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Blue Economy: Non-Living Resources with special reference to coastal placer deposits

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Abstract

Blue Economy refers to the sustainable development of ocean resources and affords huge prospects and promises of economic development of the country/society. Major Blue Economy sectors include living resources, non-living resources (minerals), services, and renewable resources. Minerals (and metals) are unavoidable commodities as they have an inevitable place in the development of society in the digital era. In addition to land-based mineral resources, we must look for marine mineral resources to address the massive demand. Since rare earth and placer minerals have tremendous economic value due to their applications in high-tech electronic industries, they encourage marine geologists to look for new deposits in the marine environment. This paper discusses marine mineral reserves, especially coastal placer resources and their sustainable development in India. As well, the "mineral to marketing" concept in an economical and sustainable framework is suitably explained, and related "policy takeaways" are summarized.

1.0 Introduction

The Blue Economy is defined as the sustainable development of ocean resources for economic prospects and societal advancement within the conserved and secured framework (Pauli, 2010). The blue economy concept has emerged to include the sustainable development of blue resources. In addition to the economic potentiality of the available blue resources, the blue economy is viewed in terms of social security, conservation of resources, and environmental sustainability of oceans (Ebarvia, 2016). Conservation of available blue resources and a new discovery of additional/alternative natural resources form the essential elements of the Blue Economy (Choi, 2017). Thus, the blue economy aims to move beyond the business-as-usual scenario. It is a long-term strategy designed to support sustainable and reasonable economic growth through ocean-related sectors and accomplishments.

The marine fisheries activity employs more than 200 million people. Nearly 90,000 commercial ships transported about 9.8 billion tons of merchandise in 2014 alone. Among the established sectors of the blue economy, i.e., living resources, non-living resources, services, and renewable resources, the non-living resources (mostly marine minerals) have a momentous character. This paper deliberates upon the marine minerals and their possible influences and importance on blue economy strategies.

2.0 Blue Economy and Marine (Placer) Minerals

The minerals are essential resources for the development of any country, and the demands are proportionately ever increasing. Tens of tons of minerals (in the form of different materials) are constantly consumed by each person yearly. Because of the fast depletion of terrestrial mineral resources, the oceans are regarded as an alternative source. To date, the marine mineral exploration statistics indicate a variety of minerals occurrences in different physiographic provinces of the ocean. In Indian coastal and marine provinces, the heavy mineral sands usually occur on the beaches as well as the offshore areas up to 40 to 50m depth. CSIR-National Institute of Oceanography and Marine Wing of Geological Survey of India is actively engaged in marine mineral exploration works in India. In addition, AMD, NCESS, and several coastal universities are substantiating their contributions. In the 1980s, CSIR-NIO initiated a significant mineral mapping in the Indian Ocean (Siddiquie et al. 1984). India is bestowed richly with placer deposits on beaches and offshore areas (Mohan and Rajamanickam, 2001; Loveson et al., 2007), which is being discussed in detail hereunder.

Systematic mapping of coastal placer mineral deposits along many Indian coastal and offshore areas has been carried out (Loveson et al., 2007). The AMD (Atomic Mineral Directorate) and GSI (Geological Survey of India) are the primary ones associated with the exploratory surveys of placer deposits in India. Unlike other countries, India is blessed with multi-mineral placer deposits along the Indian coast. Strategic minerals such as ilmenite, rutile, and zircon are reported in several coastal sectors along with magnetite, garnet, sillimanite, kyanite and chromite deposits. The summary of the reserves of placer minerals is presented in below Table 1.

State wise	Ilmenite	Rutile	Garnet	Zircon	Kyanite	Sillimanite
Andhra	156.17	10.55	17.26	11.94	---	0.002
Jharkhand	0.73	0.01	0.11	0.08	0.426	---
Gujarat	2.77	0.02	---	0.01	---	---
Kerala	144.02	8.74	0.20	7.83	---	---
Maharashtra	5.50	0.01	---	0.01	0.262	0.20
Odisha	150.62	6.58	9.39	3.25	---	6.16
Tamil Nadu	167.70	7.85	26.92	10.20	---	0.14
West Bengal	2.06	0.19	---	0.39	---	---
Total	**629.57**	**33.95**	**56.16***	**33.71**	**0.688**	**6.50**

Table 1. Placer Mineral Reserves (in Million Tonnes) (Source: Indian Mineral Yearbook, 2019; 58th Edition; Part-III Mineral Reviews)

3.0 Concept of Mineral to Marketing

The economic itinerary of any mineral discovery is essentially the flow-sheet approach involving "exploration to mining to metal to marketing." The Mineral to Marketing concept thus expresses the evaluation of the marketing potentials of minerals during the investigative stage of mineral exploration itself. It principally embraces inclusive technologies at various stages from an end-to-end process. CSIR coordinated a comprehensive Network Project during the 10th Five Year Plan Program, and several unique indigenous technologies were industrialized, which duly addresses the "Mineral to Marketing concept" in placer mineral management in India (Anon, 2010). During 2018-19, the annual valve of Indian placer mineral marketing is around Rs.870 crores. But it was around 200 crores during last decade. During the 10th five-year plan program, CSIR initiated a National network project on placer mining. After developing several indigenous technologies and subsequent transfer to coastal mining industries, the placer mineral marketing values rose to nearly 4 to 5 times. This constructive development undoubtedly indicates that with proper focus, the marketing potential can still be elevated to par with other leading nations in this field.

The trend analysis (Figure 1) indicates that in the last years, the production of Ilmenite has been reduced. But the value of the mineral has increased because of the demand. It infers that additional focus may be accorded to produce more Ilmenite. The status of rutile also behaves the same trend. The garnet market values are fluctuating, and accordingly, efforts may be applied.

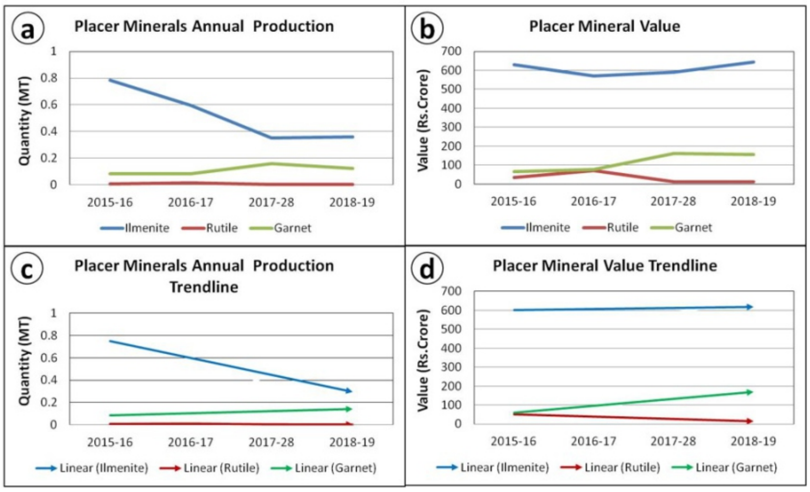

Figure 1. Trend analysis of Indian placer minerals production and its global marketing value.

4.0 Policy Takeaways

- Integrated placer mineral exploration in unexplored area in coastal and offshore areas to be carried out in close interval through planned strategies.
- The existing indigenous technologies in placer mining and processing ought to be updated in context to Indian geo-mining conditions.
- In the sustainable blue economy concept, the eco-friendly mining concept be completely realised during every stage of exploitation of placer deposits.
- Due focus and committed devotion are to be devised / deployed for the development of futuristic materials and value added products from placer minerals.
- Mineral to marketing concept in placer mining to be exercised seriously in sustainable framework.

5.0 Conclusions

It is worth mentioning that the Blue Economy initiatives endow with an alternative and additional economic potential package for the Nation's economic development. Amongst the various blue economy sectors, the non-living (mineral) resource plays a prominent role in the ocean's economic potential. Amid the various marine minerals occurrences from different physiographic provinces of the oceans, the coastal and offshore placers mineral sands are prominent and distinct economic resources due to their abundant reserves. The recent times articulate a well-designed approach in placer economics, especially in view of export potentials. Therefore, it is decidedly recommended to continue such efforts with more impetus so as to do extremely well in economic benefits of our country through exports of placer minerals, and more with value-added futuristic products.

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Research Highlights

Modification of phytoplankton composition, primary production and ocean acidification due to deposition of atmospheric pollutants

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This article is based the below publication:

Kumari, V.R., Neeraja, B., Rao, D.N., Ghosh, V.R.D., Rajula, G.R., and Sarma, V.V.S.S. 2022. Impact of atmospheric dry deposition of nutrients on phytoplankton pigment composition and primary production in the coastal Bay of Bengal, Environmental Science and Pollution Research, Doi: 10.1007/s11356-022-21477-3.

The atmospheric pollution over South and Southeast Asia is ever-increasing over the past two decades. The rate of increase in aerosol optical depth (AOD) over the northern Indian Ocean is the highest over the globe. Atmospheric pollutants not only carry elemental carbon but also bring inorganic and organic nutrients nitrates, and ammonium. The concentration of sulphate ions contributes >50% of water-soluble inorganic species (WSIS) in the aerosols over the northern Indian Ocean. The major source of WSIS comes through anthropogenic sources such as industrial activities, burning fossil fuels and biomass. The deposition of these pollutants over the sea surface results in a decrease in pH (acidification) due to the formation of acids (such as nitric and sulfuric acids) and an increase in the concentration of nitrogen nutrients (nitrate and ammonium). The source of the atmospheric pollutants varies with the season due to the seasonal reversal of wind direction that carries different sources of dust to the Bay of Bengal.

To examine the impact of deposition of atmospheric pollutants on the phytoplankton composition in the coastal Bay of Bengal, an experiment was conducted by dissolving the atmospheric dust collect at monthly intervals over the coastal Bay into the surface waters and incubated for a period of 5 to 7 days.

Air mass back trajectories (AMBT) suggested that the dominant marine source of aerosols was noticed during March-April while terrestrial sources were from the west or southwest region (Indian subcontinent) from June to September and northeast or northwest from October to February. The aerosol load, as total suspended particulate matter (TSP), over the coastal Bay of Bengal varied between 20 and 98 µg m-3 with higher concentrations during January and lower concentrations during June. The concentration of soluble nitrate and sulphate did not follow TSP as higher soluble nitrate (3.7 to 11.4 mg m^{-3}) was observed from August to November. A significant concentration of phosphate was during December and January (0.1 to 0.2 mg m^{-3}) and very low concentrations from February to April (0.005 to 0.01 mg m^{-3}) and under detection limits during other months. Higher concentrations of soluble sulphate (6.1 to 22.1 mg m^{-3}) were observed from September to November than in other months.After the addition of atmospheric dust to the microcosm tanks, the concentration of nitrate increased by 0.03 to 1.05 mM with a rise of 6 to 219%. The N:P ratio of surface water increased from 4.3±0.5 to ~7.0±2 after the addition of aerosols, which is still lower than the Redfield ratio of 16

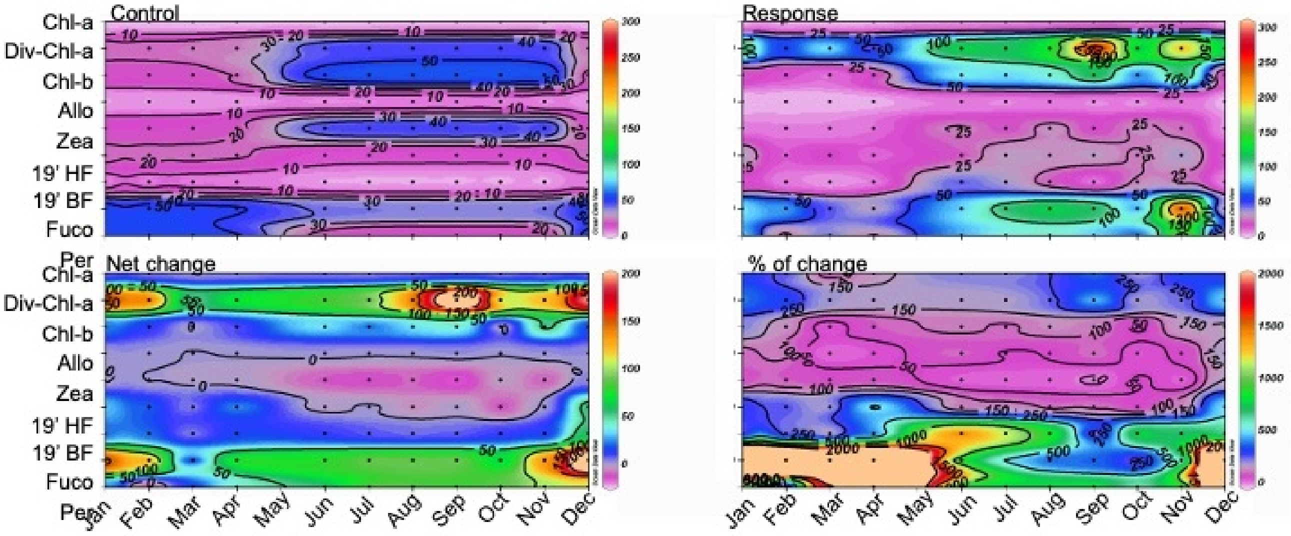

Figure 1. Monthly changes in concentrations of phytoplankton pigments composition from that of control due to the dissolution of atmospheric dust in the coastal Bay of Bengal.

The concentration of Peridinin and Fucoxanthin was higher in the control during January to May and December whereas a higher concentration of zeaxanthin, Chl-b and Div-Chl-a were observed from June to November (Fig. 1). A significant increase in peridinin and fucoxanthin (8.4-102.6 ng/l and 6.9 to 194.0 ng/l respectively) was observed due to the addition of atmospheric dust with a higher increase in Peridinin between July and December (>60 ng/l) and all months, except March, for Fucoxanthin (>75 ng/l) from that of control. The increase in Chl-b was observed from June to November and an increase in Div-Chl-a was noticed during all months with a maximum during September (75-200 ng/l) compared to control. A significant decrease in zeaxanthin and Alloxanthin was observed during the entire study period and between June to November for 19'HF from that of control. An increase in Chl-a from 0.4 to 6.4 mg/l was observed compared to the control with a higher increase during September (Fig. 1). After receiving nutrients from atmospheric dust, the contribution of microplankton to the total phytoplankton biomass increased from 40 and 68% in the surface water to 44-74%. The contribution of nanoplankton and picoplankton was decreased during the entire study period.

After the addition of aerosols, primary production increased by 0.6 to 7.6 mg C m^{-3} d^{-1} (3 to ~19%) from that of control. The rate of increase in primary production displayed linear relation with concentrations of nitrate (r^2=0.89; $p<0.001$), phosphate (r^2=0.43; $p<0.01$) and sulphate (r^2=0.68; $p<0.001$) in the atmospheric aerosols. Even though sulphate is not a nutrient for phytoplankton, however, it decreases the pH of surface water. It was noticed that the addition of 1 mg m^{-3} of aerosols in 20L of seawater decreased pH by 0.03 to 0.06 and displayed linear relation with an increase in primary production (r^2=0.45; $p<0.001$). A linear relationship was also observed between an increase in primary production to sulphate concentration in aerosols added.

Based on additional experiments, it was noticed that a decrease in pH (acidification) due to atmospheric dust enhanced 22% of primary production whereas about 80% of the primary production is contributed by an increase in nutrients. This study suggested that deposition of aerosols enhances coastal acidification and fertilisation resulting in a modification in the phytoplankton composition, size structure and an increase in primary production. The anthropogenic aerosols are ever-increasing in south and southeast Asia for the past two decades. Therefore, the impact of atmospheric aerosols on surface ocean biogeochemistry in the BoB may be highly significant. Since the northern Indian Ocean is surrounded by landmasses on three sides, more efforts are required to include aerosol composition and its impact on the coastal ecosystem in the regional models of the Indian Ocean.

Impact of COVID-19 Lockdowns on the Regional and Global Oceans and Coasts

Review of the COVID Special issue of Frontiers in Marine Science


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The response of the coastal and global oceans to the impact of reduced anthropogenic activities linked to the COVID-19 pandemic was one of the main theme of the special issue published in Frontiers in Marine Science Journal. Eleven articles were published under this theme, out of which nine articles were based on Indian Ocean scenario. The studies in general depict the significant role of anthropogenic impact on the coastal and marine environment. The significant observations from the publications are summarized.

The impact of the COVID-19 lockdown on Total Suspended Matter (TSM) in the Hooghly estuarine region, India is investigated by Jayaram et al. (2021). Satellite-derived TSM concentration data were analyzed during the lockdown period (April 2020) and was compared with the previous years (2016–2019). The analysis revealed that during the lockdown period the TSM concentrations were very low (~30-50 %) compared to the five-year average. Furthermore, the influence of TSM concentrations on primary productivity and carbon dioxide sequestration is studied. The present study emphasized the role of anthropogenic impact on the fragile coastal ecosystems and advocated for the sustainable management of the coastal water quality for ecology and economy of the region. Dias et al. (2021) investigated the variations in Colored Dissolved Organic Matter (CDOM) in the Mandovi estuary during Spring Inter-Monsoon (SIM) of 2014–2018 and was compared with that of COVID-19 outbreak imposed lockdown during 2020. Analyses showed that the low autochthonous production and less input from anthropogenic activities resulted in a low CDOM absorption at the mid-stream of the estuary during 2020. However, autochthonous production and terrestrially derived organic matter resulted in a high CDOM observed at the mouth during 2020. The study revealed the impact of anthropogenic activities on CDOM build-up and nutrients. Satellite-derived water quality parameters in the coastal waters off major Indian cities (Mumbai and Chennai) and river basins (Narmada, Mandovi-Zuari, Netravathi, Periyar, Kaveri, Krishna-Godavari, Mahanadi, and Hooghly) along the eastern Arabian Sea (EAS) and western Bay of Bengal (WBoB) during the strict lockdown period (SLP) and relaxed lockdown period (RLP) was investigated by Lotliker et al., 2021. The analyses revealed a decrease in the magnitude of water quality parameters in the coastal waters of both the EAS and the WBoB during the total lockdown period (SLP and RLP). The reduction was more significant in the WBoB as compared with that of the EAS and was attributed to the reduction in the supply of anthropogenic nutrients. The study highlighted that the importance of satellite-retrieved water quality parameters in providing valuable insights to efficiently describe the changes in the health of the Indian coastal environment in terms of phytoplankton biomass and water clarity.

The impact of COVID-19 lockdown on SST over the Bay of Bengal is analysed using satellite observations by Sarin et al. (2021). The study revealed that the lockdown resulted in decline of aerosols by ~30% which resulted in SST warming by ~0.83°C (up to 1.5°C in certain pockets) in the Bay of Bengal. The impact of the lockdown on coastal water quality along the Chennai coast of India is analysed by Prakash et al. (2021). Suspended Matter Concentration (SPM), a key element of water quality and diffuse attenuation coefficient, Kd(490), from LANDSAT-8 Operational Land Imager (OLI) data was used for the analysis. The analyses revealed a decrease in SPM concentration (15.48, 37.50) and were attributed to minimal vessel movement and cargo handling at the Chennai and Ennore ports. SPM levels over Ennore creek/estuary were reduced by 28.05%, and were attributed to limited industrial activities in Ennore-Manali area and the decreased fly ash emissions from thermal power plants. As industrial and commercial activities subsided during the lockdown period, the city's water bodies, Adyar and Cooum, were clearer than the pre-lockdown period, with no industrial effluents flowing in from closed factories. The suspended matter over these estuaries was also reduced by 22.26 and 33.97%. Sunanda et al., 2021 studied the Net Primary Productivity (NPP) changes of the North Indian Ocean during COVID-19 lockdown. The analysis of wind, SST, Chl-a, and AOD for the pre-lockdown, lockdown, and post lockdown periods of 2020 is employed to understand the impact of COVID-19 lockdown on NPP. The assessment shows the reduction in AOD, decreased wind speeds, increased SST and reduced NPP during the lockdown period as compared to the pre-lockdown, post-lockdown and climatology.

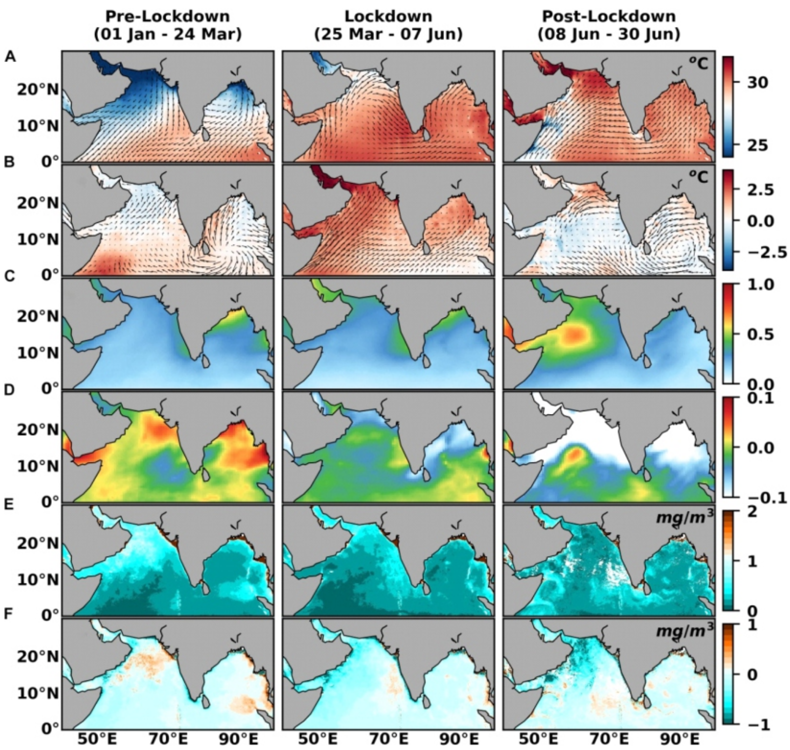

Figure 1. The Sea Surface Temperature (SST), Aerosol Optical Depth (AOD) and Chlorophyll-a (Chl-a) for pre-lockdown, lockdown, and post-lockdown period and their anomalies from climatology (2003–2019) (A) SST, (B) SST anomaly, (C) AOD, (D) AOD anomaly, (E) Chl-a, and (F) Chl-a anomaly (courtesy Sunanda et al., 2021)

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Venkatesan et al. (2021) presented the evolution of moored buoy network, the impact of pandemic restrictions on data return, enhanced support during cyclones amid the COVID-19 lockdown during the year 2020, and the specific challenges during the pandemic. The recommendations for better maintenance of a remote platform based on the operational experience for more than two decades specifically during the pandemic were also presented. Seelanki et al. (2021) investigated the impact of lockdown on chlorophyll-a (Chl-a) concentration, an index of primary productivity, over the northern Indian Ocean using the observations and a physical-biogeochemical model. It was observed that the reduced anthropogenic activities lead to a decrease in Chl-a concentration in the coastal regions of western AS and BoB. The enhanced aerosol/dust transport due to stronger westerly winds enhanced phytoplankton biomass in the western Arabian Sea in May–June of the pandemic period.

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New Hydrothermal Plumes Over the Central Indian Ridge

The deep waters over the northern Central Indian Ridge segment between 10°18'S and 10°57'S were investigated with CTD and AUV to detect hydrothermal plumes emanating from seafloor.Study area in the Indian Ocean with Carlsberg Ridge (CR) and Central Indian Ridge (CIR) systems is shown in Figure 1. During the survey, hydrocasts were made, and seawater samples were collected for analyses of chemical tracers like dissolved manganese (DMn). In the rift valley between 10°40'S and 10°57'S, consistent backscatter anomalies (up to 0.013ΔNTU) were found in deep waters, indicating excess of suspended particulate between 3050 and 3500 m water depth. The seawater samples from this turbid layer was characterized with high concentration of dissolved manganese (maximum DMn = 39 nmol/L) and excess helium-3 (maximum δ3He = 17.1%) and thus confirmed the possible hydrothermal activity in the area. The physiochemical characters of the plume suggest the source fluid might have originated from reactions involving both mafic and ultramafic rocks, and its nature is comparable to other plumes in the Indian Ocean.

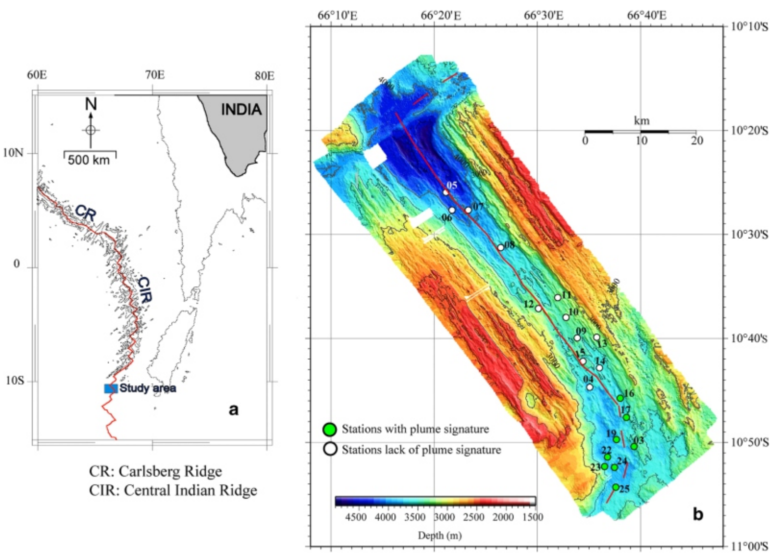


Figure 1. Study area in the Indian Ocean with Carlsberg Ridge (CR) and Central Indian Ridge (CIR) systems. b..Multibeam bathymetry of the segment of the CIR along with delineated ridge axis (red line) and the CTD station locations (Ray et al., 2020).

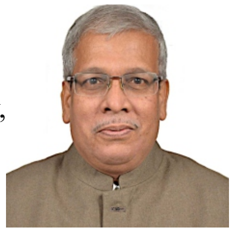
Article is based on below publication

Durbar Ray, Kamesh Raju K.A., Srinivas Rao, A., Surya Prakash L., Abhay Mudholkar, Yatheesh, V., Kiranmai, S., Dalayya, K., 2020. Elevated turbidity and dissolved manganese in deep water column near 10°47'S Central Indian Ridge: Studies on hydrothermal activities.Geo-Marine Letters, https://doi.org/10.1007/s00367-020-00657-5

OSI Webinar Series (January-March 2022)

January 2022

Topic: Indian Coastal Ocean Radar Network (ICORN) and its Application



Speaker: Dr. Basanta Kumar Jena, Scientist-G & Project Director, National Institute of Ocean Technology, Chennai

Date & Time: 27 January, 2022, 1600-1700 IST

About the Talk:

NIOT operates the 'Indian Coastal Ocean Radar Network (ICORN)' as a part of Ocean Observational Network (OON) project of Ministry of Earth Sciences, Government of India. ICORN provides an edge over conventional single point current measurements by providing two-dimensional surface circulation in near real time basis. 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 High Frequency Radar systems improves the ocean circulation models and their validation.

February 2022

Topic: Assessment of Litter and Microplastic contamination along the Indian coasts - Necessity of National Marine litter policy

Speaker:Dr Pravakar Mishra, Scientist -'F', National Centre for Coastal Research, Chennai.

Date & Time: 25 February, 2022, 04:00 PM – 05:00 PM IST

About the Talk:

Accumulation of litter and microplastic is a growing marine environmental problem, the solutions to managing plastic pollution require a combination of measures including scientific information, social awareness, and regulations. The National Centre for Coastal Research (NCCR), MoES, has been identified as one of nodal agencies to combat marine litter and plastics through various scientific programs. The present talk will focus on the initiatives undertaken in developing a science strategy for conducting marine litter and microplastic monitoring along the Indian coast (beaches and offshore) to assess the distributions of plastics (micro to mega) in the environment and marine life.

March 2022

Topic: Progress and Prospects of Hydrographic Surveying Technology in Research & Development

Speaker: Dr. Basanta Kumar Jena, Scientist-G & Project Director, National Institute of Ocean Technology, Chennai

Date & Time: 25 March, 2022; 04:00 PM – 05:00 PM IST

About the Talk:

The bathymetric data is a primary source for any basic oceanographic study. Shallow water bathymetry shall improve our understanding of the seabed morphology mainly nearshore including surf zone. At present, scientific communities are depending on earlier surveyed charts and freely available coarse datasets. This talk includes recent technology available for carrying out shallow water bathymetry for research and development works along the Indian coast. The shallow water bathymetric dataset along Indian Ocean shall provide better understanding of seabed, coastal processes, and numerical model studies.

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

Cover Photo: First Record of Galatheid Squat Lobster, *Shinkaia crosnieri* Baba & Williams, 1998 NIO1013/22 (Decapoda: Galatheoidea) from Cold-seep Environment of the Indian Ocean. Specimens were collected from cold seep environment located at 1755 m depth in the Krishna–Godavari basin, western Bay of Bengal, India. Image courtesy: Dr. Gonsalves Maria-Judith , Senior Principal Scientist, CSIR -National Institute of Oceanography, Dona Paula, Goa