An Innovative Mechanisms for Sustainable Development of Hangzhou Bay Regional Economic Based on the Marine Ecological Carrying Capacity

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***Abstract* — China's economy has created the world's attention 30 years of sustained high growth miracle, but also facing more and more prominent conflicts and between economic, resources and environmental. China is also facing enormous pressure of climate change, as well as major challenges to implement sustainable development. This paper takes marine ecological carrying capacity as the focal point to the Hangzhou Bay area as the research object and it establishes the evaluation model of marine ecological carrying capacity, from the four aspects which are sustainable resource supply capacity, assimilative capacity of the ecological environment, the role of human support and ecological resilience. Then this paper quantitatively measures 2004-2014 marine ecological carrying capacity levels and trends of Hangzhou Bay area. Quantitative data estimates show that the level of marine ecological carrying capacity of Hangzhou Bay area showing a downward trend wave, which ecological resilience index increased slowly. In recent years, marine ecological carrying capacity of Hangzhou Bay area is still in full load condition. And therefore, it needs to strengthen the efforts in five areas which are human resources development innovation, marine science and technology innovation, marine ecological environment innovation, circular economy innovation, and the institutional innovation.**

Keywords - marine ecological carrying capacity; sustainable development; innovative mechanisms; Hangzhou Bay regional economic

I. INTRODUCTION

Whether regional economic development is sustainable, and is able to coordinate with the environment, the criteria for assessing has not only emphasize the amount of economic growth, but more on the quality, which namely, the development objective is to pursue the continuous improvement of the social and equal justice, ecological sustainability and the welfare of the people. Using a scientific method to evaluate the sustainable status of regional economic has important strategic significance for the promotion of sustainable development. The carrying capacity of resources and environment as the basis for sustainable development has been widely recognized by everyone. The concept of ecological carrying capacity, resource capacity, environmental carrying capacity, etc. have been proposed in order to increase carrying capacity study from law studies in non-human biological populations gradually shift the practical problems faced by human economic and social development. With the emphasis on ocean issues, some scholars began to focus on the issue of marine ecological carrying capacity. As an important basis for measuring the level of sustainable development of marine economy, marine ecological carrying capacity has become an important identity to judge coastal population, resources, environment and social coordinated development or not. And the core is based on the actual carrying capacity of marine resources and the environment, to determine the socio-economic development of coastal speed, structure and size, in order to better address the coastal economic development, balance and coordination of resources and environmental carrying capacity between the development of the marine ecosystem issue, thus contributing to a virtuous cycle of marine ecosystems to achieve sustainable development of coastal economy.

This article selected Hangzhou Bay area as research subjects, including six cities which are Hangzhou, Ningbo, Shaoxing, Jiaxing, Huzhou, and Zhoushan. And the resident population of 2973.48 million in 2012, a land area of 45,400 km2, sea area of 5000km2, accounted for 54.6%, 44% and 2% of the province, respectively. And this area created 67.5% of the province's gross domestic product, with per capita GDP 79,519 yuan, which was 1.23 times the provincial average. This is the fastest growing region in Zhejiang modernization, which 7 of the 14 important industry cluster development and construction projects during the "Twelve Five period" were in this region. With the develop of petrochemical,

shipbuilding, ports and other heavy polluting industries in the region and the formation of industrial agglomeration area, the Hangzhou Bay receives contaminants bound to continue to increase and there will be more serious environmental pollution, further exacerbating the contradiction of regional economic development and Hangzhou Bay marine resources and ecological environment. The bearing capacity of the marine ecosystem as a quantitative measure method of the degree of human use of natural and it has attracted the attention of many scholars, and has been widely used for quantitative measurement of sustainable development of the marine economy, Since the proposed. Therefore, the study of sustainable economic development situation in the region under the marine ecosystem carrying capacity constraints, and propose the corresponding countermeasures and suggestions to improve the ecological environment has a strong practical significance for the sustainable development of the region and the Hangzhou Bay in Zhejiang Province.

II. MARINE ECOLOGICAL CARRYING CAPACITY

A. Concepts

Di Qian-Bin give the definition of marine carrying capacity is a specific concept of regional capacity, which means during a period of time, the capacity or limits of the ocean can support marine, environmental and socio-economic development by ocean self-regulation, self-sustaining population, and the sustainable use of marine resources, with the marine environment not destroyed as a principle, in line with the social and cultural norms stage material standard of living conditions[2]. Liu Kang believes that the marine carrying capacity should contain two meanings: ① bearing capacity of marine resources, through the development of the marine industry to reflect the scale; ② carrying capacity of the marine environment, by the total social and economic development of the oceans surrounding communities to characterize[3]. Overall the bearing capacity of marine resources is the basis, the carrying capacity of marine environment is the key, and the ecological carrying capacity is a comprehensive. Therefore, marine ecological carrying capacity should include two meanings, which one if supporting force of marine resources and environment system and the other is pressure of population socioeconomic system in oceans surrounding area. This paper illustrates the bearing capacity from four aspects of marine ecosystems: sustainable resource supply capacity, assimilative capacity of the ecological environment, human supporting and ecological resilience.

B. Construction and empowerment of the index system of marine ecological carrying capacity

This paper draws on previous research on the bearing capacity of marine ecological system, and follows the above principles, combined with the status quo Hangzhou Bay marine environment, a comprehensive theoretical basis, consulting experts and experience selection. Then this paper takes consideration Key indicators which have greater influence, through a large number of existing statistics and data analysis, filtering and sorting, and extract information closely related to the marine ecosystems. It use socio-economic statistical analysis software SPSS linear regression method to exclude multicollinearity among indexes and eventually establish the evaluation system which included a resource supply, consumption of resources, environmental quality, climate, hydrology and biological and ecological quality, technological level and quality of life, the system exchanges. This evaluation system consist of eight criteria levels and 20 index layers which is targeted, clear hierarchy, the more comprehensive reflect the status of the marine ecosystem. Meanwhile, the scientificity of the weights assigned to index system is directly related to the accuracy of the results for a comprehensive measure and the rationality of the scientific evaluation. In this study, the Analytic Hierarchy Process (AHP) is used to determine the weights of indicators in the index level. And then the entropy of information theory techniques [9] is used to determine the corrected results. Finally, the expert group of democratic decision-making [10] method is used to specifically identified weights of indicators in the level of comprehensive measurement system. The results obtained are shown in Table I.

TABLE I. THE İNDEX SYSTEM OF MARİNE ECOLOGİCAL CARRYİNG CAPACİTY

Target layer		subsystem layer	single index layer	weights
marine ecological carrying	sustainable resource supply capacity(A1)	resource supply (B1)	Per capita water use area(sqm/person) X1	0.0244
			Per capita fish mass (kg / person) X2	0.1598
			Coast Economic density (kilometers people) X3	0.0541
	assimilative capacity of the ecological environment(A2)	Resource consumption (B2)	GDP energy consumption (ton standard coal / million) X4	0.0316
			GDP water consumption (m/million) X5	0.0316
		Environmental Quality (B3)	The total amount of wastewater discharge (ten thousand tons) X6	0.0589
			Coastal waters Water Environment Comprehensive Index X7	0.1146
	ecological resilience(A3)	Climatic conditions (B4)	The annual average temperature (degrees Celsius) X8	0.0368
			Average annual precipitation (mm) X9	0.0368
		Ecological quality (B5)	Wetland area (hectares) X10	0.0316
			Mariculture area (hectares) X11	0.0206
			Forest coverage rate (%) X12	0.0529
			Biodiversity (a) X13	0.1196
			The proportion of marine nature reserve area(%) X14	0.0470
	human supporting(A4)	Technological level and quality of life(B6)	Quantity marine science and technology projects (item) X15	0.0922
			Engel coefficient X16	0.0362
		Systems exchang(B7)	Ocean freight turnover (million ton-km) X17	0.0327
			Ocean passenger turnover (person million km) X18	0.0186

C. Determination of the sustainable situation of marine ecological carrying

Determination the standard of health of marine ecosystems is critical of its evaluation process. However relying solely on the marine ecosystem carrying capacity index is difficult to fully assess their health status, and therefore it's more complex to judge health status of each level. In this study, three reference criteria are used to determinate the carrying status of complex systems depending on the selected indicator system for quantitative. First the ideal is dimensionless index after treatment is: 1,1,1,. . . 1 (a total of n), which the regional ecological carrying capacity of the ideal size is for:

$$MECC_0 = |M_0| = \sqrt{\sum_{i=1}^{n} w_{i0} x_{ir0}^2} = 1 \quad (1)$$

But in fact there are some differences between marine carrying capacity of ideal state and the reality of the situation. And this bias is reflected the state of the marine carrying situations in the reality, and the formula is:

$$MECC = |M| = \sqrt{\sum_{i=1}^{n} w_i x_{ir}^2} \quad (2)$$

In the above equation, Xir is the spatial coordinates (value after pretreatment) for human activities and environmental resources in real state, lMl is vector module of marine carrying capacity for real state. From the foregoing analysis it can be concluded that: the vector module of the marine carrier when overloading status must be greater than the vector module when the ideal state. On the contrary, when the marine carrier status can load, the vector module is less than the one in ideal state.

When MECC≥1, overloading;

When MECC = 1, full loading;

When MECC <1, can carry.

Taking into account the volatility and complexity of the "natural - Economy - Society" systems, WANG Kai-yun set the tolerance of carrier standard to 0.3. This study referring to the standards, which namely:

When MECC≥1.2, overloading;

When 0．9≤MECC<1．2, full loading;

When MECC<0．9, can carry.

III. ANALYSIS OF THE STATUS OF MARINE ECOLOGICAL CARRYING CAPACITY OF HANGZHOU BAY

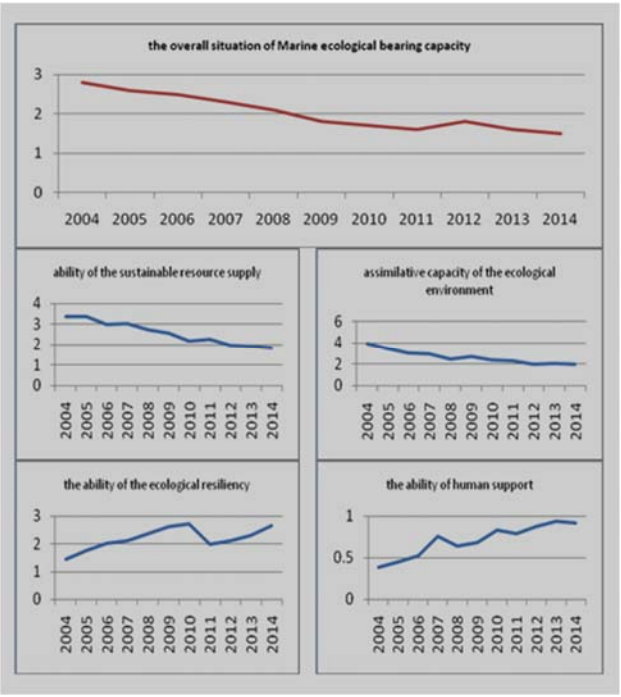

Fig.1 the changing status of marine ecological carrying capacity of Hangzhou Bay

Calculated based on the statistical Yearbook Zhejiang Natural Resources and Environment 2004 to 2014, it obtained the original value of composite indices. Among them, the eigenvalues of coastal waters environment reference findings by Zhang Jie, who calculated. In order to eliminate the influence of dimensionless between different indicators, this study used standard deviation method to standardize each index value in index layer. Then the index values were put into the formula, and calculated Hangzhou Bay 2004-2014 status of the marine ecological carrying capacity in the target layer of the system, and its four sub-target layers which are marine ecosystems: sustainable resource supply capacity, assimilative capacity of the ecological environment, human supporting and ecological resilience. The situation and branch target level curve of marine ecological carrying capacity of Hangzhou Bay shown in Figure 1.

Overall, during the 2004 to 2014, the value of the ecological carrying capacity of each year is greater than 1.2, which are in overload condition. Wavy curve has overall decreasing trend, and gradually to full loading, which suggesting that the carrying situation gradually improved.

1) Analysis of ability of the sustainable resource supply. Trends from the perspective of each year, pressure of the system withstanding during 2004 to 2014 showed a decreasing trend as a whole. Pressure decreased from 3.38 in 2004 to 1.85 in 2014, which have similar situation with trends of ecological carrying. Further analysis showed that the various indicators, per capita fish quality, coastal economic density gradually declined. And the per capita use of sea area has remained at around 1.2. The reason is the 10 years of changes caused by population growth pressure are very little, which is due to natural population growth rate has been effectively controlled. On the other hand from 1998 it proposed the development of marine economy, the marine economy in Zhejiang Province adopted a strategy of rapid development in a longer period of time. However, this extensive development mode will cause excessive consumption of resources, environmental pollution, which exert enormous pressure on the resources and environment system. And starting from 2009, in order to promote coordinated development between economic development and environmental protection, the Zhejiang province change the development path, and adjust the industrial structure. After taking a series of measures to protect marine resources, the marine fishery resources have been significantly improved. In 2011 Zhejiang Province further put forward strategic positioning of "economic development of Zhejiang Ocean demonstration area planning", and the index also dropped significantly, further improvement in conditions in the marine carrying capacity.

2) Analysis of assimilative capacity of the ecological environment. A trend from the perspective of each year, ecological carrying capacity is reduced year after year. In 10 years, the per ten thousand Yuan of GDP energy consumption and the per ten thousand Yuan of GDP water consumption has dropped dramatically, far higher than the "Tenth Five-Year " and "Eleventh Five-Year" plan requirements. Meanwhile, investment in infrastructure and environmental investments the Hangzhou Bay regions in recent years, increased every year, making the overall improvement in environmental quality. Therefore, control the total amount of pollutants into the sea is the key to improve the environmental carrying capacity and the supportive ability. And it is also the key to reduce the system pressure.

3) Analysis of the ability of the ecological resiliency. Trends from the perspective of each year, the basic ecological resiliency changed little, but still slow upward trend. This proves climate and ecological quality of Hangzhou Bay area nearly 10 years changed little, but showing the deterioration of the situation.

4) Analysis of the ability of human support. From 2004 to 2014, human support capabilities have been significantly improved, from 0.33 in 2004 to 0.98 in 2014. And per capita GDP tripled, and Engel coefficient dropped by 3.3 percentage points in decade. At the same time, a substantial increase in the number of marine science and technology projects.

IV. THE RESEARCH ON INNOVATIVE MECHANISMS FOR SUSTAINABLE DEVELOPMENT OF HANGZHOU BAY REGIONAL ECONOMY

In short, the key to develop the marine economy, promote regional economic development of Hangzhou Bay and increase the carrying capacity is to establish innovative mechanisms for sustainable development. This paper describes the innovation issues of Hangzhou Bay Regional Sustainable Development in five aspects, which are human resources development innovation, marine science and technology innovation, marine ecological environment innovation, circular economy innovation, and the institutional innovation. The innovation strategies presented in these five areas not only laid a theoretical basis to achieve sustainable development for the Hangzhou Bay area, but also have strong operational.

A. human resources development innovation

In the era of knowledge economy now, science and technology are primary productive forces. How much a country's stock of human capital determines its ability of comprehensive competitiveness and sustainable development. Therefore, we believe that the increase in the stock of human capital is a prerequisite for economic development. And the growth in human capital stock is inseparable from personnel training of universities and research institutions. So we should actively support the development of sea-related research institutions, and guide university institutes extend the research to the ocean. While we need to support the establishment of marine technology enterprise development platform, and the establishment of marine science and technology extension service system, in order to encourage scientific research institutes, universities, extension agencies, and companies get involved in marine science and technology innovation to promote the application of marine science and technology, and to support training institutions, research agencies to promote building capacity. Then, it will improve the support and depth of marine science and technology for the marine capacity.

B. marine science and technology innovation

Sustainable development of marine industry including four interrelated aspects: First, conserve resources, improve the environment; second is the implementation of both the technical and institutional innovation; the third is to meet the contemporary demand for marine products; and fourth is to

ensure the survival of future generations and development. Among them, the first two are ways and means, and the latter two are the purposes. Thus, technological innovation of marine industry is the most effective way to achieve growth in the marine industry. Marine industry through technical innovation to increase production, improve quality, improve resource utilization, increase economic efficiency and protect the ecological environment to implement the sustainable development of marine industry.

We should use technology innovation to transform traditional marine industry, to optimize allocation of production factors, and to promote the restructuring of the marine industry. Hence it need for further optimization port layout of transport, fisheries, tourism and etc, and to improve all kinds of port transportation system, and to take strict examination and approval system for the use of coastal resources, to ensure orderly use of shoreline resources. At the same time, we need to develop tourism services, taking the heritage and the development of marine culture as a basis, marine cultural tourism industry as a breakthrough, to increase cultural interaction with various marine-related industries integration, and to accelerate the prosperity of marine culture.

C. marine ecological environment innovation

Development and utilization of marine resources, the growth of the marine industry, and the rapid development of marine economy are inseparable from the marine environment. Good marine environment can improve the service functions of the supply of marine resources and marine ecosystems function, thus contributing to the sustainable development of marine resources utilization and sustainable development of marine economy. First, we need to improve the marine environment monitoring mechanism. That means we should strengthen collaboration among ocean, environmental protection, transportation, marine, water conservancy, forestry, meteorology, fisheries and other sea-related sectors, to orderly promote sea-related monitoring, observation data sharing among departments. Second, we need to improve the current situation and trends assessment of marine environmental, further optimize monitoring stations and the monitoring indicators, and increase monitoring frequency. We should carry out key marine environment capacity assessment, to identify the main sources of sea contamination pathways, intensity and distribution, and also to assess the specific characteristics of the sea and the main source of pollution. Third, we need to establish the joint land and sea, regional cooperation mechanism, working mechanism of marine environmental protection and pollution control system of the total amount and the concentration of pollutants into the sea. We should promote the development and implementation of marine ecological damage compensation approach, and establish marine ecological damage assessment and marine ecological damage tracking and monitoring mechanisms. Besides, we need to carry out the study of marine environmental emissions trading system, promoting land of sewage on the marine eco-compensation mechanisms

D. circular economy innovation

Sustainable development strategy has become the trend of today's world, and the development of circular economy is the only way to achieve sustainable development. Circular economy is a both economic development and environmental protection mode, which reflects the connotation and requirements of the new road to industrialization. And it is also the strategic needs and inevitable way to achieve the goal of building a moderately prosperous society. Due to historical and institutional reasons, Hangzhou Bay marine economy is basically resource-based economy which is predominantly agrarian economy. Economic development depends on excessive consumption of resources and development. Long-term development of resource-based economy results in that the superior resources are not well integrated with scientific and technological advantages. Therefore it does not fully translate into economic advantages. Therefore, we must update the concept, the implement sustainable development strategy and take the road of development of circular economy and a recycling society.

E. The institutional innovation

With the continuous development of marine economy, especially with the increasing degree of specialization on ocean, marine production has the new higher requirements of marine services. Gradually establish a more perfect system of marine service production is the foundation of marine agriculture modernization, which can meet the requirements of a wide range of supply and marketing, technology, capital, information, processing, storage, transportation. Therefore, we must change on operation management of marine agricultural production, strengthen macro-control and service functions, strengthen professional technical services, enhance service functions, and improve service effectiveness. We must also take effective measures to support social service system for marine agricultural. At the same time, we should strive to create a beneficial external environment for marine agricultural social service system.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

ACKNOWLEDGMENT

This work is supported by the Zhejiang Soft Science No.2010C25068.

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