CHAPTER 4

CURRENTS

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4. CURRENTS

4.1 INTRODUCTION

Though waves are the most important hydrodynamic force in the coastal zone, currents also are also equally important. While wave orbital motions are strong enough to cause resuspension of sediments in shallow waters the movements are oscillatory in nature. Currents, though relatively weak, are translatory in nature and hence cause transport of resuspended sediments, in addition to other forms of transport. Considering its importance in sediment transport and hence sediment budgeting, an exhaustive set of current data covering different months and periods were collected and the characteristics of currents studied in this chapter. As detailed in Chapter 2, currents were measured both at nearshore and offshore sites. While an ADP current meter was used for measurement at the nearshore site, two FSI current meters were used at the offshore site for measurement at two levels. In addition to these one ADP was installed for one day each in two seasons and the data used for calibration of models.

4.2 LITERATURE REVIEW

Very few direct measurements of currents have been reported in the literature for the Indian coast, particularly for the southwest coast of India. Thus the currents have been mainly inferred from computations using observed data on physical and chemical properties of seawater (e.g. Shetye et al., 1990 and 1991; Antony, 1990; Suryanarayana and Rao, 1992; Rao and Murthy, 1992). The available measured data were either very short term spanning for a few days (Sanil Kumar et al., 1989; Sarma and Gangadhar Rao, 1986; Rama Raju et al., 1986; Swamy and Suryanarayana, 1992; Fernandez et al., 1993) or seasonal, occasionally ranging up to a few months (John et al., 1979; Narasimha Rao et al., 1989; Narasimha Rao and Prabhakara Rao, 1989). No work utilising recorded data is seen in the literature for the SW coast of India.

The available literature shows that the Indian Ocean is characterised by seasonal changes of its surface circulation due to two opposite atmospheric regimes, namely
southwest and northeast monsoons. According to Basu et al. (2000) the seasonal variation in the Indian Ocean is greater than that in any other ocean.

A schematic diagram of the north Indian Ocean circulation pattern during northeast (November–March) and southwest (June–September) monsoon is given by Shankar and Shetye (1997) and it is reproduced here as Fig. 4.1. A remarkable feature of the coastal circulation pattern is the formation of an anticyclonic eddy east of Lakshadweep Islands during the northeast monsoon and a cyclonic eddy during the southwest monsoon. The mechanism for the eddy formation is given by Shankar and Shetye (1997) based on their interpretation of previous studies of Nerem et al. (1994) that the sea level starts rising at the southwest coast of India during December, when East India Coastal Current (EICC) is equatorward. The EICC turns around the southern tip of Sri Lanka (Cutler and Swallow, 1984) and joins the poleward current along the west-coast of India (Shetye et al., 1991). During June, the sea level drops at the southwest coast of India, when the current at the western Indian coast, the West India Coastal Current (WICC) is equatorward. Shankar and Shetye (1997) conclude that the formation of the eddy off southwest India during the northeast is one manifestation of an annual cycle of events that are linked not only to the coastal currents around India, but also to the circulation in the southern Arabian Sea as a whole.

Shetye (1998) observed that the West India Coastal Current (WICC) flows northward during November-February and southward during April-September. He attributed the annual cycle of WICC and that of the Lakshadweep high/low to a set of circumstances that are special to North Indian Ocean. Shetye et al. (1998) found that the currents in the North Indian Ocean basin are primarily due to free and forced long waves of three kinds: (1) Equatorial Rossby waves, (2) Equatorial Kelvin waves and (3) Coastal Kelvin waves. They concluded that the surface circulation off Arabian sea is typical of a wind driven system with similar patterns of longshore current and wind stress. They also found that the circulation off the west coast of India is consistent with the dynamics of wind-driven eastern boundary currents only during the southwest monsoon.
Other studies (McCreary et al., 1993; Bruce et al., 1994) also have shown the formation of a cyclonic eddy off the southwest coast of India during northeast monsoon. Recent studies of Bruce et al. (1998) suggests that the anticyclonic circulating feature that forms off the SW coast of India during northeast monsoon is comprised of multiple eddies.

Fig. 4.1 Schematic representation of the circulation in the Indian Ocean during January (winter monsoon) and July (summer monsoon). The abbreviations are as follows. SC, Somali Current; EC, Equatorial Current; SMC, Summer Monsoon Current; WMC, Winter Monsoon Current; EICC, East India Coastal Current; WICC, West India Coastal Current; SCC, South Equatorial Counter Current; EACC, East African Coastal Current; SEC, South Equatorial Current; LH, Lakshadweep high; LL, Lakshadweep low; GW, Great Whirl; and SH, Socotra high (after Shankar and Shetye, 1997)
Shetye et al. (1990) investigated the hydrography and circulation off west coast of India during the southwest monsoon season. They concluded that the circulation off the west coast of India during southwest monsoon season, though weak, is dynamically similar to the wind-driven eastern boundary currents found elsewhere in the ocean.

Shetye et al. (1991) carried out investigation on the coastal current off western India during the northeast monsoon using the hydrographic data obtained from O.R.V. Sagar Kanya and described the pole ward coastal current along the west coast of India. They found that longshore pressure gradient overwhelms the winds during the northeast monsoon, whereas during the southwest monsoon the winds dominate.

Shenoi and Antony (1991) collected current data using moored array of current meters from the offshore off Goa. They measured currents for a period of three months and found that the mean flow was towards south during May and March and it was towards north in November. They found that the inertial and semidiurnal frequency motions are the major contributor to the current structure. The inertial currents were concentrated near the surface with a rapid decay towards the bottom. Their analysis indicates that the diurnal and semidiurnal motions are mainly due to baroclinic internal tides rather than due to barotropic surface tides.

Prasada Rao et al. (1996) studied the premonsoon current structure in the shelf water off Cochin using current data collected from the depths of 10, 20, 40, 60 and 80m. They observed a southerly current in near-surface and north-westerly currents in subsurface. Seasonal fluctuation in the coastal currents off Mangalore was observed by Sahu et al. (1991). They observed a maximum current of 60cm/s during November and a minimum current of 5-9 cm/s during February.

Shankar et al. (2002) described in detail the monsoon currents in the north Indian Ocean using the data from ship drifts, winds and Ekman drifts and geostrophic currents derived from altimetry and hydrography and also by using numerical models. They found that the monsoon currents are seasonally reversing. The Summer
Monsoon Current (SMC) flows eastward during the summer monsoon (May-September) and the Winter Monsoon Current flows westward during the winter monsoon (November-February).

Shetye et al. (1998) observed that it is a consequence of the remote forced Kelvin wave which in turn radiates Rossby waves that cause the formation of a weak, but nonetheless upwelling favourable coastal currents off southwest coast of India, this current being integral to the dynamics of the high. The flow field off southwest India at 8° N during the southwest monsoon period was measured by Stramma et al. (1996) using ADCP and CTD. They found that the upper ocean between 75°E and 76° 52' E near the south Indian shelf was governed by a northward flow with a subsurface velocity maximum of 25 cm/s at about 100m depth.

Thus the available literature gives a reasonably good picture about the general circulation of the Northern Indian Ocean and the Arabian Sea which is mostly based on the hydrographic data. One notable feature of the currents in the Arabian Sea as understood from the recent studies is the occurrence of an anticyclonic eddy east of Lakshadweep islands during the northeast monsoon and a cyclonic eddy during the southwest monsoon. Lack of literature based on measured current is evident, particularly for the southwest coast of India.

4.3 CURRENTS MEASURED UNDER THE PRESENT INVESTIGATION

4.3.1 Nearshore Site

The time series data for nearshore site are shown in Fig. 4.2 to Fig. 4.8 and the progressive vector plots are shown in Fig. 4.9a-g. An analysis of the velocity into cross-shore (u) and alongshore components (v) of each data is presented along with speed and direction. In October 1999, current speed was generally in the range of 5-10 cm/s, but occasionally high values were observed, and a value as high as 19.30 cm/s was recorded on 19th October (Fig. 4.2). Current speed oscillated between 0
and 360° due to tidal influence. Comparison of alongshore and cross-shore components shows that alongshore components were stronger than cross-shore components. The data indicated a predominant offshore flow in the cross-shore direction. The longshore component changed direction at frequent intervals, with a high frequency of southerly component. The progressive vector plot (Fig. 4.9a) shows a predominant offshore movement with a slight southerly alongshore movement. This is in contrast to the time series where the alongshore component were stronger when compared to the cross-shore. During November 1999 (Fig. 4.3), the currents were weaker except in the first week when speed up to 22 cm/s was recorded. Current direction oscillated from 0 to 360°. During November also the alongshore components were stronger than cross-shore components. The data indicated a strong onshore and southerly current during the first week of the month. Onshore and southerly directions dominated during the rest of the month with reduced speed. The progressive vector plot (Fig. 4.9b) shows more or less same pattern with a net south-easterly movement of water.

In March-April 2000 (Fig. 4.4), current speeds in the range of 5-10 cm/s were common in the beginning with speeds as high as 21 cm/s. After third week of March current speeds were generally less than 5 cm/s but occasionally increased up to 17 cm/s. Cross-shore components were very weak than alongshore components as seen earlier. Alongshore components were predominantly southerly in the first 10 days and thereafter the dominance reduced with occasional northerly currents. The progressive vector plot (Fig. 4.9c) shows intense southerly movement with a weak offshore component.

In May-June 2000 (Fig. 4.5), current speeds were very low and most of the days it was less than 10 cm/s except for a shore period, 7-10th June. During this short period the current speed increased to 58 cm/s and then decreased to values less than 10 cm/s. The direction of current for these 4 days is purely southerly. One notable feature is that the tidal oscillations are masked by this very strong current. As observed during the previous months alongshore components were stronger than cross-shore components. The cross-shore components though weak for major part of the month,
were persistently offshore throughout. The alongshore component was predominantly southerly with very strong speeds during 7-10\textsuperscript{th} June. The progressive vector plot (Fig. 4.9d) for the period confirms the above results. The domination of southerly movement is very much evident.

Current speeds were higher than May-June period during July-August 2000 (Fig. 4.6). The speeds were commonly in the range 5-10 cm/s except for the beginning and end of the recording period. Current speed up to 24 cm/s was recorded during the second week of August. An important feature observed was that, both cross-shore and alongshore components are more or less equal in magnitude during this period. In general offshore flows dominated the observation period. Likewise, southerly currents have dominance over northerly flows, although northerly flows were strong occasionally with speeds exceeding 15 cm/s. The dominance of southerly and offshore flows is reflected in the progressive vector plot (Fig. 4.9e) with net movement of water in the SW direction. During October-November 2000 (Fig. 4.7), the current speeds were less, similar to those recorded in November 1999, with current speeds generally around 5 cm/s. Maximum speeds recorded are 19.6 cm/s on 4\textsuperscript{th} November and 19.1 cm/s on 20\textsuperscript{th} November. Comparison of alongshore and cross-shore components shows that, alongshore components are stronger than cross-shore components. The velocity of cross-shore components remains to be less than 5 cm/s throughout the period but persistently onshore. The alongshore components were stronger and predominantly southerly. The flow pattern results in a net transport in the SE direction as seen in the progressive vector plot (Fig. 4.7f).

In April-May 2001, currents were weak, typical of pre-monsoon period, with speeds reaching 10 cm/s only a few times (Fig. 4.8). As seen in most of the cases, the alongshore components are stronger than cross-shore. The cross-shore components were predominantly onshore and the alongshore components southerly. The progressive vector plot (Fig. 4.9g) shows a net movement in the SSE direction indicating the dominance of southerly transport over onshore transport.
Fig. 4.2 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore ($U$ cm/s) and alongshore ($V$ cm/s) velocities during the deployment period 07 October – 27 October 1999 at the Nearshore site.
Fig. 4.3 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 02 November – 26 November 1999 at the Nearshore site.
Fig. 4.4 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore ($U$ cm/s) and alongshore ($V$ cm/s) velocities during the deployment period 07 March–07 April 2000 at the Nearshore site.
Fig. 4.5 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore ($U$ cm/s) and alongshore ($V$ cm/s) velocities during the deployment period 21 May – 13 June 2000 at the Nearshore site.
Fig. 4.6 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 20 July–19 August 2000 at the Nearshore site.
Fig. 4.7 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore ($U$ cm/s) and alongshore ($V$ cm/s) velocities during the deployment period 29 October – 27 November 2000 at the Nearshore site.
Fig 4.8 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore ($U$ cm/s) and alongshore ($V$ cm/s) velocities during the deployment period 25 April – 17 May 2001 at the Nearshore site.
Fig. 4.9a-g The progressive vector plots of currents at the Nearshore site
As mentioned already, the current measurements at the offshore site commenced in May 1999. During May 1999 S4 current meter was deployed in the offshore site. From September 1999 onwards two FSI current meters were used, one at 0.75m and the other at 2.25m above bottom. Due to damage to the equipment on a few occasions, the data for the 2.25m level are not regular.

During the deployment period 7-22 May 1999, the current velocity ranged up to 25 cm/s (Fig. 4.10). The alongshore components were stronger than cross-shore components. Both cross-shore components and alongshore components are
oscillating in directions. However it can be seen that the alongshore component is predominantly in the southerly direction, particularly after the middle of May. This is reflected in the progressive vector plot (Fig. 4.18a), which shows a southerly transport.

During August-September 1999, the bottom current speeds were normally in the range of 5-15 cm/s, and speeds less than 5 cm/s were also recorded frequently (Fig. 4.11). Current direction oscillated between 0 and 360°. In general, the data indicated a predominant onshore flow in the cross-shore direction and northerly flow in the alongshore direction, but during the period when a high current speed of up to 35 cm/s was recorded, the alongshore flow was southerly. Since the recording period was only 2 weeks, the progressive plot doesn’t show any significant movement of water (Fig. 4.18b). However, a net southeasterly movement is seen. The current meter deployed at 2.25m above bottom (Fig. 4.12) also recorded similar trends in current speeds, but the current speeds were in general higher, as expected. The cross-shore components were stronger than alongshore components with the domination of onshore flow. Northerly flows were more dominant in alongshore direction, but southerly flows when recorded were stronger than northerly flows. In accordance with the above pattern, the progressive vector plot (Fig. 4.18c) shows significant onshore movement. During the period September-October 1999, current speed was weaker and ranged between 0 and 10 cm/s for most part of the observation period (Fig. 4.13). However, in the last quarter, the current speed increased, and ranged from 5 to 15 cm/s. A maximum speed of 24 cm/s was recorded on 25 October. The cross-shore components were weaker than the alongshore components. Throughout the measurement period, cross-shore flow was offshore. The longshore flow was dominantly northerly in the first three weeks, but when current speeds recorded higher values in the last quarter, the longshore flows were consistently southerly. Progressive vector plot for the period indicates predominantly offshore flow in the first three quarters followed by southerly flow in the last quarter (Fig. 4.18d). Data from the upper current meter was not available during this period.
As to equipment failures/damages, the next recording available for the offshore station is only in June-July 2000. In June-July 2000, current velocities in the range 0-10 cm/s were recorded on most of the days (Fig. 4.14) though it is considered to be a peak monsoon period. Very rarely current speeds exceeding 15 cm/s were recorded. Current direction oscillates between 0 and 360° due to the tidal influence. During this period, the alongshore components were stronger than cross-shore components. In the cross-shore components of flows, the onshore and offshore flows were equally prevalent and appear to be well balanced. The same is applicable to the alongshore components. The progressive vector plot (Fig. 4.18e) amply demonstrates the above by not showing any net movement. During July-August 2000, the current is stronger than the June-July period. The speeds are commonly in the range 0-10 cm/s (Fig. 4.15). Speeds above 10 cm/s too occur several times with a maximum speed of 22.5 cm/s. The alongshore components were stronger than cross-shore components. The cross-shore components were distributed more or less equally between onshore and offshore flows. However, among the alongshore components, the northerly flows have a slight edge over southerly flows. Thus the progressive vector plot for this period (Fig. 4.18f) shows a not so significant northerly movement.

During the period October-November 2000 also, the current speed between 0 and 10 cm/s is common, but towards the last quarter, there is a significant increase in speed with speed up to 40 cm/s (Fig. 4.16). As is the usual case, during periods of strong currents, the direction of current is consistently southerly overcoming the tidal influence. Even during the first three quarters when the currents are weak, the southerly components dominate over the northerlies. Thus the progressive vector plot for this period (Fig. 4.18g) shows a predominant southerly movement.

During July-August 2001, the current speed was generally between 0 and 10 cm/s except for a few days (Fig. 4.17). On 1st August the maximum current speed of 29 cm/s was recorded. Both cross-shore and alongshore components have more or less equal magnitude. Among the cross-shore components, there appear to be a slight edge for the onshore flow. The alongshore flow is dominated by southerly components. The progressive vector plots shows a strong southerly movement (Fig. 4.18h)
Fig. 4.10 Time series plot of S4 current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 7 May - 22 May 99 at the offshore site.
Fig 4.11 Time series plot of FSI-CTD current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 22 August – 05 September 1999 at the offshore site.
Fig. 4.12 Time series plot of FSI current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 22 August – 03 September 1999 at the offshore site.
Fig. 4.13 Time series plot of FSI-CTD current meter measured mean burst mean current cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 27 September – 28 October 1999 at the offshore site.
Fig. 4.14 Time series plot of FSI current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 20 June – 11 July 2000 at the offshore site.
Fig. 4.15 Time series plot of FSI current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 20 July – 18 August 2000 at the offshore site.
Fig 4.16 Time series plot of FSI current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities during the deployment period 29 October – 27 November 2000 at the offshore site.
Fig. 4.17 Time series plot of FSI current meter measured mean burst current speed, direction, cross-shore (U cm/s) and alongshore (V cm/s) velocities and stick plot of current velocity during the deployment period 18 July–7 August 2001 at the offshore site.
Fig. 4.18a-h Progressive vector plot of current meter data for the deployments from May 1999 to August 2001 at the offshore site.
Fig. 4.18 Progressive vector plot of current meter data for the deployments from May 1999 to August 2001 at the offshore site (contd...)
Vertical Profile of Currents

The data used in the earlier sections are mostly bottom currents (1m above sea bed) which are important from the point of view of sediment budgeting. Vertical profile of currents is useful in understanding the relation between wind and currents and calibration of circulation models. Since the instrument required for the same was not available in CESS and was to be hired, only limited data were collected.

An upward-looking Acoustic Doppler Profiler was deployed on a bottom-mounted frame at the offshore and nearshore sites for about 24 hours each on 22 and 23 March 2000 during the non-monsoon and at the offshore site only on July 10, 2000 in the monsoon. The instrument simultaneously measures current speed and direction throughout the water column in a succession of vertical layers of 0.5 m thick. The results are shown as pseudo-colour plots where the horizontal axis shows time, the vertical axis shows elevation above the instrument sensor in the water column and the colours represent scaled velocity and direction in two separate plots (Fig. 4.19-4.21).

During the non-monsoon in March, the maximum currents at the offshore site are of the order of around 25 cm/s (Fig. 4.19). The strongest flows occur at the surface and during the late afternoon when the wind is strongest. The velocity gradient through the water column is largest at this time and is indicative of a surface wind stress forcing which only penetrates to about mid-depth. Currents are onshore to southerly at the surface and offshore at the bed, which also indicates wind-induced downwelling circulation. In the very early morning just after midnight, the flows are mostly longshore to the south and currents are of similar magnitude through the water column, suggesting a response to a large-scale (longshore) pressure gradient, rather than a cross-shore set-up induced by wind. The current speeds show the semi diurnal pattern in the variation with low speed around noon on 22\textsuperscript{nd}. In the afternoon the speed picks up, as already discussed due to the sea breeze. The semidiurnal influence is manifested by low speeds in the evening. In the early morning the speed picks up, but again reduced in the late morning. This semidiurnal pattern is indicative of the domination of tidal current.
At the nearshore site in March, the vertical partitioning is less pronounced (Fig. 4.20). However, similar tendencies occur with the flows onshore at the surface and rotated partially offshore at the bed during the afternoon. The velocity pattern indicates a semi-diurnal response, which is possibly a tidal modulation of the dominantly southerly currents. A northerly reversal when currents are very slow occurs in the late morning in synchrony with the patterns offshore at this time on the previous day. Significant semidiurnal variability in current velocity is indicated. Thus in the late afternoon, surface current velocities achieve the maximum values, most probably under the influence of winds. Then the surface current velocities get decreased, but within six hours of the afternoon maximum values a minimum values is recorded. After that the value gets increased and another maximum is observed though the magnitude of the second peak is slightly reduced. Thus, maximum and minimum values observed in surface current velocity get repeated every six hours, alternatively. This can be the effect of oscillatory tidal currents.

The most striking feature of the profile for monsoon (Fig. 4.21) is a stronger tendency for currents near the surface to be opposite to those near the bed for much of the time. In accordance with the earlier measurements, the current at the seabed during the monsoon is mostly southerly and offshore, although there are periods of slow flow to the north at the bed. The strongest currents occur near the surface, presumably due to the direct action of wind stress and the frictional seabed boundary layer, which reduces near-bed currents. This effect is very strong with periods when currents are around 30 cm/s at the surface and as low as 8 cm/s near the bed. The fastest surface flows occur in the late afternoon when the winds are strongest. The semi-diurnal pattern of variation in the current speed is evident here also, though not to the extend seen in March.

Though the variability of current velocity with depth is not very conspicuous at the nearshore site, significant variation is observed at offshore site. The variability in current speed is mainly caused by the semi-diurnal tidal flows, and the influence of wind on current velocity become evident when the wind activity is strong in the afternoon hours.
Fig. 4.19 Mean current speed and direction measured by the upward looking Acoustic Doppler Profiler (ADP) at the offshore site on 22-23 March 2000
Fig. 4.20 Mean current speed and direction measured by the upward looking Acoustic Doppler Profiler (ADP) at the Nearshore site on 23-24 March 2000
Fig. 4.21 Mean current speed and direction measured by the upward looking Acoustic Doppler Profiler (ADP) at the offshore site on 10-11 July 2000
DISCUSSION AND SUMMARY

The observed current appears to be a resultant of tidal currents, wind-driven currents and continental shelf currents. The influence of tides on the current is quite evident from the semidiurnal oscillations seen in the time series distributions presented for different measurement periods. However one notable feature is the absence of this tidal influence in occasions when strong currents are present. It is observed that a good relationship exists between wind and currents on many occasions in the study area (Fig. 4.22a-n). Applying the Ekman’s theory of wind driven currents, when the wind is onshore, the surface currents will move shorewards on average. This sets up the water level at the coast and creates a cross-shore pressure gradient that drives a return offshore flow at the bed. The reverse occurs in the case of offshore wind when the seabed currents head onshore. The progressive vector plot of current of May 1999 shows a southerly flow while wind vector during this period is northwesterly. In October 1999, westerly to southwesterly flow is observed while the wind is northwesterly. May-June 2000 and July-August 2000 currents show southwesterly flow while the wind vector during this period is predominantly northwesterly. Thus a clear correspondence between the winds and currents is evident in these cases. Exceptions to this correlation are also observed. For example in November 1999, a southeasterly flow was observed while the wind vector is northwesterly for few days and southwesterly after that.

The predominant winds in this region are from the northwest quadrant and so the wind-driven currents are mostly longshore to the south on the inner shelf. The dominance of southerly flow is quite evident from the progressive vector plots for different periods. On this wind-driven pattern is superimposed a shelf current associated with larger-scale circulation in the Indian Ocean. As already seen, this appears to take the form of an eddy, which stretches from Lakshadweep Island to the south-west coast and is opposed to the prevailing flows that pass around Sri Lanka and through the Arabian Sea (see Fig. 4.1). Consequently, the general current is directed north in the monsoon period around July. Thus when the northwest wind abates the shelf currents flows in response to the general circulation, although the net movement is southward. In addition to the three components viz. tidal, wind driven
and continental shelf currents listed above, there could also be the contribution of coastal trapped waves and baroclinic flow associated with the plumes of fresh water coming from the estuaries. The observed currents have lot of implication on the sediment transport in the innershelf and littoral zone. The predominance of southerly flows suggests that sediment in the innershelf is moving to the south. Onshore currents lead to accretion and offshore currents to erosion. The predominant winds are from the NW quadrant. These winds depending on the actual directions induce onshore and offshore currents deciding the net erosion-accretion scenario. This aspect will be studied in the next chapter on beach process.

Fig 4.22a-n Progressive vector plot of burst mean $S_4$ current meter data, for the deployments from May 1999 to November 2000 and Alleppey wind records. The cross-shore and alongshore current velocities are rotated onto a shore-parallel direction (23° relative to True North) to get shore-normal and shore parallel components. North-south is alongshore and positive east is onshore.
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