CHAPTER-1

THE SHALLOW MARINE ENVIRONMENT OFF BETUL-KARWAR COAST

1.1. Introduction

Oceans occupy about 70% of the Earth’s surface, which play an important role in the climatic conditions of the adjacent land regions. Coastal waters form a multi-dimensional system where the dynamic processes are rarely in equilibrium. Moreover, 90% of the world’s fish catch comes from coastal and shelf seas (Pernetta and Milliman, 1995). Coastal areas are potential zones of marine resources for a country like India which has approximately 7500 km of coastline. In the ocean, the physical, chemical, and biological processes are linked in an intimate manner (Tang et al., 2002). The study of these processes in the shallow marine environment provides information necessary for understanding the coastal oceanographic processes. The hydrography in the coastal water body is gaining importance in terms of studying the water quality parameters such as chlorophyll, total suspended matter, colored dissolved organic matter, temperature, salinity, dissolved oxygen, optical properties, distribution of sediments and foraminifers.

Compared to the open ocean systems, the coastal region exhibits environmental gradients occurring spatially and temporally on micro or macro-scale. Oceanic water circulation dynamics and spatial variability of light in the coast are important in understanding and quantifying the numerous optical, physical, chemical and biological processes in operation nearshore (Clark, 1995; Dickey and Falkowski, 2002).

The coastal ocean, defined as extending towards the sea from the coast to the edge of the continental margin is the most productive area of the global ocean (Chen et al., 2001; Koblenz-Mishke et al., 1970). Coastal waters are classified as Case 2 waters (Prieur and Sathyendranath, 1981) as they contain organic matter (DOM), resuspended sediments, terrigenous yellow substances from river run-off,
and other non-chlorophyllous particles of clay and sand. In case 2 waters, constituents are independent of each other and don't co-vary with chlorophyll. The coastal oceans are largely under-sampled. Hence, it is necessary to arrive at a complete understanding of the floor of the shelf that dominates the region off the west coast of India focusing on the eastern Arabian Sea.

The west coast of India is environmentally unique because it is bordering one of the most sensitive ecosystems in the world, the Arabian Sea which is an important site of biogeochemical ocean - atmosphere transfers that play a crucial role in regulating the atmospheric chemical composition and earth's climate (Naqvi and Jayakumar, 2000). Off the west coast of India an upwelling regime exists during the summer monsoon, when the surface currents are southward and the subsurface undercurrents are northward (Banse, 1959; Ramasastry and Myrland, 1959; Sharma, 1968; Ramamirthan and Rao, 1973; McCreary et al., 1993; Shankar and Shetye, 1997; Maheswaran et al., 2000). In this region, upwelling is driven by wind-forced Ekman transport away from the shore and the strength of the alongshore wind stress modulates the coastal divergence and hence the input of cold upwelled water over the shelf (Shetye et al., 1990). During the summer monsoon, northwesterly winds that are prevalent across the continental shelf waters favour offshore Ekman transport and vertical advection. Muraleedharan and Prasannakumar, (1996) have reported upwelling along the west coast of India during the peak summer monsoon. The west coast of India receives around 3000 mm of rain annually of which around 80% occur during the southwest monsoon period between June to October (Ramaswamy and Nair, 1989).

The basic hydrographic characteristics of the Arabian Sea have been studied by many researchers (e.g., Shenoi et al., 2005; Shenoi et al., 1994; Bauer et al., 1992; Brock et al., 1992; Shetye et al., 1990; Rao et al., 1989; Qasim, 1982; Sharma, 1976 a, b; Colborn, 1975; Wyrtki, 1973; Sastry and De Souza, 1972, 1970). Hydrographic characterization of southeast Arabian Sea during the wane of the southwest monsoon and spring inter-monsoon was studied by Kumar et al., (2008) indicating strong upwelling during the southwest monsoon and the region
being dominated by oligotrophic waters during the spring inter-monsoon season. Krishnaprasad et al., (2011) studied the hydrographic conditions in the Bhatkal and Kundapur regions off Karnataka and reported the stratified nature of these waters due to significant upwelling and buoyant mixing of the water masses. Annigeri, (1968) carried out a classic work on hydrological conditions of the inshore regions of Karwar to show a distinct demarcation in the distribution of physico-chemical properties.

Extensive studies on the sea water in the Kanara coast was carried out by Noble, (1968) to appreciate the role sea water plays in the availability of the basic producers and suppliers to the food chain in the sea. Shirodkar et al., (2009) have studied the sea water quality parameters and sediment quality parameters in the coastal waters off Mangalore to understand the interrelationships between the variables and to identify probable source components for explaining the environmental status of the area. Chauhan et al., (2011) studied the influence of orographically enhanced southwest monsoon flux on coastal processes along the southeast Arabian Sea and reported the sequestering of fluvial influx due to the prevalence of strong winds, upwelling and equatorward flow.

oceanographic parameters for their occurrence and distribution in the shallow marine environment. Statistical analyses of foraminiferal assemblages have been the most common method for carrying out environmental studies, however, more recent applications are utilizing foraminiferal indices as tools for understanding overall ecosystem states and changes (Carnahan et al., 2009; Schueth and Frank, 2008; Hallock et al., 2003).


Optical and thermal characteristics of surface waters can be used as natural tracers of dynamic patterns. Understanding the physical and biological processes, as well as their interactions, is a central goal for fisheries management over continental shelf areas (Solanki et al., 2008). Remote sensing of ocean colour yields information on the constituents of sea water such as the concentration of phytoplankton pigments, suspended sediments and yellow substance (Chauhan et al., 2001). Measurements of ocean color and the fate of light in the ocean are extremely useful for describing biological dynamics in surface waters (Yentsch, 1960; Lorenzen, 1972; Smith and Baker, 1989). Remote sensing images of ocean color, converted into chlorophyll-a concentration, provide a window into the ocean ecosystem with synoptic scales (Sarangi, 2012). Satellite data serve as a tool for monitoring the spatial distribution of regional upwelling, the larger-scale ocean patterns, as well as phytoplankton (Tang et al., 2002). Chlorophyll concentrations dynamics over the Arabian Sea have been studied using various satellite data.
such as OCM and CZCS data (Dey and Singh, 2003; Kumar et al., 2002; Banse and English, 2000).

Singh and Chaturvedi, (2010) have made an excellent comparison of chlorophyll concentrations in the Arabian Sea using IRS-P4 and MODIS Aqua. Chauhan, (2000) has retrieved water constituents using IRS-P4 data. Raghavan et al., (2006) have studied the summer chlorophyll-a distribution in eastern Arabian Sea off the Karnataka-Goa coast from satellite and in-situ observations. Chauhan et al., (2002) made an excellent comparison of ocean color chlorophyll algorithms for IRS-P4 OCM sensor using in-situ data. Remote sensing of Asian waters for ocean colour products of high spatial resolution and long time series have been studied by Tang and Kawamura, (2001). Total Suspended Matter distribution in the coastal waters of the Arabian Sea has been studied by Raghavan and Chauhan., (2012 a, b) using in-situ and satellite derived data and proposed that higher fluvial flux during the southwest monsoon does not necessarily enhance the supply of TSM into the offshore regions of the southeast Arabian Sea.

The shallow marine environment has been widely investigated using GIS and statistical techniques to relate biological oceanographic environment with other parameters in the island environment off Karwar in the eastern Arabian Sea (Alva, 2002). Shylini, (2010) used GIS to relate chlorophyll, optical properties, TSM, benthic foraminifers, and sediment distribution in order to isolate microenvironments in the oceanic environment off the eastern Arabian Sea. Suryanarayana and Amit, (2006) have used GIS for analyzing the marine environmental data off the Karnataka coast. Raghavan et al., (2011) studied the heterogeneous microbial environment using GIS technology to decipher the microenvironment scenarios off the central west coast of India.

Hence, this work is an attempt to assess the shallow marine environment off Betul-Karwar, west coast of India, with respect to the spatial and vertical
distributions of the oceanic parameters. Also, this work provides baseline data that would aid in correlating other areas of the eastern Arabian Sea.

1.2. Objectives

The shallow marine environment off Betul to Karwar, west coast of India is investigated with the following objectives:

- To study the spatial distribution of oceanographic parameters and to detect their heterogeneity in the shallow marine environment.
- To study the texture of the ocean floor (surface) sediments along with their spatial distribution in the study area. Also, to decipher their transport and depositional environments using grain size statistics.
- To appreciate the association of Total Foraminifera Count with other oceanic parameters using cluster analysis.
- To quantify the vertical distribution of optical properties in the water column from the continental shelf retrieved from a Satlantic® Hyperspectral Radiometer.
- To study the distribution of in-situ and satellite derived Chlorophyll-a and Total Suspended Matter in the study area.
- To un-mask the occurrence of heterogeneous bodies of water in the shallow marine environment of the study area using Geographical Information System techniques.

1.3. Study Area

The study area represents 1520.17 km² in the coastal waters off Betul-Karwar in the eastern Arabian Sea along the central west coast of India (Fig. 1.1). The area bounded by longitude 73°40′46″E and 74°05′04″E and latitude 15°04′59″N and 14°48′45″N experiences tropical climatic conditions.
The central west coast of India is the only region of the Arabian Sea at which there is an excess seasonal rainfall due to orography (Raghavan and Chauhan, 2012a). The study area is represented in naval hydrographic charts bearing numbers 215 and 216. The important landmarks and towns in the study area are Point Betul which is a coastal town and is located at the northern most point of the study area; Cape de Rama and Kankon belong to the state of Goa and are located in the north and central of the study area. To the south is Karwar, a seaside town and provincial headquarters which has an all weather seaport. The Sal River, Talpona River and Kali River are the important rivers that drain into the study area.
1.4. Area of Sampling

Thirty sampling stations were established (Fig. 1.2) in the shallow marine environment off the Betul-Karwar coast in the eastern Arabian Sea. The area has 6 transects of 25km length that are shore normal. Each transect has 5 sampling stations with an interval of 5 km. The post-monsoon season of 2010 and the summer season of 2011 were sampled to appreciate the changes occurring in the study area.

Fig. 1.2: Study area showing the sampling locations in the shallow marine environment.
Plate 1: The islands off Karwar in the southern part of the study area.
1.5. Bathymetry

The Bathymetry of the study area was measured using a Simrad NX 40 Echosounder with a built in GPS (Fig. 1.2). The Bathymetry varies from 0 msl in the east to -50 m towards the west. The depth increases from the coast (east) towards offshore (west) with parallel depth contours. The bathymetry is characteristic of the shelf off the west coast of India.

![Bathymetry of the study area](image)

Fig. 1.3: Bathymetry of the study area.

Bathymetric data that describe the sea floor topography are usually in the form of a grid or Triangular Irregular Network (TIN). The importance of data models for marine and coastal GIS has been recognized by researchers and developers since the early days of GIS applications for these environments. Raghavan et al., (2004) explained the study of a 3D model for the Indian Ocean. The work of Shylini, (2004) is an excellent example to develop a 3D view of the Indian Ocean using TIN. Similar work of generating a 3D model of the Lakshadweep Sea using TIN has been carried out by Sunil, (2004). The
geographic information system for the marine environment has been brought out with an emphasis on the use of TIN to develop a 3D model.

Table 1.1: Station locations along with the Bathymetry (m) retrieved from the study area.

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1.6. 3D Model of the study area

A 3-D model of the sea-floor was designed to appreciate the sea-floor morphology of the study area (ESRI, 1997). The 3-D model was brought out using Z-data or elevation data that was fixed to the location co-ordinates and the
submarine topography was constructed through Triangulated Irregular Network (TIN).

![Fig.1.4: Triangulated Irregular Network (TIN) model of the study area.](image1)

![Fig 1.5: 3D view of the shallow marine environment off Betul – Karwar in the eastern Arabian Sea.](image2)
The Bathymetry (Z data) was mainly retrieved from the field surveys carried out during the post-monsoon 2010 and summer 2011 seasons. The naval hydrographic chart was also used for cross correction. Erdas Imagine 9.1, ArcView 3.2a and Arc GIS 9.3 softwares was used for generating the 3-D model. The depth in the study area located off Betul – Karwar increases from east to west with parallel depth contours. The bathymetry was confined to less than -50m (Fig. 1.3).

The study area is associated with a few islands which are located in the southern part of Karwar (Figs. 1.4 and 1.5) (Plate 1). The islands are the Kangigudda, Kurmagadagudda, Shimisgudda, Devagadagudda, Karkalgudda, Mandalgudda, Mogeragudda and Anjadeep.

This work is anticipated to provide to the best extent a holistic view of the shallow marine environment off the central west coast of India.

References


