International Journal of Marine Science, 2023, Vol.13, No.6, 1-7
http://www.aquapublisher.com/index.php/ijms

Review and Progress Open Access

Current Status and Future Trends of Marine Biodiversity

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International Journal of Marine Science, 2023, Vol.13, No.6, doi: 10.5376/ijms.2023.13.0006
Received: 22 Sep., 2023
Accepted: 21 Nov., 2023
Published: 12 Dec., 2023

Preferred citation for this article:
Wu J.N., and Chen M.Y., 2023, Current status and future trends of marine biodiversity, International Journal of Marine Science, 13(6): 1-7 (doi: 10.5376/ijms.2023.13.0006)

Abstract Marine biodiversity is an important component of the global ecosystem, and the current status and changing trends of marine biodiversity are complex issues that require consideration of multiple factors in their research. It is estimated that there are over 2 million species in the ocean, many of which are still undiscovered. However, due to factors such as human activities and climate change, global marine biodiversity is facing serious threats and challenges. This article aims to explore the current status and future trends of global marine biodiversity, and propose measures and methods for protecting marine biodiversity. Emphasize the importance and necessity of protecting marine biodiversity, propose future prospects and development directions, and call on the global community to jointly protect marine biodiversity.

Keywords Marine biodiversity; Changing trends; Current status of biodiversity; Protective measures

According to some studies, the biomass of marine organisms has been declining in the past few decades. The International Union for Conservation of Nature (IUCN) estimates that currently over 30% of marine species are endangered or threatened. Among them, the decline in the numbers of fish and benthic organisms (Figure 1) is particularly significant. Many marine species are on the brink of extinction, such as seals, turtles, and whales. The populations of some species have decreased to critically endangered levels. The changing trend of global marine biodiversity is influenced by multiple factors, with human activities such as overfishing, climate change, marine pollution, and habitat destruction being one of the main reasons for the reduction of marine biodiversity (Tiziana and Michaela, 2022).

Figure 1 Marine benthos

The impact of climate change on marine biodiversity is increasingly evident, and some temperature-sensitive species may continue to decrease as global temperatures rise, resulting in a reduction in global marine biodiversity. The rise in ocean temperature and the intensification of acidification pose a threat to the survival and reproduction of marine organisms. Marine pollution also has potential implications for marine biodiversity, with the discharge of plastic waste and chemical substances being significant concerns.

Marine biodiversity has undergone significant changes in recent years. While some measures have been taken to protect marine biodiversity, more efforts and actions are still needed to safeguard the diversity of marine organisms and the health of ecosystems (Li and Ji, 2013). This review aims to analyze the current status of global marine biodiversity, identify the impacts on existing marine biodiversity, and highlight some shortcomings in conservation measures. Furthermore, it seeks to analyze the future trends in marine biodiversity and summarize the collective measures required to address the issue of global marine biodiversity.

1 Current Status of Marine Biodiversity

1.1 Status of species numbers

Currently, there are over 200 000 known species in the world's oceans, and it is estimated that there may be over 2 million species. However, over the course of approximately 250 years of human activity, humans have already driven at least 15 whale species, 7 dolphin and seal species, over 70 sea turtle species, and other marine organisms to extinction or near-extinction (Lu et al., 2016). According to data from the International Union for Conservation of Nature (IUCN), there are currently seven whale species that are classified as endangered, including the blue whale, fin whale, and Arctic whale. The numbers of these whale species have drastically decreased, with some species having populations of fewer than 500 individuals. The global population of sea turtles is also rapidly declining, with species such as the green turtle, olive ridley turtle, and leatherback turtle being classified as endangered. Global coral reefs face severe destruction and threats, with some reefs being on the brink of extinction. Due to factors like climate change and ocean acidification (Figure 2), the number and coverage of coral reefs are rapidly decreasing, while overfishing and pollution have led to a significant decline in fish populations. It is estimated that one-third of global fish species are threatened by overfishing.

Figure 2 Phenomenon of ocean acidification

1.2 Current status of species diversity

Species diversity within marine ecosystems is an important component of marine biodiversity. Currently, marine biodiversity is widely distributed globally, encompassing various ecosystems such as coral reefs, seagrass beds, deep-sea habitats, and coastal ecosystems. The number and diversity of species vary across different ecosystems, but overall, marine biodiversity is incredibly rich. The distribution of marine biodiversity in different countries or regions is influenced by multiple factors, including water temperature, ocean currents, water depth, and human activities. Alaska is an area with abundant marine biodiversity (Figure 3), supported by its cold waters and rich nutrients, which sustain a diverse range of marine organisms. Marine species in Alaska include Arctic whales, seals, sea lions, and various fish species. The waters surrounding Antarctica are also an area of rich marine biodiversity due to the cold Antarctic waters that harbor abundant planktonic and benthic organisms, including seaweeds, crustaceans, and fish. There are various corals, fish, turtles, and dolphins in the Caribbean Sea. However, the Caribbean Sea also faces numerous threats, including climate change, pollution, and overfishing. The Pacific Ocean, one of the largest oceans globally, hosts a plethora of fish, dolphins, whales, sea turtles, and more, showcasing the impressive complexity and diversity of its ecosystems.

Figure 3 Alaska Sea Area

1.3 Existing threats and challenges

Global marine biodiversity faces numerous threats and challenges, including climate change, ocean pollution, overfishing, and habitat loss. These threats and challenges can result in a reduction of marine biodiversity, species extinction, and ecosystem degradation (Fernanda and Edvaldo, 2018).

1.3.1 Climate change

Climate change leads to rising sea temperatures, which can impact the distribution and growth of marine organisms. Some species may be forced to migrate to more suitable habitats, while others may die due to an inability to adapt to the new temperatures. Additionally, increased temperatures can lead to changes in nutrient availability in the seawater, affecting the stability of marine food chains. As atmospheric carbon dioxide increases, the pH of the oceans is declining, resulting in ocean acidification. This has negative impacts on the survival and reproduction of marine organisms. For example, acidified seawater can affect the shell growth of shell-forming organisms, making them more susceptible to other threats. Climate change also contributes to rising sea levels, which affect coastlines and coastal ecosystems. Rising sea levels can cause shoreline retreat (Figure 4), leading to the loss of coastal wetlands and impacting the habitats and breeding grounds of many marine organisms.

Figure 4 The phenomenon of coastline retreat

In recent years, both sea temperatures and sea levels have been rising. According to research by international climate scientists, the global average sea temperature has increased by approximately 0.13 °C to 0.20 °C over the past few decades and is continuing to rise. At the same time, sea levels are also rising at a rate of approximately 3 mm per year. These changes are primarily attributed to climate change caused by human activities such as greenhouse gas emissions and deforestation. The rising sea temperatures and sea levels have significant impacts on marine biodiversity, leading to declines in the populations of many species and changes in ecosystems.

1.3.2 Overfishing

Overfishing is currently one of the primary threats to marine biodiversity, with a large number of fish, shellfish, and other marine organisms being excessively harvested, leading to drastic declines in many species. In recent years, the issue of overfishing has remained severe, with the populations of many fish, shellfish, and other marine organisms declining, and some even nearing extinction. This is primarily due to overfishing and irresponsible fisheries management. The impact of overfishing on marine biodiversity is significant, and if it continues, some species may go extinct, while others will decrease to a level where they cannot sustain their ecological functions, resulting in the collapse of entire ecosystems. Countries such as China, Japan, Indonesia, and the Philippines are among the largest fishing nations globally, and their fishing activities and methods have a significant impact on marine biodiversity. Additionally, fishing activities in regions like Europe and North America are also prominent, and these countries have implemented measures to mitigate the impact of overfishing (Natali, 2023).

1.3.3 Pollution situation

Marine pollution is another significant threat to marine biodiversity, including wastewater discharge, oil spills, and plastic waste, among others. These pollutants have a severe impact on the health and living environment of marine organisms. Wastewater, industrial effluents, chemicals, and other pollutants in the ocean can lead to a decline in water quality. These pollutants can directly poison or kill marine organisms or affect their reproduction and growth. Plastic waste has particularly severe effects on marine organisms, and the harm caused by plastic pollution to marine life includes ingestion, entanglement, poisoning, and suffocation. These will lead to a decrease in the number of many species and changes in ecosystems.

Sediment pollution (Figure 5) is caused by land erosion and human activities. Sediment pollution can result in sedimentation and slowed water flow, thereby impacting the habitats and breeding grounds of marine organisms. Due to large populations and rapid economic development, marine pollution issues are particularly prominent in Asian regions. For example, many coastal cities in China face serious water and plastic pollution, which significantly impact local fisheries and ecosystems. In Europe, marine pollution issues are relatively milder but still exist. The Mediterranean region also experiences significant marine pollution, primarily due to tourism and marine traffic. In North America, marine pollution issues are concentrated around coastal areas near major cities such as Los Angeles and New York, where serious water and plastic pollution problems occur (Siân et al., 2021). Pacific island nations face marine pollution issues mainly due to marine debris and climate change, which have significant impacts on local fisheries and ecosystems. Marine pollution is a global issue, and pollution levels vary across different regions due to factors such as geographical location, economic development, and population size.

Figure 5 Marine pollution caused by ship explosions

1.3.4 Urbanization and coastal development

With the acceleration of urbanization and coastal development, many marine organisms have lost their habitats and are even facing extinction. As urbanization progresses, the water bodies around cities are significantly impacted. Sewage, wastewater, and industrial effluents from urban areas are directly discharged into water bodies, leading to marine pollution and a decline in water quality, which affects the survival and reproduction of marine

organisms. Additionally, construction activities in coastal cities can also disrupt the habitats and breeding grounds of marine organisms, resulting in a decrease in species populations and changes in ecosystems. The Gulf of Mexico is an important region along the U.S. coastline, but activities such as oil extraction have had a significant impact on local marine biodiversity. Oil spills, explosions, and the discharge of pollutants can poison or kill marine organisms, threatening the sustainability of local fisheries and ecosystems. Coastal development activities inevitably have negative effects on marine biodiversity. The Marina Bay area in Singapore is an emerging region for urbanization and coastal development, but the construction of the Marina Bay Sands Hotel may impact local marine biodiversity. The construction process could potentially damage local habitats and breeding grounds, leading to a decrease in species populations.

2 Future Trends in Marine Biodiversity

2.1 Trends in the impact of future climate change on marine biodiversity

Future climate change is likely to have broader and deeper impacts on marine biodiversity. Trends such as ocean acidification, rising ocean temperatures, and sea-level rise may lead to a decrease in species populations and changes in ecosystems, affecting the sustainability of local fisheries and ecosystems. Future global temperatures are expected to continue rising. By the end of this century, the global average temperature may be 2 °C~4 °C higher than pre-industrial levels. Global warming is a major trend that will result in the melting of ice caps, rising sea levels, and a reduction in the area available for aquaculture. Additionally, as temperatures rise, water temperatures will also increase, leading to shorter "degree heating days" required for the embryonic and post-embryonic development of marine fish, which accelerates the growth and development of marine fish. Continued ocean acidification in the future may impact the growth and reproduction of species such as shellfish, certain seaweeds, and corals. There may also be an increase in extreme weather events, including heatwaves, droughts, floods, and hurricanes. These events can cause changes in coastlines and marine ecosystems, thereby impacting marine biodiversity.

2.2 Trends in the impact of future overfishing on marine biodiversity

Future overfishing may lead to a decrease in populations of certain species, thereby affecting the sustainability of local fisheries and ecosystems. Some species may face extinction due to overfishing, such as large sharks and sea turtles. Natural resource populations have inherent regulatory capabilities to maintain balance, and with moderate fishing, the original marine populations can still be maintained at certain levels. However, in the future, coastal areas will experience an increase in fishing vessels, and fishing methods will become more sophisticated. Fishermen may expand production without proper regulation, resulting in further damage to marine biodiversity, particularly the continuous decline of economically important fish resources. The fundamental principle of fisheries resource management is to maintain the reproductive capacity of fishery resources. Its purpose is to ensure the maximum sustainable utilization of marine species by humans and to ensure that natural water bodies provide abundant economic marine resources for humans in the long term. If future fishing practices continue to be excessive, it will further reduce the ability of marine fish populations to cope with environmental changes, leading to changes in marine biodiversity and direct destruction of marine ecosystems.

3 Measures to Address the Issue

Governments around the world have taken measures to address the issue by establishing marine protected areas to safeguard marine habitats and ecosystems (Li, 2019). These protected areas can restrict human activities and reduce the impact on marine biodiversity, thus preserving the diversity of marine life. The United States government has established numerous marine protected areas, including the Papahānaumokuākea Marine National Monument in Hawaii and the Florida Earth Reserve in Florida. These protected areas aim to safeguard coral reefs, marine organisms, and ecosystems, minimizing the impacts of human activities (Arthur and Milali, 2019).

The Chinese government has established marine protected areas in the East China Sea, including the Zhoushan Marine Protected Area and the Fujian East China Sea Marine Ecological Protection Area. In the South China Sea, marine protected areas have been established, such as those encompassing the Nansha Islands and Xisha Islands. Additionally, there is a marine protected area in the Bohai Sea, covering the waters of Liaoning, Tianjin, and

Hebei provinces. The Australian government has also established various marine protected areas, including the Great Barrier Reef Marine Park and marine protected areas in Antarctica. These marine protected areas serve to safeguard marine biodiversity and ecosystems, reducing the impact of human activities.

Scientific research and monitoring play crucial roles in maintaining marine biodiversity. Governments worldwide have intensified research and monitoring efforts to understand the distribution, abundance, and changes in marine organisms and ecosystems, providing scientific foundations for the conservation of marine biodiversity (Helike, 2021). By monitoring whale populations, scientists can gather information on their numbers, distribution, habitats, and migration routes. This data assists in formulating policies and measures to protect whales and their habitats, mitigating the impact of human activities. Monitoring the DNA of marine organisms allows scientists to assess population numbers, distribution, and genetic variations, enabling a better understanding of marine biodiversity and evolutionary history. Consequently, this aids in formulating effective policies and measures to conserve marine organisms.

In the future, we need to continue promoting the establishment of marine protected areas to safeguard the habitats and ecosystems of marine organisms. Additionally, we should strengthen the supervision and management of these protected areas to minimize the impact of human activities on marine life. Control the impact of human activities on marine life, including reducing fishing, controlling marine pollution, and limiting marine development. Professionals need to enhance scientific research and monitoring of marine biodiversity to understand the population, distribution, and health of marine organisms, as well as the impact of human activities on them. National governments should enhance marine education to raise public awareness and understanding of marine biodiversity and ecosystems. This will foster public concern and support for the protection of marine organisms, promoting the conservation and sustainable development of marine biodiversity. International cooperation is crucial to collectively protect the health and sustainable development of marine biodiversity and ecosystems. Governments and scientists from different countries can share data and research findings to collaboratively develop conservation plans for marine biodiversity.

4 Summary and Outlook

Marine biodiversity provides crucial ecological resources for marine ecosystems. The interactions among various marine organisms contribute to a complex ecological balance, which is essential for maintaining the stability and health of marine ecosystems. Marine biodiversity holds significant importance for humanity. Many pharmaceuticals and food resources are derived from marine organisms, such as fish, shellfish, and seaweed. The ocean harbors numerous undiscovered species, many of which may possess unknown characteristics and functions, holding great potential for scientific research and technological innovation.

Marine biodiversity also has a significant impact on the biogeochemical cycles of the Earth (Marie, 2015). Marine organisms in the ocean participate in crucial biogeochemical processes, such as the carbon and nitrogen cycles, by absorbing carbon dioxide and organic matter. This study explores the current status and future trends of marine biodiversity, as well as measures to protect marine biodiversity. By understanding marine biodiversity, we can better formulate protective measures to safeguard the diversity of marine life and the health of ecosystems.

In the future, it is necessary to continue strengthening the establishment of marine protected areas, limiting unnecessary human activities, enhancing scientific research and monitoring, promoting marine education and awareness, and fostering international cooperation to address the fragmented state of marine biodiversity. Additionally, it is important to recognize that protecting marine biodiversity is a complex and long-term endeavor that requires collective efforts from across various sectors. Apart from the involvement of governments and scientists, public awareness and support are also crucial. We need to educate and promote more people about the importance of marine biodiversity through popular science education, orderly use and reasonable protection of abundant marine life, and thus promote the implementation and implementation of conservation measures.

Authors' contributions

CMY is the primary author of this review, responsible for the initial draft writing and revisions. WJN conceived and supervised the

project, participated in data organization and analysis, and provided guidance in writing the paper. Both authors read and approved the final manuscript.

Acknowledgments

We would like to express our gratitude to Ms. Lingfei Jin and Ms. Chuchu Liu for their valuable suggestions and revisions during the writing process of this paper. Some of the illustrations used in this study are sourced from the internet. If any of the images infringe upon copyright, please feel free to contact the authors. We respect and uphold the rights of every image owner. Once again, we appreciate your understanding and support.

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