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RESULTS OF AN INITIAL TRIAL OF A SATELLITE TELEMETERING BUOY MEASURING NEAR SURFACE CURRENT

P.G. Collar and C.A. Hunter

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey GU8 5UB
(042-879-4141)

(Director: Dr. A. S. Laughton, FRS)

Bidston Observatory,
Birkenhead,
Merseyside L43 7RA
(051-653-8633)
(Assistant Director: Dr. D. E. Cartwright)

Crossway,
Taunton,
Somerset TA1 2DW
(0823-86211)
(Assistant Director: M. J. Tucker)

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Results of an initial trial of a satellite telemetering buoy measuring near surface current

An initial trial was made during Discovery Cruise 132 of a satellite telemetering drifting buoy which incorporates a vector averaging electromagnetic current meter (VAECM). This has been developed for two reasons:

(a) When used as a drifter it enables measurements to be made of the integrated slippage past the hull. This, combined with the vector displacements derived from the Argos system should provide a much improved estimate of near-surface current, by eliminating, for example, spurious contributions arising from wind forcing of the buoy through the water.

(b) A need was foreseen for obtaining near-surface current data from moored instruments on a long term basis in near-real time.

The buoy has the form shown in Fig. 1. It is discus shaped and can carry a payload of ~150 kgm, so enabling an adequate number of batteries to be carried to run the VAECM for several months.

Within the hull, as much of the equipment as possible is carried in individually sealed cases. Thus the buoy should continue to function even if the main equipment compartment seal fails. Beneath the buoy the electromagnetic sensor is mounted around a central tubular spar through which all cables are led into the hull. This arrangement allows a length of chain (or wire and drogue) to be carried beneath the buoy so as to provide a righting moment in the event of capsize, while affording some degree of protection for the sensor. The sensor is mounted at a depth of 0.75 m beneath the hull, i.e. ~1 m beneath the water line. Tow tank tests conducted on a ½ scale model suggested that errors in flow arising from the presence of the hull should be insignificant.

The initial tests were carried out on the buoy when used as a drifter. The VAECM was powered continuously and produced vector averaged E and N components once every half hour. These, together with rectified E and N values, spot compass reading and serial number, were read into a buffer store of 512 bits capacity, i.e. 8 samples or 4 hours of data. Argos transmissions are made at 56 second intervals and the system has a capacity of 256 bits. The store was therefore arranged to recirculate and thus transmission of the entire contents was effected every 112 seconds.

In the initial tests, conducted near $40^{\circ}N$, $20^{\circ}W$, the buoy was deployed without a drogue, but carried a wire and length of chain beneath the spar. It drifted steadily southwards under the influence of a strong NNE wind until the early afternoon of the following day, at which time it was recovered, equipped with a drogue at 80 m depth, and redeployed. The wind generally increased over the next few days, reaching storm force, although conditions were calmer by the time the buoy was recovered approximately 9 days later. Buoy positions were received throughout this period, but current meter data became garbled during the fourth day and ceased altogether a day or so later.

Inspection of the buoy on retrieval pinpointed several weaknesses, one of which had caused the loss of data. First, the mechanical construction was inadequate: maximum loads were probably imposed during the deployment/retrieval and these induced cracks in the welded seams at the base of the hull. However, the hull interior remained dry. Secondly, the antenna cover gasket was sealed against a thin metal plate, which, in flexing, admitted water to the compass gimbal housing. Although further contained in a metal can, the compass assembly is not watertight and ultimately a modest amount of water found its way there also, destroying the compass electronics and shorting a current meter supply. Overall some valuable lessons were learned from this first deployment, not the least of which is the need for double sealing of <u>all</u> equipment.

RESULTS

The E and N components of the slippage corrected to true North are plotted in Fig. 2. The records are not continuous. The gaps arose mainly because at the twice hourly sampling frequency adopted the store size could not always cope with the interval between satellite passes. Values have been interpolated where necessary. There is also uncertainty in the data caused by the inclusion in the vector-averaged signal of a small zero offset. This is known to have remained constant throughout the deployment (to within ± 0.9 cm/s, the resolution of the system), but for several reasons it was not balanced out beforehand. However, for much of the time the heading of the buoy remained reasonably constant - judged by the spot compass samples - and it has been possible to examine the effect of an offset on the measurement and to derive a first order correction. Overall the results are not greatly affected by the inclusion of the offset, although the high frequency 'noise' evident at times during the first half of the data may result from inadequate correction: the heading was more variable in the absence of the drogue.

The major feature in the data is the reversal of sign of the North component of the slippage on attachment of the drogue. Until that time the slippage was ~7 cm/s in a generally N.E. direction, consistent with the forcing of the buoy through the water by the NNE wind. Thus, approximately one third of the total displacement of the undrogued buoy over the Earth's surface can be attributed to wind forcing. On attachment of the drogue at 80 m depth, the steady southward progression ceased; the abrupt change of sign in the N-S slippage suggests that the buoy was then recording a wind driven near-surface component.

In Fig. 3 the displacements and integrated currents have been combined between adjacent position fix times to produce resultant currents over the Earth's surface. While the buoy was wind driven these were consistently slightly East of South (173°) and over approximately 24 hours were 13.8 cm/s. With its drogue attached the buoy apparently moved to the West before turning south and then consistently eastwards to the point of recovery. During this period the currents are remarkably well correlated with the displacements, and the southward component apparently weakened: a 36 hr average yielded 7.8 cm/s at 177°.

The accuracy of these results overall is difficult to estimate. Some aspects are very plausible, others are less easy to understand, for example the sudden westward change in current between Day 40.67 and 40.74, following a quiescent period of nearly 22 hours. The rather close correlation between current and displacement may reflect a real eddying motion: the region contained a frontal system and motions were consequently far from predictable. (For example, another buoy similarly drogued and deployed at the same time close to the original deployment position showed little inclination to move for several days and then moved rapidly (~10 cm/s) to the south east.) It had been intended to mount a recording VAECM above the drogue, and to equip the buoy with a temperature sensor. In the event neither measurement could be arranged. Unfortunately, also, lack of time precluded a Batfish survey which would have defined better the structure of the front.

An alternative explanation is in terms of noise in position determination by the Argos system, perhaps in this case resulting from position correction routines. We shall now investigate this further since it may determine the minimum scale at which the technique can be usefully applied.

CONCLUSION

The characteristics of the satellite system are not easily matched to the efficient collection of an evenly sampled time series. The present arrangement resulted at times in the transmission of much redundant data - and in spite of this some data were lost through uneven satellite coverage. Nevertheless the transmission of data is inexpensive compared with the cost of position location - and there may be improvements which can be made. In the case of a drifter the advantage of using the transmission link rather than recording in-situ is that a data set can be accumulated even if the buoy is ultimately lost. Likewise the output of a moored system can be monitored continuously for correct operation and there is an additional advantage in that the position of the buoy is available in the event of loss of mooring integrity.

We are encouraged by even these modest results to proceed further. It is planned to moor the buoy at some suitable location later this year in order to test engineering modifications. Early next year it is hoped to test its accuracy of measurement by making comparisons with the rate of displacement of acoustically tracked drifting floats.

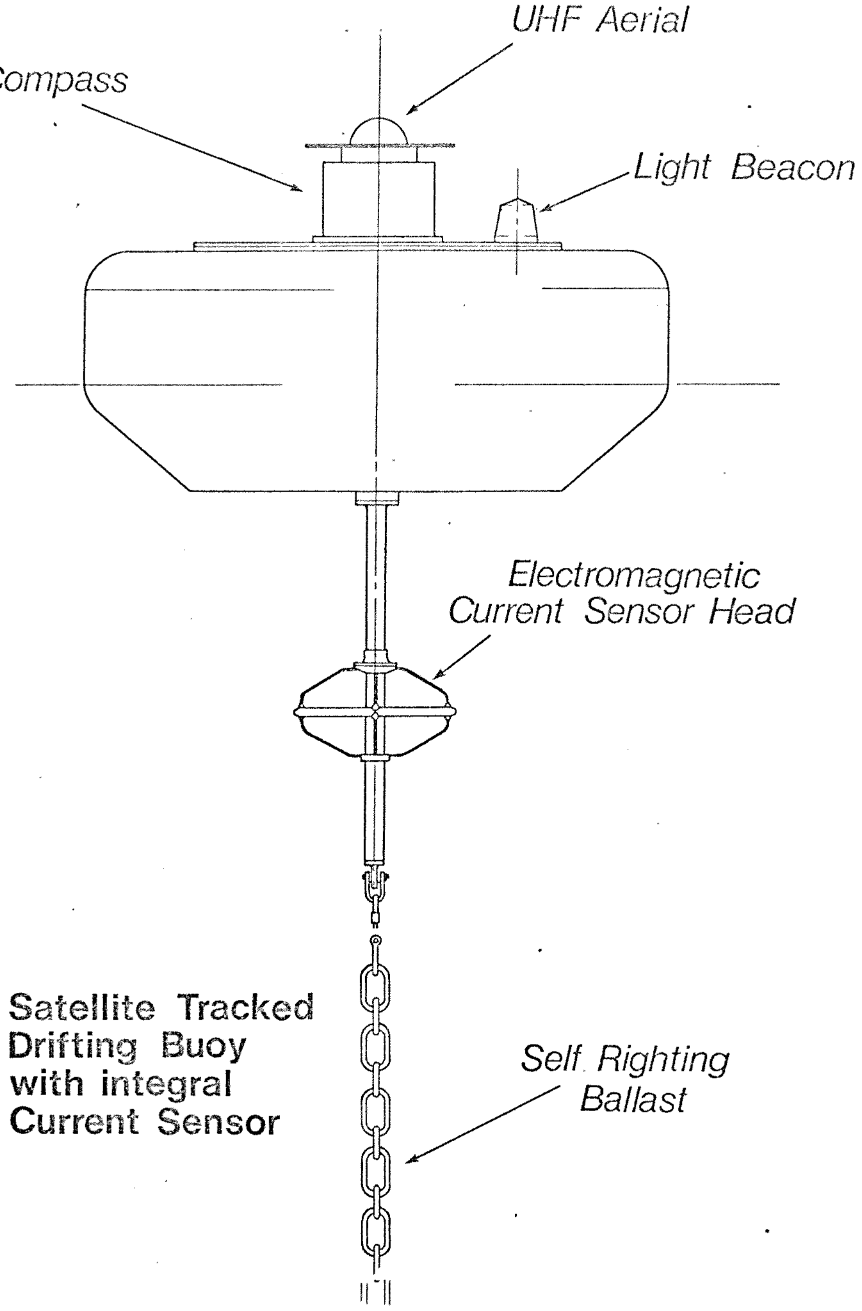

Fig.1 Satellite Tracked Drifting Buoy with integral Current Sensor

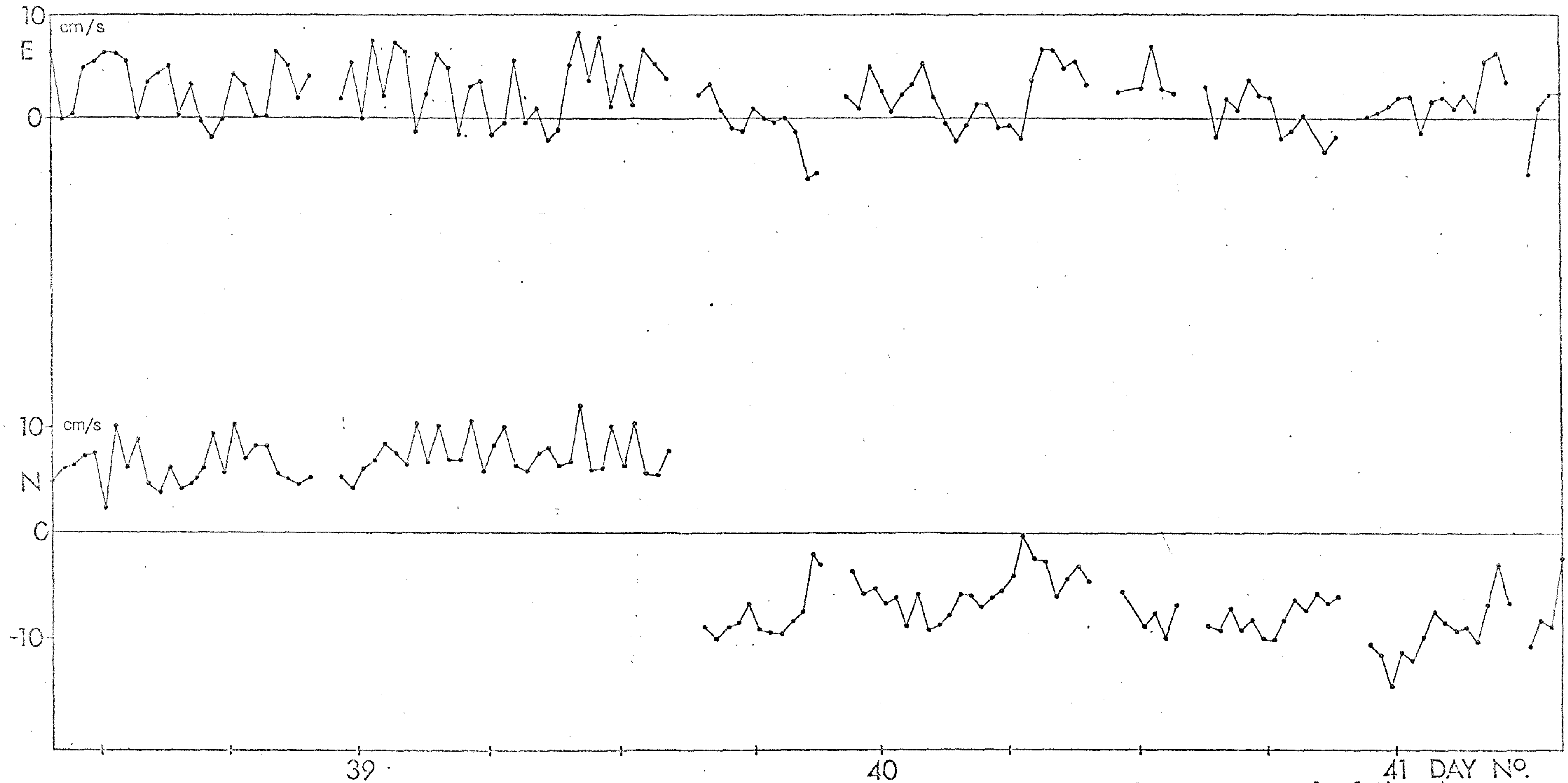

Figure 2. Continuous half-hourly averages of current slippage measured by buoy. Reversal of the sign of the North component in the early afternoon of Day 39 corresponds to the attachment of the drogue at 80 m depth. Prior to this wind drag had forced the buoy steadily downwind.

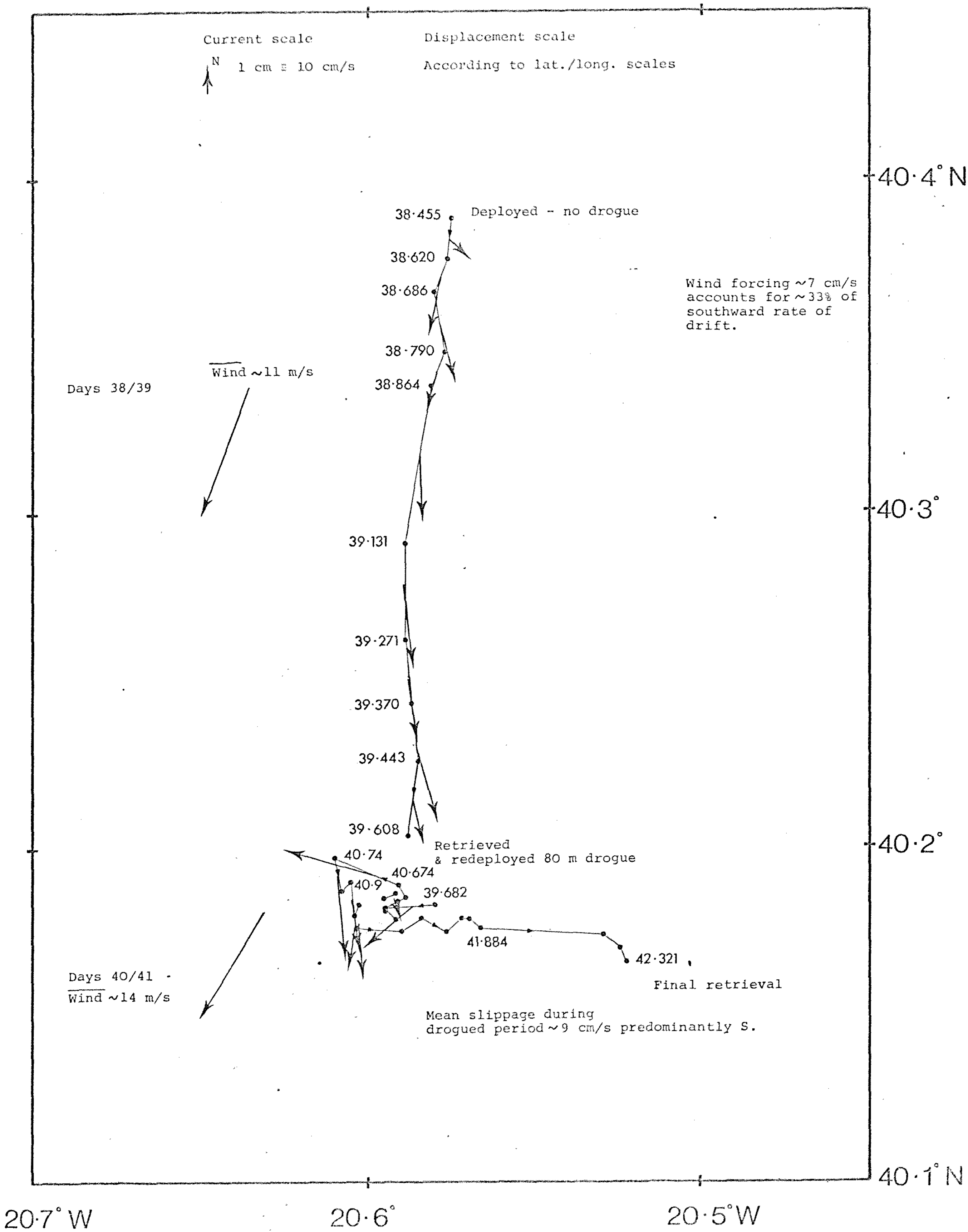

FIGURE 3. PLOT OF BUOY TRACK AND ESTIMATES OF NEAR SURFACE CURRENT. THESE HAVE BEEN DERIVED BY COMBINING DISPLACEMENT VECTORS AND INTEGRATED VECTOR SLIPPAGE BETWEEN FIX TIMES.