

Commentary

Marine Ecology and Coastal Ecosystem Resilience

Isabella Marino*

Department of Freshwater Biology, University of Kerala, Thiruvananthapuram, India

**Corresponding author E-mail: i.marino@unina-marine.it*

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Marine ecology examines the interactions between marine organisms and their physical, chemical and biological environments within oceans and coastal regions. Coastal ecosystems, including mangroves, coral reefs, seagrass meadows, salt marshes and estuaries, provide essential ecological services and support a significant portion of global biodiversity. Ecosystem resilience refers to the ability of these environments to withstand, adapt to and recover from natural and human-induced disturbances. Understanding the factors that influence coastal ecosystem resilience is critical for biodiversity conservation, climate change adaptation and the sustainable management of marine resources.

Keywords: Marine ecology, coastal ecosystems, ecosystem resilience, coral reefs, mangroves, seagrass meadows, climate change, biodiversity conservation, marine pollution, sustainable coastal management.

Introduction

Marine and coastal ecosystems are among the most productive and biologically diverse environments on Earth. They support countless species of plants, animals and microorganisms while providing vital ecosystem services such as fisheries, coastal protection, carbon sequestration, nutrient cycling and tourism opportunities. Coastal regions also support the livelihoods of millions of people worldwide. However, increasing pressures from climate change, pollution, habitat destruction, overfishing and urban development threaten the health and stability of these ecosystems. Marine ecology provides valuable insights into the functioning of marine environments and helps identify strategies to enhance ecosystem resilience in the face of environmental change.

Description

Marine ecosystems encompass a wide range of habitats, from shallow coastal waters and estuaries to deep ocean environments. Coastal ecosystems are particularly important because they serve as ecological transition zones between terrestrial and marine environments. These habitats support high levels of biodiversity and play essential roles in maintaining ecological balance and productivity. Mangrove forests stabilize shorelines, coral reefs provide habitat for thousands of marine species, seagrass meadows serve as nursery grounds for fish populations and estuaries act as critical breeding and feeding areas for numerous organisms.

Ecosystem resilience is the capacity of marine and coastal systems to absorb disturbances while maintaining their ecological structure, functions and services. Natural disturbances such as storms, hurricanes, floods and seasonal environmental fluctuations have historically shaped coastal ecosystems. However, human activities have intensified pressures on these environments, often exceeding their natural capacity for recovery. Coastal development, land reclamation, dredging and habitat fragmentation have resulted in significant losses of critical habitats and biodiversity.

Climate change is one of the most significant challenges affecting marine ecosystem resilience. Rising sea surface temperatures contribute to coral bleaching events, where corals lose their symbiotic algae and become more vulnerable to disease and mortality. Ocean acidification, caused by increased absorption of atmospheric carbon dioxide, reduces the availability of carbonate ions necessary for shell and skeleton formation in corals, mollusks and other marine organisms. Additionally, sea-level rise threatens coastal wetlands, mangroves and low-lying coastal communities, altering ecosystem structure and species distributions. Marine pollution further undermines ecosystem health and resilience. Plastic debris, oil spills, agricultural runoff, industrial waste and untreated sewage introduce contaminants into marine environments, affecting water quality and marine life. Excessive nutrient inputs often lead to eutrophication and the formation of hypoxic or "dead zones," where oxygen levels become too low to support many aquatic organisms. Overfishing and destructive fishing practices also disrupt food webs, reduce biodiversity and weaken the ability of ecosystems to recover from environmental stress.

Despite these challenges, many coastal ecosystems demonstrate remarkable resilience when protected and properly managed. Conservation measures such as marine protected areas (MPAs), habitat restoration programs, sustainable fisheries management, mangrove reforestation and pollution reduction initiatives have shown positive outcomes in enhancing ecosystem recovery and biodiversity conservation. Scientific monitoring, adaptive management and community participation are increasingly recognized as essential components of successful marine conservation strategies. Emerging research highlights the importance of ecosystem connectivity, biodiversity and genetic diversity in promoting resilience. Healthy and diverse ecosystems are generally better equipped to adapt to changing environmental conditions and recover from disturbances. Integrating ecological knowledge into coastal planning and policy development can help strengthen the long-term sustainability of marine resources and ecosystem services.

Conclusion

Marine and coastal ecosystems are vital components of the Earth's environmental and economic systems, supporting biodiversity, climate regulation, food security and human well-being. However, growing pressures from climate change, pollution, habitat loss and unsustainable resource exploitation threaten their resilience and long-term sustainability. Strengthening coastal ecosystem resilience through conservation, restoration, sustainable management and climate adaptation strategies is essential for protecting marine biodiversity and maintaining ecosystem services. Continued research, international cooperation and community engagement will play a crucial role in ensuring the health and resilience of marine ecosystems for future generations.

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Conflict of Interest

The authors declare no conflict of interest.

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