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GUEST EDITORIAL

Anti-submarine Warfare Oceanography

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Anti-submarine warfare (ASW) Oceanography has become an important and independent discipline, especially after World War II as the threat perception from hostile underwater platforms has been on a continuously rising trajectory worldwide. There is no doubt that till date, acoustic energy remains the only viable and most effective means to detect underwater objects. However, sound waves are highly susceptible to refraction, reflection, scattering, reverberation and absorption in the ocean medium. Among these, refraction is controlled by the 3D sound speed structure in the specific ocean region and reflection loss by the sea state and ocean bottom characteristics. Water quality parameters such as sediment concentration and suspended biological masses influence attenuation, scattering, reverberation and absorption. Oceanographic variability emerges from diurnal heating, seasonal changes, river discharges, etc. are the most important environmental factors deciding the 3D sound speed structure in any given area in the ocean.

In the Indian Ocean, seasonal changes are more prominent among the world oceans because of the effect of the reversal of monsoon winds. Moreover, inter-annual variability of monsoon winds and phenomena such as El Nino, La Nina, Indian Ocean Dipole, etc. induce further variability. Therefore, to understand the oceanographic variability in the Indian Ocean, continuous observations are required. Since Sonar is utilised to detect and classify the underwater objects and even for underwater navigation, the environmental variability affecting the detection ranges of the Sonar system is to be monitored and studied continuously. In this regard, acoustic ambient noise in the given environment is an important parameter to be understood as it affects the detectability of the acoustic signals. Ocean bottom, viz. bathymetry, sediment characteristics and sediment layer thickness are the other parameters which determine the attenuation of sound waves. However, their diurnal and seasonal variability are insignificant for any given location in the ocean. Hence, one time observation on these parameters is generally sufficient.

The Naval Physical and Oceanographic Laboratory (NPOL) has been carrying out research in ASW Oceanography since early 1960s. The primary goal of NPOL is to develop Sonar and other under water surveillance systems for Naval applications. Working with this mandate, the lab has today emerged as one of the most prestigious and successful laboratories of DRDO with an enviable track record of delivering state of the art underwater systems to the Indian Navy. As brought out above, the major pre-requisite in achieving this goal is understanding the medium, i.e. the ocean environment. It is against this background that the ocean scientists at NPOL have studied the variability of the ocean environment relevant to acoustic propagation and sonar performance. Over the years, they have formulated and tested several theories to explain the phenomena from the observed field data. A variety of floating platforms ranging from small boats and general purpose vessels to dedicated huge ships, are used for making observations and conduct experiments to collect data and later prove the theoretical formulations and models.

The birth of *INS Sagardhwani,* NPOL's research ship originated from the very pressing need of having a captive platform to meet the above mentioned requirements. The research vessel *INS Sagardhwani* (*SD*) was built under the project Marine Acoustic Research Ship (MARS) at Garden Reach Shipbuilding Establishment (GRSE), Kolkata and commissioned in 1994. The operation and maintenance of the vessel was entrusted to the Indian Navy and that is how the vessel got the INS prefix and flies the Naval ensign. Since then, *SD* has been contributing enormously to the advancement of ocean research, and towards a greater understanding and growth of ASW Oceanography at NPOL.

During 2016-17, *SD* missions focused on studies on oceanic features relevant to acoustic propagation. This special issue focusses mainly on the analysis of those *in situ* observations. Maximum deployments of SD were in the South Eastern Arabian Sea (SEAS) during the above period. SEAS is characterised by many dynamical features under the influence of the seasonally reversing winds. To study these features and their influence on acoustic propagation, *SD* covered the region encompassing from the Indian coast to nearly 200 nautical miles offshore and from the Gulf of Mannar to the regions off Goa at monthly intervals. These data sets were utilised to bring out the characteristics of Upwelling/sinking (Dominic, *et al.*), Arabian Sea Mini Warm Pool (Anu, *et al.*), Arabian Sea High Salinity Water-mass and its influence on acoustic propagation (Maheswaran, *et al.*), Surface forcing and horizontal advection and their

influence on acoustic propagation (Maheswaran, *et al.*) and Chlorophyll (Chl *a*) distribution (Eldhose, *et al.*). Anand, *et al.* have utilised the same data sets for the validation of 3D ocean circulation model viz. Princeton Ocean Model. Another paper examines the influence of upwelling / sinking on transmission loss of acoustic energy in various azimuthal angles utilising 3D acoustic propagation model (Raju, *et al.*). Other major deployment of the ship was in the Bay of Bengal to study the winter thermohaline features across the Basin along 10 °N (Dominic, *et al.*). *SD* can operate nearly an hour under 'silent regime', a unique capability of the vessel to carry out acoustic measurements. Keeping *SD* at silent regime, special experiments to assess the influence of ocean environment on Bit Error Rate in under water communication systems (Balaji, *et al.*) and pattern of loss of propagation of low frequency broad band signal in a deep sea environment (Nimmi, *et al.*) were carried out. Analysed results of those data sets are also included in this special issue.

We hope that this issue presents a welcome update on the broad domain of ASW oceanography which will hopefully stimulate more interest in observational, theoretical and modelling studies in this area. Together with all the authors, we would like to place on record our most sincere gratitude to DESIDOC team and Editor-in-Chief, *Defence Science Journal*, for the opportunity given to us to bring out this special issue. Numerous revisions of the papers have been diligently and selflessly scrutinised by many experts both from within and outside NPOL, which have resulted in considerable improvements of all the manuscripts. This invaluable and unselfish contribution of the reviewers is indeed praiseworthy and is gratefully acknowledged.