OCEAN DIGEST

Quarterly Newsletter of the Ocean Society of India

Volume 7 | Issue 1 | Jan 2020 | ISSN 2394-1928

Climate Resilient Coastal Protection – Bhatye Dune in Maharashtra

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Abstract

The coastal protection structures in India are mainly seawalls and groynes. Nowadays sand-based solutions are being adopted worldwide. The climate change impacts threaten the Indian coast further. Today's low erosion areas can be protected against climate change impacts by natural systems. The Bhatye dune project demonstrated how a degraded dune can be strengthened by nourishment.

Introduction

The overwhelming preference for coastal protection structures has been seawalls and groynes. International best practice has favored a wider variety of solutions including 'sand-based solutions' such as 'dune care' for nurturing existing or artificial sand dunes, focusing on methods to enhance the dunes by vegetating, 'nourishment' for inducting of new sand to the beach-dune system and many others.

The dune, a mound or ridge of sediment that has been deposited by wind landward of a beach on the coast, provide a physical buffer between the beach and inland areas. As waves hit a dune and its sediments move and shift, the wave energy is absorbed, protecting landward areas from the full brunt of the storm. Inland areas become more vulnerable to storms when beach and dune are weakened. Protecting these landforms helps prevent loss of life and property during high waves, storm surge (water build-up above the average tide level) and sea level rise in the long term, preventing or delaying intrusion of waters into inland areas. In addition, because of their more natural appearance, dunes can be more aesthetically pleasing than hard structures.

Climate Change Impacts

The climate change impacts (over and above natural wave, wind, and physical coastal dynamics) threaten the Indian coast further. The basic premise for resilience is that the natural systems are the most appropriate and time tested protection measures for the coast. Hence, the coastal protection and management measures shall try to emulate the natural systems wherever possible while designing the measures suitable for climate change impacts. The Climate Change Adaptation Guidelines (Black et al, 2019) recommended dune as a first choice in coasts suitable for it as a low-cost and most environment-friendly protection measure. Dune care involves nurturing existing or artificial sand dunes, focusing on methods to enhance the dunes by planting and the use of fencing to prevent trampling.

Dune care does not involve sand nourishment to create a new or larger dune, although a dune care program is recommended for artificial dunes. The goal is to simply improve the vegetation to create a more stable dune and to revitalize the natural systems that existed before dunes were trampled, built upon or damaged by man in general. This natural defense can be repaired or strengthened by increasing the height and stability of existing dunes (dune nourishment). Building new artificial dunes are also possible in suitable locations. The selected design depends on the environmental conditions, location of the source material and the method of delivery to the beach.

Sand Dune in Bhatye

Thus the sand dunes are the least expensive and most efficient defence for the present day low erosion areas. Re-nourishing the eroded beaches and dunes are widely accepted elsewhere as low-cost, natural and tourism friendly practices. A similar demonstration using Climate Change Adaptation Guidelines (Black et al, 2019) was attempted at Bhatye in the Ratnagiri district of Maharashtra. A low dune which existed here got eroded over a course of time. The re-nourishment of the dune was for a 500 m length, planting it with native vegetation employing the local Dune Care Group and providing fencing around the dune for its protection from trampling.

Figure 1. The wide Bhatye beach site selected for rebuilding of the dune

The Bhatye beach (Fig.1) undergoes considerable seasonal changes, with the beach width almost halved during the monsoon and the entire beach getting submerged during high tide. However, there is not much of elevation difference between the monsoon berm and the fair weather berm which is hard to distinguish because of the very gentle slope of the beach. The slope of the beach face during the fair weather is of the order of 1:60. The backshore has creepy vegetation throughout and the sand dune in the northern part is intact. The major portion of the dune in the central portion is eroded (Fig. 2). The southern sector has a sand dune which is more or less flattened and degenerated. The project focussed on the eroded central portion. The Minimum Beach Level (MBL) required for beach-dune stability was estimated (as provided in Black et al, 2019) as 5.41 m from chart datum and hence a minimum dune height of 5.5 m above chart datum was therefore recommended. For the reconstruction of this dune a slope (based on the slope of the

Figure 2. The eroded and degenerated sand dune in the central portion of Bhatye

existing northern dune, the dry beach width, and the sediment grain size) of 1:5 for both seaward and landward side were recommended.The dune width was decided as 25 m and the dune height of 1.25m above the baseline dune level. The design dune cross-section is shown in Figure 3.

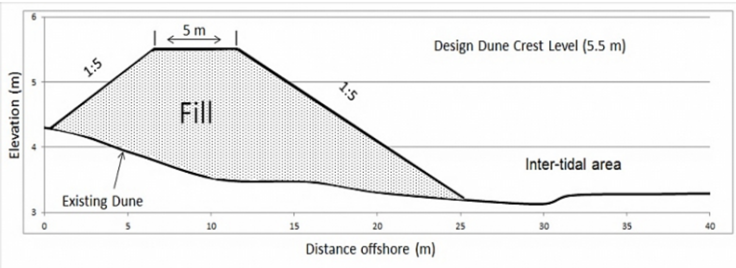

Figure 3. The cross section of the designed dune

It was ensured that there was some dry beach between the dune and the mean high tide line to prevent erosion during the normal monsoonal conditions. The estimated sand volume required for the dune nourishment was 16,500 cu m. The required sand was available near the Kajali River mouth as a sand shoal (Fig. 4). The dune was established during October-December 2018.

All the four sides of the nourished dune was fenced to avoid damages from pedestrian or vehicular traffic (Fig. 5). The species chosen for vegetating the dune were *Ipomoea pes caprae* on the first tier facing the sea, *Vinca rosea* the flowering herb on the second tier and *Clerodendrum Inerme* and *Lawsonia inermis* the shrubs on the third tier facing the land. The vegetation (Fig.5) was watered as it was a dry season. All the works related to vegetation were executed by the Dune Care Group.

There were cyclonic storms ('Vayu' in the second week of June 2019 and 'Nisarga' in the first week of June 2020) which were accompanied by strong winds, high waves and flooding at the location. These unusual cyclones in the Arabian sea were reported to be associated to the climate change impacts in the Northern Indian Ocean. Many coastal areas around Bhatye were affected. These storms however did not affect the dune, which is now well protected also by the vegetation (Fig. 6).

The Bhatye dune project demonstrated how a degraded or low-lying dune can be strengthened by increasing its height and stability by nourishment.

Figure 4. The dune site and sand source location (shoal) at Kajali river inlet

Figure 5. Planting of the vegetation in the fenced dune

Figure 6. Dune after 18 months of its completion

Acknowledgements

This project was part of a program funded by the Global Environment Facility (GEF) through ADB. The project was executed for CWC & MoWR,RD&GR of Government of India and the Maharashtra Maritime Board. FCG ANZDEC Ltd, New Zealand was the consulting agency. The author thanks Drs Joseph Mathew, Deiva Oswin Stanely and all the members of the consulting team for providing support.

References

Black K.P., Baba M., Mathew J., Chandra, S., Singh S.S., Shankar R., Kurian N.P., Urich P., Narayan B., Stanley D.O., Parsons, S., and Ray G. (2018) 'Climate Change Adaptation Guidelines for Coastal Protection and Management in India' (Eds: K.P. Black, M. Baba and J. Mathew), prepared by FCG ANZDEC (New Zealand) for the Global Environment Facility and Asian Development Bank, Volumes 1 (72p) and 2 (335p).

Cryoconite holes on glacier surfaces: a refuge for microorganisms and a concern in a warming climate




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Changing climate is causing a rapid change in the supraglacial (glacier surface) environments resulting in a retreat of the margins of ice sheets and glaciers, and expansion of the biologically active ablation areas. Supraglacial system comprises the surface/top layer of ice which can freely interact with the overlying atmosphere and receives solar radiation as well as deposition of dust, aerosols and microbes. They can also significantly impact the neighbouring ecosystems through meltwater percolation and export of organic carbon, microbial activities, and nutrient cycling. Cryoconite holes are water-filled depressions on the surface of glaciers, which may contribute to glacier disintegration and biological colonization of ice-free areas in polar regions (Fig. 1). In the recent years, research involving supraglacial ecosystems like cryoconite holes have received a wide interest.

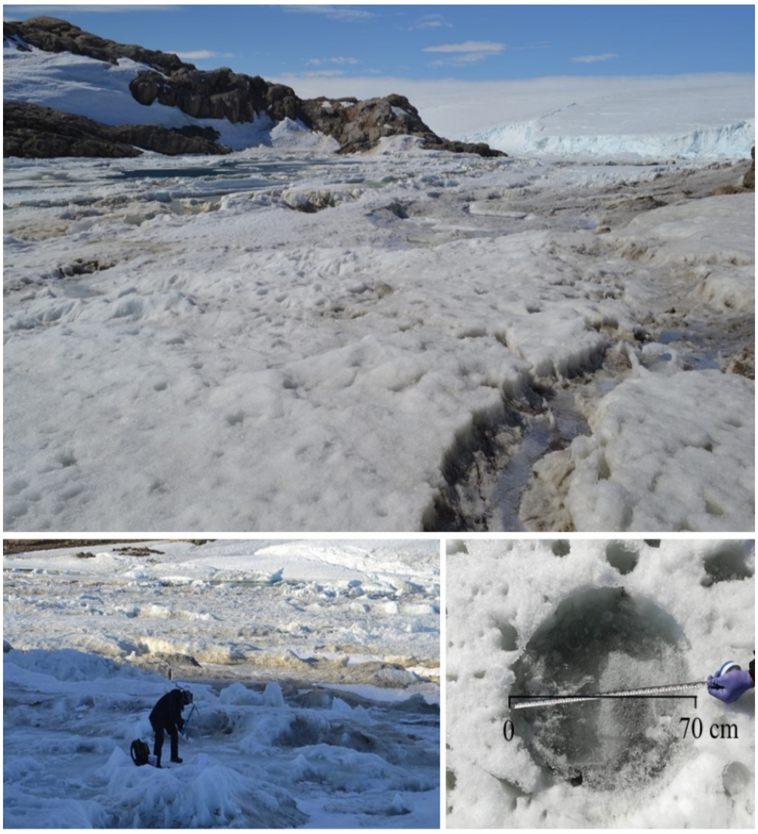

Figure 1. Cryoconite holes in Larsemann Hills, East Antarctica

Cryoconite holes, which can cover upto 10% of glacial surface area, can potentially contribute to at least 13% of total meltwater runoff from the glacial surface (Fountain et al., 2004). They are formed when windblown dust and organic matter gets accumulated on the glacier surface and due to lower albedo, the ice beneath starts melting forming a cylindrical hole (McIntyre, 1984). With increased solar radiation and reduced albedo, the cryoconite holes will increase in size and therefore attract even more radiation, which in turn, melts more ice and creates a positive feedback loop. Due to the high abundance and diversity of microorganisms inoculated by the sediments forming the cryoconite hole, these environments are important sites for biogeochemical cycling of carbon, nitrogen and other nutrients on otherwise relatively passive glaciers and ice sheets. For instance, using a conservative average cryoconite hole distribution in non-Antarctic glacier regions, Anesio et al. (2009) proposed that the cryoconite holes have the potential to fix as much as 64×10^9 g carbon per year. Cryoconite holes are common in ablation regions and in temperate regions characterized by low melt rates and deficient runoffs that are incapable of washing the sediments off the glacier surface. The depth and diameter of the cryoconite holes vary from a few centimetres to nearly one meter. The deepening of these holes is enhanced in clear weather conditions due to high incident solar radiation. Apart from the physical parameters, resident microbes within the cryoconite holes also enhance melting through the heat generated by metabolic activity (Gerdel and Drouet, 1960). Decay of cryoconite holes occur due to shrinkage, caused by accumulation of ice on the walls of the cryoconite hole, as well as, by the intrusion of water through the walls in the event of increased meltwater drainage.

Cryoconite holes can be distinguished into open/closed and hydrologically connected/isolated cryoconite holes based on their physical features (Fig. 2). This in turn affects their biogeochemical characteristics. Whether a cryoconite hole would remain open to atmosphere or develop an ice lid affecting the atmospheric exchange of gases is determined by the air temperature. Further, depending on the extent of water exchange with any nearby stream, and other cryoconite holes or channels below the ice surface, cryoconite holes are differentiated into hydrologically connected and isolated holes. Closed and hydrologically isolated cryoconite holes studied in East Antarctica have shown an accumulation of 2 to 96 times in concentration of ions and total organic carbon (TOC) in cryoconite hole water compared to the surrounding surface snow (Samui et al., 2018). This is attributed to the interaction between water and sediment within a cryoconite hole during the period of isolation, resulting in leaching of nutrients and organic carbon from the sediment layer through mineral or salt dissolution and/or microbial activity. Individual cryoconite holes can stay isolated for a year up to a decade forming unique water chemistry that is distinct from surrounding ice. On the other hand, open and hydrologically connected holes show lower concentration of ions and TOC in water compared to surface snow due to discharge of nutrients and organic matter through interconnected streams (Samui et al., 2018). Therefore, constraints in hydrological connectivity, as well as atmospheric interaction can affect the concentration of chemical components within the holes. Furthermore, closed and isolated holes storing an abundance of nutrients and carbon compared to open and connected holes may also affect the rate of transport of carbon and nutrients to the downstream environments through surface meltwater runoff.

Difference in the physical and chemical conditions between cryoconite holes also result in higher diversity of bacteria in open and connected cryoconite holes than closed and isolated cryoconite holes (Sanyal et al., 2018). Microbial isolates in cryoconite holes from Antarctica and Himalayas are dominated by Proteobacteria (92%) followed by Firmicutes, Actinobacteria, Bacteroidetes and Basidiomycota. Furthermore, Betaproteobacteria,which account for 84% of all Proteobacteria, is known to play an important role in various biogeochemical activities such as mineral weathering (Frey et al., 2010), nitrogen cycling (Miteva et al., 2007) and carbon cycling (Klann et al., 2016). Laboratory incubation experiments show that 13-60% of dissolved organic carbon (DOC) within cryoconite holes is labile and available for heterotrophic activity. Resident microbes are also capable of metabolizing organic carbon components within the cryoconite holes such as acetate, lactate, formate and oxalate (Sanyal et al., 2018). Additionally, it is found that the presence of viral communities results in increased DOC within the system through bacterial lysis (Säwström et al., 2007). Consequently, the water chemistry of a cryoconite hole gets

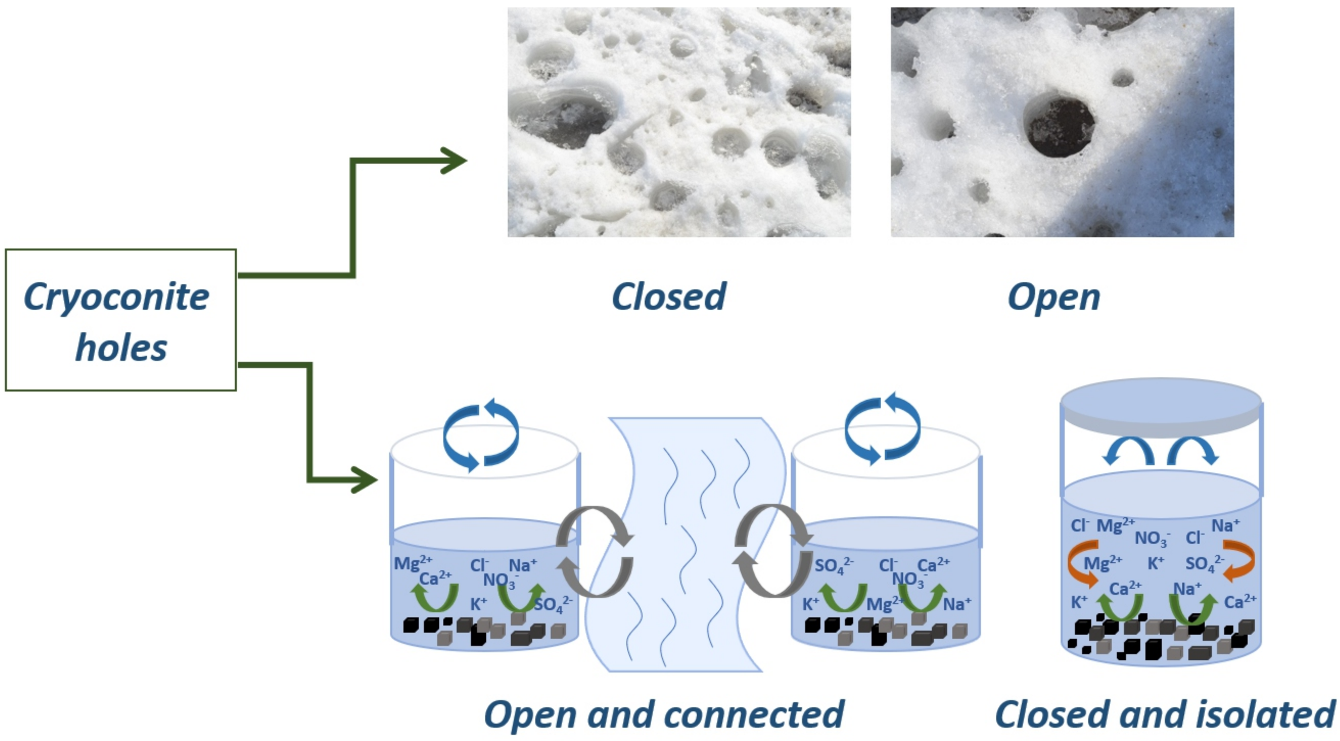

Figure 2. Flowchart showing the distinction of cryoconite holes

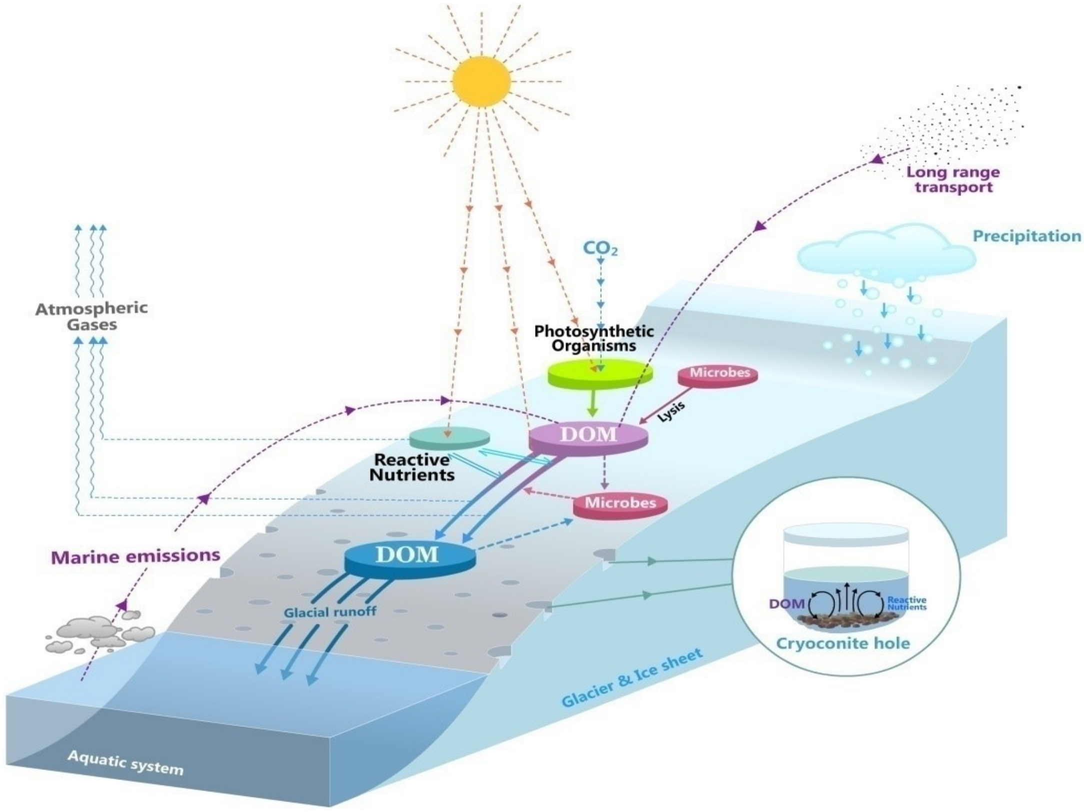

Figure 3. Cycling of dissolved organic matter on a glacier surface with cryoconite holes

significantly modified during the course of melt period as a result of microbial activities.

Overall, cryoconite holes, irrespective of their physical distinction from each other, provide a mechanism for storage of chemical and microbial constituents on glacier surfaces. Furthermore, microbial activity, modifying the composition of organic matter and nutrients, is a determining factor of the chemical composition within a cryoconite hole before they are introduced to other supraglacial/subglacial ecosystems or atmosphere through meltwater runoff or atmospheric exchange (Fig. 3). Finally, considering the significance of biogeochemical cycling associated with cryoconite holes and the extent of glacial runoff they can produce, cryoconite holes may potentially affect the downstream ecosystem by seeding them with labile carbon, nutrients, and microorganisms. A comprehensive understanding of biogeochemical processes within these habitats is therefore crucial and fundamental to accurately determine the flux of carbon and nutrients within the supraglacial environments and the impacts on the surrounding environments that receive their runoff. Therefore, cryoconite holes over ice sheets and/or glaciers of Antarctica, Arctic and Himalaya offer one of the most pristine natural laboratories for testing the cycles of ecosystems on a much smaller scale.

References

1. Anesio, A. M., Hodson, A. J., Fritz, A., Psenner, R., & Sattler, B. (2009). High microbial activity on glaciers: importance to the global carbon cycle. Global Change Biology, 15, 955-960.
2. Fountain, A. G., Tranter, M., Nylen, T. H., Lewis, K. J., & Mueller, D. R. (2004). Evolution of cryoconite holes and their contribution to meltwater runoff from glaciers in the McMurdo DryValleys, Antarctica. Journal of Glaciology, 50, 35-45.
3. Frey, B., Rieder, S. R., Brunner, I., Plötze, M., Koetzsch, S., Lapanje, A., Brandt, H., & Furrer, G. (2010). Weathering-associated bacteria from the Damma glacier forefield: physiological capabilities and impact on granite dissolution. Applied and Environmental Microbiology, 76, 4788-4796.
4. Gerdel, R. W., & Drouet, F. (1960). The cryoconite of the Thule area, Greenland. Transactions of the American Microbiology Society, 79, 256-272.
5. Klann, J., McHenry, A., Montelongo, C., & Goffredi, S.K. (2016). Decomposition of plant- sourced carbon compounds by heterotrophic betaproteobacteria isolated from a tropical Costa Rican bromeliad. Microbiology Open, 5, 479-489.
6. McIntyre, N. F. (1984). Cryoconite hole thermodynamics. Canadian Journal of Earth Science, 21, 152-156.
7. Miteva, V., Sowers, T., & Brenchley, J. (2007). Production of N_2O by ammonia oxidizing bacteria at subfreezing temperatures as a model for assessing the N_2O anomalies in the Vostok ice core. Geomicrobiology Journal, 24, 451-459.
8. Samui, G., Antony, R., & Thamban, M. (2018). Chemical characteristics of hydrologically distinct cryoconite holes in coastal Antarctica. Annals of Glaciology, 59, 69-76.
9. Sanyal, A., Antony, R., Samui, G., & Thamban, M. (2018). Microbial communities and their potential for degradation of dissolved organic carbon in cryoconite hole environments of Himalaya and Antarctica. Microbiological Research, 208, 32-42.
10. Säwström, C., Granéli, W., Laybourn-Parry, J., & Anesio, A. M. (2007). High viral infection rates in Antarctic and Arctic bacterioplankton. Environmental Microbiology, 9, 250-255.

Passive acoustics techniques for the shallow water environmental studies

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Anthropogenic sound (human-caused) is recognized as a global pollutant as identified by the World Health Organization. Human-caused sound is omnipresent (terrestrial and aquatic ecosystems). All fish studied to date can hear sounds, and fishes use sound to perceive their environment for mating, communication, and predator avoidance. Researchers have shown how sound impacts on functioning such as communication, orientation, feeding, parental care, and prey detection, and increased aggression. These can lead to less group cohesion, avoidance of critical habitat, fewer offspring, and higher death rates. Similarly, human-caused sound impacts on physiology. This in turn can cause reduced growth rates, decreased immunity, and low reproductive rates. Anatomical impacts from noise can include abnormal development or malformations, hearing loss, or injured vital organs, which can result in strandings, disorientation, and death. While some animals may recover from behavioral or physiological impacts, others, such as changing the DNA, or genetic material, or injury to vital organs, are irreversible.

Humans have always been fascinated by marine life, from extremely small diatoms to the largest mammal that inhabits our planet. However, studying marine life in the ocean is demanding because an ocean environment is vast and opaque to most instruments. The environment is hostile in which to perform experiments and research. The use of acoustics is one way to study animal life in the ocean effectively. Acoustic energy propagates in water more efficiently than almost any form of energy and can be utilized by animals for a variety of purposes and also by scientists interested in studying their behavior and natural history. The underwater acoustics have traditionally been in the domain of physicists, engineers and mathematicians. Considering the natural history of animals is in the domain of biologists and physiologists. Understanding the behavior of animals has traditionally involved psychologists and zoologists, and marine bioacoustics is a diverse discipline involving investigators from a variety of backgrounds. The inherently interdisciplinary nature of marine bioacoustics presents a significant challenge.

Underwater acoustics is the science of sound waves in the water that has become an essential tool for underwater remote sensing. Hydro-acoustics can be broadly classified as two disciplines: i) active and ii) passive acoustics. For an active acoustic system, acoustic pulses are transmitted into the water for producing backscatter echoes. By examining the received echoes, it is possible to estimate the range and in certain cases detecting the presence and bearing of an underwater target. Active acoustic systems are widely used for many oceanographic applications. However, the transmission of sound levels in the ocean for a prolonged duration may cause long-range effects on aquatic animal health. Active acoustic activities (for e.g. in marine protected areas) are now being subject to formal permission as emerged recently. Therefore, passive acoustic technique, a method for detecting and monitoring acoustic signals in an underwater environment, is advancing as a vital tool for ocean soundscape studies.

The passive acoustic system transmits no signal, and it is designed to detect acoustic signals emanating from the original sources, including natural processes in the ocean, underwater noise sources of biological origin such as marine mammals, crustaceans or fish, and anthropogenic noise sources. By analyzing passive acoustic recordings, it is possible to discriminate and identify different animal species and to calculate the relative number of animals present within the measurement range. These critical pieces of information can be complemented by ocean productivity or yearly migratory passage of animals such as great whales. A new application of passive acoustics involves awareness of environmental issues, which has spurred the development of passive acoustic techniques. Progress in the field of passive acoustics has attracted researchers to investigate physical and biological processes such as oceanic features, seafloor habitats, and associated processes. There is a growing consensus that anthropogenic sound levels in oceans are increasing that can have adverse effects on marine life.

Most fish and invertebrates use sound for vital life functions. A review of 115 primary studies encompasses various human-produced underwater noise sources, 66 species of fish and 36 species of invertebrates reveal noise impacts on development include body malformations, higher egg or immature mortality, developmental delays, delays in metamorphosing and settling, and slower growth rates (Weilgart 2018). Anatomical impacts from noise involve massive internal injuries, cellular damage and even death, and hearing loss. Ecological services performed by invertebrates such as water filtration, mixing sediment layers, and bio-irrigation, which are key to nutrient cycling on the seabed, were negatively a ected by noise. Once the population biology and ecology are impacted, it is clear fisheries and even food security for humans are also affected. Studies on population and ecosystem impacts are vastly easier to do on fish and invertebrates than most marine mammal species. Many fish species rely on vocal signaling during their activities and produce sounds using sonic muscles that vibrate the swim bladder or bony elements (stridulation). Fishes use sound to attract mates and defend their territory. In shallow water, the ambient sound field generally consists of various types of sound sources such as fish sounds (biophonies), wind and flow sounds (geophony), and boat sounds (anthrophony). The spatial structure of the sound field is dependent on the nature of the waveguide which forms due to the multipath propagation between the sea surface and the seabed. Hence the characteristics of any signal received at a recorder's location can be affected by the variability in environmental parameters. While these propagation features are recognized, one can aim to quantify the soundscape and fish sound as received at the recorders to serve as a representation of what others may receive from their environment at a given location.

In India, passive acoustic research is carried out jointly at CSIR- National Institute of Oceanography, Goa and ESSO- National Institute of Ocean Technology, Chennai, which helps understanding the biodiversity of the study area. The passive acoustic data acquisition using an autonomous system consists of a wideband hydrophone which is vital for recording fish sound data. The recorded fish sound from the shallow waters needed to be analyzed using the passive acoustic technique. In general, temporal and spectral fish characteristics such as "oscillogram," "spectrogram," and peak sound level of the "power spectral density" (PSD) are used for fish sound identification (Fish and Mowbray 1970) (Fig. 1). Fish sound identification in different locations such as off Goa Britona, Grande Island, Betul where major findings involve Tiger perch, Batrachodidae, Sciaenidae etc. The soundscape characterization involves analysis of the "waveform", "spectrogram", and the "power spectral density" (PSD) of the recorded passive acoustic data. Similarly, biophonies such as the fish chorus of *Terapon theraps* (Tiger perch), sparse calls of Carangidae along with other unnamed fish species community from the Malvan area is reported with dominant wave breaking sound identified in the area. Broadbased studies involving passive acoustic techniques are given below:

I) Underwater soundscape and fish sound identification using temporal and spetral characterization:

The recorded fish sound from the shallow waters needed to be analyzed using the passive acoustic technique. In general, temporal and spectral fish characteristics such as "oscillogram," "spectrogram," and peak sound level of the "power spectral density" (PSD) are used for fish sound identification (Fig. 1). Fish sound identification in different locations such as off Goa Britona, Grande Island, Betul where major findings involve Tiger perch, Batrachodidae, Sciaenidae etc. The soundscape characterization involves analysis of the "waveform", "spectrogram", and the "power spectral density" (PSD) of the recorded passive acoustic data. Similarly, biophonies such as the fish chorus of *Terapon theraps* (Tiger perch), sparse calls of Carangidae along with other unnamed fish species community from the Malvan area is reported with dominant wave breaking sound identified in the area (Chanda et al. 2020).

ii) Fish sound characterization using non-linear techniques multifractal detrended fluctuation analyses (MFDFA):

The power spectrum encompasses several dominant

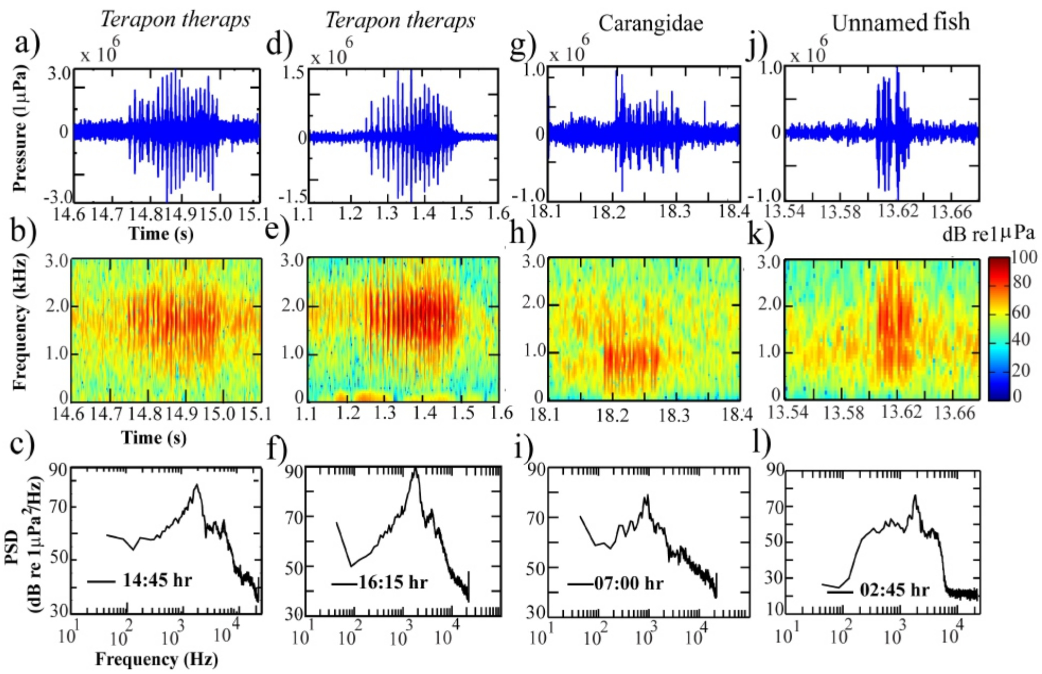

Figure 1. Waveform, spectrogram and PSD of representative fish species calls: (a-c) Terapon theraps on 18 May 2016 @ 14:45 hr, (d-f) Terapon theraps on 19 May 2016 @ 16:15 hr, (g-i) Carangidae on 20 May 2016 @ 07:00 hr, and (j-l) Unnamed fish on 20 May 2016 @ 02:45 hr

frequencies, which presumably represent major oscillation modes in the feeding clicks, but the amplitudes of these modes vary in a complex manner (Chakraborty et al. 2014). The phase couplings generated by a nonlinear process can be fundamentally differentiated by estimating Lyapunov exponents or fractal exponents. Considering the latter aspect, the MFDFA (multifractal detrended fluctuation analyses) (Haris et al. 2014 and references therein), is employed to characterize the phase couplings which revealed in the fish sounds of Toadfish and Sciaenidae (Chanda et al. 2020). The multifractal analysis is a robust technique to identify the scaling behavior in both the fish sounds. Employing MFDFA, the second order Hurst exponent ($h_{q=2}$) values are found to represent Batrachodidae and Sciaenidae fish families. The higher $\Delta h(q)$ (width of the generalized hurst exponent) values for Batrachodidae and Sciaenidae vocalizations are found to indicate higher multifractality, implying greater heterogeneity (Fig. 2).

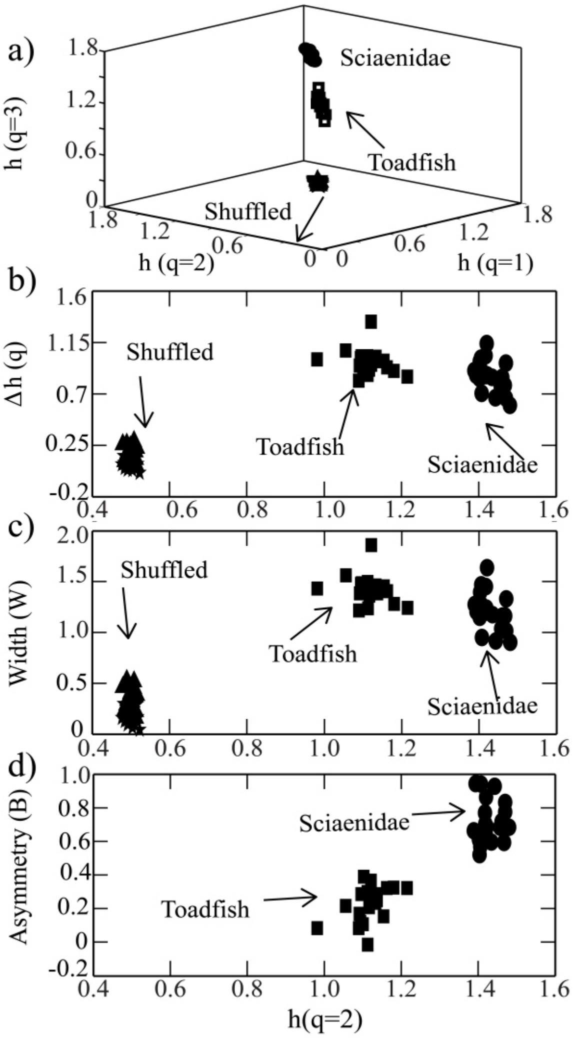

Figure 2. Scatter plots of (a) Δh(q), W and B for and Sciaenidae; (b) Δh(q) versus call duration (s); (c) W versus call duration (s); and (d) B versus call duration (s). Plots are presented for the estimated parameters using the original signals

iii) Estimation of Echo-acoustic indices from coral reef areas:

The biodiversity assessment is an important function to be carried out for habitat monitoring in shallow waters, especially in reef areas using the sound data acquired using the passive acoustic technique (Harris et al., 2016 and references therein). In this context, quantitative characterization of shallow water soundscape of the *Burnt Island* located off the Malvan and Grande Island areas off Goa in the west coast of India (WCI) is carried out (Chanda et al. 2020; in press). The eco-acoustics study is also an important tool for biodiversity characterization (Farina 2014). Major eco-acoustic studies have been carried out in terrestrial as well as underwater, yet there a lack of knowledge of shallow water reef and off reef system. Presently in Indian context, eco-acoustics metrics application were initiated to develop a comprehensive understanding of the shallow water reef and off reef system, and the biodiversity of the coastal environmental habitat. Besides identifying the sound sources using spectral and temporal methods as mentioned above, three acoustic metrics namely acoustic entropy (H), acoustic

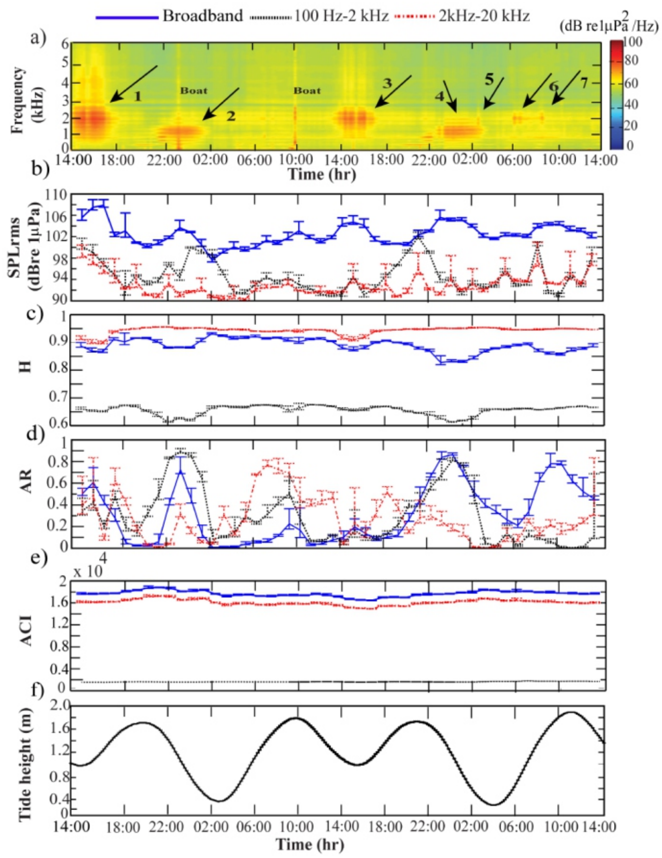

Figure 3. Concatenated PSD (dB re 1µPa²/ Hz), of the recorded passive acoustic data with derived metrics, (b) SPL_{rms} (dB re 1µPa), (c) Acoustic entropy (H), (d) Acoustic richness (AR), (e) Acoustic complexity index (ACI) for broadband, fish and shrimp bands. Panel (f) presents tide level (m) in the study location

richness (AR), and acoustic complexity index (ACI) of passive acoustic recordings are computed and analyzed to understand their role in relation to the fish chorus, wave-breaking, and sparsely available fish sounds (Fig. 3).

International Quiet Ocean Experiment (IQOE) (https://www.iqoe.org/sites/default/files/files/IQOE_Science_Plan-Final.pdf) is an international program of research, observation, and modeling to characterize the ocean sound field to promote understanding of the effect of sound on marine life. IQOE initiatives involve mobilization of participating communities to investigate sound in the ocean in a way that will be useful for the management of sound sources to mitigate harm to marine life. It develops a global approach to investigating the sound, engaging the worldwide community of ocean scientist. The science plan of the IQOE is prepared through series of discussions and joint meetings of the Scientific Committee of the Ocean Research (SCOR) and Ocean Studies Board of the US National Research Council at the Woods Hole Oceanographic Institution USA. Through funding from the Sloan Foundation, SCOR and POGO convened an International workshop at the University of Rhode Island. Finally, comprising a group of scientists under the co-chairmanship of Prof. George Frisk (USA) and Prof. Peter Tyack (UK), first IQOE committee was formed in 2016. Present author was a founding member of IQOE (2016-2018).

References:

1. Chakraborty, B., Saran, A.K., Sinai D., Kuncolienker., Sreepadaa R. A., Haris K., and William Fernandes. A.: Characterization of Yellow Seahorse Hippocampus kuda feeding click sound signals in a laboratory environment: an application of probability density function and power spectral density analyses, Bioacoustics., 23, 1–14, 2014.
2. Chanda Kranthikumar, Chakraborty , B., Vardhan Y. V., Gracias D., Mahanty M. M., Latha G., Fernandes W., and Chaubey A. K.: Passive acoustic metrics to understand shallow water biodiversity off Malvan area in the west coast of India, Indian journal of Geo Marine Sciences., 2020, (in press).
3. Chanda Kranthikumar, Shubham, S., Chakraborty, B., Saran, AK., Fernandes, W.A., and Latha, G.: fish sound characterization using multifractal detrended fluctuation analysis, Fluctuation and Noise Letters., 19, 2050009, 2020.
4. Farina, A.: Soundscape ecology: principles, patterns, methods and applications, Springer-Verlag, New York, 2014.
5. Fish, M.P., and Mowbray,W.H.,: Sounds of the *western North Atlantic Fishes*, *A reference file of biological underwater sound,* rhode island univ kingston narragansett marine lab (Johns Hopkins Press. Baltimore MD), 1970.
6. Haris, K., Chakraborty, B., Menezes, A., Sreepada, R. A., and Fernandes, W. A.: Multifractal detrended fluctuation analysis to characterize phase couplings in seahorse (Hippocampus kuda) feeding clicks. *The Journal of the Acoustical Society of America.*, 136, 1972-1981, 2014.
7. Harris, S. A., Shears, N. T., and Radford, C. A.: Ecoacoustic indices as proxies for biodiversity on temperate reefs, *Methods in Ecology and Evolution.*, 7, 713-724, 2016.
8. Weilgart, L. I. N. D. Y.: The impact of ocean noise pollution on fish and invertebrates.
9. Report for Ocean Care, Switzerland. *(URL:https://www.oceancare.org/wpcontent/uploads/2017/10/OceanNoise_FishInvertebrates*_May 2018).

Run-off and tidal forcing on suspended sediment transport of Cochin estuary, West coast of India





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Abstract

An observational study was conducted in Cochin estuary to examine the relative impacts of tidal and river runoff forcing upon suspended sediment dynamics at different time scales. Time series measurements of salinity, tides, currents and suspended sediment concentration (SSC) were conducted at spring and neap periods of wet and dry seasons. The results showed that SSC was maximum at the main inlet and decreased towards upstream for both seasons. The tidal asymmetry is prominent along the estuarine main channel for all seasons. The residual sediment transport at the inlet was directed outward irrespective of tidal ranges and seasons due to the strong ebb currents with longer duration. These findings are significant for the development and protection of harbors situated close to the inlet in estuaries and for the efficient implementation of an integrated coastal management system.

Introduction

Tropical estuaries offer an excellent opportunity to study the sediment processes in an environment influenced by fluvial and marine factors. Cochin estuary is the second largest wetland ecosystem in India. Considering its ecological significance and high biodiversity, it has been designated as the Ramsar Site at the Convention on Wetlands organized by the UNESCO in 1981. Rapid industrialization and urbanization have exerted considerable stress on the ecosystems. Construction of hydraulic barriers within the estuary has imposed severe flow restrictions and increased sedimentation in the estuary [1]. The harbor area undergoes siltation and requires frequent dredging to maintain its depth [2]. For the efficient implementation of estuarine management plans, it is essential to gain insights on the suspended sediment dynamics in Cochin estuary where massive anthropogenic interventions occur. Moreover, the estuary is found to be turbid irrespective of seasons which adversely affect the primary productivity through its effect on light attenuation. Therefore, an exhaustive study on the variations of SSC distribution at intra-tidal, fortnightly and seasonal time scales in Cochin estuary is conducted.

Study area and methodology

Cochin estuary is a complex two-inlet estuarine system of about 80 km long and covers a total area of about 300 km^2. The Cochin Port, situated on the Willington Island, is near Cochin inlet which is 13m deep and provides the main entrance channel to the harbor. The average tidal range in the estuary is 1 m and six rivers discharge in to the estuary [4].

Field sampling was done on four occasions: (a) spring tide (6-7 Oct 2009) and (b) neap tide (13-14 Oct 2009) during moderate runoff periods, (c) spring tide (1-2 March 2010) and (d) neap tide (22-23 Feb 2010) during low runoff periods. The field sampling included measurements of hydrographic properties and the collection of water samples for SSC analysis during the 24 h tidal cycle surveys at five stations (stations A-E) along the main channel. During all surveys, surface and bottom water samples (for SSC) were collected at each station for every 3 h and SSC (in milligrams per liter) was determined using standard procedures. Surface and bottom salinity of each station was also determined. At station C (Cochin inlet), water level, currents and CTD time series measurements were conducted. Vertical profiles of SSC for this station were derived by linear fits to the relation between CTD turbidity sensor output and SSC in water samples collected in situ. The dominant mechanisms contributing for the net sediment fluxes through the Cochin inlet were delineated by partitioning are found using the flux decomposition method [3].

Results and discussion

Variations in physical parameters and SSC

For all periods, SSC's typically decreased upstream and bottom concentrations were larger at all stations. SSC during spring tides were generally higher than neap tides. Stratification in SSC corresponded well with that of salinity. Temporal variations in water level, currents, hydrography and SSC for spring and neap tides of wet and dry seasons at the main inlet are shown in Figures 1 and 2 respectively. The average SSC of wet-spring was 127 mg l^{-1} while that of wet-neap was 67 mg l^{-1} (Fig. 1a-1j).

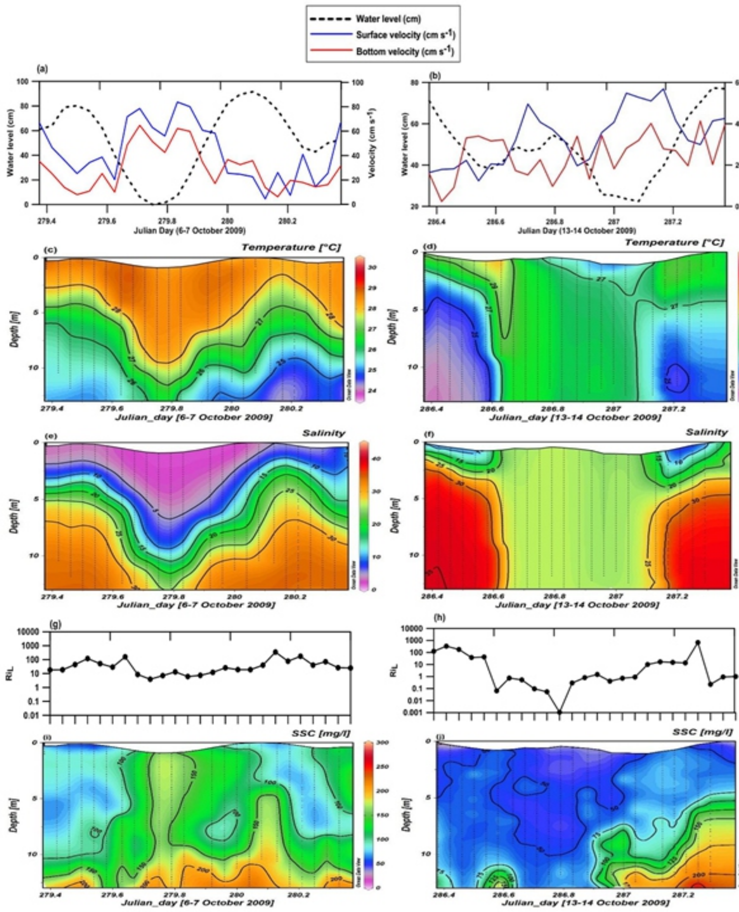


Figure 1. Time series of physical parameters and SSC of spring (left panel) and neap (right panel) tidal phases of wet season: (a &b) water level and current velocity, (c & d) temperature (e & f) salinity, (g & h) layer Richardson number and, (i& j) SSC

During wet-spring, the low saline surface layer showed concentrations ranging from 20-80 mg l^{-1} as against the bottom layer showing about 220 mg l^{-1} (Fig. 1i). When the bottom currents exceeded its average value of about 30 cm s^{-1}, enhanced resuspension caused high turbidity at the bottom. During peak ebb (~84 cm s^{-1}), it reached its highest value of 257 mg l^{-1} at the bottom as the zone of high turbidity reached almost the surface (>150 mg l^{-1}). During wet-neap period, at the end of the first flood (Julian day 286.66) when the bottom currents peaked to about 33 cm s^{-1}, a maximum turbidity of 174 mg l^{-1} occurred near the bed while surface values

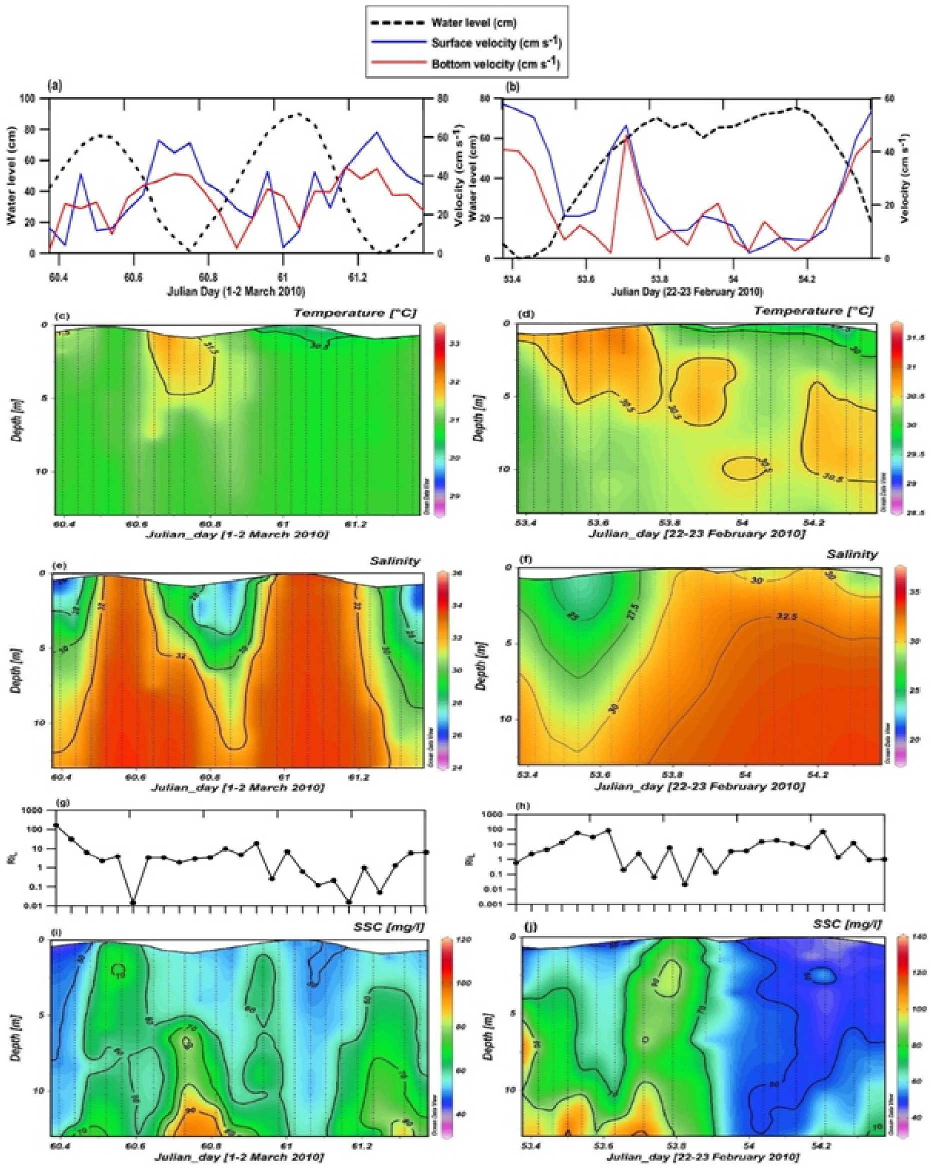


Figure 2. Time series of physical parameters and SSC of spring (left panel) and neap (right panel) tidal phases of dry season: (a &b) water level and current velocity, (c & d) temperature (e & f) salinity, (g & h) layer Richardson number and, (i& j) SSC

While for dry-neap, stratification of about 70 mg/l was found during the initial ebb followed by turbulent mixing during flood causing sediment resuspension in the water column (Fig. 2j). Maximum SSC of 129 mg/l occurred at the bottom during a peak in flood currents (~59 cm/s). For the following tidal cycle, the currents were weak and SSC decreased to about 50 mg/l throughout the water column.

Conclusion

Analysis of SSC fluxes at the main inlet

Eulerian advection term (due to river runoff) T1 and tidal pumping term T4 were found to be the significant components in SSC fluxes decomposition responsible for causing net seaward fluxes caused by prolonged strong ebb currents. Hence, suspended sediment transport through Cochin inlet can be regarded as being the product of the interplay between tidal pumping and advection. These preliminary results reveal the mechanics of SSC variation and thus provide a general framework for examining the sediment budget of Cochin estuary.

ranged from 40-50 mg l^{-1} (Fig. 1j). The well-mixed ebb phase lead to homogeneous SSC vertical profiles of about 54 mg l^{-1} in the water column. Thereafter, the intensity of currents increased and near highest high tide, maximum turbidity of 338 mg l^{-1} was obtained at bottom.

SSC distribution ranged from 34 to 101 mg/l and from 32 mg/l to 129 mg/l during dry-spring and dry-neap periods respectively (Fig. 2i and 2j). During dry-spring, the maximum turbidity (~100 mg/l) at the bottom coincided with the occurrence of peak ebb currents (Fig. 2i). However, the upward mixing was constrained by the pycnocline and as a consequence; resuspension was limited to a height of about 8 m above the bottom (Julian day 60.66).

References

1. Balachandran KK (2001). Chemical oceanographic studies of the coastal waters of Cochin. Ph.D thesis, Cochin University of Science and Technology, Cochin, pp. 148.
2. Balchand AN, Rasheed K (2000). Assessment of Short Term Environmental Impacts on Dredging in a Tropical Estuary. Terra et Aqua, 79.
3. Dyer KR (1997). Partially mixed and well-mixed estuaries. In Estuaries—A Physical Introduction, 2nd edition, eds. John Wiley and Sons, 136–164.
4. Revichandran C, Srinivas K, Muraleedharan KR, Rafeeq M, Amaravayal S (2012). Environmental set-up and tidal propagation in a tropical estuary with dual connection to the sea (SW Coast of India). Environ Earth Sci 66: 1031- 1042. doi: 10.1007/s12665-011-1309-0.

Highlights of OSICON - 19 Ocean Society of India Conference 2019

The Ocean Society of India (OSI) conducted its Sixth Conference (OSICON-19) in Kochi during 12-14 December 2019 at Centre for Marine Living Resources and Environment (CMLRE), a premier research centre of the Ministry of Earth Sciences, Government of India.Since 2009, biennial conferences of OSI have become the major events of OSI and so far five conferences were held in different parts of the country. OSI which was formed 13 years ago is working for the advancement and dissemination of knowledge in science, technology, engineering and allied fields related to oceans.

With the UN Decade of Ocean Science for Sustainable Development, beginning in 2021 emphasizing on the vital roles of the ocean of global dimension OSI zeroed in on a focal theme **Indian Ocean Processes and Resources - A Key to Blue Economy f**or the Kochi Conference. The three day Conference in Kochi started on 12th December and was attended by more than 400 delegates. The Conference was inaugurated by Shri. S. Kedarnath Shenoy, former Director of Naval Physical & Oceanographic Laboratory (NPOL), DRDO, Kochi and presided over by Dr.M. Sudhakar, President, OSI.

Lighting of the lamp at the inaugural function

The Ocean Society of India has instituted an award in the name of Dr.D.Srinivasan, former Director of NPOL one of the pioneers of Indian naval ocean research in India to honour eminent scientists/ engineers and other professionals who have contributed to the growth of ocean related science and technology. The award given once in two years commencing from the year 2019 was given away during the inaugural function by the President, OSI.

The first Dr.Srinivasan Endowment Award was shared by two leading researchers: Dr.Muthalagu Ravichandran, Director, National Centre for Polar and Ocean Research (ESSO-NCPOR), Goa and Dr.Bishwajit Chakraborty of National Institute of Oceanography, Goa. Dr.Ravichandran's contributions and leadership in operational oceanography by establishing in-situ ocean observingsystems in the entire Indian Ocean and successfully using the data in coupled ocean-atmosphere modeling is commendable. Dr. Bishwajit Chakraborty has made several outstanding contributions in the area of ocean geo-science and technology particularly in marine geo-acoustic research and related technologies.

Dr.Muthalagu Ravichandran receiving the award

Dr. Bishwajit Chakraborty receiving the award

The Keynote address on the focal theme of the Conference was given by Dr.P.V. Joseph, leading Meteorologist of the country. Thirteen expert invited speakers and six expert lead speakers drawn across the country threw more insight into the dynamics of the Indian Ocean, the unusual atmospheric events, the changing scenario of the living resources and the critical health of the ocean.

The invited speakers were Prof. Prasad Bhaskaran of IIT, Kharagpur (Wind-wave growth and wave modelling), Dr.G. Latha of NIOT, Chennai (Acoustical oceanography - Indian scenario and future endeavours), Dr. L. Sheela Nair of NCESS, Trivandrum (Data gaps in coastal management), Dr.SatheeshShenoi of INCOIS, Hyderabad (Health of the oceans), Dr.VN. Sanjeevan of KUFOS (Blue economy), Dr.M.A.Atmanand of NIOT (Blue economy - India's strides),Dr. M. Ravichandran of NCOPR (Tele-connection between poles and tropics), Dr.N. PurnachandraRao of NCESS, Trivandrum (Seismo-tectonics of the Indian Ocean), Dr.Hareesh Kumar of NPOL, Kochi (Acoustics and naval applications), Dr.M.V. Ramana Murthy of NCCR, Chennai (Innovative approach for coastal protection in the context of climate change), Dr. K.K. Vijayan of CIBA and Cdr Manoj Kumar Singh of Indian Navy (Security implications of climate change in maritime domain).

The lead talks were given by Dr.C. Gnanaseelan (IITM), Dr, A.D. Rao (IITD), Dr. Ramiah (NIO), Dr. Vinu Valsala (IITM), Dr.Kamesh Raju (Andhra University) and Dr. Jyoti Babu (NIO) on the different themes of the Conference.

The Technical Committee of the Conference with the help of expert reviews accepted 240 abstracts - 156 for oral and 75 for poster presentations. The abstract volume brought out had 129 oral presentations and 64 poster presentations spread over 5 themes: ocean processes, ocean living resources, ocean health, ocean geosciences and ocean engineering and technology. The Conference finally had 120 presentations and about 50 posters which explored the present scenario and challenges in the understanding of the oceans. The Conference had arranged an exhibition of advances in ocean science and technology contributed by both leading institutions of the country and the ocean industry. Overall there was tremendous response for the Conference from the leading experts and young researchers in the country.

There were several presentations on carbon budget and ocean acidification which have direct bearing on our living resources – cardinal to Blue Economy. The rapidly changing climate and human development are teasing the researchers with ever growing questions. The need for sharing brilliant and stimulating ideas in this important research field is met with equal enthusiasm and support from the research community as witnessed from the presentations in the Conference. Additionally, non-living resources and technological developments and information delivery to target stakeholders have also been significantly articulated in the Conference.

The Conference concluded with a Valedictory Address by Dr.Shailesh Nayak, Former Secretary, MoES. Best paper and poster awards were given away to young researchers by the chief guest.The National Centre for Polar and Ocean Research (ESSO-NCPOR), Goa was declared as the venue for the next OSICON in 2021.

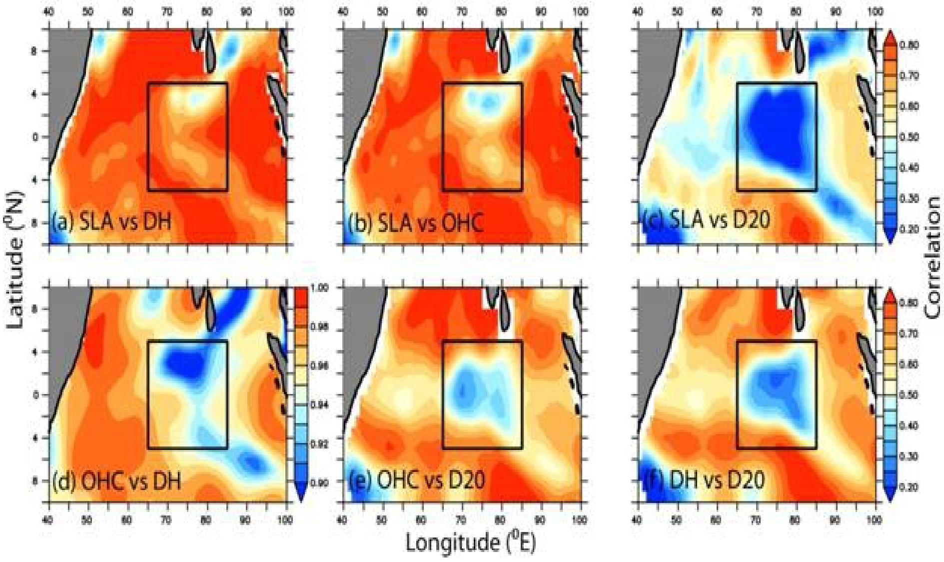
Release of OSICON-19 Abstract Volume

Release of Ocean Digest 2019

Mrs. Revathi Srinivasan, daughter of Dr. Devanatha Srinivasan addressing the gathering

Research Highlights

A sea-level monopole in the equatorial Indian Ocean



Using sea level anomaly data, a "Mono Pole" in the Equatorial Indian Ocean was observed a new mode of interannual variability was found. This monopole is defined as a region with low sea-level variability in the central equatorial Indian Ocean (EIO) and locked between oscillating western and eastern ends of the EIO. Sea-level over this monopole region showed low correlations with ocean heat content, dynamic height and 20°C isotherm depth (D20) as compared with eastern and western EIO. Oscillating SLA over western and eastern EIO during summer and winter monsoon months is found to be responsible for locking this monopole in the central EIO. This work also highlighted the rapidly increasing sea-level in the EIO during last decade and persisting pattern of these oscillations coupled with several oceanic and atmospheric phenomena over this region. These findings show that the EIO has some similitude with the oceanic component of the El Niño southern oscillation (ENSO) occurring in the equatorial Pacific.

Citation: Thandlam, V., Udaya Bhaskar, TVS., Hasibur, R. et al. A sea-level monopole in the equatorial Indian Ocean. npj Climate Atmospheric Science 3, 25 (2020). https://doi.org/10.1038/s41612-020-0127-z

[**Report Courtesy**: TVS Udaya Bhaskar, INCOIS, Hyderabad, India. E-mail: uday@incois.gov.in]

Events

The kick-off event of the United Nations Decade of Ocean Science for Sustainable Development will take place in Berlin, Germany, from the 31st of May to the 2nd of June 2021. It will be hosted by the Federal Ministry of Education and Research of Germany.

Opportunities

DST-CNRS Targeted Programme

Following the Memorandum of Understanding signed between DST and CNRS in May 2015, Indian and French research institutions wish to strengthen scientific cooperation between both countries by contributing to researchers' mobility and by fostering joint research. In India, on behalf of the Department of Science & Technology, Indo-French Centre for Promotion of Advanced Research (CEFIPRA) invites proposals from the Indian scientists / researchers, organize expert & review committee meetings for management/ disbursement of funds to the approved projects, etc.

Areas of collaboration:

Biodiversity, Ecosystems and Human-environment interactions (including terrestrial/marine, past/present environments and socio-ecosystems)
Detector and theory developments in nuclear and particle physics
Engineering and Systems Sciences
Further details may be found at http://www.cefipra.org/DST-CNRS.aspx

Last date for submission of proposal is 31st September 2020.

Call for contributions

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**