.

Table 4. Evaluation of the type of coordinated development of China's marine industrial structure and marine low-carbon economy

		C	D	Type evaluation
Run-in stage	2007	0.992	0.451	On the verge of dysfunctional recession
	2008	0.899	0.479	On the verge of dysfunctional recession
	2009	0.844	0.410	On the verge of dysfunctional recession
Coordination stage	2010	0.993	0.625	Barely coordinated development
	2011	0.969	0.692	Barely coordinated development
	2012	0.999	0.644	Barely coordinated development
	2013	0.997	0.741	Moderately coordinated development
	2014	0.984	0.756	Moderately coordinated development
	2015	0.979	0.802	Well-coordinated development

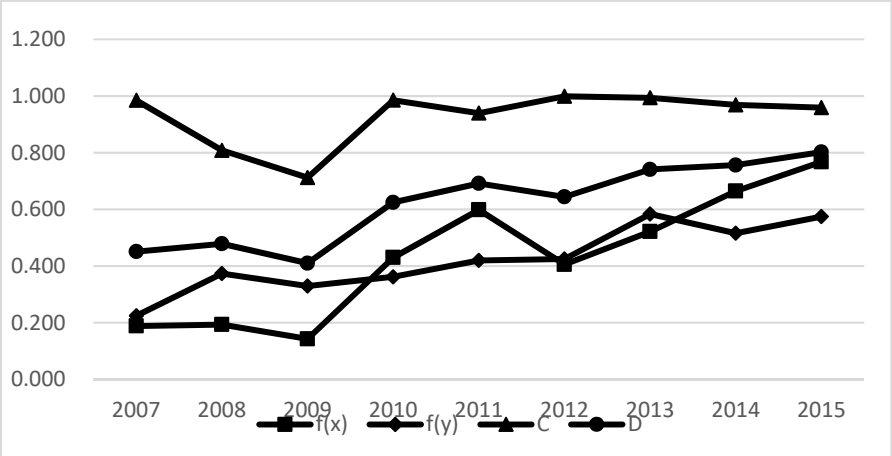

Figure 1. Time changes in coupling between China's marine low-carbon economy and marine industrial structure (2007-2015)

According to the coupling coordination degree model, the data related to marine low-carbon economic indicators and marine industrial structure from 2007 to 2015 are calculated and analyzed, and the data in Table 3 is obtained, and Figure 1 is made.

From 2007 to 2009, the comprehensive development index of marine industrial structure was greater than the comprehensive development index of low-carbon economy, and the development of marine low-carbon economy lags behind. After 2010, data showed that the

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comprehensive development index of marine low-carbon economy has steadily increased and exceeded the comprehensive development index of marine industrial structure. The system has entered a lagging stage of industrial structure development. This may be due to the convening of the 2009 Copenhagen Climate Change Conference. An economic model based on low energy consumption, low pollution and low emissions-the "low carbon economy" is presented to the people of the world. At the two sessions in 2010, ecological and environmental protection and sustainable development became the themes of the two sessions. my country began to vigorously promote ecological construction, attach importance to the green and sustainable development of the marine economy, rapidly reduce the amount of garbage discharged into the sea, and improve the quality of seawater. It further illustrates that in the future development of a low-carbon ocean economy, emission reduction is a very important part. The degree of coupling between the marine low-carbon economy and the marine industrial structure has been at a high level, indicating that the two systems have a high degree of mutual influence. Further analyze the orderly degree of the coupling between the marine low-carbon economy and the marine industrial structure. It can be seen from the figure that the marine low-carbon economy and the comprehensive development index of marine industrial structure are both rising. The coordinated development of marine low-carbon economy and industrial structure composite system can be divided into two stages. From 2007 to 2009, the value of the coupling degree was between 0.4 and 0.5, indicating that the system is in the running-in phase and the two systems are on the verge of out of adjustment. After 2010, the value of the coupling degree reached an inflection point of 0.6, and the coupling relationship between the marine low-carbon economy and the industrial structure changed and entered the coordination stage. From 2010 to 2012, it was in the stage of mild coordinated development. From 2013 to 2014, the system entered the stage of moderate coordinated development. In 2015, the coupling coordination degree was 0.805, which is a good development type.

4.2. Analysis on the Spatial Difference of the Coordinated Development of Marine Industry Structure and Marine Economy

Table 5. Evaluation on the type of coordinated development of China's marine industrial structure and marine low-carbon economy in 2015

Province	C	D	Type evaluation
Liaoning	0.966	0.533	Barely coordinated development
Hebei	0.987	0.377	Mild dysregulation
Tianjin	0.997	0.585	Barely coordinated development
Shandong	0.964	0.587	Barely coordinated development
Jiangsu	0.980	0.509	Barely coordinated development
Shanghai	0.962	0.619	Mildly coordinated development
Zhejiang	0.891	0.502	Barely coordinated development
Fujian	0.983	0.737	Moderately coordinated development
Guangdong	0.995	0.599	Barely coordinated development
Guangxi	0.919	0.350	Mild dysregulation
Hainan	0.798	0.504	Barely coordinated development

According to the calculation method of the degree of coupling and coordination, the spatial difference analysis of 11 coastal provinces across the country in 2015 is carried out. The data obtained is merged into Table 4. It can be concluded from Table 4 that in 2015, the overall level of coupling between the marine low-carbon economy and industrial structure of the 11 coastal provinces was not high, and most of them were in the stage of barely coordinated development. A more detailed division of the coupling strength of each province, 11 provinces can be divided into 4 types: mild disorder and recession type: Hebei, Guangxi; barely coordinated development type: Liaoning, Tianjin, Shandong, Jiangsu, Zhejiang, Guangdong, Hainan; Slightly coordinated

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development type: Shanghai; Moderately coordinated development type: Fujian. It can be seen from the distribution of types that most coastal provinces are still at a relatively low level of coupling and coordination. Coastal cities with a high degree of coupling coordination, including Shanghai, Fujian and other regions, are my country's major marine provinces. After years of marine structural adjustment and ecological construction, their marine low-carbon economy and industrial structure have shown coordinated development. status. The degree of coupling and coordination in Liaoning, Tianjin and other regions is at an intermediate level, reaching a stage of barely coordinated development. It is necessary to further strengthen the optimization of industrial structure and ecological construction. Regions with low coupling strength, including Hebei and Guangxi provinces, have a relatively low degree of marine economic development. There is still a large gap between Hebei and Guangxi provinces and other developed coastal provinces. Due to their own conditions, they're Both marine economic development and ecological construction are under great pressure, and there is an urgent need to adjust the development mode.

5. Conclusion

The results of the coupling and coordination analysis of the marine low-carbon economy and the marine industrial structure show that from 2007 to 2009, the marine low-carbon economy and industrial structure were in a state of imbalance. After 2010, the two systems began to develop in coordination. Among them, in 2010- 2012 was a mildly coordinated development, and the period from 2013 to 2014 was a moderately sustainable development. In 2015, it has entered a stage of good coordinated development, and the overall trend continues to strengthen. Both the marine low-carbon economy and the comprehensive development index of the marine industry structure are in the rising stage, indicating that my country has achieved remarkable results in transforming the development mode of the marine economy and strengthening the protection of marine ecology. Although the marine industrial structure and the marine low-carbon system have not yet achieved complete simultaneous development, in-depth research can conclude that with the continuous optimization of the marine industrial structure, the marine low-carbon economy has achieved a steady upward development. In order to promote the development of marine low-carbon economy, the marine industrial structure should be further upgraded and optimized, and the coordination mechanism between the two systems should be used to promote the common development of the two systems. At the same time, there are obvious regional differences in the degree of coupling and coordination among coastal provinces in terms of spatial distribution. The degree of coordination in southern coastal provinces is generally higher than that in northern coastal provinces. Provinces with a more developed marine economy pay more attention to the construction of marine ecology and have a higher degree of coupling and coordination; provinces with a lower level of marine economy have a lower degree of coordination.

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