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Marine Biology under Climate Change: Challenges, Adaptations, and Future Directions

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Abstract In facing the challenges of global climate change, the changes in marine ecosystems have attracted widespread international attention. The ocean is not only a treasure trove of biodiversity but also a key factor in regulating the Earth's climate. This study provides a comprehensive analysis of the impacts of climate change on the marine environment and its biodiversity, including the long-term effects of rising sea temperatures, acidification, and sea level rise on marine life and ecosystem services. Through an in-depth exploration of the adaptive changes in marine organisms, this study reveals the vulnerability of marine ecosystems to climate change and their adaptation mechanisms, highlighting the importance of marine biology research in understanding and responding to climate change. This research looks forward to future directions and technological developments in marine biology, focusing on the scientific challenges faced and strategies for transitioning to sustainable development, with the aim of promoting the health of marine ecosystems, the conservation of biodiversity, and the development of human society.
Keywords Climate change ; Marine ecosystem; Biodiversity; Marine conservation; Sustainable management

In the current context of global climate change, marine environments are undergoing unprecedented changes that are having profound impacts on the largest ecosystems on Earth. Rising sea levels, increased seawater temperatures, ocean acidification, and the increased frequency and intensity of extreme climate events not only threaten the living environment of marine life, but also pose direct challenges to the economic development and quality of life of human society. In this case, marine biology research is particularly important. It not only helps us understand the specific impacts of climate change on marine life and ecosystems, but also provides scientific basis and solutions for dealing with these changes.

Ruckelshaus et al. (2013) discussed the vulnerability of marine ecosystem services that humans depend on under future climate change, as well as preliminary attempts at climate adaptation planning. Miller et al. (2018) discussed adaptation strategies in marine systems through specific case studies, including evidence that organisms adapt to climate change by changing distribution and timing of biological events, as well as the issue of limited evidence of adaptation through evolutionary processes. The study of marine biology ranges from the physiological and behavioral adaptations of individual species to the functions and services of entire ecosystems, and these studies have acquired new significance in the context of the global issue of climate change. By deeply studying the response mechanisms of marine organisms to environmental changes, scientists can predict future change trends, assess the risk of biodiversity loss, and develop effective conservation and management strategies. Marine biology research can also help reveal the potential impacts of climate change on human society, such as food security, coastal protection and economic activities, and provide support for the development of climate adaptation and mitigation measures.

The goal of this study is to comprehensively evaluate the impact of climate change on marine organisms and ecosystems, explore the response mechanisms of marine organisms to these environmental changes, and assess the potential impact of these changes on human society. This study systematically analyzes the interaction between climate change and the marine environment, including changes in the distribution of marine life, impact assessment of ecosystem services, and marine life protection strategies in the face of climate change.

As climate change continues, marine biology research plays an increasingly important role in global environmental protection and ocean management. By in-depth study of the impact of climate change on the ocean and the adaptation strategies of marine life, we can not only better understand the complexity of marine ecosystems, but also provide a solid scientific basis for developing effective protection measures and response strategies to ensure the protection of the ocean, and the sustainable development of its precious resources.

1 Responses of Marine Ecosystems to Climate Change

1.1 Biological impacts of ocean temperature changes

Changes in ocean temperatures and their extreme manifestations, such as heat wave events, have profound effects on biological survival rates, reproductive cycles, and predator-prey relationships in marine ecosystems. As the global climate warms, the frequency and intensity of marine heat wave events continue to increase, causing many marine organisms to face unprecedented survival pressure. During heat wave events, the survival rate of marine life is significantly reduced, especially species that are more sensitive to temperature changes, such as corals in coral reefs. Research by Sahin et al. (2023) believes that heating rate is a good predictor of coral bleaching susceptibility, and rapid heating can lead to more severe bleaching and decline in coral health.

Rising ocean temperatures are also having an impact on reproductive cycles, with temperature being a key trigger for reproduction in many marine species. Changes in temperature will affect the timing of reproduction, the development rate of larvae, and reproductive success, thereby further affecting the long-term survival and community structure of the species. Research by Hays et al. (2021) shows that marine heat waves not only have a destructive effect on coral reef ecosystems, but may also have a negative impact on the reproduction of endangered species such as sea turtles, showing the expansion of the scope of influence of marine heat waves.

The impact of temperature changes on predator-prey relationships cannot be ignored. This impact may be manifested through changes in species behavior, distribution range, and physiological responses. Changes in temperature may lead to asynchronous spatial distribution between predators and prey. For example, some prey may migrate to cooler waters, but their predators may not be able to follow, leading to a break in the food chain. At the same time, rising temperatures may also accelerate the growth and development rate of prey, affecting its role and quantitative balance in the ecosystem. Such changes in predator-prey relationships can lead to major changes in ecosystem function and stability, affecting biodiversity and ecosystem services.

1.2 Impact of changes in ocean chemistry

With the intensification of industrialization and human activities, the marine chemical environment is undergoing significant changes, and these changes have a profound impact on marine organisms and ecosystems. The increase in the concentration of carbon dioxide (CO_2) in the atmosphere is one of the main factors leading to seawater acidification. As more CO_2 is absorbed by the ocean, the pH of the seawater drops, causing the environment to acidify. Seawater acidification poses a threat to many marine species, especially those species that rely on calcium carbonate structures, such as shells and coral skeletons, to protect themselves and support ecosystems. This chemical change weakens their ability to build and maintain structure, affecting the structural integrity and biodiversity of coral reefs.

The decrease in dissolved oxygen in the ocean also has important consequences for organisms, especially those in the deep sea. The deep-sea environment is inherently hypoxic, but as stratification increases due to global warming, oxygen exchange between the surface and deep layers decreases, further reducing the dissolved oxygen content in the deep ocean. This low-oxygen environment is a huge challenge for deep-sea organisms that are highly dependent on oxygen. They may not be able to adapt to hypoxic conditions, leading to the loss of biodiversity and ecosystem functions.

The accumulation of heavy metals and other pollutants is also an important aspect of changes in ocean chemistry. As industrial wastewater, agricultural runoff, and urban discharges continue to enter the ocean, concentrations of heavy metals and other harmful substances in water bodies increase, and these substances can accumulate through the food chain and ultimately cause toxic effects on the ocean's top predators. In a changing environment, the bioavailability and toxicity of pollutants may increase, causing additional pressure on the growth, reproduction, and survival of marine life.

1.3 Biological effects of physical changes

Physical changes caused by global climate change have a wide range of impacts on marine ecosystems and organisms, among which sea level rise, changes in ocean currents, and extreme weather events are the most significant aspects. The continued rise in sea levels not only threatens the integrity of coastal habitats and leads to the loss of biological habitats, but also exacerbates the problem of saltwater intrusion and affects the freshwater supply of estuaries and wetland ecosystems. These habitat changes force many marine and coastal species to face migration or adaptation pressure, thereby affecting their distribution, population structure, and biodiversity. As habitats are submerged by seawater, some terrestrial and low-lying creatures are forced to move inland or higher, and it is still unknown whether these new habitats are suitable for their survival and reproduction.

Changes in ocean currents also have a profound impact on marine life. Hays (2017) explored the multiple impacts of ocean currents on marine life, such as cycles that carry organisms and nutrients, distribute heat and nutrients, and the latest developments in these impacts in the context of climate change. Poloczanska et al. (2016) reviewed the response of marine organisms to recent climate change in various ocean regions from tropical waters to polar oceans, and the impact of ocean currents on species distribution. Ocean currents are an important driving force for the migration and distribution of marine organisms, affecting the circulation and transfer of nutrients in the ocean, as well as the reproduction and spread of organisms. As climate change affects ocean temperature and salinity, ocean current patterns change, which may lead to changes in biological migration paths, affect the distribution range of specific species, and even change the structure of the marine food web (Figure 1).

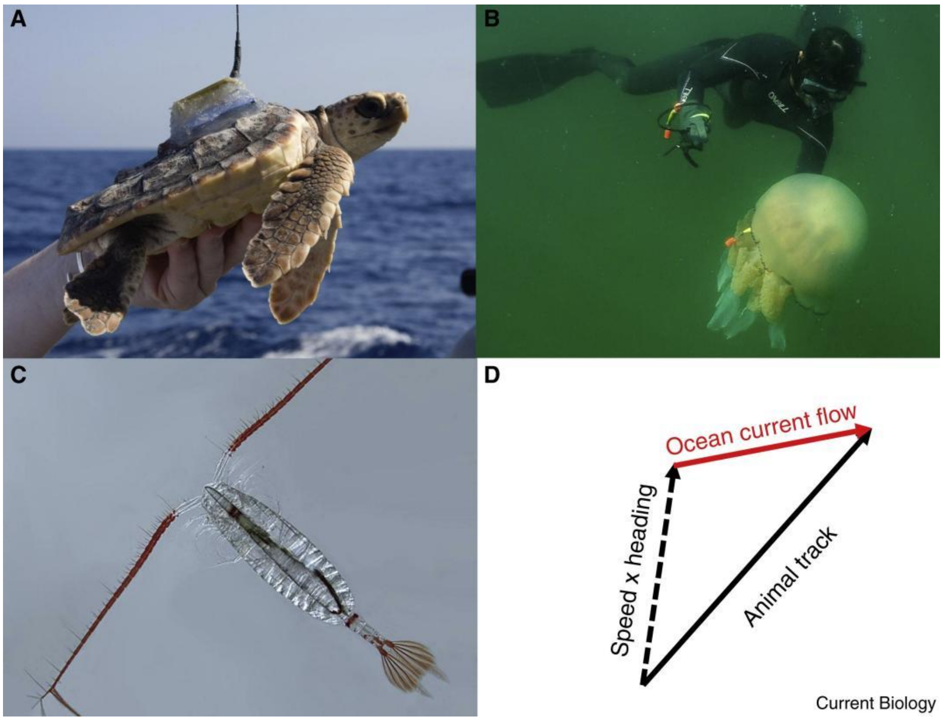

Figure 1 Impact of ocean currents on swimming animals (Adopted from Hays, 2017)

Extreme weather events, such as severe storms and heat waves, have a direct impact on marine life. These extreme events can not only cause short-term severe fluctuations in ocean surface temperature, affecting the living environment of marine life, but can also indirectly affect the growth and reproduction of marine life by increasing the amount of suspended sediment and changing the salinity of the water body. Extreme weather can also cause physical damage, such as hurricanes and severe storms that can destroy fragile ecosystems such as coral reefs and seagrass beds, which means the loss of food sources and habitat for marine species that rely on these ecosystems.

2 Biodiversity and Ecological Adaptation Strategies

2.1 Changes in species diversity

Changes in species diversity have always been a key factor in maintaining ecological balance and ecosystem functions. Over time, countless species have evolved under the influence of natural selection, and environmental changes, human activities and other factors have also led to the extinction of species and the emergence of new species. Species extinction is often caused by the inability of certain key populations in the ecosystem to adapt to rapidly changing environments or excessive human development activities, thus losing the basis for their survival. On the contrary, the emergence of new species is usually the result of natural selection and evolution, reflecting the ability of life to adapt and evolve to environmental changes. However, in modern times, human activities have accelerated the rate of species extinction, and the formation rate of new species has been far unable to keep up, leading to a sharp decline in biodiversity.

Reductions in species diversity have profound consequences for ecosystem functioning. Each species plays a specific role in the ecosystem in which it lives, and each layer, from basic producers to apex predators, is critical to maintaining ecological balance. The loss of species means that certain functions in the ecosystem may be weakened or eliminated, such as pollination services, soil formation and nutrient cycling, which are necessary to maintain ecosystem health and human well-being. Therefore, reduced species diversity directly affects ecosystem stability, resilience, and productivity.

Genetic diversity is the cornerstone for species to adapt to environmental changes. It is not only related to the survival and reproduction of individual organisms, but also the key to species' response to external stress, disease and environmental changes. Higher genetic diversity means there are more genetic variations in a population, which provides richer "raw materials" for natural selection, thereby enhancing the species' adaptability and evolutionary potential. However, when a species faces extreme environmental pressure or a sharp decline in population, genetic diversity will be affected, reducing the species' ability to adapt to new environmental challenges and further exacerbating the species' extinction risk.

2.2 Adaptation mechanism and evolution

In nature, biological populations respond to environmental changes through various adaptive mechanisms and evolutionary processes, including phenotypic plasticity, genetic adaptation, and interaction and co-evolution between species.

Phenotypic plasticity is an important mechanism for species to adapt to environmental changes, which allows organisms to exhibit different physiological and behavioral characteristics under different environmental conditions without involving changes in genes. This plasticity allows individuals to respond quickly to environmental changes throughout their lives to survive and thrive in different environments (Fox et al., 2019). Complementing phenotypic plasticity is genetic adaptation, a longer-term process involving genetic variation and natural selection that enables species to adapt to specific environmental conditions during evolution.

Mutation is the basis of genetic adaptation and provides the raw material for natural selection. Under new environmental conditions, certain mutations may confer higher survival and reproductive advantages to organisms. These beneficial mutations are subsequently retained through the process of natural selection, thus promoting the adaptation and evolution of species. Over time, these adaptive variations accumulate, potentially leading to the formation of new species.

Interactions between species, such as predation, symbiosis, competition, etc., also play a key role in the evolution process. These interactions change as the environment changes, prompting the species involved to coevolve. A plant may evolve more sophisticated defense mechanisms to resist predation by herbivores, and the herbivores may subsequently evolve the ability to overcome these defense mechanisms. This process of co-evolution not only deepens the interdependence between species, but also increases the complexity and stability of the ecosystem.

2.3 Ecosystem services

Ecosystem services are a series of important benefits and resources provided by nature to human society and are the basis of human well-being. In marine ecosystems, these services include, but are not limited to, biological resource provision, carbon cycle regulation, water purification, and cultural and recreational values. The sustainable use of marine biological resources is key to maintaining ecological balance and ensuring long-term human well-being. As the global population grows and demand for marine resources rises, overfishing, pollution, and destruction of marine habitats threaten the diversity of marine life and the stable provision of ecosystem services. Therefore, sustainable management of marine resources has become an urgent global issue that needs to be solved.

In recent years, as people's understanding of the value of ecosystem services deepens, the changing trends of ecosystem services have received widespread attention. Climate change, environmental degradation, and biodiversity loss have led to a decline in ecosystem service capabilities, which in turn affects human food security, health, and quality of life. For example, the degradation of coral reefs not only reduces fish stocks, it also weakens coastal protection and tourism revenue, directly affecting the economic well-being of coastal communities.

In the face of these challenges, ecosystem restoration and protection strategies are particularly important. Ecosystem restoration includes a range of activities aimed at restoring damaged ecosystem function and diversity, such as restoring coral reefs, rebuilding coastal wetlands and reducing pollution sources. van Oppen et al. (2017) discussed enhancing coral tolerance to environmental stress through assisted evolution. These measures not only help protect biodiversity, but also enhance the ecosystem's ability to adapt to climate change and improve its ability to provide long-term services. The conservation strategy covers the development of more stringent resource management policies, raising public awareness of environmental protection and promoting international cooperation, aiming to create a more harmonious and sustainable future for nature and humans.

3 Application of Technologies and Methods in Marine Biology Research

3.1 Remote sensing and satellite monitoring technology

Remote sensing and satellite monitoring technologies play an increasingly important role in global environmental and ecosystem research, especially in the study of oceans. These technologies provide a unique method to continuously monitor the physical, chemical and biological processes of the ocean on a global scale, thereby providing valuable data on the health and changing trends of marine ecosystems.

Using remote sensing technology to monitor ocean temperature and biological distribution, scientists are able to track changes in seawater temperature and how these changes affect the distribution and migration patterns of marine life in near real-time conditions. Arora et al. (2019) used NOAA OISST v2 data to conduct thermal stress analysis on five major coral reef areas in India from 1982 to 2018. The results were closely related to the large-scale coral bleaching events recorded in 1998, 2010 and 2016. Klemas (2010) reviewed the utility of remote sensing technologies in monitoring coastal ecosystems such as wetlands, estuaries, and coral reefs, including the use of multispectral and hyperspectral imagers for coastal land cover mapping, and the use of thermal infrared scanners to accurately map sea surface temperatures and current charts.

Although ocean acidification and its impact on biological community structure are difficult to monitor directly through remote sensing technology, related indirect methods and models are being developed and applied. By monitoring key variables of the ocean carbon cycle, such as the concentration of dissolved carbon dioxide, and combining data with other ocean chemistry parameters, scientists can assess acidification trends and the impact they may have on the structure of biological communities. Although research in this area is still in its developmental stages, it demonstrates the potential of remote sensing technology in understanding marine ecosystem responses to global change.

Long-term ecosystem health monitoring is another important application of remote sensing technology. By collecting and analyzing data over time on ocean color, temperature, sea ice coverage and sea level height, scientists are able to track trends in ecosystem change and identify signs of potential environmental stress and ecosystem degradation. This long-term monitoring is critical for assessing the impact of global change on marine ecosystems, developing conservation and management strategies, and evaluating the effectiveness of restoration measures.

3.2 Molecular biology and genetics technology

In the advancement of modern biological sciences, the application of molecular biology and genetics techniques has become a key tool for understanding the complexity of life and promoting biological conservation. These technologies play a crucial role in the study of species adaptation, conservation biology, and the revelation of adaptation mechanisms.

Genomics, as a branch of molecular biology, provides in-depth insights into how species adapt to changes in their environment by analyzing their genome-wide information. This technique allows scientists to identify which genes or regions of the genome are involved in responses to specific environmental stresses, such as climate change, disease, or changes in the food supply. In the study of species adaptability, the application of genomics not only reveals the relationship between genetic variation and species adaptability, but also provides valuable information about how species enhance their ability to survive and reproduce through genetic diversity.

Population genetic analysis plays a central role in conservation biology. By comparing genetic differences between different populations, this technique helps scientists identify genetic flow between populations, population bottleneck events, and the impact of geographic and environmental isolation on species' genetic diversity. This information is critical for developing effective species conservation and management strategies, especially in the face of threats such as habitat fragmentation and climate change. By understanding the genetic structure of populations, conservation biologists can better plan species recovery projects and protected areas to promote the conservation of genetic diversity and population health.

Functional genomics focuses on the study of gene expression and regulatory mechanisms, revealing how organisms respond to environmental changes at the molecular level. This technology helps scientists understand which genes are involved in adaptation processes by analyzing changes in gene expression under specific environmental conditions, and how these adaptations are achieved by changing gene expression patterns. For example, functional genomics can reveal how plants regulate the expression of specific genes under temperature changes or water stress to adapt to these conditions (Floris et al., 2009). Such research provides an important perspective on revealing the complex mechanisms behind biological adaptation and is of great significance for understanding how species respond to rapidly changing environments.

3.3 Model and prediction methods

In today's rapidly changing world, models and prediction methods have become powerful tools in the hands of scientists, especially in studying the impact of climate change on ecosystems, predicting future trends in species distribution, and conducting ecological risk assessments under climate change scenarios. evaluation aspect. These methods not only help us understand the current ecological state, but more importantly, they provide us with the ability to foresee the future and develop adaptation and mitigation measures.

Ecosystem models play a key role in studying the impacts of climate change. By building comprehensive models that include multiple ecological processes and factors, scientists can simulate and analyze the potential impacts of climate change on biodiversity, ecosystem services, and ecosystem functions. These models take into account factors such as rising temperatures, changing precipitation patterns, and increases in extreme climate events, allowing us to predict ecosystem responses under different climate scenarios. In this way, ecosystem models provide a basis for understanding the long-term effects of climate change and assessing vulnerability and resilience (Metzger et al., 2008).

Species distribution models are another important prediction tool that predict species distribution in geographic space and future distribution trends by combining species presence records with environmental variables. These models focus specifically on how climate change affects species' habitat areas, migration routes, and whether species can adapt to new habitat conditions. As global temperatures rise and habitat fragmentation intensifies, species distribution models have become an important basis for predicting potential extinction risks of species, planning conservation areas, and formulating species management strategies.

Under climate change scenarios, ecological risk assessment is a vital task, which involves the assessment of the vulnerability and adaptive capacity of various organisms in the ecosystem and their interactions under future climate change pressures. By using models and prediction methods, scientists can assess ecological risks under different climate change scenarios, including the risk of species extinction, degradation of ecosystem functions, and risk of biodiversity loss. The results of these assessments are critical to developing effective climate adaptation measures, biodiversity conservation strategies, and natural resource management policies.

4 Policy, Management and Future Research

4.1 Climate change and ocean protection policies

The impact of climate change on marine ecosystems is becoming increasingly significant, from rising sea levels and acidification to the loss of biodiversity. These changes not only threaten the survival of marine life, but also affect human society. In this context, the formulation and implementation of climate change and marine protection policies are particularly important, in which international cooperation plays a decisive role. Global problems require global solutions, and international cooperation can promote the sharing of knowledge, technology and resources and help countries jointly cope with the impact of climate change on the ocean. By setting common goals and standards, international cooperation can help achieve more effective ocean protection and management, ensuring the health and biodiversity of global marine ecosystems.

The establishment of protected areas is one of the important strategies for protecting biological diversity. By designating specific sea areas as protected areas and restricting or prohibiting development activities and resource extraction in these areas, marine ecosystems can be effectively protected from damage by human activities and provide safe habitats for threatened species. Protected areas not only help maintain biodiversity but also protect the stability of the marine environment and ecosystem services such as carbon storage and food supply. However, the establishment and management of protected areas need to be based on scientific research and sufficient data support to ensure the effectiveness and adaptability of conservation measures.

In the fight against climate change, adaptation and mitigation policies are equally important. Adaptation policies aim to increase the resistance and adaptive capacity of societies and ecosystems to the impacts of climate change, such as by reducing the negative impacts of climate change through improved shoreline management, enhanced ecosystem resilience, and increased public awareness. Mitigation policies focus on reducing greenhouse gas emissions and slowing down the speed and extent of climate change, such as by promoting clean energy, implementing carbon pricing mechanisms, and protecting and restoring blue carbon ecosystems (such as mangroves, salt marshes, and seagrass beds) to absorb carbon dioxide. These policies require not only national-level efforts, but also global consensus and coordinated action to ensure global coverage and efficiency of climate action.

4.2 Socioeconomic factors and marine ecosystem management

Socioeconomic factors play a crucial role in marine ecosystem management because they directly influence the utilization of marine resources and the development of conservation strategies. Marine resources include not only rich biological diversity, but also economic resources that are vital to human society, such as fisheries, tourism, and transportation. The economic value of these resources drives global dependence on the oceans and raises the challenge of how to manage them sustainably. Sustainable management aims to ensure that current and future human activities do not harm the health and biodiversity of marine ecosystems, while safeguarding economic benefits. This requires finding a balance between marine resource development and marine protection to ensure socio-economic development without sacrificing environmental health and ecosystem functions.

Achieving this balance requires a comprehensive understanding of the value of marine resources, not just economic value, but also environmental and social value. Coral reefs, for example, are not only repositories of biodiversity but also provide breakwaters, protecting coastal communities from storms. Therefore, marine protection strategies need to comprehensively consider the value of ecosystem services and guide policy formulation and resource management through scientific research and socioeconomic analysis.

Public participation and environmental education play a key role in promoting sustainable management of marine ecosystems. By raising public awareness of the importance of marine protection and enhancing their understanding of marine issues, social support for protecting marine resources can be stimulated. Environmental education not only targets schools and students, but also includes popular public education, aiming to improve everyone's understanding of the impact of their actions on the environment and promote the formation of environmentally friendly behaviors. Active public participation can not only promote environmental protection policies and actions, but also promote community-based sustainable utilization models of marine resources based on protection, such as community-managed fisheries and eco-tourism.

4.3 Future research directions and technology development

As the environmental problems facing the world become increasingly severe, especially the increasing pressure on marine ecosystems, future research directions and technological development are particularly important in the field of marine biology. Emerging science and technology, such as genetic editing, remote sensing monitoring, big data analysis and artificial intelligence, provide unprecedented opportunities for the study of marine biology and the management of marine ecosystems. These technologies can help scientists gain a deeper understanding of the adaptation mechanisms of marine organisms, ecosystem functions and services, and the impact of human activities on the marine environment, thereby providing scientific basis for the sustainable use and protection of marine resources.

However, the application of these technologies also brings new scientific and management challenges. On the one hand, the use of advanced technologies requires corresponding technical support and professional knowledge, which is a big challenge for countries and regions with limited resources. On the other hand, technology is developing rapidly. How to effectively integrate and utilize these technologies to ensure the accuracy and reliability of data is also a problem that needs to be solved.

Faced with these challenges, the transition to sustainable ocean management has become an inevitable trend in the future. Chen and Yen (2023) discussed the contribution of remote sensing technology in fisheries management and marine ecosystem protection, emphasizing the importance of international cooperation in the realization of sustainable development goals. El Mahrad et al. (2020) discussed the contribution of remote sensing technology to an integrated coastal and marine environmental management framework, emphasizing the importance of data accessibility and integration for ecosystem management. We should not only pay attention to the development and application of technology, but also strengthen interdisciplinary and cross-field cooperation and promote the integration between scientific research, technology development and management practice. At the same time, it is also necessary to strengthen international cooperation, share data and resources, and jointly respond to global marine environmental problems.

5 Summary and Outlook

In the face of climate change, research in marine biology reveals our deep understanding of the impacts on marine ecosystems, while also pointing out the direction for future research and management. Key findings in marine biology highlight the widespread impacts of climate change on marine life distribution, ecosystem services, and biodiversity. These studies confirm the negative impacts of rising ocean temperatures, acidification and sea level rise on multiple aspects including coral reefs, plankton and deep-sea ecosystems. At the same time, scientists are working to understand how organisms respond to these changes through genetic and behavioral adaptations, and what these adaptation mechanisms mean for the future survival of the species.

However, research in this area still faces many limitations, especially in predicting the long-term impacts of climate change, ecosystem response complexity, and biological adaptability. Data acquisition is often limited by technical and methodological limitations, and the dynamics and complexity of the marine environment make accurate predictions more difficult. Therefore, future research needs to make efforts to improve model accuracy, enhance long-term monitoring capabilities, and gain a deeper understanding of biological adaptation mechanisms.

With the development of emerging science and technology, such as genomics, remote sensing monitoring and artificial intelligence, we are expected to gain deeper insights into understanding the operation and adaptation mechanisms of marine ecosystems. Advances in these technologies are giving us new tools to better manage and protect marine resources. However, achieving the transition to sustainable ocean management also faces scientific and management challenges, including how to find a balance between protecting biodiversity and promoting socioeconomic development, how to increase public awareness of the importance of ocean protection, and How to strengthen international cooperation to deal with global ocean issues (Malde et al., 2020).

While we have made significant progress in understanding the impacts of climate change on marine ecosystems, there is still much work to be done. Future research not only needs to focus on the deepening of scientific knowledge and technological innovation, but also needs to strengthen interdisciplinary cooperation and promote dialogue between scientific research and policy formulation. By working together, we can pave the way to protect our marine ecosystems and ensure ocean health and well-being for generations to come.

Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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