

VOLUME 9

ISSUE 2

2023

ISSN 2454 – 3055



**INTERNATIONAL
JOURNAL OF
ZOOLOGICAL
INVESTIGATIONS**

***Forum for Biological and
Environmental Sciences***

Published by Saran Publications, India



International Journal of Zoological Investigations

Contents available at Journals Home Page: www.ijzi.net

Editor-in-Chief: Prof. Ajai Kumar Srivastav

Published by: Saran Publications, Gorakhpur, India



ISSN: 2454-3055

Coastal Marine Biodiversity for Human Health and Well-Being

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Received: 18th October, 2023; **Accepted:** 22nd November, 2023; **Published online:** 27th November, 2023

<https://doi.org/10.33745/ijzi.2023.v09i02.128>

Abstract: Coastal ecosystems provide products and valuable services which yield both direct and indirect benefits to residents in coastal areas, and impact their well-being. The clear link between ecosystem status and human well-being is well established. Degradation of coastal ecosystems causes profound economic and social costs, along with loss of livelihoods. Humanity depends on biodiversity for health, well-being, and a stable environment. Conservation and protection of the marine and coastal biodiversity mainly depends on the knowledge of the taxonomy of the flora and fauna constituting the biodiversity and the species interaction in the ecosystem. The coastal marine biodiversity faces several threats such as indiscriminate fishing, habitat degradation, pollution, social conflicts, the introduction of highly sophisticated fishing gadgets, and needs management measures and conservation to maintain sustainable use. Anthropogenic activities are the major causes for the loss of biodiversity and degradation of marine and coastal habitats, which needs immediate attention and comprehensive action plan to conserve the biodiversity for living harmoniously with nature. Measures such as implementation of reference points and notification of marine reserves for protection and conservation of marine and coastal biodiversity are necessary. The ocean should be healthy to support the coastal marine biodiversity for the human health and well-being. The aim of this review was to update recent information from the available literature relating with coastal marine biodiversity with respect to human health and well-being, types, goods & services, threats/ major risks, root causes, and recommendations for protection.

Keywords: Marine biodiversity; Ecosystem; Conservation, Human health; Well-being; Threats; Marine drugs

Citation: Naik Mayur S. and Sarwade Varun V.: Coastal marine biodiversity for human health and well-being. Intern. J. Zool. Invest. 9(2): 1157-1164, 2023.

<https://doi.org/10.33745/ijzi.2023.v09i02.128>



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Introduction

Fenical (1996) described that there is an inextricable link between the status of coastal ecosystems and the vulnerability of coastal inhabitants to natural disasters. Also, direct correlation between the health of coastal

ecosystems and the degree of shoreline protection was demonstrated. Coastal ecosystem provides products such as food (fish, shrimp, crab), timber and fuel wood, shoreline protection, and income supporting services, such as fisheries and tourism.

Hence, the degradation of coastal ecosystems results in losing shoreline protection services and also loss of livelihoods (Kallesoe *et al.*, 2008).

Coastal ecosystems include brackish water lakes, lagoons, estuaries, back waters, salt marshes, rocky bottom, sandy bottom and muddy areas; which provides a home and shelter for the marine biodiversity. They support very rich fauna and flora and constitute rich biological diversity. Most of these regions face serious threats due to increasing human population and resulted human interventions characterized by pollution, deforestation, over exploitation of marine resources, dredging, quarrying and other activities leading to environmental degradation. Hence, conservation of ecosystem through policies for protected areas and sustainable management is an urgent need (Joshi, 2018).

Bernhardt and O'Connora (2021) stated that, seafood, consisting of wild-caught marine finfish and invertebrates, provides an important source of protein and calories to humans. Further, humanity depends on biodiversity for health, well-being, and a stable environment. There is growing concern that biodiversity change leads to changes in human health and well-being. Species losses and range shifts because of climate change, harvesting, and other human activities are altering aquatic biodiversity locally and globally. Also, due to unprecedented global change and increasing reliance on seafood to meet nutritional demands, there is an urgent need to understand how changing aquatic ecosystem structure may alter the provisioning of seafood-derived human nutrition (Borja, 2022).

At least since the ancestors, the ocean has been part of the development of human society. Human interaction with the ocean over this long period profoundly influenced the development of non-physical ecosystem services (aesthetic, religious and spiritual) that humans derive from the environment around them. Several goods produced by the ocean have been taken up as elite goods, i.e. goods that can be used for conspicuous consumption or to demonstrate status in some

other way. Since history, human derive aesthetic, cultural, religious and spiritual ecosystem services from the marine environment (Sandifer *et al.*, 2015).

Jerónimo *et al.* (2014) noted that, coastal areas provide critical ecological services such as nutrient cycling, flood control, shoreline stability, beach replenishment and genetic resources. Ocean and coastal systems contribute 63% of the total value of Earth's ecosystem services. Population growth is a major concern for coastal areas with more than 50% of the world population concentrated within 60 km of the coast. Growth of human population and per capita consumption has resulted in unsustainable exploitation of Earth's biological diversity, exacerbated by climate change, ocean acidification, and other anthropogenic environmental impacts. The effective conservation of biodiversity is essential for human survival and the maintenance of ecosystem processes.

According to EnviStats India (2022), biodiversity refers to the 'diversity' of life on Earth at all levels, from genes to ecosystems. It includes diversity within species, between species and of ecosystems, such as: manmade (plantations, farms, croplands, aquaculture sites, urban parks) and natural (forests, nature preserves or national parks) and represents the wealth of biological resources available to human beings. The diversity of life on earth is essential for the healthy functioning of ecosystems and it is biodiversity that boosts ecosystem productivity. It is high time the mankind realizes the fact that economies are embedded in nature and are not external to it.

Valuation of biodiversity is widely recognized as a useful approach to conservation and management. Despite its recognized value to humans, the marine environment is facing increasing anthropogenic pressures from resource exploitation, habitat destruction, pollution and the effects of climate change, with associated widespread declines in biodiversity and threats to key ecosystem services. Although these threats and declines are widely acknowledged, the ocean

presents major challenges for its conservation and management (Cavanagh *et al.*, 2016).

The World Bank Group (2022) pointed that, the diverse and rich biodiversity which provides critical ecosystem services, drives the continent's economy, and serves as a buffer to climate change; are increasingly threatened by ocean and coastal degradation, overfishing, erosion, and the effects of climate change. To mitigate these threats and improve the resilience of marine habitats, governments need to partner with the private sector and development finance institutions, including the World Bank, to improve collaborative marine resource governance, enhance the knowledge base of marine ecosystems and species to inform decision-making, and strengthen the restoration, monitoring, and control of marine and coastal areas.

The term "biodiversity/biological diversity" is one of the most often cited terms in both ecological research and environmental management and conservation. Its precise definition and understanding of the concept vary widely both between and within disciplines. Biodiversity refers to descriptions or assessments of the status and condition of all or selected groups of organisms, from the genetic variability, to the species, populations, communities, and ecosystems. The elements of biodiversity are fundamental properties of an ecosystem, and, in the marine realm, these encompass all life forms, including the environments they inhabit, and at scales from genes and species to ecosystems (Cochrane *et al.*, 2016).

Gray (1997) reported that, marine biodiversity is higher in benthic rather than pelagic systems, and in coasts rather than the open ocean since there is a greater range of habitats near the coast. Losses of marine diversity are highest in coastal areas largely as a result of conflicting uses of coastal habitats. The oceanic system is open and continuous and contaminants will lead to measurable effects on diversity, such as local or regional extinctions (Oakley, 2023). Marine and

coastal ecosystems are important habitat with a distinct structural diversity and flow of energy. The salt marshes, mangroves, wetland, estuaries and bays form the main area of coastal ecosystem with high biodiversity. Of all the factors affecting the health and sustainability of the ocean, the status of protection of threatened, vulnerable and endangered species may be the most familiar problem. In spite of the sustained efforts to save the coastal biodiversity, there are some species such as dolphins, turtles, sharks, sea cow and horseshoe crab showing the sign of degradation and extinction. Biodiversity provide important services to mankind and needs to be protected (Shaikh and Ansari, 2020).

The aim of this review was to update the published information on 'coastal marine biodiversity for human health and well-being' and to explore the knowledge gaps along with scope for future research. Special emphasis is given on types, goods and services, threats/ major risks, root causes, and recommendations for protection.

The review was carried out through extensive literature search, using electronic databases, and online search tools, such as EMBASE, Google Scholar, Medline, NCBI, PubMed, Science Direct, Scopus, and Web of Science databases. Data and information was collected from the thorough study of the journal articles, research papers, reports and various literatures. The keywords used for reviewing the literature were the ones that refer to the issues concerning the 'coastal marine biodiversity'. For literature search, keyword "coastal marine biodiversity" is combined with: definition, human health, well-being, types, functions, key species, threats, challenges, and conservation.

Definition of Biodiversity/ Biological Diversity:

Table 1 illustrates the definition of biodiversity. Table 2 depicts the definition of coastal marine biodiversity.

Types of Coastal and Marine Habitats:

Joshi (2018) stated that coastal and marine biomes and habitats were represented by different

Table 1: Definition of Biodiversity

Author	Definition
Wilson (1988)	The variety of life at every hierarchical level and spatial scale of biological organizations: genes within populations, populations within species, species within communities, communities within landscapes, landscapes within biomes, and biomes within the biosphere.
CBD (1992)	The variability among living organisms from all sources including, Inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.
de Fontaubert <i>et al.</i> (1996)	Variability among the living organisms from all sources including terrestrial marine and other aquatic inter alia ecosystems and the ecological complexes of which they are apart.
Denny (1997)	A assemblages of plant, animals and micro-organisms, their genetic variability expressed and populations, their habitats, ecosystems and natural areas, the mosaic of which constitutes the landscape which gives the richness to the natural environment.
Swingland (2001)	Species, genetic, and ecosystem diversity in an area, sometimes including associated abiotic components such as landscape features, drainage systems, and climate.
Jeronimo <i>et al.</i> (2014)	It comprises the variety of life on Earth, from genes and organisms to larger units such as ecosystems and landscapes.
Borja (2022)	The intrinsically-inbuilt plus the externally-imposed variability in and among living organisms existing in terrestrial, marine and other ecosystem at a specific period of time.
EnviStats India (2022)	Biodiversity means the 'diversity' of life on Earth at all levels, from genes to ecosystems. It includes diversity within species, between species and of ecosystems.
Oakley (2023)	Biodiversity or biological diversity is the scientific study of nature or the natural world within a geographically defined region.

Table 2: Definition of Coastal Marine Biodiversity

Author	Definition
https://www.msc.org/en-au/what-we-are-doing/oceans-at-risk/marine-biodiversity (Accessed on 26/09/2023)	Marine biodiversity is the variety of life in our ocean and includes all animals, plants and microorganisms living in ocean, from barnacles to whales to coral reefs. It also describes the abundance of species living in an area.

marine ecosystems like mangrove ecosystems, coral reef ecosystem, estuarine ecosystem, coastal marine ecosystem, lagoon, systems, coastal ecosystems and marine protected areas (Table 3).

Goods and Services Provided by Coastal Marine Biodiversity (Lloret, 2010):

Coastal marine biodiversity play a crucial role in almost all biogeochemical processes that sustain the biosphere, and provide a variety of products

(goods) and functions (services) which are essential to humankind's well-being.

- **Production of seafood:** Healthy and sustainable seafood, about 100 million tonnes annually.
- **Seafood with health benefits:** Cardio and cancer protective effects attributed to the high intake of seafood-derived n-3 (omega-3) fatty acids.
- **Bioactive metabolites:** Natural substances, ingredients for biotechnology and pharma-

Table 3: Types of Coastal and Marine Biomes and Habitats

Coastal and Marine Habitats	Ecological services
Mangrove ecosystems	• Shoreline protection, Sea erosion • Breeding and larval rearing & dispersal • Safe habitat for migratory species • Breeding and nursery grounds for prawns and fishes. • Provides nutrition for various organisms. • Protection to the coastline from natural disasters like cyclone, flood and Tsunami. • Boating, hunting, bird watching, wildlife observation, education trips and photography.
Coral reef ecosystems	• Biologically productive and diverse ecosystems. • Rich biological diversity. • Recreation, tourism and shore limp protection. • Calcium carbonate as raw material for lime waste industries, cement and calcium carbide. • Used as building blocks in many parts of the world. • Raw materials for industries (cement, lime and calcium carbide).
Estuarine ecosystems	• Important buffer zones. • Most productive habitats in the world. • Natural nurseries for many marine animals.
Lagoon ecosystem	• Rich biological diversity. Aquaculture practices. • Wintering; feeding, resting and breeding habitat for migrating birds. • Home to migratory bird, gastropod, bivalve, reptile and mammal populations.
Coastal ecosystems	• Fishery resources and primary production. • Medicines, drugs and pharmaceuticals (Jha and Xu, 2004; Patrick <i>et al.</i>, 2010; Arizza, 2013; Singh <i>et al.</i>, 2020). • Boating, hunting, bird watching, and photography.
Marine Protected Areas	• Ecological values and biodiversity conservation.
Wetlands	• Areas of standing water and support aquatic plants. • Examples: Marshes, swamps, and bogs. • Highest species diversity of all ecosystems. • Home for amphibians, reptiles, birds and furbearers

ceuticals. New drugs to treat major human diseases (cancer).

- **Environments for practising maritime leisure activities:** This provides physical and psychological benefits to users.
- **Recreation:** Fishing, tourism, photography etc.
- **Essential services:** Production and mineralization of organic material; storage of carbon; storage of pollutants and waste products from land; buffering of the climate and of climate change; coastal protection (mangroves, dune-beach systems, coral reefs).

Threats/Major risks to Coastal Marine Biodiversity:

Martens (2023) reported that, the ways that

humans threaten marine biodiversity (Table 4) can be grouped into proximate threats and root causes; the former are driven by the latter.

Root causes of coastal marine biodiversity loss:

The main root causes of biodiversity loss lie in: demographic pressure and unsustainable use of natural resources; economic policies that fail to value the environment and its resources; insufficient knowledge and its poor application; weakness in legal and institutional systems (Martens, 2023).

Recommendations to protect Coastal Marine Biodiversity:

The study supports the following recommendations:

- Value provided by coastal marine biodiversity are a foundation for multiple economic sectors and for millions of people living on the shorelines.
- Extraction of resources (mineral and energy), may impact on the ability of ecosystems to regenerate and provide services into the future.
- Coastal marine biodiversity is a primary national assets and it must be sustained and enhanced, rather than overexploited and degraded.
- Coastal marine biodiversity will provide the greatest benefit to national economies and local communities.

Table 4: Human activities that damage coastal marine biodiversity

Proximate threats	Types of human activities
Over-exploitation	• Over-exploitation of essential products (foods, medicines, raw materials and recreational facilities). • Tourist populations increase the local exploitation for crustaceans (lobsters, crabs and prawns). • Direct exploitation of marine mammals, seabirds, sea turtles and many invertebrate species. • Collection of marine organisms for curios or jewellery: Corals, sponges, molluscs, echinoderms, puffer and trigger fishes, and turtles. • Over-fishing of shallow inshore populations: Serious local effects on species and their habitats.
Physical alterations & habitat loss	• Clearance of mangroves, estuaries and beaches for coastal development, industrialisation, aquaculture or agriculture. • Trawling disturbs the benthic communities on the seabed. • Physical damage by the trawling gear and reduced photosynthesis by re-suspension of sediment. • Deforestation and careless agricultural practices increase the sediment load in runoff. • Threatens coastal diversity burying marine organisms, clogging large their feeding or respiratory organs, coating photosynthetic surfaces, or increasing then turbidity reducing the light available for photosynthesis.
Pollution	• Pollutants pose a serious threat to estuaries and coastal waters. • Entry of anthropogenic nutrients in coastal waters as runoff from fertilized agricultural lands, sewage effluents (domestic and industrial wastes), dredging, vessels dumping cargo at sea and atmospheric deposition of air-borne pollutants. • Hypoxia or anoxia due to nutrient enrichment (eutrophication) with increased primary production, changes in plant species composition, dense and toxic algal blooms, and changes in structure of benthic communities. • Contamination by chemicals (trace metals, radionuclides and petroleum residues). • Long-term effects of chemicals in the environment and concentrated in trophic chain. • Toxins cause death, disease, reduced reproduction and developmental aberrations in exposed marine organisms.
Introduction of alien species	• Extinctions of indigenous biota without defensive or competitive capabilities. • Transportation of marine organisms by humans, for aquaculture and private collections or from fouling and ballast-water of ships. • Exotics become dominant species in coastal communities and replace native species.
Global climate change	• Global warming: Greenhouse gases (carbon dioxide and chlorofluorocarbons) accumulate in the atmosphere. • Alteration in patterns of ocean circulation, precipitation and storm tracks. • Rise in sea level. • Thermal expansion of the water & melting of icecaps.

Conclusion

Results of this study indicated that the best way to conserve marine diversity is to conserve habitat and landscape diversity in the coastal area. Marine protected areas are only a part of the conservation strategy needed. It is suggested that a framework for coastal conservation is integrated coastal area management where one of the primary goals is sustainable use of coastal biodiversity.

Acknowledgements

Encouragement and support provided by Dr. Ganesh A. Thakur, Principal, Mahatma Phule Arts, Science and Commerce College, Panvel, Raigad, Navi Mumbai, India is gratefully acknowledged. Authors are thankful to The Head, Department of Zoology for providing necessary facilities for the present study.

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