Marine Biodiversity and Fisheries Environment Management

Grinson George, K. S. Sobhana and Vineetha Gopinath

ICAR-Central Marine Fisheries Research Institute, Kochi Email: grinsongeorge@gmail.com

Biodiversity or biological diversity refers to the enormous variety of life forms on earth spanning all levels of biological organisation from genes to ecosystems. The term "biodiversity" was coined by Walter G Rosen in 1985. Later, it became a cornerstone in conservation biology and environmental science highlighting the interconnectedness and variety of life forms on earth. Marine biodiversity refers to the variety and variability of life forms in ocean. It encompasses organisms spanning size range from microscopic virioplankton to large mammals inhabiting marine habitats ranging from the sunlit coastal waters to the deepest oceanic trenches (Ormond *et al.*, 1997). As per the World Register of Marine Species (WORMS) 2022 census, approximately 242,000 marine species are described till date and even continue to be discovered and named at a current average of 2332 new species per year. Marine biodiversity are often classified at several levels to reflect the complexity and variety of life in ocean which includes,

- **Genetic Diversity** comprising variation of genes within a particular species. It is highly crucial for organisms to adapt to changing environments and in resisting diseases.
- **Species Diversity** comprising the vast array of diverse species within the marine habitats. High species diversity is vital for maintaining ecosystem stability and productivity of oceans and in ensuring ecosystem resilience to disturbances.
- **Ecosystem/Habitat diversity** comprising of variety of habitats in marine ecosystems such as coral reefs, kelp forests and open ocean. It contributes greatly to ecological processes and services such as nutrient cycling, water filtration and climate regulation on earth.
- **Functional diversity** comprising of the variety of biological processes, functions or characteristics of ecosystems crucial in maintaining ecosystem services and health of marine ecosystems.

Marine biodiversity in India

India, having an extensive coastline of 7500 kilometres are bestowed with rich marine biodiversity. The key marine habitats in India comprising of coral reefs, mangroves, sea grass beds, estuaries and coastal lagoons along with the Indian Exclusive Economic Zone (EEZ) covering an area of 2 million square kilometres is home to

around 2492 marine fish species, 2439 crustaceans, 3827 molluscs, 765 echinoderms and 493 sponges. Around 585 sceleractinian corals belonging to 108 genera and 23 families are reported from coral reef ecosystems of India. More than 70 species of mangroves, 844 species of sea weeds contribute to the marine flora of the Indian coast. India hosts 5 out of the 7 species of sea turtles recorded globally. India is home to around 30 species of marine mammals and 70 species of sea birds all indicating to its rich marine biodiversity (Ragunathan *et al.*, 2019)

Significance of Marine biodiversity

Marine Biodiversity is crucial for ecosystem functioning and in sustaining ecosystem services such as fisheries, tourism and coastal protection. It is also an important resource that provides food, security, and livelihoods for millions of people. Many marine organisms are potential sources of bioactive compounds used in medicine and pharmaceutical industry. Marine flora, particularly phytoplankton and seagrasses, play a significant role in carbon sequestration and thus help in mitigating impacts of climate change (Beaugrand et al., 2010). Marine habitats such as coral reefs, mangroves, and seagrass beds protect coastlines from erosion and storm surges and thus reduce the vulnerability of coastal areas to natural disasters and sealevel rise. Marine biodiversity also contributes immensely to nutrient cycling thus ensuring the availability of essential nutrients for marine life (Duarte, 2000). Marine biodiversity also underpins many recreational activities, such as diving, snorkeling, and wildlife watching and contribute to revenue generation through tourism activities. Furthermore, marine organisms forms a reservoir of genetic diversity, and are crucial for adapting to changing environments and for breeding programs in aquaculture required for resilience against diseases and environmental changes (Worm & Lotze 2021).

Threats to marine biodiversity

Though marine biodiversity is critical in sustaining the health and stability of oceans, it faces a multitude of threats mostly driven by human activities. These stressors can lead to biodiversity decline and loss, disrupt ecosystem functioning and make marine ecosystems more vulnerable to human induced and natural disasters. Of the many threats, the prominent ones that needs attention include overfishing, pollution, habitat destruction and climate change (Gray J.S., 1997; Pan *et al.*, 2013)

• Overfishing – Unsustainable fishing practices such as over harvesting and increased capture of non-target species is a major threat affecting marine biodiversity

leading to depleted fish stocks thus disrupting marine food webs to a greater extent.

- *Habitat destruction* Coastal habitats such as mangroves, estuaries and sea grass beds are threatened by the coastal developments occurring in conjunction with construction of ports, resorts and aquaculture facilities.
- *Pollution* –Agricultural runoff, industrial discharges and plastic waste disposals from land-based sources contaminate marine ecosystems, degrade habitats and threaten the survival of marine organisms.
- *Climate change* –Rising ocean temperatures concurrent to global warming, ocean acidification, changes in weather patterns witnessed as more frequent and severe storms stress ecosystem functioning of marine ecosystems through bleaching corals, altering species distributions, spawning grounds, and disrupting food webs.
- *Invasive species* Introduction of non –native species through shipping and aquaculture practices which outcompete the native species is another cause of biodiversity loss.
- *Disease* Disease outbreaks and mass mortality of marine organisms arising from bacterial, viral and parasitic infections is one another threat impacting marine biodiversity.
- *Illegal wildlife trade* The illegal trade of endangered species such as sea horses and sea turtles further aggravate biodiversity loss happening concurrent to climate change and anthropogenic interventions.
- *Noise pollution* Underwater noise pollution arising from shipping, drilling and sonar use impede with the communication, navigation and feeding behaviours of marine animals resulting in stranding and mortality.

Impacts associated with marine biodiversity loss

Marine biodiversity loss exerts a profound impact on marine ecosystem and its functioning and may have far reaching consequences (Lotze, 2021). Some of which are,

- *Reduces Resilience* Marine biodiversity loss make marine ecosystem more vulnerable to environmental stressors such as climate change, pollution and invasive species resulting in severe ecosystem collapses.
- *Altered ecosystem functioning* Loss of key species from an ecosystem can disrupt ecosystem processes, leading to changes in primary productivity, nutrient cycling and food web dynamics
- *Economic consequences* Decline in marine biodiversity cause significant economic impacts specifically on livelihood of coastal population relying on fisheries and

tourism. Severe storm and cyclone resulting from changed weather patterns cause massive infrastructure damages and economic loss.

International Union for Conservation of Nature (IUCN)

The International Union for Conservation of Nature (IUCN) plays a crucial role in the conservation and sustainable use of marine biodiversity. The IUCN Red List is one of the most comprehensive inventories of the global conservation status of species. It assesses the extinction risk of species based on criteria such as population size, rate of decline, and geographic range. For marine biodiversity, the Red List includes assessments of various marine species such as corals, fish, marine mammals, and sea turtles, helping to identify those most at risk and prioritize conservation efforts. The IUCN advocates for the establishment and effective management of Marine Protected Areas. The IUCN Species Survival Commission (IUCN-SSC) is a global network of experts working to conserve species and their habitats. Within this commission, there are specialist groups focused on specific marine species, such as mammals, sharks etc. These groups conduct research, provide expert advice, and develop conservation strategies for these vulnerable marine species.

Global Marine and Polar Programme (GMPP) of IUCN works to promote the sustainable management of marine resources and the conservation of marine biodiversity. It focuses on key issues such as marine pollution, climate change, and overfishing. The programme collaborates with governments, NGOs, and other stakeholders to implement marine conservation initiatives and influence policy. IUCN works at the international level to influence marine policies and agreements. This includes participation in conventions such as the Convention on Biological Diversity (CBD) and the United Nations Convention on the Law of the Sea (UNCLOS)

As per the IUCN Red list data of 2022, over 1,550 of the 17,903 marine animals and plants assessed are at risk of extinction, with climate change impacting at least 41% of threatened marine species. Some critically endangered marine flora according to the latest IUCN Red List assessments include, *Zostera chliensis* (Chilean eel grass), *Halophila beccarii* (Beccaris's sea grass), *Phyllospadix torreyi* (Torreys's surf grass), *Thalassodendron ciliatum* (Indian Ocean sea grass) etc. while critically endangered fauna includes, Hawksbill turtle (*Eretmochelys imbricata*), Vaquita (*Phoceana sinus*), Pillar Coral (*Dendrogyra cylindrus*), etc.

Fishery environment management

Fishery environment management often involves the sustainable management of fisheries resources to ensure their long-term viability while minimizing negative impacts on the aquatic environment. This includes a variety of strategies and practices aimed at balancing the ecological, economic, and social aspects of fisheries.

1. Effective management to curb pollution

Pollution is one major threat to the fishery and fishery environment eliciting detrimental impacts on fish populations, marine ecosystems, and the overall health of the aquatic environment. Pollution comes from various sources, including landbased activities, marine operations, and atmospheric deposition. Effective management strategies are essential to mitigate these impacts and promote sustainable fisheries. Some major pollution threatening the fishery environment include,

Chemical pollution – Chemical pollutants in the marine environment poses a severe threat to aquatic ecosystems, marine life, and human health. The toxic substances such as heavy metals, pesticides, and polychlorinated biphenyls (PCBs) stemming from sources like agricultural runoff, industrial discharges, and untreated sewage, can accumulate in marine organisms, causing reproductive, developmental, and immune system impairments, leading to decline in biodiversity and fish populations.

Stringent regulatory measures must be enforced to control pollutant discharge from industrial and agricultural activities. Enhancing wastewater treatment facilities to effectively remove contaminants before they reach marine ecosystems is crucial. Promoting best management practices in agriculture, such as reduced pesticide use and the establishment of buffer zones, can significantly decrease runoff. Public awareness campaigns and educational programs can inform and engage communities in reducing chemical use and proper disposal of hazardous substances

Plastic pollution - Plastic pollution in the marine environment poses a severe threat to ecosystems, marine life, and human health. Vast quantities of plastic debris, from large, discarded items to microscopic particles, accumulate in the oceans, affecting all levels of the marine food web. Marine animals often ingest plastics, mistaking them for food, which can lead to physical harm, chemical contamination, and even death. Entanglement in plastic waste, such as abandoned fishing nets, further endangers marine species, including fish, turtles, and seabirds. Moreover, plastics can smother coral reefs and seagrass beds, degrading critical habitats that support diverse marine

life. The persistence of plastics in the environment, combined with their ability to absorb and concentrate toxic chemicals, poses long-term risks to marine biodiversity and food security.

Mitigating plastic pollution requires comprehensive strategies that address its sources and impacts. Policy measures, such as bans on single-use plastics and microbeads, coupled with Extended Producer Responsibility (EPR) programs, can significantly reduce the influx of plastic waste into the marine environment. Additionally, regulations targeting microplastics, such as the ban on microbeads in personal care products, prevent these harmful particles from entering waterways. Improving waste management infrastructure, especially in developing regions, is crucial for preventing plastics from entering waterways. Community-based initiatives, like beach and coastal cleanups, play a vital role in removing existing debris and raising public awareness. Technological innovations, such as the development of biodegradable plastics and advanced recycling techniques, offer promising solutions for reducing plastic waste. International cooperation is also essential, as plastic pollution is a transboundary issue requiring global action and agreements. By implementing these strategies, we can protect marine ecosystems, ensure the sustainability of fisheries, and safeguard the health of our oceans. International agreements, like the Basel Convention's amendments to control plastic waste trade and the United Nations' initiatives on marine litter, promote global cooperation in tackling plastic pollution. Enforcement of these laws, combined with public education and corporate responsibility, is essential to reducing plastic waste and preserving marine biodiversity.

2. Sustainable Fishing practices

Sustainable fishing practices are essential for maintaining the health and productivity of fish stocks, and marine ecosystem. Some of the strategies and practices followed as per sustainable fishing practices are

Catch limits and Quotas

Through setting a scientifically determined limit on the total amount of fish that can be caught in a particular fishery to prevent overfishing and allocating a specific portion of the total allowable catch to individual fishers or companies to be bought, sold for promoting economic efficiency

• Size and species restrictions

Implementing regulations on size of fish that can be legally caught to protect juveniles to ensure a chance to reproduce and also through prohibiting the capture of the endangered or threatened species to protect vulnerable populations

- Employing selective fishing gears such as circle hooks and other selective gears, and By catch Reduction Devices (BRDs) that allow non-target species to escape from fishing gear to reduce by catch, installing Turtle Excluder Devices (TEDs) in trawl nets to reduce incidental capture of turtles
- **Fishing effort control** Through restricting the number of days fishers operate to prevent over exploitation of resources and also by setting limits on the amount of gear that can be used by each fisher or vessel

3. Habitat protection and restoration

Habitat protection and conservation are critical for maintaining healthy fishery environment and ensuring sustainable fish populations. Key strategies include establishing Marine Protected Areas (MPAs) that restrict or regulate human activities to safeguard critical habitats such as coral reefs, mangroves, seagrass beds, and spawning grounds. These protected areas provide safe havens for marine species to breed, feed, and grow without the pressures of fishing and other harmful activities. Additionally, habitat restoration projects, such as replanting mangroves, restoring oyster reefs, and rehabilitating damaged coral reefs, help to rebuild ecosystems that have been degraded by pollution, overfishing, and climate change. Implementing sustainable coastal development practices and reducing land-based sources of pollution, such as agricultural runoff and sewage, further protect these vital habitats. Engaging local communities in conservation efforts and promoting sustainable fishing practices are essential to the success of these initiatives.

Laws for marine habitat conservation are pivotal in safeguarding the intricate ecosystems that underpin the health of our fishery environment. Marine Protected Areas (MPAs), established through legislation, serve as sanctuaries where fishing, mining, and other potentially harmful activities are restricted or prohibited altogether, allowing marine ecosystems to thrive undisturbed. Additionally, laws protecting endangered species mandate the preservation of habitats vital to the survival of threatened marine organisms, preventing further degradation of their populations. Coastal zone management laws govern development along coastlines, aiming to balance economic interests with the preservation of fragile coastal habitats like mangroves, salt marshes, and coral reefs. Fisheries management laws often incorporate habitat protection measures to sustain fish populations and the

ecosystems on which they depend, such as regulating fishing gear to minimize habitat damage. International agreements and conventions further strengthen marine habitat conservation efforts by fostering collaboration among nations to address transboundary conservation challenges. By upholding and enforcing these laws, governments can ensure the resilience of marine ecosystems, safeguard biodiversity, and promote sustainable use of marine resources for the benefit of present and future generations.

4. Strengthening of international and national policies and legal frameworks

Marine laws for fishery management are designed to ensure the sustainable use of marine resources, prevent overfishing, and protect marine ecosystems.

Major international laws aimed at biodiversity conservation and fishery management are,

o United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea (UNCLOS) is an international treaty that provides a legal framework for the use and conservation of the world's seas and oceans and their resources. It was adopted in 1982 and came into force in 1994. UNCLOS provides a comprehensive legal framework that governs all aspects of ocean space, from delimitation of maritime boundaries to the management of marine natural resources. By defining rights over marine resources, UNCLOS plays a crucial role in economic activities such as fishing, mining, and oil exploration.

o Convention on Biological Diversity (CBD)

The Convention on Biological Diversity (CBD) is an international treaty aimed at conserving biological diversity, promoting the sustainable use of its components, and ensuring the fair and equitable sharing of benefits arising from genetic resources. Adopted at the Earth Summit in Rio de Janeiro in 1992, it came into force on December 29, 1993.

o Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement aimed at ensuring that international trade in specimens of wild animals and plants does not threaten their survival. CITES contributes to the conservation of endangered species and promotes sustainable use of wildlife resources through controlling and monitoring trade.

o International Whaling Commission (IWC)

The International Whaling Commission (IWC) is an international body established under the International Convention for the Regulation of Whaling (ICRW) in 1946. The IWC's primary purpose is to regulate the whaling industry to ensure the conservation of whale populations and manage whaling practices on a global scale.

o Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention)

The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as the Bonn Convention, is an international treaty aimed at the conservation of migratory species across their migratory ranges. Adopted in Bonn, Germany, in 1979, and entering into force in 1983, CMS is under the aegis of the United Nations Environment Programme (UNEP).

o Food and Agricultural Organisation Code of Conduct of Responsible Fisheries

Developed by the Food and Agriculture Organization (FAO), this voluntary code sets principles and standards for responsible practices in fisheries. It covers aspects such as fishing operations, management practices, aquaculture development, and the trade of fishery products. Emphasizes sustainable use of fishery resources, ecosystem-based management, and the prevention of overfishing and Illegal, Unreported, and Unregulated (IUU) fishing.

o Ramsar Convention on Wetlands

The Ramsar Convention on Wetlands represents a critical international effort to safeguard wetland ecosystems that are vital for biodiversity, human well-being, and climate resilience. The Ramsar Convention on Wetlands, officially known as

the Convention on Wetlands of International Importance especially as Waterfowl Habitat, is an international treaty aimed at the conservation and sustainable use of wetlands. It was adopted in the Iranian city of Ramsar on February 2, 1971, and came into force on December 21, 1975. Through its emphasis on wise use, international cooperation, and the designation of Ramsar Sites, the convention promotes the sustainable management and conservation of wetlands worldwide. It ensures conservation and wise use of all wetlands through local, regional, and national actions and international cooperation.

In India, marine biodiversity conservation is governed by a combination of national laws, policies, and regulations aimed at protecting marine ecosystems, species, and habitats (Rawat & Agarwal., 2015)

o Wildlife Protection Act, 1972

The Wildlife Protection Act of 1972 is a comprehensive legislation enacted by the Government of India to ensure the protection of wild animals, birds, and plants. The Wildlife Protection Act, 1972, is a cornerstone of India's efforts to protect and conserve its wildlife and biodiversity. The Act provides the legal framework for the conservation of wildlife and the management of protected areas in India.

o Biological Diversity Act, 2002

The Biological Diversity Act, 2002, is a critical piece of legislation for the conservation and sustainable use of India's vast biological resources. It provides a structured approach to ensuring that biodiversity is protected and that the benefits arising from its use are shared equitably with those who have traditionally conserved and utilized these resources.

o Environment Protection Act, 1986

The Environment Protection Act, 1986, is a landmark piece of legislation that underscores India's commitment to environmental protection and sustainable development. By providing a comprehensive legal framework and empowering regulatory agencies, the Act plays a crucial role in mitigating environmental pollution and promoting ecological balance.

o Coastal Regulation Zone (CRZ), 2019

The Coastal Regulation Zone (CRZ) Rules, 2019, is a set of regulations formulated by the Ministry of Environment, Forest and Climate Change, Government of India, under the Environment Protection Act, 1986. These rules govern activities along the coastal areas of India to ensure sustainable development, protect coastal ecosystems, and safeguard coastal communities.

Future directions in marine biodiversity conservation and fisheries management

The future of marine biodiversity conservation requires a multifaceted approach that addresses emerging challenges and leverages innovative strategies to protect and sustainably manage marine ecosystems.

- Integrated Ecosystem Management planning: Based (EBM) and Implementing ecosystem-based management approaches that integrate ecological, social, economic considerations, and recognizing the interconnectedness of marine ecosystems and human well-being.
- Enhanced Marine Protected Areas (MPAs): Through prioritizing the establishment of new MPAs in critical marine habitats, including areas of high biodiversity, spawning grounds, and migration routes
- **Climate Resilience and Adaptation**: Developing and implementing strategies to enhance the resilience of marine ecosystems to climate change impacts such as ocean warming, acidification, and sea-level rise.
- Sustainable Fisheries Management: Transitioning towards sustainable fisheries management practices that prioritize ecosystem health, reduce overfishing, minimize bycatch and discards, and promote the adoption of ecosystem-based approaches.
- **Public Awareness and Education**: Increasing public awareness and understanding of marine biodiversity conservation issues through education, outreach, and communication initiatives.
- International Cooperation and Governance: Strengthening international cooperation, collaboration, and governance frameworks to address transboundary marine conservation challenges effectively.
- Nature-Based Solutions: Promoting the use of nature-based solutions, such as mangrove restoration, coral reef rehabilitation, and seagrass conservation, to mitigate climate change impacts, enhance coastal resilience, and support biodiversity conservation.

References

- Beaugrand, G., Edwards, M., & Legendre, L. (2010). Marine biodiversity, ecosystem functioning, and carbon cycles. Proceedings of the National Academy of Sciences, 107(22), 10120-10124
- Duarte, C. M. (2000). Marine biodiversity and ecosystem services: an elusive link. Journal of experimental marine Biology and Ecology, 250(1-2), 117-131.
- Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., ... & Thomson, R. J. (2014). Global conservation outcomes depend on marine protected areas with five key features. Nature, 506(7487), 216-220.
- Gray, J. S. (1997). Marine biodiversity: patterns, threats and conservation needs. Biodiversity & Conservation, 6(1), 153-175.
- Hiscock, K. (2014). Marine biodiversity conservation: A practical approach. Routledge.
- Lotze, H. K. (2021). Marine biodiversity conservation. Current Biology, 31(19), R1190R1195.
- Ormond, R. F., Gagean, J. D., & Angel, M. V. (1997). Marine Biodiversity. Patterns and Processes.
- Pan, J., Marcoval, M. A., Bazzini, S. M., Vallina, M. V., & Marco, S. (2013). Coastal marine biodiversity: Challenges and threats. Marine ecology in a changing world, 43-67.
- Qureshi, W. A. (2017). Marine biodiversity conservation: The international legal framework and challenges. Hous. J. Int'l L., 40, 845.
- Raghunathan, C., Raghuraman, R., & Choudhury, S. (2019). Coastal and marine biodiversity of India: challenges for conservation. In Coastal Management (pp. 201-250). Academic Press.
- Rawat, U., & Agarwal, N. K. (2015). Biodiversity: Concept, threats and conservation. Environment Conservation Journal, 16(3), 19-28.
- Ward, D., Melbourne-Thomas, J., Pecl, G. T., Evans, K., Green, M., McCormack, P. C., ...
 & Layton, C. (2022). Safeguarding marine life: conservation of biodiversity and ecosystems. Reviews in fish biology and fisheries, 32(1), 65-100.
- Worm, B., & Lotze, H. K. (2021). Marine biodiversity and climate change. In Climate change (pp. 445-464). Elsevier.



ICAR- Central Marine Fisheries Research Institute ¹²¹