

Surfzone dynamics of the Konkan coast, India

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Abstract - The Konkan coast has the distinct morphological features than the rest of the Indian coast. Field studies on beach variation, littoral environmental observation and longshore sediment transport were carried out for a period of one year, between Ratnagiri and Mangalore, from April 1989 to March 1990. Study shows that the beaches are stable over the annual cycle. Longshore current direction varies from place to place. Deep water wave heights predominantly vary between 1 and 4 m during June to September and between 0.5 and 1 m during the rest of the year. About 85 % percent of the total wave power is contributed from the sector between southwest and west direction. The annual net transport direction vary along the study area showing southerly at Ratnagiri, Tadri and Mangalore and northerly along Vengurla, Goa and Coondapur. The sediment transport rate is relatively low at Vengurla, Coondapur and Mangalore throughout the year.

INTRODUCTION

The Konkan coast stretching from Ratnagiri to Mangalore along the west coast of India, is about 500 km long. It has the kind of morphological features distinctly different from rest of the Indian coast. The coastal region is hilly, narrow, highly dissected with transverse ridges of the western ghats and at many places extending as promontories into Arabian Sea. The shoreline is very irregular associated with features like cliffs, notches, promontories, sea caves, embayments, submerged shoals and offshore islands. Numerous west flowing rivers form estuaries, bays, mud flats, creeks, and tidal marshes. In addition to pocket beaches, the presence of long sandy beaches all along the stretch, adds the exquisite beauty, the lone heritage for the Konkan region. Major harbours at Marmagao and Mangalore, and small fishing havens rest on most estuaries support the major economy for the coastal hamlets. In spite of abundant resources found over this region, the available scientific knowledge on the coastal environment is practically absent for this coast. In the present study, field observations were carried out at six shore stations along the Konkan coast between Ratnagiri and Mangalore. Observations on the daily variation on the littoral environment (LEO) and monthly variation on the beach profile were done from April 1989 to March 1990. The longshore sediment transport was theoretically estimated and compared with field results. Based on the field and theoretical studies, the dynamics of the surfzone of the Konkan coast is evaluated.

METHOD OF STUDY

Six stations were established along the coast, at places explained in Table 1, between Ratnagiri and Mangalore (Fig.1). The monthly changes in beach levels were measured at each station using the surveyor's dumpy level and graduated staff from the backshore dune to 1m water depth in the surfzone. The heights of 10 consecutive breakers were visually measured and the average of them is noted as breaking wave height. The time elapsed for 10 waves to break was noted and the average time was considered as breaking wave period. The breaking wave angle with respect to the coastline was measured using magnetic compass. Longshore current velocity and direction were measured by releasing neutrally buoyant floats in the surfzone and noting the distance

covered in 2 minutes. The deep water wave characteristics were compiled based on the ship observations, reported from 1968 to 1986 in Indian Daily Weather Reports published by the India Meteorological Department (Ships Weather Code, 1982). These wave data were grouped for 5° latitude and 5° longitude grids for the study region as shown in Fig. 1. From the observed data on breaking wave characteristics, the longshore sediment transport rate at each station was estimated using Walton's eqn. (Walton, *et al.*, 1989),

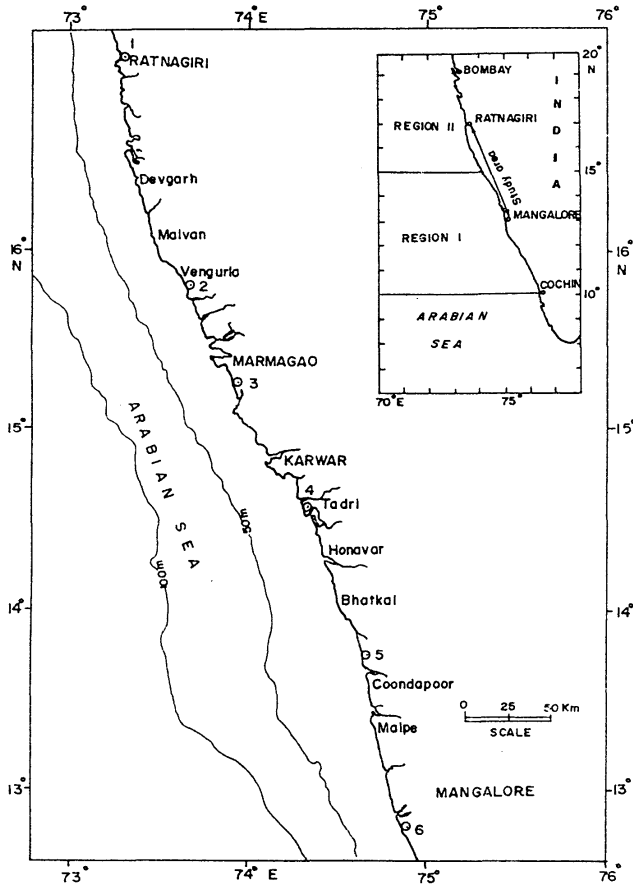


Fig. 1. Location map.

Table 1. Details of station locations

Stn.No.	Description
1	Kalbadevi beach north of Ratnagiri and Mriya bay
2	Abu Dande beach south of Vengurla
3	Tourist point at Colva beach in Goa
4	Dhupanchesi beach at Bavikole between Gangavelli and Kokarn
5	Maravanthe beach north of Coondapur
6	Ullal beach south of Mangalore

$$Q = \frac{1288 \rho_g H_b W V C_f}{0.78(5\pi/2)(v/v_0)_{LH}} \quad (1)$$

where, Q = annual longshore sediment transport rate in m^3 /year, ρ = seawater density ($1025 \text{ Kg}/m^3$), g = acceleration due to gravity, C_f = coefficient of friction (0.01), H_b = breaking wave height in m, W = surfzone width in m, V = longshore current velocity in m/s, $(v/v_0)_{LH}$ = theoretical dimensionless longshore current velocity (Longuet-Higgins, 1970).

RESULTS AND DISCUSSION

Beach process

The monthly changes in the volume of sediment per metre length of the beach at each station, estimated between the backshore dune and 1 m water depth are shown in Fig.2. The fluctuation indicates that the beaches at all stations experience seasonal erosion during the southwest monsoon period from June to September and start building up from November. They attain stable profile by February. The variation on the beach level indicates that the beaches are stable and they regained their original profile at all stations over the period of one year cycle.

Longshore currents

The typical variation on the longshore current velocity and direction, the breaking wave height and period, and the breaker angle for stn.1 is presented in Fig.3. The daily observation shows that at Ratnagiri (stn.1), the longshore current direction was towards south in August, September and November to January, towards north in June and it was variable in July and October. At vengurla (stn.2), it was towards south from April to June, towards north in September, November, December and March, and was variable during the rest of the year. At Goa (stn.3), the longshore current direction was towards north from October to June and it was variable rest of the year. At Dadra (stn.4), it was towards south from June to August and February to April, towards north in December, and variable during rest of the year. At Coondapur (stn.5), it was towards south in May and August, towards north in June and September, and variable during the rest of the year. At Mangalore (stn.6), the longshore current direction was towards south from March to August, towards north in October and November, and variable during the rest of the year. These observations show that the longshore current direction is not identical along the study area and it varies considerably from place to place.

The longshore current speed was comparatively high exceeding 40 cm/s throughout the year at stns. 4 and 6 and it was all the time less than 30 cm/s at stns. 5. It was varying between 25 and 50 cm/s at stns. 1,2 and 3. The breaker height was exceeding 1 m during June to August and it was mostly less than 0.6 m rest of the year. The breaking wave period was between 6 and 10 s at all stations throughout the year.

Deep water waves

The percentage occurrence of the wave height and wave period based on ship observation (1968-86) for the region off Mangalore - Karwar, and for the region off Goa and Ratnagiri is presented seasonwise in Figs. 4 and 5. It shows that deepwater wave height mostly varied between 1 and 4 m during southwest monsoon period (June-September) and between 0.5 and 1.5 m during the rest of the year. The predominant wave period varied between 5 and 9 s during June to September and between 5 and 7s during rest of the year. The directional distribution of percentage of wave power

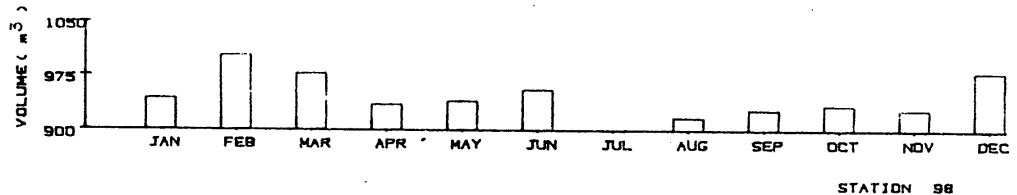
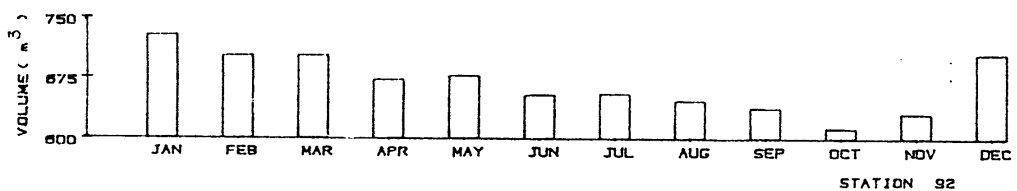
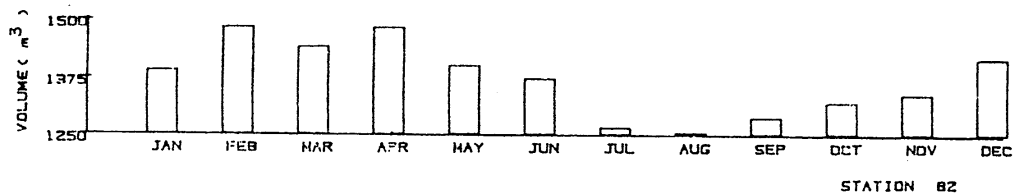
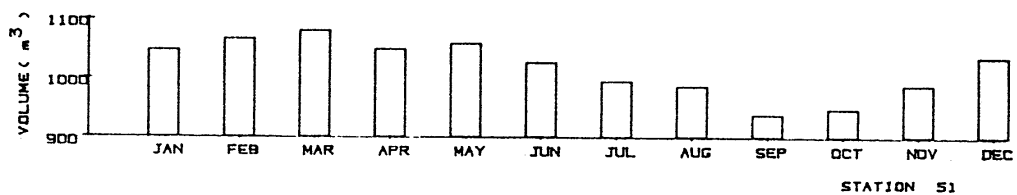
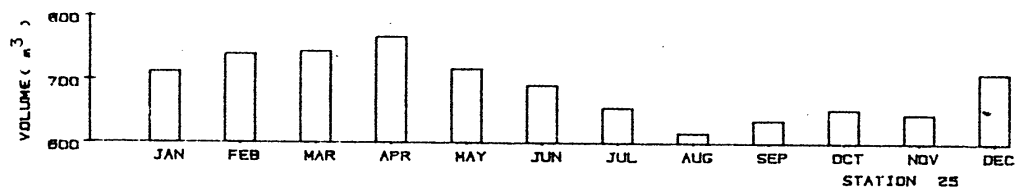
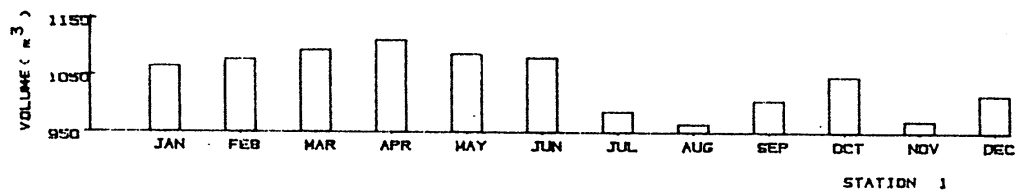


Fig. 2. Variation of volume of beach sediment/metre width.

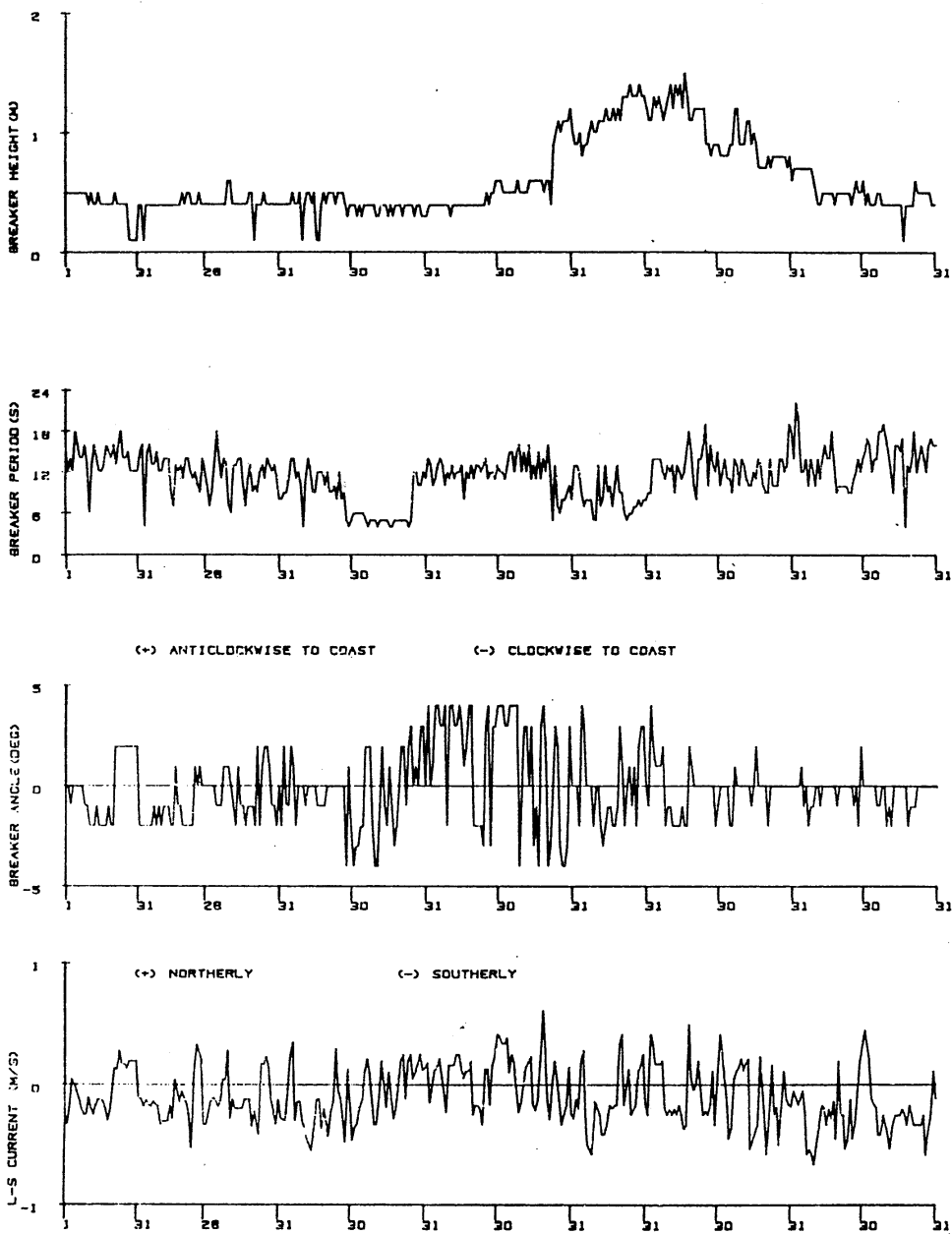


Fig. 3. Daily littoral environmental observation at Ratnagiri.

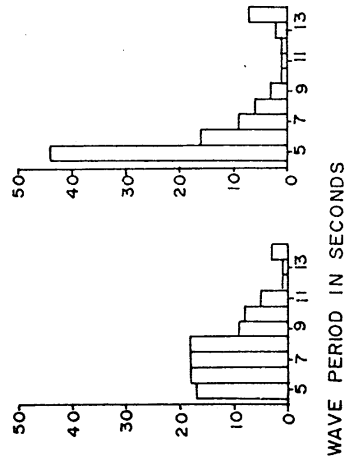
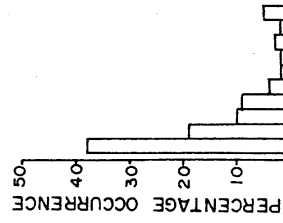
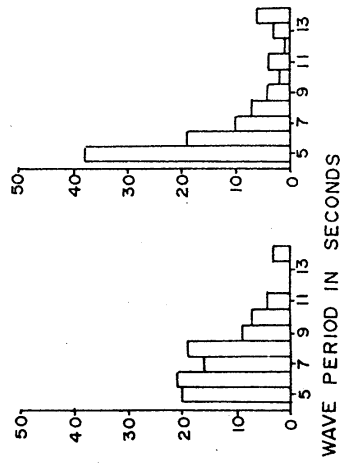
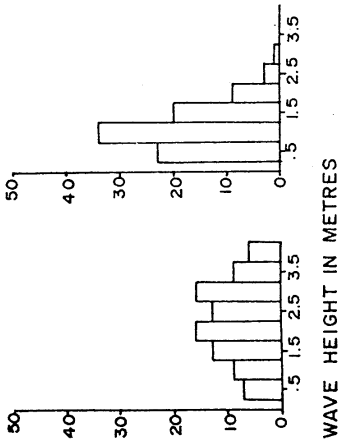
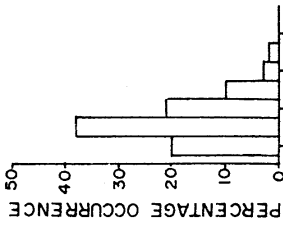
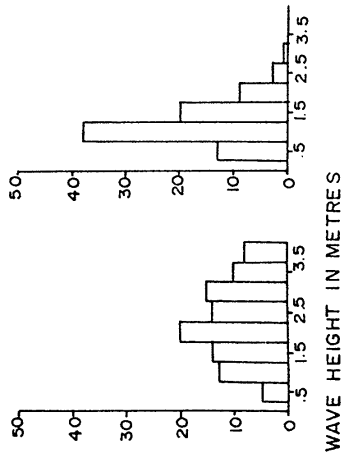


Fig. 5. Variation of wave height and period between Mangalore and Karwar.

Fig. 4. Variation of wave height and period between Ratnagiri and Goa.

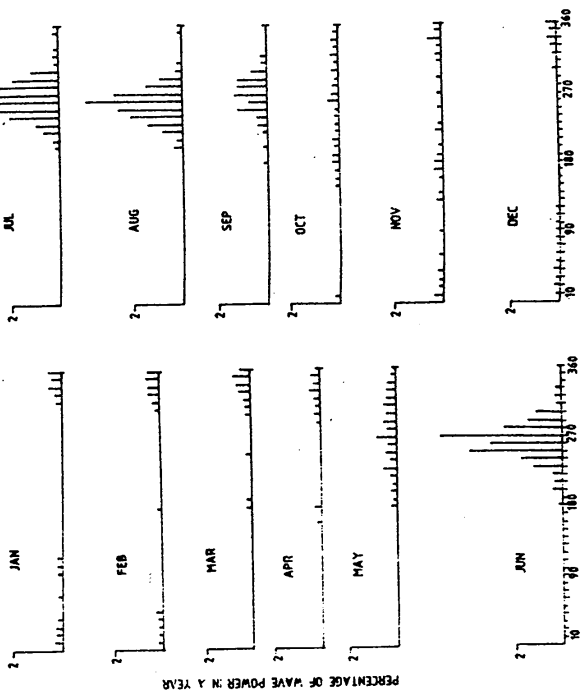


Fig. 6. Directional distribution of wave power between Ratnagiri and Goa.

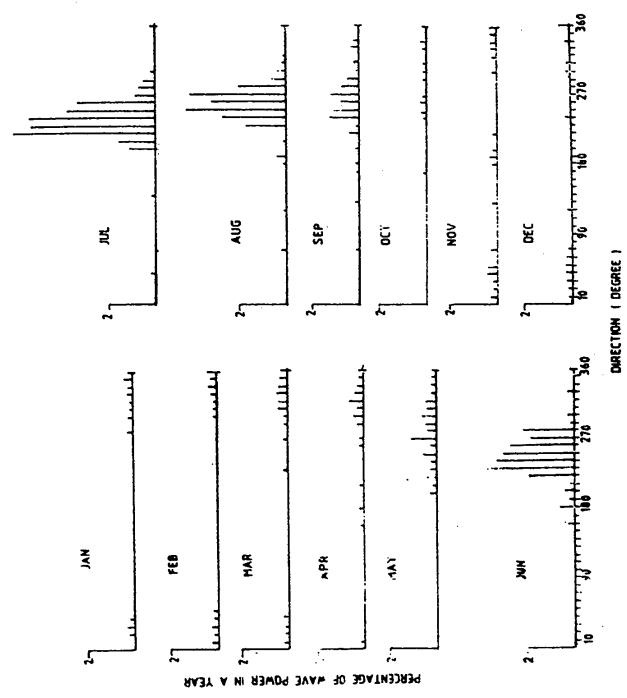


Fig. 7. Directional distribution of wave power between Mangalore and Karwar

during different months for these two regions are presented in Figs. 6 and 7. It shows that about 85 percent of the total wave power was contributed from the sector between the southwest and west direction from June to September. The available wave power was very low in other direction.

Longshore sediment transport

Using the measured daily littoral environmental parameters in eqn.1, the longshore sediment transport rate at each station was estimated and is presented monthwise in Table 2. It shows that the annual net transport rate was $3.76 \times 10^4 \text{ m}^3$ at Mangalore, $2.56 \times 10^4 \text{ m}^3$ at Coondapur, $14.39 \times 10^4 \text{ m}^3$ at Tadri, $17.34 \times 10^4 \text{ m}^3$ at Goa, $2.97 \times 10^4 \text{ m}^3$ at Vengurla and $11.86 \times 10^4 \text{ m}^3$ at Ratnagiri. The annual net transport direction was not analogous along the study area showing southerly at Ratnagiri, Tadri and Mangalore and northerly along Vengurla, Goa and Coondapur. Beach Erosion Board (1987) has reported that the annual net transport along the Karnataka coast is in south and is about $10 \times 10^4 \text{ m}^3$ in a year. It agrees to certain limit with the present results obtained for Mangalore and Tadri for the Karnataka coast. The sediment transport direction along the Goa coast is observed to be northerly throughout the year which needs further field investigation to confirm the present study. The sediment transport rate was comparatively low at Vengurla Coondapur and Mangalore throughout the year.

Table 2. Longshore sediment transport rate in 10^4 m^3

Month	Station Numbers					
	1	2	3	4	5	6
Jan	-0.55	-0.15	0.74	0.08	0.02	-0.07
Feb	-0.66	-0.23	0.60	-1.97	0.00	-0.04
Mar	-0.41	0.61	2.13	-2.62	0.03	-0.11
Apr	-1.37	0.14	0.26	-3.18	0.03	-0.24
May	-0.18	0.38	0.99	-0.72	-0.08	-0.24
Jun	1.09	-3.43	1.92	-1.56	2.26	-1.18
Jul	0.36	1.79	0.25	-2.91	0.29	-0.78
Aug	-4.43	1.92	4.25	-1.59	-0.15	-1.19
Sep	-2.58	0.14	0.23	0.15	0.11	0.02
Oct	-0.30	0.33	3.39	-1.21	0.01	0.07
Nov	-1.65	0.80	1.43	-0.05	0.02	0.05
Dec	-1.18	0.38	1.15	1.19	0.00	0.00
Annual Gross	14.76	10.30	17.34	17.23	3.00	3.99
Annual Net	-11.86	2.98	17.34	-14.39	2.56	-3.76

(-) sign indicates transport in southerly direction and vice versa.

The anomaly over the annual net sediment transport direction between Ratnagiri and Mangalore indicates the significance of the differential morphological characteristics of the Konkan coast. It is observed along the Konkan coast that the incoming wave direction is closely parallel to the coast both during monsoon and fair weather periods. Consequently, the prominent change in the morphology of the nearshore causes the waves to refract and alter the sediment transport direction accordingly. Chandramohan (1988) reported that the annual net transport along the east coast of India remains always towards north and it is high, varying between $50 \times 10^4 \text{ m}^3/\text{year}$ and $150 \times 10^4 \text{ m}^3/\text{year}$. The volume of the annual net sediment transport rate observed along the Konkan coast is very less compared to the east coast and the direction is quite variable from place to place.

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