

Restoration and management of marine ecosystem in China: A sustainable perspective of indicator evaluation

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Despite recognizing the significance of marine ecosystem and the important role in the development of China's marine economy, the efforts to manage and conserve appear poor. Based on the existing research results of marine ecosystem in China, this research establishes the indexes system on evaluating marine ecological health and uses the analytic hierarchy process to weight each of the existing indicators. The results show that the restoration ability of marine ecosystem is the most important influencing, followed by the organizational structure of marine ecosystem.

[Keywords: Marine ecosystem; Marine economy; AHP; Restoration; Management]

Introduction

With a certain complexity of structure and function, marine ecosystem is composed of marine life system and marine environmental system within a certain time and space¹. As the ocean accounts for 70% of the earth's surface area, marine ecosystem is the world's most productive ecosystem and it holds the pivotal status. On the one hand, the marine ecosystem as an important support to the social development, provides human supply and cultural functions, including abundant marine resources, raw materials, other material interests and entertainment, knowledge acquisition and other non-material interests. On the other hand, known as a natural purifier of the global environment, the marine ecosystem can adjust the ecological balance and optimize the ecological environment.

With the deepening understanding of the ocean, more and more countries begin to pay attention to the ocean, constantly increase the exploitation of marine resources. Especially since the 1990s, humans have entered the new era of marine industry development, with the rising of marine emerging industries, such as aquaculture, marine oil and gas, coastal tourism, marine bio-pharmaceutical and marine new energy². Due to the lack of proper understanding of the carrying capacity of marine ecosystem, however, the over-exploitation of marine resources leads to the increasingly poor operation of marine ecosystem. In

recent years, the global marine disasters are frequent and the variegation of organism is reducing sharply, while marine purification and balance capacity is declining. All of these warn us that marine ecosystem is facing serious threats, while China's situation is less optimistic. With the contradiction between economic development and marine environmental protection increasingly sharp, more and more Chinese scholars devoted to studying the marine ecosystem.

Throughout the existing papers, the research on marine ecosystem in China mainly focuses on diversity, service function and value evaluation, existing problems and sustainable development ability, marine ecosystem restoration status and health evaluation. You-Shao Wang explained the diversity of marine ecosystem divided by different standard, introduced the research progress of marine ecosystem diversity and put forward the key areas of research on the diversity of marine ecosystem in China³.

There are many achievements in the research on the service function and value evaluation of marine ecosystem. Especially since 2005, when China National Oceanic Administration launched the research program named "Marine ecosystem services function and its value assessment", Chinese scholars have begun to reference and introduce more sophisticated estimation methods from the other countries (The study of Daily⁴ and Costanza⁵ are the most representative). And a great breakthrough was

made in the transformation of qualitative analysis to quantitative evaluation.

Zhong-Xin Chen, who adopted the study method of Costanza, concluded that the value of the marine ecosystem in China was 3,301.59 billion USD per year, while it is lower than practice due to the defect of the calculation method⁶. Taking the ecological system of JiaoZhou Bay as the research object, Chen Shang, funded by China State Oceanic Administration, firstly constructed the service function classification system of China bay ecosystem, and described its service functions⁷. Based on the connotation of service function of marine ecosystem, Cong-Chun Xu cited the evaluation indexes on Costanza and constructed the evaluation frame system of its service function value⁸. After questionnaire survey, Li Wang measured the value of biodiversity conservation services in LuoYuan Bay ecosystem by conditional value method, and found the main factors influencing the ecological value assessment⁹. According to the regional profile of Guangdong Province, Zhi-Yong Li established a offshore marine ecosystem service system in Guangdong Province, he chose the market price method to obtain the value of coastal marine ecosystem services and the average unit sea area ecosystem service value of Guangdong Province in 2009. Then sort the scores of the four functions of the marine ecosystem. The results showed that cultural service value was maximum, adjust service value was secondly, and supply services value was minimal. The results also showed that the development of marine ecological resources in Guangdong province is backward and the disposal ability of sewage is very low¹⁰. Zhao-Hui Zhang defined the connotation of marine ecosystem services, analyzed the service function of marine ecosystem from three aspects: composition structure, ecological process and biological diversity, and concluded the function of marine ecosystem services into 15 types¹¹.

Ming-Yuan Zhu introduced the marine ecosystem in the Yellow Sea and pointed out a series of ecological problems, such as serious pollution, ecological degradation, severe fishery form and climate change. By analyzing the existing problems of marine management in Yellow Sea, he put forward a strategic plan of action to realize sustainable development¹². Qian-Bin Di constructed the index system on evaluating sustainable development ability of marine ecosystem and evaluation model based on information entropy, he pointed out that the

sustainable development ability of China's marine ecosystem is on the rise¹³.

Huan-Huan Jiang, who presented the definition of the marine ecological restoration, analyzed the present situation of several typical marine ecosystem restorations in China, pointed out the existing problems, and put forward the focus of China's marine ecological restoration in the future¹⁴. Yun-Chuan Cai focused on ten technical management measures for the restoration of offshore marine ecosystem in Guangdong province¹⁵. Hui-Min Li analyzed the factors affecting marine ecosystem health, and assessed the health of marine ecosystem, using the analytic hierarchy process (AHP) to establish evaluation index system on the marine ecosystem¹⁶. Based on the concepts and standards of marine ecosystem health, Fan Qi analyzed two evaluation methods of marine ecosystem health, elaborated the method of index system systematically, and put forward the problems existing in the marine ecosystem health evaluation¹⁷.

Xiao-Jing Wang pointed out that marine ecosystem management is different from traditional single department, which is a new type of management mode. The paper analyzed the achievements and challenges of marine ecosystem management from three aspects: concept, policy and implementation¹⁸. Shu-Feng Ye summarized the research progress of ecosystem management. Combining with the characteristics of the marine ecological system in China, the paper expounded the problems of marine ecosystem in China and analyzed the causes, finally put forward how to develop the management of the marine ecological system in China¹⁹.

Materials and Methods

China is a coastal country, with a coastline of more than 1.8 million kilometers, which is one of the longest coastline in the world. What's more, China also owns one of the largest coastal territory in the world. China's waters include the Bohai Sea, the Yellow Sea, the East China Sea, the South China Sea and the eastern part of Taiwan waters, connected to the Pacific Ocean, all of these waters are curved around the Chinese mainland. Therefore, according to geographical location and marine climate, China's marine ecosystem is composed of the Yellow Sea, East China Sea, South China Sea and Kuroshio four marine ecosystems. Among them, the Yellow Sea and the Bohai Sea flora adjacent to the Chinese mainland are at the edge of the northern temperate sea, and the

East China Sea and the South China Sea are subtropical in nature, each presenting the characteristics of the marine ecosystem. There are more than 28,000 species of marine creatures recorded in the Chinese waters, accounting for 11% of the world, one of the world's most abundant marine lives.

Index system on evaluating marine ecological health

From the literature review, scholars have realized that marine ecosystem plays an important role in the continuation and development of human economy, society and human civilization. The marine ecosystem in China is already over-exploited, and the health of marine ecosystem is not optimistic. However, there are few articles on how to maintain marine ecosystem. Based on the previous research results, this paper attempts to establish the evaluation index system of marine ecosystem health, and to sort out the indicators that affect the health status of marine ecosystem by using the analytic hierarchy process (AHP) method, to obtain the key influencing factors from the quantitative point of view. According to which, the paper explain the strategy about how to scientifically maintain the health of China's marine ecosystem.

Based on the basic principles of setting the index system, such as scientificity, comprehensiveness and particularity, according to the availability of data, combined with the unique characteristics of marine ecosystem vulnerability, complexity and variability, the indicators selected in this paper should be as different as possible, relative stability, dominance and so on. In addition, they should be easy to understand, collect, quantize and evaluate by statistical method²⁰.

This paper draws on Costanza's definition to the ecosystem health that healthy ecosystem must be able to maintain their own organizational structure and be able to self-regulate, which have some flexibility in the face of external pressures, and have the ability to self-recovery, that is, stability, sustainability and vitality. The mathematical formula of concept of ecosystem health is expressed as $CHI = \text{organizational structure} \times \text{vitality} \times \text{restoring force}$ ²¹.

As one of the main areas of human activity, the health of coastal and offshore areas interacts with human activity level and activity mode. Therefore, human social factors must be put into the study of the health of marine ecosystem²². Moreover, marine ecological civilization has become the key content of environment protection work in China. Therefore, this

paper set up the index system made up with 4 criteria layers (organization structure, vitality, resilience, and ecological civilization) and 17 indicators, which reflects the health status of marine ecosystems comprehensively.

Analytic Hierarchy Process (AHP), Principal Component Analysis, Gray relational method are more commonly used to determine the weight of indicators. As the evaluation method will greatly affect the results of the comprehensive evaluation, therefore, we should choose the evaluation method according to the characteristics of the research object.

Marine ecosystem is a complicated system composed of many interrelated and interdependent factors, many of which are not quantitative but qualitative. Analytic Hierarchy Process (AHP) is a multilevel sub-weighted analytic decision-making method proposed by T.L.Saaty (American, 1926-2017) in the early 1970s. It is characterized by simplified analysis and calculation of the system to make people's thinking process level, by comparing a variety of related factors layer by layer, and some qualitative or semi-qualitative factors, and to provide a quantitative basis for the development of analysis, evaluation, decision-making and control affairs. For this consideration, analytic hierarchy process is used in this evaluation, and the weights of indicators are divided into the next four steps:

First, construct the hierarchy pattern. Which is divided into target layer A, criterion layer (primary index) B and scheme layer (secondary index) C in this paper.

Second, construct judgment matrix. The judgment matrix is as follows: $B = [b_{ij}]_{m \times m}$. b_{ij} indicates the importance of B_i relative to B_j (equally important, slightly important, obviously important, important and extremely important) for the previous level A. Usually b_{ij} is scaled by 1-9 and their reciprocal. The expert scoring method used in this paper is to construct a judgment matrix by weighted average of scores played by each expert, according to the results of experts, the calculation results (using Excel software) are as follows:

The judgment matrix A - B_j

$$W = \begin{bmatrix} 0.2452 \\ 0.0931 \\ 0.5050 \\ 0.1567 \end{bmatrix}, \lambda_{\max} = 4.0873, CR = 0.0327 < 0.1$$

The judgment matrix $B_1 - C_j$

$$W = \begin{bmatrix} 0.3676 \\ 0.0637 \\ 0.1464 \\ 0.0433 \\ 0.2155 \\ 0.0938 \\ 0.0697 \end{bmatrix}, \lambda_{\max} = 7.0190, CR = 0.0023 < 0.1$$

The judgment matrix $B_2 - C_j$

$$W = \begin{bmatrix} 0.6250 \\ 0.1365 \\ 0.2385 \end{bmatrix}, \lambda_{\max} = 3.0183, CR = 0.0176 < 0.1$$

The judgment matrix $B_3 - C_j$

$$W = \begin{bmatrix} 0.1007 \\ 0.2255 \\ 0.6738 \end{bmatrix}, \lambda_{\max} = 3.0858, CR = 0.0825 < 0.1$$

The judgment matrix $B_4 - C_j$

$$W = \begin{bmatrix} 0.4832 \\ 0.2717 \\ 0.0882 \\ 0.1569 \end{bmatrix}, \lambda_{\max} = 4.0145, CR = 0.0054 < 0.1$$

In the above, the meaning of “W” is the eigenvector of the matrix; the meaning of “ $\lambda_{\max}$ ” is the largest eigenvalue of the matrix; the meaning of “CR” is the abbreviation for consistency ratio.

Third, calculate the weight coefficient of each index. This paper adopts square root method

to calculate weight, and the results are shown in Table 1.

The fourth step is to check the consistency of each judgment matrix. In general, it is impossible for decision makers to give an accurate pairwise judgment matrix, so the consistency test of the characteristic root is performed until the characteristic root, $CR < 0.1$. In this case, the judgment matrix is passed the consistency test, the result of the judgment matrix is shown in Table 1.

Results

The weight of the primary index and the weight of each secondary index relative to the total index (using analytic hierarchy process) are shown in Table 1. The primary index is ranked as $B_3 > B_1 > B_4 > B_2$; secondary index ordering is ranked as $C_{13} > C_{12} > C_1 > C_{14} > C_8 > C_5 > C_{11} > C_{15} > C_3 > C_{17} > C_6 > C_{10} > C_7 > C_2 > C_{16} > C_9 > C_4$. The resilience and organizational structure of marine ecosystem are most important for marine ecosystem health, while the vitality of marine ecosystem (output efficiency) is the least. This conclusion is roughly in line with the results of previous scholars.

Discussion

The results show that the health of the marine ecosystem depends mainly on the organizational structure of the resilience of marine ecosystem. In spite of this, due to the high degree of social

Table 1 — Indexes system on evaluating marine ecological health and how each index weighs in the system

Aims	Primary index	Primary index weight	Secondary index	Secondary index weight
Indexes system on evaluating marine ecological health (A)	organizational structure (B ₁)	0.2453	dissolved oxygen(C ₁)	0.3676
			inorganic phosphorus(C ₂)	0.0637
			inorganic nitrogen(C ₃)	0.1464
			chemical oxygen demand(C ₄)	0.0433
			benthic organisms(C ₅)	0.2155
			Plankton(C ₆)	0.0938
			Phytoplankton(C ₇)	0.0697
	Vitality (B ₂)	0.0931	primary productivity(C ₈)	0.6250
			aquaculture capacity per unit area(C ₉)	0.1365
			catch per unit effort(C ₁₀)	0.2385
	Recovery ability(B ₃)	0.5050	inorganic phosphorus environmental capacity(C ₁₁)	0.1007
			inorganic nitrogen environment capacity(C ₁₂)	0.2255
			inorganic COD environmental capacity(C ₁₃)	0.6738
			marine technology investment ratio(C ₁₄)	0.4832
	ecological civilization (B ₄)	0.1567	number of marine talents per ten thousand people(C ₁₅)	0.2717
			proportion of days for swimming(C ₁₆)	0.0882
			popularity level of marine Culture(C ₁₇)	0.1569

development and the comprehensive intervention of humans on nature, the ocean can no longer exist independently of human activities. Therefore, in order to maintain the health of marine ecosystem, human influence on the oceans must be consider. Take the marine ecosystem and human activities as a whole, human progress should be coordinated with the organizational structure and mechanism of marine ecosystem, obeying natural rules. In other words, the traditional concept such as “humanity first” “all for human services” should be abandoned, while the new concept that only healthy and stable marine ecosystem is a prerequisite for providing rich resources and a beautiful environment for humans should be accepted by human society.

The marine economy has become the new engine driving economic growth in the coastal provinces of China, while the sustainable development of the marine economy is based on marine ecological security. Therefore, handling the relationship between marine development and marine environmental protection is the focus of attention of all circles of society. Although marine environmental protection laws and regulations are constantly improving and there is some success in the construction of marine ecological civilization, currently, the marine ecosystem in many parts of China is in sub-health or unhealthy conditions (Wen-Hai Lu²³; Wen-Lu Lan²⁴; Qian-Bin Di¹³), so it requires us to take effective action and measures to protect and manage the oceans. Based on the principle of “Both Oceans and Land, rivers and oceans in co-ordination”, the sustainable development of marine ecosystem and its functions as the target of regulation and management, this paper puts forward the control idea of “Prevention and Regulation, Governance and Rehabilitation, Protection and Development” to restore and manage China's marine ecosystem.

Laws, regulations and supervision

The coastal waters should be managed in accordance with the strategy of “prevention first, control combination”. The environmental protection departments at various levels should clearly division of labor, perform their duties and coordinate with each other. Codify and implement the relevant laws and regulations in near shore marine to provide a strong guarantee for the prevention and control of marine environmental protection.

Land-based pollution is a source of marine water pollution and eutrophication, so measures must be

taken to prevent it from the source. For example, according to the characteristics of biodiversity in the ecological region and the overall characteristics of the environmental conditions, management department plan out the protected river in the basin, where dams and hydropower stations, hot spots, etc. are forbidden, and formulate relevant standards to control the amount of pollutants discharged into the sea. In addition, all localities should form a fishing moratorium according to the actual situation and adjust the standard fishing activities to obtain long-term sustainable development of fishery resources, energetically develop the ecological aquaculture and appropriately develop the pelagic fishing industry²⁵. Besides, We should establish the monitoring and warning mechanism of foreign species, build the endangered species repository, and protect the biodiversity of the sea; and it is necessary for us to make relevant planning and develop the tourism industry reasonably according to the carrying capacity of tourism resources.

It is necessary to strengthen the marine environmental monitoring and monitoring capabilities in land and sea integration. The government set up relevant monitoring stations such as the Ocean Monitoring, Forecasting Center and the Water Quality Station Biological Station, and set up professional departments to set up special personnel to carry out uninterrupted monitoring of the marine environment. The administrative department guides the industry to establish monitoring, assessment and prevention systems for emergencies and risks, in order to timely assess, predicate, forecast, warn and take control measures for disaster events and emergencies.

Restoration of marine ecosystem

The restoration of the ecosystem is a complex system project, subjected to both human activity and natural factors. This paper puts forward some suggestions in the following three aspects, providing reference for the maintenance of marine ecosystem health.

At the spatial aspect, the activities and time of marine development should be projected reasonably, taking ecological protection and the development of marine economy into account. We must coordinate complex and diverse activities with conflicting interests. The marine development and environmental protection should coordinate with the development of land and sea, follow the principle of “Ecological Harmony, River and Ocean integration”, and assess the impact of the development of coastal integrated

economic zones on the sustainable of ecosystem comprehensively. Every area establishes a target system to maintain the stability of ecosystem and takes measures to monitor the marine ecological changes comprehensively, so the development of the ocean is limited to the ecological threshold.

At the technical aspect, Science and technology provide support for improving the management of the marine environment. On the one hand, we should make full use of the university and experimental resources, increase the cooperation between universities and enterprises, and carry out marine ecological restoration experiments based on scientific research. Advanced technical measures and scientific management methods (such as controlling pollution or changing the input of nutrients and contaminants, controlling physical parameters, controlling biological productivity, intervening in social and economic processes) can restore and improve the function of ecosystem. On the other hand, in the adherence to the implementation of artificial reefs, artificial propagation and releasing and other traditional technical measures, we will actively develop new technologies (such as scientifically assessing the capacity of specific waters), develop environment-friendly fishing techniques and optimize marine aquaculture mode. What more, traceability system of food, research and development of beneficial species of new technologies should be given more attention.

At the human cultural aspect, the popularization of marine ecological civilization can create a strong atmosphere in which everyone cares for, supports and actively participates in environmental protection. Relevant departments organize environmental protection activities that can strengthen citizens' awareness of marine resources crisis to establish a correct outlook on marine development. The public should change the living habits, reduce land pollution and cultivate low-carbon life awareness. Eventually, it was established supervision mechanism in the whole society, when government departments incorporate environmental protection plan of enterprise into the government management plan, invite relevant enterprises and environmentalists to participate in the supervision, inspection and monitoring work, in order to support the implementation of environmental protection and ecological management measures.

Ways to exploit marine resources

For a long time, China has adopted a predatory approach to the exploitation and utilization of marine

resources, ignoring the environmental carrying capacity and the sustainability of resources, which greatly damaged the marine ecological environment and caused irreparable loss. In this regard, we should comprehensively review the original development model, learn from the experience of developed countries, and explore the development model of marine resources suitable for the national conditions.

Firstly, the exploitation and utilization of marine resources must be based on environmental protection and biodiversity. Materialist holds that things are dialectically unified. In the short term, resource development and environmental protection are contradictory, but in the long run, they are unified. The further development of marine resources is based on current protection. Therefore, the development of marine resources must be based on the sustainable development of marine ecosystem.

Secondly, the exploitation and utilization of marine resources must balance the various service functions and values of the marine ecosystem. The marine ecosystem has four functions: supply, adjust, culture and support. There are many overlapping services in many offshore and coastal zones. Some of them are both nursery grounds for fish and shrimp and natural landscapes with beautiful scenery. Not only can it protect the water quality of embankment, but also be a good place for human activity. There are contradictions in various service functions, therefore, each region must balance economic and social development with ecological protection in the light of local realities, and make the marine ecosystem play the greatest value²⁶.

Thirdly, we must actively explore new areas of marine economic development. At present, the marine emerging industries, especially marine technology industries, such as tidal energy, marine wind energy and other new energy development and utilization are the focus and the main direction. China should increase efforts to cultivate talents in marine science and technology, actively encourage technological breakthroughs and break through the difficulties of traditional industrial technologies to promote progress in environmental protection technology, to promote the development of marine services (such as the coastal tourism industry and the modern marine logistics industry), and to promote the coordinated development of various industries.

Conclusions

This study evaluates the indicators that affect the health of Chinese marine ecosystem. The results show

that the resilience and organizational structure of marine ecosystem are more important to the health of marine ecosystem, and the vitality (output efficiency) of marine ecosystem is the smallest in the primary indicator. This warns us that the exploitation and utilization of the oceans should be based on the premise of respecting the laws of nature and should not override their interests above nature. So the Chinese government should take measures to restore the unhealthy marine ecosystem immediately, change the traditional way of exploiting oceans and use marine resources in a more scientific , environmental and friendly way.

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References

- 1 Biological exploration, Marine Ecosystem Protection Is Imminent, <http://www.biodiscover.com/news/research/95315.html>, (2011).
- 2 Macro economy, Opportunity and Challenge of China Ocean Economy, <http://news.hexun.com/2017-03-15/188504989.html>, (2017).
- 3 Wang, Y.S. Research on the diversity of marine ecosystems. *Bulletin of Chinese Academy of Sciences*, 26.2(2011):184-189.
- 4 Daily, G.(Ed.). Nature's services: societal dependence on natural ecosystems. *Island Press*, (1997).
- 5 Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ...&Raskin, R.G. The value of the world's ecosystem services and natural capital. *Nature*, 387.6630 (1997): 253-260.
- 6 Chen, Z.X. and Zhang, X.S. The value of China's ecosystem benefits. *Chinese Science Bulletin*, 45.1(2000): 17-22.
- 7 Chen, S., Zhang, Z. H., Ma, Y., Shi, H. H., Ma, A. Q., Zheng, W., ... & Liu, J. Program for service evaluation of marine ecosystems in China waters. *Advances in earth science*, 21.11 (2006): 1127-1133.
- 8 Xu, C.C. and Han, Z.L. A framework for estimating the value of marine ecosystem services. *Ecological Economy*, 10(2003): 199-202.
- 9 Wang, L., Chen, S., Ren, D. C., Ke, S. Y., Li, J. M., & Wang, D. Valuation of species diversity maintenance service in Luoyuan Bay based on contingent valuation method. *Advances in Earth Science*, 25.8 (2010): 886-892.
- 10 Li, Z.Y., Xu, S.J., Xu, H.Y., & Cai, X. Value assessment of offshore marine ecosystem service in Guangdong province. *Guangdong Agricultural Sciences*, 38.23(2011): 136-140.
- 11 Zhang, Z.H. Sources and implementation of marine ecosystem services. *Chinese Journal of Ecology*, 25.12 (2006): 1574-1579.
- 12 Zhu, M.Y. Research on the changes and sustainable development of marine ecosystems in the Yellow Sea. *Ecological Civilization Construction Expert Papers*, 11(2013):175-180.
- 13 Di, Q. B. and Han, Y.X. Sustainable development ability of China's marine ecosystem in the perspective of entropy. *Scientia Geographica Sinica*, 34 (2014): 6664-6671.
- 14 Jiang, H.H., Wen, G.Y. and Zhou Y.R. Current Situation, Existing Problems and Prospects of Marine Ecological Restoration in China. *Ocean Development and Management*, 30.1 (2013): 35-38.
- 15 Can, Y.C., Xian, F.Y. and Jiang Z.Y. Strengthen the research on the restoration of marine ecosystem in the near shore of Guangdong province. *China Fisheries*, 8 (2009): 24-25.
- 16 Li, H.M., Wang, H.L. and Guo, J.L. Study on marine ecosystem health assessment. *Productivity Research*, 10 (2007): 50-51.
- 17 Qi, F., Li, Q.X. and Zhu, L. Assessment Method of Marine Ecosystem Health. *Marine Science Bulletin*, 26.3(2007): 97-104.
- 18 Wang, X.J. Marine ecosystem management: concepts, policies and problems. *Ocean Development and Management*, 31.7 (2014): 30-34.
- 19 Ye, S.F., Wen, Q. and Zhou Q.L. Marine ecosystem management: new model of Marine management based on ecosystem. *Ocean Development and Management*, 23.1 (2006): 77-80.
- 20 Yan, J.L., Zhao, H.F. and Xue, Y.Y. Restricting Factor Analysis of Farmer Cooperatives Involved in Farmer-Supermarket Direct-Purchase Based on Hebei Province. *Guizhou Agricultural Sciences*, 3 (2013): 189-191.
- 21 Costanza, R., Norton, B. G. and Haskell, B. D. (Eds.). Ecosystem health: new goals for environmental management. *Island Press*, (1992).
- 22 Yuan, X.Z., Liu, H. and Lu, J. J. Assessment of ecosystem health—concept framework and indicator selection. *Chinese Journal of Applied Ecology*, 12.4(2001): 627-629.
- 23 LU, W.H., Zeng, R. and Xiang, X.Q. Study of the marine ecological health assessment for the coastal area. *Marine Science Bulletin*, 32.5(2013): 580-585.
- 24 Lan, W.L. and Li, T. S. Problems and Countermeasures of Marine Ecosystem Qinzhou Bay. *Environmental Science and Management*, 38.1 (2013): 118-122.
- 25 Nichols R, Yamazaki S, Jennings S, et al., Fishing access agreements and harvesting decisions of host and distant water fishing nations. *Marine Policy*, 54 (2015): 77-85.
- 26 J.C. Nava Fuentes, P.A. Granados and F.C. Martins. Coastal management in Mexico: improvements after the marine and coastal policy publication, *Ocean Coast*. 137 (2017) : 131–143.