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Analysis of the Functions and Values of Marine Ecosystems

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Abstract The ocean is one of the important ecosystems on Earth, covering 70% of the Earth's surface. Marine ecosystems are composed of various organisms and non organisms, which are not only important components of biodiversity, but also play a crucial role in global climate, water cycle, energy flow, and so on. The marine ecosystem is also one of the oldest ecosystems on Earth, which has existed for millions of years and has been continuously adapting and evolving. This article aims to explore the functions and values of marine ecosystems, enhance people's understanding of their functions and values, and promote the sustainable development of marine ecosystems.
Keywords Marine ecology; Circulation; Value services; Marine resources

The marine ecosystem is one of the largest ecosystems on Earth and has important ecological functions and economic value, including oxygen supply, carbon dioxide absorption, nutrient cycling, food chain maintenance, and coastal protection. Among these, the regulatory role of the marine ecosystem in the global carbon cycle is particularly important. Phytoplankton and marine organisms in the marine ecosystem absorb carbon dioxide through photosynthesis and store it in the deep sea through death and sedimentation, which helps to slow down global climate change. In addition, the marine ecosystem also has significant economic value, including fisheries, tourism, marine transportation, and offshore oil. According to statistics, more than 300 000 people are involved in the fishing industry globally, and marine fisheries provide more than 300 million tons of seafood, which is an important guarantee for global food security. The marine tourism industry is also constantly developing, creating enormous value for global economic growth and employment.

As globalization accelerates and human activities increase, the marine ecosystem is facing greater threats and challenges. Issues such as ocean pollution, climate change, overfishing, and biological invasion have led to the destruction and collapse of the marine ecosystem, causing serious impacts on the global ecosystem and human health. It is of great practical significance to comprehensively and deeply understand the various functions and values of the marine ecosystem through information integration, in order to promote the development of the marine ecosystem.

This study aims to introduce the concept and importance of marine ecosystems, as well as provide a specific overview of their functions and value. It will provide a detailed analysis of the ecological functions of marine ecosystems, including energy flow, material cycling, and biodiversity maintenance, and explore the role and importance of these functions in the marine ecosystem. Additionally, this study will examine the economic, social, and cultural values of marine ecosystems to humans, analyze their impact on the global environment, and summarize and review their functions and value. It emphasizes the importance of protecting and managing marine ecosystems, and provides suggestions and outlooks with the aim of providing theoretical support for the protection and management of marine ecosystems.

1 Functions of Marine Ecosystems

1.1 Energy flow

Energy is the foundation of all living activities, and energy flow is the basis for interactions among organisms in

the marine ecosystem (Pan, 2022). The flow of energy in marine ecosystems is mainly achieved through food chains and food webs. A food chain is a linear chart that describes the food relationship between organisms, while a food web is a complex network that describes the food relationship between organisms.

In the marine ecosystem, the source of energy is usually sunlight, which is used by stratobios such as plankton, phytoplankton, and shallow benthic organisms through photosynthesis and chemical synthesis to produce organic matter. These stratobios are the foundation of marine food chains and food webs, and they are consumed in turn by intermediate organisms such as shallow benthic organisms and plankton, and top carnivores such as whales, seals, and sharks.

In the marine food chain (Figure 1) and food web, each organism is divided into a trophic level. The lowest level organisms, such as plankton, Phytoplankton, and shallow benthic organisms are called primary consumers, and they produce organic matter through photosynthesis and chemical synthesis. The second-level consumers are those that feed on primary consumers such as shallow benthic organisms and plankton. The third-level consumers are those that feed on second-level consumers such as fish and whales. In the marine food chain and food web, some organisms can be at multiple trophic levels at the same time, and these organisms are called omnivores.

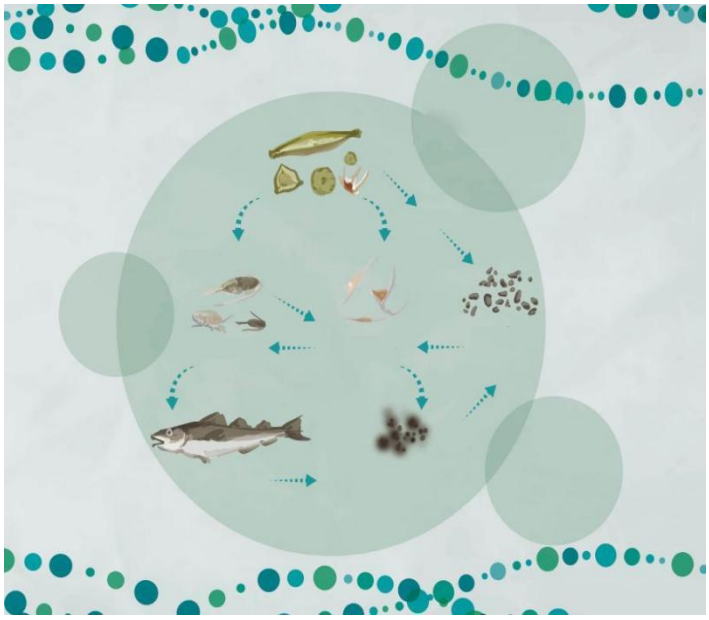

Figure 1 Classic food chain of marine ecosystems

In the marine food chain and food web, there are interactions between each trophic level. When the number of organisms in a trophic level decreases or increases, it will have an impact on the trophic levels upstream and downstream. For example, when the number of plankton in the ocean decreases, the number of top carnivores such as whales will also decrease, which will affect other organisms in the marine ecosystem. Additionally, the interaction between trophic levels can also affect other ecological functions such as material cycling in the marine ecosystem.

The transfer and flow of energy through food chains and webs in the marine ecosystem can maintain the stability of the marine ecosystem and have a profound impact on the global ecosystem and human health. For example, plankton in the ocean can absorb a large amount of carbon dioxide (CO_2), slowing down global warming, while large carnivores such as whales can control the number of intermediate organisms, maintaining the balance of the marine ecosystem (Shen and Mao, 2019).

1.2 Material cycling

Material cycling in the marine ecosystem refers to the exchange and circulation of materials between living and non-living components (Li et al., 2022). Material cycling in the marine ecosystem mainly includes water cycle,

carbon cycle, nitrogen cycle, phosphorus cycle, and so on. The water cycle in the marine ecosystem refers to the circulation of water between the ocean, atmosphere, and land. Solar radiation causes water vapor in the ocean to enter the atmosphere through evaporation and form clouds. Then, water droplets in the clouds return to the ocean through precipitation. In addition, water in the ocean can also enter the ocean through rivers, groundwater, and glaciers.

The carbon cycle in the marine ecosystem refers to the exchange and circulation of carbon dioxide (CO_2) between the ocean and the atmosphere. Marine organisms manufacture organic matter through photosynthesis (Figure 2) and chemical synthesis, absorbing and storing a large amount of CO_2. In addition, CO_2 in the ocean can also dissolve into seawater through physical and chemical processes, or enter the atmosphere through gas exchange.

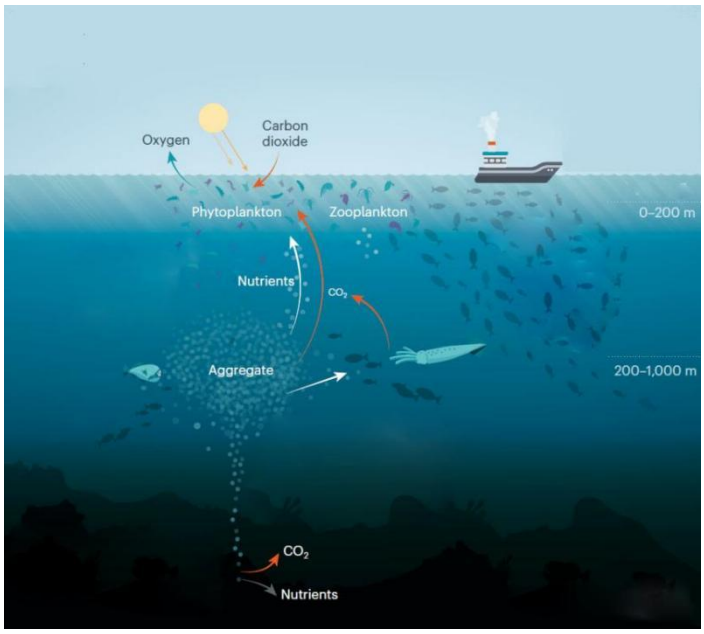

Figure 2 Photosynthetic turnover of marine organisms

Nitrogen gas is one of the main gases in the atmosphere, but most organisms cannot directly use nitrogen gas. The nitrogen cycle in the marine ecosystem refers to the exchange and circulation of nitrogen gas (N_2) between the ocean and the atmosphere. Some microorganisms in the ocean, such as *Azotobacter* sp and nitrifying bacteria, can convert nitrogen gas into some organic compounds, such as ammonia, nitrates, and nitrites, which can be used by other organisms. On the other hand, phosphorus is an important component of living organisms, playing an important role in life molecules such as DNA, RNA, and ATP. The phosphorus cycle in the marine ecosystem refers to the circulation of phosphorus between the ocean and the land. Phosphorus in the ocean mainly comes from rivers and sediments flowing into the ocean from the land. Marine organisms can use phosphorus by ingesting and absorbing it, and then release it back into the ocean through excretion or death.

1.3 Maintaining biodiversity

Biodiversity in the marine ecosystem refers to the number and diversity of different types of organisms in the ocean, including species diversity, genetic diversity, and ecosystem diversity. For example, plankton in the ocean can manufacture organic matter through photosynthesis and chemical synthesis, which is an important foundation for marine food chains and food webs. Shallow benthic organisms (Figure 3) and plankton can remove harmful substances in the ocean through filtration and ingestion, protecting the health of the marine ecosystem. Biodiversity plays a crucial role in the marine ecosystem (Xiang, 2015).

Figure 3 Marine shallow bottom organisms

Biodiversity in the marine ecosystem can help maintain ecosystem stability. Interactions between different types of organisms form complex ecosystems, preventing the over-reproduction of a single species. When the population of a particular species becomes too large, the number of its predators will also correspondingly increase, thereby balancing the population of the species. Furthermore, biodiversity can also promote material cycling. Different types of organisms play different roles in the ocean, promoting the circulation and reuse of materials. For example, bottom-dwelling organisms manufacture organic matter through photosynthesis and chemical synthesis, providing energy for upper-level organisms. When these upper-level organisms die, their bodies are decomposed by bottom-dwelling organisms, releasing nutrients and re-entering the cycle. Biodiversity in the marine ecosystem also plays an important role in maintaining the genetic diversity of marine organisms. Different types of organisms have different genetic characteristics, which can help them adapt to environmental changes. When the genetic diversity of a species decreases, its adaptability also decreases, making it more susceptible to disease, pollution, and climate change. In addition to the above three points, marine biodiversity can also provide economic and cultural value to humans. Many species in the ocean are used by humans as food, medicine, industrial raw materials, and decorations, providing important economic value (Stelzenmüller et al., 2013). Marine organisms are also used in cultural activities such as traditional fisheries and marine cultural festivals.

2 Value of the Marine Ecosystem

2.1 Maintaining global climate stability and providing abundant food resources

The value of the marine ecosystem in maintaining global climate is significant. The most important value is its ability to slow the impact of climate change by regulating the global carbon cycle. The marine ecosystem absorbs and stores large amounts of carbon dioxide (CO_2), which helps to mitigate and reduce the concentration of greenhouse gases in the atmosphere, thereby reducing the impact of global climate change (Duarte et al., 2013). In addition, plants and plankton in the ocean also produce oxygen (O_2) through photosynthesis and the absorption of carbon dioxide, which helps to maintain global climate stability and human health.

The South China Sea (Figure 4) is an important marine ecosystem with rich marine life and coral reef ecosystems. The coral reefs in the South China Sea can absorb large amounts of carbon dioxide while providing habitats and food resources for numerous marine organisms, maintaining the balance of the entire ecosystem. In addition, diatoms and zooplankton in the South China Sea can also absorb carbon dioxide through photosynthesis and store it in the deep sea, thereby regulating the global carbon cycle.

Figure 4 South China Sea

The ocean surrounding Antarctica is one of the largest marine ecosystems in the world, and the marine organisms within this ecosystem play an important role in regulating the global carbon cycle. Phytoplankton in the marine ecosystem surrounding Antarctica can absorb large amounts of carbon dioxide, supporting the operation of the entire ecosystem. In addition, the phytoplankton and organic carbon in the marine ecosystem surrounding Antarctica sink to the seafloor, forming a huge carbon sink, which helps to slow down the rate of global climate change. However, changes in the Antarctic marine ecosystem caused by climate change, including rising sea temperatures, melting sea ice, and ocean acidification, may lead to the collapse of the ecosystem, disrupting the balance of the global carbon cycle and bringing greater uncertainty and risks to the process of global climate change.

The marine ecosystem is one of the largest sources of food resources in the world, providing humans with a rich and diverse range of food resources such as fish, shellfish, and shrimp. The food value of marine organisms is not only abundant in quantity but also includes the quality and nutritional value of the food. These food resources play a crucial role in the survival and health of humans.

2.2 Promoting economic development and creating employment opportunities

The marine ecosystem not only provides humans with rich food resources (Figure 5) but also provides important support for the economic development of many countries and regions (Huang and Zhang, 2019). Industries such as fisheries, shipping, tourism, oil, and natural gas in the marine ecosystem are important economic industries, and the economic development of many countries and regions around the world is closely related to fisheries. For example, a part of the economy in countries such as Norway, Canada, and Chile comes from fisheries. Arctic cod in Norway, Atlantic lobsters in Canada, and salmon in Chile are popular seafood species that provide a lot of employment opportunities and economic benefits for the local community through farming and fishing. The ports in cities such as Shanghai, Shenzhen, and Tianjin in China are among the busiest ports in the world and are operated through maritime transportation. Ports, docks, ships, and related service industries in the marine ecosystem create opportunities and economic benefits for economic development and employment (Li and Ren, 2007).

2.3 Maintaining biodiversity and cultural heritage

The biodiversity and cultural heritage value in the marine ecosystem cannot be ignored (Pauly and Watson, 2005). The marine ecosystem has a wide variety of species, some of which are unique and rare, and their existence not only maintains ecological balance but also provides beautiful natural landscapes and cultural heritage for people. For example, coral reef communities in the ocean are one of the most beautiful ecosystems in the world, providing not only beautiful natural scenery but also important economic value and ecological conservation significance for humans.

Sea turtles, dolphins, and many marine fish are important and abundant organisms in the marine ecosystem, playing important roles in many marine ecosystems. For example, sea turtles can control the growth of seagrass and coral reefs and maintain the balance of the food chain. At the same time, sea turtles are also symbolic of many cultures. In cultures such as Hawaii and Mexico, sea turtles are considered sacred animals.

Figure 5 Marine food resources

3 Summary and Prospects

The protection and management of the marine ecosystem are important measures to ensure global ecological security and human health. The marine ecosystem has immense value for the development and survival of humans and the entire planet, so research on the functions and values of the marine ecosystem is of great significance. Research on the functions and values of the marine ecosystem can help us gain a deeper understanding of the importance and fragility of the marine ecosystem, and thus formulate more effective protection and management measures. For example, understanding the important role of the marine ecosystem in climate stability can promote global emission reduction actions, and understanding the important support role of the marine ecosystem in economic development can promote the planning and management of sustainable marine use.

Promoting ecological civilization construction, which is an important part of the cause of socialism with Chinese characteristics. Research on the functions and values of the marine ecosystem helps us to have a deeper understanding of the importance and urgency of ecological civilization construction. Only by strengthening marine protection and management can we achieve the goal of ecological civilization construction and achieve sustainable development of the economy, society, and environment.

Research on the functions and values of the marine ecosystem requires the use of modern scientific and technological means, such as remote sensing, ecological models, and molecular biology. The application of these technologies can help us gain a deeper understanding of the complexity and diversity of the marine ecosystem and promote the innovative development of marine science. For example, ecological models can help us predict the trend of changes in the marine ecosystem and provide scientific basis for adopting effective protection and management measures. Molecular biology techniques can help us study the genetic diversity of marine organisms and provide scientific support for the protection and use of marine biological resources.

The marine ecosystem is a shared global resource (Zheng et al., 2007), and countries need to strengthen cooperation and communication to protect and manage this important ecosystem together. Research on the functions and values of the marine ecosystem can promote international cooperation and communication, strengthen communication and cooperation among countries, and jointly promote the protection and management of the marine ecosystem. Countries can jointly formulate standards and norms for marine protection and management, strengthen scientific and technological innovation and information sharing, and jointly respond to global challenges such as climate change and environmental degradation.

Authors' contributions

WJN is the main author of this review, completing the collection and analysis of relevant literature and the writing of the initial draft of the paper, as well as participating in the analysis and organization of the literature XJ is the supervisor of this study, providing guidance on the writing of the paper. Both authors read and approved the final manuscript.

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