

## Littoral & Rip Currents off Calangute Beach, Goa

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Littoral currents were measured by injecting rhodamine 'B' dye into the surf zone at distances of about 200 m along the beach (from Sinqerim to Baga) during January to September 1972. These currents were associated with the mass transport due to breaking waves and are directed towards north during a greater part of the fair weather season. During premonsoon and monsoon, months, the littoral currents were northward in some places and southward in other places. Littoral current velocities, which generally depend on the breaker heights, angle of incidence of wave orthogonals to the shore, shoreline configuration, the nearshore bottom topography and the rise and fall of water level due to tides, were found to be higher during monsoon as compared to fair weather season. Rip currents along certain parts of the beach appear to be due to the convergence and divergence of wave energies. The area where rip currents were persistently observed in most of the surveys was demarcated as dangerous to bathers. The changes in current regimes were reflected in the patterns of sediment distribution and sediment transport.

NEARSHORE current system may be broadly classified into coastal currents and littoral currents. Coastal currents flow more or less parallel to the shore and contribute to a relatively uniform drift in the deeper water adjacent to the coast. They are semi-permanent in nature and can get modified by the configuration of the bottom and the coast, Littoral currents comprising flow in the surf zone, form several distinct patterns of water circulation. Shepard and Inman<sup>1</sup> have distinguished these into (i) a shoreward mass transport due to the wave action carrying water through the breaker zone in the direction of wave propagation, (ii) a movement of this water parallel to the coast as a longshore current, caused by the oblique approach of the waves to the beach and partly due to wave refraction, (iii) a seaward flow of the water piled up on the beach due to the incoming waves, from the surf zone, as a strong, narrow, surface current, known as rip current and (iv) longshore movement of the expanding rip head. These often, in conjunction, form a circulation cell. These currents vary in space and time and are most important from the point of view of beach processes. They play a vital role as for example in the (a) interchange of water between the surf zone and the offshore zone, (b) distribution of nutrients, and (c) distribution of land runoff and other materials injected into the surf zone by the breaking waves and suspended or particulate matter filtered out of the beach face<sup>2</sup> and sorting of the beach sediments.

Of late, studies on the nearshore current patterns, in understanding the movement and dispersion of pollutants introduced into the surf zone, have attracted much attention. However, littoral current patterns along the coast of Goa have not been studied adequately. The present attempts to investigate the nearshore current system inside the breaker zone, apart from studying the net sediment

drift along the shore, have been made to locate zones of rip currents (as these have led to several accidents to bathers resulting in drowning along certain parts of the coast) and for demarcating the safe regions for bathing along the Calangute beach.

### Study Area

The study area includes the Calangute beach along the coast of Goa and the immediate breaker zone (Fig. 1). The regional setting, physiography and bathymetry off Calangute have been described earlier<sup>3</sup>. The beach is composed of coarse to fine sand grade, moderate to well sorted sediments. The

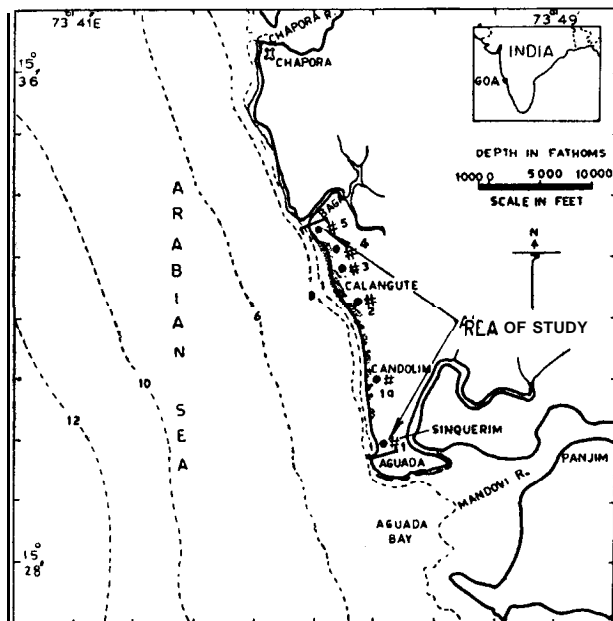


Fig. 1 — Location map

breaker zone is characterized by the presence of medium to fine sand grade, moderately to poorly sorted sediments.

Tides in this region are of semi-diurnal type and have a range of about 2 m at spring time. The width of the foreshore varies between 35 and 45 m and is terminated at its base by a low tide terrace and at times with an offshore bar and a step. Foreshore slopes vary between 3" and 17". Predominant directions from which severe waves are experienced lie between west and south-west (during the south-west monsoon) generated by the west and south-west winds, with periods ranging from 5 to 14 sec. Waves approaching from west and west-north-west directions reach the shoreline during the rest of the year<sup>4</sup>. The prevailing as well as the dominant winds with speeds of about 16 km/hr and at times gusty winds with high speeds of about 50 km/hr blow on shore during the monsoon. During the study period, breaker angles vary between 5" and 1.5°, breaker heights between 1 and 3.5 m in the monsoon. In the fair weather season, they vary between 0.5 and 1.5 m (Table 1).

Methods

Littoral currents in the surf zone were measured at intervals of 200 m along the Goa coast from Sinqerim to Baga (Calangute) during January to September 1972. However, the observations were also made at much closer intervals (100 m) occasionally. Measurements were made by following the centre of a dye patch injected into the surf

zone. About 5 g of rhodamine 'B' dye (red), loosely packed in tissue paper, were released into the surf zone at approximately 1½ to 2 m water depth. The time of appearance of the colour of the dye was recorded; simultaneously, a perpendicular line from the point of appearance of the dye colour on the beach was drawn. The movement of the centre of the dye patch was recorded for 2 min. The distance covered during this time interval was noted. Due to heavy breakers and the quick diffusion of the dye together with relatively turbid waters, a larger quantity (about 10 g) of dye was used during the monsoon months, to enable tracking of the movement of the dye patch for at least 1 min. To obtain a representative picture of the littoral currents, the observations were made along the entire stretch of the beach.

Results and Discussion

Data on tides, wave periods, breaker heights and angles, and foreshore slopes during the days of observations are shown in Table 1. Results of littoral currents are summarized in Fig. 2 (a to g), wherein the regions of convergence and divergence of wave energies are indicated. The observations reveal the following :

(1) Water masses within the breaker zone move along the shore (north as well as south) and also onshore and offshore. The mass transport of water is mainly towards north during the fair weather season (January-March) ; however, a reversal in flow is observed in early February 1972 (Fig. 2b), which

TABLE 1 — DATA ON TIDES, WAVE PERIODS, BREAKER HEIGHTS AND ANGLES, AND FORESHORE SLOPES DURING THE OBSERVATION PERIOD

Date	Predicted tide for Mormugao		Rate of rise/fall of water level (cm/hr)		P <sub>w</sub> mean (sec)	H <sub>b</sub> mean (m)	α <sub>b</sub> (°)		Foreshore slope (°)
	Time (hr)	Ht (m)	Rise	Fall			North	South	
25 Jan. 1972	0431	1.92		20	9.5	0.5-1.5	5	8-6	
	1201	0.34	18						
	1958	1.80							
3 Feb. 1972	0722	0.66	19	19	8.5	0.5-1	5	9-5	
	1328	1.80							
	1902	0.73							
14 Feb. 1972	0434	1.07	15		12	0.5-1.5	5	6-3	
	0959	1.87		25					
	1621	0.25							
28 March 1972	0412	0.71	18		12	1-2	Alternating	8-4	
	1034	1.97		17					
	1616	0.83							
11 May 1972	0246	0.26	26		10	1-2.5	10	11-6	
	0942	2.09		20					
	1505	1.03							
	2050	2.13							
14 July 1972	0046	1.76			8, 11	1-3.5	15	17-T	
	0643	0.28							
	1339	2.14	26						
	1938	0.64		25					
16 Sept. 1972	0529	1.70			7, 12	1-2	Alternating	12-4	
	1134	1.23		8					
	1629	1.37	2						

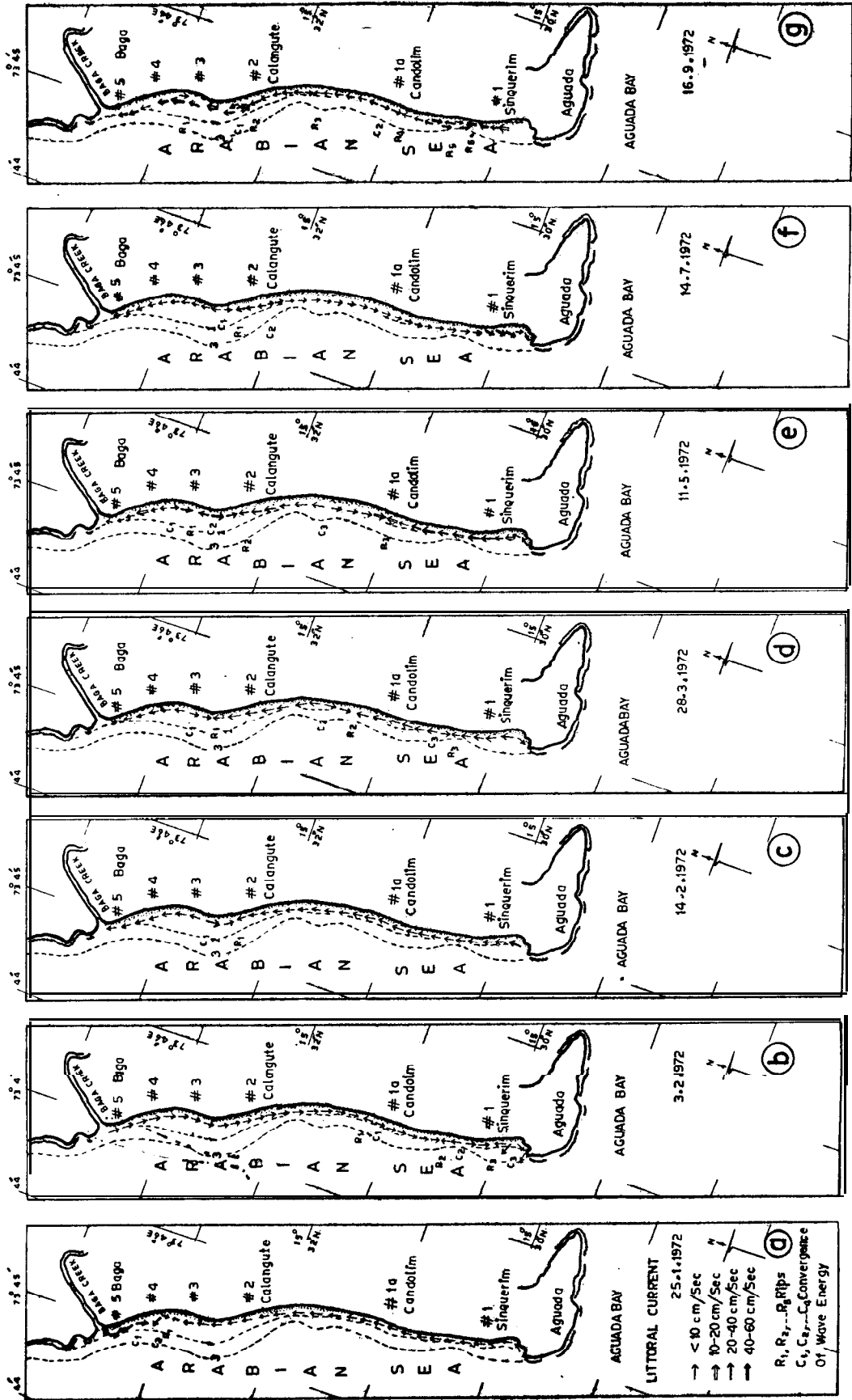


Fig. 2 — Results of littoral current observations (a to g) in the area of study along with regions of convergence and divergence of wave energies [Arrows indicate the directions of littoral currents. Bathymetric contours are indicated in fathoms: ---- 1 fm, - - - - 3 indicates 3 fm]

is due to the change in the direction of waves approaching from west to west-north-west. During the period of study, the littoral currents ranged from negligible speeds to speeds ranging up to 67 cm/sec. The speeds and directions of these currents varied in space and time. At times, the currents along the southern portion of the beach flowed with high velocities, while the velocities were low along the northern portion. Occasionally, the reverse feature was also noticed.

(2) A number of rip zones exist along the shoreline. These rips appear to be more prevalent just before the onset of the monsoon and during the monsoon season. The rips are due to the convergence of the flows directed in opposite directions along the shore, for example, the north flowing currents retarded just a little south of the divergence zone located between stations 2 and 3 by the southward flows north of it. Here, the configuration of the shoreline is convex seaward. The bulging offshore depth contours at this place might produce a convergence of wave energy with divergence on either side of it. Currents flow from the converging zone towards the diverging zone. This feature was clearly noticed in most of the surveys in the neighbourhood of stations 2 and 3. Further, it was observed during the dye studies that the dye patch moved offshore near these convergences and gradually became diffuse.

(3) During certain months of the monsoon the flow is towards the south in certain places and to the north in other places along the beach. At times, it is also onshore and offshore at certain places, indicating that the currents are not completely two-dimensional. According to Longuet-Higgins<sup>5</sup>, the pattern of the longshore currents is broken up by rip currents into a sequence of circulating cells. This may partly be due to the presence of cusped features on the beach face and the changes in the nearshore bottom topography as a result of the offshore movements of beach sediments due to beach erosion during the monsoon. These findings are in agreement with those of Bowen and Inman<sup>6</sup>. By September, the south flowing currents reverse and give way to a northerly flow in association with the change in the condition of wave climate. Low and long period swells from directions ranging from WSW to SW were found to prevail during this period. Hence, these currents are quite transient so is the presence of rips. Nevertheless, the results indicate a dominant flow for most of the time towards the north. A large number of littoral current observations made during the general beach profile surveys at the 6 beach profile stations along the coast also revealed similar results; a predominant flow towards the north during a greater part of the fair weather season. The changes in current directions are induced partly by the corresponding changes in wind and wave conditions. On the southern part of the beach, waves break closer to the shoreline, while on the northern side they break a little away from the shoreline, resulting in a narrow surf zone

on the southern side as compared to the northern side. Further, breaker heights were more in the south than in the extreme north, indicating higher wave energies on the southern side. This alongshore variation in the breaker heights induces a flow in the surf zone from the region of high breakers to the region of low breakers, as observed also by Bowen and Inman<sup>6</sup> in their studies. These high breakers in the south seem to be responsible also for the relatively higher littoral current velocities in the south. These currents are caused by the piling up of water as a consequence of the convergence of wave energy along the narrow surf zone with relatively steep foreshore slope.

Textural characteristics of the beach sediments off Calangute, which have been studied earlier, indicate a decrease in mean grain size and improvement in sorting of the foreshore sediments from south to north<sup>3</sup>. The present study indicates a predominant flow towards the north along the shoreline. This northward longshore water movement may, perhaps, be responsible for the transport of fine grained sediments towards the north. Thus the changes in current regimes are reflected in the patterns of sediment distribution and transport<sup>7</sup>.

These studies on littoral and rip currents along the Calangute beach have revealed a predominant northward flow along the beach during the fair weather season and a persistent zone of rip currents between stations 2 and 3 (Fig. 2) during major part of the period of study. Rip currents are also occasionally noticed between stations 1 and 1a, stations 1a and 2, and stations 3 and 4. During premonsoon and monsoon months the littoral currents were northward in some places and southward in other places along the beach, leading to numerous converging current patterns (rip currents) near the beach.

Swimming against the direction of the seaward flowing rip current can cause exhaustion and drowning for inexperienced swimmers. On the other hand, if the swimmers who are caught in a rip current swim parallel to the coast there is a good chance of their being saved and brought to the shore by the onshore flow at the peripheries of the rip current system.

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