

Observational Evidence of Upwelling off the Southwest Coast of India During June - July 2006

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Abstract

Considerable latitudinal variability exists in the forcing mechanisms and intensity of coastal upwelling along the southwest coast of India. Present work is based on the insitu observations conducted onboard FORV Sagar Sampada for 12 days along two transects off Thiruvananthapuram (8.5°N) and off Kollam (9°N), during June 25th – 6th July 2006. Observed upwelling parameters (local temperature anomalies, salinity, isothermal layer depth (ILD), Mixed Layer Depth (MLD), isotherm slope, nutrients) are examined with reference to the local forcing along the two transects. In addition, the day-to-day variations in the vertical distribution of different oceanographic parameters are also documented. During the period of observation, wind was predominantly north northwesterly. The alongshore component of the wind stress (local forcing) is weaker off Kollam (0.1-0.5 dynes/cm²) compared to that off Thiruvananthapuram (0.3-1.0 dynes/cm²). However, the observed upwelling parameters are not in tune with the local forcings. ILD off Kollam (11–17 m) is shallower than that off Thiruvananthapuram (18–21 m). If the observed upwelling is forced by local wind, then the ILD off Kollam should shoal less compared to that off Thiruvananthapuram. Other upwelling parameters (isotherm slope towards the coast and local cooling) also reveal this contrast between local forcing and observed upwelling. The surface salinity off Kollam is comparatively lower (30.8-33.8 PSU) to that off Thiruvananthapuram (34-34.6 PSU) with significant difference in vertical stratification. The runoff data during the observation period support the surface salinity distribution. High precipitation off Kollam also has a significant role in determining the surface water characteristics (Temperature and Salinity).

Keywords: Southwest coast of India, Coastal upwelling, latitudinal variability, Arabian Sea, River discharge.

1. Introduction

Upwelling is one of the several oceanic processes, which are considered to have a significant effect on coastal dynamics. It is a phenomenon of vertical

movement of subsurface cooler waters towards the surface layers. This upwelling phenomenon mainly occurs in the coastal regions when the surface winds blow with the coast on the left side. Atmospheric winds are the major source of upwelling. In addition to this, both the local and remote forces are also favorable for the upwelling. It depends on latitude and stratifications. The coastal upwelling affects coastal weather, fishery, productivity and circulations.

Enormous amount of effort was put into study the coastal upwelling of the southwest coast of India and its dynamics and biological impacts. McCreary et al., (1993) pointed out that both remotely and locally forced coastal upwelling contributes to the surface cooling along the southwest coast of India. Studies on the spatial and temporal variations of the coastal upwelling along the southwest coast of India are limited in number. Present study is focused on the latitudinal variability exists in the intensity of coastal upwelling along the south-southwest coast (stretching 8.5°N to 9°N latitude) mainly to understand the forcing mechanisms, the local influences, spatial variations, and day-to-day variations.

2. Data

In situ data collected onboard FORV Sagar Sampada during June 24th to July 6th 2006 along two transects of 5 stations (20m, 50m, 100m, 150m, 200m) each off Thiruvananthapuram (8.5°N) and Kollam (9°N) (Fig.1) is used to illustrate the spatial variations in the coastal upwelling process along the south-southwest coast of India. Temperature and Salinity parameters from conductivity-Temperature-Depth profiler (CTD Seabird 911 series), atmospheric data including wind speed and direction from Automated Weather System (AWS), are used to understand the physical process in the region. Daily rainfall data for the observation period are obtained from weather report. River discharge data (Kallada River, Vamanapuram River) is collected from Centre for Water Resources Development and Management (CWRDM).

3. Result and Discussion

The west coast of India has been noted to have well – known upwelling areas. Along the Indian coast on the whole, the upwelling is largely generated during the southwest monsoon. During the observation period sea was very rough with frequent rainfall. Vertical profiles of various physical and chemical parameters indicate upwelling along both transects, with varying intensity. The undulations in the thermal structure, preferably due to the varying windfield is evident in the time-series observations at 50m-depth station (Fig. 2). SST is higher by 1°C off Kollam (26°C) than that of Thiruvananthapuram (25°C). The 23°C isotherm shifted from bottom (on 28th June) to 20m depth (on 6th July) off Kollam, while the same isotherm did not show any considerable vertical shift off Thiruvananthapuram. Local Temperature Anomalies (Fig.3a) supports this with high values off Kollam (1.3 to 3.75 °C) than that off Thiruvananthapuram (1.2-3 °C). The alongshore component of the wind stress (Fig.3b) is weaker off Kollam (0.1-0.5 dynes/cm²)

compared to that off Thiruvananthapuram (0.3-1.0 dynes/cm²).

Daily observations of Isothermal layer depth (ILD) and mixed layer depth (MLD) at 50m depth stations are computed from the respective vertical profile of temperature and salinity. ILD off Kollam (11–17 m) is shallower than that off Thiruvananthapuram (18–21 m). (Figure not shown). Same trend is also observed in the Mixed Layer Depth (MLD) with values 14-17m of Thiruvananthapuram and 8-12m off Kollam. The variation of MLD and ILD with depth and station (station 1 being close to the coast and station 5 being away from the coast) indicates that the MLD and ILD pattern supports intense upwelling close to the coast at Kollam and slightly away from the coast of TVPM (Fig. 4).

Time series observations in the salinity (Fig.5) and temperature (Fig.2) distributions shows significant difference on vertical stratifications along these two transects. The surface salinity off Kollam is significantly lower (30.8-33.8 PSU) compared to that off Thiruvananthapuram (34-34.6 PSU). Presence of low saline warm water off Kollam and comparatively high saline cold water off Thiruvananthapuram is also evident in the temperature-Salinity scatter plot (Fig. 6). The stratified upper layer upto 15m with strong gradient off Kollam suggests the presence of fresh water in the region. Similar phenomenon of suppression of upwelling by freshwater river flow has been reported elsewhere in India (Johns et al., 1993; Gopalakrishna et al., 1985; De Sousa et al., 1996).

During the observation days, daily rainfall data shows moderately heavy rainfall off Kollam (total rainfall during monsoon period is 614 mm) than Thiruvananthapuram (total rainfall during monsoon period is 344mm). Time series observations of Sea Surface Temperature (SST), Sea Surface Salinity (SSS), and rainfall off Kollam and Thiruvananthapuram shows that, off Kollam variation of these parameter are in same phase, whereas off Thiruvananthapuram rainfall variation is independent of SST and SSS (Fig.7). By checking the discharge data of the Kallada (1595Mm³) and Vamanapuram (656 Mm³) river off Kollam and off Thiruvananthapuram respectively, it can be seen that heavy discharge from Kallada River supports the presence of upper stratified layer (warm and low saline) off Kollam.

4. Conclusion

Considerable latitudinal variability of upwelling intensity and magnitude was noticed during the observation period (25th June-7th July 2006). Though local wind stress is strong at Thiruvananthapuram, the time series of temperature, salinity, local temperature anomaly, daily and station wise observation of mixed and Isothermal layer depth, indicated the presence of strong upwelling off Kollam. Influences of high precipitation and river runoff off Kollam formed a warm low saline surface stratified layer upto 15m. This strong stratified layer inhibited the downward transfer of momentum flux and prevented the vertical wind mixing of the surface water column to cause shallow MLD off Kollam. Compared to Kollam,

deep mixed and isothermal layer observed at Thiruvananthapuram and it can be best explained by weak stratified layer and the strong wind mixing of the surface water column.

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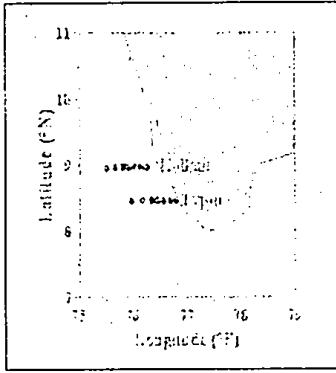


Figure.1

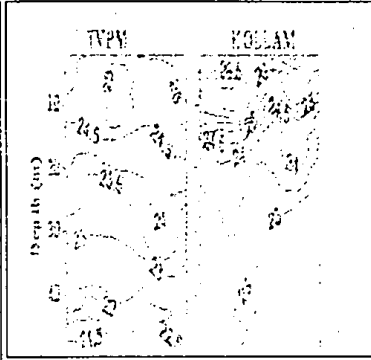


Figure. 2

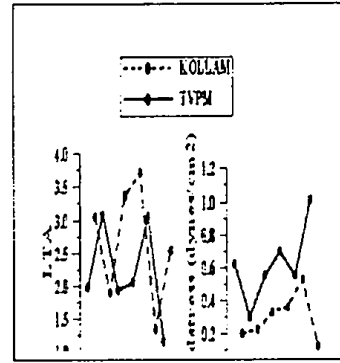


Figure.3

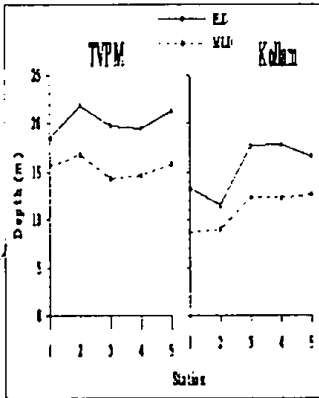


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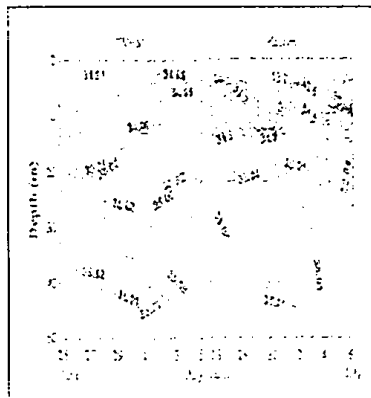


Figure.5

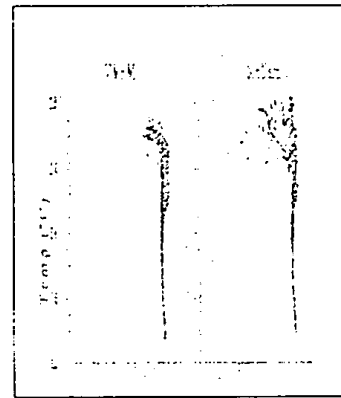


Figure.6

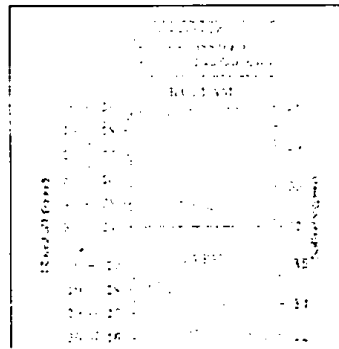


Figure.7