

Exploring Marine Biodiversity from Concepts, Classifications, and Influencing Factors

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Abstract The ocean is the cradle of life, and caring for the ocean and protecting marine biodiversity is protecting humanity itself. In recent years, global marine governance with biodiversity as its focus has entered a period of rule reshaping. The Convention on Biological Diversity (CBD) negotiations, negotiations on biodiversity conservation and sustainable use of offshore areas beyond jurisdiction (BBNJ), international undersea regional environmental management (REMP), and the construction of Antarctic protected areas have been promoted in a coordinated manner from multiple levels of science, management, legislation, policy, and practice, showing a chain trend. Understanding the formation, basic concept classification, and influencing factors of marine biodiversity is not only an essential issue in life science, but also has important guiding significance for the protection, development, and utilization of marine biological resources. This study analyzes the formation of marine biodiversity, focusing on the concept, classification, influencing factors, etc. of marine biodiversity, and provides basic suggestions for future research on marine biodiversity.

Keywords Marine life; Biodiversity; Concept classification; Balance of nature

Marine ecosystems cover approximately 71% of the Earth's surface. However, with the continuous increase in human activities, the marine environment is facing severe pollution and degradation, posing a threat to marine biodiversity. The loss of marine biodiversity has become a global issue, with increasingly evident impacts on humans and ecosystems. Therefore, the protection and management of marine ecosystems have become a global focus (Liu and Chen, 2021). It is necessary for people to have a deeper understanding of the basic concepts of marine biodiversity in order to better protect and manage marine ecosystems.

Diversity refers to the differences and variations among different species, genetic types, and ecological types within an ecosystem. Biodiversity is an essential component of ecosystems and serves as a source of stability and resilience. Marine biodiversity refers to the diversity and variation among different species, genetic types, and ecological types within marine ecosystems. Marine biodiversity includes the diversity of various types, quantities, distributions, and ecological effects of marine organisms. Biodiversity enables interdependence and interactions among different species, collectively maintaining the balance of ecosystems. Once biodiversity is disrupted, the ecological balance may also be affected, which may lead to the collapse of ecosystems.

Biodiversity provides various ecological services for humans, such as water source protection, climate regulation, soil conservation, flood control and disaster reduction, and the provision of resources like food and medicine. These ecological services provide important support and guarantee for human survival and development (Nadia and Roberto, 2020). Promoting scientific research is of great significance for human understanding in fields such as life sciences and earth sciences. It can lead to the development of new biotechnologies, improvement of product quality, exploration of new drugs, and also provide scientific basis and strategies for ecosystem protection.

Biodiversity is also an integral part of human culture. Various plants and animals hold different symbolic meanings and values in different cultures, reflecting the diversity of human cultures. This review aims to introduce the basic concepts of marine biodiversity, explore its importance to humans and ecosystems, and analyze the factors influencing marine biodiversity. Through this review, readers can gain a deeper understanding of the

relevant knowledge of marine biodiversity and enhance their awareness and capacity for marine environmental protection and management.

1 The Definition and Basic Concept of Marine Biodiversity

Marine biodiversity (Figure 1) refers to the diversity and variation among different species, genetic types, and ecological types within marine ecosystems. It encompasses the variety of categories, abundance, distributions, and ecological roles of various marine organisms. Marine biodiversity is represented by the presence of many different biological categories in marine ecosystems, including marine plankton, benthic organisms, fish, cetaceans, sea turtles, crustaceans, mollusks, cnidarians, seaweeds, corals, and so on. Among these different categories, there are numerous different species, and each species exhibits distinct morphological, physiological, and behavioral characteristics in different ecological environments. These variations and diversities are the manifestations of marine biodiversity. The diversity of marine organisms is not only reflected in their quantity, but more importantly, it includes different ecological types, nutritional modes, morphological characteristics, and behavioral habits. These diversities constitute the fundamental features of marine ecosystems and are of vital significance for maintaining the stability and ecological security of marine ecosystems.



Figure 1 Distribution of marine biodiversity

Marine biodiversity is manifested as the distribution diversity of different types of marine organisms in the marine environment, ranging from the ocean surface to the deep seafloor, from coastal areas to open waters. Different types of marine organisms survive and reproduce in different environments. For example, plankton predominantly inhabit the ocean surface, while benthic organisms are primarily found on the seafloor sediments. Marine biodiversity also manifests as the ecological diversity of different types of marine organisms within marine ecosystems. Different types of marine organisms play various roles in the ecosystem, including food chain builders, parasitic organisms, predators, scavengers, ecological engineers, etc. Through mutual interactions and interdependencies, they collectively maintain the balance and stability of the ecosystem. For instance, in coral reef ecosystems, corals serve as the foundation of the entire ecosystem, providing habitat, food, and protection, while various fish and invertebrates within the coral reef system act as predators, builders of food chains, and important participants in interspecies interactions throughout the ecosystem.

2 Classification of Marine Biodiversity

2.1 Species diversity

Species diversity refers to the number and distribution of different types of organisms present in marine ecosystems. Different species play different roles in the ecosystem, including food chain builders, parasitic organisms, predators, scavengers, and ecological engineers, etc. Protecting and maintaining species diversity is crucial for the balance and stability of marine ecosystems. The abundance and distribution of organisms in marine ecosystems are highly diverse. The distribution and abundance of different marine species are influenced by various factors, such as water temperature, salinity, ocean currents, illumination, and nutrients.

Planktonic organisms is one of the most abundant biological categories in marine ecosystems and primarily inhabits the ocean surface. Plankton includes both phytoplankton and zooplankton, which play a significant role in the marine food chain and are an important component of the food chain in marine ecosystems. Benthic organisms primarily inhabit the sediment on the seafloor, including benthic animals and plants. The increase and decrease in in the number of benthic organism have a significant impact on maintaining the balance and stability of the marine bottom ecosystem. In terms of fish, there are various species of fish in the ocean that play different roles in the marine ecosystem, including food chain builders, predators, and prey (Philip et al., 2023). Different species of fish are distributed in different marine areas and depths, with some species restricted to specific regions. Marine mammals (Figure 2) primarily include whales, dolphins, and manatees, among others. They play important roles as predators and prey in the marine ecosystems. Different species of marine mammals are distributed in different marine areas and depths, with some species restricted to specific regions.



Figure 2 Marine mammal

2.2 Genetic diversity

Genetic diversity refers to the variation in genotypes and phenotypes among different individuals within a population of marine organisms. Individuals with different genotypes and phenotypes exhibit different adaptability and survival abilities in response to different environmental pressures. Protecting and maintaining genetic diversity in marine organisms has an impact on enhancing their adaptability and risk resistance. The genotype differences among different marine organisms are very significant, and this variation exists among different individuals within the same species. Genetic variation is mainly manifested in differences in gene sequences or genomic structures. Marine organisms with different genotypes exhibit different adaptability and survival abilities in response to different environmental pressures. There is also phenotypic diversity, which refers to differences in morphology, physiology, behavior, and other aspects among different marine organisms. Phenotypic diversity is primarily the result of the interaction between genetic variation and environmental factors. Marine organisms with different phenotypes exhibit different growth and reproductive characteristics in different environments. Additionally, there is reproductive diversity, which refers to differences in gender and reproductive methods among different marine organisms. For example, some fish are oviparous while others are viviparous; some fish are unisexual while others are hermaphroditic. These reproductive differences have corresponding impacts on the roles and adaptability of different marine organisms in the ecosystem.

2.3 Ecosystem diversity

Ecosystem diversity refers to the differences and variations in different ecological types within marine ecosystems, including the physical, chemical, and biological characteristics of marine ecosystems (Sun et al., 2022). Different ecosystems have different ecological niches, functions, and processes, collectively constituting the diversity of marine ecosystems. Protecting and maintaining ecosystem diversity is of great significance for maintaining the balance and stability of marine ecosystems. The physical characteristics include seawater temperature, salinity, light availability, water currents, and waves, among others. Different marine areas and depths exhibit significant differences in the physical characteristics of their ecosystems. For example, coral reef ecosystems in the ocean

(Figure 3) require suitable water temperatures and light conditions to survive and reproduce, while deep-sea ecosystems require appropriate water pressure and temperature conditions for survival and reproduction. The chemical characteristics of marine ecosystems include dissolved oxygen, salinity, pH value, nutrients, and organic matter in the water. Different marine areas and depths also exhibit significant differences in the chemical characteristics of their ecosystems (Petro and Alice, 2021). For instance, estuarine and nearshore areas have higher nutrient levels in the water, while open ocean areas have lower nutrient levels.



Figure 3 Coral reefs in the ocean

3 Factors Influencing Marine Biodiversity

Marine biodiversity is influenced by various factors, including hydrological conditions, climate change, pollution, and overfishing. In order to maintain the stability of marine biodiversity, a series of measures need to be taken to reduce the negative impact of these influencing factors and protect marine ecosystems and biodiversity.

3.1 Impact of hydrological conditions and climate change

Changes in hydrological conditions such as water temperature, salinity, water currents, and waves can significantly impact the habitat and reproduction of marine organisms. For example, increased water temperature can lead to mass coral mortality in coral reef ecosystems, while excessive nutrients in seawater can cause algal blooms, affecting the survival of other organisms. Climate change-induced changes in water temperature, sea-level rise, ocean acidification and other changes can also affect the survival and reproduction of marine organisms. Temperature directly affects the metabolic intensity of marine organisms, thereby controlling their growth, development, population dynamics, and distribution. For example, climate change-induced melting of Arctic ice can impact the stability and biodiversity of Arctic ecosystems (Matias et al., 2023). Additionally, temperature influences food availability and the dynamic changes in physical and chemical factors in marine waters, indirectly influencing the life and survival of marine organisms. The rising temperatures can inhibit the growth and reproduction of marine organisms while accelerating their metabolism, shortening their lifespan. In recent years, due to the increasing greenhouse gas emissions, UV radiation reaching the Earth's surface has been increasing annually. The increase in UV radiation is likely to reduce the productivity of marine phytoplankton and impact the early development of animals such as fish, shrimp, and shellfish in the ocean (Jason et al., 2022).

3.2 Impact of marine pollution and overfishing

Marine pollution, including the impact of pollutants such as organic matter, chemicals, plastics, and radioactive substances on marine ecosystems. Common plastic waste can cause severe harm to marine organisms, and prolonged pollution can lead to population reduction and ecosystem degradation. Pollution can harm or poison marine organisms, affecting their normal reproduction and potentially causing genetic mutations (Dan et al., 2023). Pollution has already altered the coastal ecological environment and the biodiversity of estuaries. Overfishing can deplete certain fish populations and disrupt ecosystem balance. Marine fishing can significantly reduce the biomass or abundance of target species in the ocean, and targeted and high-intensity marine fishing often leads to

rapid reduction and depletion of target organisms. Overfishing of sharks, for example, resulting in a sharp decrease in their population, will impact the balance and stability of the entire marine ecosystem.

3.3 Impact of marine aquaculture

The establishment of marine aquaculture farms (Figure 4) is highly likely to occupy the original habitats of wild marine organisms, causing changes in their survival environment and thus disrupting marine biodiversity. The high demand for natural seedlings in marine aquaculture often has adverse effects on natural populations, resulting in a decrease in marine biodiversity. Feeding in aquaculture can also have an impact on marine biodiversity. In the case of net cage aquaculture in seawater, the discharge of residual feed and metabolites can lead to changes in organic matter and the content of solid and dissolved nutrients, potentially causing changes in benthic communities in the farming area and leading to a decline in marine biodiversity. Previous studies have shown that eutrophication and imbalanced nitrogen-phosphorus ratios in aquaculture areas are significant factors in the occurrence of red tides, which are concentrated manifestations of extreme reduction in marine plankton biodiversity. Additionally, escaped organisms from marine aquaculture can have implications for disease transmission and changes in the genetic composition of wild populations, further impacting marine biodiversity.



Figure 4 Seawater aquaculture farm

4 Summary and Outlook

The vast oceans harbor a multitude of familiar and yet undiscovered organisms, making them a treasure trove of resources. From the colorful seaweeds on the ocean surface to the majestic whales, diverse mollusks, and an array of fish species that inhabit the ocean floor. Therefore, it is crucial for us to enrich our understanding of marine biodiversity and recognize its significance.

Marine biodiversity holds important ecological, economic, scientific, and cultural values and is one of the fundamental and crucial characteristics of marine ecosystems. The protection and rational utilization of marine biodiversity are of great significance for maintaining the sustainable development of marine ecosystems and human society (Guo and Zhu, 2010). Marine biodiversity is closely linked to the ecological functions of marine ecosystems, including material circulation, energy flow, ecological balance and stability. The diversity and stability of ecosystems prevent disruptions and collapses, thereby safeguarding the various ecological functions of the ecosystems. Additionally, marine biodiversity provides abundant marine resources such as food, pharmaceuticals, chemicals, fuel, and building materials. These resources hold significant economic value for human production and livelihood, emphasizing the importance of protecting and responsibly utilizing marine biodiversity for human economic and social development.

Marine biodiversity is an integral component of overall biodiversity and holds significant scientific value for research in various disciplines such as biology, ecology, environmental science, and earth science. Exploring the interactions between marine biodiversity and marine ecosystems enables a deeper understanding of the structure and functions of marine ecosystems, thus providing scientific basis for the protection and rational utilization of marine ecosystems. Furthermore, marine biodiversity serves as an important source of inspiration for human culture and art, with various marine organisms representing significant symbols and imagery in human cultural and artistic expressions. Protecting marine biodiversity contributes to the preservation and inheritance of the richness and diversity of human culture and art.

Authors' contributions

WJN is the primary author of this review, responsible for conducting relevant literature research, writing the initial draft of the paper, and participating in the analysis and organization of the literature. HQK contributed to the revision and guidance of the paper. Both authors have read and agreed to the final text.

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