

# **ABSTRACT**

## TITLE

A GIS EVALUATION OF THE SPATIAL BEHAVIOUR OF SEDIMENT TEXTURE, INHERENT OPTICAL PROPERTIES AND BENTHIC FORAMINIFERA OF THE SHALLOW ARABIAN SEA, OFF THE KANKON-KARWAR COAST, INDIA

SUBMITTED

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## INTRODUCTION

The eastern Arabian Sea fringes the west coast of the Indian Peninsula and provides an 'open-laboratory' for evaluation of the spatial behaviour of numerous parameters of the shallow marine environment. The shallow continental shelf along the west coast of India and that part adhering to the coastline largely constitutes the Case-II marine environment. These Case-II regions possess a unique environment in being oceanographically 'active' and rather 'perturbed'. Few workers have assessed the water quality and management. However, GIS and remote sensing techniques have been but rarely used in appreciating the existence of microenvironments, thus pointing to the need for the use of novel techniques. Similarly, research in the eastern Arabian Sea has brought out among other aspects, the importance of Optical Properties and the complex nature of inland and coastal waters.

Hypothetically the oceans do not adhere to the behaviour of a single large composite environment but are over printed by numerous microenvironments that includes the parameters of the sedimentary environments, biological environments, light environment, and the marine water column. These hypothetical assessments are necessary to arrive at a holistic understanding of the ocean-floor, aquatic and optical realms that dominate the shelf off the west coast of India focusing on the eastern Arabian Sea. Thus, it could be observed that various ocean related work has been carried out and yet a holistic appraisal of local scales are found wanting. Hence, this work envisages the assessment of various ocean related parameters and their spatial distribution- a consequence of which is the isolation of microenvironments that is brought about by modeling techniques provided in Geographic Information Systems (GIS).

## OBJECTIVES

The shallow marine environment off the central west coast of India is less understood in terms of the parametric relations and spatial behaviour especially of ocean floor relief, sediment texture, optical properties, ocean color, suspended matter, benthic foraminifers etc. that could provide a holistic appreciation of the shallow marine environment. A 3-D model of the sea-floor was designed to appreciate the sea-floor morphology of the study area. Distribution of surface oceanographic parameters were assessed and presented in order

to discern the heterogeneity in spatial distribution. Satellite derived Chlorophyll-a and TSM have been used in this study to appreciate the variations in surface distribution during the summer of 2004 and 2005.

No attempt has been made to decipher the existence of micro environments in the shallow marine shelf in the Arabian Sea off the central west coast of India. Hence, this work is envisaged to evaluate the existing natural scenario of the shallow marine environment off the Kankon-Karwar coast and to decipher the existence of microenvironments.

## STUDY AREA

The area of investigation represents the eastern Arabian Sea and is located off the coast of Kankon-Karwar along the central west coast of India. The study area covers 2468.83km<sup>2</sup>. The area is located between latitudes 15° 08' 97" N and 14° 38' 43"N and longitude 74° 17' 05"E and 73° 42' 75"E. The area experiences tropical climatic conditions. Some of the landmarks and towns are *Point Betul* the northern most point, *Cape de Ram*, *KanKon* that belong to the state of *Goa* a former Portuguese colony located in the north of the study area and to the south *Karwar* is a provincial headquarters with an all weather seaport and further south the towns of *Amdalli* town and *Belikeri* a minor port are located. *Ankola* is a small town demarcating the southern extremity of the coastline. The study area is represented in Naval Hydrographic Charts bearing numbers 215 and 216.

## RESULTS

The thesis is presented in seven chapters with an epilogue of conclusions. The first Chapter provides information of the objectives and study area. The bathymetry varies from east to west with a maximum depth of -45m. 33 sampling stations were established using a GPS for the summer seasons of 2004 and 2005. The surface samples focused on Salinity, Sea Surface Temperature (SST), pH, and Dissolved Oxygen (D.O). The physical oceanographic parameters included Wave height, Wave period, Wind speed, and Current speed. Variations were recorded as in the case of salinity the changes for summer 2004 there is an increase towards the offshore and in the northern part of summer 2005 the salinity increases.

In summer 2004 the SST increases towards the Kali river mouth and further offshore. In the summer 2005 there is an increase of SST in the north. During summer 2004 and 2005 D.O increases offshore. The pH increases offshore during summer 2004 and decreases towards the offshore during the summer of 2005. The wave height is low towards the nearshore and increases offshore. During summer 2004 and 2005 the wave environment is more energetic towards the coast and less offshore as seen through the wave period records. There is heterogeneity in the wind environment during both the summer of 2004 and 2005. The current speed too mimics the wind environment. In general, the natural environment displays variations from both the summer season.

Thirtythree sediment samples each, representing the summer of 2004 and 2005 depict variations in the size parameters. Sediment distribution is imprinted with changes in the energy conditions. Multigroup discriminant analysis suggests that the sediments did not have enough time of residence in the shallow marine environment to acquire imprints of a

shallow marine shelf environment. Bi-variable scatter plots suggests more than one sedimentary environment to have contributed material to the shallow marine environment. Scanning Electron Microscopy of quartz surface texture, provides insights to the shallow marine environment of the central west coast of India. Various signatures reflecting the heterogeneity of sediment size during the summer of 2004 and 2005 invokes the changing the energy levels in the marine environment.

The Inherent and Apparent Optical properties of the shallow marine waters that include Secchi Depth, K-par, Kd, c, Ag(380) Chl-a, TSM, Turbidity, that were recorded and Cluster Analysis for the Summer 2004 and Summer 2005 depict heterogeneity in the clustering pattern throwing light on the inherent variations in the shallow marine environment.

A Hyperspectral Radiometer deployed in the study area at Bethul in the north and Karwar south of Bethul depicts the IOPs and AOPs to vary downwards suggestive of the heterogeneity of the seawater column. The heterogeneity suggests stratification of the shallow marine environment of the shelf off Bethul-Karwar Coast in the eastern Arabian Sea. About twentynine species of benthic foraminifers were isolated from the shallow marine environment during the summer of 2004 and 2005. Cluster analysis of Total Foraminifers, Beam attenuation Co-efficient (IOP) and Irradiance attenuation Co-efficient (AOP) along with sand percentage, silt, clay, sorting D. O, Salinity and depth depict heterogeneity of the clustering pattern are precursors to the appreciation of the existence of probable microenvironments.

The distribution of Chl-a and TSM in the study area was envisaged to decipher the variations if any, during the summer of 2004 and 2005. IRS-P4 OCM data was processed for both the summers. Shore parallel trends were isolated for Chl-a and TSM followed the same trend. A GIS evaluation was carried out to isolate if any microenvironments existed. The GIS query results of summer 2004 and 2005 includes 144 steps that establishes the existence of microenvironments in the study area.

## CONCLUSIONS

This study of the seabed with an area of 2468.83 km<sup>2</sup> provides results for two consecutive summers depicting microenvironments, enveloping areas as small as 1.1.9 km<sup>2</sup> to 38.6 km<sup>2</sup> (summer 2004) and 10.55 km<sup>2</sup> to 25.94 km<sup>2</sup> for the summer of 2005. This study demonstrates the use of GIS to isolate microenvironments using various spatial layers including bathymetry, physical oceanographic parameters, sediment texture, *in situ* Chl-a and TSM, satellite derived Chl-a and TSM and benthic foraminifers.

This study would enable comparative studies within the Arabian Sea with end-users being from research institutes, universities, inter-governmental agencies etc.