

## **The Marginal Seas of the Northwestern Indian Ocean: Drivers, Dynamics, and Sustainable Future**

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### **Abstract**

The Regional Organization for the Protection of the Marine Enviro (ROPME) Sea Area (RSA) is intrinsically connected to the Northwestern Indian Ocean through a suite of physical, biogeochemical, and ecological processes. These linkages include regional ocean circulation patterns, temperature and salinity exchanges, nutrient and sediment fluxes and ecosystem-level interactions shaped by the monsoon effects, phytoplankton variability, marine productivity and biological connectivity across the basin.

As a highly sensitive marginal sea, the RSA functions as both an environmental subsystem of the wider Indian Ocean and a natural laboratory for examining ecosystem responses to extreme conditions. Rapid coastal development, oil pollution, desalination brine discharge, marine litter and microplastics, combined with climate change, invasive species, and recurring harmful algal blooms, exert compounded pressure on the existing marine ecosystems. The RSA's pronounced temperature and salinity gradients, along with its high ecological tolerance thresholds, make it an instructive model for studying environmental change, cumulative stressors, and ecosystem resilience.

Despite the clear interdependencies between the RSA and the Northwestern Indian Ocean, integrated research addressing two-way influences, biogeochemical feedback, and shared environmental drivers remains limited. There is an urgent need to close this knowledge gap through integrated research and strengthened regional cooperation among ROPME and its Member States, IOCINDIO, and the IIOE-2 community. Advancing collaborative research will improve understanding of RSA–Indian Ocean connectivity and help translate scientific insights and data into effective policy action and sustainable management strategies.

This plenary lecture will present an overview of the RSA's unique oceanographic characteristics, the current state of its marine environment, and the most pressing environmental challenges and emerging issues. It will further explore oceanographic linkages with the Northwestern Indian Ocean and highlight key past and ongoing ROPME scientific initiatives. Finally, it will outline future research directions and opportunities for enhanced collaboration within the IIOE-2 & IOCINDIO frameworks

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