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Theme Session S

CURRENT MEASUREMENTS OVER THE UPPER SLOPE OFF THE WEST COAST OF PORTUGAL, 1994-1995

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Abstract

In an attempt to study the characteristics of the slope current off the Iberian Peninsula, as part of its contribution to the EU funded project SEFOS (Shelf Edge Fisheries and Oceanography Study), the Instituto Hidrográfico, Lisbon, Portugal, has been carrying out current measurements in the upper 600 m of the water column over the upper continental slope off the west coast of Portugal.

At latitude 39° 45′ N, a clear northward slope current was observable in the upper 300-400 m over 910 m bottom depth, from October 1994 to January 1995, and again in April 1995. The mean monthly signal was baroclinic, with maximum values close to 11 cm s^{-1} around 200 m in October, and 100 m in December 1994. The northward (residual) current reached 35 cm s^{-1} in December 1994. 16 km offshore, over 2300 m bottom depth, the current showed larger cross-slope fluctuations than over 910 m, except in April 1995, when the current was clearly polarized along the slope at both moorings, with maximum velocity between 100 m and 150 m. This suggests that the core of the current is usually close to (or inshore of) the 900 m isobath, with occasional meanders, as might have happened in April 1995.

INTRODUCTION

Slope currents along eastern ocean boundaries, either as undercurrents or with surface expression, have been widely reported in the literature (e.g. Neshyba, Mooers, Smith and Barber, 1989). Off Portugal, such current has been identified on satellite images as a warm filament a few tens of kilometers wide, as well as on hydrographic data collected during winter (Frouin, Fiúza, Âmbar and Boyd, 1990). The existing direct current measurements are, however, sparse and of short duration.

As part of its contribution to the European project SEFOS (Shelf Edge Fisheries and Oceanography Studies), the Instituto Hidrográfico, Lisbon, began a series of direct current measurements over the upper slope off the Portuguese west coast. This is a short report on the corresponding findings. This paper reports the results that were successfully gathered from May 1994 to October 1995 in three moorings: one at the latitude of SEFOS Standard Section 1 (37° 45′ N), over 491 m depth, and the other two at the latitude of Section 2 (39° 45′ N), over 910 m and 2300 m, each one consisting of 4 Aanderaa current meters at nominally 50, 100, 300 and 600 m (or 480 m).

DATA AND METHODS

In May-June 1994 two pairs of moorings were deployed along the lines defined by the SEFOS Standard Sections 1 and 2 (Turrel et al., 1995). Assistance to the moorings was provided in November-December 1994 and again in October 1995. Due to accidents or malfunctions some of the series may have been significantly reduced as shown in the table below. The mooring locations are indicated in Figure 1. Mooring 1A was never recovered and therefore is not displayed in the figure.

Mooring	SEFOS Section	Bottom depth (m)	Actual depth of the observations	Valid period of the observations
1A	1	200	50-100-190	LOST
1B	1	491	59 104 295 482	21 Jun - 15 Sep 1994[a] 21 Jun - 12 Jul 1994 21 Jun - 15 Sep 1994 21 Jun - 09 Dec 1994
2A	2	910	145 195 390 680	10 May - 23 Nov 1994 16 Jun - 23 Nov 1994 10 May - 23 Nov 1994 10 May - 23 Nov 1994
2B	2	2300	50-100-300-600	LOST
2A	2	908	97 145 342 639	23 Nov 94 - 29 May 95 23 Nov 94 - 29 May 95 23-26 Nov 1994 23 Nov 94 - 29 May 95
2B	2	2300	72-120-312-615	14 Dec 94 - 11 Oct 95

a) An interruption of ca. 24 hours occurred in the series on 16 July

Aanderaa RCM 7, or RCM 4, have been used in all moorings, set for a sampling rate of 1 per hour. Following validation, the series have been submitted to a spectral analysis in order to find the best cutoff period to remove tidal and inertial frequencies. Residual currents were thus obtained by passing a seventh order Butterworth filter with a cutoff period of 35 hours.

RESULTS AND DISCUSSION

Comparative statistics of the original and the filtered time series in all moorings provide indication of the amount of variance contained in the low-frequency domain. As can be seen from the table below, the residual current contains a major part of the variance in the N-S component at the latitude of Section 2. The variance of the E-W component of the residual current is much smaller than that of the N-S component in mooring 2A, but of similar magnitude in mooring 2B, which may be associated with different topographic steering (see Figure 1). It is, however, interesting that in the lowest level of mooring 2A, while the variance level (not shown) is much smaller than above, the percentage contained in the low frequency is similar in both current components. On the other hand, while the variance of the E-W current component in mooring 2B has a similar magnitude throughout the water column, its residual part looses importance. In mooring 1B the variance retained in the low frequency is nearly the same in both current components, being quite smaller in the N-S component than in the time series from the two northern moorings, which may be a result of a much smaller topographic steering.

Variance in the low frequency domain (residual current) as a percentage of the variance in the original series			
Mooring	Depth of observation (m)	E-W component	N-S component
1A (Jun - Dec 1994)	59	32.7	48.4
	104	33.9	49.2
	295	35.3	29.7
	482	27.7	27.7
2A (May - Nov 1994)	145	10.3	62.3
	195	9.9	61.2
	390	12.5	51.4
	680	28.3	27.5
2A (Nov 94 - May 95)	97	24.6	64.4
	145	21.9	72.0
	(a)	(a)	(a)
	639	21.0	30.8
2B (Dec 94 - Oct 95)	72	63.4	61.2
	120	66.0	68.2
	312	52.7	57.1
	615	39.4	66.0

(a) The series is only 4 days long

Figure 2 shows current spectra of the original, unfiltered series obtained in the upper current meters in moorings 2A and 2B in 1995, showing a detail of their low-frequency domain. Obvious peaks of variability correspond, as expected, to the semi-diurnal tide and the inertial frequency. A tidal harmonic is also identifiable, although with a much lower energy level. The energy level in the low frequency domain is quite significant and some energetic bands are observable: that around 5 days in mooring 2B is quite prominent, and present throughout the water column. Also to be noticed the higher energy in N-S component in mooring 2A and the reverse situation in mooring 2B.

In most of the spectra obtained with blocks of 1024 hours the second spectral estimate (21.3 days) appeared quite prominent. When the analysis was made with half the fundamental frequency the peak was centered either around the same period or around 42.6 days. Although it was not possible to obtain a good statistical significance at such periods given the length of the series, one was led to look for basic periods around 1 month to perform another statistical analysis. The actual time intervals for the statistics have been chosen in such a way that, whenever possible, they would not contain any major current reversals in the upper three series of mooring 2A. The results of such statistic calculations are presented in Figures 3-7.

When analyzing Figures 3-7 it is necessary to bare in mind that the surface layer - understood as the upper 50-100 m, - was never covered by the measurements. In mooring 1B, almost 40 km away from the coast, it is just possible to observe what might have been the onset of the upwelling by early July and its further development until September. A southward jet, or its outer border (5 cm s^{-1}), appeared in the area and progressively extended downward, while an eastward compensation current (2-5 cm s^{-1}) could be seen down to about 300 m. No evidence was found of a northward undercurrent.

Until mid-September 1994, the situation observed in mooring 2A (Figure 4) was not much different from that in mooring 1B, except for the negligible cross-slope component. In late September a northward current became evident, a situation that persisted until the end of January 1995 (Figure 5), with the tendency for the largest values to be found at shallower levels. In February, while the monthly mean longshore current component was negligible at mooring 2A, it became evident in Mooring 2B throughout the whole observed water column (Figure 6), which points to the possibility of a long periodic meander. In April 1995 the longshore current was similar in both moorings, in a suggestion that the current core might have been centered in between them. In May the situation observed the previous year at the same season was apparently resumed, again lasting the whole summer during which the motion was basically southward at mooring 2B (Figure 7). Throughout the observational period the mean monthly cross-slope component was negligible, except in January 1995, when it was important and towards the coast in both moorings, particularly 2B.

At the deepest observational level, below 600 m, the monthly mean was usually very small at both moorings, pointing to a very weak circulation at the distribution levels of the Mediterranean water, that was probably shifted offshore due to the effect of the submarine promontory south of Section 2 (Figure 1).

In some disagreement with the generally accepted idea that the slope current is maximum in winter, the results of the investigations now being reported point to a maximum expression of the current in late autumn, which is quite evident in the progressive vector diagrams of the residual current presented in Figure 8. On the other hand, the usual absence of the current signal in one of the moorings when it is present in the other (which is only 16 km apart) points to its filament nature. Finally, the recurrent presence of the slope current in autumn and winter at mooring 2A together with the proximity of the 200 m isobath, which roughly coincides with the shelf edge, provides reasons to suspect that the transport at the outer shelf may be non-negligible.

REFERENCES

Frouin R., A.F.G. Fiúza, I. Âmbar and T.J.Boyd (1990) Observations of a poleward surface current off the coasts of Portugal and Spain during winter. *Journal of Geophysical Research*, **95**, 679-691.

Neshyba S.J., C.N.K. Mooers, R.L. Smith and R.T. Barber (Eds.) (1989) Poleward flows along eastern ocean boundaries. Coastal and Estuarine Studies, **34**, Springer-Verlag, New York, 374 pp.

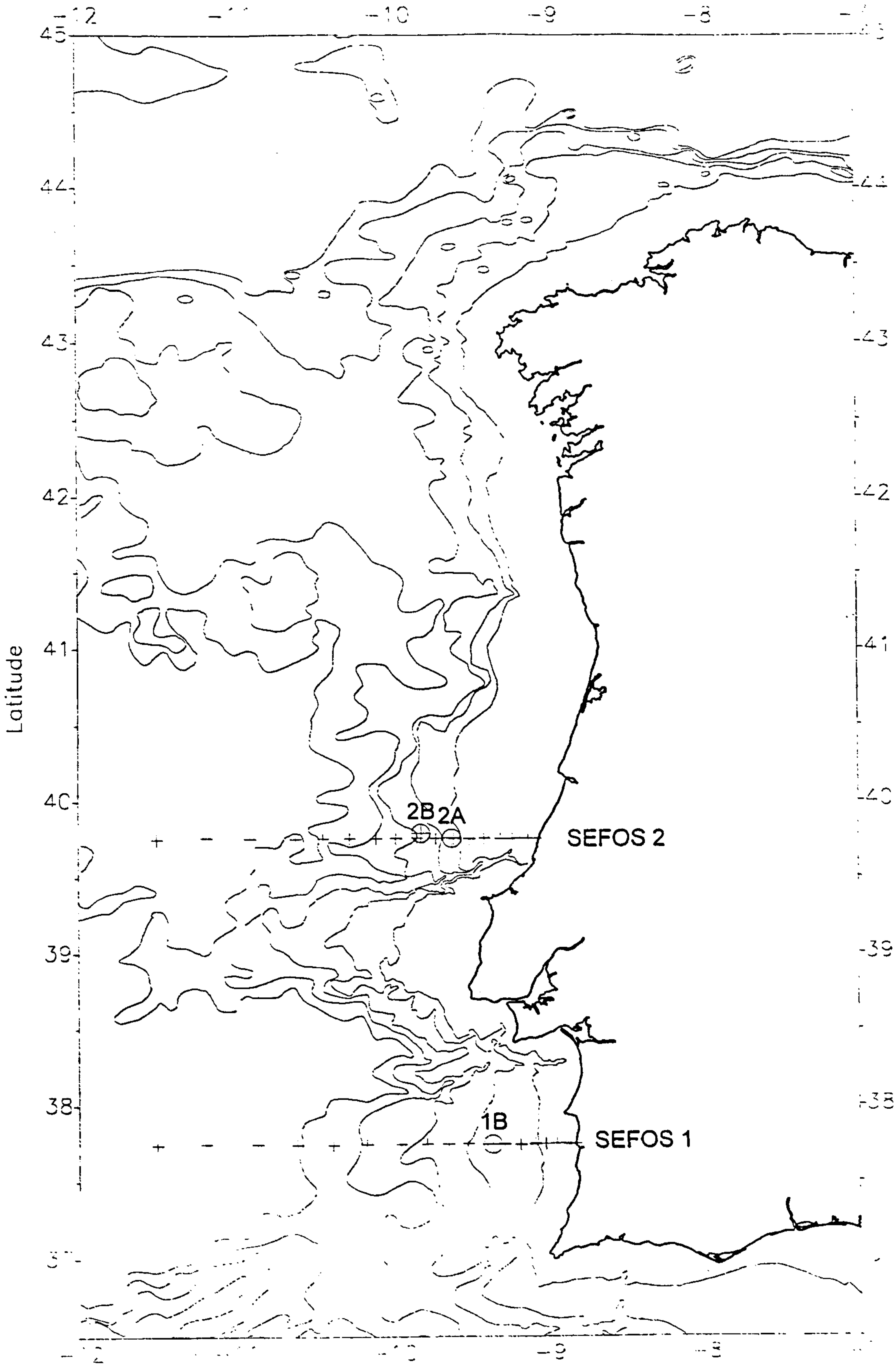

Figure 1. Bathymetric chart of the W Iberian Peninsula and positions of the current meter moorings. Station positions for SEFOS Standard Sections 1 and 2 are also referenced. Isobaths correspond to 200 m, 1000 m, 2000 m, 3000 m, and 4000 m.

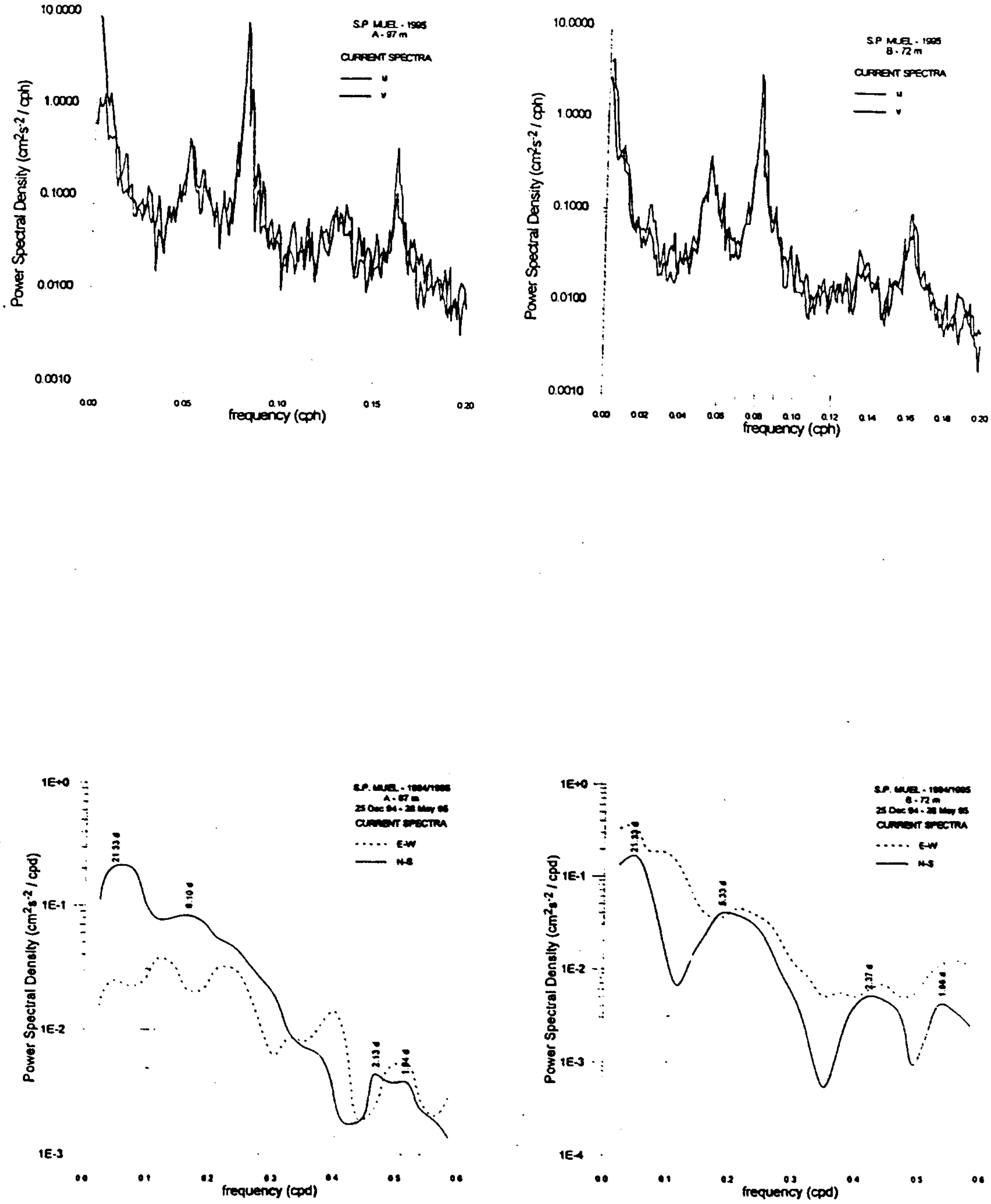
S.P. MUEL - 1995
A - 97 m
CURRENT SPECTRA
u
v
Power Spectral Density (cm²s⁻² / cph)
frequency (cph)
S.P. MUEL - 1995
B - 72 m
CURRENT SPECTRA
u
v
Power Spectral Density (cm²s⁻² / cph)
frequency (cph)
S.P. MUEL - 1994/1995
A - 97 m
25 Dec 94 - 28 May 95
CURRENT SPECTRA
E-W
N-S
Power Spectral Density (cm²s⁻² / cpd)
frequency (cpd)
S.P. MUEL - 1994/1995
B - 72 m
25 Dec 94 - 28 May 95
CURRENT SPECTRA
E-W
N-S
Power Spectral Density (cm²s⁻² / cpd)
frequency (cpd)

Figure 2.

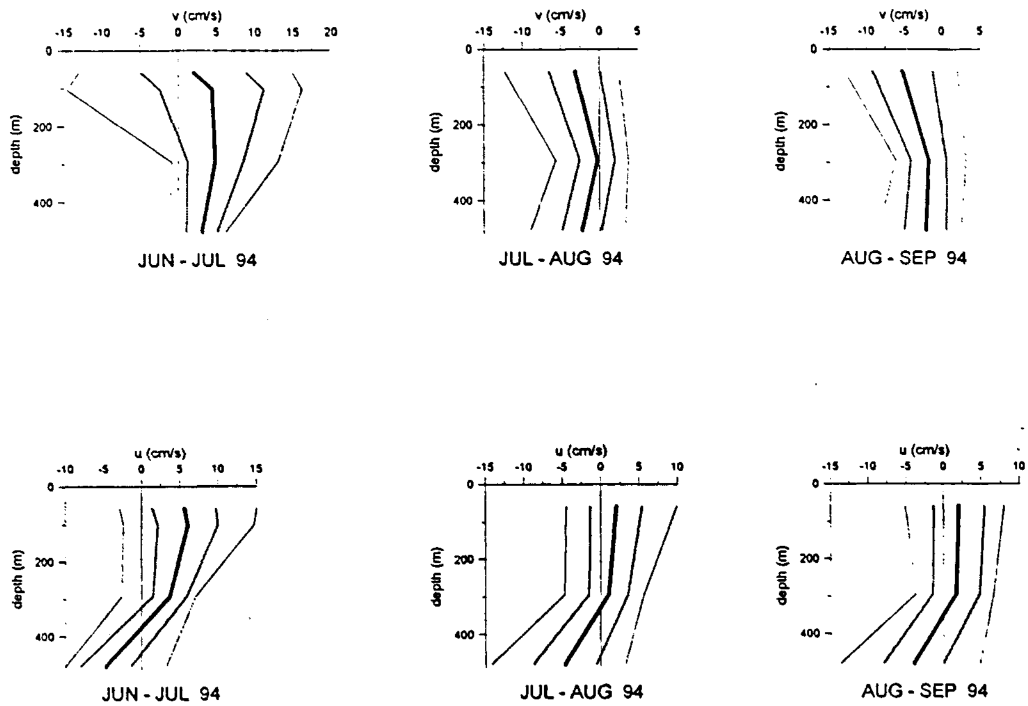

Figure 3. Near monthly means, standard deviations and extremes of N-S (v - upper pannel) and E-W (u - lower pannel) current components at mooring 1B, June - September 1994.

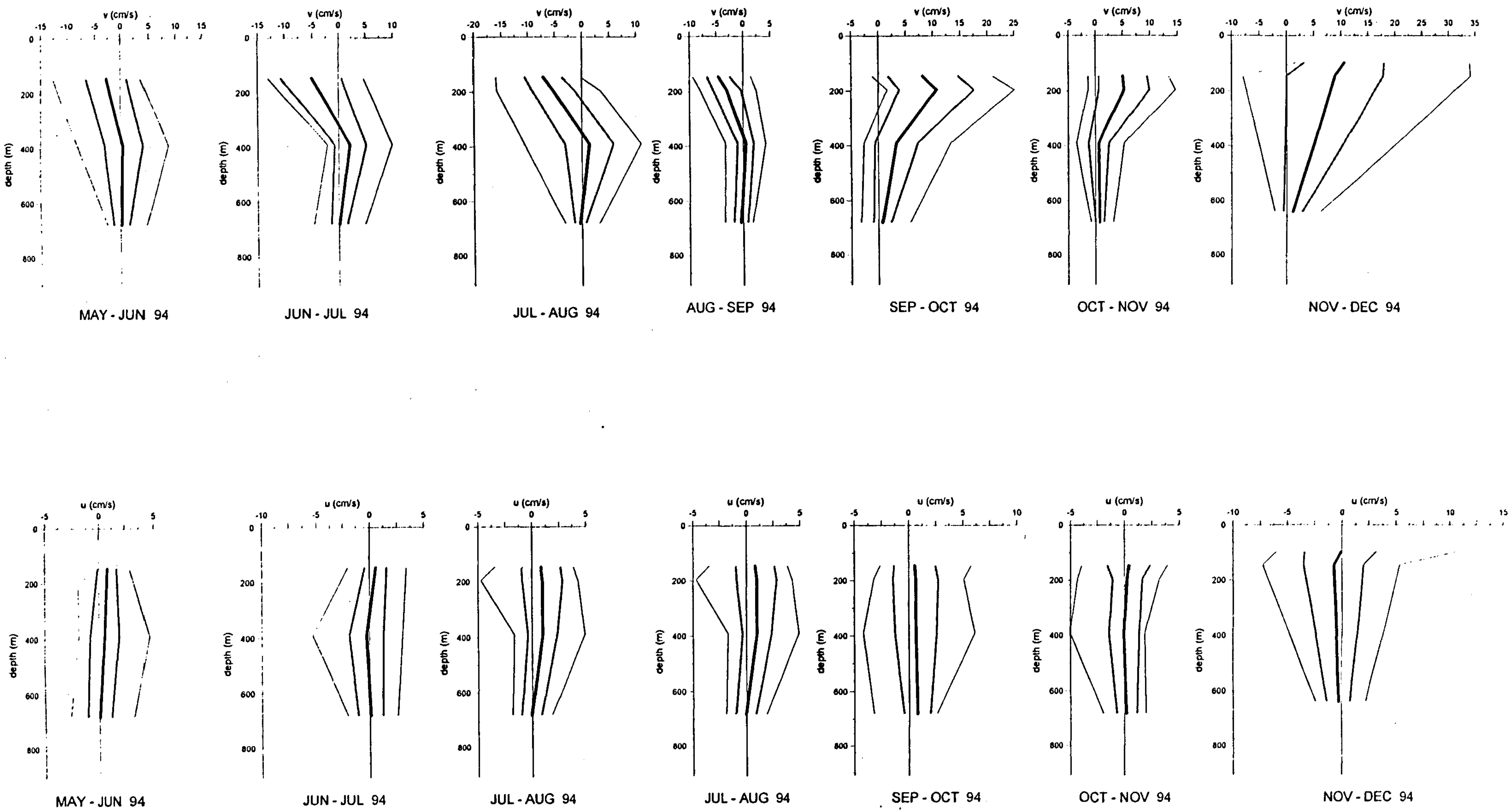

Figure 4. Near monthly means, standard deviations and extremes of N-S (v - upper pannel) and E-W (u - lower pannel) current components at mooring 2A, May - December 1994. Note the different scales of u and v.

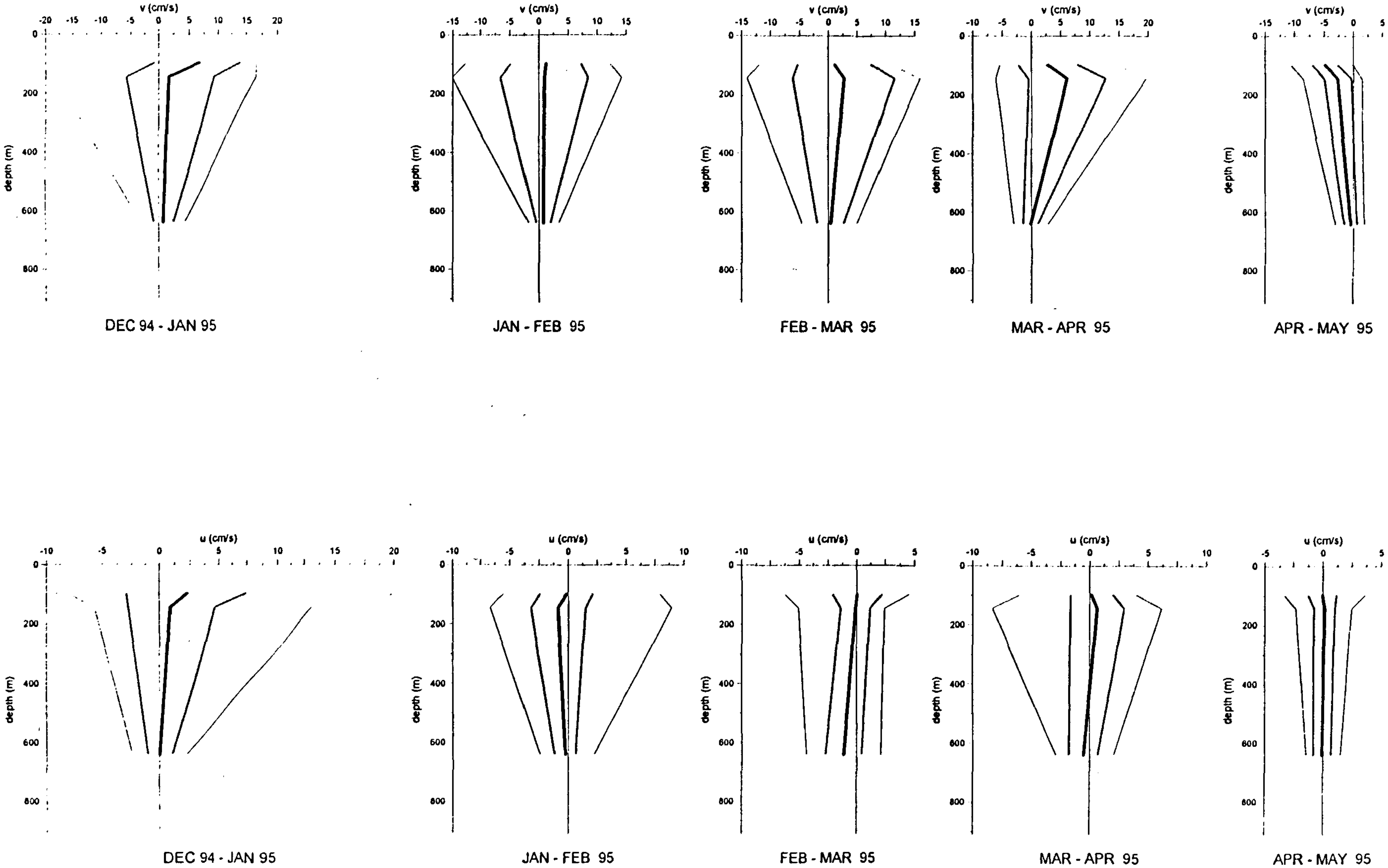

Figure 5. Near monthly means, standard deviations and extremes of N-S (v - upper pannel) and E-W (u - lower pannel) current components at mooring 2A, December 1994 - May 1995. Note the different scales of u and v.

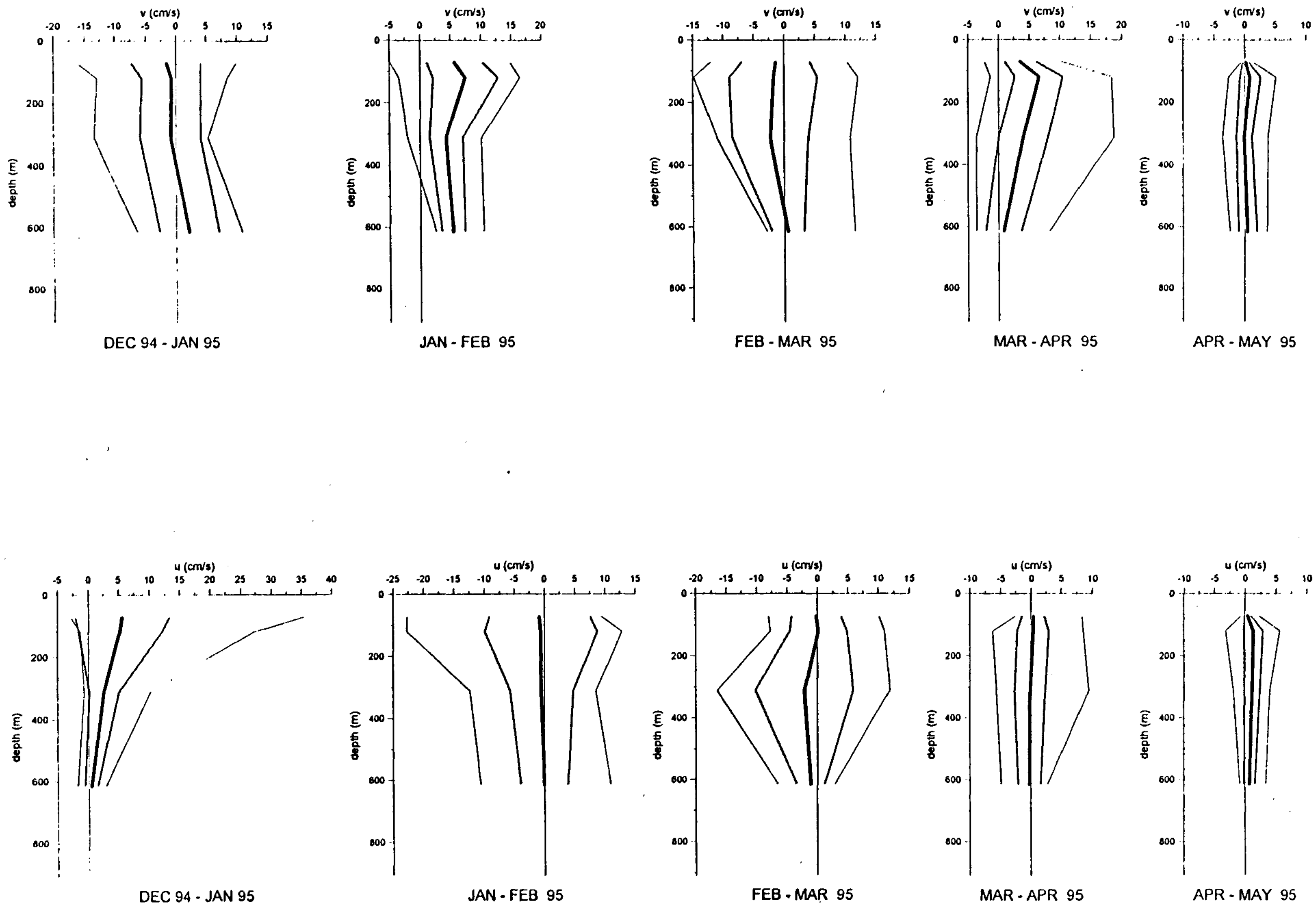

Figure 6. Near monthly means, standard deviations and extremes of N-S (v - upper pannel) and E-W (u - lower pannel) current components at mooring 2B, December 1994 - May 1995

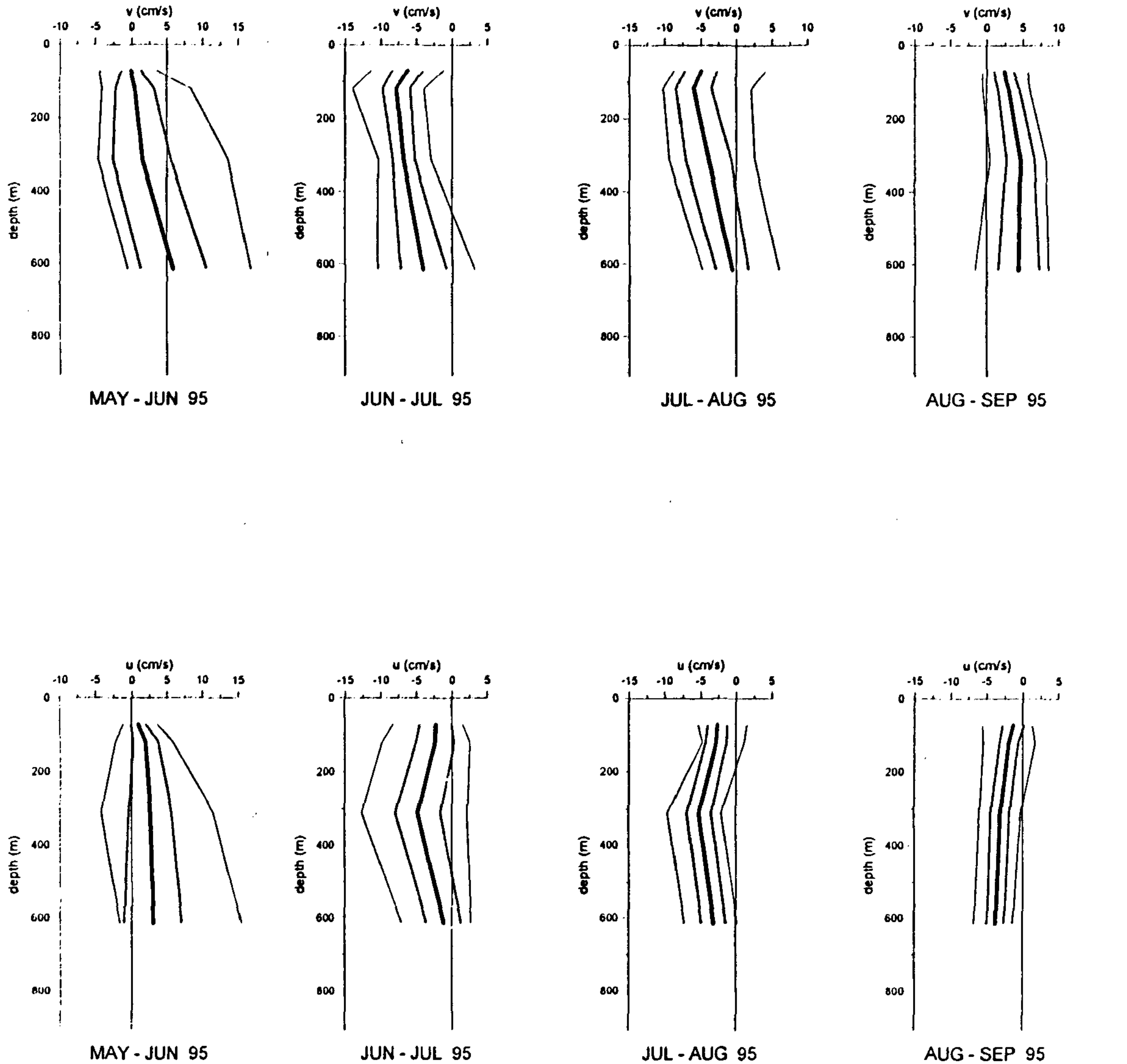

Figure 7. Near monthly means, standard deviations and extremes of N-S (v - upper pannel) and E-W (u - lower pannel) current components at mooring 2B, May - September 1995.

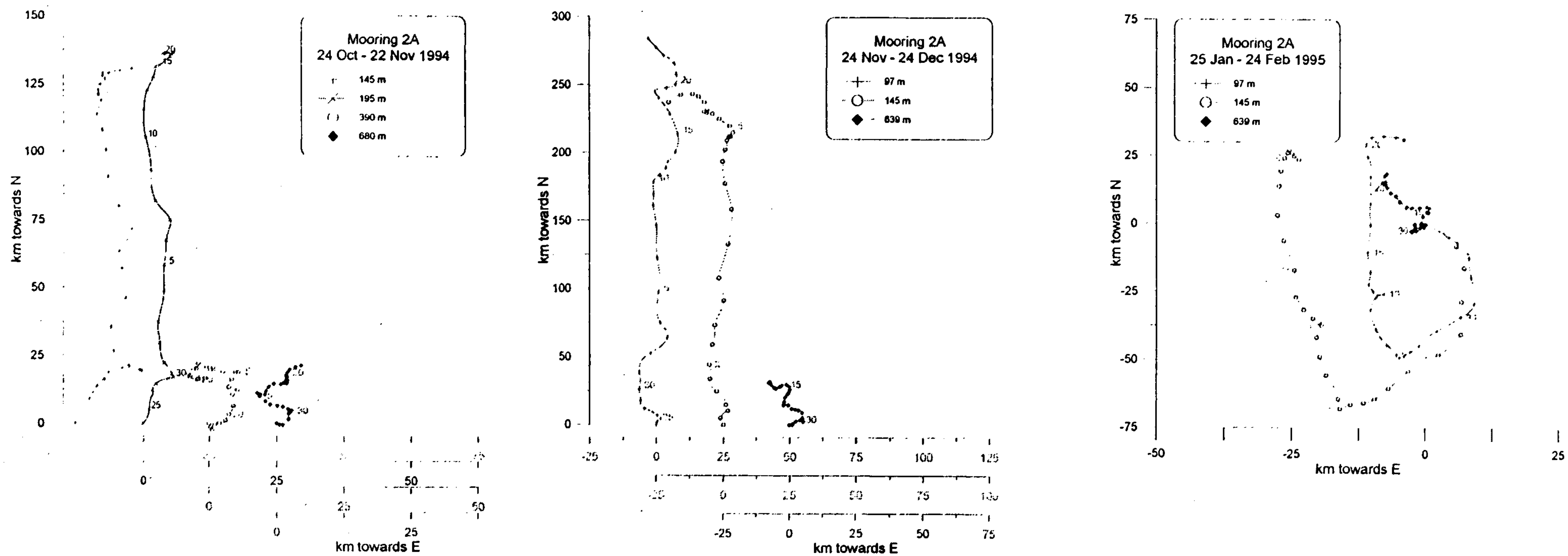

Figure 8. Mooring 2A - progressive vector diagrams for selected periods in late autumn and winter 1994-95