OCEAN DIGEST

Quarterly Newsletter of the Ocean Society of India

Volume 8 | Issue 3 | July 2021 | ISSN 2394-1928

Indian Coastal Ocean Radar Network (ICORN) and it's application

Basanta Kumar Jena, Rajkumar J, Vishal Jain,
Amol D and G Velu.
Coastal and Environmental Engineering (CEE) Division
National Institute of Ocean Technology (NIOT)
Ministry of Earth Sciences (MoES),Government of India
Pallikarani, Chennai 600 100 Tamil Nadu

Coastal and Environmental Engineering Division (CEE) of NIOT has been successfully operating (24X7) and maintaining a network of High Frequency Radar (HFR) systems along the Indian coast and Andaman Islands namely Indian Coastal Ocean Radar Network (ICORN) as a part of Ocean Observation Network (OON) program of MoES (5 pairs at 10 remote locations and two receiving stations INCOIS and NIOT) since 2008. The first phase of the installation of HF radar systems started in 2008 and was completed by 2010. Out of 10 sites, 6 are located along the east coast of India (Odisha, Andhra Pradesh and Tamil Nadu), one pair covering Gulf of Khambhat in the state of Gujarat and the remaining two are in Andaman Islands. It is a land-based remote sensing system capable of measuring surface currents as far as 200 km from the coast and wave height, Wave direction, wave period and wind direction nearly 100 km offshore from the coast with the same grid spacing.

A HF RADAR system consists of one transmitting and one receiving antenna, signal generating and receiving circuitry, and data processing software shown in Figure 1. Typically, HFR system is installed at respective site near the coast. It measures surface oceanographic parameters, up to about 200 km depending upon the transmitting frequency used. Every single HFR installation is capable of measuring the Tsunami signature and wave parameters, while it requires a pair of radars to measure the surface current vector.

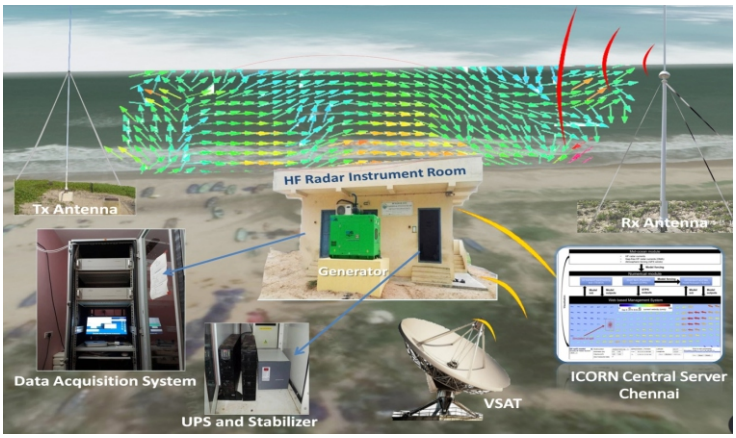


Figure 1. HF RADAR system

Applications of HFR networks

HFR network gives us an edge over conventional single point current measurements by providing two-dimensional surface circulation in near real time. These high-resolution data help in studying the dynamics of the coastal ocean, the interaction between physical and biological parameters in the ocean, transport mechanisms between the estuary and coastal waters.

Assimilation of data from HFR systems improve the ocean circulation models and their validation. Application of HFR systems can be further extended to monitor the marine resources, vessel traffic near the coast and tracking marine pollution. Use of HFR data in studying the movement of larvae can bolster the fisheries and related industries. The data from the HFR system can be used as an input for weather forecast modelling and aid in tidal and storm measurements.

Apart from these applications, the data can also be used for algorithm development to enhance the utility of the HFR systems. Portable HFR systems can be deployed at any location to support disaster mitigation, search and rescue operations, oil-spill monitoring/tracking, warning to the surfers and rip current advisories for the public.

The operational utility of HFR systems include:

Tsunami detection - HF radar could detect a tsunami signal through its impact on surface currents and the first demonstration of this followed the 2011 Japanese earthquake. Radars in Japan, the west coast of the USA and in Chile all showed clear signatures of the tsunami. High Frequency (HF) Radar installed at Andaman by NIOT detected the Weak Tsunamis in the year 2012 which occurred at Indonesia.

Cyclone information – Surface currents and wave measurements before, during after the cyclone, helps in identifying the intensity of the cyclone and helps in improving the prediction models. NIOT shares the information with INCOIS and plan to use this data in real time during cyclone with IMD for improving the prediction models.

Storm surge and flooding - The ability to measure current, wave and wind simultaneously is advantageous for this application. Cyclone can be monitored closely using the HF radar network. This system provides sufficient lead time to the Coast Guard to successfully notify mariners and to take necessary action in the harbour and port during the storm.

Oil and pollution spill monitoring- HF radar data are used in the forecasts and to assimilate into INCOIS models and make quick actions.

Search and rescue services - The depth and horizontal resolution of the HF radar current measurements are consistent with their SAR projection modelling. The measured data are critical for determining the best trajectory modelling approach. There are two limiting factors. One is spatial coverage, other is the latency of the measurements.

Ports and harbours - The high-resolution spatial measurements for navigational safety around and beyond ports and harbours is one of the drivers for the HFR system. HF radar data aid port and harbour managers in strong cross channel currents on oil tankers negotiating the channel into the terminal on the coast. Methods to track ships with these radars, simultaneously with the oceanographic measurements are being developed.

Marine biology - Current systems are important in the life cycle of most marine life from small to large scales.

Coastal eddies, upwelling, storm events and climate change are important drivers for the survival and development of marine communities over their life cycles. HF radar observations have made it possible to carry out extensive connectivity studies to aid in the determination of spatial boundaries for marine protected areas.

Marine renewables - Measurements are needed to assess the available resource, to plan and carry out the installations of systems and to monitor performance and impact. Operational monitoring of currents and waves are also needed for wind farm installation.

Ship Detection and Tracking - The target locations detected by the HF radar using adaptive technique are passed on to a tracking filter to track the ship position. NIOT has plans to carryout R & D work at one of its existing sites installing ship detection module with required accessories for the study.

Upgradation and expansion programme

It is plan to upgrade the central server at NIOT will so as to send and receive data from the different sensors, visualize the maps and time series and enable online use of these data for various application including predictions. The expansion programme has been proposed along the entire Indian coast. This enables to provide real time data to IMD to improve the weather prediction system for identifying the High wave activity during the extreme events and also to INCOIS and other institutions for various applications like Oil spill, search and rescue, Circulation modelling etc. The existing and the proposed future sites of ICORN are shown in figure below.

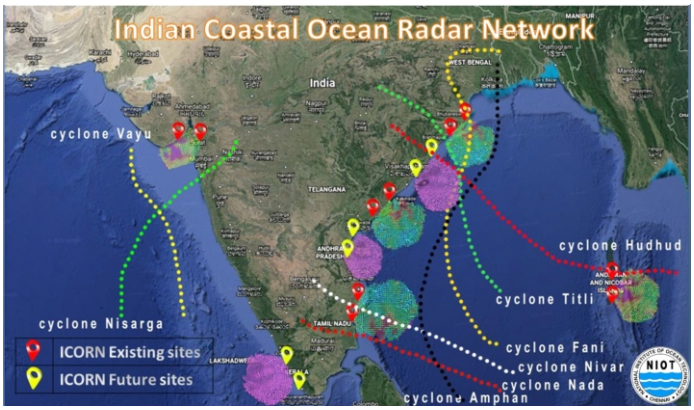


Figure 2. Existing and Future ICORN sites with cyclone data measured by HF Radars

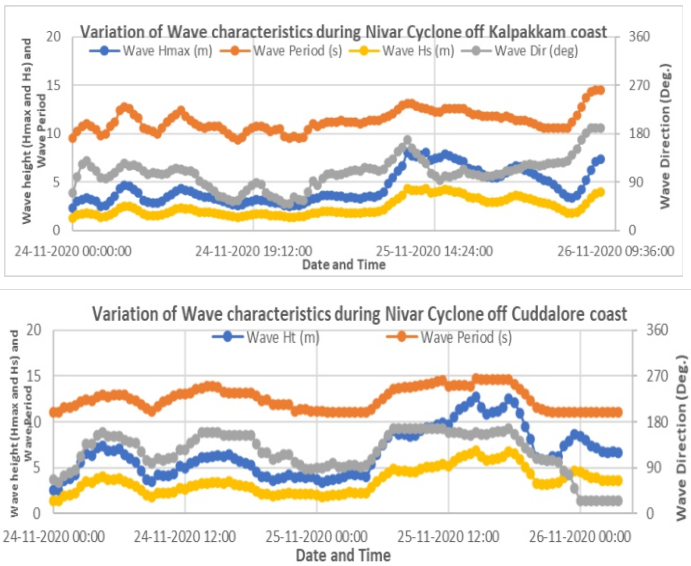


Figure 3. High wave measured during cyclone Nivar off Kalpakkam and Cuddalore coast

Publications of ICORN data in the national and international Journals

S. Mandal, S. Sil, A. Gangopadhyay, B. K. Jena, R. Venkatesan and G. Gawarkiewicz, (2021) "Seasonal and Tidal Variability of Surface Currents in the Western Andaman Sea Using HF Radars and Buoy Observations During 2016–2017," in IEEE Transactions on Geoscience and Remote Sensing, vol. 59, no. 9, pp. 7235-7244, Sept. 2021, doi: 10.1109/TGRS.2020.3032885.

B. K. Jena, K. S. Arunraj, V. Suseentharan and M. V. Ramanamurthy, (2020)"Surface circulation off the Andaman Islands from HF radar observations", CURRENT SCIENCE, VOL. 118, NO. 11, 10 JUNE 2020, 1739-1745, doi: 10.18520/cs/v118/i11/1739-1745.

Samiran Mandal, Sourav Sil, Saikat Pramanik, Arun Raj K, and Basanta KumarJena,(2020) "On the natute of tidal asymmetry in the Gulf of Khambhat, Arabian Sea using HF radar Surface currents", 2020, Estuarine, Coastal and Self Sciences.

Samiran Mandal, Saikat Pramanik, Sourav Sil, Kondetharayil Soman Arunraj, and Basanta Kumar Jena, (2020) "Sub-Mesoscale Circulation Features along the Andhra Pradesh Coast, Bay of Bengal: Observations from HF Radars", Journal of Coastal Research, SI89 132-138, 2020, DOI: 10.2112/SI89-022.1

Veluchamy Suseentharan, Kondetharayil Soman Arunraj, Basanta Kumar Jena, Mallavarapu Venkata Ramana Murthy, and Kukadiya Tushar, (2020)"Interference Patterns Observed in the Indian Coastal Ocean Radar Network", Journal of Costal research, SI89, 63-66, 2020, DOI: 10.2112/SI89-011.1

B. K. Jena, (2019) QA/QC Manual for Indian Coastal Ocean Radar Network (ICORN)" Published by ESSO-National Institute of Ocean Technology, Ministry of Earth Sciences (GOI), January 2019.

B K Jena, K S Arunraj, V Suseentharan, Kukadiya Tushar, T Karthikeyan,(2019) "Indian coastal ocean radar network", Current Science, Vol. 116 no. 3, February 2019.

Samiran Mandal, Sourav Sil, Saikat Pramanik, Arun Raj K, and Basanta KumarJena, (2019) "Characteristics and evolution of a coastal mesoscale eddy in the Western Bay of Bengal monitored by high-frequency radars", Dynamics of Atmospheres and Oceans, Volume 88, December 2019, Article number 101107, Published online August 2019.

Aditya Chaudhary, Neeraj Agarwal, Rashmi Sharma, B. K. Jena & Raj Kumar, (2019): Coastal currents from Jason-2 and SARAL/AltiKa in the Indian region, International Journal, of Remote Sensing, 2019.1602793, ISSN: 0143-1161 (Print) 1366-5901 (Online 13 Apr 2019)

K S Arun Raj, B K Jena, V Suseentharan, J Rajkumar, (2018) "Variability in Eddy Distribution Associated With East India Coastal Current From High-Frequency Radar Observations Along Southeast Coast of India" Journal of Geophysical Research: Oceans, 123, 9101-9118. Dec 2018.

John, Manu; Jena, Basanta Kumar; Sivakholundu, K. M. (2015). Surface current and wave measurement during cyclone Phailin by high frequency radars along the Indian coast. Current Science. Vol. 108 (03).

Lipa B, Barrick D, Diposaptono S, Isaacson J, Jena BK, Nyden B, Rajesh K, Kumar TS (2012). High Frequency (HF) Radar Detection of the Weak 2012 Indonesian Tsunamis. Remote Sensing. 4(10): 2944-2956.

Transcriptomics studies as robust signatures of tuna biology




Rekha Govindan[1*], Raisa KCP[2], Nadilla Maryam[2] and Sabyasachi Senapati[3]

[1]*Assistant Professor in Biochemistry, Government College of Arts and Science (Affiliated to Pondicherry University), Andrott, UT of Lakshadweep 682551*
[2]*Government College of Arts and Science (Affiliated to Pondicherry University), Andrott, UT of Lakshadweep 682551*
[3]*Department of Human Genetics & Molecular Medicine, Central University of Punjab, Bathinda- 151401*

**Corresponding author: Dr. Rekha Govindan*

Author contributions: RG, RKCP and NM conceptualized and wrote the manuscript. SS reviewed and guided in writing the manuscript. All the authors read the final draft and approved the manuscript.

Conflict of interest: Nothing to declare

Abstract

A proteomics data search was done on open source biological databases, in-silico analysis tools as well as literature search engines using the key words tuna species, proteomics as well as transcriptomics. The findings summarized enable a better understanding on the molecular basis of tuna biology needed for the establishment and management of tuna aquafarms.

Introduction

The transcriptomic data sets are generated through a combination of bioinformatics methods, algorithm and databases of genes and proteins related to tuna fish physiology, developmental biology and health status. These datasets further are used as real time markers of energy metabolism, population dynamics, migratory patterns and oceanic admixtures of tuna species. In the present study, the available literatures on transcriptomics studies of tuna species (table 1) were retrieved and summarized. They provide an insight about mechanisms significant for tuna seafood industry, tuna aquafarm management and species conservation of the highly migratory and pelagic tuna fishes. However, as seen from the present study, it can be concluded that the amount of transcriptomics studies and data availability for the tuna species are limited.

Table 1: Retrieval of Literature from Pubmed (*July 2021 data)

Title	Published works available (Numbers)
Lakshadweep	70
Tuna species	1021
Yellow fin tune	278
Transcriptomics of Tuna species	19
Protemics of Tuna species	7

Proteomics data search on Tuna fish spp

In aquaculture, proteomics analyses are applied in fish products to examine proteins of different origins to evaluate the seafood quality. It is also used in the species identification of seafood products based on their protein fingerprints. For eg., the proteins of different tuna species can be subjected to 2D gel electrophoresis followed by MALDI-TOF mass spectroscopy. The mass spectra obtained from different tuna species that shows variations in the protein spots are then used as species specific markers (Pepe et al., 2010; Sara et al., 2014). Further large scale tuna transcriptomic studies identify the expression patterns of different gene loci during the cellular growth, maturation, environmental tolerance and disease resistance.

Proteome database analysis benefit from the information stored in different databases and makes use of different protein analysis tools to provide computational analysis of whole proteomes. Hence, in the present study, a proteomics data search was performed for proteins of the yellowfin tuna. The proteins were retrieved from Uniport (www.uniport.org) through the key words, yellow fin tuna proteins and proteome. A total of 104 entries were found for the yellowfin tuna. The uniport entry of individual proteins specifies each protein with an accession number and includes the protein function, primary structure and molecular weight mainly. For example the uniport accession number for the yellowfin tuna protein somatotopin is UniProtKB– P34747 (SOMA-THUAL). It is a metal binding protein growth hormone with a molecular weight of 21.3KDa. It is involved in osmo-regulation and seawater adaptation.

Transcriptomic data on tuna fish species

Transcriptomic data is the representation of actively expressed genes in a cell at any given time. In general, large scale transcriptomic studies are performed to identify the expression patterns of different gene loci during the cellular growth, maturation, environmental tolerance and disease resistance (Shibata et al., 2016). Earlier transcriptomic studies were based on generation of expressed sequence tags (ESTs) generated at different stages of an organism using traditional Sanger sequencing. These studies were restricted to the analysis of a few thousand ESTs at a time. Recent technological improvements in cDNA sequencing, using next generation sequencing (NGS) platforms are able to generate millions of reads, to record the transcript profile of an organism at a given developmental stage. These reads are then assembled into long consensus sequences (clusters) known as contigs using assemblers (Carlsson et al., 2007; Garg and Ranganathan., 2011; Ngamniyom et al., 2020). Since the genomes of only a very few tuna fish species are currently available, de novo assemblers are the only option for NGS data.

The transcriptomic studies can be used for comparing tuna species grown in wild and aquaculture conditions. In the study by Trumbic et al., (2015), a custom oligo-microarray was designed and validated using the sequences of a mixed-tissue normalised cDNA library, derived from different tissues of the adult T. thynnus. A total of 976,904 raw sequence reads were assembled into 33,105 unique transcripts having a mean length of 893 bases and an N50 of 870. Of these, 33.4% showed similarity to known proteins or gene transcripts and 86.6% of them were matched to the congeneric Pacific bluefin tuna (Thunnus orientalis) genome, compared to

70.3% for the more distantly related Nile tilapia (Oreochromis niloticus) genome. Transcript sequences were then used to develop a novel 15 K Agilent oligonucleotide DNA microarray for T. thynnus and comparative tissue gene expression profiles were inferred for gill, heart, liver, ovaries and testes. Functional contrasts were strongest between gills and ovaries. Gills were particularly associated with immune system, signal transduction and cell communication, while ovaries displayed signatures of glycan biosynthesis, nucleotide metabolism, transcription, translation, replication and repair. In a related study, Yasuike et al., (2016) developed a global transcriptome profiling of bluefin tuna species based on whole-genome shotgun (WGS) sequencing and large-scale expressed sequence tags (ESTs) data. It consisted of 44K PBT oligonucleotide microarray (oligo-array) where the methodology involved 4,202d non-fused gene sequences out of total of 27,332 gene sequences after conducting two condition of AUGUSTUS and correcting all possible erroneously fused genes by reference to the RefSeq protein data of zebrafish. Then from cDNA contigs assembled from a large-scale EST project, BLAST searches were performed against the tuna genes and the Ensembl five teleost database. Non overlapping cDNA contigs with an identity of ≤ 95%) matched to the Ensembl database were selected. Finally the PBT non-redundant reference sequences were used for the PBT oligo- array probe design. However, in the cardiac and skeletal muscle tissue-specific gene-expression profiles, little difference in the overall expression profiles of calcium-cycling and cardiac contraction pathways between atrium and ventricle tissues were reported (Ciezarek et al., 2020). The expression of a key sarcoplasmic reticulum calcium-cycling gene, SERCA2b that plays a key role maintaining intracellular calcium stores despite being higher in atrium than ventricle. Also, the expression of genes involved in aerobic metabolism and cardiac contraction were higher in the ventricle than atrium. The two morphologically distinct tissues that derive the ventricle, spongy and compact myocardium, had near-identical levels of gene expression. More genes had higher expression in the cool, superficial muscle than in the warm, deep muscle in both the aerobic red muscle (slow-twitch) and anaerobic white muscle. This indicates tissue specific widespread transcriptomic differences between the Pacific tuna ventricle and atrium. The study provides an insight into the mechanism of the elevated cardiac capacity and increased cold-tolerance of the Pacific bluefin tuna. Similarly tuna larval transcriptomics study is set to unravel the detailed physiological responses occurring during the different developmental stages of tuna species (Luca et al., 2020). The de novo larval transcriptome comprised of 37,117 protein-coding transcripts, out of which 13,633 full-length (>80% coverage), with an Ex90N50 of 3,061 bp and 76% of complete and single-copy core vertebrate genes orthologues were assembled and characterized. Of these transcripts, 34,980 had a hit against the EggNOG database and 14,983 with the KAAS annotation server. By comparing the obtained transcriptomic data with a set of representative fish species proteomes, it was found that 78.4% of the tuna transcripts were successfully included in orthologous groups.

Conclusion

In the present work, several bioinformatics databases were searched for the key words – tuna, proteome, omics studies. Open source bioinformatics databases and tools, Pubmed, DNA Data bank of Japan (DDBJ), European molecular biology lab (EMBL), SWISS-PROT and Uniport were used as the bioinformatics search engines and tools. Similarly, the high-through put genome and proteome studies in tuna seafood industry, tuna aquafarm management, tuna species oceanic admixture, tuna migratory patterns and species conservation were reviewed. From our study, it can be concluded that there is a growing interest in the field of tuna transcriptomics. The genomic assemblies of most of the tuna species are now available as data repositories. Yet more transcriptomic studies are needed to generate the secretome and cell membrane proteins of tuna species. New strategies based on omics studies are needed to improve tuna captivity and maintenance of tuna aquafarms.

References

Carlsson J, Jan R. McDowell, Jeanette E. L. Carlsson, John E. Graves (2007). Genetic Identity of YOY Bluefin Tuna from the Eastern and Western Atlantic Spawning Areas, Journal of Heredity, Volume 98, Issue 1, January 2007, Pages 23–28.

Ciezarek, A., Gardner, L., Savolainen, V. et al. (2020). Skeletal muscle and cardiac transcriptomics of a regionally endothermic fish, the Pacific bluefin tuna, Thunnus orientalis. BMC Genomics 21, 642.

Garg and Ranganathan., (2011) In silico secretome analysis approach for next generation sequencing transcriptomic data., BMC Genomics; 12(Suppl 3):S14.

Luca M, Danilo Basili, Giorgia Gioacchini, Adriana Canapa, Oliana Carnevali, (2021). De novo transcriptome assembly, functional annotation and characterization of the Atlantic bluefin tuna (Thunnus thynnus) larval stage, Marine Genomics, 58, 100834 .

Ngamniyom A, Sriyapai T, Sriyapai P. (2019). Molecular analysis of population and De Novo transcriptome sequencing of Thai medaka, Oryzias minutillus (Teleostei: Adrianichthyidae). Heliyon. 6(1):e03079. doi: 10.1016/j.heliyon.2019.e03079

Pepe T, Ceruso M, Carpentieri A, Ventrone I, Amoresano A, Anastasio A. (2010). Proteomics analysis for the identification of three species of Thunnus. Vet Res Commun. 34 Suppl 1:S153-5. doi: 10.1007/s11259-010-9400-7.

Sara T, Mullen William and Cristobal Susana, High-Throughput Proteomics, (2014). A New Tool for Quality and Safety in Fishery Products, Current Protein & Peptide Science 15(2). 118-133.

Shibata M, Mekuchi M, Mori K, Muta S, Chowdhury VS, Nakamura Y, Ojima N, Saitoh K, Kobayashi T, Wada T, Inouye K, Kuhara S, Tashiro K. (2016). Transcriptomic features associated with energy production in the muscles of Pacific bluefin tuna and Pacific cod. Biosci Biotechnol Biochem. 2016 Jun;80(6):1114-24. doi:10.1080/09168451.2016.1151341

Trumbić et al., (2015) Development and validation of a mixed-tissue oligonucleotide DNA microarray for Atlantic bluefin tuna, Thunnus thynnus (Linnaeus, 1758)., BMC Genomics; 16:1007

Yasuike M, Atushi Fujiwara, Yoji Nakamura, Yuki Iwasaki, Issei Nishiki, Takuma Sugaya, Akio Shimizu, Motohiko Sano, Takanori Kobayashi, Mitsuru Ototake, (2016). A functional genomics tool for the Pacific bluefin tuna: Development of a 44K oligonucleotide microarray from whole-genome sequencing data for global transcriptome analysis, Gene, 576, 603-609, ISSN 0378-1119 .

Mechanisms controlling the summer monsoon chlorophyll bloom of the Somali upwelling system



R. S. Lakshmi[1,2], Abhisek Chatterjee[1], Satya Prakash[1], and Teesha Mathew[1,2]
[1]Indian National Centre for Ocean Information Services, Ministry of Earth Sciences, Hyderabad, India
[2]Kerala University of Fisheries and Ocean Studies, Kochi, Kerala
Contact: Dr. Abhisek Chatterjee, abhisek.c@incois.gov.in

Dr. Satya Prakash, our co-authorand friend, passed away on 22 July 2021. This article is dedicated to his memories.

This article is based on the following paper:
Shenoy, L. R., Chatterjee, A., Prakash, S., & Mathew, T. (2020). Biophysical interactions in driving the summer monsoon chlorophyll bloom off the Somalia coast. Journal of Geophysical Research: Oceans, 125, e2019JC015549.

The Arabian Sea is characterized by its unique large-scale seasonal variability driven by the seasonally reversing monsoon winds. During Southwest Monsoon (SWM) the strong Findlater jet (Findlater, 1969) blows southwesterly across the Arabian Sea resulting in a strong upwelling along the coast of Somalia and Arabia. This process brings nutrient-rich cold subsurface water into the euphotic zone making the western Arabian Sea one of the most productive regions of the globe (McCreary et al., 1996; Smith & Codispoti, 1980; Wiggert et al., 2005) and considered to be the fifth-largest upwelling system in the world ocean. Recently, based on a modelling study, Chaterjee et. al. (2019) transpired the complex physical dynamics behind the Somali upwelling system during SWM.They reported that upwelling along the Somali coast is mainly confined to the northern part of the coast along the cold front of the Great Whirl eddy. Whereas, in the southern and central part of the coast downwelling Rossby waves generated by the offshore negative windstress curl opposes the wind-driven coastal upwelling. This resulted in deepening of thermocline along the coast of Somalia as the monsoon progresses despite the increasing strength of alongshore winds. They further added that while upwelling cools the SST in the northern part of the Somalia, entrainment and surface heat flux dominate the SST in the central and southern part of the coast. These new findings necessitate a detailed study to understand the processes controlling the summer monsoon bloom along this coast.

The influence of these physical processes on the biogeochemistry off the coast of Somalia is studied using a physical-biogeochemical model known as Modular Ocean Model (MOMv5) coupled with Tracers of Phytoplankton with Allometric Zooplankton (TOPAZ) biogeochemical module. Our analysis suggests that the chlorophyll distribution along the Somalia coast during summer monsoon is strongly heterogeneous. Observations and the model simulation suggest that the intense chlorophyll

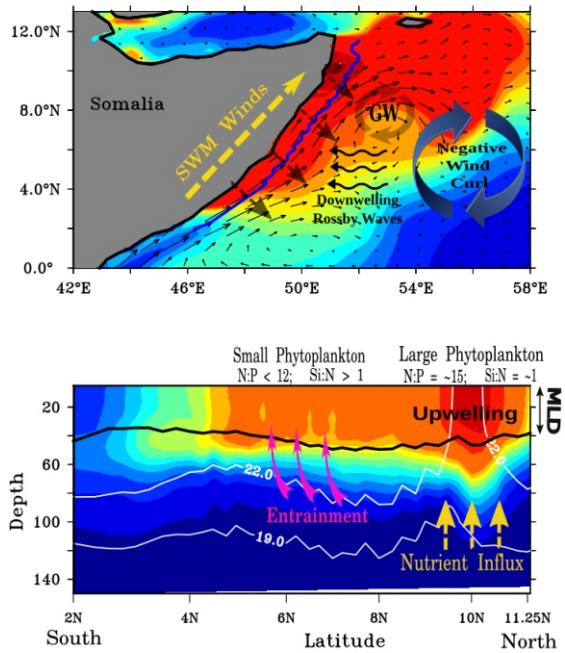


Figure 1: (Top panel) Climatological surface chlorophyll concentration (µg/L) overlayed by the surface currents. Cross-shore arrows represent the strength of Ekman transport driven by alongshore winds. (Bottom panel) Vertical section of chlorophyll (µg/L) along the 1000 m isobath parallel to Somalia coast (Blue contour along the Somali coast in the top panel) during the Southwest Monsoon season. White lines represent the isotherm layers and the black line is the mixed layer depth.

concentration is restricted mainly to the northern part (north of 9oN) of the Somali coast where strong nutrient influx induced by coastal upwelling is evident. The maximum concentration of chlorophyll (~5µg/L) and nutrients (Nitrate: 8-10 µmol/kg, Phosphate: 05-0.7 µmol/kg) is observed in this northern section during the peak summer monsoon in August. Moreover, strong poleward Somali currents advect nutrient from the central and southern part of Somalia to the Great Whirl frontal regions which add to the upwelled nutrient available for primary production there. In contrast, south of 9oN sees a low to moderate concentration of Chlorophyll (~1 µg/L) because of the entrainment of nutrients in the upper mixed layer due to the deepening of the thermocline. Advection of nutrients by the swift Somali currents also limits the nutrient availability in this part of the coast.

The model analyses based on size-based phytoplankton during summer monsoon months shows that both the large and small phytoplankton communities contribute to the total chlorophyll concentration seen in this region. The northern section of the Somali transect is dominated by large phytoplankton (two-fold of the small phytoplankton) because of the large influx of nutrients. However, in the rest of the section, small phytoplankton stands over the large phytoplankton owing to the limited availability of nutrients. The relative contribution of different types of nutrients along the Somali coast has been analysed and found that towards the northern part of the coast, the nutrient ratio satisfies the Redfield Stoichiometry [N:P:Si = 16:1:16; Redfield (1963)] for the healthy growth of phytoplankton. During the peak summer monsoon, the N:P ratio is ~15 and the Si:N ratio stays around 1. This suggests that macro-nutrients do not limit the growth of both the phytoplankton groups in this region.Here dissolved iron concentration also ranges between ~1.2-1.8 nM (Naqvi et al., 2010) and the NO3:Fe ratio less than 15,000 (Measures & Vink, 1999)

indicating an iron-replete condition which is favourable for the growth of primary productivity in this region. The central and southern sections, however, exhibit a nitrate limited condition for the healthy growth of phytoplankton as N:P ratio (<12) and Si:N (>1) ratio remains non-favourable for the growth of phytoplankton communities along this part of the Somali coast.

References

Chatterjee, A., Kumar, B. P., Prakash, S., & Singh, P. (2019). Annihilation of the Somali upwelling system during summer monsoon. Scientific reports, 9(1), 7598.

Findlater, J. (1969). A major low-level air current near the Indian Ocean during the northern summer. Quarterly Journal of the Royal Meteorological Society, 95(404), 362–380.

McCreary, J. P., Kohler, K. E., Hood, R. R., & Olson, D. B. (1996). A four-component ecosystem model of biological activity in the Arabian Sea. Progress in Oceanography, 37(3-4), 193–240.

Measures, C., & Vink, S. (1999). Seasonal variations in the distribution of Fe and Al in the surface waters of the Arabian Sea. Deep Sea Research Part II: Topical Studies in Oceanography, 46(8-9), 1597–1622.

Naqvi, S., Moffett, J. W., Gauns, M., Narvekar, P., Pratihary, A., Naik, H., et al. (2010). The Arabian Sea as a high-nutrient, low-chlorophyll region during the late Southwest Monsoon. Biogeosciences, 7(7), 2091–2100.

Redfield, A. C. (1963). The influence of organisms on the composition of seawater. The Sea, 2, 26–77.

Smith, S. L., & Codispoti, L. A. (1980). Southwest Monsoon of 1979: Chemical and biological response of Somali coastal waters. Science, 209(4456), 597–600.

Wiggert, J., Hood, R., Banse, K., & Kindle, J. (2005). Monsoon-driven biogeochemical processes in the Arabian Sea. Progress in Oceanography, 65(2-4), 176–213.

Nature and Evolution of the Andaman Backarc Basin: Some Outstanding Questions

The Andaman Backarc Basin is characterized by active seafloor spreading spurred by the right stepping dextral shear imposed on the trans-basinal Sagaing-Andaman-Nicobar- Sumatra fault system. The backarc basin presents a complex tectonic history owing to some unique geophysical characteristics such as the absence of magnetic anomalies and thickly sedimented spreading center.

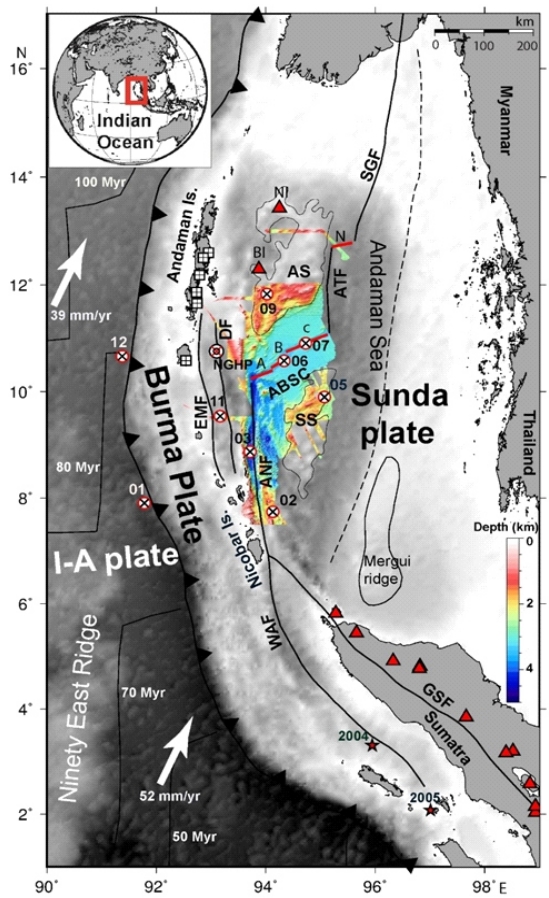


Figure.1 General tectonic framework of the Andaman Sea encompassing the Andaman Backarc Basin presented on a gray shaded bathymetric image with age contours and the plate motion directions (white arrows) Multibeam bathymetry coverage in the bacarc basin is depicted. Black squares with cross denote broad band seismic stations from the ISLANDS network red circle with black cross represents the Ocean Bottom Seismometer deployments. Black double circle with red cross represents NGHP deep drilling site. Great Sumatra Fault (GSF), West Andaman Fault (WAF), Eastern Margin Fault (EMF), Diligent Fault (DF), Andaman-Nicobar Fault (ANF), Andaman Backarc Spreading Centre (ABSC), Andaman Transform Fault (ATF), Sagaing Fault (SGF), Sewell Seamount (SS) and Alcock Seamount (AS) are marked. The dashed black lines represent the ocean-continent boundary. Red triangles represent volcanoes. Red star represents major earthquake events of 2004 and 2005. (See Kamesh Raju et al., 2020 for full caption with references).

With respect to the morphotectonics, the high-resolution mapping efforts have greatly improved our understanding of the Andaman Backarc Basin. The most crucial being the remarkable evidence about the existence of the backarc spreading center, the identification of series of volcanoes defining the active volcanic arc and the delineation of the Andaman-Nicobar Fault system. Extensive volcanism in the geological past is documented in a 691.6 m deep drilling core recovered by D/V JOIDES Resolution (Kumar et al. 2014).

There are very few examples, where very young crust failed to generate significant magnetic anomalies. Such unique situation arises in the Andaman Sea over the sedimented spreading center. The deep seismic imaging of the spreading center (Singh et al. 2010) provided compelling evidence for the presence of sill-sedimented structure and the absence of oceanic layer 2A beneath this spreading center. The nature

of the oceanic crust underneath the backarc spreading segment and the composition of the sill complexes are of special interest. Further, the age and nature of the crust beneath the Alcock and Sewell seamounts is critical to define the recent evolutionary history of the Andaman Backarc Basin.

Barren Island volcanism has been in focus for some time. What is needed may be a modern permanent observatory designed to cover the island and also the offshore region. Deployment of OBS clusters in the offshore region around the Barren Island would provide crucial information regarding the temporal variation of tectonic and magmatic activity associated with the Barren Island volcano.

Four decades have elapsed after the major geological and geophysical investigations initiative undertaken by the Scripps Institute of Oceanography in late seventies. The 2004 tsunamigenic earthquake caught the attention of several international scientific groups and the spur in the investigations have provided considerable knowledge about the Andaman Backarc Basin. The region now awaits an IODP campaign to resolve some of the outstanding problems.

Article is based on below publication

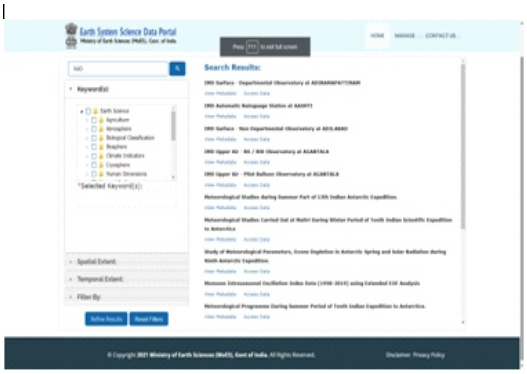
Kamesh Raju, K.A., Aswini, K.K. and Yatheesh, V., 2020. Tectonics of the Andaman Backarc Basin – Present Understanding and Some Outstanding Questions. In: J. S. Ray and M. Radhakrishna (eds.), The Andaman Islands and Adjoining Offshore: Geology, Tectonics and Palaeoclimate, Society of Earth Scientists Series, Springer Nature Switzerland AG 2020.

Launch of MoES Earth System Science Data Portal (MoES-ESSDP)

The Ministry of Earth Sciences (MoES) is mandated to provide services for weather, climate, ocean and coastal state, hydrology, seismology, and natural hazards; to explore and harness marine living and non-living resources in a sustainable way and to explore the three poles (Arctic, Antarctic and Himalayas). Several scientific programmes implemented by the Ministry over the years have generated voluminous multi-disciplinary data pertaining to Atmosphere Sciences, Ocean Sciences, Polar Sciences and Geo Sciences. All these data are being organised and managed by respective data centres of the MoES institutions.

There is a growing demand for the earth system science data from a single source to foster inter-disciplinary research and its utilisation for several applications. Further, the advancements in the information and communication technology facilitate to integrate the heterogeneous data for effective utilisation through a single platform. Considering the imperative to make available data through a single source, MoES has developed the Earth System Science Data Portal (ESSDP) to host metadata of the data generated by its institutions and available across multiple data portals and provide links to respective geo-spatial datasets covering different themes of earth system sciences such as Atmosphere, Ocean, Polar and Geo Sciences. ESSDP developed using latest technology facilitates ease of search and discovery of various datasets collected and maintained under different programmes implemented by MoES over the years and link them to the relevant data centres. ESSDP serve the increasing data-discovery needs of a wide range of users including research institutions, operational agencies, strategic users, academic community, industry, policy makers and the public. ESSDP is a one of its kind platforms bringing together the data and information of earth system science comprising of different themes and contributes to the Digital India programme of the Government of India to transform India into a digitally empowered society and knowledge economy. ESSDP will play a central role in sustainable management of our Earth System resources and expanding our knowledge base in the earth sciences. Further, ESSDP will be promoted as an integrated platform for capacity building on earth system data management and to build a centralized MoES data repository.

The ESSDP was developed by the Indian National Centre for Ocean Information Services (INCOIS) with the support from the participating institutions of Ministry of Earth Sciences viz., Indian Institute of Tropical Meteorology (IITM), India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF), National Institute of Ocean Technology (NIOT), National Centre for Polar and Ocean Research(NCPOR), National Centre for Earth Science Studies (NCESS), National Centre for Seismology (NCS), Centre for Marine Living Resources and Ecology (CMLRE), National Centre for Coastal Research (NCCR).



Home page of the MoES-ESSDP (), a one-of-a-kind digital platform bringing together data and information of earth system science on a single dynamic web platform. ESSDP can be accessed at .

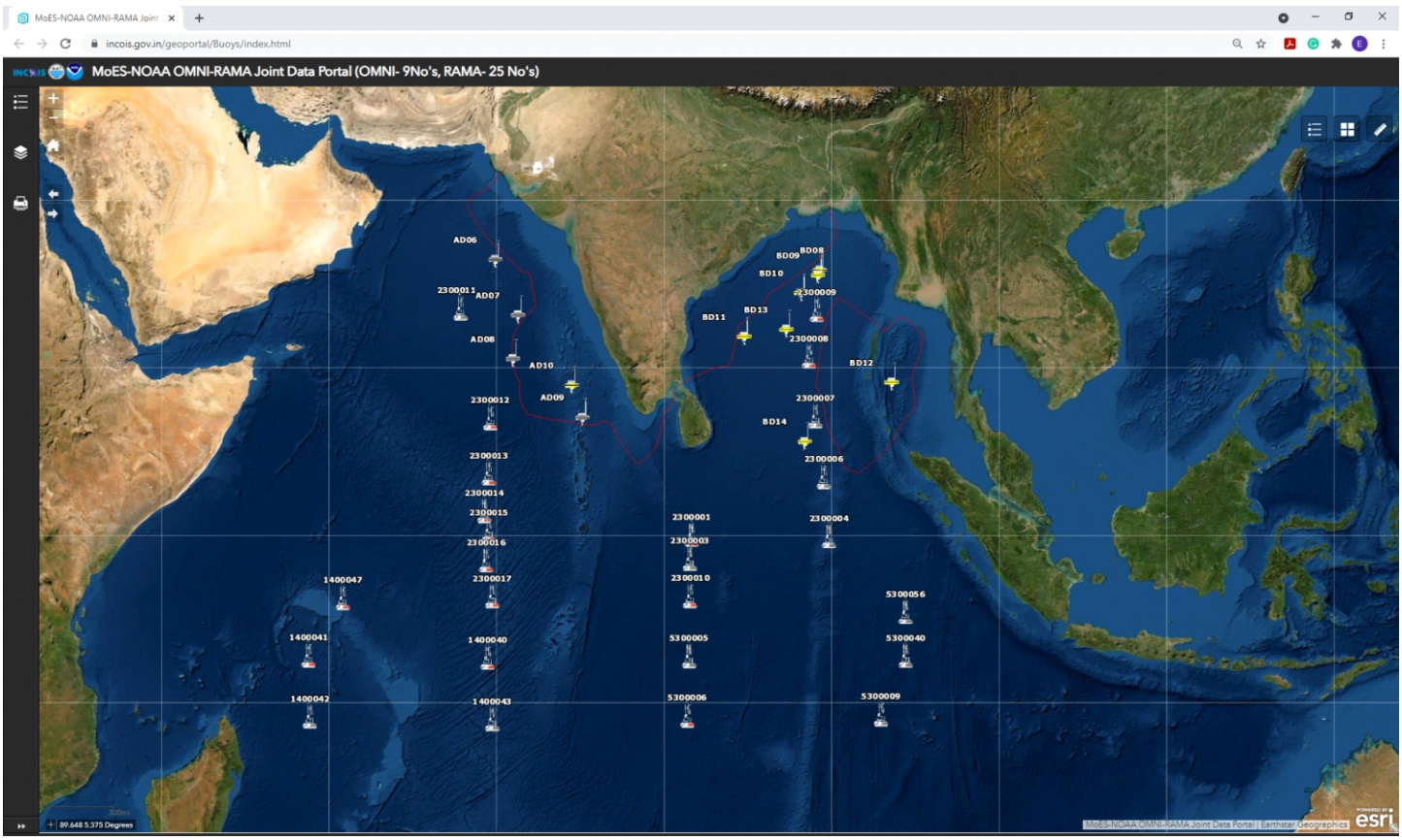
Dr Jitendra Singh, Honourable Union Minister of State (Independent Charge) Science and Technology; (Ind Charge) Earth Sciences; MoS PMO, PP/DoPT, Atomic Energy and Space launched the MoES-ESSDP during the 15th Foundation Day of the MoES celebrations on 27 July 2021.

Launch of the MoES-NOAA OMNI-RAMA Joint Data Portal

The moored buoy observations are largely utilized to address ocean-atmosphere interactions that brought out many new insights of weather and climate variability. The National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences (MOES) established the Ocean Moored buoy Network in the northern Indian Ocean (OMNI) in the Indian Ocean. Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction (RAMA) programme is a multilateral moored buoy program in Indian Ocean, by the National Oceanic and Atmospheric Administration (NOAA)/Pacific Marine Environmental Laboratory (PMEL), USA in collaboration with scientific agencies in India, Indonesia, Japan, and China. The RAMA network was launched under Indo-US collaboration with the deployment of four ATLAS moorings near the equator by NOAA/PMEL in October-November 2004. Currently data from the RAMA buoy observations are available to the public through the data portal operated by PMEL -NOAA.

Considering the importance of the moored buoy data and its wide applications in various facets of life, a common data portal was developed for public access to the international research community by integrating the observations from the OMNI and RAMA Buoy Network in the Indian Ocean.

The Indian National Centre for Ocean Information Services (INCOIS), Hyderabad being the central repository for the oceanographic data, receives the data from OMNI buoy network in real-time and made available to the operational agencies and different users through the data center at INCOIS. The OMNI-RAMA Joint Data Portal was developed by INCOIS jointly with NIOT and PMEL, and can be accessed at https://incois.gov.in/portal/datainfo/buoys.jsp.



The portal hosts 9 OMNI buoys and 25 RAMA buoys in Indian ocean providing marine meteorological and surface and sub-surface oceanographic parameters. The OMNI-RAMA portal would showcase the large inventory of meteorological and oceanographic data sets with direct access for data display and delivery. The data sets with frequency as high as 2 minutes to the regular transmission interval of one hour is provided with a supporting meta data information such as deployment, sensors specification, calibration, sampling strategy, data processing, quality control etc. The portal would facilitate the visualization of measured as well as estimated parameters at various frequencies along with provisions for data downloading in various formats. The OMNI-RAMA partnership is meant to improve access to high-quality moored time series data and is anticipated to stimulate broader utilization for scientific research and applications. This OMNI-RAMA endeavour of public access to long term data will be beneficial to 1.5 billion people of the Indian Ocean Rim countries to manage their marine environment better and to use the ocean's resources sustainably.

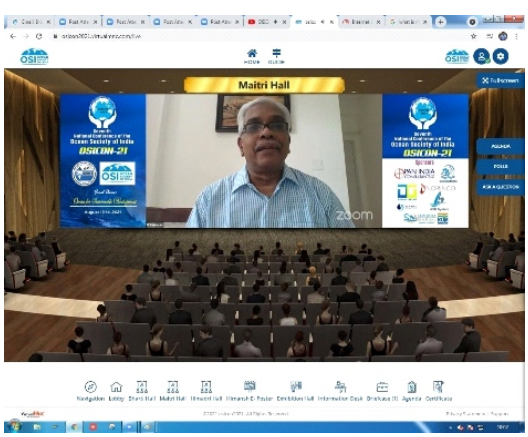
The joint data portal was launched by Dr. Ashutosh Sharma, the then Secretary, MoES in the presence of Mr. Craig McLean, Assistant Administrator for Research and Acting Chief Scientist, NOAA during the signing ceremony of the implementing arrangement for technical cooperation in development of RAMA and OMNI for improving weather and monsoon forecasts between NOAA and MoES on 9th August 2021.

Report on OSICON-2021 (12 – 14 August 2021)

The Ocean Society of India (OSI) has initiated in organizing the biennial OSI Conference (OSICON) since 2009. There were six conferences already held and the previous OSICON-2019 was held at CMLRE, Kochi. All these six conferences were hosted by leading academic/research institutes such as Andhra University, Visakhapatnam; NIOT Chennai; IITM Pune; NIO Goa; NCESS Thiruvananthapuram, and the sixth one at CMLRE Kochi. This is the 7th National Conference of OSI, the OSICON-2021 organized in collaboration with National Centre for Polar research (NCPOR) from 12-14th August 2021 at NCPOR, Goa through virtual platform. This conference has been very successful in bringing and bridging together professionals and students working in the broad area of Ocean Sciences, Engineering & Technology, and allied fields in sharing their knowledge. The theme of the OSICON-21 this year was "Ocean for Sustainable Development".

OSICON-2021 was organized in three parallel sessions on each day from 12th to 14th August 2021 at NCPOR, Goa through virtual mode. During these three days, we had a total of 13 invited talks, a total of 216 abstracts (113 oral presentations, and 103 poster presentations). The conference was inaugurated by Dr. M. Rajeevan, Former Secretary, MoES and ended with a plenary talk by Dr. Shailesh Nayak, Director NIAS and Former Secretary, MoES. The invited talks were delivered by eminent personalities from organizations such as CMLRE Kochi; INCOIS Hyderabad; University of Maryland, USA; CSIR-NIO Goa; Cotton University Guwahati; NCCR Chennai; IITM Pune; Sanctuary Beach Pvt. Ltd, Singapore; NCPOR Goa; IIRS/ISRO Dehradun; NIOT Chennai; and NCESS Thiruvananthapuram. There were seven themes that covered various aspects on: (i) Marine Ecosystems and Biogeochemistry of the Ocean, (ii) Coastal and open Ocean processes, (iii) Climate change, (iv) Polar Science and cryosphere, (v) Ocean Engineering and Technology, (vi) Marine Geology and Geophysics and (vii) Mathematics in Ocean sciences. A total of 38 abstracts were received for the Award category. The theme 'Climate change' had a total of 07 (Oral: 05 and Poster: 02); 'Coastal and Open Ocean processes' had a total of 10 (Oral: 06 and Poster 04); 'Marine Ecosystem and Biogeochemistry of Oceans' had a total of 12 (Oral 05: Poster 07); 'Mathematics in Ocean Science' had a total of 02 (both were Oral); 'Ocean Engineering & Technology' had a total of 05 (all 05 were Oral); and 'Polar Science & Cryosphere studies' had a total of 02 (both were under Oral category).

In this conference, the first Honorary Fellow of OSI was awarded to Dr. Nayak with a citation and memento, Dr. Prasad Bhaskaran and Prof. Jayachandran received OSI fellow of the year 2021 award with a citation and memento and Dr. D. Srinivasan Endowment Award for the year 2021 presented to Dr. M. A. Atmanand, Visiting professor, IIT Madras and former Director NIOT with a citation, memento and cash prize.

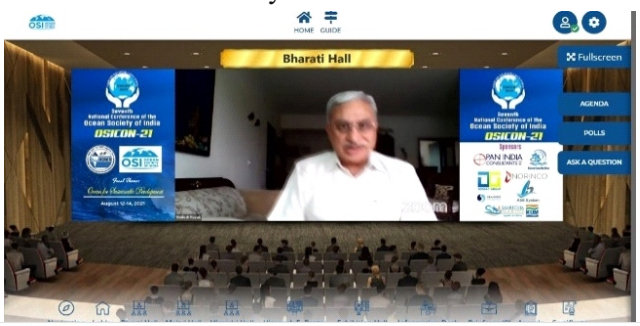


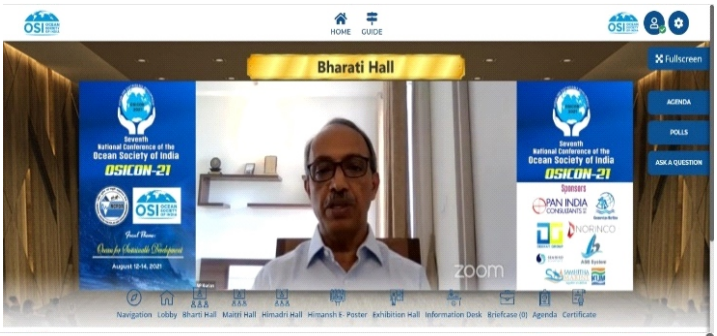
To encouraging the young researchers in the various related field of Oceanography, 7 different categories (Physical, Chemical, Geological, Biological Oceanography, Ocean & Atmosphere, Ocean Engineering & Technology and Marine Microbiology and Biotechnology) were chosen for PG Dissertation award. Winners (Ardra D, Sreevidhya R, Anjana Gireesh, Akalesh Patel Gopikrishnan G S, Tepplal Vikranth and Nizam Ashraf) were presented a Certificate, memento and a cash prize. A special certificate and memento were presented to Ms. Saranya in the field of Ocean & Atmosphere.

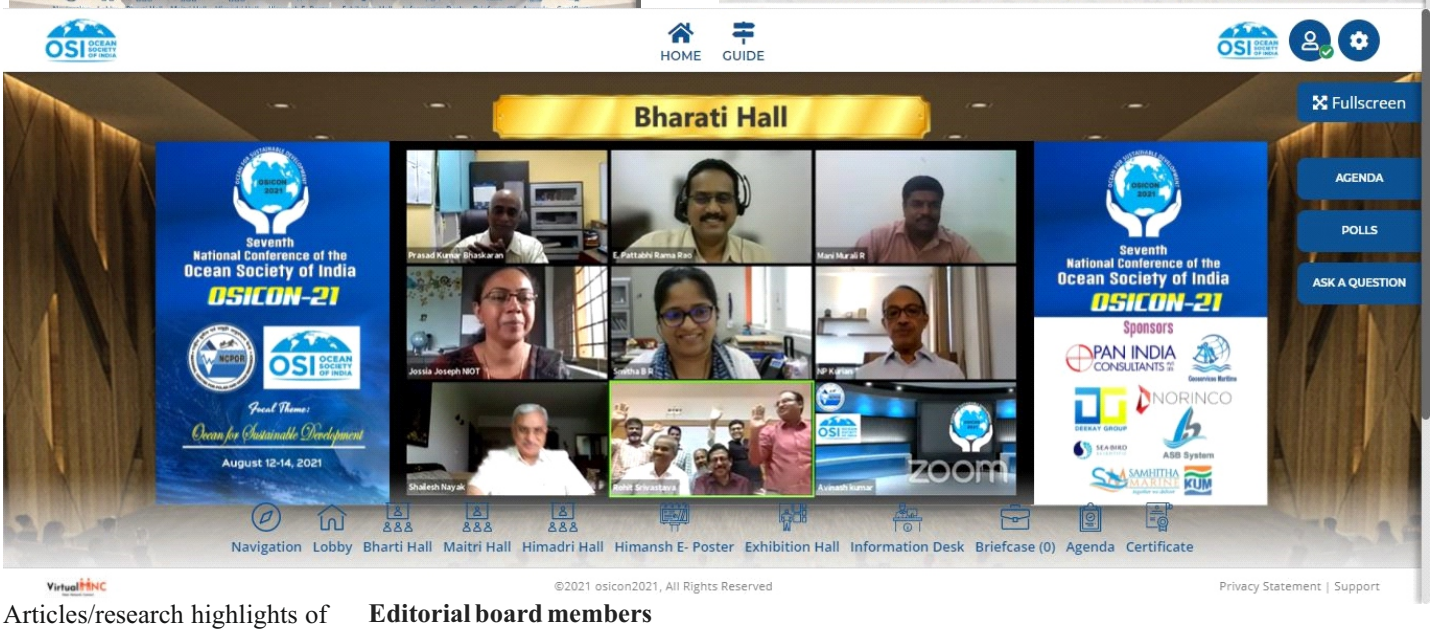
Ocean Society of India has conducted an online competition for students from various university, research institutions across India under the focal theme of the OSICON21 "Ocean for Sustainable Development". The 1st prize was presented to Mr. Midhun Shah Hussain, CUSAT, Kochi, 2nd Prize to Ms. Maria James, IIT Bhubaneswar and Consolation prize to Ms. Devika Jaysree, KUFOS, Kochi, Certificate of Appreciation to Mr. Vikranth Teppala, IIT Kharagpur.

As every year, this year also awards were presented winners in 7 different themes of the conference for Oral and poster Presentation. The award winners in the Oral presentations were 1. Sndanda N, IIT Kharagpur, 2. Samiran Mandal, IIT Bhubaneswar, 3. Akhil Vargees, KUFOS, 4. Biswajit Haladar, NIOT, 5. Sritamma Baag, Presidency University, 6. K Shitjita, NCPOR and 7. Vaishnavi S, VIT, Chennai. The award winners in the Poster presentations were 1. Diksha Sharma, CSIR-NIO, 2. Shruti Shah, CSIR-NIO, 3. Midhun Shah Hussain, CUSAT, 4. Abdhul Aziz, NIO Kochi, 5. Akash Trivedi, ISSER Pune, 6. Anvita Kerkar, NCPOR and 7. Juhi Yadav.

This year in this pandemic situation we have received active participation and very good quality papers from the students and researchers from the length and breadth of this country. Our gratitude to all the national advisory committee, technical committee, organizing committee and GC members for rendering their active support in conducting the review process of all the abstracts received for OSICON-2021 in a timely manner.







Articles/research highlights of general interest to the oceanographic community are invited for the next issue of the Ocean Digest. Contributions may be emailed to osioceandigest@gmail.com

Design/Typset/Editing: Kirti Dubhashi
Cover Photo: *Zoanthus sp.* from rocky intertidal habitat of Anjuna, Goa. Photograph by Ms. Prerna Shet