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WIND DRIVEN CURRENTS OVER ARABIAN SEA

1. Ekman (1905) showed theoretically that the effect of wind blowing steadily over an ocean of infinite depth, extent and uniform eddy viscosity is to drive the surface water at an angle 45° to the right of the surface wind direction in the northern hemisphere (to the left in the southern hemisphere). A few attempts have been made to test Ekman's theory by observations over selected areas of world ocean (Ekman 1953), but little is known about it's validity over Arabian Sea which is very much influenced by wind driven circulation during southwest monsoon. Using simultaneous observations of surface currents and winds an attempt has been made here to test Ekman's theoretical results for Arabian Sea.

2. Observations of surface currents and winds recorded in Arabian Sea and north Indian Ocean during ORV *Sagar Kanya*'s test cruise (3 in June 1983) have been used in the present study.

3. Three representative areas, namely, A, B and C (Fig. 1) have been considered.

(*i*) *Area A*

Current roses for area A for the periods 2-7 and 8-11 June 1983 are shown in Figs. 2(a and b) respectively. No. of observations is given inside the circle. The length of the arrow is proportional to the frequency of the current in that direction.

The interesting feature between 2&7 June, is that the surface currents in area A are predominantly ENE'ly (most of the currents are set to WSW). From 8 June onwards they turned anticlockwise and were set to S or E between 8 & 11 June.

Now let us look at the wind roses for area A for the periods 2-7 and 8-11 June (*see* Figs. 2 c and d).

Unlike currents the winds are predominantly SW'ly with very high constancy during both the periods, 2-7 and 8-11 June.

This shows that persistent SW'ly winds turned the surface currents towards S or E. The currents responded to the prevailing surface winds after about a week or so. This is in accordance with the Ekman's investigation. Ekman (1905) investigated the transient response to a suddenly imposed wind system and showed that it might take several days before his steady state solution was fully applicable.

Now the relationship between winds and currents may be investigated. From Figs. 2(b-d) it is clear that on most of the occasions currents deflected to the right of the prevailing surface winds in area A. The deflection angle was close to 45° on fairly large number of occasions.

(*ii*) *Area B*

Current and wind roses for area B for 12-14 June are shown in Figs. 2 (e & f) respectively. By 12 June the influence of SW'ly winds has reached the steady state

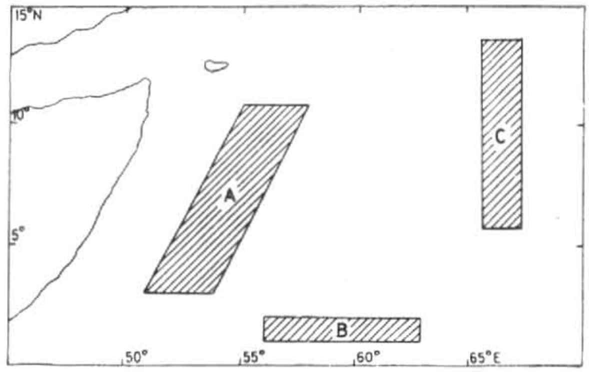


Fig. 1. The representative areas, A, B and C

and the seasonal surface currents are fully established. Most of the currents are set to E to NNE while winds are SW'ly to SSW'ly.

The observations show remarkable agreement with the Ekman's theoretical results. In addition to the turning of surface currents to the right of the wind the deflection angle close to 45° was observed on most of the occasions. The constancy of currents and winds both were quite high.

(*iii*) *Area C*

Current and wind roses for area C for 20 - 22 June are shown in Figs. 2 (g & h) respectively.

Most of the currents are set to SE to SSW. Therefore, the currents in area C have turned clockwise as compared to the currents in area B. Same is the case with the winds. The deflection angle was higher than 45° on most of the occasions. The currents were more variable than those observed over area B but less variable than those over area A.

4. The uncertainty of the wind stress-wind relationship, in addition to the poor knowledge of the value of eddy viscosity coefficients and their dependence on wind speed makes it very difficult to evaluate the speed of surface drift current. Thorade (1914) studied this relationship empirically on the basis of current observations. He was able to confirm the dependence of current speed on latitude. According to Thorade :

$$V = \frac{2\cdot 59\sqrt{W}}{\sqrt{\sin\phi}} \quad \text{for } W \leqslant 6 \text{ m/sec}$$

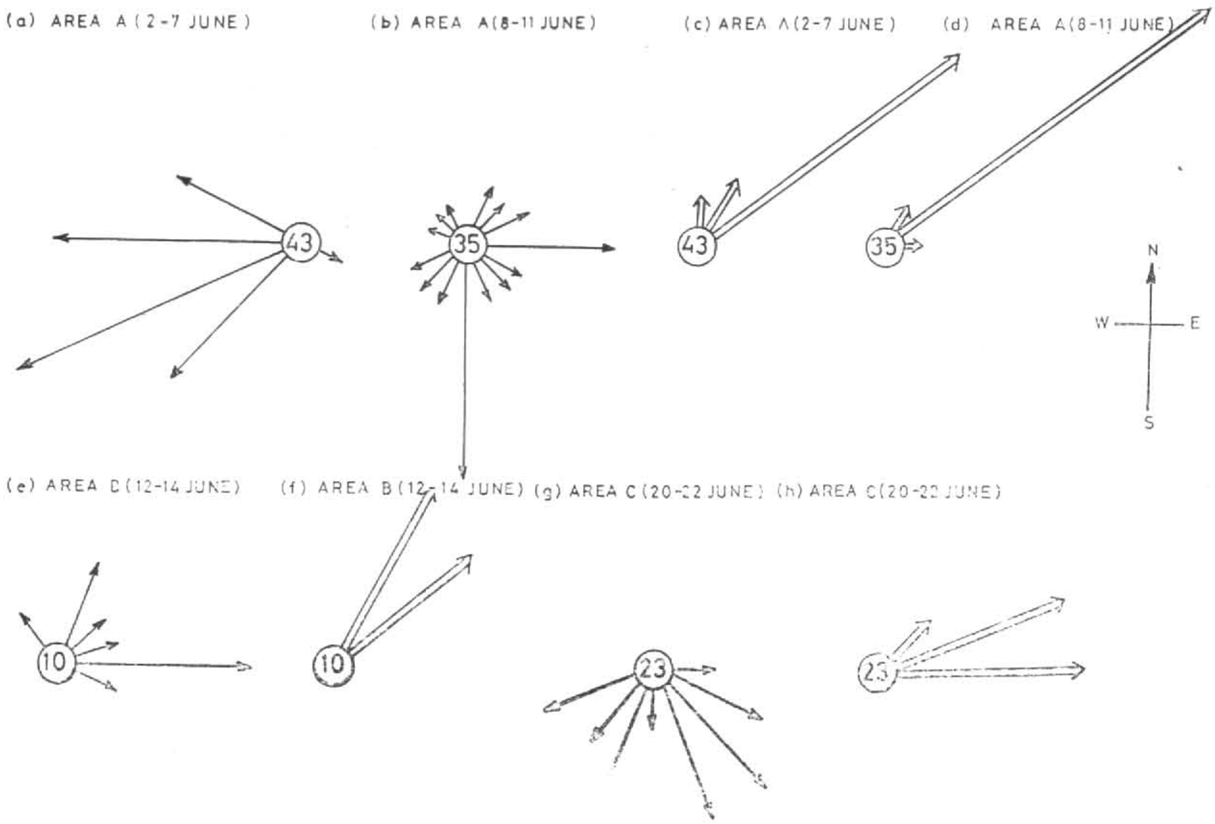
and

$$V = \frac{1\cdot 2W}{\sqrt{\sin\phi}} \quad \text{for } W > 6 \text{ m/sec} \qquad (1)$$

where V is the current speed in cm/sec and W is the wind speed in m/sec.

Durst (1924) obtained for currents in open ocean :

$$V = \frac{0\cdot 79\, W}{\sqrt{\sin\phi}} \qquad (2)$$



Figs. 2 (a-h). The current and wind roses for areas A (2-7, 8-11 June), B (12-14 June) and C (20-22 June)

TABLE 1

	Current speed ($\times 10^{-2}$ kt) for wind speed (kt)			
	8	12	16	20
Thorade	24.5	36.3	48.3	60.4
Durst	15.2	22.7	30.3	37.8
Present study	24.4	36.6	48.8	61.0

All available observations of current and wind for 10° N (about 35) were analysed and the following relationship has been suggested for 10° N in the Arabian Sea.

$$V = 3{\cdot}05 \times 10^{-2}\ W \qquad (3)$$

where, V and W both are in knots.

A comparison of the results for 10° N is given in Table 1. There is a remarkable agreement between the current speeds computed from relation (3) and those obtained from Thorade's Eqns. (1). Durst's (1924) Eqn. (2), however, gives slower speeds.

5. The following conclusions may be drawn :

(*i*) The surface currents were found to respond to the prevailing surface winds after about a week.

(*ii*) The deflection of surface current towards right of the surface wind was observed. This is in accordance with the results of Ekman's theory for pure wind drift current.

(*iii*) The relationship between current and wind for 10°N suggested here gives results that agree well with those obtained from Thorade's relationship.

References

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