

Coastal Oceanography: An Underwater Domain Awareness Perspective

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Underwater Domain Awareness (UDA) in the Indian Ocean has become a strategic necessity due to increasing geopolitical competition, growing maritime traffic, and heightened ecological sensitivity in the region. In this context, UDA is essential for India's national security, blue economy, and environmental stewardship. In recent years, the Indian Ocean is exposed to be a critical area for submarine activity, maritime trade, and illegal fishing. To address these challenges, India is enhancing its surveillance and data fusion capabilities through integrated UDA frameworks. These initiatives include deploying seabed sensors, utilizing autonomous underwater vehicles (AUVs), and leveraging AI-powered data analytics to monitor underwater threats, map resources, and support the conservation of marine biodiversity. Collaborations among navies, research institutions, and civilian stakeholders are enhancing multi-dimensional situational awareness, aligning with India's broader vision of maritime security under the SAGAR initiative (Security and Growth for All in the Region).

In addition, Oceanography is essential for the development of sonar technology because it provides critical insights into how sound travels through water. Important oceanographic factors, such as temperature, salinity, pressure, and the composition of the seabed, significantly affect the speed, direction, and attenuation of acoustic waves. Understanding these factors is crucial for creating sound velocity profiles, predicting how sound bends (acoustic refraction), and optimizing sonar performance for detecting, locating, and classifying targets. Additionally, knowledge of oceanography allows for the design of adaptable sonar systems that can accommodate seasonal and regional changes in the marine environment. This adaptability improves operational accuracy in both defence applications and civilian uses, such as underwater navigation, resource mapping, and monitoring marine life.

The future of Anti-submarine Warfare (ASW) oceanography lies in the development of real-time, data-driven ocean models that enhance underwater environmental awareness and acoustic performance. Key focus areas moving forward include high-resolution ocean modeling, the integration of artificial intelligence for acoustic predictions, and ongoing monitoring through autonomous platforms such as gliders and underwater drones. A better understanding of dynamic ocean parameters—like temperature gradients, salinity, and seabed variability—will enable adaptive sonar tuning, leading to improved detection capabilities in complex

coastal zones. Additionally, collaborative regional data-sharing initiatives and climate-resilient acoustic modeling will be essential for maintaining ASW superiority in changing maritime environments.

In this strategically significant field, Naval Physical & Oceanographic Laboratory (NPOL) is enhancing the efforts of the national and scientific community by conducting focused research in ASW Oceanography. This research is based on observations and modeling to study oceanographic processes and understand the oceanic environment, which is crucial for developing new technologies and knowledge. As the emphasis on maritime defence shifts towards comprehensive UDA, NPOL timely organized COSMOS-24, which focused on the theme "Coastal Oceanography: An Underwater Domain Awareness Perspective" from April 17-19, 2024. This special issue of the Defence Science Journal includes 10 articles selected from presentations made during the symposium by researchers from NPOL, DRDO, and other national laboratories and research centers. These articles address research challenges relevant to UDA, covering topics such as shallow water acoustics, observational methods, and satellite oceanography, utilizing data collected from the shallow and deep waters of the Arabian Sea, Bay of Bengal, and Andaman Sea.

The paper by Akshara, *et al.*, "Interaction of Mid-to-High Frequency Acoustic Waves with a Sandy Riverbed – Estimation of Geoacoustic Parameters and Modelling of Transmission Loss" presents methods and analysis for the estimation of geo-acoustic parameters from geophysical parameters (compressional wave speed and attenuation) from sediment samples with potential application to buried object detection in shallow water.

The paper by Eldhose, *et al.*, "Relation between Deep Chlorophyll Maximum and Vertical Thermal Structure in the Andaman Sea" provide an empirical relationship between vertical thermal structure and deep chlorophyll maximum (DCM) based on measured profiles from the Andaman Sea.

Maria, *et al.*, "Sub-Mesoscale Eddy Detection from Sentinel-1A SAR Image: A case study along Vizag Coast" uses the Sentinel-1A Synthetic Aperture Radar (SAR) images to extract the sub-mesoscale features in the ocean which altimeters fail to capture.

Adithya, *et al.*, "Hydrodynamic Modelling of Tides and Tidal Currents in Cochin Estuary" examine the spatial variability of tides and tidal currents in Cochin estuary using two-dimensional (2D) numerical model.

Anu, *et al.*, “Exploring Intra-annual Variability in pH, Dissolved oxygen and Thermo-haline Properties: Acoustic Implications in the Central Arabian Sea” explores the impact of pH variations on sound absorption and propagation characteristics in the Central Arabian Sea.

The paper by Preetha, *et al.*, “OCEANVIZIO: A Dynamic and Scalable Visualization Tool for Comprehensive Analysis of Ocean Parameters”, introduces a software tool developed to visualize the 2D and 3D visualization of ocean parameters.

Ullas, *et al.*, “Influence of Climatic Events on Sea Level Variability over the Bay of Bengal: Insights from EOF Representation” investigate the role of climatic events such as ENSO and IOD on sea level variability over the Bay of Bengal using Empirical Orthogonal Function.

Anjali, *et al.*, “Inter-Annual Variability of Salinity in the Upper Layer of South Eastern Arabian Sea and Its Acoustic Relevance” examine the inter-annual variability of salinity in the upper layers of South Eastern Arabian Sea and further investigates its influence on acoustic propagation.

Maheswaran, *et al.*, “Variability of Hydrographic Properties in the Alleppey Terrace Region: Insights from July

2023 Observations” investigate the variability of hydrographic properties in the Alleppey Terrace Region of southeastern Arabian Sea during summer monsoon utilizing the observations from INS Sagardhwani.

Finally, Bain, *et al.*, “A Portable Atomic Magnetometer with pico-Tesla Sensitivity” of DRDO Young Scientists’ Laboratory for Quantum Technologies presents a single axis compact atomic magnetometer sensor head with pico-Tesla sensitivity developed in close collaboration with TIFR Hyderabad.

On behalf of all the authors, we would like to express our heartfelt gratitude to the Director, DESIDOC and the Editor-in-Chief of the *Defence Science Journal* for providing us the opportunity to bring out this special issue. We sincerely appreciate the meticulous and selfless efforts of reviewers, who rigorously examined multiple revisions of the manuscripts. Their invaluable feedback has significantly helped in improving the quality of the papers. We sincerely appreciate and commend the dedicated contributions of the organizing committee of COSMOS-2024 for creating a platform that promotes research excellence.