

Exploring Sustainable Development Paths for Marine Resources and the Marine Economy

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Abstract:

Marine resources are the core foundation to support the development of the marine economy, in the global ocean development fever climbing, ecological protection of the increasing demand, to explore its sustainable development path to balance the development and utilization and ecological protection, to promote the long-term prosperity of the marine economy is of key significance, the purpose of this paper is to explore the sustainable development of the marine resources and the marine economy path, the main analysis of the marine biological resources, mineral and energy development and industrial synergistic innovation model. This paper aims to explore the path of sustainable development of marine resources and marine economy. The study finds that the sustainable use of marine biological resources requires the construction of a synergistic system of scientific fishing, stocking and releasing and marine pasture to balance the development and ecological protection; the development of marine minerals and energy relies on the breakthroughs in green technology to reduce environmental disturbances and enhance the efficiency of development. The synergistic innovation of industry can be fostered through the mode of “fishery and tourism integration”, “ocean + digital” and other modes to cultivate new industries such as marine carbon sinks, information technology and so on, so as to enhance the resilience of the economy. It provides a theoretical reference for the high-quality development of the marine economy and promotes the sustainable development of blue economy.

Keywords: Marine resources; Marine economy; Sustainable development; Industrial synergy; Resource development

1. Introduction

The oceans and seas, which cover about 71 percent of the Earth's surface, are a key strategic space for the sustainable development of human society [1,2]. With the advancement of science and technology, the exploration and exploitation of marine resources have been constantly innovated. High-precision ocean exploration technologies, such as multibeam bathymetric systems and ocean remote sensing technologies, have enabled mankind to gain a more accurate understanding of the topography and distribution of resources in the oceans [3]. The development of deep-sea submersibles, underwater robots and other equipment has enabled mankind to conduct research and operations in the deep sea [3]. However, ocean development also faces many challenges. In the development of marine biological resources, the overuse of traditional fishing techniques has led to the decline of resources; in the development of marine minerals and energy, deep-sea high-pressure, low-temperature, complex geological conditions, etc. put forward extremely high requirements for mining technology, and the development process is prone to ecological damage [3-5]. In the construction of a new model of marine economic development, the technological transformation and integration of emerging marine industries also need a breakthrough [2]. Therefore, it is urgent to explore a new path for the sustainable development of marine resources and marine economic development.

Many scholars focus on the development of marine resources and economic development, such as Liu Dahai (long-term focus on the development of marine resources and marine economic research, in the field of marine energy, fishery economy and other areas of fruitful results) analyzed the economic potential of marine energy development and environmental costs, pointing out that the development of marine wind power, tidal energy and other green energy not only injects new growth poles into the marine economy, but also needs to balance ecological protection [6]. Chen Xinjun (who is deeply engaged in the field of marine fishery resources and economy) focuses on the transformation of marine fisheries and proposes the integration model of "aquaculture - processing - culture and tourism", which expands diversified economic paths for the development of marine biological resources [7-8]. These studies provide theoretical references and practical ideas for exploring the synergistic path between the sustainable development of marine resources and the high-quality development of the marine economy [4].

Based on the double challenges faced by the development of marine resources in the exploitation of economic value and the maintenance of ecological balance, this paper focuses on the study of the sustainable development path of

marine resources and the marine economy. It aims to analyse the development modes of marine biological resources, mineral energy and the path of industrial synergy and innovation, clarify the practical logic of scientific fishing, green technology application and "fishery and tourism integration", and provide a synergistic solution with both theoretical reference value and practical guidance for the sustainable development of marine resources and high-quality development of the marine economy[9,10].

2. Status of the development and conservation of marine living resources

In the process of global ocean development, the contradiction between the development and protection of marine living resources has become more and more prominent. From the perspective of development, modern fishing technology has been upgraded iteratively, and satellite remote sensing, sonar detection and other means of accurate positioning, together with large-scale trawlers and purse-seiners, have significantly increased the efficiency of human fishing for marine fishery resources, and fishery production has maintained its growth over the past few decades, providing a key source of protein for billions of people around the world. At the same time, the scale of marine aquaculture has continued to expand, with the promotion of technologies such as factory-based recirculating water aquaculture and deep-water net-pen aquaculture, which has led to a sustained breakthrough in the aquaculture production of fish, shellfish and algae, making the oceans an important "blue breadbasket" for human beings' access to food resources.

However, the hidden worries and challenges behind exploitation are increasing. Overfishing is the first to bear the brunt, with more than 30% of the world's fishery resources in a state of overfishing, the number of stocks of traditional economic fish such as cod and tuna decreasing drastically, and the trend of individual catches in some areas of the sea being smaller and younger, which is a serious blow to the regeneration capacity of fishery resources. Rare marine organisms are even more difficult to escape the fate of cetaceans, sea turtles, corals, etc., due to by-catch, and habitat destruction, endangered level continues to rise, such as coral reefs as marine organisms, "Garden of Eden", by the ocean warming, acidification and the impact of human development, the world's coral reefs more than 20% has been dead, depending on the coral reefs tens of thousands of species of organisms to survive to lose their homes.

The sloppy mode of marine aquaculture has also brought about a chain reaction to the ecology. Large-scale bait farming, so that the residual bait, feces in the aquacul-

ture sea enrichment, triggering seawater eutrophication, red tide disasters occur frequently, in 2023, only China's coastal red tide monitored more than 60 times, covering an area of more than 1,000 square kilometers, a large number of marine organisms due to a lack of oxygen, poisoning death. The spread of aquaculture diseases is also intensifying, with viruses and bacteria spreading rapidly in high-density aquaculture environments, which not only cause the death of a large number of aquaculture organisms, but also contaminate the surrounding natural waters through seawater exchange and destroy the habitat of wildlife.

In addition, the "utilisation over protection" mentality in the development of marine living resources has impaired the function of marine ecosystem services. Important marine ecological habitats such as mangrove forests and seagrass beds are constantly being reduced as a result of pondering and land reclamation, and their ecological values, such as carbon sequestration, shore protection and larval reproduction, are being neglected, further weakening the self-repair and sustainable supply capacity of marine living resources, and the balance between the development and protection of marine living resources is continuing to tilt towards the edge of imbalance.

3. Sustainability analysis

The development of marine resources needs to take into account the economic development and ecological balance, this paper mainly on the ecological conservation of marine biological resources, marine minerals and energy green development of two major dimensions, to explore the sustainable development of the marine economy path, to promote ecological protection and industrial upgrading synergistic co-progress.

3.1 Living marine resources: ecological conservation and rational use

Living marine resources are the foundation of the marine economy, covering fishery resources (e.g. fish, shrimps and crabs), marine shellfish, algae, and ecosystem-associated organisms such as mangroves and seagrass beds. In the past, overfishing in the fisheries industry has led to a drastic reduction in the number of stocks of cod striped bass, etc. Today, the construction of marine pastures is needed. Nowadays, it is necessary to solve the dilemma through the construction of sea ranch - A sea ranch is a specific sea area that relies on artificial reefs, intelligent monitoring, and other facilities to simulate the natural marine ecology, forming a closed loop of "placement - conservation - proliferation" [11]. It can create a safe habitat for fish and shrimp, replenish the population through

artificial breeding and release, and combine with the system of closed fishing areas and seasons to allow fishery resources to recuperate [11]. At the same time, deep-sea aquaculture is developed, breaking through offshore space limitations with intelligent netting and underwater monitoring systems, improving aquaculture efficiency and product quality, promoting the transformation of fisheries to "eco-friendliness + high efficiency", ensuring the long-term and stable supply of marine biological resources, and building the ecological foundation of the marine economy [11].

3.2 Marine mineral and energy development: green technology-driven transformation

The development of marine minerals (such as oil and gas, polymetallic nodules, etc.) and energy (tidal energy, wave energy, etc.) is an important new growth pole for the marine economy, but due to the vulnerability of the marine ecosystem and the complexity of the development activities, it is faced with multiple environmental risks - oil spills from oil and gas extraction are prone to cause the suffocation of marine organisms and the pollution of habitats; the polymetallic The mining of polymetallic nodules may destroy the deep-sea ecological chain; the construction of tidal and wave energy facilities will also interfere with the marine dynamic environment.

In oil and gas development, the promotion of underwater production systems can reduce the encroachment of surface facilities on the marine surface ecology; the use of new technologies for oil spill emergency disposal (such as microbial degradation agents and intelligent booms) can quickly respond to and accurately control the scope of pollution and reduce ecological disturbances. As for new marine energy, we will accelerate the miniaturization of tidal energy power generation devices and adapt them to the characteristics of different sea currents; overcome the bottleneck in the efficiency of wave energy power generation, and improve the stability of energy capture and conversion with the help of flexible power generation devices and intelligent control algorithms, so as to solve the problems of high cost and poor adaptability. Green technology is used throughout the entire development process, from the source to optimize the design of the scheme, to the end to strengthen the prevention and control of pollution, so as to achieve controllable environmental costs in the development of marine minerals and energy, and to inject technological kinetic energy for sustainable development.

3.3 Optimisation and synergistic development of the maritime economy

To promote the sustainability of the marine economy, the layout of the industry needs to be optimised. On the one

hand, it is necessary to promote the upgrading of traditional industries, such as marine fisheries, coastal tourism and marine manufacturing, and to incorporate digital and intelligent elements, such as intelligent fisheries management platforms and immersive marine tourism projects. On the other hand, we should strengthen the synergy of industries, build the whole fishery industry chain of “aquaculture - processing - sales”, create the integration mode of “tourism + energy experience”, break the industrial boundaries, enhance the overall resilience and competitiveness of the marine economy, and form a sustainable development ecology in which all industries can coexist and co-prosperate.

4. Outlook

Looking ahead, the sustainable development of marine resources and the marine economy is promising, and marine science and technology and emerging industries will become the core driving force [9]. In the field of marine science and technology, gene editing technology empowers the development of marine biological resources, accurately improves varieties, and builds a sustainable closed loop of “breeding - conservation - utilisation” [11]; scientific and technological breakthroughs in deep-sea mineral development, with intelligent robots and monitoring systems, realize green and intelligent mining and reduce ecological disturbances [12]; technological leaps in new marine energy conversion, such as wave energy, tidal energy power generation, and hydrogen energy applications, provide clean power [6].

Emerging marine industries are flourishing, with marine biopharmaceuticals leveraging genetic achievements to extract active substances for innovative medicines and healthcare products, creating a full chain [9]; marine information technology integrating 5G and the Internet of Things to build a monitoring network and support intelligent ocean management [13]; and the ocean carbon sink industry has great potential, with a clear mechanism for carbon sequestration in ecosystems and a perfect trading market to promote the realisation of ecological value [8]. In terms of industrial synergy, the “Ocean +” model has been upgraded; “Ocean + Digital Economy” has spawned intelligent platforms to realise digital synergy of the industry chain [13]; and “Ocean + Culture and Tourism Economy” has created immersive experiences to extend economic value [7]. Global ocean governance cooperation has deepened, and the sharing of science and technology and the synergy of rules have built a solid foundation for development [9]. In the future, the ocean will become a blue growth pole, writing a new chapter of harmonious coexistence between human beings and nature in resource

supply and ecological protection, and driving global sustainable development towards the deep blue.

5. Conclusions

This paper focuses on the core issue of sustainable development of marine resources and marine economy, comprehensively uses the literature research method to sort out the theoretical vein, combines the case study method with data analysis, and explores the development and utilisation mode of marine resources and the path of economic development in depth.

The study found that the sustainable use of marine biological resources requires a balance between development and protection, scientific fishing systems, stock enhancement and release and the construction of marine pastures can restore fishery resources; the development of marine minerals and energy should rely on technological innovation to reduce the environmental impact of green mining, new energy technology breakthroughs can achieve the development of ecological compatibility; the synergistic innovation of industry can break the boundaries of the “fishery and tourism integration”, “marine + digital” and other models and emerging marine carbon sinks, information technology industries can build a diversified sustainable development ecosystem. The synergistic innovation of industries can break the boundaries, and the mode of “fishery and tourism fusion”, “ocean + digital” and the emerging marine carbon sink and information technology industries can build a diversified and sustainable development ecology.

Looking ahead, interdisciplinary research can be deepened, integrating oceanography, economics and environmental science to explore better paths; and international cooperation research can be expanded to promote synergy in global ocean governance. This study provides theoretical references for the high-quality development of the marine economy, helps to explore the value of marine resources and guard the ecology, which is of great significance in realising the sustainability of the blue economy and the harmonious coexistence of human beings and nature, and promotes the ocean as a new engine of economic growth.

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