Analysis of the global marine biodiversity security assessment

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Abstract

Purpose – The study aims to assess marine biodiversity security, which is closely linked to a healthy planet and societal well-being. It defines marine biodiversity security, identifies threats such as climate change, marine debris and invasive species and explores mechanisms impacting this security to aid in achieving Aichi Targets and enhancing ecological sustainability.

Design/methodology/approach – Using spatial statistical methods, the research analyzes the temporal and spatial distribution of marine biodiversity. It provides a comprehensive multi-layered perspective on the current state of global marine biodiversity, facilitating the identification of threats and the understanding of their mechanisms.

Findings – The findings indicate significant threats to marine biodiversity, with an emphasis on climate change, marine debris and invasive species. The report reveals the spatial distribution of endangered species and underscores the need for urgent actions to address these threats and improve marine biodiversity security globally.

Originality/value – This report serves as a critical reference for promoting healthy, productive marine biodiversity that supports societal welfare. It underscores the importance of establishing a protective framework for marine biodiversity, contributing to the realization of the United Nations Sustainable Development Goals, particularly SDG 14.

Keywords Biodiversity, Fish species, Marine biodiversity security, Threatened

Paper type Research paper

In recent years, global ocean governance has entered a period of significant transformation, with a focus on marine biodiversity as a central factor driving the agenda. This shift has drawn considerable attention from scholars, who are increasingly engaging in research related to the conservation of marine biodiversity, equitable access to marine resources, the spatial dynamics of marine ecosystems, and the protection of marine biodiversity. The Sustainable Development Goal (SDG) 14 emphasizes the need to conserve and sustainably use the oceans, seas, and marine resources as a pathway to sustainable development, while highlighting the intricate connections between marine biodiversity and the broader framework of the SDGs. Grounded in the principles of biodiversity economics, this paper aims to provide a comprehensive definition of marine biodiversity security by summarizing the core aspects of biodiversity. It further explores the current state of marine biodiversity, identifies the factors posing threats to its security, and elucidates the distinctive characteristics of marine biodiversity security. The study ultimately seeks to contribute to

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the achievement of the Aichi Biodiversity Targets and the United Nations Sustainable Development Goals by advancing the understanding and governance of marine biodiversity security.

By clarifying the purpose of this research, the paper underscores the urgency of addressing global marine biodiversity security challenges. This involves not only conserving marine life and habitats but also ensuring that access to marine resources is fair and sustainable. The evolving landscape of ocean governance presents opportunities and challenges in securing marine biodiversity, as new policies and frameworks are shaped to mitigate threats such as overfishing, habitat destruction, climate change, and pollution. Understanding the economic value of biodiversity and the implications of its loss is essential for developing effective strategies that integrate ecological, social, and economic dimensions of sustainability. Thus, this study provides a timely and critical examination of marine biodiversity security, offering insights that are crucial for policymakers, stakeholders, and the scientific community working towards the sustainable management of the world's oceans.

1. Analysis of the current status of global marine biodiversity security

1.1 Definition of marine biodiversity security

1.1.1 Marine biodiversity. "Biological diversity" has a long history in biological research, but the compound word biodiversity was coined by Wilson (1985) as a scientific term for the richness and variability of organisms and the ecological complexes in which they live. Subsequently, Chen Binghao explained biodiversity in his article as follows: Biodiversity is a general term for the abundance, variety, variability and complexity of all organisms on earth on land, in water and in the oceans, as well as the genes they possess and the ecosystems they form.

The oceans and seas are rich in biological resources and occupy an important place in global biodiversity. Marine biodiversity generally refers to the abundance of all living species in the oceans, including species diversity, genetic diversity and ecosystem diversity. Species diversity refers to the number and distribution of different species present in the oceans; genetic diversity involves the genetic differences of different individuals within the same species; and ecosystem diversity refers to the type and complexity of different ecosystems in the oceans. Marine life is not limited to marine fish, but refers to all living species in the oceans, including marine animals, marine plants, micro-organisms and viruses.

1.1.2 Marine biodiversity security. Marine biodiversity is closely linked to the economy, society and the environment, supporting the healthy functioning of the planet and providing services that promote human health, well-being and prosperity. Marine biodiversity security is more focused on the security aspect, this paper defines it as the maintenance of a certain region or a country or even the global scope of the state of marine biodiversity is not threatened, can provide ecological security for the entire marine ecological and economic system and human well-being, and its specific meaning can be extended to maintain the function of the marine ecological services as well as the self-regulation of various types of material resources derived from the rational use. Avoidance of short- and long-term adverse impacts on human well-being and social production activities resulting from the loss of marine biodiversity and the decline in marine ecosystem services and self-regulation.

1.1.3 Classification of marine biodiversity security. As an important part of non-traditional security, the study of marine biodiversity security can include different scales; divided by the level of marine economic development, it can be extended from the developing economies of emerging markets to developed economies; divided by the intercontinental level, the study area can cover Europe, the Americas and the Asian region, etc.; divided by the national level, the study area can cover coastal countries and coastal cities. At the national level, the study area can cover coastal countries and coastal cities, etc. At the special economic development region level, the study can cover the European Union, RCEP member countries, and Belt and Road countries. At the research content level, the study can specifically include the comprehensive evaluation of marine biodiversity security, the identification of the drivers of marine biodiversity security, and research on monitoring and early warning of marine biodiversity security.

1.2 Generalization of the characteristics of marine biodiversity security

Marine biodiversity security is an important guarantee for maintaining the health of marine ecosystems and an important cornerstone for ensuring the abundance of marine species and the balance of ecosystems, and precisely because of its important role, the characteristics of marine biodiversity security involve multiple levels, multiple links and multiple areas.

1.2.1 Global nature of marine biodiversity security. In the context of economic globalization, the issue of marine biodiversity security is not only a problem of a specific country, but a global issue that concerns the whole human society (Li and Chen, 2024Li and Chen, 2024a, b). The loss of marine biodiversity in one country or one sea area may jeopardize the biodiversity of neighboring countries or adjacent sea areas. Therefore, any country should attach great importance to the protection of marine biodiversity, the conservation of marine ecosystems and the security of marine biodiversity.

1.2.2 Irreversibility of marine biodiversity security. Marine biodiversity has a certain safety threshold, and once it falls below its "safety threshold", it often leads to irreversible processes, such as the "population collapse" crisis faced by some marine species. According to Convention on Biological Diversity. Since 1970, the global population of marine plategill has declined by 71%, with more than three-quarters of marine species threatened with extinction. Once marine biodiversity is extinct, it is gone forever.

1.2.3 Linkage of marine biodiversity security. The circulation of substances and the flow of energy within the marine ecosystem are accomplished through intricate food chains or food webs. If the level of biodiversity in the marine area decreases, the food chains or food webs that are in a stable state will be forced to be interrupted. Relationships between species within marine communities need to be re-established, and existing marine species may form new habitats and patterns of food competition, the evolution of which will inevitably affect the survival of species within the marine area.

1.2.4 Variability of marine biodiversity safety. Due to the differences in the level of economic development, the level of governmental regulation, geographic location, ecosystem components and ecological functions (Li *et al.*, 2023), the evaluation of the safety of marine biodiversity in each sea area has a certain degree of regional variability. Marine biodiversity is also hierarchical due to differences in ecological functions, with lower-level marine biodiversity security being the basis for higher-level marine biodiversity security, and higher-level marine biodiversity security being an organic combination of lower-level marine biodiversity security.

1.2.5 Long-term nature of marine ecosystem restoration. The solution to many problems of marine biodiversity damage requires high costs in terms of time and economy, and requires comprehensive consideration of natural, perceived and scientific and technological factors, and usually takes several years or even decades or even longer to accomplish. For example, the protection of marine endangered species and the construction of their habitats, changes in the utilization of marine resources and other impacts on the security of marine biodiversity cannot be lifted in a short period of time.

1.3 Analysis of the current status of global marine biodiversity security

1.3.1 Development of global biodiversity research. Nowadays, the understanding of the economics of biodiversity is the cornerstone of marine biodiversity security research. After analyzing the development of biodiversity research, we know that in the 1950s and 1960s, the world economy was in the stage of recovery, at this time, the most important goal of economic science is economic recovery. With the continuous development of society, the population explosion and environmental pollution have become the biggest constraints on the economy, at this time, the development of economics. in the mid-20th century, oil surpassed coal to become the largest energy resource, economists around the world began to explore energy. With the oil crisis in the 1960s and 1970s, economists began a more profound study of energy, and energy economics emerged. Along with the use of energy, the resulting global warming problem became prominent, so the 1970s also saw the emergence of economic research on climate change.

In recent years, the problem of biodiversity loss induced by climate crises (Thomas *et al.*, 2004; Scheffers *et al.*, 2016; Mori *et al.*, 2021), among others, has gradually caused to become visible. Climate change exposes species to dangerous temperatures, leading to widespread contraction of species populations as well as biological habitats (Pigot *et al.*, 2023), and increased biodiversity risk. The article published in Nature in 2020 states that climate warming will cause a precipitous decline in biodiversity (Trisos *et al.*, 2020). The current biodiversity loss crisis has emerged as one of the two major challenges facing humanity, alongside the climate crisis. Addressing and even reversing both climate change and biodiversity loss is an urgent global issue that requires immediate action.

At the same time, the issue of global biodiversity loss has attracted a great deal of academic attention, and in February 2021, The Dasgupta Review was released, which explains the economic value of biodiversity and provides a framework for integrated economic research based on studies in ecology and earth sciences. Subsequently, relevant research on global biodiversity loss has gradually attracted scholars in recent years, setting off a wave of biodiversity research, and the pioneering research on the allocation of responsibility for embodied biodiversity loss and the measurement of accounting has laid a good theoretical and empirical research foundation for the development of biodiversity research.

With the increasingly severe global biodiversity loss and the continuous improvement and deepening of the theory of biodiversity economics, the relevant policies and practices are also evolving. Governments and international organizations have formulated policy measures for biodiversity conservation and promoted the practical application of biodiversity economics. Academics are also improving the practical exploration of the organic interaction between biodiversity loss and economic development (Li *et al.*, 2023; Li and Chen, 2024a; Li and Chen, 2024b) [2, 3, 9], providing theoretical support and policy suggestions for quantitatively weighing biodiversity conservation and economic development.

1.3.2 Analysis of the current status of global biodiversity security. Created in 1964, the IUCN Red List of Threatened Species (IUCN) has evolved into the world's most comprehensive source of information on the status of the extinction risk of animal, fungal and plant species globally, and is a key indicator for assessing the health of biodiversity. Under the IUCN Red List Strategic Plan (2021–2030), the current goal is to assess 260,000 species and reassess 142,000 of them to ensure that the information is up-to-date and to enable monitoring of trends in status changes. Based on a full understanding of the database, this paper integrates the global status of biodiversity based on the IUCN(version 2024–1).

As of today, the IUCN has about 45,300 species endangered, including 41% of amphibians, 34% of conifers, 36% of reef corals, 37% of sharks and rays, 26% of mammals and 12% of birds. According to the statistics, sharks and rays are the second most endangered species after amphibians.

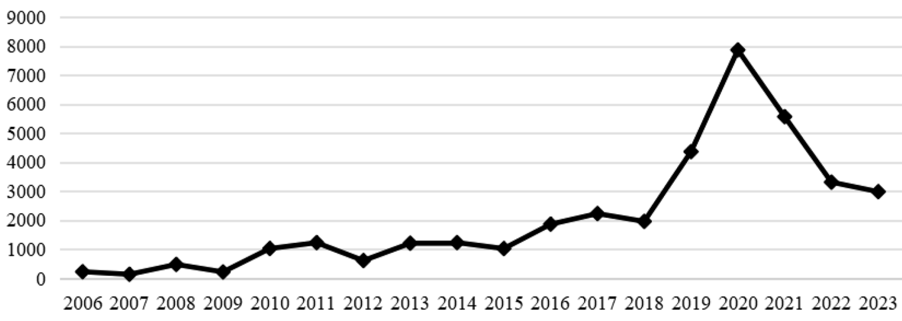
In this paper, Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) endangered level classifications were selected to first give the number of endangered species in different regions from the terrestrial perspective, and the specific number of endangered species is shown in Figure 1.

Based on Figure 1, it is known that the number of endangered species shows a general upward trend over time, with a sharp increase between 2019–2021, and a decline in the number of endangered species in 2021 possibly due to COVID-19, which further gives the number of endangered species in each region during the period of the study, as shown in Figure 2.

According to Figure 2, the Sub-Saharan Africa region has the highest number of endangered species, which supports the study of Li *et al.* (2022). Taking Madagascar in Sub-Saharan Africa as an example, based on the studies of Li *et al.* (2023) and Li and Chen (2024a, b), it is known that Madagascar is a highly biota-diverse country (in terms of the number of species, Madagascar can be included in the top 10 countries globally, and in terms of the endemism, Madagascar should be the first important country globally. Madagascar should be the first country of global importance). The country is rich in biophysical resources, and its excellent resource base will lead to large-scale exploitation and utilization, with the ultimate result being the further exploitation and destruction of biodiversity resources.

In particular, with the deepening of participation in the international division of labor and the increasing utilization of biological resources by human beings, the demand for biodiversity products and services will not decline accordingly, and as the whole industrial chain of the biodiversity resource exploitation industry has been formed and is still expanding, the loss of biodiversity in the country will further increase, which will ultimately have a devastating impact on the ecological environment of the region. The ecological environment of the region will ultimately be devastated.

1.3.3 Analysis of the status of global marine biodiversity security. Based on the data in the previous subsection, sharks and rays have the highest number of endangered species other than amphibians. Sharks, rays and sculpins are one of the oldest surviving vertebrate groups and one of the only three extant fish species that are irreplaceable components of the world's biodiversity, play an important ecological role in the oceans and have significant economic and cultural value. While the trade in sharks and rays provides livelihoods for millions of people, traceability and sustainability are largely missing throughout the global trade chain. If this trend continues, the trade in sharks and rays will pose a serious threat to the survival of their wild populations, as well as to the wider marine ecosystem. The Global Strategy for



Source(s): The original data was obtained from IUCN and compiled by the authors

Figure 1. Global number of endangered species in terrestrial areas

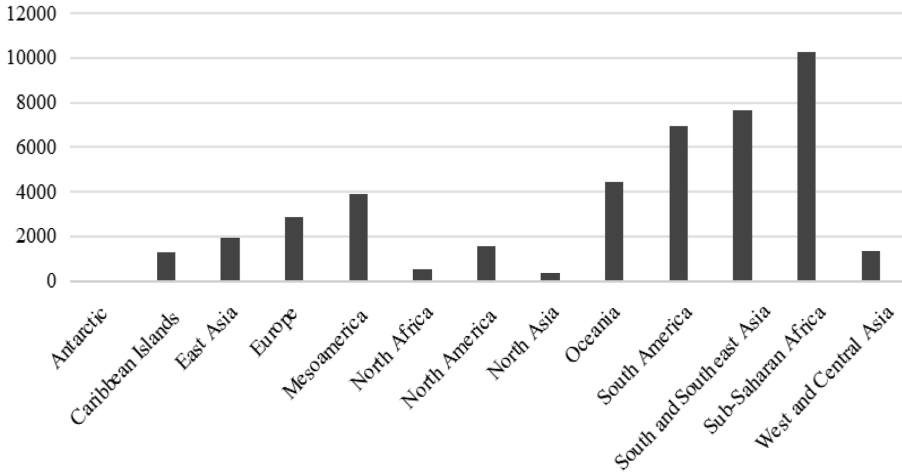


Figure 2.
Number of endangered species in major regions of the world

Source(s): The original data was obtained from IUCN and compiled by the authors

the Conservation of Sharks and Rays (2015–2025) aims to manage shark and ray species populations from the perspectives of Save the Species, Fisheries Management, Responsible Trade and Responsible People.

In this paper, the research perspective is further landed on the marine biodiversity component and further gives the loss of endangered species in different sea areas as shown in Figure 3.

According to Figure 3, the distribution of endangered species in marine areas is slightly different from that in terrestrial areas. The number of endangered species in the Pacific Ocean and the Indian Ocean is the highest, specifically, the Pacific - western central is in the first place, followed by the Indian Ocean - eastern and Pacific - northwest, and then the Indian Ocean - western. In response to this phenomenon, it has been noted that the Great Coral Triangle in the Indian and Pacific Oceans is the region with the highest marine biodiversity

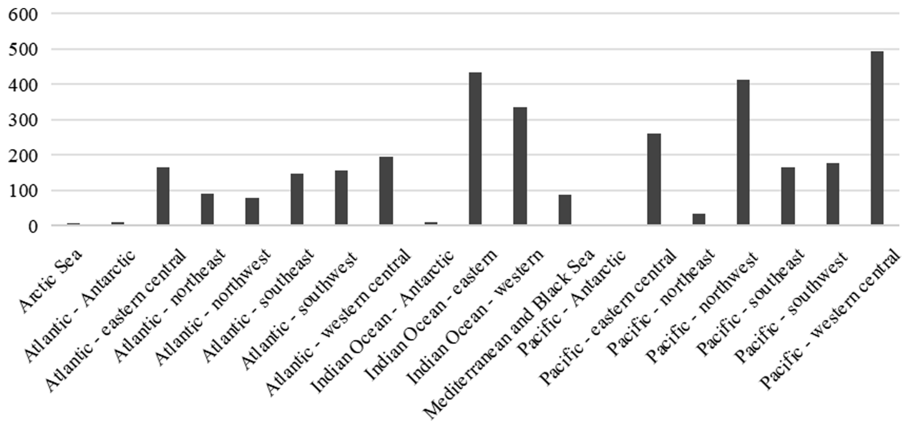


Figure 3.
Number of endangered species in major global marine areas

Source(s): The original data was obtained from IUCN and compiled by the authors globally, and that 75% of the world's mangrove species, 45% of seagrass species and 58% of tropical mollusc species can be found in the Indian and Pacific Oceans. While this region has the greatest marine biodiversity, it is also the region most affected by climate change and fishing, and as a result, the Pacific and Indian Ocean waters have the highest number of marine endangered species.

2. Analysis of factors affecting global marine biodiversity security

2.1 Overfishing and marine biodiversity

Overfishing has far-reaching impacts on marine ecosystems and marine biodiversity. On the one hand, overfishing will directly lead to a sharp decline in the number of marine species, or even extinction; on the other hand, overfishing will affect the role of a species in the food chain, which will lead to the destruction of the marine ecosystem. According to the Earth Vitality Report 2022 released by the WWF, the global population of mammals, birds, fish, and amphibians has declined by an average of 69% since 1970, with the largest decline in the populations of freshwater species, which have declined by an average of 83% in just a few decades, and the number of sea lion pups in South Australia and Western Australia has decreased by two-thirds.

2.2 Climate change and marine biodiversity

Climate change is one of the biggest environmental problems currently facing the world, and its impacts on marine biodiversity are all-encompassing. Since the twenty-first century, the impacts of climate change (mainly driven by human activities) on biodiversity loss have increased significantly. Approximately 75% of terrestrial ecosystems and 66% of the marine environment are negatively impacted by human activities, and 25% of the world's species are threatened with extinction. By mid-century, climate change is likely to be the most important driver of marine biodiversity loss. The main ways in which it will be affected are categorized as follows.

2.2.1 Ocean warming and ocean acidification. Ocean warming is one of the most direct and significant impacts of climate change. According to the IPCC (2019), the oceans have absorbed more than 90% of the global excess heat, leading to an increase in ocean temperatures. This increase in temperature is not only accelerating the phenomenon of coral bleaching, but also changing the distribution patterns of marine species. Many marine organisms, especially fish and other highly mobile species, have begun to migrate towards the poles in search of suitable temperatures for survival. In the face of these challenges, it has become particularly urgent to protect and enhance marine biodiversity, which is related to increasing the adaptability and resilience of marine ecosystems to climate change.

Ocean acidification is another important impact of climate change. As atmospheric carbon dioxide dissolves in seawater, it increases the acidity of seawater, which not only affects the growth of corals and other calcifying organisms, but may also interfere with the physiological functions of marine organisms, including reproduction and growth. Ocean acidification may lead to declining populations of certain marine organisms, which in turn may affect the stability of the marine ecosystem as a whole. Ocean acidification not only leads to a decline in the populations of some species, but may also contribute to an increase in the populations of some species, thus reshaping the composition of marine communities, which reduces the level of biodiversity in general. Currently, human activities, in particular overfishing and marine pollution, place additional pressures on marine biodiversity, which not only reduces the variety and abundance of organisms, but also weakens ecosystem resistance to environmental stresses such as acidification.

2.2.2 Sea-level rise and extreme weather events. Sea-level rise not only threatens coastal ecosystems, such as mangroves and coral reefs, but may also lead to habitat loss and biodiversity decline. In addition, sea-level rise may alter the salinity of coastal areas, affecting ecosystems in areas where freshwater and saltwater meet. Extreme weather events, such as hurricanes and typhoons, are becoming more frequent and intense as a result of climate change. These events cause physical damage to marine ecosystems, while also affecting the survival and reproduction cycles of marine organisms.

2.3 Marine litter and marine biodiversity

Plastic marine litter poses a serious threat to marine ecosystems and marine biodiversity (Lincoln *et al.*, 2022). Because of their small size, microplastics are easily ingested by marine organisms and thus enter the food chain. Microplastics are capable of adsorbing persistent organic pollutants and heavy metals in water, and these toxic substances may ultimately have an impact on human health through bioaccumulation and amplification.

The presence of marine litter may also alter the behavior of marine organisms. For example, some marine organisms may alter their normal migratory patterns or reproductive behaviors as a result of litter disturbance. Such alterations may reduce the reproductive success of the organisms, thereby affecting population stability and biodiversity. Marine litter may also have negative impacts on the structure and functioning of marine ecosystems. For example, plastic debris may entangle or cover coral reefs, affecting coral growth and reproduction and thereby undermining the integrity of coral reef ecosystems.

2.4 Invasive species and marine biodiversity

Species invasions negatively affect the ecosystems of new environments and can lead to changes in the main ecosystem hierarchy due to their adaptability, rapid reproduction rate and competitiveness. As sea water temperature increases, some temperate marine organisms move towards the polar seas, of which more than 600 species of alien organisms are already present in the Mediterranean Sea and are still rising, affecting the stability and health of the whole ecosystem.

In addition, alien organisms may carry pathogens or become vectors of disease, posing a threat to the biological health of the original marine ecosystem. At the same time, species invasions may also affect the service functions of marine ecosystems, such as deteriorating water quality, which in turn affects marine biodiversity. However, there are currently many uncertainties about the impact of species biodiversity on marine biodiversity, and some alien species can have a positive impact on ecosystems in the short term, so comprehensive considerations need to be taken into account when making assessments.

2.5 Shipping and marine biodiversity

Shipping has a complex and far-reaching impact on marine biodiversity. First of all, shipping activities will lead to marine pollution, including wastewater discharged from ships, fuel oil leaks, solid wastes, etc. These pollutants may directly poison marine organisms, destroying their living environment and affecting their reproduction and growth. This can lead to a reduction in the number of certain species or even their extinction, thus reducing the diversity of marine life.

Secondly, shipping activities may also introduce alien species into the original ecosystem, which may become invasive species, causing competitive pressure on local biological populations, altering the ecological balance and affecting the diversity of marine life. For example, some ships may introduce alien species into new marine areas through bio-attachments on the bottom of the ship, thus affecting local biodiversity.

In addition, shipping activities may also lead to marine noise pollution. Noise from ship engines may interfere with the normal behavior of marine organisms, affecting their communication, foraging, migration and other behaviors, and even leading to injuries to marine organisms. These impacts may cause certain sensitive marine organisms to decrease or migrate, with implications for marine biodiversity. In addition, shipping activities increase marine traffic, increasing the likelihood of collisions between ships and marine life, which poses a threat to large marine organisms such as whales and sea turtles, reducing their survival rate and affecting marine biodiversity.

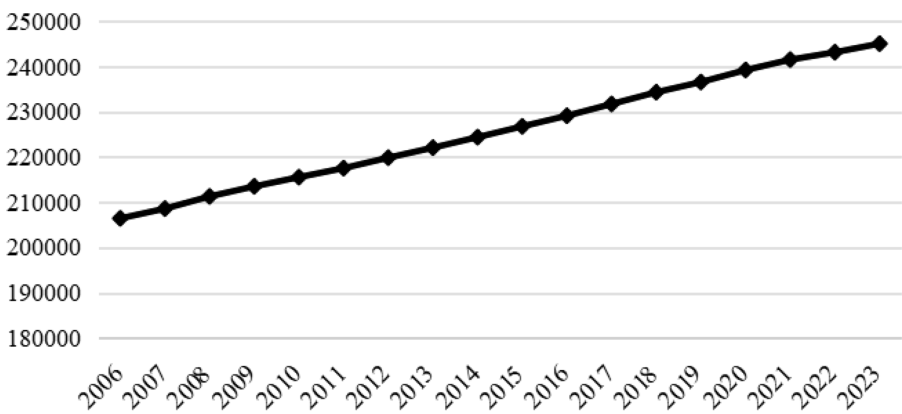
3. Statistical analysis of the spatial and temporal distribution of global marine biodiversity

3.1 Characterization of the temporal variation of global marine biodiversity

As a crucial part of marine biodiversity security, the number of marine species plays an important role in maintaining the ecological equality of the marine biosphere. In view of this, the cumulative number of species names found in the World Register of Marine Species database was firstly analyzed in Figure. Based on Figure 4, it can be seen that the number of species names has been on an increasing trend during the study period. Despite the emergence of different marine species during the study period, the issue of marine biodiversity security still deserves great attention.

Coverage of the marine realm by the IUCN Red List is low, representing less than 5% of listed species, and IUCN has identified priority taxa for marine fish, invertebrates, plants (mangroves and seagrasses) and macroalgae (seaweeds). If these priority taxa could be assessed, the number of marine species on the IUCN Red List would increase more than six-fold. The first consolidation of the study ranges of endangered species in marine areas is shown in Figure 5, with marine systems leading the way at 82.52%, followed by freshwater systems at 5.15%.

In order to comprehensively analyze the distribution of marine biodiversity, we integrated the biodiversity data of each marine area in the IUCN to conduct a detailed study, see Figure 6. According to Figure 6, the number of registered endangered species in each marine area showed a fluctuating upward trend during 2006–2023, with the first peak occurring in 2008, with the number of endangered species at 175, and the second peak occurring in 2020–2021, with the number of endangered species rising sharply to 239 and 226



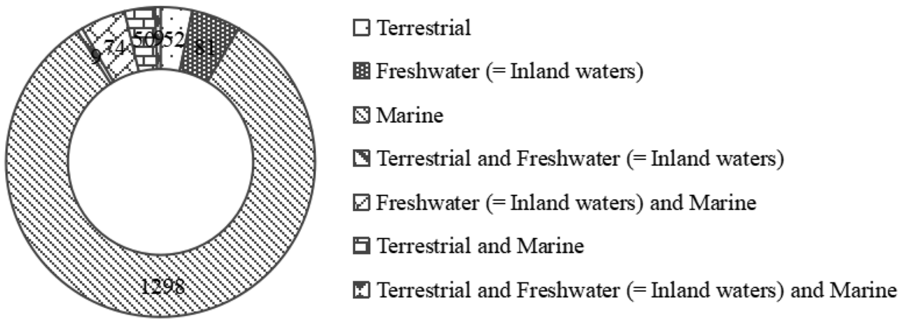
Source(s): The original data was obtained from World Register of Marine Species

Figure 4. Cumulative number of species names found globally

in the marine area. The second peak occurs in 2020–2021, when the number of endangered species in the sea area rises sharply to 239 and 226.

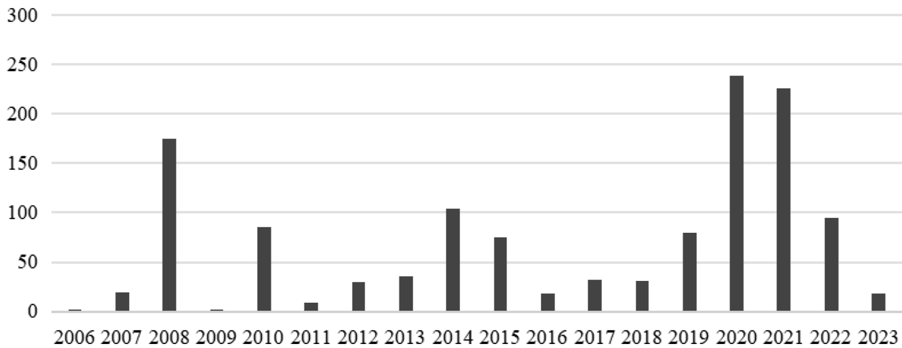
Consolidating the habitat distribution of listed endangered species by marine area (see Figure 7), it can be concluded that the Marine Neritic area has the highest number of endangered species (1,078), accounting for 58.33% of the total number of endangered species. Further refinement of the Marine Neritic classification shows that Marine Neritic - Coral Reef (499 species) and Marine Neritic - Subtidal Sandy (421 species) are the top two habitat endangered species.

Integrating the data on the causes of threatened species in each sea area (see Table 1), we can conclude that Biological resource use has the highest danger level, and the number of endangered species caused by it is 980, which accounts for 25% of the total number of endangered species, among which the number of endangered species caused by Fishing and harvesting aquatic resources is 951, which accounts for 97.04% of the total number of endangered species. Climate change and severe weather was the second most dangerous, with 526 endangered species, accounting for 14% of the total, of which 396 endangered species were caused by temperature extremes, accounting for 75.04%. Therefore, the loss of marine biodiversity caused by fish fishing and climate change should be highly emphasized in the follow-up process of marine biodiversity conservation.



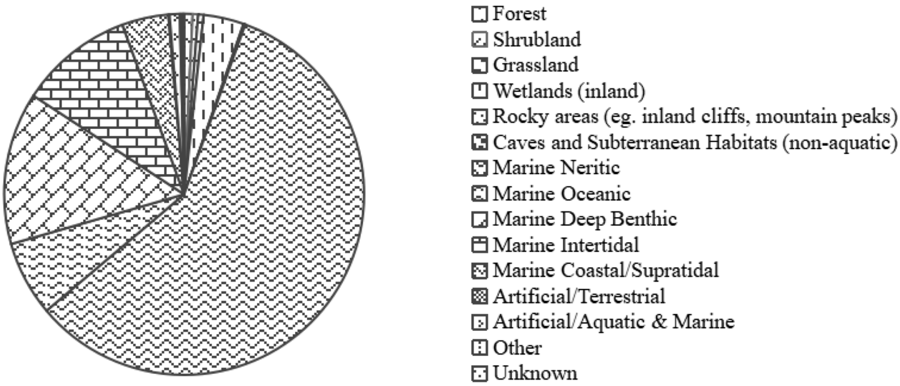
Source(s): The original data was obtained from IUCN and compiled by the authors

Figure 5.
Research coverage of endangered species in major global marine areas



Source(s): The original data was obtained from IUCN and compiled by the authors

Figure 6.
Listed endangered species in major global marine areas



Source(s): The original data was obtained from IUCN and compiled by the authors

Figure 7. Global distribution of habitats of major endangered species

Table 1. Integration of the causes of threats to major globally endangered species

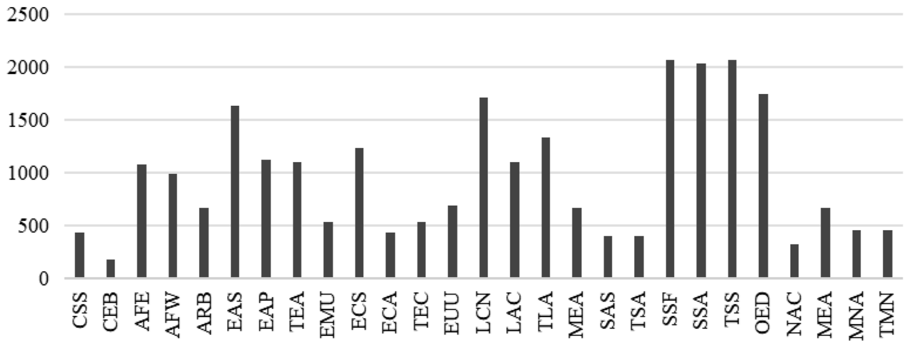
Causes of threats to major endangered species	Number of endangered species
Residential and commercial development	517
Agriculture and aquaculture	82
Energy production and mining	161
Transportation and service corridors	312
Biological resource use	980
Human intrusions and disturbance	320
Natural system modifications	96
Invasive and other problematic species, genes and diseases	375
Pollution	491
Geological events	4
Climate change and severe weather	526
Other threat	4

Source(s): The original data was obtained from IUCN and compiled by the authors

3.2 Analysis of endangered fish species in major countries worldwide

In 2021, a new report-The World's Forgotten Fishes-was jointly released by 16 conservation organizations, including the World Wide Fund for Nature (WWF), the International Union for Conservation of Nature (IUCN) and the Alliance for Freshwater Life. The World's Forgotten Fishes, a new report released by 16 conservation organizations, including the IUCN and the Alliance for Freshwater Life, states that 80 species of freshwater fishes are known to be declared extinct, with 16 of these species going extinct in 2020 alone. Based on this, the data of endangered fishes are extracted on the basis of biodiversity data of each sea area, in order to get the comparison of endangered fishes data of major countries and regions in the world. Firstly, the endangered fish data of typical regions are given in Figure 8.

Based on Figure 8, it can be seen that there are significant differences in endangered fish data by region, with SSF (Sub-Saharan Africa) having the highest number of endangered fish, followed closely by SSA (Sub-Saharan Africa (excluding high-income countries)). One study noted that 7.5 million people in SSA depend on freshwater fish for food and economic income, with chambo being the most prized fish for African fishermen's subsistence. Due to overfishing, about 70% of the fish in the lake has disappeared in the last 10 years, posing a huge threat to the livelihoods of the local people, which may be one of the reasons for the high



Source(s): The original data comes from the World Bank

Figure 8. Data on endangered fish species in typical areas of the world

number of endangered fish in the SSF region. Comparison of abbreviations in major regions of the world is shown in Table 2.

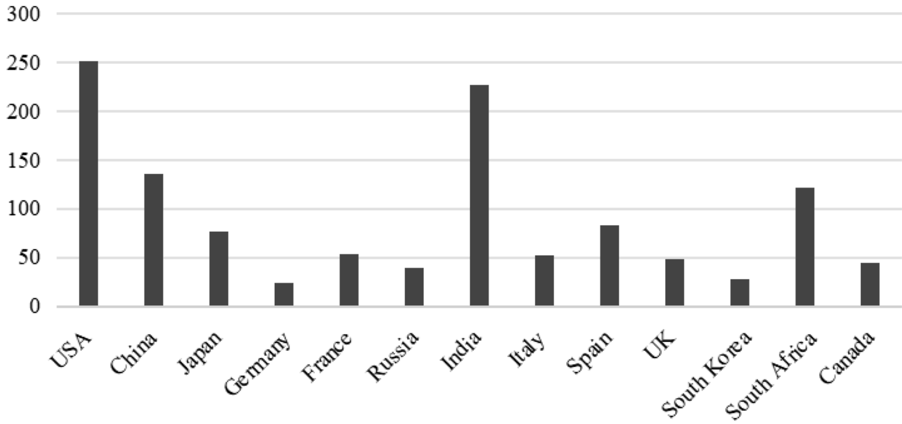
Referring to the related study of Li *et al.* (2023), the data of endangered fishes of major countries in the world in 2018 were integrated for data comparison. According to Figure 9, the endangered fish of the United States is in the first place, followed by India, and then China and South Africa. From the data comparison, the endangered fish data of the United States is about 1.85 times that of China, and the endangered fish data of India is 1.67 times that of China.

A deeper look at the data on endangered fish in the USA, for example, shows that more than 1,700 plant, mammal, fish, insect and other species are currently listed as threatened or endangered in the United States. In an analysis of the 2020 data, it was found that fish received 67% of the rescue funding, most of which went to protect dozens of species of salmon and hardhead trout in California, Oregon, and Washington. Caught between the overlapping

Table 2. Comparison of abbreviations in major regions of the world

Areas	Abbreviations	Areas	Abbreviations
Caribbean small states	CSS	Latin America and Caribbean (excluding high income)	LAC
Central Europe and the Baltics	CEB	Latin America and the Caribbean (IDA and IBRD countries)	TLA
Africa Eastern and Southern	AFE	Middle East and North Africa	MEA
Africa Western and Central	AFW	South Asia	SAS
Arab World	ARB	South Asia (IDA and IBRD)	TSA
East Asia and Pacific	EAS	Sub-Saharan Africa	SSF
East Asia and Pacific (excluding high income)	EAP	Sub-Saharan Africa (excluding high income)	SSA
East Asia and Pacific (IDA and IBRD countries)	TEA	Sub-Saharan Africa (IDA and IBRD countries)	TSS
Euro area	EMU	OECD members	OED
Europe and Central Asia	ECS	North America	NAC
Europe and Central Asia (excluding high income)	ECA	Middle East and North Africa	MEA
Europe and Central Asia (IDA and IBRD countries)	TEC	Middle East and North Africa (excluding high income)	MNA
European Union	EUU	Middle East and North Africa (IDA and IBRD countries)	TMN
Latin America and Caribbean	LCN		

Source(s): Area code abbreviations derived from the World Bank



Source(s): The original data comes from the World Bank

Figure 9.
Comparison of data on endangered fish species in major countries worldwide

biological realities and political pressures in USA, there are spending inequities in related funding. For example, restoring salmon and hardhead trout populations will require a huge financial investment because their habitats are widely distributed and impacted by large hydroelectric plants. In addition, these fish have the attention of many political constituencies, including Native American tribes and commercial fishing interests that want to revitalize the fishery. The fact that there are still other endangered fish species that are unprotected may be one of the reasons for the high number of endangered fish in the United States region.

4. Policy recommendations for the safe protection of global marine biodiversity

In line with the Aichi Targets and the United Nations Sustainable Development Goals, systematic programs for marine biodiversity security in the context of biodiversity conservation need to be able to support "double decoupling", i.e. progressively lowering the correlation coefficient between GDP growth and marine biodiversity loss, so that higher GDP is supported by lower marine biodiversity loss. Growth. In the long term, the enhancement of marine biodiversity security is a process of continuous exploration and practice, requiring the joint efforts of governments, scientific research institutions, enterprises and the public.

4.1 Emphasizing the formulation of policies for the conservation of marine biodiversity

Currently, insufficient attention is being paid to biodiversity conservation policies, especially marine biodiversity conservation policies. Against this background, countries should strengthen the protection of marine biodiversity, actively participate in global and regional ocean governance, and call on governments to strengthen the formulation and enforcement of relevant laws and regulations, protect the habitats and migration corridors of marine organisms, and prohibit illegal fishing and the destruction of the marine environment.

4.2 Increasing the area of marine protected areas to enhance the effectiveness of protection

The number of marine endangered species shows a fluctuating upward trend, and the division of marine protected areas can effectively curb the loss of marine species. Therefore, countries should speed up the establishment of a system of marine nature reserves, taking the bay (bay area) as a unit, and strengthen the overall protection of typical marine ecosystems, rare and endangered marine organisms and habitats, and ecological corridors.

At the same time, coastal areas are urged to strengthen the repair and restoration of damaged marine ecosystems, implement targeted marine ecological repair and restoration measures, and strengthen the supervision and management of ecological and environmental conditions in marine ecological restoration areas.

4.3 Strengthening global transboundary cooperation for marine biodiversity conservation

No country can be excluded from the protection of marine biodiversity, and it is vital to seek cross-border cooperation. Firstly, the establishment of cross-border protected areas, the establishment of jointly managed cross-border marine protected areas, the implementation of joint management and monitoring, and the protection of shared marine biological resources. Secondly, joint scientific research and data-sharing should be pursued, with efforts being made to carry out joint scientific research projects, share data and information, and strengthen the monitoring and assessment of transboundary marine biodiversity. Lastly, we will actively implement the United Nations Convention on the Law of the Sea and the Code of Conduct for Responsible Fisheries and strengthen cooperation in the areas of marine pollution control, protection of marine living resources and marine fisheries harvesting.

4.4 Popularizing the awareness of all people to participate in the safe protection of marine biodiversity

Reversing the declining trend of marine biodiversity is a common goal of humankind, and based on the public nature of this goal, it is necessary for all of society to participate in the formation of a universal conservation pattern. First, the importance and urgency of marine biodiversity conservation should be conveyed to the public through education and publicity activities. Social media, television, newspapers and other channels can be utilized to let more people understand the importance of marine life and the impact of human activities on it. Secondly, organize various forms of marine conservation volunteer activities, such as beach cleaning, marine life rescue and marine environment monitoring, so that the public can personally participate in actions to protect marine life and enhance their sense of responsibility and participation. Finally, the public is encouraged to support and purchase seafood from sustainable fisheries to reduce the impact of overfishing on marine biodiversity. It is also possible to provide financial and resource support for the conservation of marine life by supporting environmental organizations and projects.

5. Research outlook

In recent years, with increased environmental awareness and technological advances, new ideas and approaches have been proposed for the conservation and utilization of marine biodiversity, such as marine ecological restoration, sustainable fisheries and the blue economy. These new ideas and practices provide new impetus and opportunities for the development of marine biodiversity security. However, there is still a lack of systematic research by current scholars on the connotation, measurement and spillover impacts of marine biodiversity security, which could further strengthen the foundation of marine biodiversity security in the future.

In addition, the existing literature has made little mention of the security of marine species diversity, but with the unusually rapid loss of marine species, the security of marine biodiversity has gradually attracted attention. As a matter of fact, the difference between the concept of marine biodiversity security and that of marine species diversity security should be noted in terms of connotation. A complete concept of marine biodiversity security should be an organism of marine species diversity, marine animal genetic diversity and marine ecosystem diversity, which is an important prerequisite for coping with the crisis of marine biodiversity loss, improving the level of marine biodiversity security and thus promoting the realization of the Aichi Targets.

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