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NIMBUS BUOY TRACKS IN THE N.E. ATLANTIC

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ABSTRACT

Two three month long tracks of satellite located buoys are analysed from an area south and west of Rockall. The difficulty in interpretation of such tracks without adequate supporting information is stressed and recommendations made for the minimum additional information that would be needed to analyse tracks from remote ocean areas.

The measurements of near surface currents to be reported here were made by satellite tracked buoys drogued at a depth of 50 m by a 13 m (shaped diameter) parachute. Details of the overall U.K. drifting buoy programme and the buoy construction are reported by Dickson (1974).

The positional data together with observations of surface wave statistics (which will not be discussed here) are relayed back to onshore receiving stations via the satellite NIMBUS 6. The frequency of position fixing is somewhat irregular and does not allow the full resolution of the tidal/inertial motions of the buoy although in some case the magnitude of these high frequency excursions may be estimated.

Fig. 1 shows a plot of latitute and longitude against time for a drogue track during the 10 day period July 3 to July 12 1976. It is, in this case, difficult to distinguish between random fixing errors and tidal/inertial excursions. The typical variations from a smooth progression are of the order of $\pm$ 3km(the positions are given to a resolution of 0.01 degrees of latitude and longitude - approximately 1 km N-S and 0.5 km E-W at this latitude). In order to study the low frequency motions of the buoy some smoothing is necessary.

In the data analysed here the latitude and longitude of the buoy positions were plotted against time in the manner of Fig. 1 and positions were estimated at 2 day intervals. The tracks of two buoys so derived are shown in Figs. 2 and 3. The first ran from Sept 30 1975 to January 2, 1976 (Fig. 2)and the second from February 3 to June 19, 1977 (Fig. 3). In both cases data transmissions stopped most likely due to battery failure. The data in Fig. 1 were from a buoy which lasted for approximately 30 days in 1976 in this case the buoy lost its drogue and was washed ashore in the west of Scotland. There are some appreciable gaps in the data from the 1977 buoy and these have been indicated by dashed lines.

In both of the long tracks there is an impression that the buoy motion is constrained by the general trend of the continental shelf edge to their northeast. The local 1,000 and 2,000 m contours are shown on the charts. The distribution of 2 day mean speeds shows maximum values around 40 cm/sec and speeds most commonly in the range 5-15 cm/sec.

The motion of the buoy is determined by the three main factors:

a) the wind driven circulation

b) the near surface expression of the non-wind driven circulation

c) errors induced by the windage of the buoy, by current shear between the sea surface and the depth of the drogue, and the drag force from the wave orbital velocity.

If we consider the error terms in (c) it is found that a 20 m/s wind would produce a direct slippage of the order of 3 cm/sec, and 5 cm/sec current shear between the buoy and the drogue depth would produce a negligible error. Saunders (1976) produced a detailed error analysis for a drogued buoy and considered a term due to the drag forces due to the wave orbital velocity. The force has a mean value $\frac{1}{2} \rho A C_D (c.\overline{U}.a\omega)$ where ρ is the water density.

A the cross sectional area of the submerged buoy

C_D the appropriate drag coefficient (1.1)

C a constant between 1.5 and 1.27

$\overline{U}$ the mean surface current speed

$a\omega$ the wave orbital velocity

The force magnitude for a 50 cm/sec orbital velocity is found to be 2.2×10^6 dynes compared with 2.6×10^7 dynes for a 40 kt wind. This would lead to a spurious current of the order of 2 cm/sec. The force acts approximately in the direction of the mean current in the case when the current and wave field are not colinear.

The error terms although complex and acting in various directions are in general small < 5 cm/sec but could be significant in areas of weak current and strong winds.

The relationship between the surface wind field and the measured currents is shown in Fig. 4 for the buoy track in 1975. The wind values are predictions by the Meteorological Office for the ½ degree rectangle in which the drogue is found on any particular day. The plotted values are daily vector means of six hourly predictions. Subject to the inherent uncertainties in the wind field values the response of the surface currents to wind fluctuations with periods of 5-10 days is clear. The response to long period fluctuations is better appreciated by plotting a progressive vector diagram from the wind values (Fig. 5). This figure is scaled by 2% (the same scaling as is implied by Fig. 4). Differences in the buoy response through the period of observation now become clear. From day 273 to 327 the wind is predominantly south westerly but during this time there is relatively little mean motion of the buoy. Between days 327 and 357 with westerly and northeasterly winds the buoy responds in a fashion which follows closely the mean motion of the wind.

There are several possible explanations of this change:

a) The drogue may have become detached from the buoy around day 327. This rather drastic interpretation is difficult to assess. The buoy was not recovered and there was no telemetry of the integrity of the buoy-drogue system. The failure of the drogue may at times be difficult to detect. Fig. 6 shows an example of the wind-current variability in a case where the buoy was known to have become detached from its drogue at the time marked by the arrow - the failure is not obvious.

b) A possible explanation is that the mixed layer in the area deepened to a point where at about day 327 it exceeded the drogue depth. Thus the drogue which had previously been partly isolated from the surface forcing by the thermocline would have started to behave in a manner more similar to the wind. There were no temperature measurements made from this buoy and the few XBT observations in the region at that time were in a small area well removed from the track. These measurements in early November (days 305-310) show mixed layer depths between 60 and

and 80 m, not greatly different from the 50 m drogue depth. Without detailed knowledge of the local variability of mixed layer depths the relevance of this mechanism is difficult to assess.

(c) The most probable explanation of the change of behaviour is the interaction of the wind-driven and wind-independent current components. Support is lent to this hypothesis by the fact that between days 273 and 327 there are occasional winds from the west and north west e.g. days 287-289, 303-305, and during these periods the drogue does respond in a manner similar to that of the latter part of the track. The implication is that winds from the south-west quadrant produce a wind driven circulation that opposes and approximately equals the non-driven flow and that the periods of north westerly and north easterly winds produce currents that add to the non-wind current. Since the non-wind current is most unlikely to remain constant over the 3 month period of the observation it is impossible to separate the contributions of the two components.

CONCLUSIONS

This study highlights the difficulty in interpreting the tracks of these buoys. The main problems are as follows:

1) Without telemetry of the attachment of the drogue it is difficult to tell from the track alone when the drogue becomes detached - this is particularly true in areas of weak winds.

2) There may be marked changes in the buoy behaviour depending on the relationship between the drogue depth and the depth of the mixed layer. The addition of thermistors along the buoy line or at least at the upper and lower ends of that line would help with this problem.

3) For work in remote areas (e.g. Antarctic) the only source of meteorological data may be the buoy itself. The development of sensors for both wind speed and direction even for buoys with a primarily oceanographic objective should be of high priority although the problems of making such sensors work reliably when only a very few metres above the sea surface are probably great.

All of this subsidiary information is probably essential for a full analysis to be made of the buoy tracks.

REFERENCES

Dickson, R.R. (1974) U.K. Plans for drifting buoy experiments during the NIMBUS-F (TWERLE) programme. ICES Hydrography Committee C.M. 1974/C:15.

Saunders, P.M. (1976) Drifting Buoy Langrangian Test. Unpublished Manuscript prepared for NOAA Data Buoy Office. (Contract NAS 13-5).

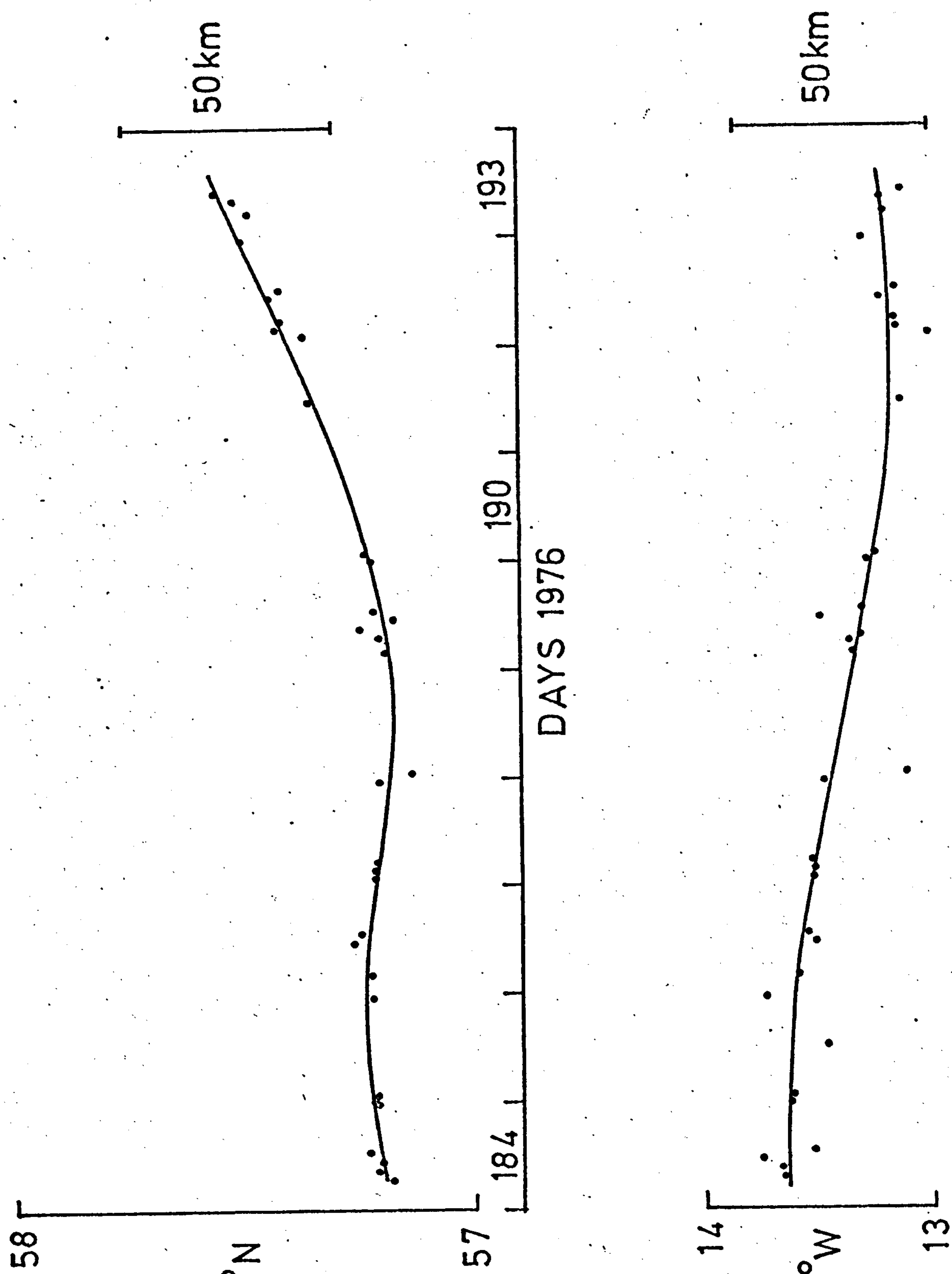

Figure 1. Plot of latitude and longitude against time for long buoy track in 1976 illustrating the errors in position fixing and typical fix frequency.

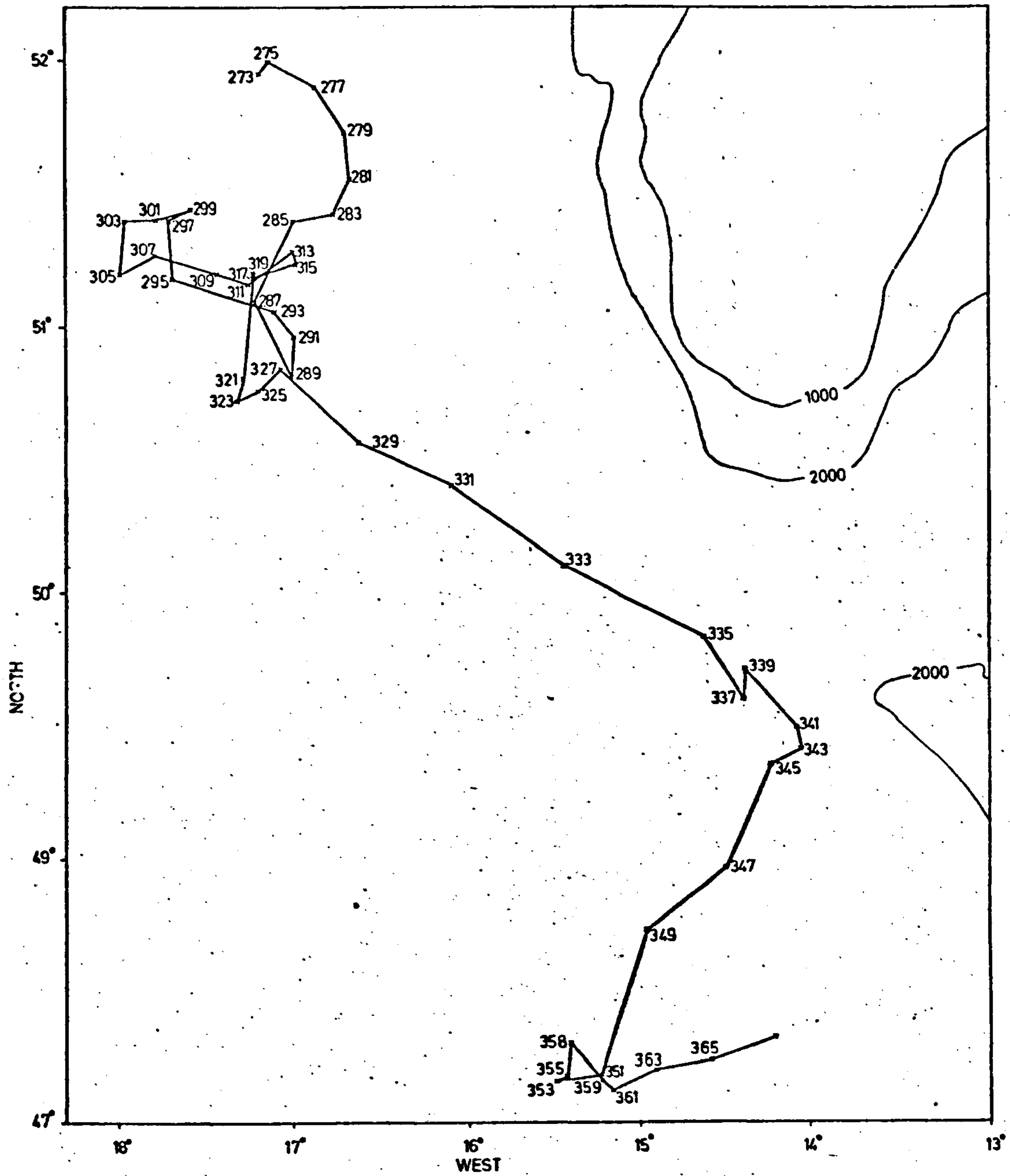

Figure 2. Buoy track 1975.

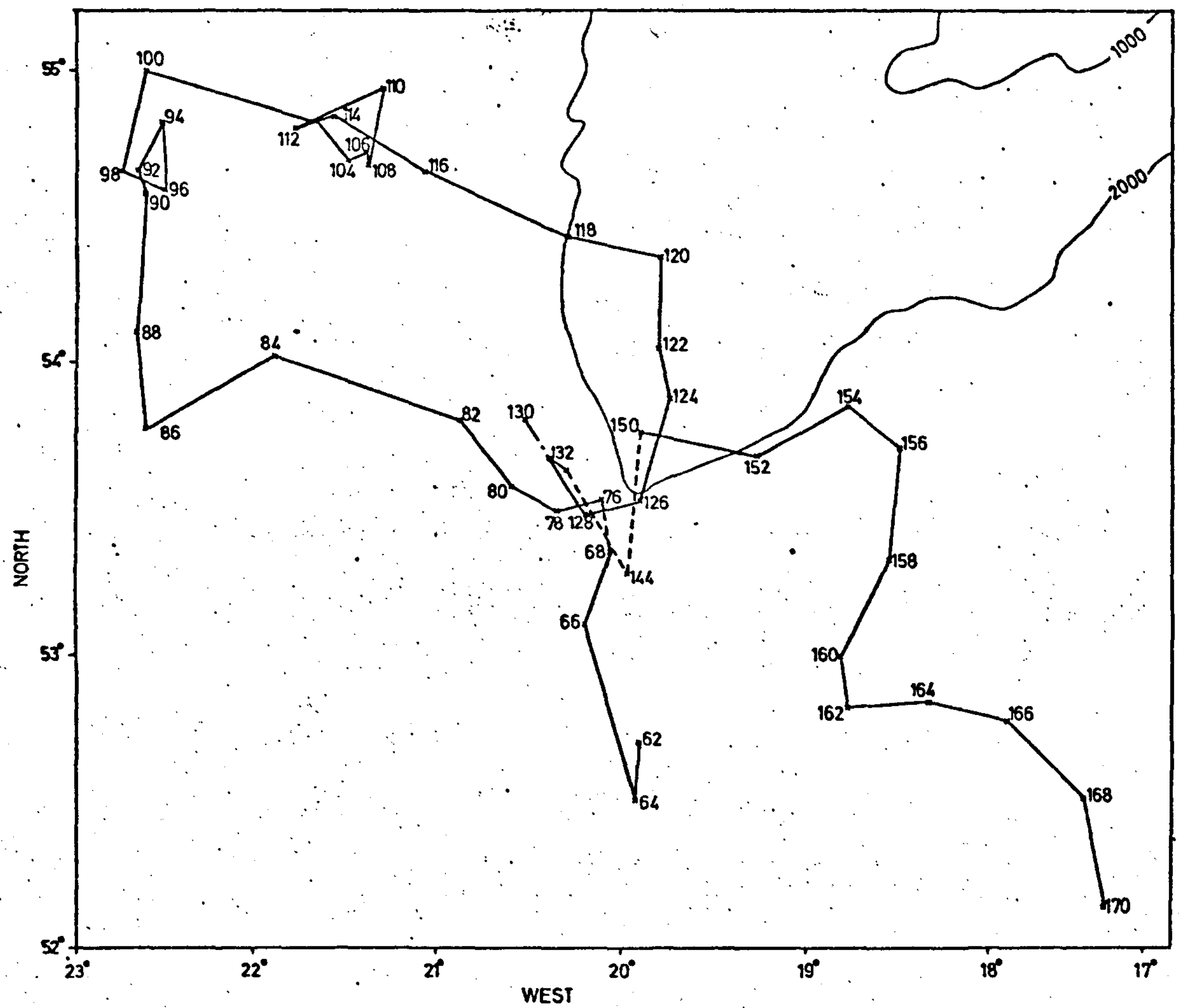

Figure 3. Buoy track 1977.

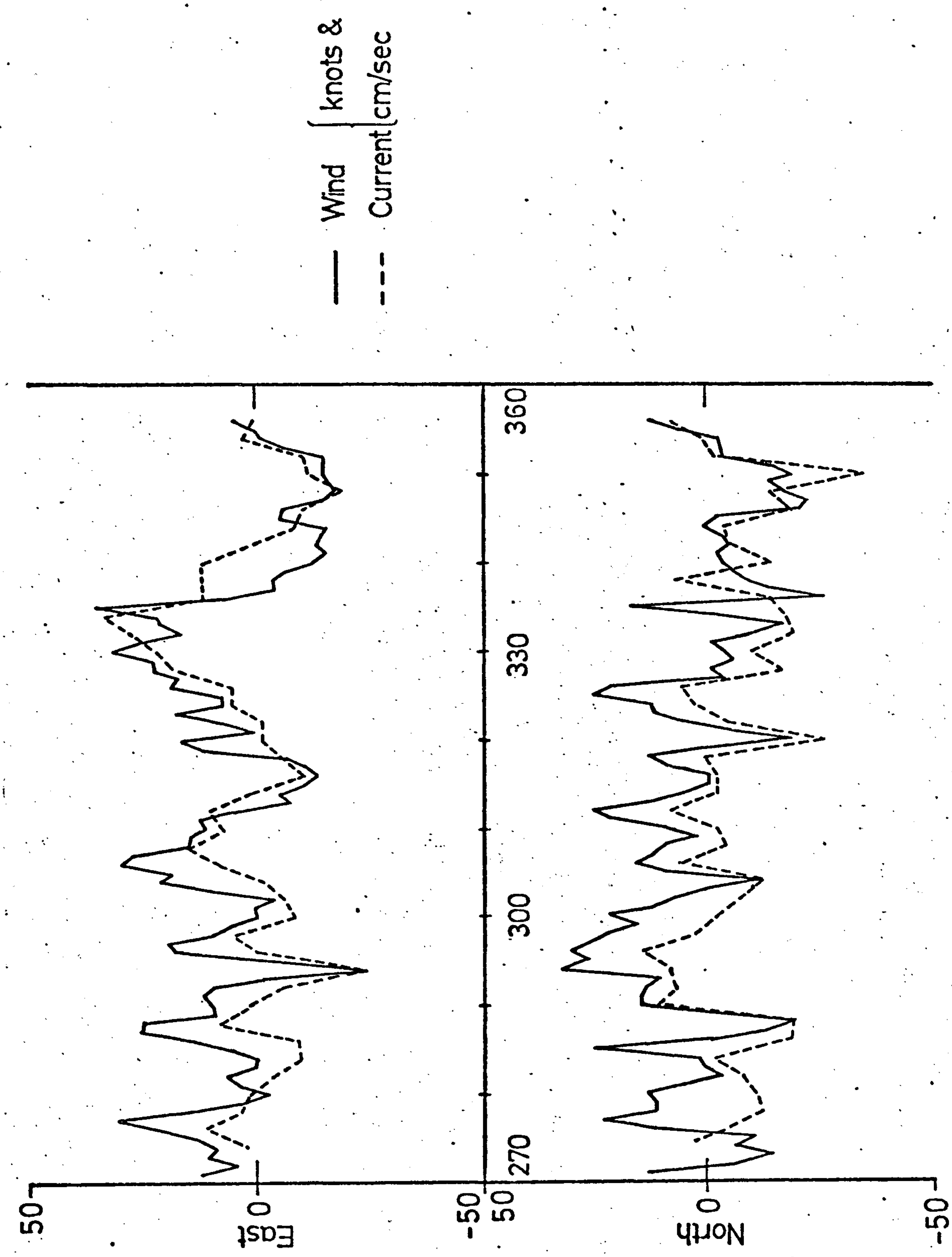

Figure 4. 2 day mean current vectors and daily mean winds for the 1975 buoy.

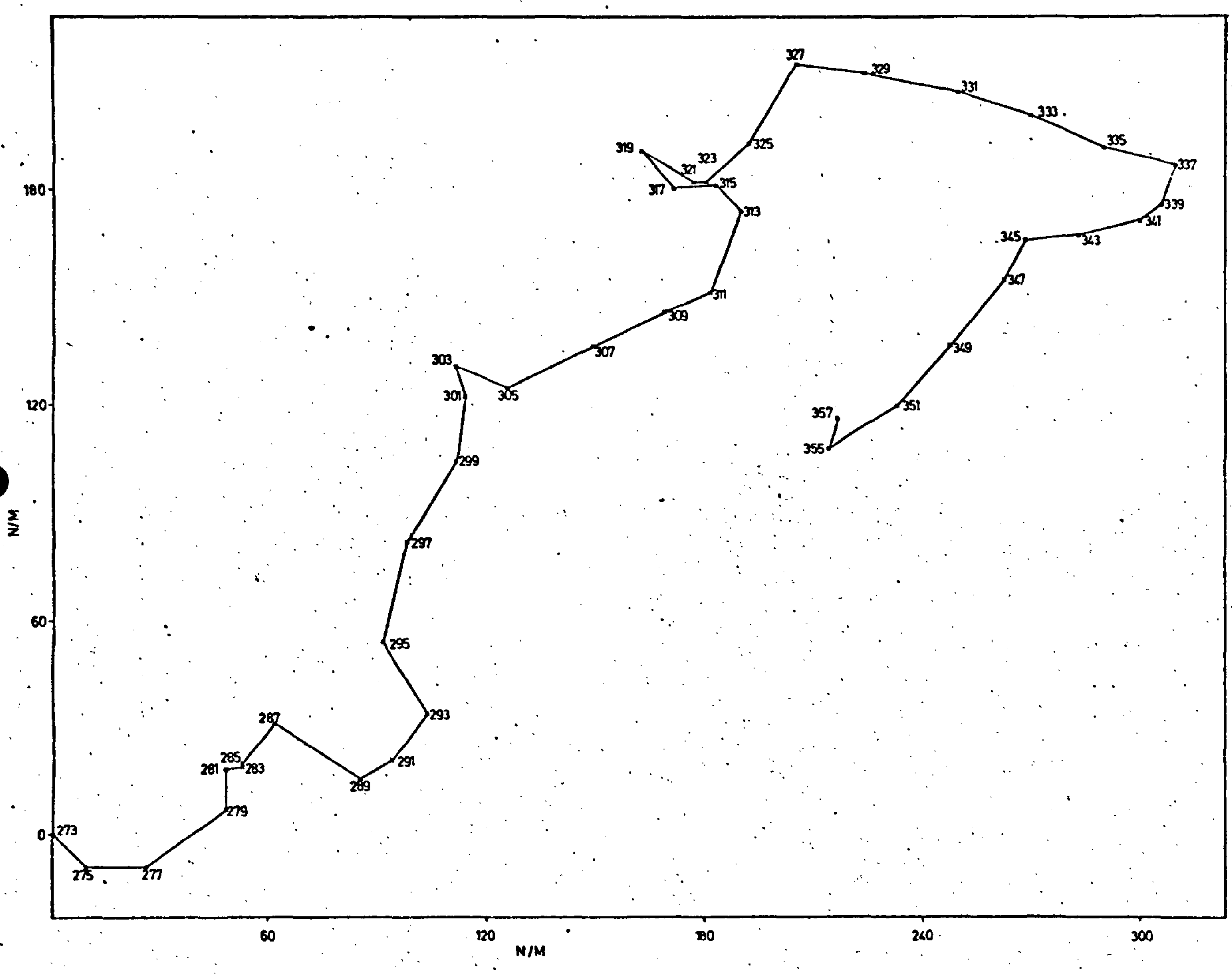

Figure 5. Wind progressive vector diagram corresponding to the buoy data in Fig. 2.

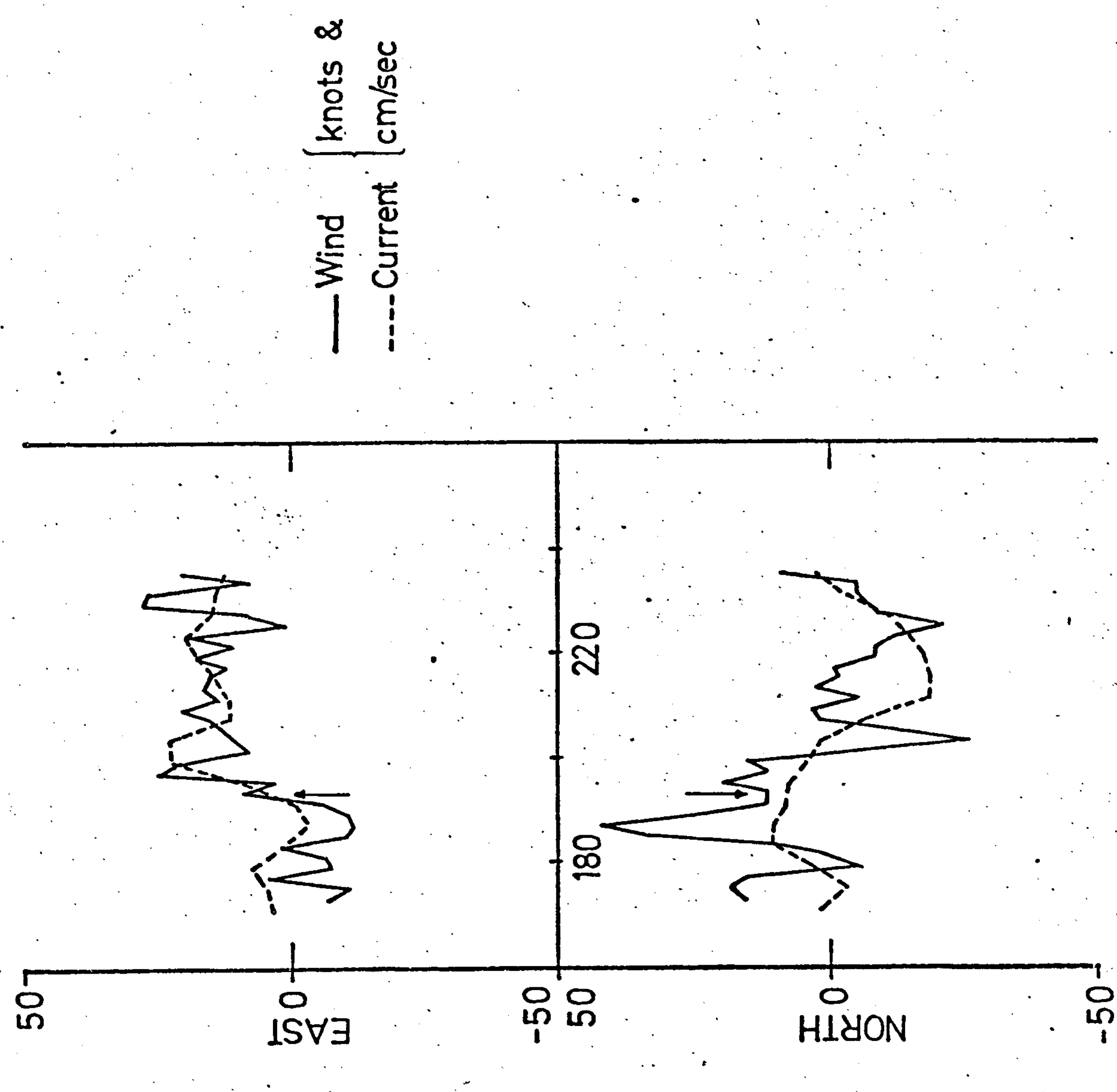

Figure 6. Wind and current data for buoy track in 1976. Arrow marks point at which drogue was lost.