Research on Relationship between Marine Industry Agglomeration and Marine Ecological Environment in Guangdong Province

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Abstract: As the marine industry continues to grow, industrial agglomeration's impact on the coordinated development of the marine biological environment system has grown in importance. In this paper, an index system and an empirical analysis model of the coupling relationship between the ecological environment system and marine industry agglomeration are established from the perspective of the relationship between the two. The degree of coordinated development between the resources and environment in Guangdong Province and the marine industry agglomeration is also studied. The empirical results show that the coordinated development level of Marine industrial agglomeration and Marine ecological environment in Guangdong province generally shows a trend of increasing year by year, but the coupling coordination degree is reduced to intermediate coordination after reaching good coordination. Finally, countermeasures and suggestions are put forward for the empirical analysis results of Marine industry agglomeration and ecological environment system in Guangdong Province.

Keywords: Guangdong Province; Marine Industry Agglomeration; Marine Ecological Environment; Coupling Relationship; Agglomeration Level

1. Introduction

One of China's largest marine provinces is Guangdong. Guangdong province ranked first in China for 29 years in a row with a marine GDP of 1.88 trillion yuan in 2023, representing a nominal growth of 4.0% year over year and 13.8% of the regional GDP and 18.9% of the national marine GDP. In Guangdong Province, the rise of the marine economy has emerged as a significant driver of economic expansion. At the same time, the Marine industry in Guangdong province is gradually showing a trend of agglomeration and development, and has basically formed an industrial chain and industrial group with a certain scale, and the agglomeration scale is constantly expanding. There are two outcomes from the growth and consolidation of the marine sector. On the one hand, the agglomeration effect, scale effect, radiation effect and other benefits generated by the agglomeration process help to optimize the allocation of resources, improve the ecological environment, effectively drive the development of regional economy; on the other hand, the industrial agglomeration process will bring population agglomeration, thus increasing the demand for water, land and other resources, the higher the agglomeration, the more demand for resources and environment, and once the carrying capacity of the ecological environment, resource shortage and environmental pollution will cause damage to the ecological environment. Therefore, in the process of promoting the formation of Marine industry agglomeration, it is necessary to coordinate the scale of Marine industry agglomeration with the carrying capacity of resources and environment, and the sustainable development goal of Marine industry can only be realized. Based on Guangdong Province's present state of development, the marine industry agglomeration there is progressively growing. However, issues like inefficient resource allocation, environmental contamination, irrational industrial structure, and industrial dispersion limit the growth of industrial agglomeration. Therefore, based on the national strategy of "maritime power" and "Maritime Silk Road", In order to support the benign and healthy development of the marine

industry in Guangdong Province, it is especially important to investigate the relationship between the agglomeration of the marine industry and the ecological environment. Additionally, the mechanism of the agglomeration and ecological environment must be built.

2. Literature Review

(1) Research on the relationship between industrial agglomeration and ecological environment

The research results form two opposing views: one is that industrial agglomeration will cause damage to the ecological environment of the region. When studying the sustainable development of Shandong Peninsula urban agglomeration, Gai (2000) found that the excessive concentration of population and industrial activities in the urban agglomeration, as well as the problems of repeated construction and inefficient utilization of resources caused by the convergence of industrial structure in the agglomeration area, caused the deterioration of the ecological environment [1]. Wang et al. (2020) used the coupled coordination model and spatial autocorrelation method to analyze the panel data of 30 provinces from 2003 to 2017, and the results show that the level of industrial agglomeration development is easy to improve, but the ecological balance is difficult to maintain stability [2]. Second, industrial agglomeration can improve the regional environmental quality. Wang et al. (2009) verified that the manufacturing agglomeration has a positive effect on promoting the ecological environment [3]. Li et al. (2014) based on the dynamic panel model of 20 industrial industries in 2001-2007, the analysis showed that the industrial agglomeration degree has a negative correlation with the pollution emission, and the higher the agglomeration degree, the less the industrial pollution emission [4]. Zheng et al. (2023) made an empirical analysis on the coupled coordinated development of industrial agglomeration and ecological environment in Chengdu-Chongqing economic circle in 2008-2019, and the results showed that the coupled coordination of industrial agglomeration and ecological environment in Chengdu-Chongqing economic circle showed a steady upward trend [5].

(2) Research on the problem of Marine industry agglomeration

The main achievements are concentrated in two aspects: one is the research on the concentration degree of Marine industry. Han et al. (2003) used the Gini coefficient to analyze the changing trend of the spatial agglomeration of China's Marine industry [6]. The analysis shows that the spatial agglomeration level of the space of China's Marine industry is high from the static perspective, and the spatial evolution trend of various industries varies significantly from the dynamic perspective. Yan et al. (2017) used the location entropy method to calculate the agglomeration degree of Fujian Marine industry, and found that the agglomeration trend of three Marine industries in Fujian presents a mode of "one, three, two" [7]. The agglomeration phenomenon of primary and tertiary industries is obvious, while the agglomeration of secondary industries is not obvious, but the agglomeration scale is forming. Huang et al. (2020) adopted the location entropy method to measure the industrial cluster degree of Guangdong, Guangxi and Hainan, and found that Guangdong far exceeded Guangxi and Hainan in terms of Marine industry development, but did not show the greatest advantage; the degree of Hainan is higher than that of Guangdong and Guangxi. In the southern Marine economic circle, the Marine industry in the region [8]. Second, the research on the contribution of Marine industry agglomeration to economic growth. Jiang et al. (2012) took the Granger causal test to analyze the relationship between Marine industrial cluster and economic growth, which shows that the relationship between Marine industrial cluster and economic growth is mutually causal [9]. Lin (2014) used the improved Solo-Swan model to quantitatively study the relationship between Marine industry agglomeration and economic growth in Fujian Province, and the results show that there is a significant positive relationship between the two [10]. Gao et al. (2023) - -Based on the analysis of the panel threshold regression model, the results show that there is a nonlinear relationship between the promoting effect of Marine industrial agglomeration on economic growth [11].

(3) The relationship between Marine industry agglomeration and ecological environment

Huang (2009) for the first time the coupling relationship in the study of environmental resources allocation, in the bohai sea economic circle, for example, construct industrial agglomeration and environmental resources coupling element index, empirical analysis of the coupling coordination degree, and design to promote the bohai rim industrial agglomeration and the coordinated development of regional environmental resources coupling mechanism [12]. Teng et al. (2016) first analyzed the dynamic correlation effect of regional carrying capacity and industrial agglomeration theoretically, and the results showed that Marine industrial agglomeration has a stimulating effect on regional carrying capacity [13]. Zheng et al. (2020) analyzed the data of Marine industries in 11 coastal provinces and cities from 2006 to 2015. On the one hand, there is a significant negative correlation of Marine environmental pollution in China coastal areas, which is the phenomenon of agglomeration pollution; on the other hand, the improvement of the Marine industrial agglomeration pollution, and there is a significant spatial spillover effect [14].

Through the summary of the existing literature results, it is found that the existing literature has many unilateral studies on the ecological environment impact of industrial agglomeration, but few studies study the research results of ecological environment on industrial agglomeration. There are, however, few studies on the relationship between marine industry agglomeration and the ecological environment, particularly the results of marine industry agglomeration in Guangdong Province, which have not yet been observed. Instead, the majority of studies on marine industry agglomeration concentrate on measuring the level of agglomeration and its effect on economic growth.

3.Research Design

3.1 Research Method

3.1.1 Location entropy method

The location entropy method can not only intuitively and accurately evaluate the agglomeration degree of Marine industry in a certain region, but also better adapt to the characteristics and development status of Marine industry, providing a powerful tool for the in-depth study of Marine industry agglomeration. Therefore, the degree of marine industry agglomeration in Guangdong Province is measured in this research using the location entropy approach.

Location entropy, also known as specialization rate, is first proposed by P·Haggett and used in location analysis to measure the spatial distribution of elements in a certain region, reflect the specialization degree of a certain industrial sector, and the status and role of a certain region in a high-level region.

The calculation formula for location entropy is:

$$LQ_{ij} = \frac{Y_{ij}/Y_j}{T_i/T} \quad (1)$$

3.1.2 entropy evaluation method

This paper uses the entropy method to calculate the index system of Marine industry and Marine ecological environment system in Guangdong province and determine its weight. The basic principle of entropy method is the dispersion degree of the index in the selected statistical test interval. If the greater the dispersion degree is, the greater the weight of the index, a smaller weight should be set.

3.2 The Construction of the Index System

A key determinant of the scientificity of the assessment of the coordinated development level of the marine industrial agglomeration and the marine ecological environment is whether or not the index system's construction was reasonable and scientific. In order to represent the system's dynamic trend, each system index should be chosen with thoroughness, scientific methodicalness, timing, and operability. According to the aforementioned guidelines, the regional resource and environmental level index system is based on three factors: resource endowment, environmental pressure, and environmental resistance. The marine industry agglomeration level index system is based on the size, composition, and quality of the marine industry. The specific index system, as shown in Table 1.

3.3 Model Building and Its Evaluation Criteria

3.3.1 The coupling degree model

The phenomenon that describes the interaction between two or more systems, influencing, and ultimately uniting to achieve coordinated development is coupling, and the degree of coupling is used to measure the degree of

action between systems. The coupling degree between Guangdong Province's resource and environmental system and the marine industry agglomeration is determined in this article using the coupling degree model. The comprehensive evaluation function of Marine industrial agglomeration system is f(x), the comprehensive evaluation function of ecological environment system is g(y), and the coupling degree model is:

$$C=2\times\{\frac{f(x)g(y)}{[f(x)+g(y)]}\}^{1/2} \quad (2)$$

In the formula, C is the coupling degree, take the value is [0, 1], the larger the value, the stronger the connection between the systems, and the better the coupling. When C=1, the two subsystems are completely coupled and influence each other; the smaller the C value is, the worse the coupling between the two systems will be. When C=0, there is no coupling between the two subsystems, indicating that there is no effect between the two.

Table 1. Evaluation Index System and Weight of the Coupling between Marine Industrial Agglomeration and Resources and Environment

project	Level 1 indicators	Secondary indicators	unit	property	weight
Marine industry agglomeration system index(X)	Cluster scale indicators	Gross Marine product(X1)	billion	positive	0.136543
		Overall agglomeration level of Marine industry(X2)	--	positive	0.13701
	Cluster structure index	Agglomeration level of Marine primary industry(X3)	--	positive	0.243146
		Cluster level of Marine secondary industry(X4)	--	positive	0.089041
	Cluster quality indicators	Value value of Marine-related industries(X5)	billion	positive	0.112876
		Value-added value of major Marine industries(X6)	billion	positive	0.104102
		Value-added value of the tertiary industry(X7)	billion	positive	0.177283
Marine ecological and environment system indicators(Y)	Ecological resources indicators	Sea water farming area(Y1)	hectare	negative	0.10382
		Salt pan total area(Y2)	hectare	negative	0.121533
		Total Water Resources(Y3)	billion cubic meters	positive	0.054837
		Marine natural gas production(Y4)	billion cubic meters	positive	0.07133
		Offshore crude oil production(Y5)	Ten thousand tons	positive	0.05796
	Environmental pressure indicators	The number of times when Marine disasters occur(Y6)	Time	negative	0.032344
		The cumulative area of red tide occurs in the ocean(Y7)	square kilometer	negative	0.061982
		Industrial power consumption(Y8)	One hundred million kilowatt-hours	negative	0.061121
		Industrial wastewater discharge volume(Y9)	tons	negative	0.07649
		Industrial exhaust gas emissions(Y10)	One hundred million cubic meters	negative	0.075596
		General industrial solid waste production volume(Y11)	Ten thousand tons	negative	0.037721
	Environmental resistance indicators	Treatment capacity of industrial wastewater treatment facilities(Y12)	Ten thousand tons / day	positive	0.048117
		General industrial solid waste disposal capacity(Y13)	Ten thousand tons	positive	0.038724
		Comprehensive utilization amount of general industrial solid waste(Y14)	Ten thousand tons	positive	0.116491
		The investment in the pollution treatment project was completed this year(Y15)	ten thousand yuan	positive	0.041935

3.3.2 Coupled coordination degree model

The degree of coordination development between systems cannot be quantified by the coupling degree, but it can quantitatively

represent the degree of coordination between systems. There may be differences in the system with the same coupling degree but the level of the coordination development. In order to avoid the emergence of pseudo-evaluation results and better evaluate the coupling and coordinated development level between Marine industrial agglomeration and resource and environment system, the coupling coordination degree function R(x) is further introduced with the help of the coupling coordination degree model, which is as follows:

$R = \sqrt{C \times P}$, AmongT=α f(x)+β g(y) (3)

Where R is the coupling coordination degree, C is the coupling degree, and T is the comprehensive evaluation index of the two systems, α and β are the weights of Marine industrial agglomeration system and resource and environment system respectively, and α + β = 1.Comprehensively reflect the development quality level of Marine industrial agglomeration system and ecological environment system system, α and β are the weights of the two systems, because the ecological environment and the Marine industry agglomeration are equally important, should not be biased, so chooseα=β=0.5.

According to the formula, the coupling coordination degree model may more accurately depict the evolution of the coordination quality level when compared to the coupling degree model and integrated into the two systems' overall assessment function, so its higher stability, wider application, not only can quantitative evaluation and compare the coupling development of the two systems between different regions, and can be used to judge the same area in different periods between the two system coordinated development trend change, have more operability.

It is not difficult to prove that the values of f(x), g(y), and R are all between (0,1). The larger the R value of the coupling coordination degree calculated by the following formula is, the higher the coordination development degree of the two systems at the high comprehensive evaluation level is.

3.3.3 Coupled development type evaluation criteria

Certain biological, resource, and environmental conditions are necessary for the growth of the marine industry. Simultaneously, the growth of the marine industry will put it under stress and strain and present a problem for the environment, ecology, and resources to expand sustainably. Therefore, while vigorously developing the Marine industry and promoting its industrial agglomeration, it must give consideration to the bearing threshold of the ecological environment, in order to bring the interactive coupling development of the two into a virtuous cycle, mutual benefit and coordinated development. In view of this, this paper, based on the comprehensive evaluation index of the two systems, divides the evaluation criteria of the evaluation criteria of the system coupling development. See Table 2 for details.

3.4 Data Sources

In terms of timing selection, this paper selects the data of the last ten years according to the principle of data timeliness to calculate the level of the Marine industry agglomeration in the continuous period from 2011 to 2020. The Guangdong Statistical Yearbook, China Marine Statistical Yearbook, and China Environmental Statistical Yearbook are the primary sources of the original data used to measure the degree of coupling and coordinated development between the Guangdong Marine industry agglomeration system and ecological environment system, as well as to build the coupled development evaluation index system of the two systems.

4. An Empirical Examination of the Connection between Guangdong Province's Marine Biological Environment and Marine Industry Agglomeration

4.1 Analysis of the Measurement Results of the Marine industry Agglomeration Level

The agglomeration level of primary, secondary, and tertiary marine industries in coastal regions was determined using the location entropy method, as indicated in Table 3, in order to gain a better understanding of the agglomeration status and change trend of marine industries in Guangdong Province and coastal provinces (autonomous regions and municipalities directly under the Central Government).

As can be seen from Table 3, the overall level of Marine industry in Guangdong from 2010 to 2020 is always above 1, indicating that the

spatial agglomeration advantage of Marine industry in Guangdong is relatively obvious, and the advantages of local specialized production and scale are basically realized. However, the overall agglomeration level change is relatively stable, agglomeration degree increase or decrease change trend is not obvious, maintained at around 1.2 on average, Guangdong Marine industry agglomeration development is slow, the reason may be in Guangdong Marine industry resource utilization, port automation construction imbalance, research and development capabilities in marine science and technology are lacking, the early stage of Marine science and technology innovation research and development ability investment, Marine economy development mainly depends on low technology content of the industry. In addition, compared with all the 11 coastal provinces and regions, Guangdong's Marine industry overall level ranked in the middle. According to the differences in the degree of Marine industrial agglomeration, location entropy was divided into four grades, namely, strong (LQ> 1.50), strong (1.00 <LQ <1.50), potential (0.50 <LQ <1.00) and non-agglomeration (LQ <0.50). According to the calculation, Tianjin, Hainan, Shanghai and Fujian are strong clusters; Shandong and Guangdong are strong clusters, and Guangdong ranks lower than Shandong.

Table 2. Evaluation Criteria for the Development of Marine Industrial Agglomeration and Ecological Environment Coupling System and Their Basic Types

Coupling coordination degree(D)	Horizontal classification	Comparison of f(x) versus g (y)	Coupling development types
0.9≤D≤1	High quality and coordinated development	g(y)/f(x)>1.2	Marine industry-leading type
		0.8≤g(y)/f(x)≤1.2	Synchronous development
		g(y)/f(x)<0.8	Ecological environment-leading type
0.8≤D<0.9	High quality and coordinated development	g(y)/f(x)>1.2	Marine industry-leading type
		0.8≤g(y)/f(x)≤1.2	Marine industry-leading type
		g(y)/f(x)<0.8	Ecological environment-leading type
0.7≤D<0.8	Intermediate coordinated development	g(y)/f(x)>1.2	Marine industry-leading type
		0.8≤g(y)/f(x)≤1.2	Synchronous development
		g(y)/f(x)<0.8	Ecological environment-leading type
0.6≤D<0.7	Primary and coordinated development	g(y)/f(x)>1.2	Marine industry-leading type
		0.8≤g(y)/f(x)≤1.2	Synchronous development
		g(y)/f(x)<0.8	Ecological environment-leading type
0.5≤D<0.6	Mild disorders develop	g(y)/f(x)>1.2	Ecological environment lag type
		0.8≤g(y)/f(x)≤1.2	Run-in type
		g(y)/f(x)<0.8	The Marine industry lags behind the type
0.4≤D<0.5	Moderate dysregulation develops	g(y)/f(x)>1.2	Ecological environment lag type
		0.8≤g(y)/f(x)≤1.2	Antagonist type
		g(y)/f(x)<0.8	The Marine industry lags behind the type
D<0.4	Serious disorder development	g(y)/f(x)>1.2	Ecological environment lag type
		0.8≤g(y)/f(x)≤1.2	Severe unbalanced antagonistic type
		g(y)/f(x)<0.8	The Marine industry lags behind the type

Table 3. Overall Agglomeration Level of Marine Industries in Coastal Areas from 2011 to 2020

province	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	average
Tianjin	1.98	1.93	2.01	1.97	1.80	1.38	1.51	1.59	2.31	1.93	1.98
Hebei	0.38	0.39	0.39	0.43	0.43	0.38	0.42	0.42	0.47	0.42	0.38
Liaoning	0.96	0.86	0.88	0.84	0.74	0.92	0.84	0.74	0.85	0.88	0.96
Shanghai	1.86	1.86	1.85	1.63	1.62	1.62	1.67	1.67	1.69	1.58	1.86
Jiangsu	0.55	0.55	0.53	0.53	0.53	0.52	0.49	0.49	0.48	0.54	0.55
Zhejiang	0.89	0.90	0.89	0.83	0.85	0.85	0.82	0.80	0.81	0.88	0.89
Fujian	1.55	1.44	1.46	1.53	1.64	1.69	1.75	1.77	1.67	1.61	1.55
Shandong	1.12	1.13	1.12	1.17	1.19	1.19	1.18	1.21	1.17	1.19	1.12
Guangdong	1.10	1.16	1.15	1.20	1.20	1.20	1.19	1.18	1.07	1.08	1.10
Guangxi	0.33	0.37	0.40	0.40	0.41	0.42	0.45	0.44	0.47	0.49	0.33

Hainan	1.65	1.66	1.78	1.58	1.64	1.73	1.73	1.78	1.84	1.95	1.65

4.2 Analysis of Empirical Results of Marine Industrial Agglomeration and Ecological Environment System

Using Guangdong province as an example, this study examines and applies the coupled development evaluation model to determine the coupling degree and coupling coordination degree function as well as the complete evaluation index of the two systems in Guangdong province. Table 4 displays the findings

Table 4. Comprehensive Evaluation and Coordination Degree of Marine Industry Agglomeration and Marine Ecological Environment in Guangdong Province

year	Comprehensive evaluation index of Marine industry agglomeration f(x)	Comprehensive evaluation index of ecological environment g(y)	Coupling coordination degree(D)	f(x)/g(y)	Coupled development stage-coupled development class
2011	0.2583	0.2556	0.5069	1.0105	Mild dysregulated development-run-in type
2012	0.2801	0.2922	0.5349	0.9585	Mild dysregulated development-run-in type
2013	0.3062	0.3996	0.5915	0.7663	Mild disorder development-Marine industry lag type
2014	0.4406	0.3437	0.6238	1.2817	Primary and coordinated development- -Marine industry-leading type
2015	0.5429	0.4720	0.7115	1.1500	Primary and coordinated development- -Marine industry-leading type
2016	0.6035	0.5363	0.7543	1.1254	Primary and coordinated development- -Marine industry-leading type
2017	0.7130	0.6482	0.8245	1.0999	Good and coordinated development- -synchronous development type
2018	0.7914	0.7134	0.8668	1.1094	Good and coordinated development- -synchronous development type
2019	0.7161	0.7530	0.8569	0.9510	Good and coordinated development- -synchronous development type
2020	0.6116	0.6681	0.7995	0.9155	Intermediate-level coordinated development- -synchronous development type

As can be seen from Table 4, the coupling and coordinated development level of Marine industrial agglomeration and Marine ecological environment in Guangdong Province generally shows a trend of increasing year by year, but the coupling and coordinated development level of Marine industrial agglomeration and Marine ecological environment in Guangdong Province generally shows a trend of increasing year by year, but the coupling and coordination degree is reduced to intermediate coordination after reaching good coordination. To advance to a higher coupling type, the agglomeration structure must be adjusted and optimized. Then, the limitations of the coordinated growth of the marine ecological environment and marine industrial agglomeration must be further examined.

4.3 Stability Test and Correlation Analysis of the System Comprehensive Evaluation Index

(1) Stability test of systematic comprehensive evaluation index- - -ADF test

The specific form of the ADF (Angmented Dickey-Fuller) test model is:

Model 1:$\Delta X_t=\delta X_{t-1}+\sum_{i=1}^{p}\beta_i\Delta X_{t-1}+\varepsilon_t$

Model 2:$\Delta X_t=\alpha+\delta X_{t-1}+\sum_{i=1}^{p}\beta_i\Delta X_{t-1}+\varepsilon_t$

Model 3:$\Delta X_t=\alpha+\beta_i+\delta X_{t-1}+\sum_{i=1}^{p}\beta_i\Delta X_{t-1}+\varepsilon_t$

Where p is the lag order, E (ε_t)=0, D (ε_t)=σ^2. The null hypothesis H0:σ = 0, that is, there is a unit root in the time series, which is a non-stationary sequence.

Table 5. Results of the ADF Test

Variable	Differential order	t	P value	criticality value			Conclusion
				1%	5%	10%	
f(x)	0	-3.97	0.002	-5.354	-3.646	-2.901	Stable
g(y)	0	-5.122	0	-5.354	-3.646	-2.901	Stable

As can be seen from Table 5, if the significance level of h(y) and z(x) in the two

systems is α =1%, and the ADF test value is less than the Mackinnon critical value, the null hypothesis is rejected, indicating that the two sequences h(y) and z(x) are stationary.

(2) Correlation analysis of the systematic comprehensive evaluation index

$$r=\frac{cov(X,Y)}{D(X)*D(Y)}$$

Pearson correlation coefficient $r=\frac{\mathrm{cov(X,Y)}}{\mathrm{D(X)*D(Y)}}$ is the covariance divided by the standard deviation of two random variables, the magnitude of the correlation coefficient is between-1 and 1, when r> 0 indicates a positive correlation, negative correlation for r <0, and r=0 indicates no correlation.

Table 6. Pearson Related Results

Pearson Related to this issue	
	y
x	0.952**
* p<0.05 ** p<0.01	

As can be seen from Table 6, the Pearson correlation coefficient is 0.952, indicating that there is a strong positive relationship between Marine industrial agglomeration and Marine ecological environment. The p-value is less than 0.01, further confirming that this correlation is statistically significant and does not result from a random error. The correlation analysis results show that there is a significant positive relationship between Marine industrial agglomeration and Marine ecological environment, and this relationship is statistically reliable. This means that, as one variable increases, the other variable also tends to increase, and the change trend is consistent between the two.

4.4 Analyze the Conclusion

By summarizing the current situation, empirical test of coupling effect and empirical evaluation of coupling degree described in the previous chapters, the following conclusions can be drawn:

First, the quality of the marine industry agglomeration must be adjusted and optimized in order to improve the coordinated development of the marine ecological environment system and the marine industry agglomeration system. Firstly, the agglomeration effect has been observed in the overall analysis of the agglomeration of the marine industry in Guangdong Province from 2011 to 2020. However, among the three industries, the trend of marine industry agglomeration exhibits the "32 one" pattern, meaning that the agglomeration of secondary and tertiary industries is evident, while the agglomeration of primary industry is not. Secondly, the agglomeration quality, agglomeration structure, and agglomeration scale have the greatest effects on the marine ecological environment when the coupling effect between Guangdong Province's marine industrial agglomeration and marine biological environment is empirically tested. Finally, the Guangdong Marine industry agglomeration and the coupling degree of empirical evaluation, the two systems of coupling coordination type after achieving good coordination and down to intermediate coordination, in the coupling mechanism in the medium level, and to a higher coupling type across, adjust and optimize the agglomeration quality is crucial. Therefore, the key to improving the competitiveness of the marine industry agglomeration, the state of the environment and resources, and the degree of coordinated growth is to optimize and adapt the quality of the marine industry agglomeration.

Second, the coordinated growth of the Marine ecological environment system and the Marine industrial agglomeration system is predicated on the creation of a contemporary Marine industrial system and the optimization of the Marine ecological environment. In Guangdong province, the coupled development type of the marine industrial agglomeration system and the marine ecological environment system from 2015 to 2020 is both synchronous development types, based on the empirical test results of the coupling effect of these two systems. Therefore, in order to coordinate the Marine industrial agglomeration system with the Marine ecological environment system, optimize the Marine ecological environment and build a modern Marine industry system, both are indispensable.

Third, enhancing the coordinated growth of the marine ecological environment system and the marine industrial agglomeration system is predicated on the preservation of marine ecological resources. The ecological environment system in Guangdong province and the marine industrial agglomeration system have a coupling effect, according to the coupling analysis. Although its coupling and

coordination state has been significantly improved, it has tended to be in a coordinated development state. However, at the same time, there are some problems in Guangdong province, such as unbalanced speed and quality, unbalanced regional development, inadequate innovation-driven development, inadequate opening-up and cooperation, and inadequate comprehensive management capacity building. Promoting the marine economy's high-quality development is still a difficult undertaking.

5. Countermeasures for the Development of Marine Industry Agglomeration in Guangdong Province under the Threshold of Ecological Civilization

5.1 Optimize the Quality of Marine Industries and Enhance the Competitiveness of Agglomeration Industries

5.1.1 Formulate long-term development plans and optimize the industrial layout

A medium- and long-term plan for the high-quality development of the marine industry in Guangdong Province is developed in conjunction with the features and benefits of the marine economy of the province. This plan aims to make clear the objectives, routes, and essential tasks of the marine industry's development while also guaranteeing the stability and continuity of the policies. Promote the formation of a Marine industrial agglomeration area with Guangzhou and Shenzhen as the core, and Zhuhai, Dongguan, Zhongshan, Zhanjiang and other places as important nodes. Through scientific planning, the Marine industry should be guided to rationally layout in space and promote the coordinated development of the upstream and downstream of the industrial chain.

5.1.2 Promote the transformation and upgrading of traditional industries and build a high-level scientific research platform

We will guide the Marine fishery, Marine transportation and other traditional industries to achieve transformation and upgrading through technological transformation and model innovation, so as to increase the added value of the industries and their market competitiveness. We will focus on the development of emerging industries such as Marine biomedicine, Marine electronic information, and Marine engineering equipment, and promote the agglomeration effect of these industries through policy support and financial guidance, so as to build Marine industrial clusters with international influence.

5.1.3 Strengthen infrastructure development and improve supporting services

We will increase investment in Marine infrastructure construction, including ports, waterways, and coastal tourism facilities, so as to improve the carrying capacity and service level of the Marine industry. We will improve the Marine industry service system, including financial services, legal services, information services, etc., to provide all-round and one-stop supporting services for Marine enterprises, reduce their operational costs and improve operational efficiency.

5.1.4 Strengthen Marine ecological protection and promote the development of a circular economy

The principles of green development will be upheld, the marine biological environment will be better protected, and the growth of marine industry and the environment will be integrated. We will implement marine ecological restoration initiatives and bolster the protection of coral reefs, mangroves, and other marine habitats. To increase resource efficiency and lower pollution emissions, marine businesses are urged to implement cleaner production technologies and circular economy models. We will support the sustainable growth of the marine sector as well as the recycling and innocuous handling of marine garbage.

5.1.5 Expand the international market and deepen international cooperation and exchanges

Guangdong Marine enterprises are encouraged to actively participate in international competition and cooperation and expand overseas markets. International Marine industry expo, forums and other activities will be held to attract international well-known enterprises and institutions to participate in exchanges and cooperation. Strengthen cooperation and exchanges with international Marine organizations and scientific research institutions, and introduce foreign advanced technology and management experience.

5.2 Optimize the Marine Ecological Environment and Build a Modern Marine

Industrial System

5.2.1 Integrate innovative resources to cultivate Marine industries with regional characteristics

Agglomeration development reflects the scale effect. To realize the industrial agglomeration level faster, it is necessary to base on Marine characteristic resources, integrate innovative resources, accelerate merger and reorganization, and cultivate Marine industry with Guangdong characteristics. Increase the investment of Marine industry agglomeration and innovation, and continuously realize the allocation of Marine resources through scientific and technological innovation. Focusing on the regional advantages of the Greater Bay Area, we will innovate the development model of the Marine industry. Learn from the Marine development strategies of other regions, constantly check the omissions and fill the gaps, and accelerate the pace of realizing the ecological effect and economic effect in Guangdong Province.

5.2.2 Explore new models of Marine industry agglomeration and optimize resource allocation

Further study the area of the layout and thinking of Marine strategic emerging industries in the surrounding areas, out of Guangdong characteristics, can establish a mutual complement, mutual cooperation, create common benefits with other regions. To assure diversified growth, encourage the transformation and upgrading of industrial agglomerations, foster the deep integration of primary, secondary, and tertiary marine industries, and construct a marine ecological industrial chain. Implement the decentralized development mode to collectivization and large-scale development, and accelerate the transition from the traditional marine industry to the new marine ecological economic industry. We will guide enterprises related to the Marine industry to strengthen cooperation, strengthen linkage between upstream and downstream enterprises, promote the formation of a professional and large-scale Marine industry system, concentrate on the development of characteristic Marine industries, and extend the Marine industrial chain to cultivate a Marine industry system with more Guangdong characteristics.

5.2.3 Strengthen scientific and technological innovation and promote the development of industrial clusters

The Guangdong Marine Economy Development Report 2023 issued by the Guangdong Provincial Government points out to accelerate the construction of a collaborative innovation system of natural resources technology with "laboratory + science popularization base + collaborative innovation center + enterprise alliance". To realize the Marine upgrading transformation of Guangdong province need to intensify Marine industry innovation, make good use of existing resources, the Chinese academy of sciences, Guangdong ocean university and other scientific research units can provide innovation support for Marine industry development, to integrate good industry resources, intensify efforts to enhance industrial competitiveness, joint relevant scientific and technological innovation, breakthrough industry development bottleneck, strive for the construction of more national or provincial laboratory or set up science and technology research projects to boost industrial progress. At the same time, we should improve the scientific and technological innovation system, support Marine research projects, and reasonable strategies should be formulated based on the realistic Marine development prospects. Incubation scientific research achievements to ensure the implementation of Marine projects. Accelerate the cluster development of Marine industry, expand the upstream and downstream of Marine industry, use science and technology to expand the strength of Marine economy, rely on the Marine industrial chain, so as to promote the agglomeration development of Marine industry.

5.2.4 Actively introduce and cultivate talents to improve the quality of industrial agglomeration

The contribution of talents to the industry's development cannot be separated, and the marine industry's growth and advancement may be more effectively supported by the talent-driven sea revitalization plan. To encourage more talent to contribute to the growth of the marine industry, we should fully utilize the enthusiasm of the talent in this sector and set up an efficient reward system. At the same time, we should also optimize the progress of industrial technology, introduce foreign advanced technology, absorb more high-tech talents with cutting-edge technology,

and attach importance to the development of the industry to a higher level. The competition in the Marine field is more about the competition for talents. The government should increase the intensity of talent training, actively incubate talent training programs, and establish a talent training pool. To strengthen the cooperation with universities or key enterprises in the province, we can make use of the teaching resources of Guangdong Ocean University, constantly reform and innovate teaching methods, actively cultivate professionals, deepen the cooperation between industry, university and research, and combine with scientific and technological innovation to be a fuel for the development of Marine industry.

5.3 Deepen the Ecological Concept and Steadily Consolidate the base for Marine Ecological Protection

5.3.1 Work hard to control pollution in sea areas, and formulate and improve laws and regulations on Marine ecological protection

In the process of development, the Marine industry in Guangdong province will cause damage to the natural environment to varying degrees, such as the discharge of sewage by mariculture enterprises and the transportation of port ships, which will damage the Marine ecology. The government must play a part in improving the marine natural environment. First, promote the scientific idea of using the sea, assist those who utilize marine resources in putting the marine protection mechanism into place, spread the belief that development cannot come at the expense of environmental harm, and actively direct the use and development of marine resources. Second, to establish and improve the Marine protection mechanism, including environmental accountability, Marine environmental compensation mechanism, Marine industry access and exit mechanism protection system, regular Marine ecological index assessment, found that the environmental ecological behavior in time to stop, reasonable planning of Marine resources, intensify support for green Marine industry project, guide the Marine industry to green channel development, maintain the sustainable development of Marine economic environment. Third, cooperate with relevant departments in management, and at the same time, cooperate with relevant enterprises or individuals to strengthen the supervision of the Marine ecological environment, and stop the damage to the Marine environment by multiple means and methods.

5.3.2 Strengthen ecological concepts and raise the awareness of the whole society of Marine protection

Through the media, the Internet, schools, communities and other channels, to popularize the knowledge of Marine ecological protection, and improve the public's awareness and participation in Marine ecological protection. Marine ecological protection themed activities will be held to enhance the sense of responsibility and mission of all sectors of society. To guide governments and businesses at all levels in establishing the concept of green development, encourage the creation of a new pattern of marine development that features harmonious coexistence between man and nature, and integrate marine ecological protection as a significant assessment index into Guangdong Province's overall economic and social development.

5.3.3 Carry out Marine ecological restoration projects and strengthen the development of Marine protected areas

In view of the ecological problems existing in the sea areas of Guangdong province, such as mangrove degradation and coral reef destruction, a number of key ecological restoration projects have been carried out to restore the health and stability of the Marine ecosystem. Conservation areas shall be designated in important Marine ecological areas and sensitive sea areas, and strict protection measures shall be implemented to protect Marine biodiversity and ecosystem integrity.

5.3.4 Increase scientific and technological research and development for the conservation of marine environments, and set up a system for monitoring these environments

We will support universities, scientific research institutions and enterprises in carrying out scientific and technological innovation in Marine ecological protection, research, develop and promote advanced Marine ecological protection technologies and equipment, and improve the scientific and technological level of Marine ecological protection in Guangdong Province. The modern information technology should be used

to establish a Marine ecological protection monitoring network to realize real-time and dynamic monitoring and early warning of the Marine ecological environment and provide a scientific basis for Marine ecological protection.

5.3.5 Strengthen international cooperation and exchanges to jointly address Marine ecological challenges

We will strengthen cooperation and exchanges with neighboring countries and regions and international Marine organizations, jointly address Marine ecological challenges, and share experience and achievements in Marine ecological protection. Through international cooperation and exchanges, the introduction of international advanced Marine ecological protection technology and management experience, to enhance the international level of Marine ecological protection in Guangdong Province.

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