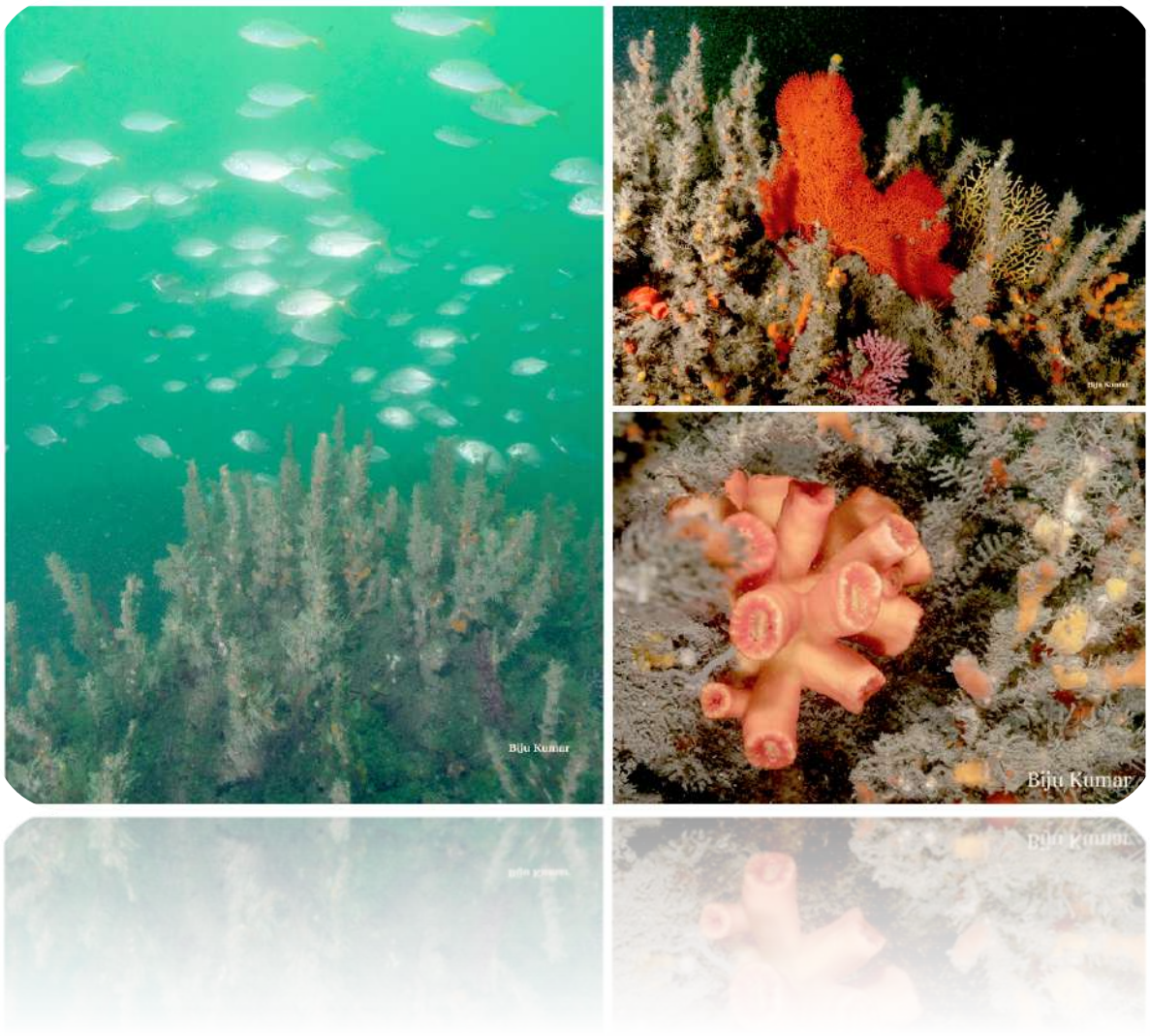
REPORT ON THE POSSIBLE IMPACTS OF OFFSHORE SEA SAND MINING OFF KOLLAM ON MARINE BIODIVERSITY AND COASTAL LIVELIHOODS



UNIVERSITY OF KERALA

DEPARTMENT OF AQUATIC BIOLOGY & FISHERIES

(UGC-SAP Centre of Advanced Study)

Karyavattom, Thiruvananthapuram 695 581, Kerala

"The depths of our oceans remain largely unexplored, but humankind's first tentative ventures into the blue abyss have revealed a hidden world full of wonders, where life thrives under great barometric pressure and far from the light of the sun. The fact that life exists at all in such unforgiving conditions, drawing energy from the chemicals expelled from the earth's core and locking away carbon from our atmosphere, is one of the world's uncelebrated marvels. What is more, we are now beginning to appreciate the extent to which life in the deep sea also affects the health of the planetary systems on which we all depend. The fate of the deep sea and the fate of our planet are intimately intertwined. That we should be considering the destruction of these places and the multitude of species they support – before we have even understood them and the role they play in the health of our planet – is beyond reason.

Sir David Attenborough

Report on the Possible Impacts of Offshore Sea Sand Mining Off Kollam on Marine Biodiversity and Coastal Livelihoods

A Biju Kumar

Dept. of Aquatic Biology & Fisheries, University of Kerala, India

Disclaimers

The opinions/views expressed in this report are that of the author compiled the report and do not necessarily reflect the views of the University of Kerala.

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Ph: +91 471 2308131; Email: aquaticbiologyandfisheries@keralauniversity.ac.in

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[Address for Communication: Dr. A. Biju Kumar, Senior Professor and Head, Dept. of Aquatic Biology & Fisheries, University of Kerala, Thiruvananthapuram 695 581, Kerala. Ph: 9447216157; Email: bijukumar@keralauniversity.ac.in]

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Photo: Gorgonian coral with sea lilies attached
(From Kollam coast, depth: 20m)

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1. Sea Sand and Sand Mining

Sand is an essential resource, forming the backbone of modern infrastructure and industry. Without it, there would be no concrete, asphalt, glass, or electronics. Various types of sand and their derivatives are crucial in manufacturing plastics, cosmetics, construction materials, land reclamation, fracking, beach replenishment, and coastal protection. Driven by industrialization, population growth, and rapid urbanization, global demand for sand has surged. **Aggregates—comprising sand and gravel—are now the world's second most consumed natural resource after water and the most extracted material.** Over the past two decades, aggregate consumption has tripled, reaching an estimated 40-50 billion tons annually, a rate of extraction far exceeding natural replenishment (Jouffray et al., 2023).

Ocean sand encompasses sand and gravel extracted from nearshore and offshore deposits, as well as beaches, bays, lagoons, estuaries, tidal wetlands, and coastal quarries. Rather than focusing solely on its origin, ocean sand is best understood within the broader coastal and marine socio-ecological system in which it is embedded. Coastal and marine environments serve as both a reservoir and a dynamic source of sand, shaped by continuous erosional and depositional processes, longshore currents, tides, waves, and bio-erosion. **Naturally occurring sand plays a critical role as both a connector and a buffer at the land-sea interface, linking marine and terrestrial ecosystems while stabilizing coastlines and mitigating erosion.** As one of the most cost-effective climate adaptation strategies, sand enhances coastal resilience by protecting shorelines from rising sea levels and extreme weather events. It shapes island morphology, seabed structures, and coastal landforms such as sandbars, beaches, and dunes—key habitats that support biodiversity, maintain nutrient cycles, and provide shelter for highly specialized marine and coastal species (UNEP, 2022; Jouffray et al., 2023).

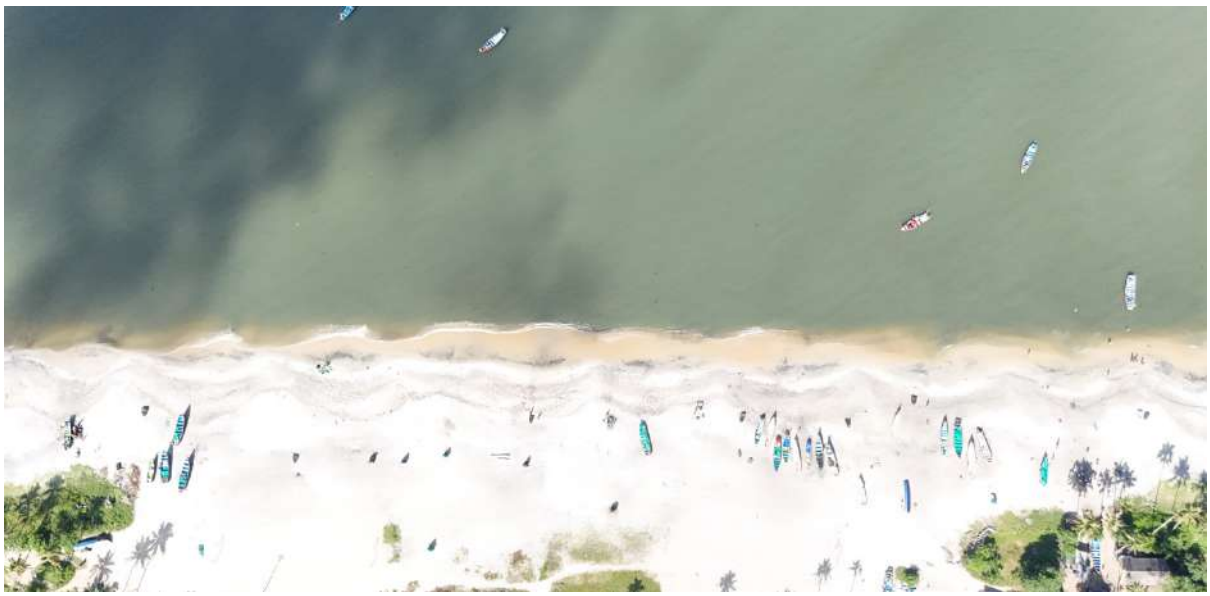
Sand is a crucial raw material for various developmental activities, making it essential for governments to identify and manage sustainable sand resources to meet societal needs. The demand for sand in India has surged due to rapid urbanization and infrastructure development. As a result, a significant amount of sand is extracted from land-based sources for use in reclamation and construction projects. Sand deposits are found within Indian territorial waters, extending up to 12 nautical miles from the coast, and in the Exclusive Economic Zone (EEZ) beyond that distance.

Experts from the Marine and Coastal Surveys Division of the Geological Survey of India (GSI) have conducted extensive surveys of the territorial waters off Kerala over the last few decades. **These surveys have revealed substantial deposits of construction-grade sand in various locations, including Ponnani, Chavakkad, Kochi, Alappuzha, and Kollam, at water depths ranging from 22 to 45 meters.** The GSI has identified over 745 million tons of construction-grade sand off the Kerala coast and 79 million tons of heavy mineral placers in the inner-shelf and mid-shelf regions off Odisha, Andhra Pradesh, Kerala, Tamil Nadu, and Maharashtra. These deposits contain sand with purity levels ranging from 80% to 96% and clay content between 4% and 20%. The sand, originally sourced from rivers, has undergone marine processes, making it suitable for construction after desalination.

With India's emphasis on the blue economy, which aims to utilize marine resources for economic growth, there has been a growing focus on extracting sand and minerals from the sea, particularly from deep-sea areas. The government argues that private sector participation will bring the necessary expertise and technology for exploring and mining mineral resources in the EEZ. Under the Offshore Areas Mineral (Development and Regulation) Amendment

Act, 2023, the plans are set to auction offshore mineral blocks under the provisions of the 2002 Act. The amendments introduce auction-based allocation of operating rights in offshore areas.

In the first phase, sand extraction will be carried out in the Ponnani, Chavakkad, Alappuzha, Kollam North, and Kollam South sectors, with the second phase extending to other coastal regions where rivers flow into the sea. As per the current timeline, companies interested in mining projects in Kerala were required to submit expressions of interest by February 18, with the tender process expected to be completed by February 27, 2025.



2. Kollam Bank and its Unique Biodiversity

Quilon Bank, also known as Kollam Paaru, is one of the most productive fishing zones on the southwest coast of India. The bank is defined as the seabed between 08'N and 09'N latitude, within a depth range of 275–375 meters. **This fertile fishing ground, located between Kollam and Alappuzha districts, supports a rich marine biodiversity, including deep-sea prawns, shrimps, lobsters, sardines, mackerel, and export-oriented squid varieties.** The Kollam Bank has been a major fishing ground for over four decades, making it a vital resource for the region's fishing industry.

Although the Kerala coast lacks extensive coral reef systems, there are patchy coral formations in the intertidal and sub-tidal regions. **The Quilon Bank is particularly significant for its submerged deep-water coral reefs, as reported by researchers like Pillai and Jasmine (1995).** Patchy coral distributions have also been recorded at Thirumullavaram and Thankassery Harbour in Kollam (George et al., 2019). The intertidal areas of Thirumullavaram host colonies of *Porites lutea* and *Favites* sp., but these coral formations are under threat due to heavy siltation during monsoons.

Research conducted aboard FORV Sagar Sampada during July-August 1987 showed that the fish fauna of Quilon Bank and Wadge Bank is dominated by nemipterids (Murty et al., 1990). Other commercially valuable marine species include rays, perches, lizardfish, carangids, shrimps, squids, and octopuses. Surveys by the Fishery Survey of India have confirmed that the deeper offshore waters of Kollam are rich fishing grounds for deep-sea prawns and lobsters.

The region's high productivity may be linked to the extended effects of upwelling, driven by drift currents extending towards the Wadge Bank.

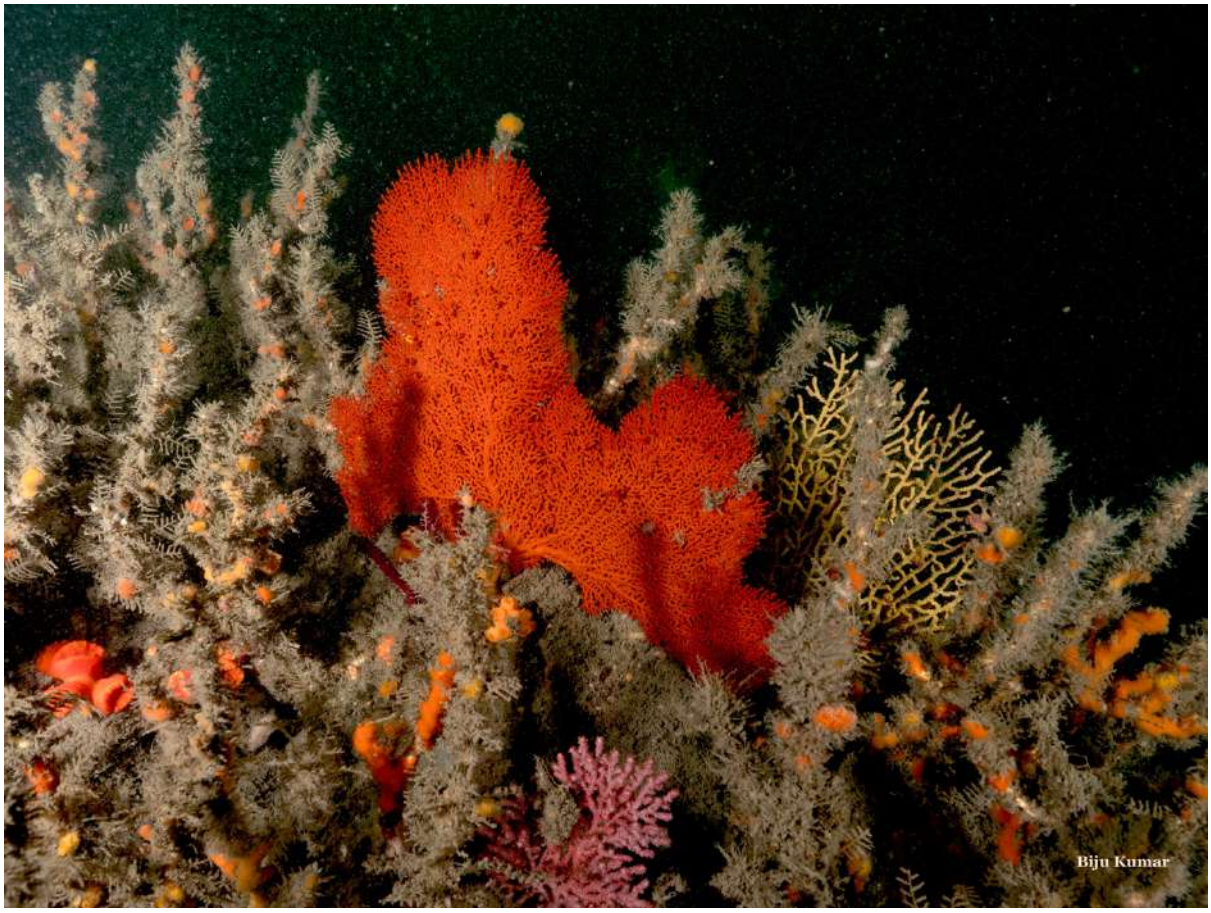
The recording of threatened hard corals off the Kerala coast dates back to the late 19th century. The Royal Indian Marine Survey Ship "Investigator" conducted deep-water surveys along the Indian coast and documented deep-water hard corals (ahermatypic corals) off the Travancore coast at a depth of 787 meters (Alcock, 1898). Later, the FORV Sagar Sampada collected and documented 16 ahermatypic corals dredged from depths of 40 to 100 meters off Quilon Bank (Pillai and Jasmine, 1995). These findings highlight the significance of the deep-sea coral ecosystems off Thiruvananthapuram and Kollam, which remain largely unexplored and could be severely impacted by the proposed sand mining activities. Further, **all corals are included in the Schedule I of the Wildlife (Protection) Act of India.**

3. Rocky Reefs and Their Ecological Importance

The shallow coastal waters off Kollam contain rocky reef formations, which support a unique marine ecosystem and provide crucial livelihoods for the region's fishing communities. **The ongoing underwater surveys conducted by the Marine Monitoring Lab (MML) of the University of Kerala's Department of Aquatic Biology & Fisheries, have recorded five species of hard corals and over 30 species of soft corals in the Kollam coastal region. Many of these are new records for the area, indicating that nearly two-thirds of Kerala's recorded soft coral species are found off Kollam. These rocky reefs are considered biodiversity hotspots, playing a vital role in marine ecosystems by offering habitats, breeding grounds, and shelter for diverse marine organisms.**

Rocky reefs rich in biodiversity off Kollam coast offer feeding grounds for several fish

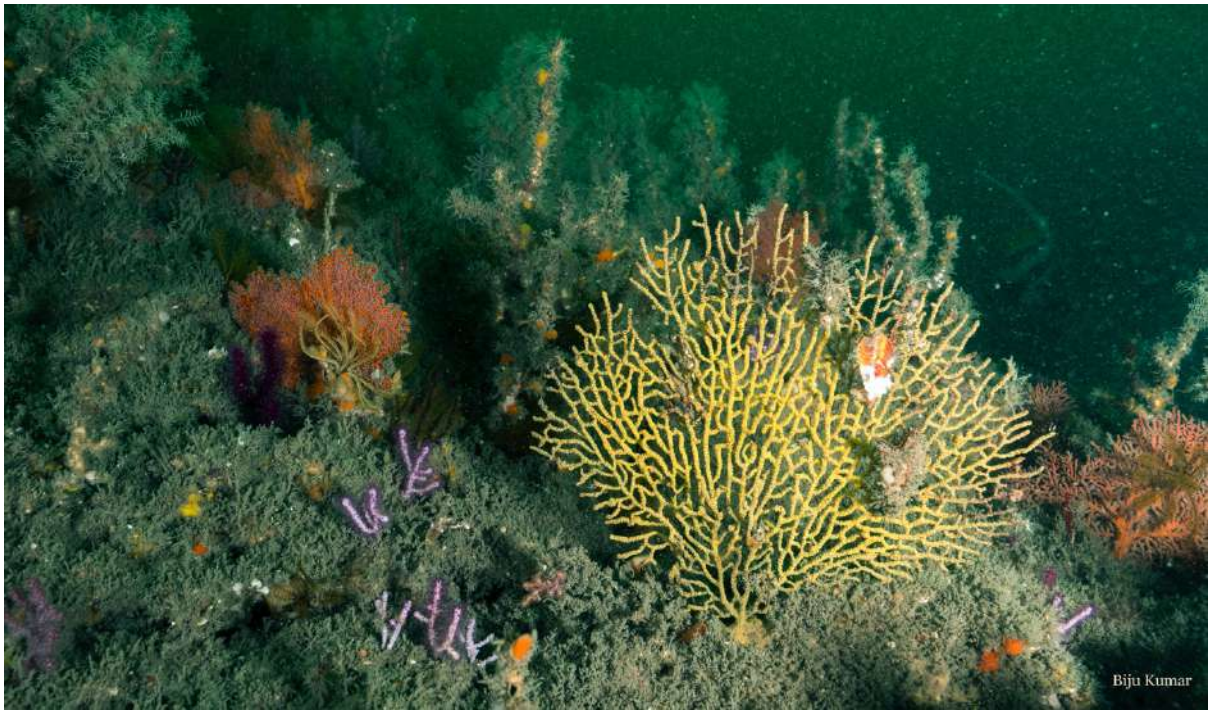
Rocky reefs support complex food webs by serving as feeding grounds and shelter for fish, crustaceans, corals, sponges, and algae. They act as nurseries for juvenile fish, thereby maintaining healthy fish populations and ecological balance. Additionally, these reefs enhance marine productivity by supporting coral communities that, in turn, provide food and habitat for numerous marine species. Beyond their ecological role, rocky reefs offer essential ecosystem services such as protecting coastlines from erosion and serving as natural barriers against strong waves and storms. These areas also have the potential to develop into ecotourism destinations for activities like diving and snorkelling, which could provide additional economic benefits to local communities.



Hard and soft corals off Kollam coast (Depth: 25 m)

Traditional fishing communities depend heavily on the rich fish stocks associated with these rocky reefs for their economic survival. The ecosystem services provided by Kollam's rocky reefs require further investigation, particularly with the involvement of local fishers who rely on these areas for their livelihoods. The proposed offshore sand mining activities, targeting depths of 40-60 meters off Kollam, directly threaten these rocky reef habitats. As these reefs serve as feeder systems that sustain marine biodiversity and ensure fishery productivity, their destruction could have severe consequences for marine life and the fishing communities that depend on them.

Rocky reefs off Kollam as the preferred habitats of commercially valuable carangids



Richness of life in the rocky reefs: Corals, molluscs, hydroids, sponges and echinoderms

Orange cup coral (*Tubastraea coccinea*) in Kollam coast

4. Ecological Impacts of Sea Sand Mining

4.1. Increase in Turbidity

Sand mining disturbs sediments during the extraction process, leading to increased turbidity and reduced light penetration in the water**. Light is crucial for phytoplankton, the primary producers in marine ecosystems, which support a large biomass of zooplankton and, in turn, higher trophic levels. The disruption of this process negatively impacts the marine food web and species distribution.** Additionally, the reduced sunlight penetration hampers carbon assimilation by rocky reef ecosystems. Increased turbidity also affects nektonic organisms by making it harder for them to hunt, reproduce, and breathe. The Kollam coastal waters already experience high siltation, likely due to dredging at Neendakara fishing harbour and increased sediment loads from Ashtamudi Lake.

4.2. Impact on Marine Life

Seafloor sediments harbour benthic fauna, crucial for sessile organisms like corals and sponges and mobile species like octopuses and squids. These sediments also serve as habitats for various marine organisms, facilitating interactions that sustain seafloor biodiversity. **Sand mining disrupts these habitats by removing or burying benthic fauna and coral colonies, which could severely impact the marine ecosystem. The Kollam region hosts the highest diversity of solitary and soft corals in Kerala, and their destruction due to sand mining would result in biodiversity loss.** Furthermore, deep waters off Kollam are prime fishing grounds for high-value species like deep-sea shrimp and cephalopods (octopuses and squids), and mining could disrupt their feeding and breeding grounds, and also migration of species such as ‘karikkadi’ shrimp *Parapenaeopsis stylifera,* affecting the livelihoods of local fishers.

4.3. Alteration in Current Patterns

Sand and gravel mining operations can alter hydrodynamic regimes, affecting water circulation, current speeds, and natural water-level fluctuations. Such changes could obstruct or divert flow, alter bottom contours, and significantly impact the marine ecosystem's stability.

4.4. Water Pollution

While mined sands generally exhibit low chemical interactions, those with high silt and clay content may contain organic material and contaminants. The disturbance of these sediments during dredging could reintroduce pollutants into the water column, exposing marine life to harmful substances. This contamination could have long-term repercussions on marine ecosystems, potentially leading to bioaccumulation of toxic metals in the food chain, ultimately affecting human health. Additionally, removing sand from the seafloor also removes vital nutrients that would otherwise be recycled back into the ecosystem, leading to a decline in overall nutrient availability.

4.5. Decline in Dissolved Oxygen and Harmful Algal Blooms (HABs)

The reduction in dissolved oxygen levels due to sand mining can force fish to migrate to safer zones, disrupting local fisheries. Increased nutrient loads in disturbed waters may encourage the proliferation of harmful algal blooms (HABs), which produce toxins that negatively impact aquatic ecosystems and human populations. Kollam coastal waters have already experienced HAB-related incidents, including recent mass fish kills in Ashtamudi Lake, likely due to sudden oxygen depletion from decaying algae.

4.6. Shoreline Erosion

Coastal shorelines provide crucial habitats for marine organisms such as sea turtles, marine birds, and crabs. Sand mining destabilizes these ecosystems by disrupting the natural drift of sand, weakening coastal defenses against tsunamis, cyclones, and erosion. The removal of sandbanks can also increase the vulnerability of shoreline communities to storm damage. Offshore dredging further disrupts the sedimentary equilibrium, causing seabed disturbances that negatively impact benthic communities and shoreline stability.

4.7. Impact on Mudbanks

Kollam experiences strong monsoonal upwelling, which enhances nutrient availability and sustains high fish populations. The region's mudbanks, formed due to wave action on muddy sediments, create calm waters that support a thriving monsoon fishery. However, the impact of offshore sand mining on mudbank formation remains scientifically unclear, raising concerns about potential disruptions to these critical habitats.

4.8. Climate Change Implications

The long-term impacts of deep-sea and offshore mining on the global carbon cycle are still not fully understood but could be significant. Disturbing seafloor ecosystems may release stored carbon, increasing atmospheric CO2 levels and exacerbating climate change. Additionally, the loss of ecosystem services provided by coral reefs and benthic habitats

would further weaken the resilience of marine organisms to climate change, increasing the vulnerability of coastal communities.

5. Economic vs. Ecological Assets

Sea sand mining plays a significant role in supporting the development of key infrastructure projects at both state and national levels. It is often seen as a strategic activity for boosting industrial and economic sectors. However, the negative environmental and social impacts associated with sea sand mining are substantial. These include declining water quality, destruction of spawning areas, increased seawater turbidity, and disruptions to local communities. Therefore, evaluating the long-term ecological and economic value of sustainable ecosystem management is essential, as the revenue generated from sand extraction may not outweigh the environmental costs.

The process of sea sand mining is complex. First, sand and sediment must be dredged and transported via barges. The collected sand requires multiple rounds of cleaning to remove clay and silt, followed by further washing on land using freshwater. **The economic implications of utilizing land-based freshwater sources for washing the extracted sand must also be carefully considered.**

Explorations have shown that the sand deposits in the sea originated from rivers. However, **river flows are now highly regulated due to upstream dams, reducing the natural replenishment of sand in marine ecosystems. The seabed, once mined, takes a considerable amount of time to recover. On the Kollam coast, this recovery is further delayed because river sand inflow is blocked by dams draining into Ashtamudi Lake**. Instead of sand, increasing amounts of silt and clay are reaching coastal waters.

The assumption that the extracted sand is primarily construction-grade must be substantiated. Field studies in the region indicate high sedimentation levels, likely exacerbated by increased silt deposits from Ashtamudi Lake. This raises concerns about the actual composition of the mined material and its suitability for construction purposes.

6. Socio-Economic Impacts and Livelihoods of Fishers

The removal of sand alters coastal morphodynamics, disrupting natural sediment transport and deposition patterns. This disturbance destroys marine habitats, creating dead zones that negatively impact fish populations. Such disruptions directly threaten the livelihoods of local fishing communities, particularly those that rely on marine resources as their primary source of income and sustenance. **The environmental damage caused by sand mining disproportionately affects economically disadvantaged populations, despite government efforts to protect marine fishery resources, such as the installation of artificial reefs along the Kerala coast.**

Sand mining near Kollam Parappu, a highly productive fishing ground, could significantly reduce fishery resources, leading to a decline in income for traditional fishers. The disturbance of seabed habitats may take years to recover, impacting trawler operations that target bottom-dwelling shrimp. Additionally, **the destruction of rocky reefs off Kollam could further reduce fish stocks, negatively affecting traditional fishers who depend on these ecosystems for their livelihoods.**

Given these risks, it is crucial to consider findings from marine ecologists and fisheries scientists worldwide, who have documented the negative impacts of sand mining on marine biodiversity and local economies (see Ratnawati et al., 2024).

Because marine ecosystems lack clear physical boundaries, the effects of deep-sea mining extend beyond the immediate extraction site. Ecological disturbances can spread across regions, crossing jurisdictional limits and resulting in unpredictable consequences. A decline in primary production, for example, could have cascading effects on global fisheries, endangering a vital protein source for nearly one billion people and threatening the livelihoods of approximately 200 million individuals, particularly in vulnerable coastal communities.

7. International Calls for Moratorium

Sand mining is a global practice that has come under increasing scrutiny due to its negative environmental and social consequences. This growing concern has led to calls for in-depth studies on marine biodiversity and the long-term impacts of sand mining on resource sustainability. **In countries like India, where the livelihoods of fishers are deeply dependent on the health of shallow coastal waters, the need for responsible resource management is particularly urgent. Many commercially valuable marine species rely on feeding and breeding grounds located at depths of up to 100 meters, often migrating from deeper waters to inshore areas that sustain fisheries.**

The 2019 Sand Governance Report by the United Nations Environment Program (UNEP) highlighted weak governance and insufficient research on sand mining. **Studies suggest that offshore sand mining is often poorly managed, leading to severe environmental, social, and economic consequences** (Ali et al., 2024). Despite the increasing volume of offshore sand extraction and its growing demand for development, policymakers have largely ignored its long-term effects (UNEP, 2019; GESAMP, 2019; Hernandez et al., 2021; Mahyuddin et al., 2022; Dou et al., 2023; Pilkey et al., 2023; Rangel et al., 2023; Aziz et al., 2024; Poonia et al., 2024).

As India takes steps toward deep-sea mining, it is essential to establish detailed management action plans, conduct comprehensive environmental impact assessments, and implement transparent governance frameworks to ensure responsible offshore sand mining. A data-driven approach is necessary to evaluate mining's scientific and ecological consequences, particularly in light of global calls for a moratorium on deep-sea mining.

Any attempt to mine sand from the coastal waters of Kollam without a thorough environmental impact assessment would be a serious ecological misstep. Kollam's waters host unique rocky reef ecosystems that support endangered patchy corals and sustain vital fishery resources. These ecosystems provide essential services that maintain marine health. Furthermore, India's commitment to the United Nations Sustainable Development Goals (SDG 1: No Poverty, SDG 2: Zero Hunger, SDG 6: Clean Water and Sanitation, SDG 8: Decent Work and Economic Growth, SDG 12: Responsible Consumption and Production, SDG 13: Climate Action, and SDG 14: Life Below Water) necessitates a more cautious approach to sand mining.

An exploratory study by the Geological Survey of India revealed that marine sediments off the Kerala coast, at depths between 20 and 80 meters, contain large quantities of sand, including construction-grade material and silica (Sukumaran et al., 2010). However, the report also

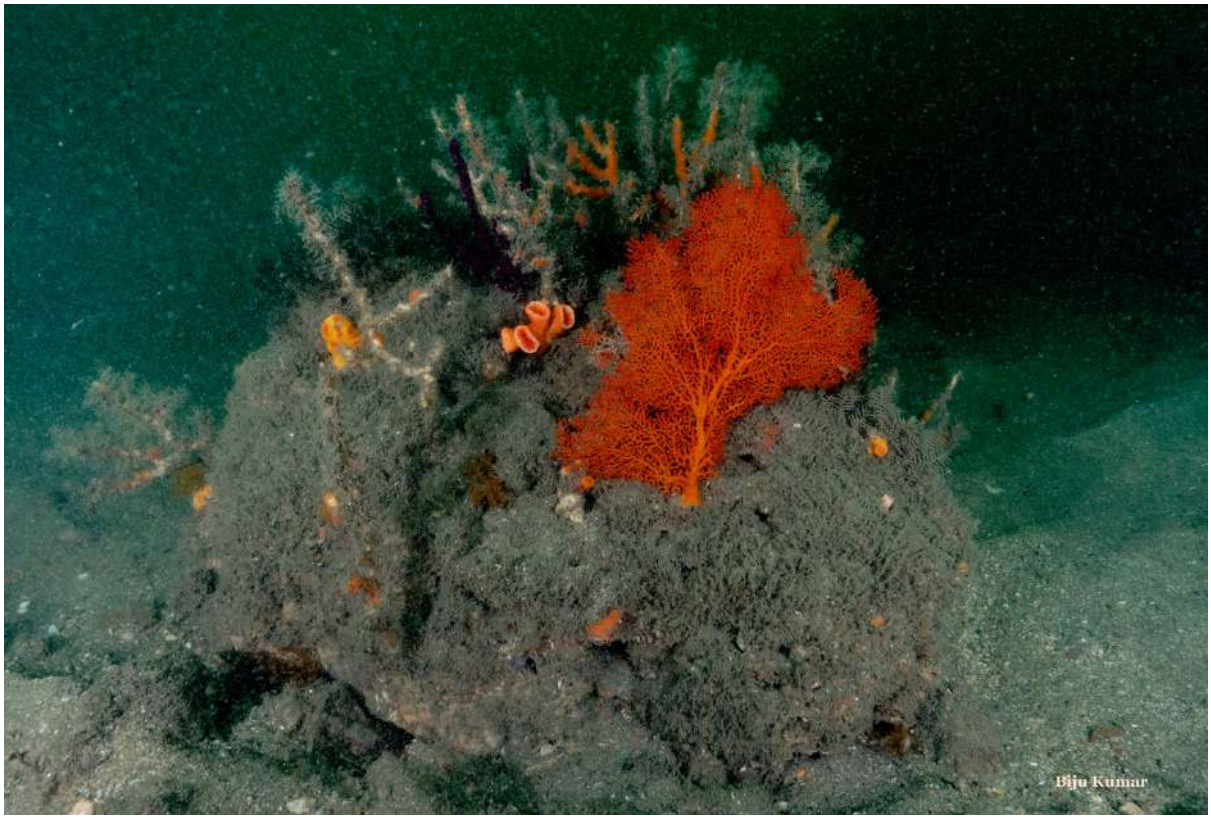
emphasizes the need for continuous monitoring and environmental assessments to understand the full impact of sand mining on ecosystems and biodiversity.

8. Conclusions

Coastal mineral resources are often promoted as a sustainable means of meeting increasing metal and construction material demands. However, the decision to mine sand off the coast cannot be classified as deep-sea sand mining. The proposed mining depth falls within shallow-water limits, contradicting international conservation goals. Additionally, regulatory frameworks for offshore sand mining are still evolving, and a lack of stringent guidelines raises concerns about its long-term sustainability.

The Quilon Bank and its surrounding shallow rocky reefs support a vast array of marine life, including numerous commercially valuable fish species that sustain the livelihoods of thousands of fishers. Particularly important are nemipterids, carangids, and shrimp, which form the backbone of traditional fisheries in the region. These waters also serve as critical breeding grounds that help maintain biodiversity and contribute to the broader marine food web. Any dredging activity in this ecologically sensitive area could have devastating effects, endangering marine species, disrupting habitats, and causing irreversible damage to the ecosystem.

Beyond environmental concerns, sand mining also poses significant economic risks. Disruptions to marine ecosystems could reduce fish stocks, threatening the primary source of income for local fishing communities and exacerbating food insecurity. Additionally, coastal erosion—already a pressing issue—could worsen due to changes in sand drifting patterns, further destabilizing shorelines and endangering nearby communities. Kollam Parappu holds cultural and ecological significance for coastal communities. It is not merely a resource for extraction but a vital ecosystem that must be preserved for future generations.



Given the absence of comprehensive environmental impact assessments and a lack of comparative studies on different mining practices, there is no justification for rushing into large-scale sand extraction. The intrinsic value of biodiversity, as recognized by the United Nations General Assembly Resolution 61/105 in 2006, underscores the need for urgent action to protect vulnerable deep-sea ecosystems. This resolution acknowledges the immense importance of deep-sea biodiversity and calls for its protection from destructive activities. Furthermore, recent global commitments to reverse biodiversity loss by 2030 reinforce the need for a precautionary approach.

As the world moves toward more sustainable resource management, India must align its policies with international best practices. Without clear guidelines, transparent governance, and a commitment to ecological sustainability, offshore sand mining in Kollam could lead to long-term environmental and socio-economic consequences.

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ANNEXURE- I

Marine Expert Statement Calling for a Pause to Deep-Sea Mining

Signed by 931 marine science & policy experts from over 70 countries

The deep sea is home to a significant proportion of Earth's biodiversity, with most species yet to be discovered. The richness and diversity of organisms in the deep sea supports ecosystem processes necessary for the Earth's natural systems to function. The deep ocean also constitutes more than 90% of the biosphere, and plays a key role in climate regulation, fisheries production, and elemental cycling. It is an integral part of the culture and well-being of local communities and the seafloor forms part of the common heritage of humankind. However, deep-sea ecosystems are currently under stress from a number of anthropogenic stressors including climate change, bottom trawling and pollution. **Deep-sea mining would add to these stressors, resulting in the loss of biodiversity and ecosystem functioning that would be irreversible on multi-generational timescales. Amongst the specific concerns over the impacts of deep-sea mining are:**

- the direct loss of unique and ecologically important species and populations as a result of the degradation, destruction or elimination of seafloor habitat, many before they have been discovered and understood;
- the production of large, persistent sediment plumes that would affect seafloor and midwater species and ecosystems well beyond the actual mining sites;
- the interruption of important ecological processes connecting midwater and benthic ecosystems;
- the resuspension and release of sediment, metals and toxins into the water column, both from mining the seafloor and the discharge of mining wastewater from ships, detrimental to marine life including the potential for contamination of commercially important species of food fish such as tunas;
- noise pollution arising from industrial machine activity on the ocean floor and the transport of ore slurries in pipes to the sea surface, that could cause physiological and behavioral stress to marine mammals and other marine species;
- uncertain impacts on carbon sequestration dynamics and deep-ocean carbon storage.

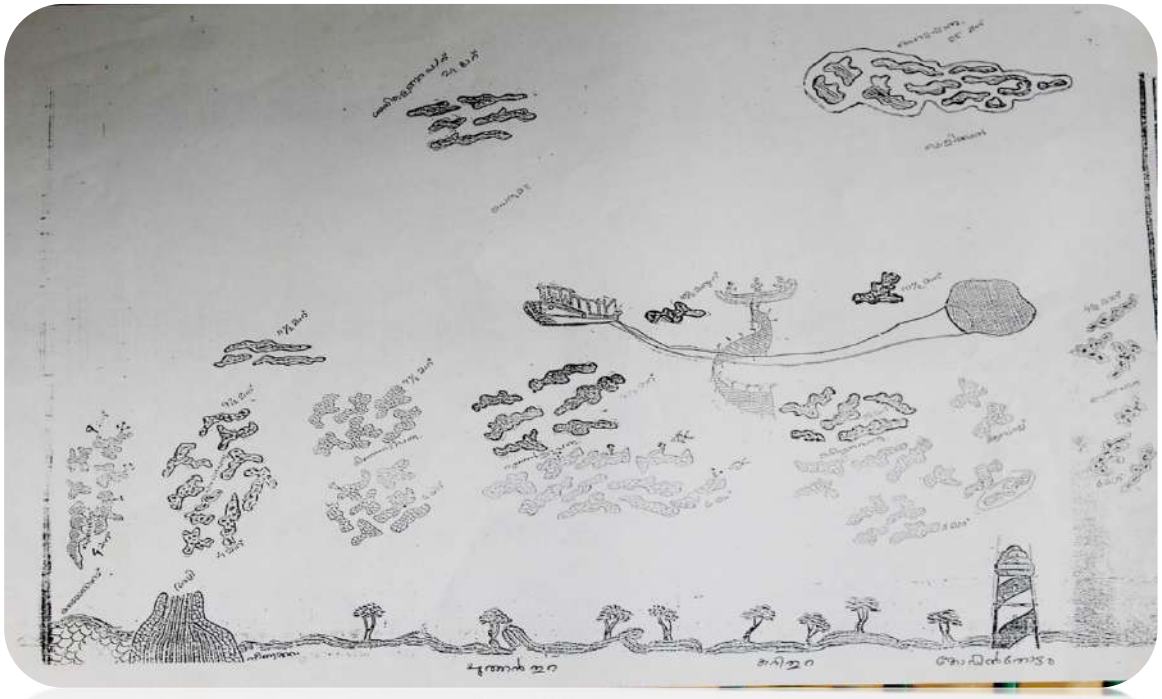
There is a paucity of rigorous scientific information available concerning the biology, ecology and connectivity of deep-sea species and ecosystems, as well as the ecosystem services they provide. Without this information, the potential risks of deep-sea mining to deep-ocean biodiversity, ecosystems and functioning, as well as human well-being, cannot be fully understood. At the same time, a growing number of scientific reports (IPBES, IPCC, etc.) indicate that Earth's biodiversity is increasingly at risk of extinction.

For the reasons outlined above, we strongly recommend that the transition to the exploitation of mineral resources be paused until sufficient and robust scientific information has been obtained to make informed decisions as to whether deep-sea mining can be authorized without significant damage to the marine environment and, if so, under what conditions. The United Nations Decade of Ocean Science for Sustainable

Development (2021-2030) provides an opportune period in which to collect more information about the species and ecosystems that could be affected by deep-sea mining. As scientists, we deeply value evidence-based decision making, especially in instances as consequential as a global decision to open up an entirely new frontier of the ocean to large-scale industrial resource exploitation. The sheer importance of the ocean to our planet and people, and the risk of large-scale and permanent loss of biodiversity, ecosystems, and ecosystem functions, necessitates a pause of all efforts to begin mining of the deep sea, in line with the precautionary principle, and an acceleration of research so that we can gain a better understanding of what is at stake.

https://seabedminingsciencestatement.org/

In loving memory of Shri A. Andrews, an artisanal fisher from Vadi, Kollam, whose storytelling and deep knowledge of Kollam's reefs have preserved invaluable traditional wisdom through his book, Kadal Muthu.



A hand-drawn illustration by Andrews depicting the reef locations along the Kollam coast.

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