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Understanding Key Stressors for Marine and Coastal Biodiversity Loss: An Overview

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The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Biodiversity hotspots are the regions with high levels of endemic species and significant habitat loss. Coastal areas can exhibit distinct biodiversity hotspots due to their diverse habitats, such as coral reefs, mangrove forests, and intertidal zones. These hotspots often support unique assemblages of species adapted to specific coastal conditions. Ecosystem services provided by marine biodiversity include provisioning services (seafood, resources for medicine); regulating services (stable climate and clean water); cultural services (recreational and mental benefits: sea bathing); and supporting services (nutrient circulation and photosynthesis). Despite some successful conservation efforts, biodiversity continues to decline. Marine ecosystems are vulnerable to rapid changes in diversity and function. Major pressures and threats causing increasing pressure on coastal and marine biodiversity include climate change, ocean acidification, habitat destruction and changes in sea use, invasive species, overexploitation, and pollution.

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Preservation of coastal biodiversity is of prime importance for human wellbeing. The coastal ecosystems sustain diverse life forms and also safeguard essential ecological services. Therefore conservation and restoration of coastal biodiversity is a timeless responsibility for sustainable development. In light of these observations, this review aims to update recent information from the available literature on the key stressors of marine and coastal biodiversity loss. This study also suggests the strategies to be implemented for successful conservation and restoration of coastal and marine biodiversity.

Keywords: Alien species; biodiversity; climate change; habitat destruction; over-exploitation; pollution.

1. INTRODUCTION

"Humankind depends on the oceans and coasts for survival, with one third of the world's population living in coastal areas, approximately 4% of Earth's total land area" [1,2]. "A combination of improved governance and ambitious, innovative investments into scalable solutions is needed to improve the resilience of the marine environment" [3]. "Marine ecosystems are important in providing services as food provision, natural shoreline protection against storms and floods, water quality maintenance, support of tourism and other cultural and spiritual benefits, and maintenance of the basic global life support systems" [4].

According to Mongruel et al. [5], "the major drivers of change, degradation, or loss of marine and coastal ecosystems and services are mainly anthropogenic" [6]. "Overexploitation of resources can result in threatened food security for coastal communities due to overexploited fish stocks; loss of habitat that in turn causes damage to the thriving tourism industry; health impacts through increasing loads of waste released into coastal waters; and vulnerability of coastal communities to natural and human-induced disasters" [7]. "The major indirect drivers include shifting food preferences and markets; subsidies; illegal fishing; population growth; technological change; and globalization" [8].

Biodiversity refers to the diversity of life in all its forms and at all levels of organization.' It is the foundation of resilient ecosystems supporting a vast array of 'functions.' Neeraj Khera et al. [9] noted that, "biodiversity can be described at three levels: the diversity within a species (genetic diversity), the diversity of species (species diversity) and the diversity of ecosystems (habitat or ecosystem diversity)". "Changes in biodiversity can influence all these functions (pollination, nutrient cycling) and the products arising out of these (food, medicinal plants)" [10].

Kavi Kumar et al. [11] noted that, "coastal and marine ecosystems, including mangroves, seagrasses, coral reefs, sand beaches and dunes, mudflats, salt marshes, estuaries and marine waters, provide a host of services that are of vital importance to human well-being, health, livelihoods and survival". "Marine biodiversity is increasingly under threat from widespread and growing pressures on marine and coastal resources. The consequences of the biodiversity loss and the resulting loss of ecosystem services have far-reaching impacts on livelihoods and the overall well-being of human communities" [12].

UNEP and CBD [13] stated that, "oceans contain a vast diversity of habitats and spectacular seascapes, hosting 32 of the 34 phyla of the planet, of which approximately 13 are exclusively or mostly marine". "Pressures on marine biodiversity will continue to increase, as 50% of the world's population is settled along the coasts, putting unsustainable pressures on coastal resources. The tremendous wealth of biodiversity and ecosystem services is threatened by human activities through overfishing, destructive fishing practices, pollution and waste disposal, agricultural runoff, invasive alien species, and habitat destruction" [14].

Gray [15] observed that "various threats to the coastal systems are: habitat loss; global climate change; overexploitation and other effects of fishing; pollution species introductions/invasions; water-shed alteration and physical alterations of coasts; tourism; and marine litter. The most effective way to conserve marine biodiversity, by almost any reckoning is to prevent the conversion or degradation of habitat. Marine biodiversity can be protected in coastal environments by a strategy for building conservation into decision making".

According to Delphi Ward et al. [16], "the key challenges faced by marine biodiversity are: pressure on biodiversity is continuing to increase (including from new & emerging threats and

illegal activities); knowledge of ecosystem management & restoration is currently inadequate for meeting the challenge of increasing production while sustaining ecosystem services; financial investment in biodiversity conservation/restoration needs to be scaled up enormously; and socio-ecological complexity".

Tertz [17] documented that, "conservation of coastal biodiversity holds immense ecological and socio-economic value. It often hosts species found nowhere else on Earth. Coastal ecosystems provide essential ecosystem services, including carbon sequestration, nutrient cycling, coastal protection, and support for fisheries". "Biodiversity hotspots within these ecosystems contribute disproportionately to these services, making their conservation crucial for maintaining ecological balance and supporting human wellbeing" [16,18-19].

This review aims to update recent information from the available literature relating to 'Key Stressors on Marine and Coastal Biodiversity Loss' concerning climate change and ocean acidification, habitat destruction and changes in sea use, invasive species, overexploitation, and pollution. Special emphasis was paid to the strategies to be implemented for conservation of coastal and marine biodiversity.

2. LITERATURE SEARCH METHODS

This review was carried out by collecting information on relevant research findings using Internet search engines like Google, Google Scholar, PubMed, ScienceDirect, and ResearchGate and other published articles, reports, and monographs. A total of 27 published articles have been reviewed and the related information was gathered for this current study concerning key stressors on marine and coastal biodiversity loss and strategies to be implemented for conservation of coastal and marine biodiversity.

3. KEY STRESSORS ON COASTAL AND MARINE BIODIVERSITY LOSS

Imtiyaz et al. [20] noted that, "human activities are causing species to disappear at an alarming rate. Loss of biodiversity impact the entire ecosystem, depriving valuable resources used to provide food, medicines, and industrial materials to human beings". "Key stressors that pose threats to the marine environments include overfishing, urban development, resource based industries (mining, dredging), air and water pollution, sedimentation, and climate change pose threats to marine biodiversity" [21,22].

According to Kennedy et al. [23], "changes in the global climate have affected the distribution of organisms and their interactions". "Human-induced increases in atmospheric concentrations of greenhouse gases may lead to modifications in the flow of energy and cycling of materials within ecosystems" [24]. "Global climate change is predicted to affect air and water temperatures, sea-level rise, precipitation, wind patterns, frequency and intensity of storms; thereby affecting the marine biodiversity" [25,26].

Küpper and Kamenos [27] and Martens [28] reported that, "the major threats to the marine biodiversity are ocean warming (e.g. species replacement and migration), sea level rise (loss of habitats including salt marshes), plastic pollution (entanglement and ingestion), alien species (outcompeting native species and parasite transmission), overexploitation (loss of energy supply further up the food web), habitat destruction (loss of nursery areas for commercially important species) and ocean acidification (skeletal weakening of ecosystem engineers including cold water corals)" [12].

3.1 Habitat Destruction and Changes in Sea Use

Unregulated coastal development and harmful practices are causing extensive loss and degradation of critical habitats. According to Imtiyaz et al. [20], "habitat destruction and fragmentation involves emergences of discontinuities or the loss of the environment inhabited by an organism" [22]. "Since organisms are adapted to specific abiotic environments, any change in the habitat should cause corresponding alteration in the community of species that live there" [28].

"Upstream deforestation and careless agricultural practices increase the sediment load in runoff. The addition of anthropogenic sediments, especially silts and clays, threatens coastal systems by smothering or burying marine organisms, clogging large their feeding or respiratory organs, coating photosynthetic surfaces, or increasing then turbidity reducing the light available for photosynthesis. Also, unregulated coastal development and harmful practices are causing extensive loss and degradation of critical habitats" [22].

3.2 Invasive Alien Species

Imtiyaz et al. [20] reported that, "invasive alien species are intentionally or accidentally transported and released into an environment outside of its historic geographical range and are ecologically and/or economically harmful". "The influx of non-native species disrupts ecosystem equilibrium, leading to the decline or extinction of native species and habitat transformation" [21]. "These species act as competitors, predators, parasites, or by spreading disease to the native biodiversity" [28]. "Examples of invasive alien species are: Jelly fish like species (*Mnemiopsis leidyi*), seaweeds like red alga (*Kappaphycus striatum*), zebra mussel (*Dreisssena polymorpha*), lion fish/aquarium fish (*Caulerpa taxifolia*)" [25,27].

3.3 Overexploitation

"Unsustainable use of natural resources leads to the resource depletion, and extinction of threatened and endangered species" [20]. "The exponential growth of the human population leads to the overexploitation of marine living resources to meet the growing demand for food. Commercial fish species are severely depleted due to unsustainable fishing practices and bycatch, placing thousands of marine species at risk of extinction. Overfishing is by far the biggest threat to the species listed as endangered or vulnerable to extinction. It also threatens many species of large sized fish such as tunas, swordfish, and sharks" [28].

3.4 Pollution

According to Martens [28], "anthropogenic pollutants pose a serious threat to estuaries and coastal waters. Nutrients from fertilized agricultural lands, domestic and industrial wastes, dredging, vessels dumping cargo at sea and atmospheric deposition of air-borne pollutants affect healthy coastal and marine diversity". "Riverine discharge and nonpoint source pollution discharge nitrogen and phosphate, and contamination of rivers by toxic materials such as organic mercury, heavy metals, pesticides, drugs, and PCBs, can cause serious pollution and deoxygenation in brackish and other coastal environments" [25].

"Marine ecosystems are compromised by pollutants like microplastics, heavy metals, and excess nutrients, causing eutrophication, harming marine life, and disrupting the food chain. Plastic pollution from fishing gear and microscopic particles resulting from physical and chemical breakdown affect the ocean's biodiversity. Plastic particles may directly impact marine animals by ingestion, mistaken for food particles, and subsequent choking of the digestive system" [27].

3.5 Ocean Acidification

Science 20 Japan [25] noted that "an increase in the atmospheric concentration of CO_2 is acidifying ocean waters and affects the marine calcifying organisms". "Ocean acidification impacts the carbonate-bicarbonate equilibrium and primarily affects calcifying organisms" [27]. "It is a global threat to marine ecosystems and its long term implications for the diversity of marine organisms and ecosystem functions are difficult to predict" [22].

3.6 Sea Level Rise

Imtiyaz et al. [20] documented that, "global warming will cause sea level rise. As a result, higher temperature decreases the ability of water to dissolve oxygen. Humans, however, have been increasing the amounts of CO_2 in the atmosphere by burning enormous amount of fossil fuels. Increasing temperature can cause coral bleaching where the zooxanthellae are expelled from the coral by the polyps". "Also, the release of seawater used for cooling the coastal power plants disturbs the ecological balance of the marine communities" [23,28].

3.7 Climate Change

According to Kennedy et al. [21], "climate change is likely to alter patterns of wind and water circulation in the ocean environment. Such changes may influence the vertical movement of ocean waters, increasing or decreasing the availability of essential nutrients and oxygen to marine organisms". "Changes in ocean circulation patterns can also cause substantial changes in regional ocean and land temperatures and the geographic distributions of marine species" [12,29].

4. STRATEGIES FOR CONSERVATION OF COASTAL AND MARINE BIODIVERSITY

Gregory [4] and Tertz [17] suggested that, for conservation of marine biodiversity, following strategies should be considered on the priority basis:

- Conservation of biodiversity hotspots in coastal areas.
- To promote resilience-focused approaches; to support habitat restoration and conservation, and to reduce greenhouse gas emissions.
- Collaboration with community and stakeholder for conservation initiatives.
- Collaboration among countries, conservation organizations, and research institutions.
- Manage threats like habitat degradation, pollution, overfishing, and climate change by protected areas, sustainable fishing, and control of pollution.
- Formulating and implementing supportive policies and regulations at local, national, and international levels is vital.
- Protecting coral reefs, mangrove forests, and seagrass meadows.
- Research and monitoring on species distribution, population dynamics, and ecosystem health.

5. CONCLUSION

Results of this study indicate that, reducing greenhouse gas (GHG) emissions, and enhancing carbon sequestration is essential to maintain the health of marine life. It is the only option to mitigate ocean warming, acidification, de-oxygenation, sea level rise, impacts of extreme weather events and destruction of particularly sensitive ecosystems at a global scale. Protection, restoration and conservation of natural resources such as wetlands, mangroves, saltmarshes, seagrasses, and coastal biodiversity is the only option left for better management of coastal ecosystem.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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