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AN INVESTIGATION OF METEOROLOGICAL EFFECTS ON CURRENTS IN THE SHELF AND CONTINENTAL SLOPE SEAS NORTHWEST OF THE U.K.

I. ANALYSES FOR INDIVIDUAL MOORINGS

BY

J.M. HUTHNANCE, J. LOYNES AND ANNE C. EDDEN

REPORT NO. 2

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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An investigation of meteorological effects on currents in the shelf and continental slope seas northwest of the U.K.

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ABSTRACT

This report describes analyses of data from the continental shelf and slope northwest of the UK in the period 19 August 1982 to 23 March 1983. Current meter data are included, notably from the Continental Slope Experiment (CONSLEX), and also sea-levels, sea-floor pressures and temperatures, atmospheric pressure and winds. The series were low-pass filtered to exclude inertial oscillations (period $\simeq$ 14 hr) but retain periods exceeding 20 hr. Mean currents, and measures of variability and its character, are discussed for the filtered series.

Mean currents are generally northwards/northeastwards along the continental shelf and slope, but are stronger over the steep slope and increase northeastwards, finally exceeding 0.4m/s near the surface at 0°E. Current fluctuations also increase northeastwards, to over 0.2m/s r.m.s. in the Faeroe-Shetland Channel; over the steep slope and many adjacent shelf positions, the fluctuations are aligned predominantly along the slope. Mean and fluctuating currents are principally barotropic (albeit decreasing downwards) except for reversals in the cold bottom waters of the Faeroe-Shetland Channel and their flow over the Wyville-Thomson Ridge. Near-diurnal oscillations are occasionally prominent, especially on the West Shetland Shelf; exceptionally they dominate the tides in 500m depth at 0°E.

Some events (slope current reversals, particularly strong current fluctuations, exceptionally deep atmospheric depressions) were chosen for individual analysis.

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Contents (cont.)

	Page
C2	100
C3	106
D1	112
D2	118
D5	124
I2	130
E2	136
E3	142
E4	148
F1	154
F3	160
G1	166
G2	171
G4	177
ST	183
OS	189
Appendix 2. Other Spectra.	195
Coastal sea level	
Bottom pressure	
Bottom temperature	
Thermistor chains	
Current meter temperatures	
Atmospheric pressure	
Winds	

Contents

		Page
1.	Introduction	7
2.	Data Reduction	8
3.	Tides	11
	3.1 Semi-diurnal	11
	3.2 Diurnal	12
	3.3 Non-linearity	13
4.	Higher Frequencies	14
5.	Lower Frequencies	15
	5.1 Mean currents	15
	5.2 Variance ellipses and integral time scales	18
	5.3 Spectra	19
	5.4 Principal components	20
	5.5 Eddies	22
	5.6 Near-diurnal oscillations	23
	5.7 Events	24
References		26
Table and figure captions		28
Table		29
Figures		30
Appendix 1. Current meter moorings.		32
Mooring data, text, variance, mean, spectra, principal components.		
	L2	36
	L3	41
	L4	46
	A1	51
	PR	57
	A5	60
	MR	66
	FR	71
	B1	76
	B2	82
	B3	88
	B4	94

et al. 1987).

The present report treats data reduced to 3-hourly values for the period 19 August 1982 to 23 March 1983, from which estimated tides had been removed; a low pass filter had also been applied, rejecting inertial oscillations but retaining diurnal oscillations (see next section). Analyses of individual data series are described here, together with analyses for single current meter moorings. Subsequent reports are planned, treating wider groupings of data and models for their behaviour.

2. DATA REDUCTION

All data were eventually reduced to 1736 3-hrly values for 0000 19 August 1982 to 2100 23 March 1983 (the unlikely value -999.0 represented absent data). The final stage in this process was application of the HILOW filter -(7) in CARTWRIGHT (1983) - with M = 8, N = 72, applied to hourly values. Figure 2 shows the filter characteristics for these parameter values. The prior stages, to give hourly values with tides removed, differed according to data type.

Currents, except at Oseberg and Statfjord A, were already held by MIAS, and the data was analysed by the TITAN suite of programs developed for the tidal current atlas (HOWARTH 1988). The following steps are included. East and north components are obtained if the currents are held as speed and direction. Hourly values on the hour are obtained by interpolation, using a cubic spline exactly fitted to adjacent data. Successive 29-day blocks of data are analysed for a least squares fit by 26 independent and 8 related tidal constituents; inter-block means (of the vectors defined by amplitude and phase) form the estimated tidal constituents. (Here and in the following, the mean value is counted as one independent 'tidal' constituent.) The 32 diurnal and higher frequency estimated tidal constituents are then subtracted, to form an hourly series from which the tides have been nominally removed, although fortnightly and longer-period tides and mean currents remain. The Statfjord A data were not held by MIAS, but the above steps were carried out in the same way as in the TITAN suite. The Oseberg data were received from Norsk Hydro with tides already removed; therefore only interpolation to hourly values was performed. Any differences in tidal analysis techniques will be apparent only at diurnal and long periods in the filtered data.

The temperature series from current meters were first analysed for a least-squares fit by the same 26 independent and 8 related tidal constituents,

1. INTRODUCTION

The steep slope between the continental shelf and the deep ocean is important both as a boundary for these two regions and in its own right; slope currents, eddy behaviour, trapped shelf waves, internal wave generation and mixing all depend on the depth variations there. A general review was given in HUTHNANCE (1981). Northwest of the UK, there are particular interests: a slope current and trapped shelf waves in the diurnal tide are known to be present (HUTHNANCE 1986); questions concern their passage past shelf irregularities, especially the Wyville-Thomson Ridge (GORDON et al. 1986); the area (on- or off-shelf?) is thought to contribute to North Sea storm surges; exchanges with North Atlantic Water may warm Scottish shelf seas (BOOTH 1985). Further incentives for observations were the desire to validate numerical models spanning the north-west European shelf across the continental slope to the deep ocean, and the prospect of oil operations requiring knowledge of currents on the Scottish shelf and slope.

CONSLEX took place during winter 1982/3 to address these questions. Participating institutes were the Institute of Oceanographic Sciences, the Scottish Marine Biological Association, the Department of Agriculture and Fisheries for Scotland (Marine Laboratory, Aberdeen) and the Ministry of Agriculture, Fisheries and Food (Fisheries Laboratory, Lowestoft). In addition, Norsk Hydro obtained and provided current time series at Oseberg and Det Norske Veritas at Statfjord A in the northern North Sea during the same winter; their permission (vested in Det Norske Meteorologiske Institutt for Statfjord) is gratefully acknowledged. Torshavn sea levels and meteorological data were kindly supplied by the Danish Meteorological Institute, and meteorological data from Daily Weather Report stations by the UK Meteorological Office. All these data (currents, temperatures, bottom pressures, coastal sea levels, atmospheric pressures and winds located as in figure 1) are the subject of this and subsequent reports.

An earlier report describes the bottom pressure records (BANASZEK et al. 1985) and descriptions of the current meter and coastal sea level data may be obtained from the I.O.S. Data and Library Services (including MIAS). Separate reports exist for tides on the north-west European continental shelf, viz. an atlas including currents measured in CONSLEX (HOWARTH 1988), and for statistical analyses of the currents in water depths exceeding 200m adjacent to this shelf, including appropriate CONSLEX measurements and extreme-value statistics (CARTER retention of 15-minute values for the year's tidal analysis. The tides so estimated were subtracted from these four respective series from specially installed gauges. Hourly values for Aughris Head and Griminish Point were subsequently obtained using a binomial filter with weights spanning values to ½hour either side. From Torshavn, the hourly values were tidally analysed as for a year's data, and the estimated tides subtracted. All coastal sea level data were subsequently converted to total (sub-surface) pressure: they were multiplied by 1.008mb/cm (corresponding to gravitational acceleration 982cm/s^2 and seawater density 1.0265gm/cc) and added to 'local' atmospheric pressure as indicated below; if more than one atmospheric pressure series was used, weights are given in brackets ( ).

Sea level station	Atmospheric pressure stations
Torshavn	Torshavn
Lerwick	Lerwick
Walls	Lerwick
Wick	Wick
Stornoway	Stornoway
Ullapool	Wick (0.48) Benbecula (0.52)
Griminish Point	Benbecula
Millport	Tiree (0.16), Abbotsinch (0.66), Mull of Galloway (0.18)
Portpatrick	Mull of Galloway
Malin Head	Malin Head
Aughris Head	Malin Head (0.37), Belmullet (0.39), Shannon (0.24)
Newlyn	Gwennap Head

Bottom pressure and temperature records were low-pass filtered and interpolated to hourly values (hardly affecting tidal and lower frequencies), and instrumental drift was removed. The pressure records were analysed for tides with 55 independent constituents (+2 related) or 27(+8) according to the record length. More details are given by BANASZEK et al. (1985). This estimated tide was removed from the pressure records. Tidal fluctuations contribute only a small irregular portion of the temperature variance and no removal was attempted.

using data for the largest possible multiple of 29 days. All 34 resulting estimated tidal constituents were subtracted, and the series interpolated to hourly values by a running mean over values spanning one hour or less. The mean value (one of the 'tidal' constituents) was subsequently reinstated. In comparison with the current components, the difference in tidal analysis procedure amounts only to a slightly different weighting of 29-day blocks in obtaining the inter-block average, and the interpolation by a running mean introduces a low-pass filtering effect (but the cutoff is at periods of a few hours). Effects on the final low-pass filtered data without tides are expected to be negligible, particularly since coherent tidal fluctuations contribute very little of the temperature series variance.

Atmospheric pressure and wind data were obtained as 3-hourly time series in most cases, but later data from the automatic weather station on Sule Skerry was hourly, some series were at 6-hourly intervals and several had occasional values missing. All were linearly interpolated to hourly values; no tidal analysis or removal was applied.

Thermistor chain data from G1 at 7½-minute and 15-minute intervals were reduced to hourly values using a binomial filter with weights spanning values to ½hour either side. At B2, only hourly values were recorded. No tidal analysis or removal was applied. (Spectral analysis indicated tidal band variance to be no higher than in adjacent bands, except perhaps at semi-diurnal frequencies in the seasonal thermocline. Even then, tidal variance levels were small compared with lower-frequency variance, and only comparable with variance at higher frequencies, together with which they are removed by the subsequent HILOW filtering.)

Coastal sea level data from UK permanent 'Class A' gauges were digitised as hourly values from charts, or (if from an Aanderaa water level recorder) interpolated to hourly values using a cubic spline exactly fitted to adjacent 15-minute values. Tides estimated using previous analyses were then subtracted. Specially installed Aanderaa gauges at Walls and Malin Head gave 15-minute values which were interpolated to hourly values as above. Two overlapping six-month tidal analyses (55 independent, plus 5 related constituents) were applied to the nine-month Walls series (September 1982 to June 1983) and averaged for a best estimate. A year's analysis (61 independent constituents) was applied for Malin Head (July 1982 to July 1983). From specially installed Aanderaa gauges at Aughris Head and Griminish Point (July 1982 to July 1983) the many gaps owing to drying out at low tides and other difficulties necessitated

The current ellipses for the M_2 tide are typically rotated from an alongshore orientation by 0(20°) clockwise, consistent with a fraction (1/3 corresponds to 20°) of the energy propagating onto the shelf (and subsequently being dissipated there). Polarisation is clockwise at all positions on the shelf, and also in a majority of other locations. However, several records show anti-clockwise polarisation, almost always in conjunction with clockwise polarisation at other depths on the same mooring. There is no clear pattern to the occurrence of anti-clockwise polarisation. In many instances its finding is uncertain, the tidal currents being poorly determined or nearly rectilinear (so that polarisation is marginal and of little significance). The latter applies especially at L3, PR, B3, B4, C2, C3, E3 and G4 on the slope.

S_2 currents are fairly consistently about 35% of M_2, a ratio close to that for tidal elevations.

There are variations with depth. Typically, amplitudes decrease downwards so that values 25m above the bottom are about 80% of those at upper levels. Phases vary by 0(30°) on several moorings but without apparent consistency. Thus the semi-diurnal tidal currents are largely barotropic. Clear exceptions are the deeper Rockall Channel moorings L2, L3, L4, FR, MR and I2 where intensified currents and phase advances at the bottom meter suggest baroclinic contributions (internal tides).

3.2 DIURNAL

Diurnal tidal currents are generally less well determined by the data. The energy in coherent tidal constituents exceeds the diurnal-band residual after analysis only at A1, B1, B2, D1, D2 and G1 on the shelf and in the bottom records from L3, L4 FR (bottom two), MR and A5 (bottom two) in the Rockall Channel, together with G4 (lower three). Uncertainties in the largest constituent (usually K_1) in these locations are of order 30% in amplitude and 20° in phase, and larger elsewhere.

In any case, only on the shelf at A1, B1, B2 and G1 do the coherent diurnal tidal currents approach 10% of the total kinetic energy. These are the locations of greatest absolute amplitude (0.05, 0.07, 0.05 and 0.03 m/s respectively), together with G2 (0.04m/s). Elsewhere, 0.01 or 0.02m/s is typical.

Phase lags of K_1 increase northwards along the deeper waters of the continental slope and the Rockall Channel and Faeroe-Shetland Channel. Values

3. TIDES

Tidal currents are described in the Tidal Currents Atlas (HOWARTH 1988) but a brief overall description of semi-diurnal and diurnal tides in the region may be appropriate.

3.1 SEMI-DIURNAL

In general, the semi-diurnal tidal currents are well determined by the several months of data typical of CONSLEX moorings. Residuals after analysis of only a small fraction of semi-diurnal band energy imply uncertainties of order 10% - 20% in amplitude and 10° in the phase of the principal M_2 constituent. Exceptions where semi-diurnal residuals are comparable or greater than the coherent tide are: the deep moorings FR, MR (upper and mid-depths) and A5 (bottom) in the Rockall Channel (where there is other evidence of significant internal tides - see below and BOOTH, 1983); the deeper records from I2 in the Ymir Channel and especially D5 at the col of Wyville Thomson Ridge (where we speculate that the stratification associated with occasional overflows of cold deep water from the Faeroe-Shetland Channel may generate incoherent internal tides); F3, G2 and G4 in 500m or greater depth towards the northeast in the Faeroe-Shetland Channel (where semidiurnal tidal currents are weaker in absolute value and especially in comparison with other flow contributions).

Semi-diurnal tidal currents form a dominant contribution to the total current only at a few locations: A1 and D1 on the shelf, and more surprisingly at the bottom of the Rockall Channel moorings L3, L4, FR and MR. They are important (contributing 1/3 or more of the variance) at other shelf moorings - B1, B2, D2 and G1 - and also at C3 in 1000m depth on the slope. Elsewhere they are relatively weaker.

Absolute amplitudes are largest on the shelf and generally increase towards the Wyville-Thomson Ridge (from either side). Thus the largest M_2 value is 0.33m/s at D1, whereas values at G2 and G4 average 0.04m/s and at L2, P and A5 0.06m/s.

Phase lags of the principal M_2 constituent increase northwards overall, from about 100° at L2 through 180° at B1, B2, B3, B4 to about 280° at G1, G2 and G4 for the maximum alongshelf currents to the north or northeast. These values are similar to those of the M_2 tidal elevation and are consistent with a progressive (Kelvin) wave travelling to the north and northeast around Britain.

4. HIGHER FREQUENCIES

We include under this heading all diurnal-band and higher-frequency currents not accounted for by analysis for coherent tides. Contributions may be expected from inertial and internal waves, incoherent tides (e.g. internal and additional non-linear tides) and motion forced by short-scale winds, e.g. at fronts or near the centre of a 'tight' depression.

Root-mean-square currents are generally in the range 0.06 to 0.13m/s, the highest values being at G2 in 500m in the Faeroe-Shetland Channel, and D5 on the Wyville-Thomson Ridge. Low values (0.03 to 0.05m/s r.m.s.) occur over the deeper slope of the Rockall Channel at L3, L4, PR and B3, and also at G4 (below its top level).

As a proportion of total residual kinetic energy (after removal of coherent tides) these higher frequencies generally contribute 10% to 20%. Notably higher proportions (up to 57%) at the shelf locations A1, B1, B2 and G1 seem merely to reflect the absence of long-period and mean flows, despite the apparent correlation with strong diurnal tidal currents. High proportions (typically 50%) at the bottom of the Rockall Channel moorings L3, C3, FR, MR and A5 are substantially in the semi-diurnal band. At the latter three, semi-diurnal residuals exceeding the coherent semi-diurnal tide have already been identified in section 3.1. The locations D1, D2, D5 and I2 near the Wyville-Thomson Ridge show slightly elevated proportions (20% to 30%) at higher frequencies.

Within these higher frequencies, the inertial frequency band consistently contributes 10% to 30% of the kinetic energy. The greatest absolute contribution (0.07m/s r.m.s. : 36%) occurs in the upper B2 record. Diurnal and semi-diurnal bands contribute 35% to 60% typically. Higher proportions (principally semi-diurnal) occur at the bottom on several deeper moorings (FR, MR, A5, C3, E4 and F3) suggesting incoherent internal tide contributions as bottom-intensified waves. Lower proportions occur at mid-depth on G2 and G4 and at several more southerly locations A1, B1, B2 (on the shelf), B3 (middle record), PR and L4 (bottom records), L3 and L2 (top records). In absolute terms, the largest diurnal + semi-diurnal contribution is 0.09m/s r.m.s. at G2 (bottom; exceptionally, the diurnal contribution predominates here). The remaining frequencies above the semi-diurnal band contribute 16% to 40%, the most notable exceptions being higher proportions from bottom records at L4, PR, B4 and especially D5 at the col of the Wyville-Thomson Ridge, with much the highest absolute value (0.09m/s r.m.s. current). Besides its location with are about 100° at A5 (130° at FR and MR), 140° at C3, 210° at I2 and D5, 230° at E3 and 260° at G2 and G4, for the northward/eastward component along the slope.

In contrast with generally elongated current ellipses in deeper water, the diurnal currents on the shelf are strongly polarised clockwise, characteristic of the continental shelf wave mode 1 which is thought to predominate here (CARTWRIGHT et al. 1980). Phase lags are quite distinct from offshore: about -60° for the K_1 clockwise rotating component at A1, B1 and B2 (when directed north; this is about 30° in advance of C4 nearby but somewhat inshore - CARTWRIGHT et al. 1980) and 300° when eastward at G1.

Currents at the frequency of the other large diurnal constituent O_1 are generally comparable with those of K_1, and the analysis yields slightly greater values at D1, D2 (0.025m/s) and G1, G2 (0.04m/s). However, these results are not firm in view of the substantial residuals and analysis uncertainties mentioned above.

There appear to be no significant variations with depth, although there is a consistent decrease downwards on the shelf so that values 25m above the bottom are about 80% of those at upper levels. Thus the diurnal tides appear largely barotropic. At this latitude, diurnal frequencies are less than the inertial frequency so that baroclinic motion cannot occur as free plane waves but must be (topographically) trapped.

3.3 NON-LINEARITY

In most locations the total coherent tidal energy in frequency bands around 3, 4 and 6 cycles per day is about 1% or less of that at the M_2 frequency. Exceptions are the bottom meters at L2 (4%), L4 (12%), G2 (19% and 13% at the bottom two meters) and most notably D5 (31%). At G2, these figures reflect the weak M_2 currents and represent current contributions of only 0.01m/s. At L2, L4 and D5 these higher-frequency contributions are almost entirely fourth-diurnal and suggest generation from the main semi-diurnal currents through advective effects (semi-diurnal particle excursions comparable with the short topographic length scales at these locations). At D5, the col of the Wyville-Thomson Ridge where cold bottom water from the Faeroe-Shetland Channel occasionally overflows, we may speculate on additional non-linearity as vertical displacements may be comparable with the shallow depth of the bottom water locally. The M_4 currents here and at L2 are about 0.02m/s, and about 0.04m/s at L4 (where the bottom semi-diurnal currents are stronger).

The slope current was observed inshore of the above-listed locations at D1 (0.09m/s), F1 (0.20m/s) and G1 (0.07m/s); contemporary measurements at Statfjord (0.06m/s) and Oseberg (0.10m/s) appear to be consistent with its continuation along the shelf edge of the northern North Sea. Further offshore, the slope current was also observed at

mooring	L3	L4	A5	B4	C3	G4
speed, m/s	0.08	0.07	0.11	0.09	0.10	0.07.

These values are notably smaller than in the slope current 'core' sampled by just one mooring over the steep upper slope, and testify to the slope current's lateral confinement. Mean currents on the Hebrides Shelf at A1 and B2 were only 0.02m/s; 0.08m/s observed at B1 would appear to be a separate feature - several infra-red images from satellites suggest an extension of cooler Scottish coastal waters around the St. Kilda island group, to perhaps influence mean flows at B1; images in BOOTH et al. (1983) and HUTHNANCE (1986) hint at this.

Over the Wyville-Thomson Ridge, there is a near-surface flow to the east or north-east (0.06, 0.09 and 0.18m/s respectively at I2, D5 and a DAFS mooring 'D3' in 500m at the eastern end of the Ridge - 59° 52.1°N, 6° 24.1'W - from June to December 1983 - JHA Martin, personal communication). Near-bottom flows seem to be topographically controlled, however:

mooring	I2	D5	D3
speed, m/s	0.17	0.18	0.07
direction, °T	97	192	-38

At D5 and perhaps I2, these mean currents probably represent overflow from the Faeroe-Shetland Channel, but at D3 the mean flow probably indicates a diversion of deeper waters from the Rockall Channel slope current along the depth contours to follow the Wyville-Thomson Ridge. (D2 shows the upper waters of the slope current continuing north-eastwards).

Measurements outside the CONSLEX period confirm the slope current at L2 (bottom) L3, L4, PR (see BOOTH et al. 1983) and along the West Shetland slope; the 'strategic' measurements between E2/3 and F1/3 show near-surface means through the year of 0.35, 0.39 and 0.33m/s along the slope in 400m, 600m and 700m depth respectively. This distribution suggests that E2, E3, F1 and F3 fail to observe the strong 'core' of the slope current. The seasonal cycle and other variability through the year of 'strategic' data (GOULD et al. 1985) also suggest that the CONSLEX mean may exceed an annual mean, but that individual months may have averages 50% greater than the CONSLEX mean.

Several years' records from 57°N 9°W near the Hebrides Shelf edge (BOOTH et susceptibility to non-linear effects of locally shallow bottom water in the Faeroe-Shetland Channel, this record is exceptional in being only 4m above the bottom.

Overall, the contribution of higher frequency currents is limited; significant features are: near-diurnal currents at G2 (bottom); inertial currents at B2 (top); semi-diurnal currents (internal tides?) at the bottom of the deeper moorings L3, FR, MR, A5, C3, E4 and F3; frequencies above semi-diurnal at D5. With these exceptions, the broad-band character of the residuals may be a result of the autumn and winter seasons prevailing for most of the records. In particular, internal tides may be more widespread with summer stratification. Meteorological forcing was strong during the CONSLEX period and may be expected to generate broad-band currents, apart from responses characteristic of the shelf topography as discussed in section 5.6.

5. LOWER FREQUENCIES

5.1 MEAN CURRENTS

These are illustrated in plots for the individual moorings (Appendix 1).

Overall, the most prominent feature is a flow northwards and then northeastwards along the continental slope around Scotland. This has been reviewed as far north as the Wyville-Thomson Ridge by HUTHNANCE (1986) taking account of the present data. North-east of the Wyville-Thomson Ridge, GOULD et al. (1985) include a discussion of 'strategic' current measurements at a line of 4 moorings in 400m to 1100m water depth near $3\frac{1}{2}$°W. These records for September 1983 to August 1984 (between CONSLEX sections E and F) form the best sampling of the slope current to date.

Taking means over the duration of the individual records within the CONSLEX period 19th August 1982 to 23rd March 1983, all the cross-shelf sections show their largest values over the slope as follows

mooring	L2	PR	B3	C2	D2	E2	F3	G2
speed of mean, m/s	0.10	0.15	0.16	0.29	0.17	0.23	0.27	0.45.

At L2 and E2 these are near-bottom values, but elsewhere the values are from the uppermost record. They all follow the local depth contours closely. Speeds decrease with depth to 0(60%) at 500m. In the Faeroe-Shetland Channel the downward decrease is more rapid; a reversal occurs at about 500m depth (F3), 400m (E3) and in the 'strategic' measurements (but not at G4); the reversal shoals to the northwest and its depth also varies in time.

are smallest (section 5.2).

Finally, we note the transport estimates of 1.5 ± 0.4 x 10^6 m³/s for the slope current adjoining the Rockall Channel (HUTHNANCE, 1986) and 7.8 ± 2.3 x 10^6 m³/s along the West Shetland slope (GOULD et al. 1985).

5.2 VARIANCE ELLIPSES AND INTEGRAL TIME SCALES

These are shown in plots for the individual moorings (Appendix 1). The total axis lengths of the drawn ellipses represent the rms current variation (about the mean) in the directions of principal and minimal variation. All variance in the 3-hrly time series (derived as in section 2) is included. The depth-average values are formed from depth-mean currents (weighting the observed currents at the various levels on the basis that they represent the currents as far as half way to the adjacent meter above or below, or as far as the surface or bottom where appropriate).

Principal variations range from about 0.03m/s r.m.s (at L3 and L4 off Porcupine Bank) to just over 0.2m/s (near the surface at E3 and E4 in the Faeroe-Shetland Channel and at Statfjord, and at the bottom two meters of F3). Elsewhere, near-surface values are between 0.1 and 0.2m/s except for smaller values at the more southerly positions L2, A1 (0.07m/s) and PR (0.05m/s - summer only). Almost everywhere, values decrease with depth, most markedly at the deep Rockall Trough moorings FR and MR. Notable exceptions are I2 and D5 (adjacent to and on the Wyville-Thomson Ridge, and possibly affected by overflows at depth) and F3 (where the bottom two meters - in the cold bottom water of the Faeroe-Shetland Channel - show more variability). At Oseberg, other evidence from principal component analysis suggests that the break of the downward trend by the bottom two meters is an artefact of the different current meter type employed there.

There is usually a trend for the ellipses to become thinner with depth, most markedly at the deeper slope moorings PR, A5, B4, C3 and F3, suggestive of an increasing constraint on the flow to align with the depth contours. Indeed, at all the shelf and slope moorings, the principal axis of variation appears to be fairly consistent through depth (typically ± 10° or less) and aligned approximately with the deeper mean currents and with the depth contours. The large near-surface variations at E3 and the 'overflow' locations I2 and D5 near or on the Wyville Thomson Ridge form exceptions with alignment less well defined (fatter ellipses) and varying through depth, as also at the deep moorings FR, MR al. 1983) confirm the lack of any significant mean current there. Extended data (1 year spanning the CONSLEX period) from FR and MR show that the 'mean' currents (up to 0.08m/s over four months) are in fact quite variable in direction over a longer period, reducing the largest whole-record mean to 0.055m/s.

The strength and direction of bottom flows near the Wyville-Thomson Ridge are confirmed by longer records at I2 (March 1982 to March 1983) and at D5 (November 1982 to May 1983).

Drogues have been released by SMBA and tracked by Argos via attached surface buoys (BOOTH et al. 1987). The releases largely post-date CONSLEX, and any coincidence with a mooring location is only instantaneous, so that in the absence of comprehensive spatial coverage by moorings or drogues a comparison can only be in general terms. Nevertheless, drogues provide a distinct, informative set of observations and their tracks, as an integral of the flow, emphasise mean currents. Several drogues in the Rockall Channel circuited apparent eddies a few times at speeds of typically 0.3m/s but occasionally 0.8m/s. An anticyclonic eddy appeared to exist on several occasions off the northern end of Porcupine Bank and cyclonic circuits occurred near Anton Dohrn seamount. When stationary, such eddies would cause a mean flow at a current meter mooring which would not be representative of a wider area and could change direction or reverse with movement of the eddy. It seems likely that the 'mean' flows at FR and MR occur thus. (There is no current meter data bearing on the suggested eddy off Porcupine Bank). Six drogues were carried north-eastwards along the West Shetland slope at mean speeds of 0.3 to 0.5m/s and with occasional speeds up to 0.8m/s. These compare with the strongest current measurements on moorings. All drogues were released offshore from the slope occupied by most of CONSLEX moorings, but a majority came over the slope somewhere; of those over the West Shetland slope, three crossed the mouth of the Norwegian Trench but two more followed the top of the slope round into the Norwegian Trench; three crossed the slope of Porcupine Bank, in two cases without being carried northwards by any slope current. This prevalent onshore migration could not be deduced from the current records, but there is not necessarily any inconsistency; the difference between Lagrangian and Eulerian measurements is $\overline{\underset{\sim}{u}^t.\nabla \underset{\sim}{u}}$ (for moderate periodic flows) which cannot be evaluated from any of the measurements; taking $\underset{\sim}{u}^t.\nabla$ as O(1) because water does move over a scale length, 0.1m/s is a conservative order of magnitude in eddies, but 0.03m/s is more appropriate in the context of the upper slope where cross-slope flows

Polarisation tends to be less distinct or cyclonic below about 0.3 cpd. Intriguingly, the frequency of the peak at G4 appears to increase with depth, and at I2 a second peak at about 0.2 cpd emerges at depth.

Of the shelf moorings, B1 and Statfjord show more distinct low frequency energy around 0.1 cpd.

5.4 PRINCIPAL COMPONENTS

The plots for the individual moorings (Appendix 1) show the principal component of variation 'mode 1' contributing to the total variance in the filtered 3-hrly time series at the mooring. In some cases further modes (2, 3, 4) also make a contribution significantly above the noise level and are also shown together with their variance contribution. A separate plot for each mooring shows the principal component (only) contributing to the variance in each stated frequency band.

Of the total variance, the principal component 'mode 1' accounts for more than 70% at all shelf and upper slope moorings (to 500m and also at L2). Exceptions are G1 and Oseberg (where strong clockwise polarisation at near-diurnal frequencies requires two modes for representation) and G2 (where the top two levels are strongly polarised in opposite senses and the bottom level is separately energetic). At the other (deeper) moorings, mode 1 accounts for 46% to 63%. However, more measurement levels and hence time series are typically involved; these lower proportions may be equally 'significant' as emphasised by the exception L4 (84%) where only bottom currents were recorded. The inclusion of further modes (whose significance is not clear-cut at C2, C3, D5, I2 and E4) makes the deeper moorings' measurements better accounted for on average.

Mode 1 is essentially barotropic at almost all moorings; it closely matches the alignment and relative size of the variance ellipses' major axes through depth; usually this implies alignment with depth contours. The most common departure from such behaviour is an exaggerated variation of magnitude with depth (usually a decrease - at PR, A5, MR, B4, E3, E4, G1, G2 - but an increase at I2 and F3). Such exaggeration is probably an artefact of the principal component's property of minimising residual variance; least-squares approximation is weighted towards those series having greater initial variance. At FR, E3 and G1 the mode 1 alignment at depth also appears to be constrained by the upper-level dominance; a significant mode 2 contribution allows representation of the depth variations. D5 and I2 are the principal exceptions and E4. Apart from these latter cases, the 'depth-average' ellipse is fairly close to an average of the ellipses at individual depths, with a tendency to be smaller (to the extent that the currents are incoherent through depth).

Integral time scales for east and north components of current vary widely within the range ½ to 5 days, without systematic trends in location or depth. Small values occur for the cross-slope component (minor axis of the variance ellipse) at a few upper-slope or shelf positions: D2 (bottom two meters: 6h), G1 (10h), G2 (bottom meter: 5h) and Oseberg (8h). Large values occur at the upper levels of the deep Rockall Trough moorings A5 and MR (up to 18 days) and at D2 (7 days in the direction of principal variation).

5.3 SPECTRA

Spectra of all variables are shown in Appendix 2, excepting currents which are discussed here. Currents' spectra are shown in plots for the individual moorings (Appendix 1).

The total energy corresponds to that in the variance ellipses which have already been discussed. Moreover, the overall frequency distribution is (loosely) related to the integral time scale. Hence the following discussion concentrates on spectral peaks and indications of polarisation.

The most pervasive distinct peak, albeit often not including a large proportion of the total energy, is at about 1.2 cpd with strong clockwise polarisation. It occurs at all shelf and upper-slope moorings with few exceptions, near the surface at MR, D5 and F3, and in the bottom I2 record. At the bottom at E2 and G2, there is no clear polarisation, and at upper G2 levels the peak does not stand out from many others at lower frequencies. At G1 the peak spans 0.9 to 1.2 cpd, while a 'substitute' clockwise-polarised peak of 0.7 cpd occurs at Statfjord and Oseberg, and of 0.8 cpd at D2 (with hints at D1 and I2 also). These lower observed frequencies, adjacent to the Norwegian Trench and Wyville-Thomson Ridge respectively, are consistent with the lower maximum shelf wave frequencies expected (GORDON et al. 1987).

Other distinct peaks have some indication of a trend towards lower frequencies in greater water depths:

mooring	A1	B2	C2 (middle)	D5(top)	E3,E4	F3	G4,I2	A5	FR	MR
frequency (cpd)	0.5	0.6	0.45	0.3,0.7	0.1-0.3	0.1-0.5	0.1-0.2	0.16	0.2	0.12

use of four or fewer for the total. (In particular, the number of degrees of freedom at the lowest frequencies is only series length/25 days, rendering the high proportions of variance accounted for relatively insignificant). Nevertheless, the frequency-band modes do clarify the presence of polarised motion and trends with increasing frequency, especially towards anticyclonic polarisation and less alongslope alignment.

5.5 EDDIES

We are led to consider eddies especially because of suggestive whirls in images of sea surface temperature (e.g. HUTHNANCE 1986) particularly over the Faeroe-Shetland Channel, and from drogue tracks (BOOTH et al. 1987).

Perhaps because the drogues were over deep water in Rockall Trough but tracked along the West Shetland slope bordering the Faeroe-Shetland Channel, they showed eddies principally in Rockall Trough. More particularly, four drogues at depths of 16m, 66m, 166m and 116m sampled an eddy to the north of Porcupine Bank with anticyclonic circulation at speeds of about 0.5m/s, 0.3 to (peak) 0.8m/s, 0.2 to (peak) 0.8m/s and 0.3m/s respectively. Around Anton Dohrn seamount, one drogue at 116m sampled (at various times) eddy currents of 0.3m/s and circulation period 2½ days near MR, 1.1 days south of the seamount and 5 days near FR; another at 166m found 3 day and 1 day-period 0.2m/s currents near B4; all these circulations were cyclonic.

These circulations only constitute a minority of any drogue track; average variance in drogue velocity (excluding monthly time scales) is much less than 0.3m/s; such strong eddies do not fill the near-surface waters. The moorings confirm that the major axis of the near-surface current's variance ellipse exceeds 0.2m/s only at E3, E4 and Statfjord (plus the bottom two records at F3).

Current meter data at individual moorings do not give clear evidence of eddies (for example, a stationary eddy has steady currents; moving eddies will manifest currents which rotate according to the mooring's position relative to the eddy track). However, various characteristics of the observed currents are suggestive of eddies at low frequencies with rotary currents, occupying surface rather than bottom waters, decreasing towards the shelf and southwards. Thus the majority of non-tidal current variance is everywhere at frequencies less than ½ cpd, especially in deep water, and variance ellipses are generally fatter and larger nearer the surface and in deep water. The variable 'mean' currents at FR and MR are consistent with the slow movement of nearly stationary eddy to a clearly barotropic mode 1; the alignment varies with depth, albeit less than 90°. Two-layer structure in the Faeroe-Shetland Channel is represented by separate contributions at upper levels from baroclinic higher modes at F3 and G4.

At Oseberg, the broken sequence of magnitude with depth, in the otherwise barotropic and (by definition) coherent modes, is the clearest evidence of different current meter responses at the bottom two levels. Both modes 1 and 2 show a marked reduction between 2 and 12m depth, but only a slight reduction factor 0.96 to 25m depth followed by an increase (factors 1.88, 1.89 respectively) to 50m depth. The bottom two meters were of different type. It is suggested here that a factor 0.53 be applied to the 50m and 99m depth Oseberg records for consistency with those above.

The principal components in separate frequency bands in general align as the total-variance mode 1, and are similarly barotropic (albeit decreasing downwards in a majority of cases). Increased anticyclonic (clockwise) polarisation is evident as frequency increases. These general characteristics apply best over the shelf. Exceptions occur at B1 where only the upper level is represented at the lowest and highest frequencies, and at Oseberg where again the bottom two levels show exaggerated values at the lowest frequencies. Clockwise polarisation at G1 is evident for all frequencies above the lowest. The upper slope also provides few exceptions (L2 and D2 have little contribution at the top level in the middle and highest frequency bands respectively; the middle level at G2 is polarised cyclonically). Bottom currents at G2 are apparent in the highest frequency band.

At the deeper locations, changing alignment with increasing frequency occurs in several cases: FR, I2 (clockwise); L4, C3, G4 (anticlockwise): cross-slope motion at high frequencies occurs at L4 and L3 bottom, FR, D5 bottom, G4 top. We remark that the geostrophic constraint (alongslope motion) is weaker as frequency increases. Most of the deeper moorings, in comparison with the general picture, show some other individual contrast, e.g. cyclonic polarisation at higher frequencies, dominance or absence of particular levels in one modal form, varied alignments. There is no systematic appearance to these contrasts.

Part of the additional variability may be attributed to the reduced number of degrees of freedom associated with each frequency band in comparison with the total variance. In effect, the mode forms have greater statistical uncertainty. The restriction to frequency bands also renders the four modes somewhat inefficient in the proportion of variance accounted for, by comparison with the

1987). These were at 16m depth above the seasonal thermocline over the northern part of Porcupine Bank (with 0.2m/s currents); 66m over the Hebrides Shelf edge (0.1m/s); 16m over the West Shetland shelf (0.1m/s) and also at 116m depth between the F and g lines (0.1 to 0.15m/s).

At the bottom at G2, the near-diurnal currents are the strongest (in root-mean-square) of all, but differ in lacking a clear polarisation (in the spectrum or highest-frequency principal component). Rather, there is approximate up-down slope alignment which results in a dramatic diurnal peak in the temperature spectrum (Appendix 2). The bottom meter was in the strong stratification of the thermocline between North Atlantic water (above) and cold bottom water; the local maximum Ω_{max} of

$$\Omega \equiv \text{buoyancy frequency} \times \text{bottom slope}$$

may be expected (HUTHNANCE 1981) to result in bottom-intensified motion of frequency $\Omega_{max} \simeq 5 \times 10^{-3}$ (SIO 1984) $\times 1.5 \times 10^{-2} \simeq 1$ cpd.

5.7 EVENTS

Table 1 lists short periods during the CONSLEX observations when the current meter records are distinctive. On different occasions, the current is particularly strong, or a mean current relaxes or reverses, perhaps extensively and on one occasion with indications of upwelling, or diurnal currents appear transiently. The choice is subjective, and limited in this first report to the observed currents with moorings treated individually. Later reports will discuss other observations, notably temperature, and relationships between moorings and with meteorological data. Hence the overall characterisation of each event is deferred.

However, it is appropriate here to consider how the current structure at individual moorings during events compares with the 'usual' structure. We use principal components calculated for the event periods and shown in plots for the individual moorings (Appendix 1).

In most cases the shelf and upper slope moorings (to 500m water depth) during events show structure very similar to the (mode 1) principal component for the total variance, with perhaps slight changes (10° - 20°) of alignment. (Changes of sign common to all depths are immaterial). Events in such cases will be represented well by the principal component for the whole records and its corresponding time series. F1 shows a fairly large variation in direction, and G2 (days 393-410) has two modes of variance with mode 2 better resembling the circulations. Substantial energy in a mode 2 principal component, with current vectors perpendicular at each level to those of mode 1, reinforces the impression given by fat variance ellipses at several locations: FR, MR, C3, E3, E4, F3 (mode 3 for the near surface variance) G2 and G4. However, the frequency-band principal components rarely (A5, MR, E3) show a clearly preferred polarisation, which is also rare (I2, MR, F3, G2) at lower frequencies in the spectra.

Perhaps the most striking evidence of cross-slope low-frequency water movements comes from the intermediate-depth (419m, 388m respectively) temperature records from 1000m moorings E3 and F3 in the Faeroe-Shetland Channel. The instruments sampled the thermocline (shoaling to the north west) between warm (8°C) overlying North Atlantic water and cold (0°C) underlying bottom water. Displacement of the Atlantic water towards the West Shetland shelf results in a drop in recorded temperature. Appendix 2 shows the consequent spectra. The corresponding cross-slope r.m.s. current is 0(0.14m/s).

5.6 NEAR-DIURNAL OSCILLATIONS

These have been remarked upon (GORDON et al. 1987) in other observations from the West Shetland shelf. In the CONSLEX data, they form a pervasive spectral peak with clockwise polarisation (the same sense as inertial oscillations). All shelf and upper-slope moorings, together with the top levels at MR, D5 and F3 show the peak. Usually, it is at about 1.2 cpd, but it is broad at G1 and lower frequencies at Statfjord and Oseberg (0.7 cpd) and D2 (0.8 cpd). It seems likely that the reduced values result from a lower maximum frequency for continental shelf waves locally (GORDON et al. 1987).

The clockwise polarisation is clear also in the principal component for the highest frequency band at all shelf and upper slope moorings, where it is essentially barotropic, as well as the in top records from MR, FR, D5 and E4. (These frequency-band principal components generally tend towards clockwise polarisation at higher frequencies).

Despite the pervasiveness, rms currents are small, at most 0.09m/s (at the bottom at G2) and usually less than 0.05m/s. We attribute this to the oscillations' transient character, discussed in (GORDON et al. 1987). Currents may be markedly stronger (0.1 to 0.2m/s) during events, such as days 295-305 (A1, B1, B3, B4), 353-362 (C2, C3) and 365-380 (B1, B2, B3).

The phenomenon has been seen in the tracks of four drogues (BOOTH et al.

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overall principal component. Otherwise, exceptions (B3, days 295-305; ST, days 348-362) are rotated modes during rotary diurnal current events, as might be expected from the mode forms in higher frequency bands already discussed. Another manifestation of rotary diurnal currents is a significant mode 2 contribution, at right-angles to mode 1, during such events at B2, ST and OS.

At F3 and G4 on the West Shetland slope, event forms are similar to the principal components for the total record. However, increasingly varied changes of alignment occur at D5, A5, B4 (where the bottom record is distinctive on days 260-280) until at C3, I2, E3 and E4 event orientations are quite varied. At B4 and these latter, the principal component form for the total variance and its associated time series will be unrepresentative during at least some events.

Table 'Events' identified in current meter records

Figure 1. Location of data
. coastal sea level
+ current meters
x bottom pressure
o thermistor chain

Figure 2. Frequency dependence of amplification introduced by HILOW (M=8, N=72) on hourly values. Phases are unchanged.

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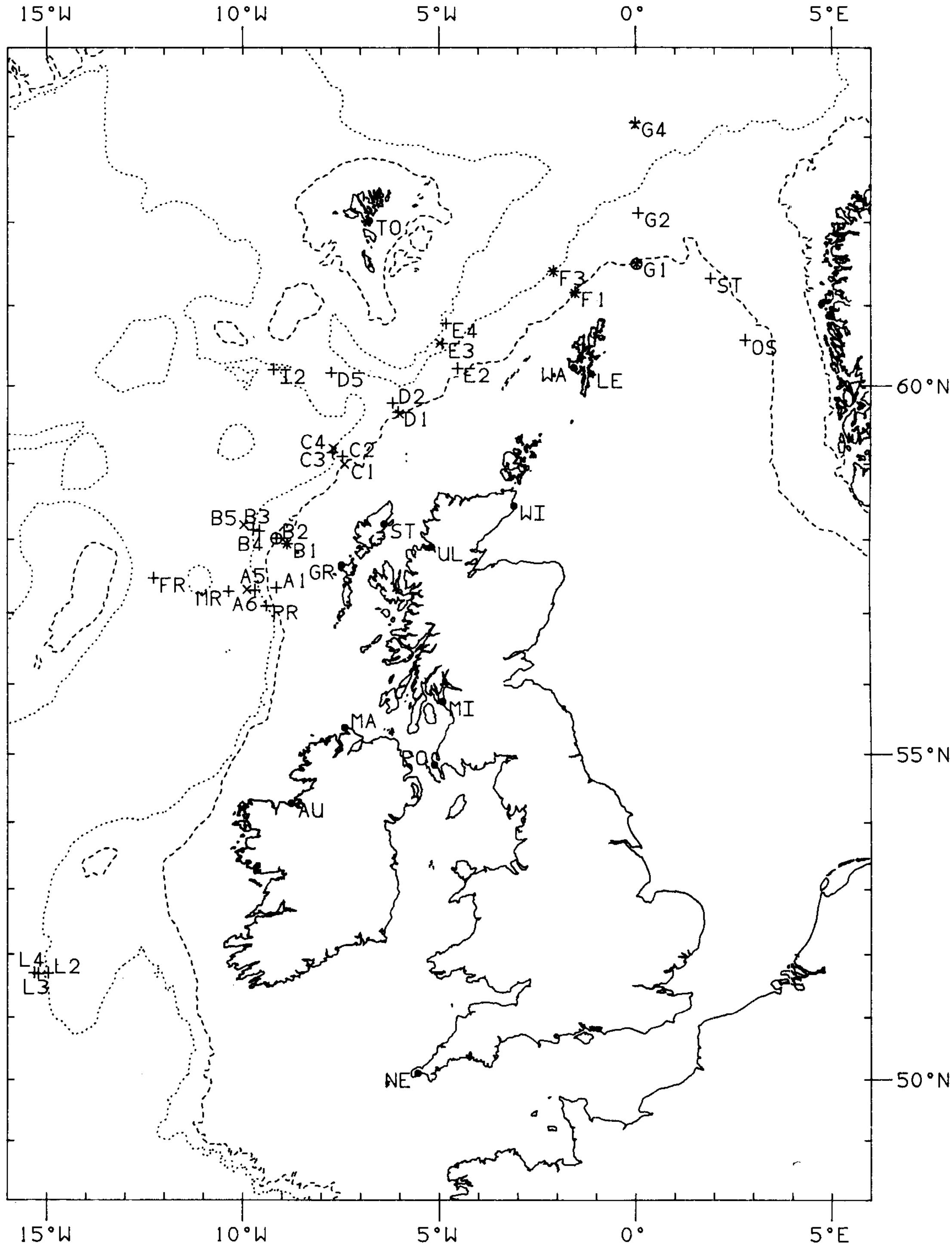


Figure 1. Location of data

- . coastal sea level
- + current meters
- x bottom pressure
- o thermistor chain

Table

'Events' identified in current meter records

Period (days, 1982)	Moorings	Character
260-280	B4 (bottom)	sharp southward peak
277-291	A1,B1,B2,C2,D1,D2	extensive southward flow or relaxation of slope current. Upwelling?
295-305	A1,B1,B3,B4	diurnal oscillations
310-340	F1,F3	large SW flows at F3 (bottom 2)
339-350	C2,C3	reversals to SW flow at C2: C3 oscillatory
341-351	I2 (bottom 2)	diurnal oscillations
348-353	G2 (top)	strong peak in E flow
348-362	ST,OS	diurnal oscillations and NW/N flow
350-370	E2,E3,E4	large reversals (not in bottom water)
353-362	C2,C3	diurnal oscillations
365-380	B1,B2,B3	diurnal oscillations
370-390	E3,E4	strong reversals
379-390	ST,OS	diurnal oscillations
380-395	C3	strong SW peak and then NE flow
390-402	OS	diurnal oscillations
393-410	A1,A5,B1,B2,B3,B4,C2,C3 D1,D2,D5,I2,F1,F3,G2	extensive southward flow or relaxation of slope current
400-415	ST	northwesterly flow
410-440	I2,E2,E3,E4,F1,F3,G2,G4	strong fluctuations
422-448	OS	diurnal oscillations

APPENDIX 1. CURRENT METER MOORINGS

Data and plots are shown, grouped according to the mooring concerned, in the following order

L2	L3	L4		
A1	PR	A5	MR	FR
B1	B2	B3	B4	
C2	C3			
D1	D2	D5	I2	
E2	E3	E4		
F1	F3			
G1	G2	G4		
ST				
OS				

which corresponds roughly to on-offshore sections from south to north (figure 1). For each mooring, there is a page of data (location, duration, etc.) and comments specific to that mooring, and the following plots in order

ellipse of principal variation, integral time, mean flow

rotary spectra

total variance (principal components)

frequency band (principal components)

Events (principal components).

We include here some notes on the calculation of these quantities.

Ellipse of principal variation

This is calculated at each depth on the mooring, using the time series u_i, v_i from which the record-means have been removed (i labels 3-hrly samples in time). The covariance matrix

$$\begin{bmatrix} \overline{uu} & \overline{uv} \\ \overline{uv} & \overline{vv} \end{bmatrix}$$

is diagonalised by a rotation to principal axes in which the new velocity components u', v' are uncorrelated ($\overline{u'v'} = 0$); $\overline{u'u'}$, $\overline{v'v'}$ are respectively maximal and minimal for variances of a velocity component in any one direction; variances in other directions trace an ellipse defined by major and minor axes $\overline{u'u'}$, $\overline{v'v'}$. (Here $\overline{uv}$ - for example - denotes $\sum_i u_i v_i / I$ where the summation is over the I good samples of the total record).

Integral time

This is calculated for a single time series w_i (east or north component of current; i labels 3-hrly samples in time) from which the record mean has been

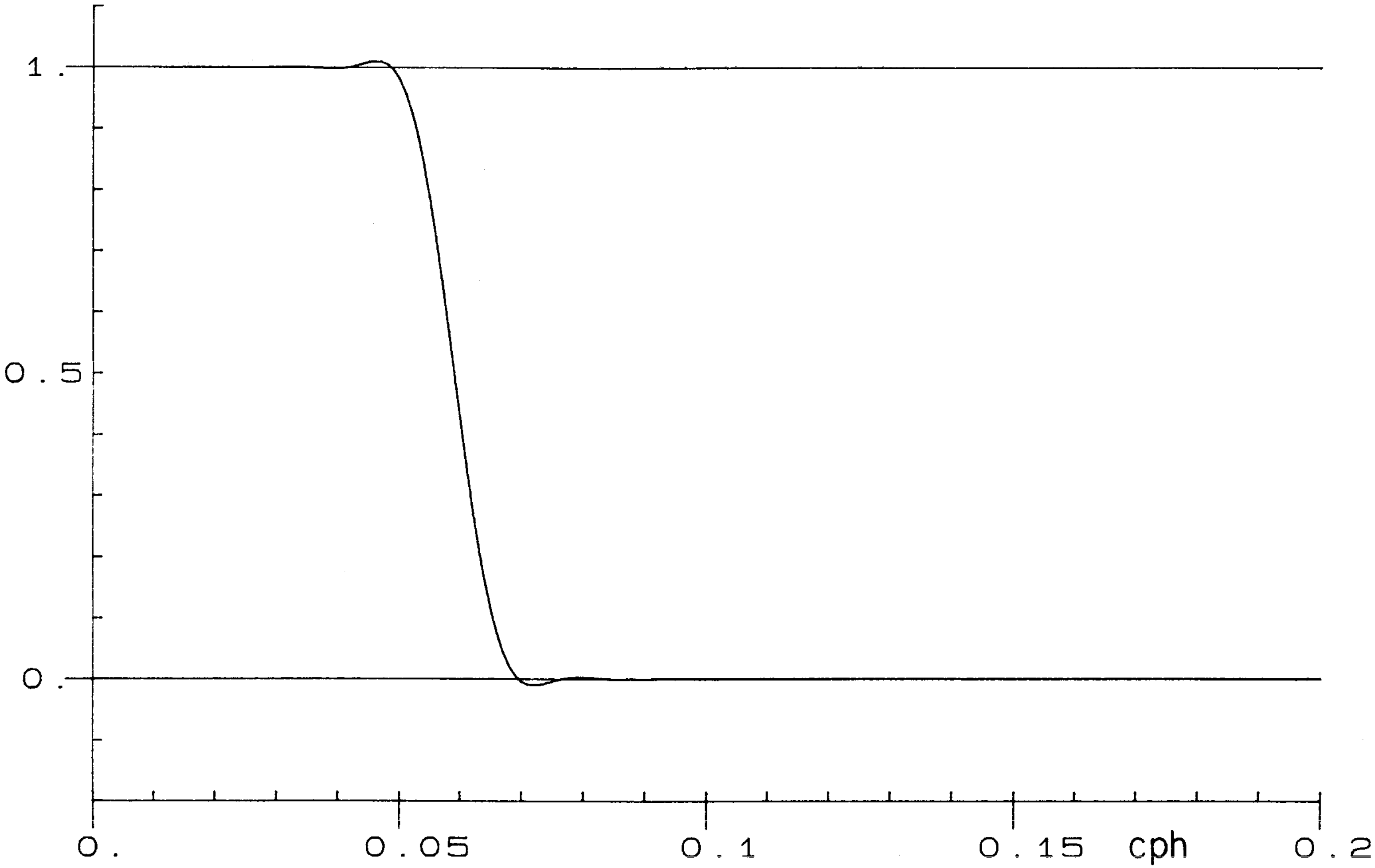


Figure 2. Frequency dependence of amplification introduced by HILOW (M=8, N=72) on hourly values. Phases are unchanged.

'explained' by $a_1\phi^1$, $a_2\phi^2$ .... This effect in total variance occurs only at G2, G4 and OS among individual moorings, and is small enough (2.1%, 3.0%, 0.3%) not to cause difficulties of interpretation. It occurs during an event at B3, and at OS where modes 1 and 2 together contribute an exaggerated variance exceeding the total. The inconsistences remain small nevertheless.

Principal components (for frequency bands).

These are based on spectral analysis as described above. Means and trends from each piece of the records contribute variance to the total record from which a covariance matrix is constructed. The low frequency band principal component mode form follows from this low frequency band covariance matrix as in the principal component analyses above.

In frequency bands 1,2, ... cross-spectral matrices were constructed as in the spectral analysis but with further averaging over the bandwidths stated on the plots. The frequency band principal component modes are the (orthogonal) eigenvectors of the cross-spectral matrix.

If the various time series do not all have the same duration, leading to ensemble averages over varying pieces for different cross-spectral elements, then the cross-spectral matrix may not be positive definite and may have some negative eigenvalues. The initial positive eigenvalues or variances associated with modes 1,2, ... will then be exaggerated. This occurs at several moorings (L2, L3, MR, FR, F3, G1, G2, G4 and OS) as noted on their data and comments page. 10% is exceeded at G2 and G4 and the corresponding modes (for bands 2 and 1 respectively) are suspect.

On the plots, 'total variance' is the sum of the variances of all component series. All plotted mode forms are normalised so that only relative signs and line lengths within one mode are significant. Plotted mode forms for frequency bands indicate a sense of rotation from the dotted 'imaginary' vector to the continuous 'real' vector around their common origin.

Principal component analysis is essentially a means of efficient data description; being entirely empirical, there is no concept of significance for the mode forms. However, the sequence of eigenvalues (variances) can indicate the extent of noise. 'Signals' cause the lowest modes to be associated with large variances, standing out above the trend of an approximate geometric progression defined by the smaller variances and associated with the remaining modes and noise. The number of modes plotted has been chosen subjectively on this basis.

removed. The autocorrelation function is

$$R(p)/R(0) \text{ where } R(p)=(\sum_i w_i \, w_{i+p}/I).$$

Here the summation is over the I good samples of $w_i w_{i+p}$ in the total record. Then the integral time is found as (a numerical approximation to) the integral of the autocorrelation function over the time for which it is positive.

Rotary spectra

Spectra were calculated by dividing the good data spans into non-overlapping pieces of 25 days (200 3-hrly samples), removing a mean and trend, applying a cosine taper to the first and last 20 samples of each piece, Fourier transforming, combining for co- and cross-spectral estimates and ensemble averaging over all pieces. Thus plots show values at intervals 0.04 cpd, multiplied by frequency so that area under the plot is proportional to band energy despite the logarithmic frequency scale. Note that the 3-hrly data has already been filtered (section 2) causing a rapid decrease in spectral coefficients between 1.2 cpd and 1.6 cpd.

If the contribution to (u,v) at the frequency w is represented by $\mathrm{Re}(\tilde{u},\tilde{v})e^{iwt}$ then the coefficients for clockwise and anti-clockwise components are $\frac{1}{2}(\tilde{u}-i\tilde{v})$ and $\frac{1}{2}(\tilde{u}+i\tilde{v})$ respectively. Rotary spectra are then $\frac{1}{4}|\tilde{u}-i\tilde{v}|^2$ and $\frac{1}{4}|\tilde{u}+i\tilde{v}|^2$ and add to $\frac{1}{2}|\tilde{u}|^2 + \frac{1}{2}|\tilde{v}|^2$, the total root-mean-square velocity.

Principal components (for total variance and events)

These are calculated for a vector time series $\underset{\sim}{w}_i$ from which record means have been removed. Here i labels 3-hrly samples in time, and $\underset{\sim}{w}$ may represent (for example) the eight series u, v from four current meters on a mooring. Writing

$$\underset{\sim}{w}_i = \underset{\sim}{a}_1 \phi^1_i + \underset{\sim}{a}_2 \phi^2_i + \dots \; (\dots + \underset{\sim}{a}_8 \phi^8_i, \text{ for example})$$

the analysis optimises the description of $\underset{\sim}{w}$ by the mode $\underset{\sim}{a}_1$ and principal component time series ϕ^1, minimising

$$\sum_i (w - \underset{\sim}{a}_1 \phi^1)_i^2.$$

Having found $\underset{\sim}{a}_1$ and ϕ^1, the analysis determines a_2 and ϕ^2 similarly for the residual series $\underset{\sim}{w} - \underset{\sim}{a}_1 \phi^1$, and so on. In fact, $\underset{\sim}{a}_1$, $\underset{\sim}{a}_2$ ... are the (orthogonal) eigenvectors of the covariance matrix $\overline{\underset{\sim}{w}\,\underset{\sim}{w}^T}$ (if $\underset{\sim}{w}$ is regarded as a columnvector, T denotes its transposition to a row vector, and the overbar denotes an average over the ensemble of good samples of both elements in the total record). Moreover, ϕ^1, ϕ^2, ... are all orthogonal to each other in time.

If the component time series of $\underset{\sim}{w}$ do not all have the same duration, $\overline{\underset{\sim}{w}\,\underset{\sim}{w}^T}$ may not be positive definite and may have some negative eigenvalues, exaggerating the initial positive eigenvalues which are the variances

MOORING L2

Set	28- VI-82	Position:	51° 41.8'N 14° 57.3'W
	25- IX-82		51° 41.4'N 14° 56.3'W
Recovered	28- IX-82	Water Depth:	758m
	14- V-83		786m

Depth (m)	Variables	Samp. Int. (hours)	Comments
332	Sp,D		Porcupine Array 2
352	Sp,D,T	0.5	Porcupine Array 3
728	Sp,D		Porcupine Array 2
757	Sp,D,T	0.5	Porcupine Array 3

Comments

Low frequency band covariance matrix not positive definite (0.03%)

Principal components including temperature

These are not plotted, but were calculated for each mooring furnishing temperature series from the current meters, i.e. excluding OS and ST. The analysis (for total variance) is just as previously described but a mooring with four current meters (say) would now give $\underset{\sim}{w}$ twelve component series. Scaling is somewhat arbitrary - temperature units differ from the units for speed! For comparison (with/without temperature) the average temperature series variance numerically equalled the average variance for the velocity component series on the mooring.

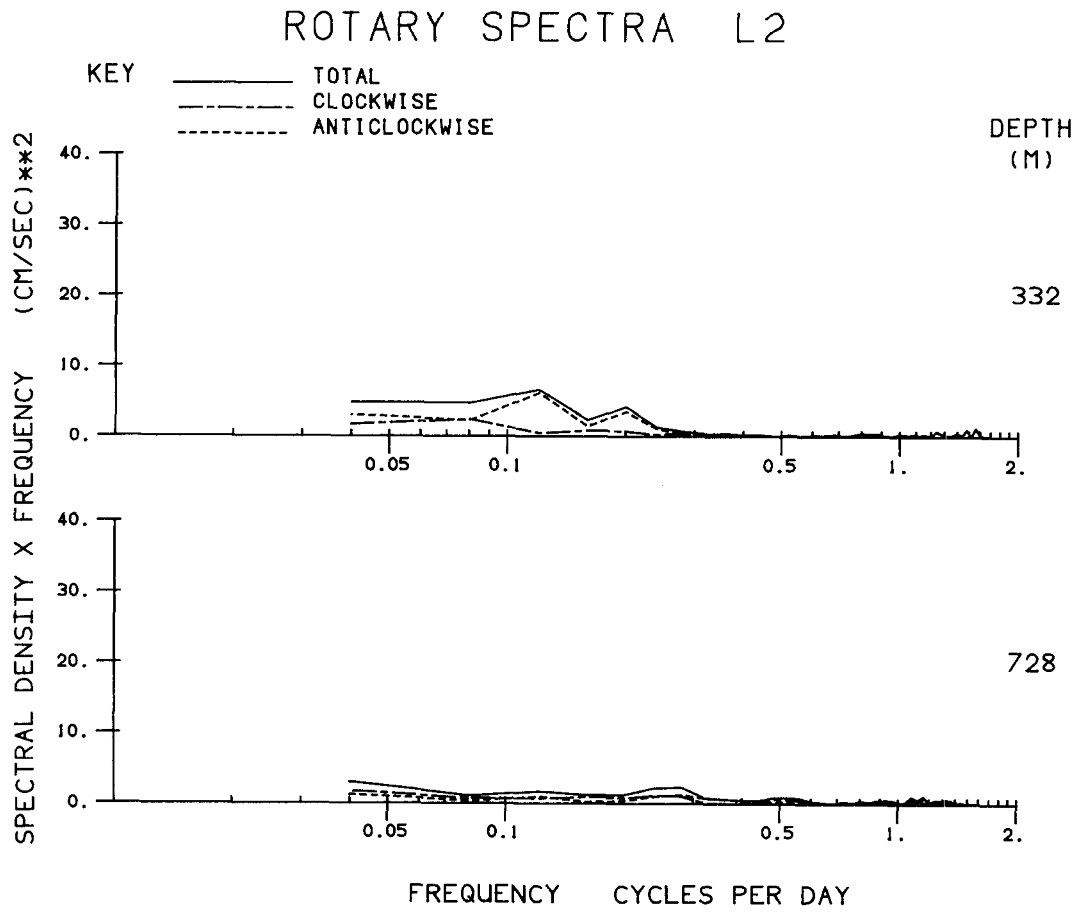
The velocity structure of mode 1 is substantially the same with or without temperature, except at D5, E3 and E4, where there is no close correspondence between any modes, and at FR where modes 1 and 2 are exchanged. At L2, the mode 2 velocity structure is affected but remains recognisable. At the other moorings (not so far mentioned in this section) where modes 2 ... stand out above noise, the inclusion of temperature results in

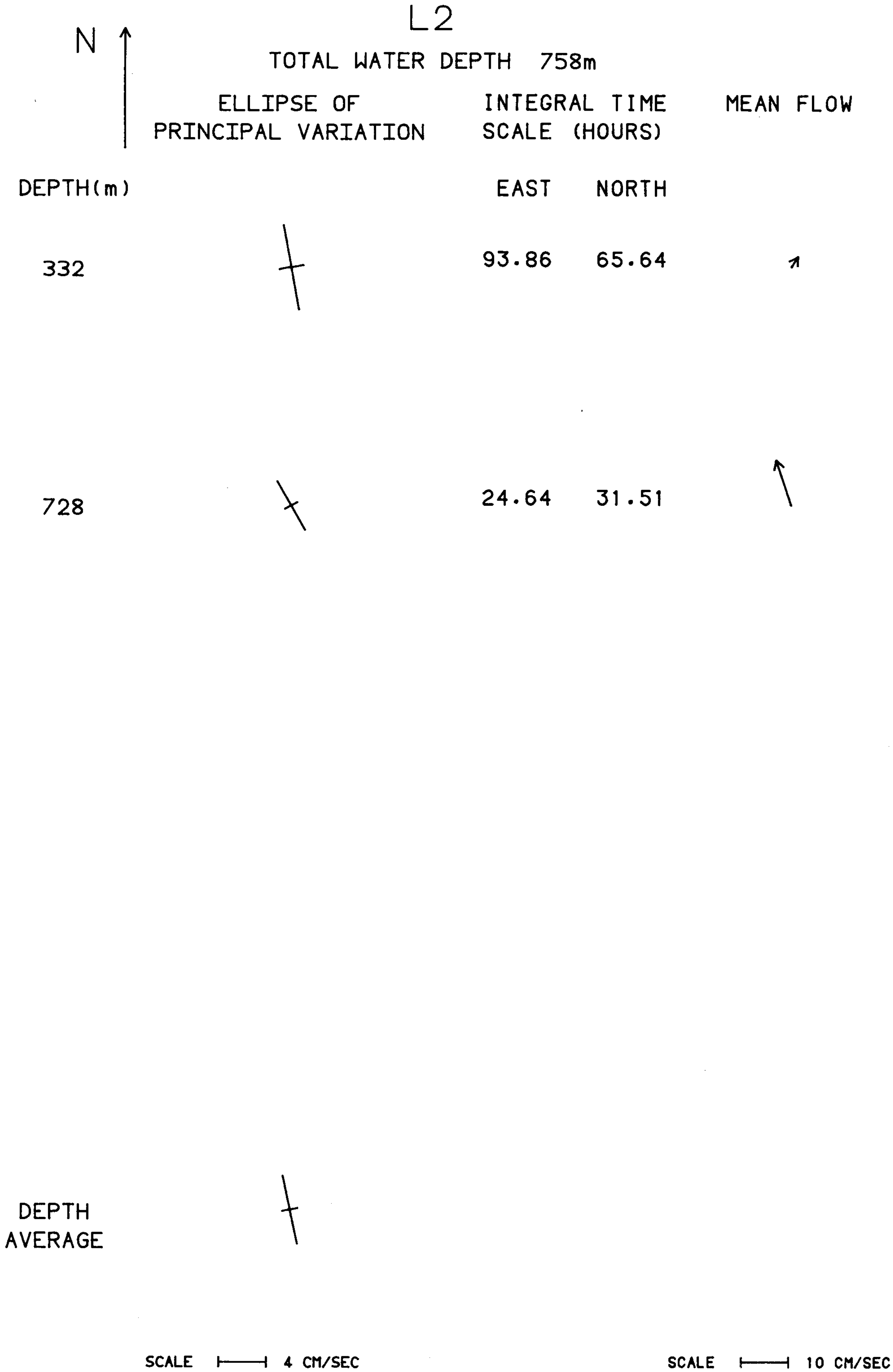
(i) a 'new' mode 2 principally describing temperature variance

(ii) former modes 2, 3 ... appearing as 'new' modes 3, 4...

(except F3: former mode 2 $\longrightarrow$ 'new' mode 4

G2: former mode 4 $\longrightarrow$ 'new' mode 6).


ROTARY SPECTRA L2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
332
728
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

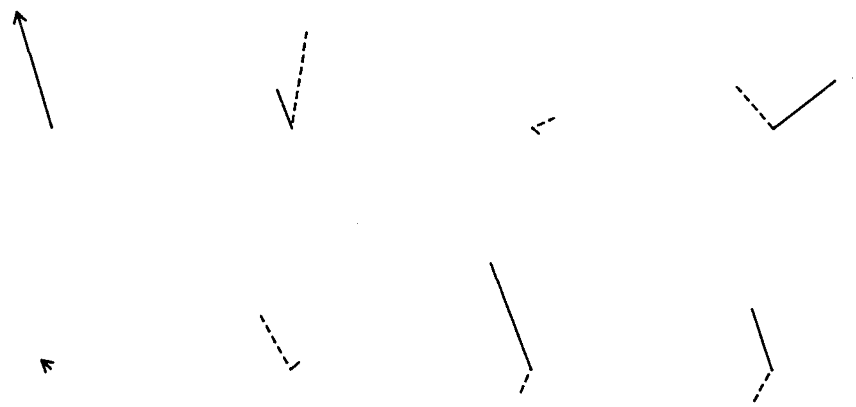

L2
N
TOTAL WATER DEPTH 758m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
332
93.86
65.64
728
24.64
31.51
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

L2

↑ N

FREQUENCY BAND (CYCLES PER DAY)

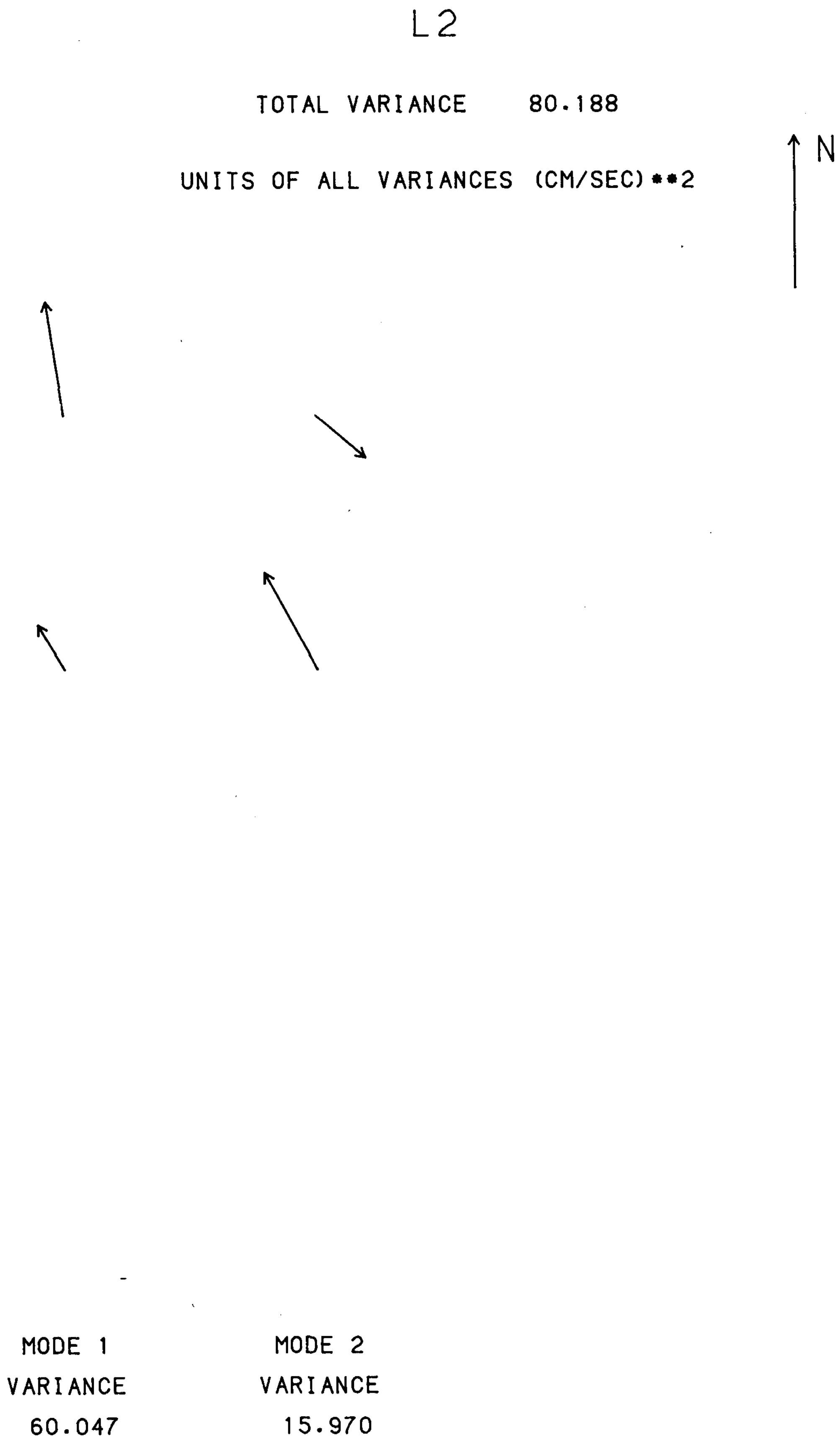
LOW FREQUENCY	1 0.02-0.46	2 0.46-0.98	3 0.98-2.02

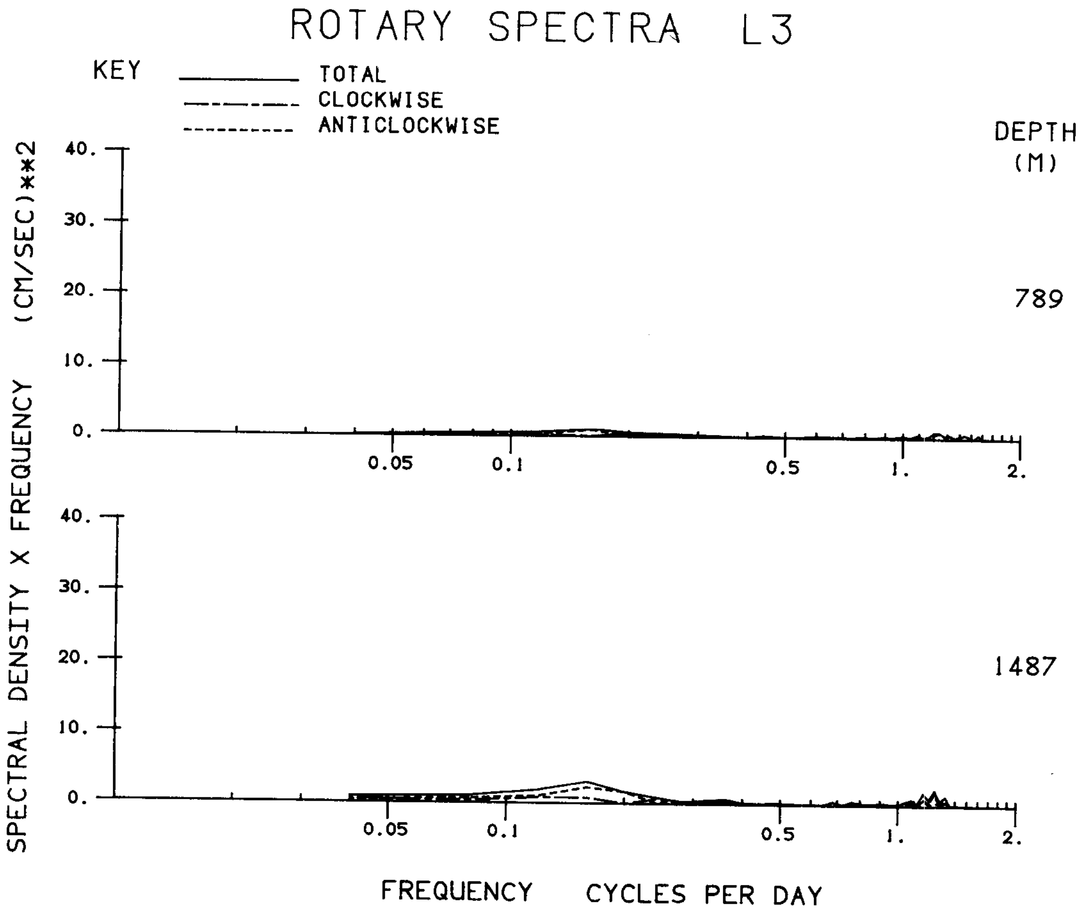


VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	36.262	TOTAL	38.411	TOTAL	1.261	TOTAL	0.961
MODE1	36.233	MODE1	29.913	MODE1	0.605	MODE1	0.509

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
------------ IMAGINARY PART


L2
TOTAL VARIANCE 80.188
UNITS OF ALL VARIANCES (CM/SEC)**2
N
MODE 1
VARIANCE
60.047
MODE 2
VARIANCE
15.970


ROTARY SPECTRA L3
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH
(M)
789
1487
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

MOORING L3

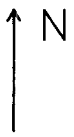
Set	26- VI-82	Position:	51° 41.1'N 15° 12.7'W
Recovered	25- IX-82	Water Depth:	1537m

Depth (m)	Variables	Samp Int. (hours)	Comments
789	Sp,D,T	1	Porcupine Array 2
1487	Sp,D,T	1	

Comments

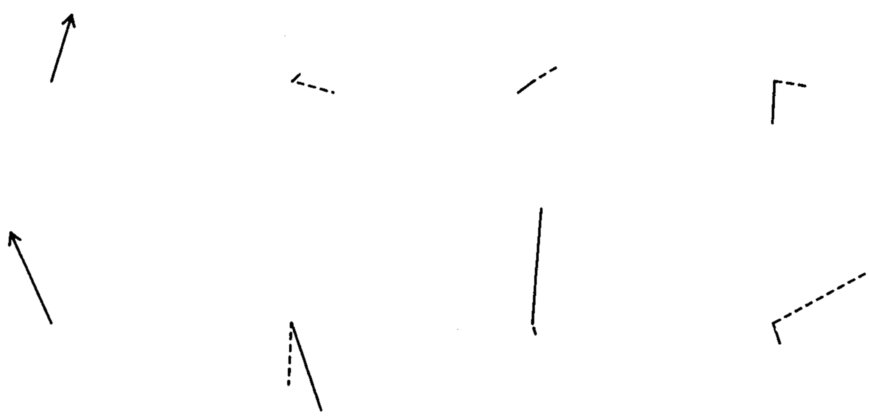
Low frequency band covariance matrix not positive definite (0.15%)

L3



FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.30	2 0.30-0.82	3 0.82-2.02



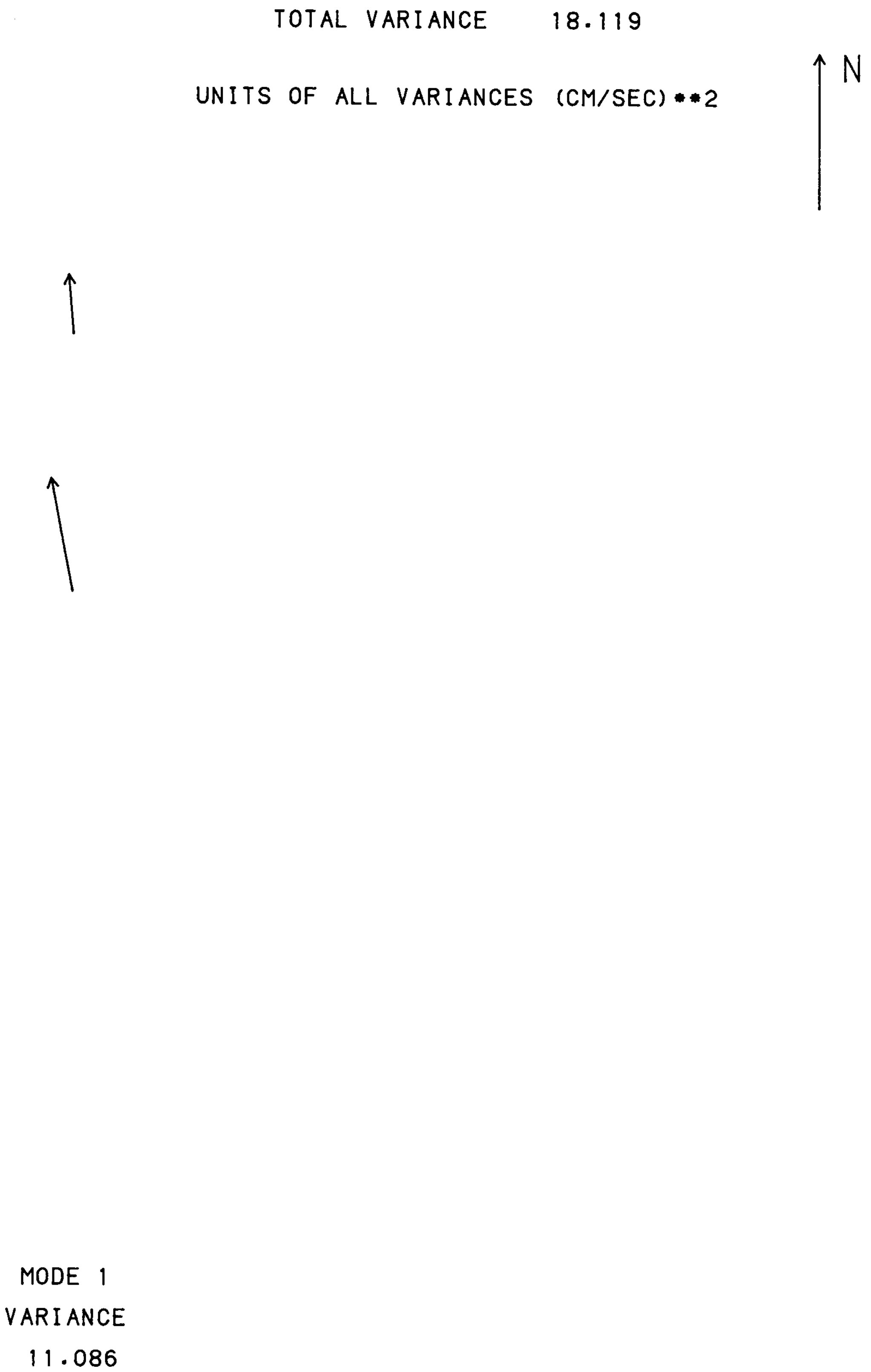
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	3.317	TOTAL	10.389	TOTAL	1.236	TOTAL	1.474
MODE1	2.785	MODE1	7.495	MODE1	0.627	MODE1	0.678

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———————— REAL PART

----------- IMAGINARY PART

L3


TOTAL VARIANCE 18.119
UNITS OF ALL VARIANCES (CM/SEC)**2
N
MODE 1
VARIANCE
11.086

MOORING L4

Set	26- VI-82	Position:	51° 42.1'N 15° 18.8'W
Recovered	25- IX-82	Water Depth:	2404m

Depth (m)	Variables	Samp. Int. (hours)	Comments
1299	Sp,D,T	1	No data
2354	Sp,D,T	1	Porcupine Array 2

L3

N

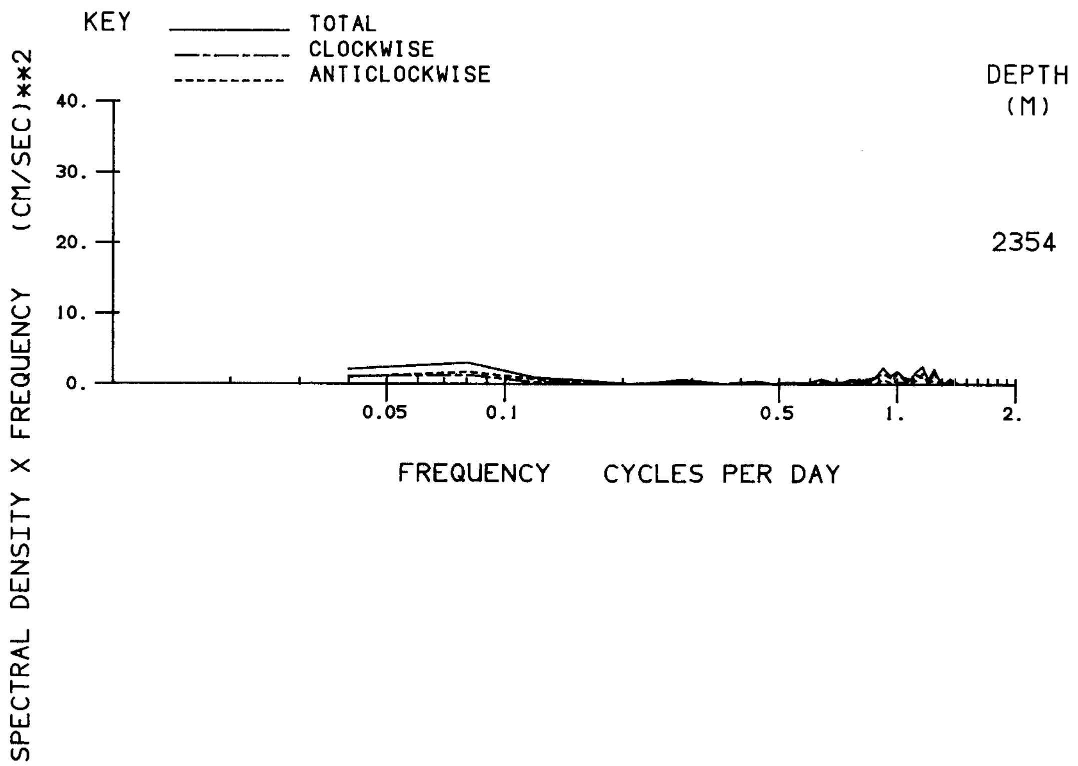
TOTAL WATER DEPTH 1537m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	INTEGRAL TIME SCALE (HOURS) NORTH	MEAN FLOW
789		18.85	54.71	
1487		31.35	32.52	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

SCALE ⊢—⊣ 10 CM/SEC

ROTARY SPECTRA L4



L4

N ↑

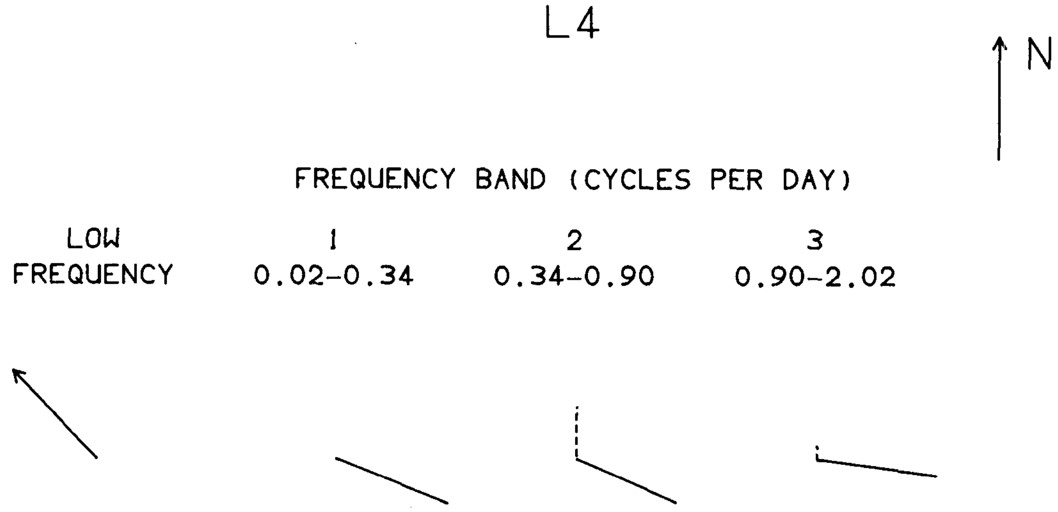
TOTAL WATER DEPTH 2354m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
2354		49.19	22.48	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

SCALE ⊢—⊣ 10 CM/SEC

L4



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	0.444	TOTAL	9.596	TOTAL	0.797	TOTAL	1.358
MODE1	0.396	MODE1	8.966	MODE1	0.556	MODE1	0.878

UNITS OF ALL VARIANCES (CM/SEC)**2

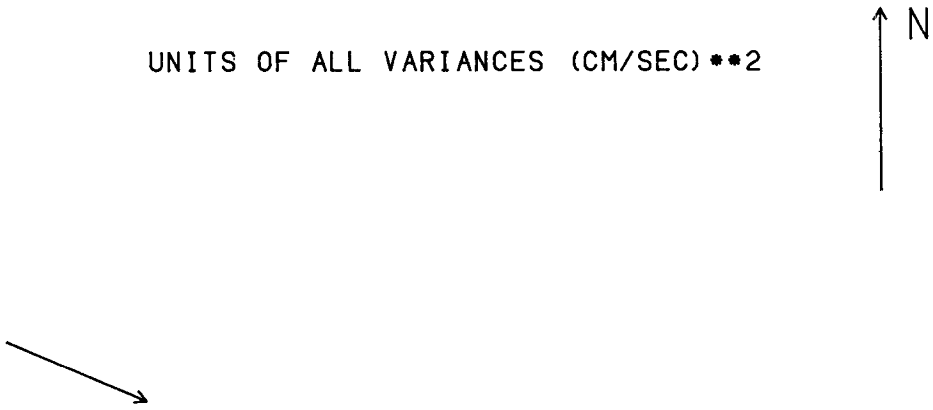
KEY ———— REAL PART

-------------- IMAGINARY PART

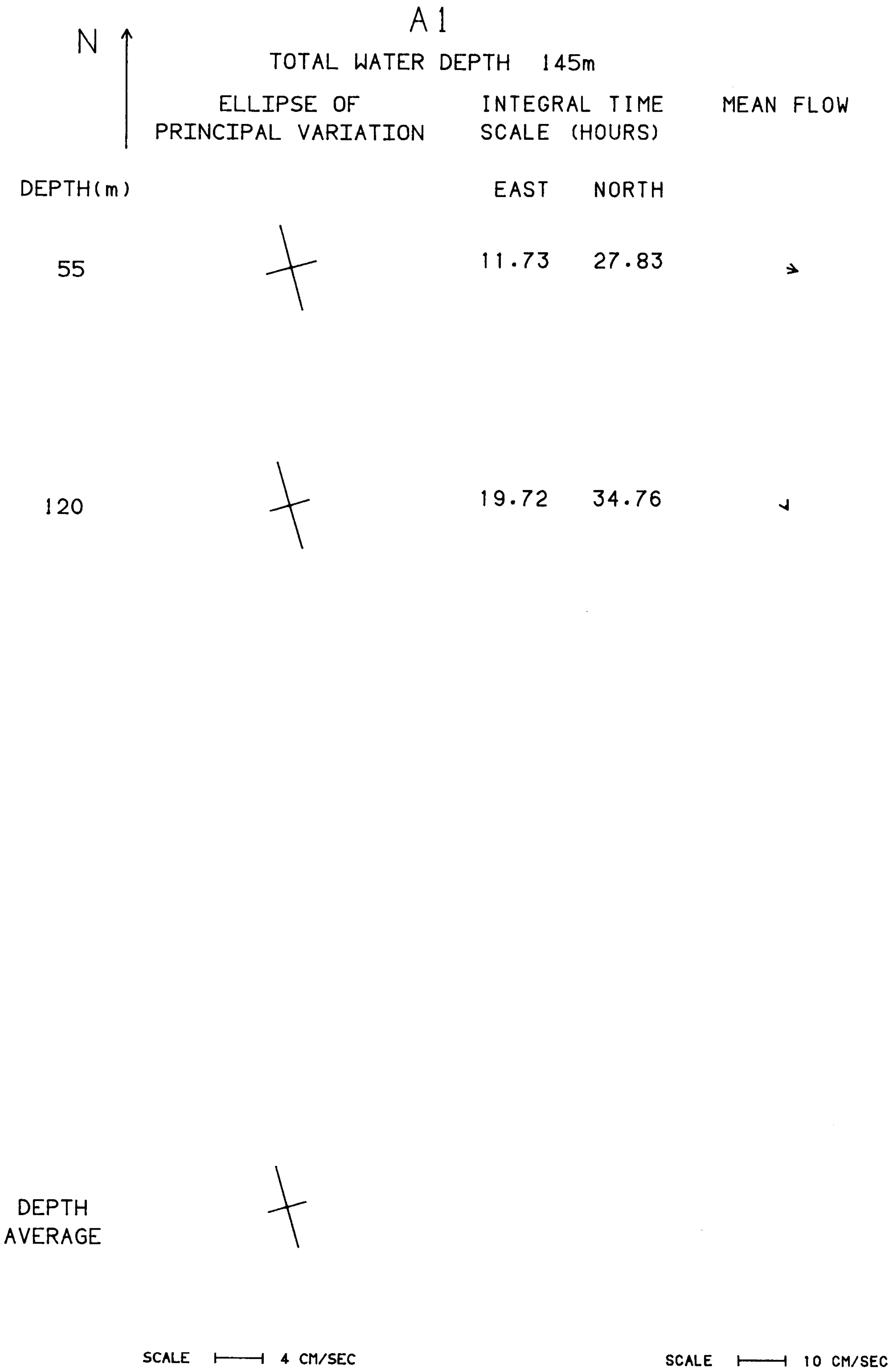
L4

TOTAL VARIANCE 11.609

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1
VARIANCE
9.744


A1
N
TOTAL WATER DEPTH 145m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
55
11.73
27.83
120
19.72
34.76
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

MOORING A1

Set	21-VIII-82	Position:	57° 20.7'N 09° 07.2'W
Recovered	18- II-83	Water Depth:	145m

Depth (m)	Variables	Samp. Int. (hours)	Comments
55	Sp,D,T,P	0.5	Encoding errors at end
120	Sp,D,T,C	0.5	

Comments

A1

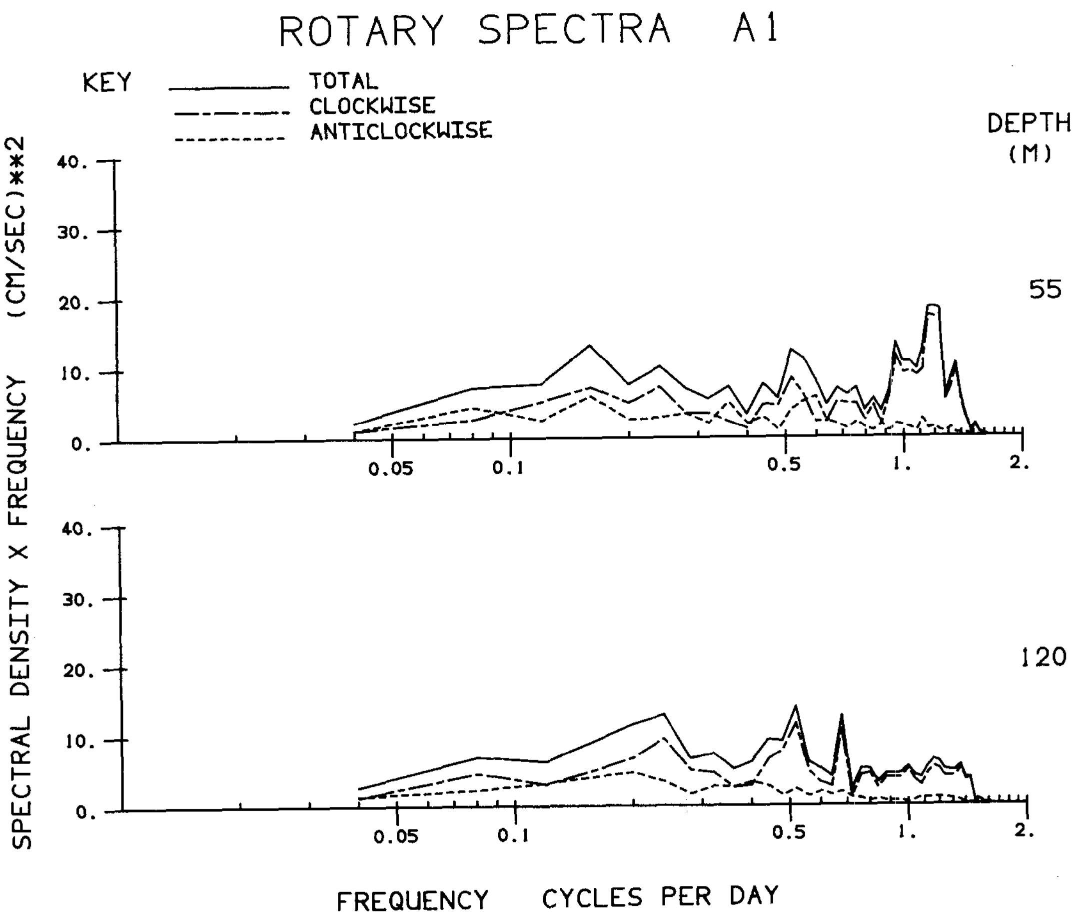
TOTAL VARIANCE 140.724

UNITS OF ALL VARIANCES (CM/SEC)**2

MODE 1

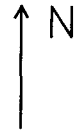
VARIANCE

100.077

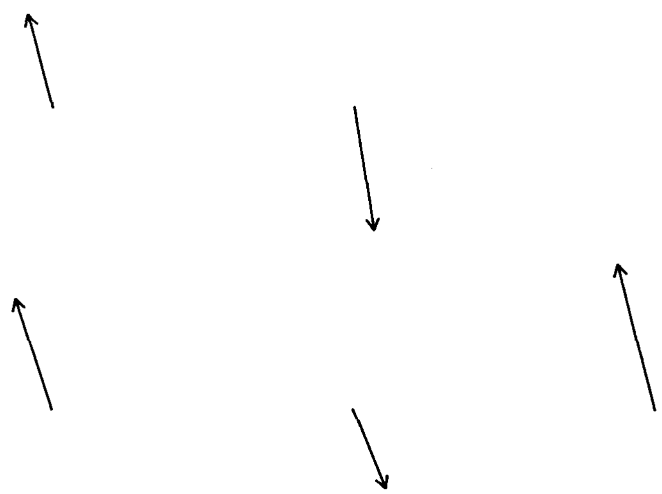

ROTARY SPECTRA A1
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
40.
30.
20.
10.
0.
55
0.05
0.1
0.5
1.
2.
120
FREQUENCY CYCLES PER DAY

A1

Event duration shown by day number in 1982. 1 Jan 1982 = 1



EVENT 1	EVENT 2	EVENT 3
277-291	295-305	393-410

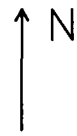


VARIANCES		VARIANCES		VARIANCES	
TOTAL	193.848	TOTAL	162.778	TOTAL	115.045
MODE 1	166.299	MODE 1	102.935	MODE 1	83.521

UNITS OF ALL VARIANCES (CM/SEC)**2

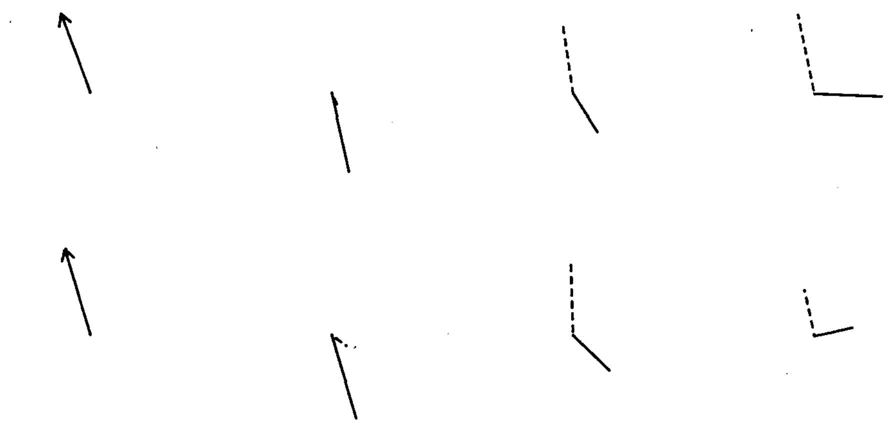
—— MODE 1
------ MODE 2

A1



FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1	2	3
	0.02-0.42	0.42-0.74	0.74-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	21.343	TOTAL	82.300	TOTAL	20.645	TOTAL	22.067
MODE1	17.088	MODE1	64.669	MODE1	15.340	MODE1	15.989

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
----------- IMAGINARY PART

PR

N ↑

TOTAL WATER DEPTH 1032m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
130		19.19	47.56	
428		20.44	25.39	
729		16.94	20.77	
980		14.47	13.73	
DEPTH AVERAGE				

SCALE ├──┤ 4 CM/SEC

SCALE ├──┤ 10 CM/SEC

MOORING PR

Set	27- IV-82		Position:	57° 05.8'N 09° 23.0'W
Recovered	22- X-82		Water Depth:	1032m

Depth (m)	Variables	Samp. Int. (hours)	Comments
130	Sp,D,T	0.5	
428	Sp,D,T	0.5	
729	Sp,D,T	0.5	
980	Sp,D,T	0.5	Encoder malfunction

Comments

Data series end 13th or 14th September 1982, when tapes ran out.

Spectra and frequency-band principal components omitted owing to short series.

MOORING A5

Set	21-VIII-82	Position:	57° 18.6'N 09° 40.4'W
Recovered	17- II-83	Water Depth:	1614m

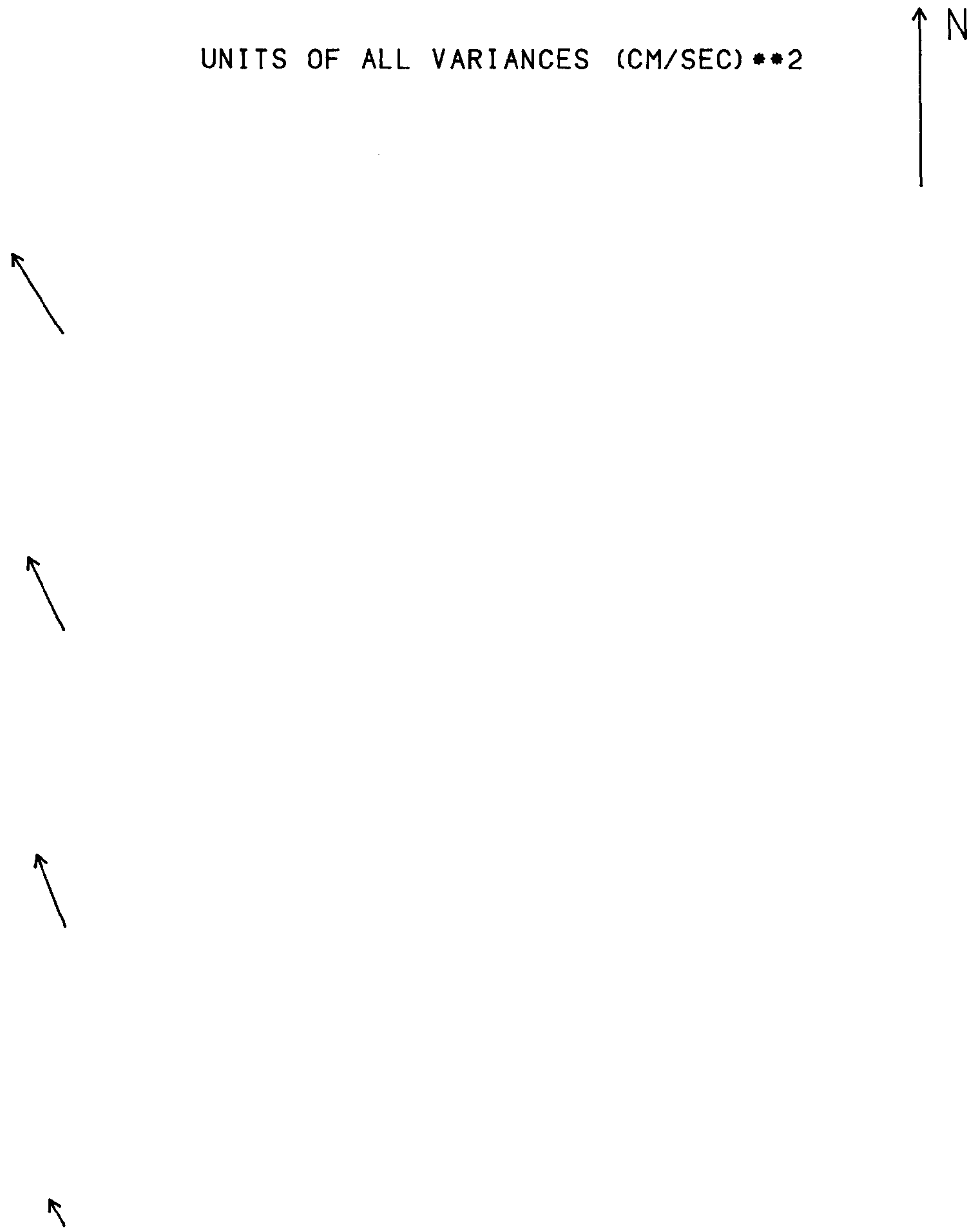
Depth (m)	Variables	Samp. Int. (hours)	Comments
209	Sp,D,T,P	0.5	
510	Sp,D,T,P	0.5	
1111	Sp,D,T,P	0.5	
1562	Sp,D,T,P	0.5	

Comments

PR

TOTAL VARIANCE 80.994

UNITS OF ALL VARIANCES (CM/SEC)**2

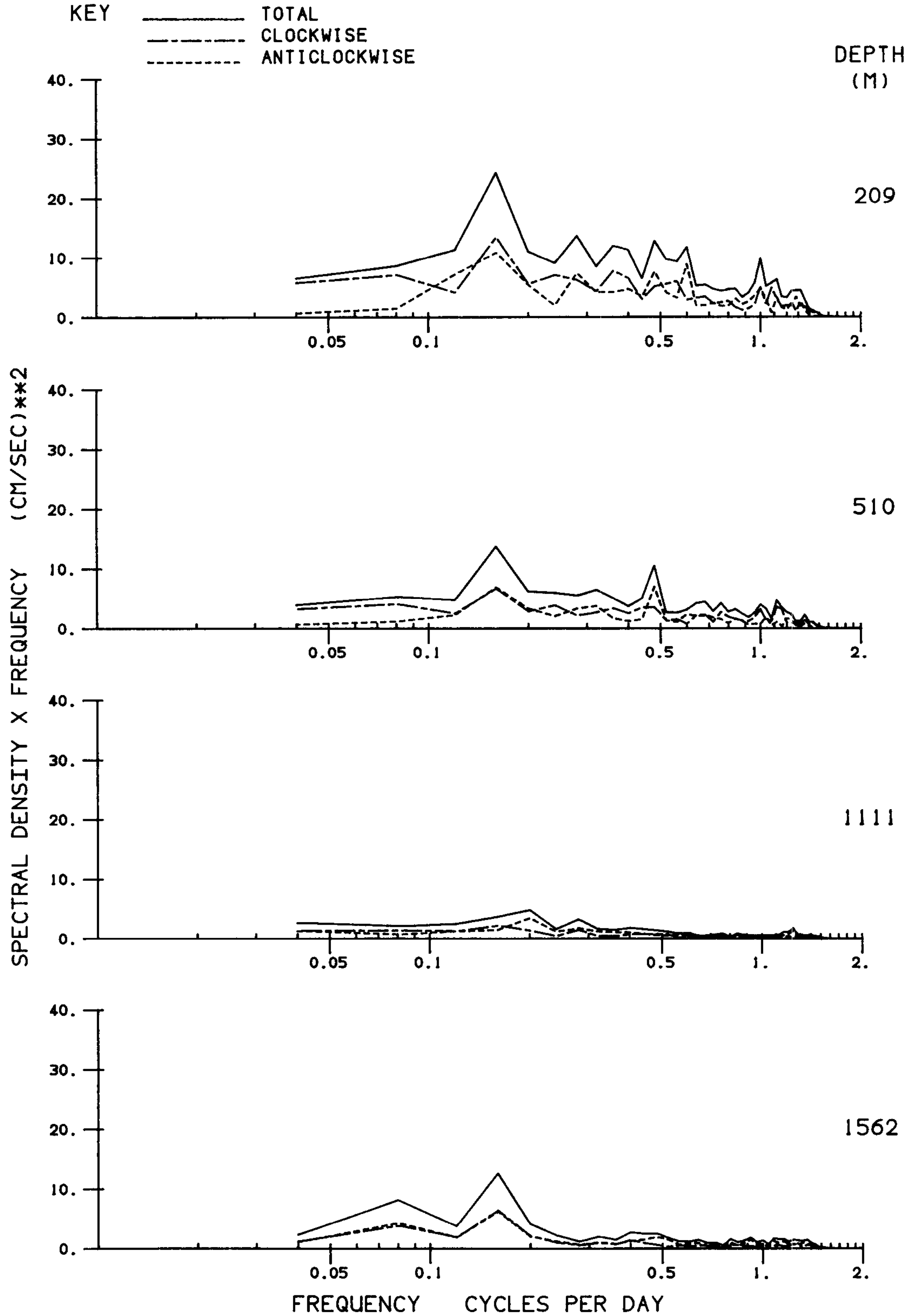


MODE 1

VARIANCE

45.747

ROTARY SPECTRA A5

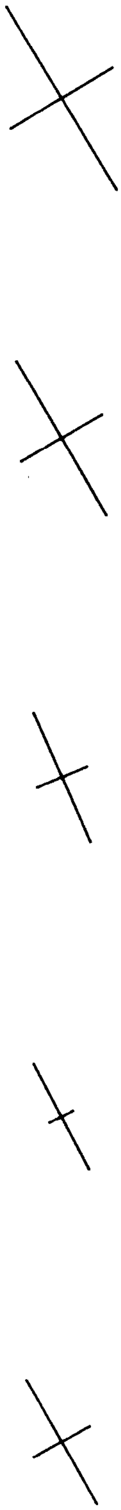


A5

N ↑

TOTAL WATER DEPTH 1614m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
209		230.14	264.22	
510		310.09	338.33	
1111		349.97	339.50	
1562		126.01	121.33	
DEPTH AVERAGE				



SCALE ├──┤ 4 CM/SEC

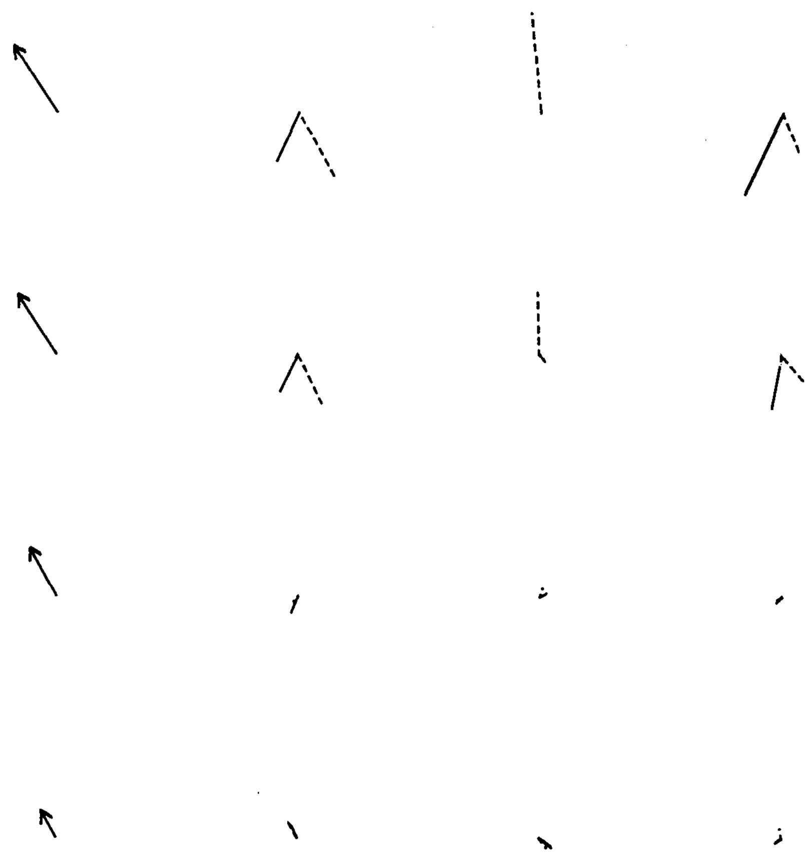
SCALE ├──┤ 10 CM/SEC

A5

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.26	2 0.26-0.74	3 0.74-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	291.302	TOTAL	131.409	TOTAL	43.236	TOTAL	14.668
MODE1	243.315	MODE1	65.035	MODE1	21.217	MODE1	4.819

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
----------- IMAGINARY PART

A5

TOTAL VARIANCE 480.804

UNITS OF ALL VARIANCES (CM/SEC)**2

MODE 1 -
VARIANCE
304.173

MOORING MR

Set	28- IV-82	Position:	57° 17.6'N 10° 20.2'W
	16- II-83		57° 16.7'N 10° 18.7'W
Recovered	12- XII-82	Water Depth:	2201m
	22- V-83		2224m

Depth (m)	Variables	Samp. Int. (hours)	Comments
156	Sp,D,T	0.5	Battery leaked
160	Sp,D,T	0.5	
567	Sp,D,T	0.5	
570	Sp,D,T	0.5	
1068	Sp,D,T	0.5	
1070	Sp,D,T	0.5	
1819	Sp,D,T	0.5	Mechanical fault
1820	Sp,D,T	0.5	

Comments

Repeated dates, position, depths and other values refer to second deployment.
Low frequency band covariance matrix not positive definite (5.7%).

A5

Event duration shown by day number in 1982. 1 Jan 1982 = 1

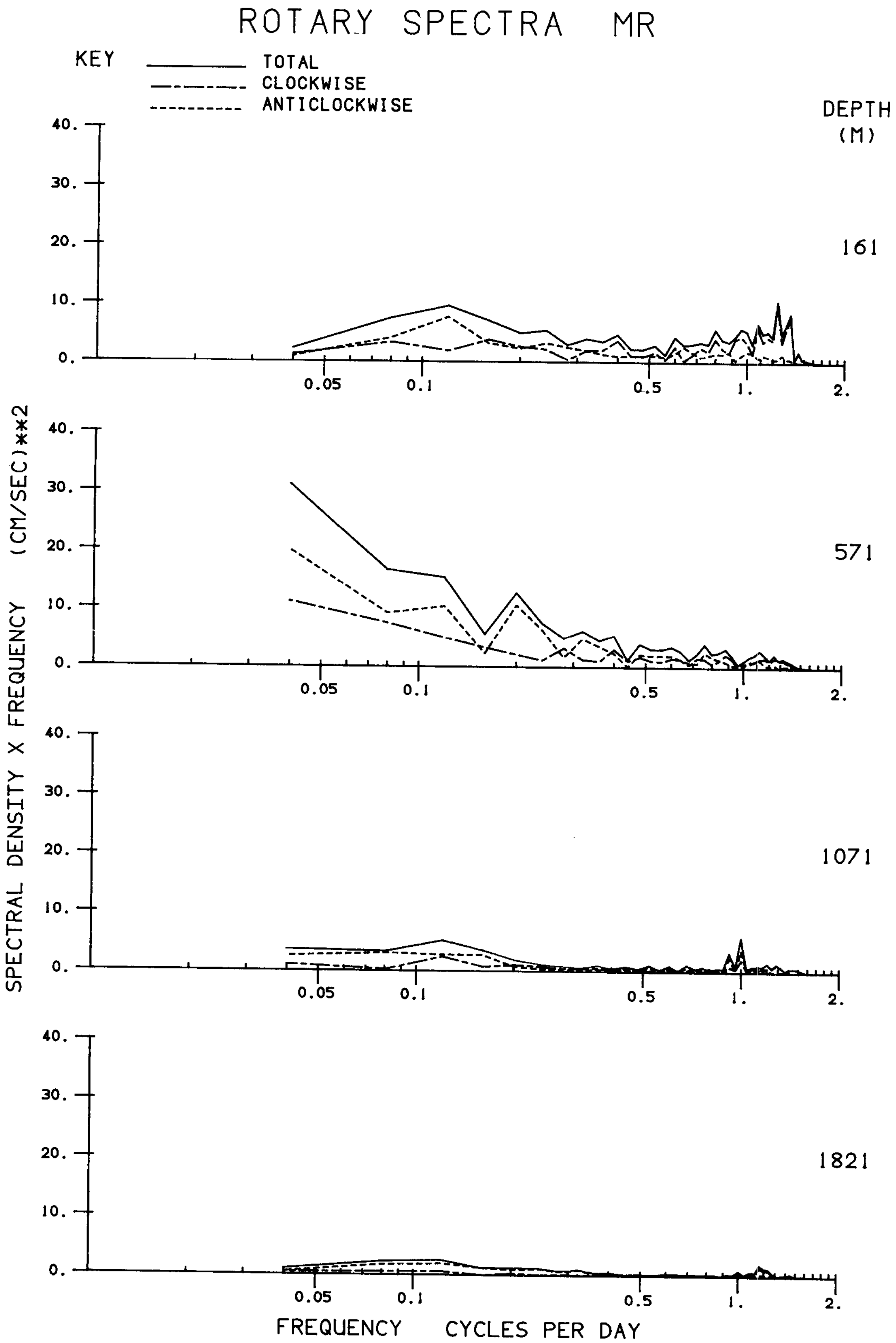
↑ N

EVENT 1
393-410

VARIANCES
TOTAL 444.658
MODE 1 244.155

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
----- MODE 2

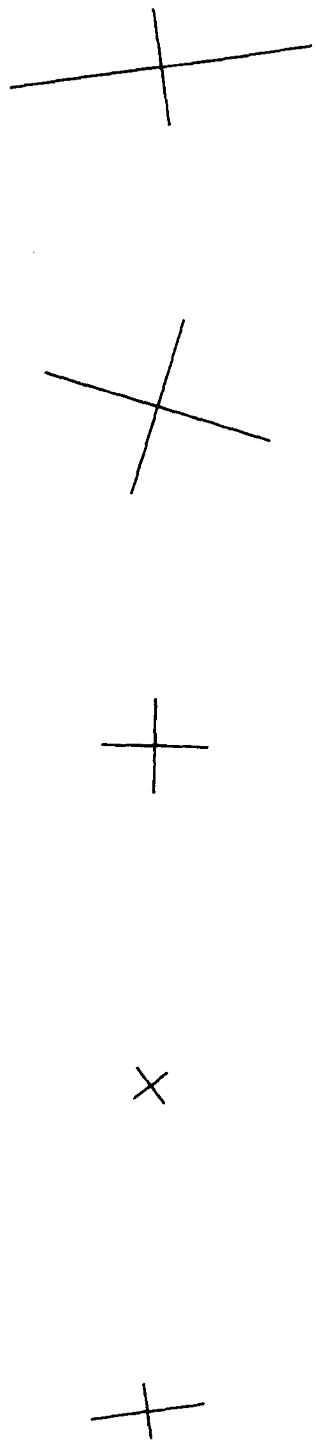

ROTARY SPECTRA MR
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
161
571
1071
1821
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

MR

TOTAL WATER DEPTH 2201m

N ↑

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
161		438.29	56.54	
571		203.43	96.31	
1071		299.40	41.21	
1821		34.21	38.38	
DEPTH AVERAGE				



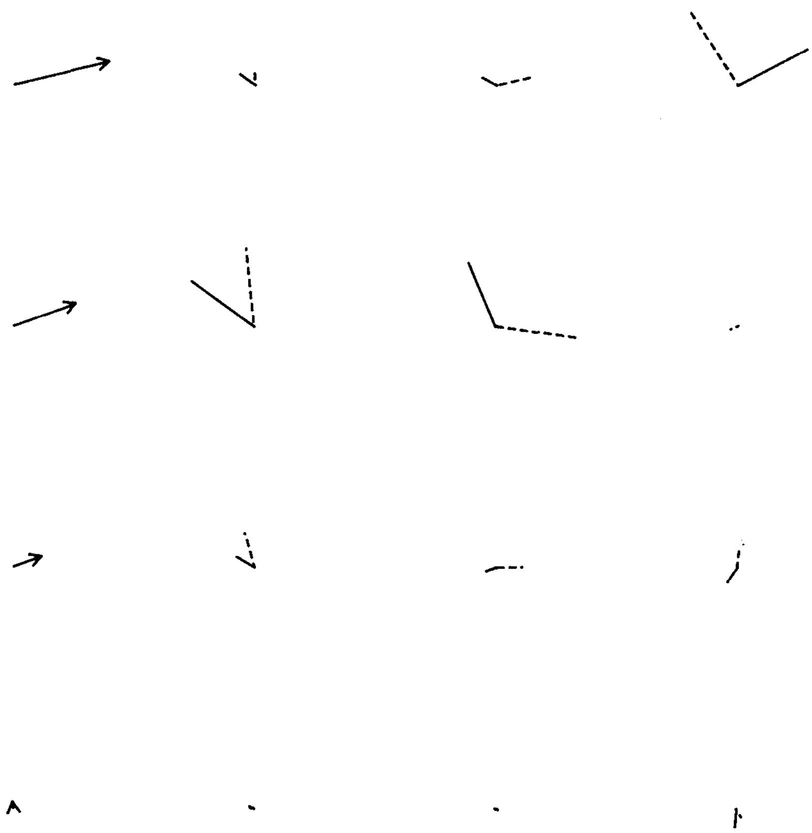
SCALE ├──┤ 4 CM/SEC

SCALE ├──┤ 10 CM/SEC

MR

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.30	2 0.30-0.82	3 0.82-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	379.709	TOTAL	175.679	TOTAL	18.985	TOTAL	11.942
MODE1	359.576	MODE1	114.763	MODE1	6.540	MODE1	5.629

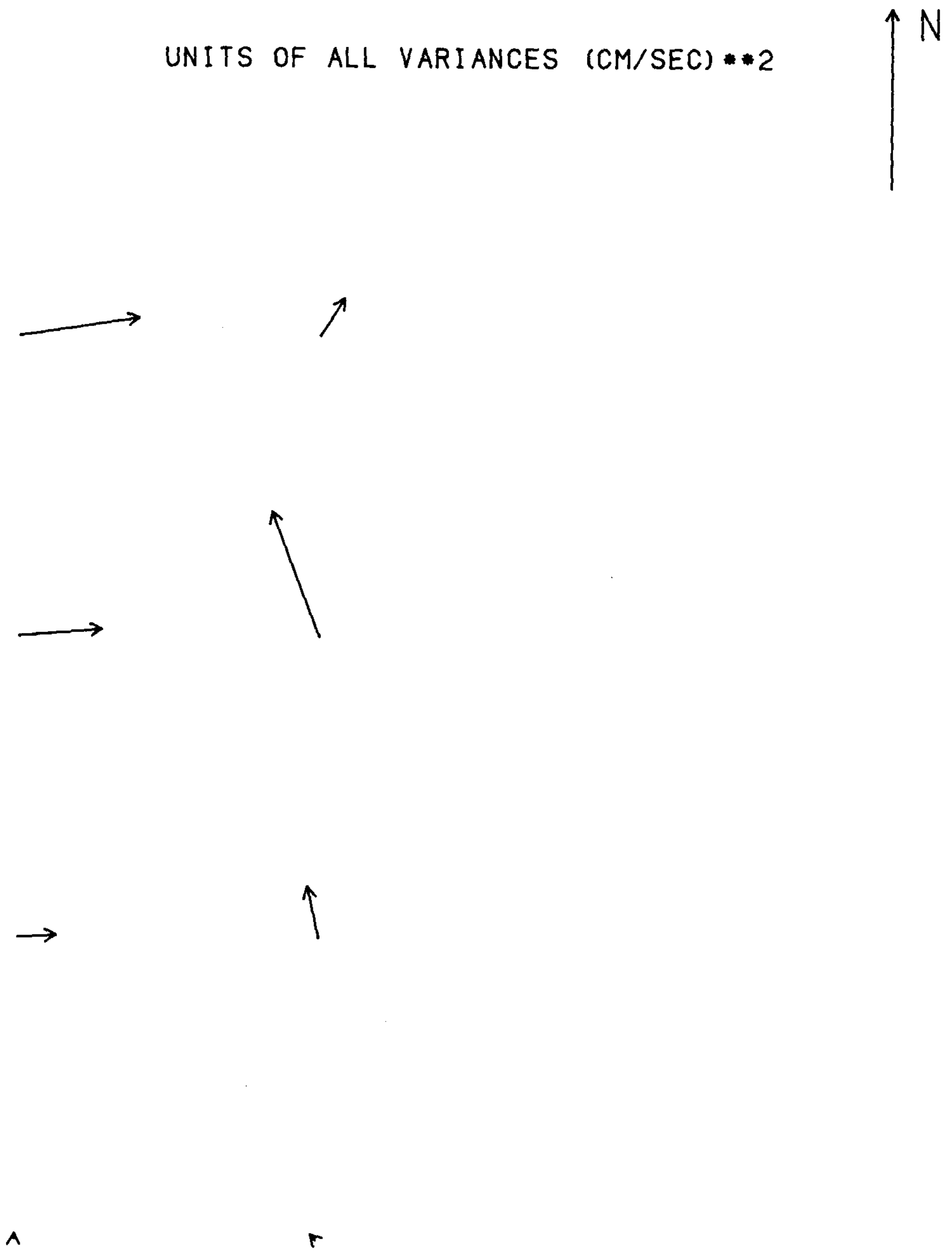
UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
----------- IMAGINARY PART

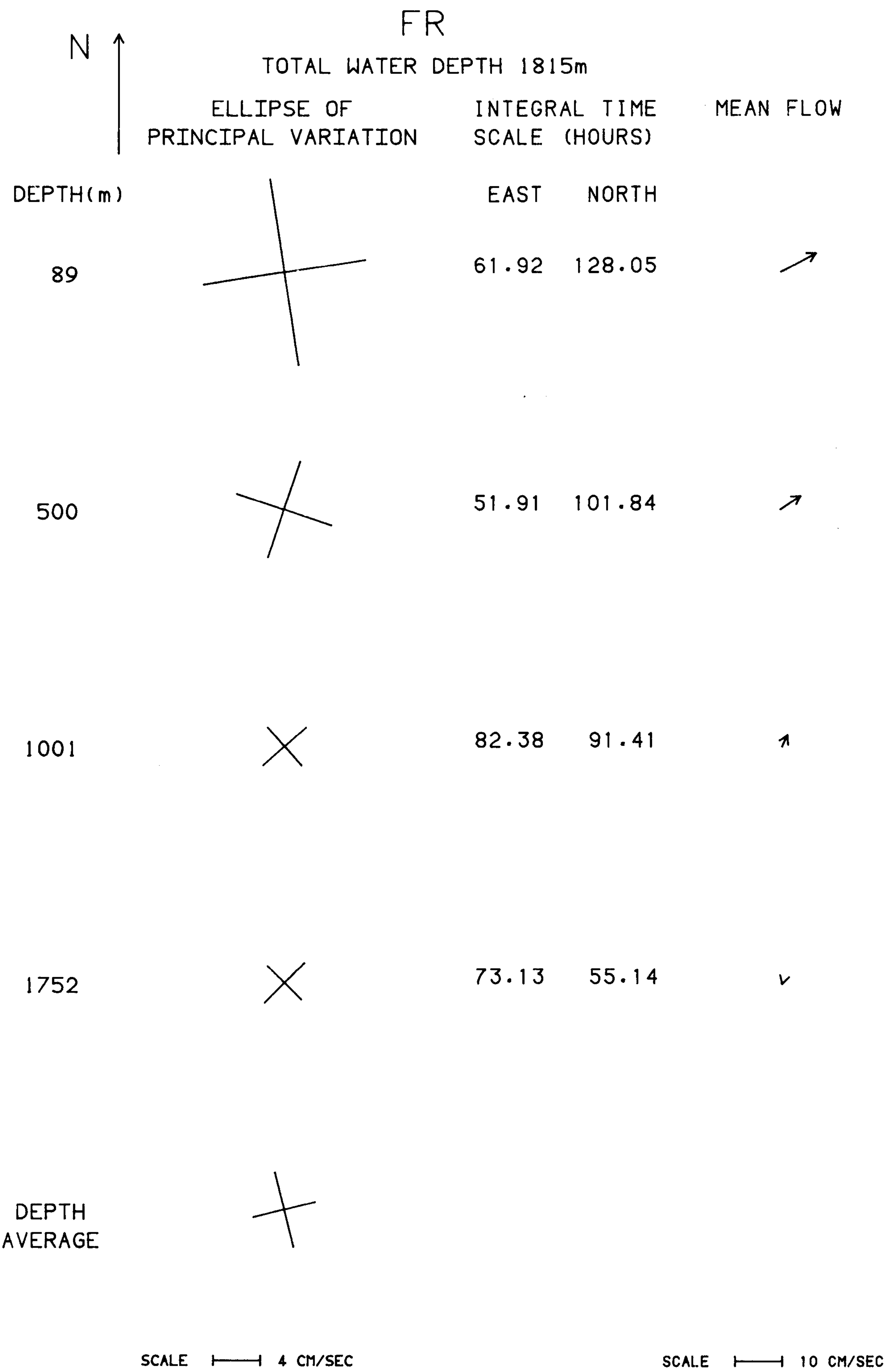
MR

TOTAL VARIANCE 755.756

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1	MODE 2
VARIANCE	VARIANCE
478.061	161.292


FR
N
TOTAL WATER DEPTH 1815m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST NORTH
89
61.92 128.05
500
51.91 101.84
1001
82.38 91.41
1752
73.13 55.14
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

MOORING FR

Set	8- V-82	Position:	57° 28.4'N 12° 15.3'W
	23- X-82		57° 27.4'N 12° 14.3'W
	16- II-83		57° 24.4'N 12° 14.3'W
Recovered	23- X-82	Water Depth:	1815m
	16- II-83		1818m
	18- V-83		1820m

Depth (m)	Variables	Samp. Int. (hours)	Comments
53	Sp,D,T	0.5	
89	Sp,D,T	0.5	
103	Sp,D,T	0.5	Meter leaked
500	Sp,D,T	0.5	
513	Sp,D,T	0.5	Corroded head
804	Sp,D,T	0.5	
1001	Sp,D,T	0.5	
1016	Sp,D,T	0.5	
1305	Sp,D,T	0.5	
1715	Sp,D,T	0.5	
1752	Sp,D,T	0.5	
1765	Sp,D,T	0.5	

Comments

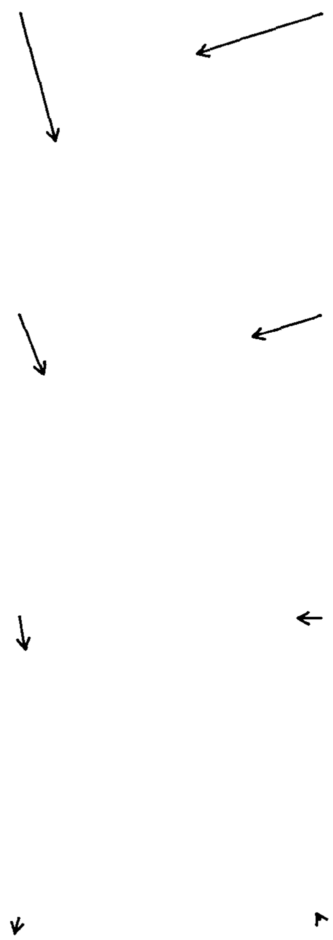
Repeated dates, position, depths and other values refer to second and third deployments.

Low frequency band covariance matrix and band 1 cross-spectral matrix not positive definite (0.6%, 1.1%).

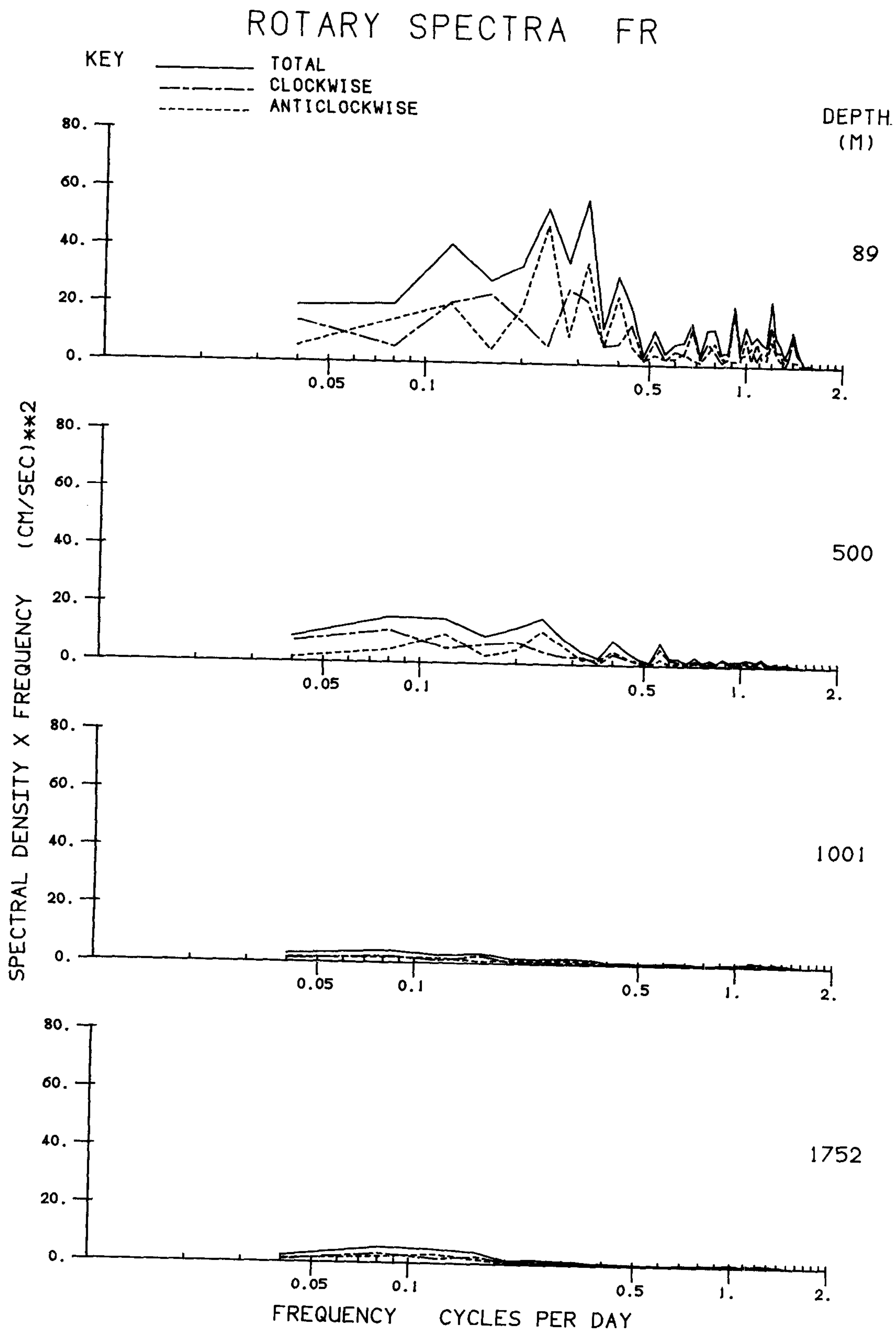
FR

TOTAL VARIANCE 665.905

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1	MODE 2
VARIANCE	VARIANCE
319.986	247.083


ROTARY SPECTRA FR
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
89
500
1001
1752
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

MOORING B1

Set	28-VIII-82	Position:	57° 56.3'N 08° 51.0'W
	25- X-82		57° 56.0'N 08° 51.4'W
Recovered	25- X-82	Water Depth:	155m
	18- II-83		152m

Depth (m)	Variables	Samp. Int. (hours)	Comments
55	Sp,D,T,P	0.5	
52	Sp,D,T,P	0.5	
130	Sp,D,T	0.5	
127			meter not recovered

Comments

Repeated dates, position, depths and other values refer to second deployment.

FR

↑ N

FREQUENCY BAND (CYCLES PER DAY)

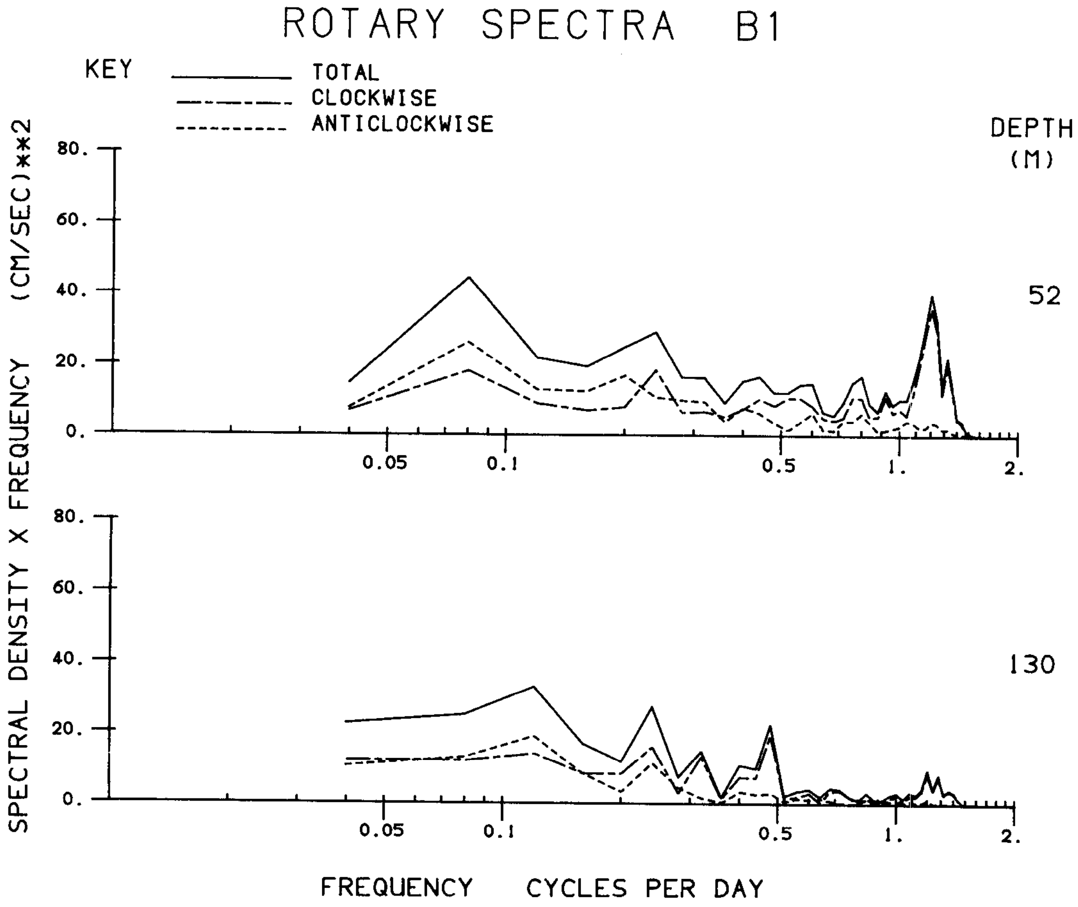
LOW FREQUENCY	1 0.02–0.38	2 0.38–0.90	3 0.90–2.02

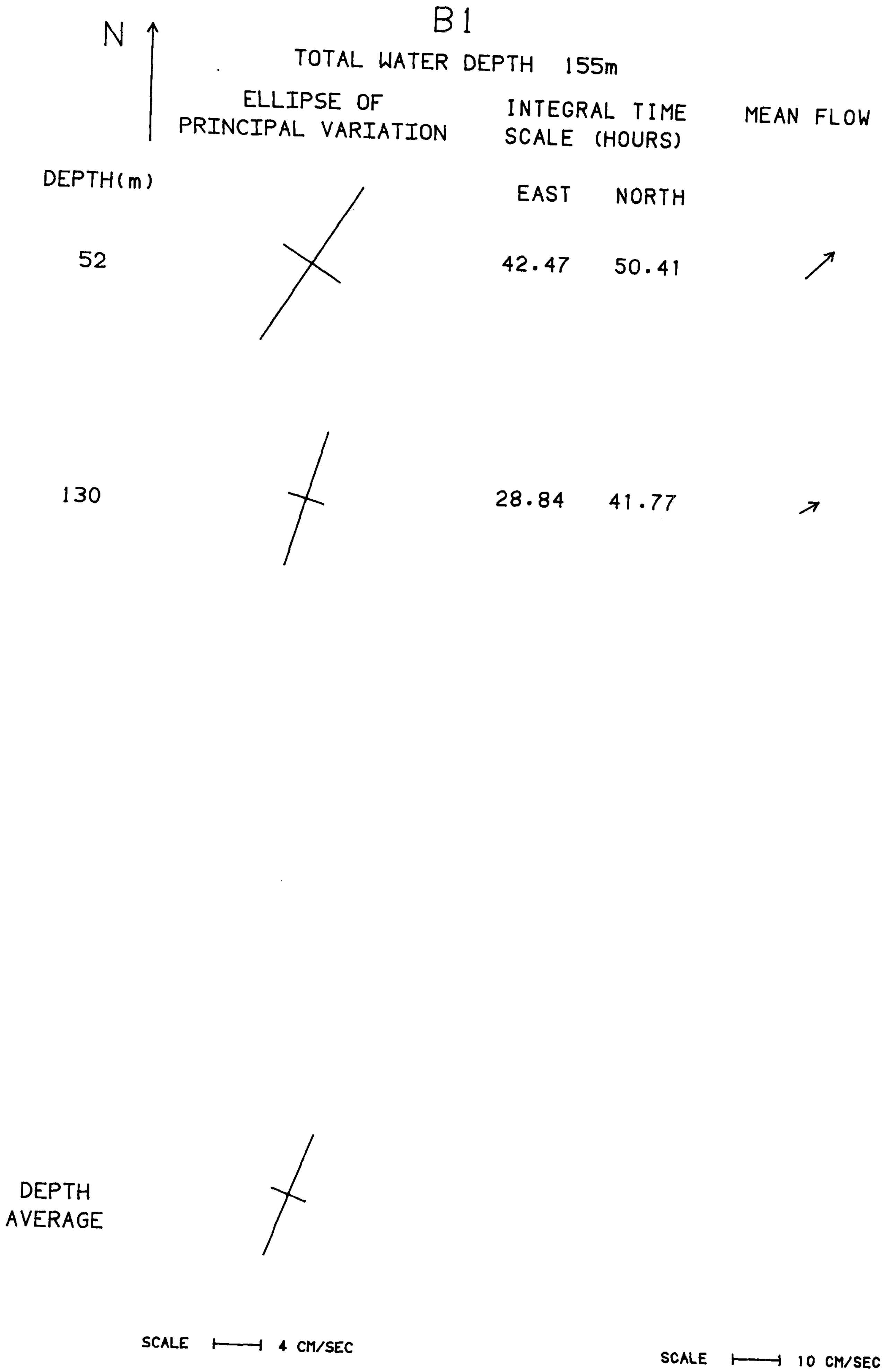
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	237.125	TOTAL	293.196	TOTAL	32.624	TOTAL	15.526
MODE1	123.528	MODE1	163.635	MODE1	17.613	MODE1	8.662

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

------------ IMAGINARY PART


ROTARY SPECTRA B1
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
52
130
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

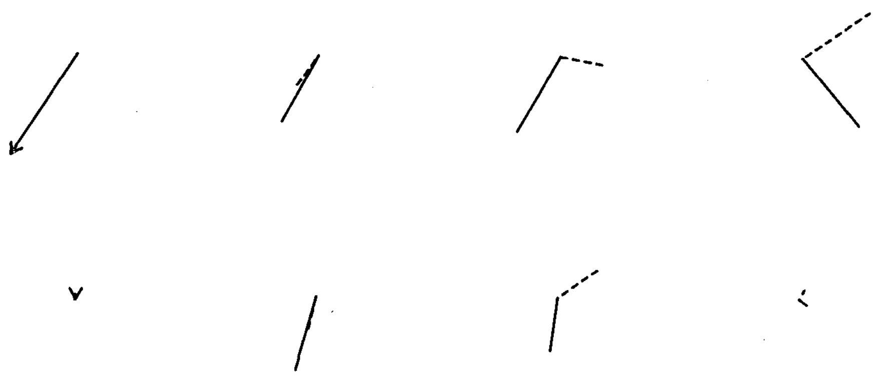

B1
N
TOTAL WATER DEPTH 155m
ELLIPSE OF
PRINCIPAL VARIATION
INTEGRAL TIME
SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
52
42.47
50.41
130
28.84
41.77
DEPTH
AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

B1

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02–0.34	2 0.34–0.62	3 0.62–2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	86.965	TOTAL	283.539	TOTAL	29.609	TOTAL	34.009
MODE1	76.297	MODE1	249.990	MODE1	18.324	MODE1	22.477

UNITS OF ALL VARIANCES (CM/SEC)**2

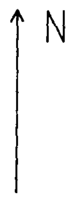
KEY ———— REAL PART

------------ IMAGINARY PART

B1

TOTAL VARIANCE 426.475

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1

VARIANCE

315.173

MOORING B2

Set	28-VIII-82	Position:	58° 00.7'N 09° 07.7'W
	12- XII-82		58° 00.8'N 09° 08.9'W
Recovered	27- X-82	Water Depth:	193m
	11- II-83		194m

Depth (m)	Variables	Samp. Int. (hours)	Comments
43	Sp,D,T,C,P	0.5	
43	Sp,D,T,P	0.5	
168	Sp,D,T,C	0.5	
169	Sp,D,T	0.5	

Comments

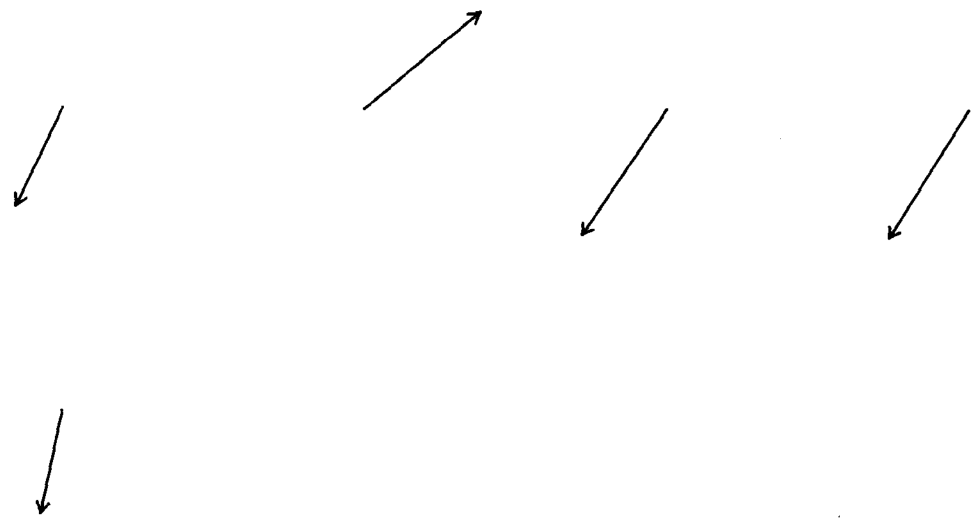
Repeated dates, position, depths and other values refer to second deployment. The first rig was trawled on 27-X-82, leaving a gap in the records until 12-XII-82.

B1

N

Event duration shown by day number in 1982. 1 Jan 1982 = 1

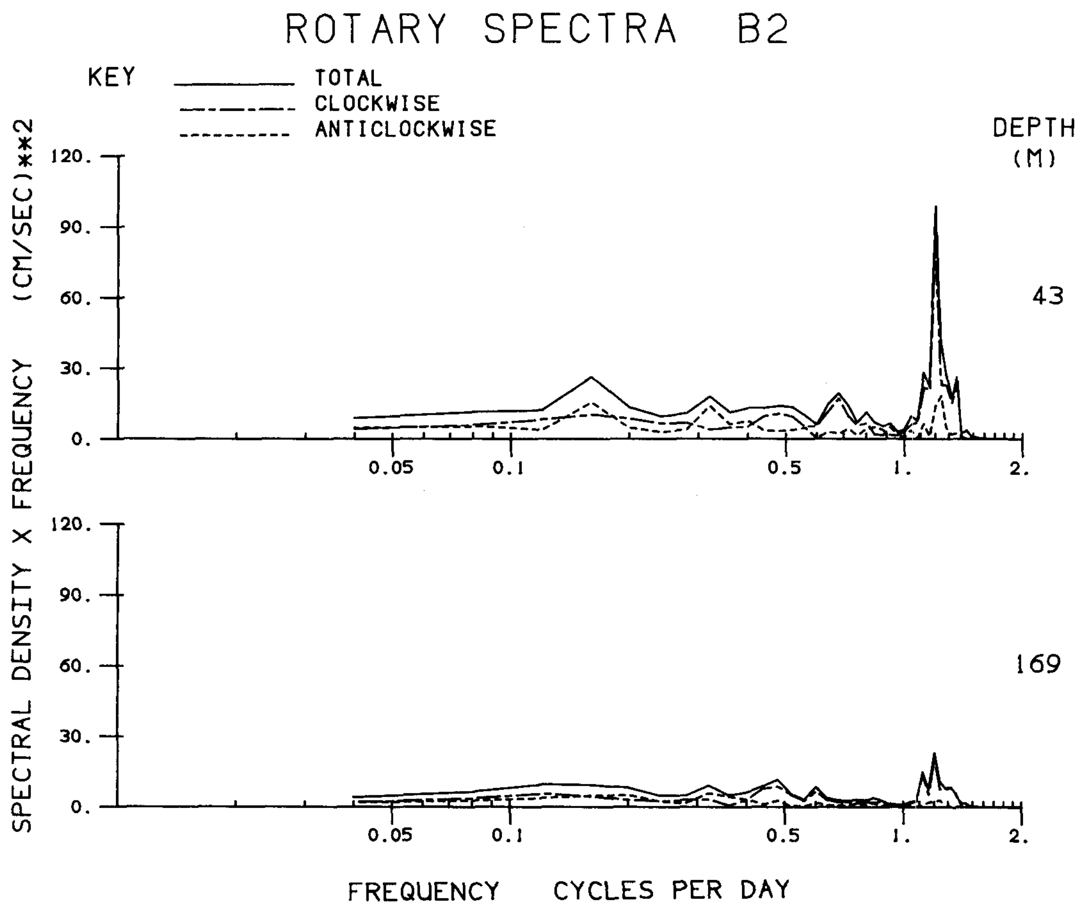
EVENT 1	EVENT 2	EVENT 3	EVENT 4
277-291	295-305	365-380	393-410



VARIANCES	VARIANCES	VARIANCES	VARIANCES
TOTAL 484.694	TOTAL 214.876	TOTAL 184.766	TOTAL 329.673
MODE 1 440.779	MODE 1 137.148	MODE 1 141.816	MODE 1 288.218

UNITS OF ALL VARIANCES (CM/SEC)**2

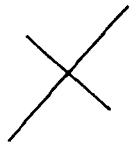
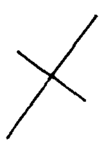
—— MODE 1
------ MODE 2


ROTARY SPECTRA B2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
43
169
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
120.
90.
60.
30.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

B2

N ↑

TOTAL WATER DEPTH 193m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
43		16.41	32.05	
169		17.81	36.74	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

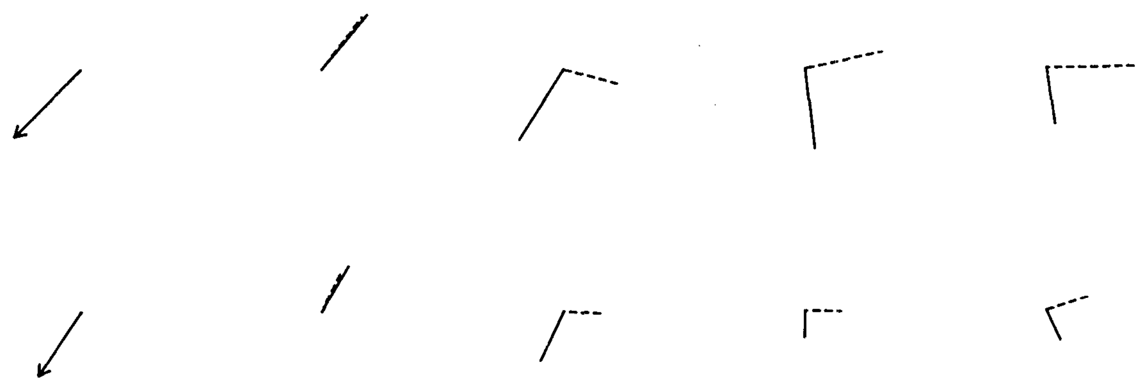
SCALE ⊢—⊣ 10 CM/SEC

B2

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02–0.26	2 0.26–0.58	3 0.58–0.98	4 0.98–2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	36.047	TOTAL	104.509	TOTAL	37.185	TOTAL	16.523	TOTAL	29.119
MODE1	32.506	MODE1	89.291	MODE1	18.541	MODE1	9.619	MODE1	24.735

UNITS OF ALL VARIANCES (CM/SEC)**2

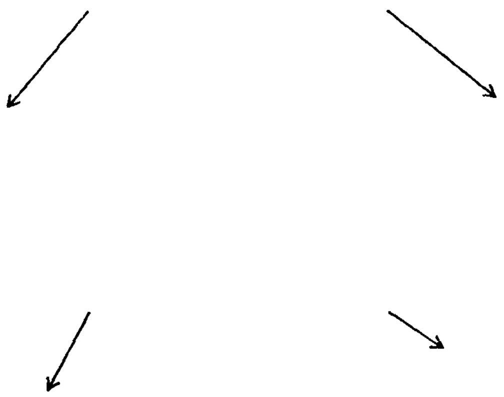
KEY ———— REAL PART

------------ IMAGINARY PART

B2

TOTAL VARIANCE 228.660

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1	MODE 2
VARIANCE	VARIANCE
160.769	49.877

MOORING B3

Set	28-VIII-82	Position:	58° 06.5'N 09° 33.1'W
Recovered	11- II-83	Water Depth:	504m

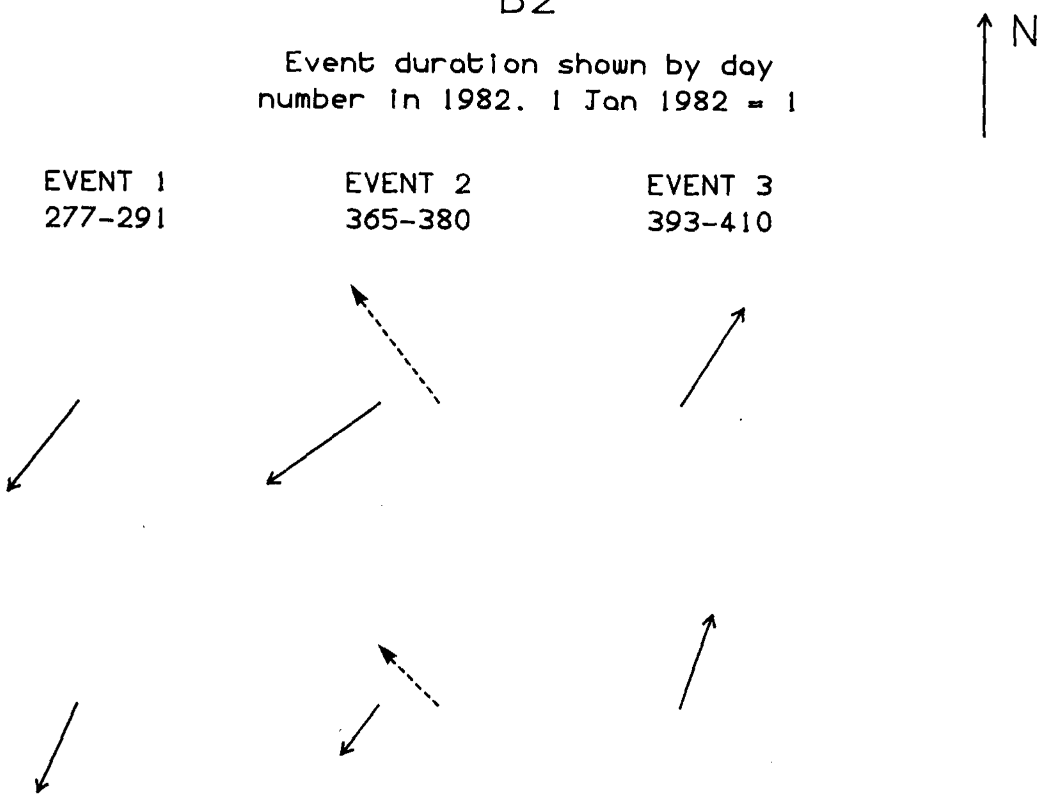
Depth (m)	Variables	Samp. Int. (hours)	Comments
104	Sp,D,T,P	0.5	
257	Sp,D,T	0.5	
457	Sp,D,T	0.5	

Comments

Event 3 covariance matrix not positive definite.

B2

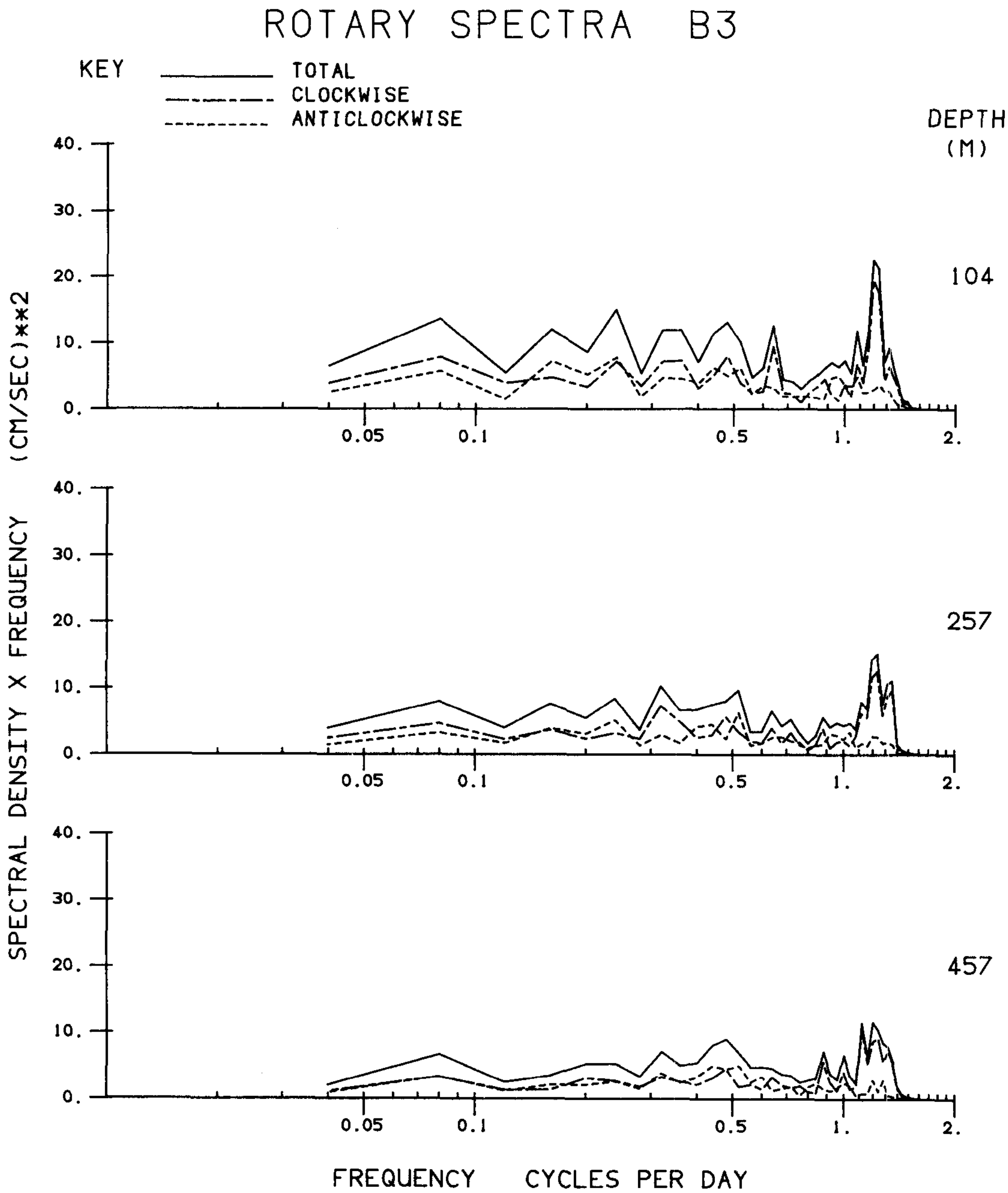
Event duration shown by day number in 1982. 1 Jan 1982 = 1



VARIANCES	VARIANCES	VARIANCES
TOTAL 222.993	TOTAL 246.192	TOTAL 320.675
MODE 1 176.463	MODE 1 145.133	MODE 1 243.991
	MODE 2 82.115	

UNITS OF ALL VARIANCES (CM/SEC)**2

——— MODE 1
------ MODE 2

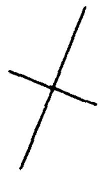
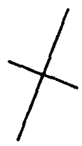


ROTARY SPECTRA B3
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
104
257
457
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

B3

N ↑

TOTAL WATER DEPTH 508m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	INTEGRAL TIME SCALE (HOURS) NORTH	MEAN FLOW
104		77.22	117.40	
257		88.59	97.46	
457		48.99	93.33	
DEPTH AVERAGE				

SCALE ├──┤ 4 CM/SEC

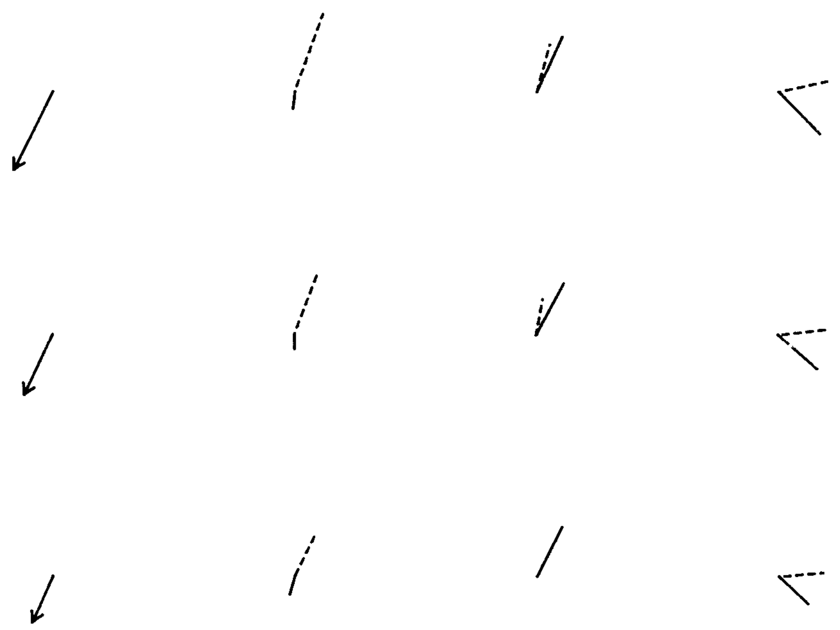
SCALE ├──┤ 10 CM/SEC

B3

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.30	2 0.30-0.62	3 0.62-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	89.769	TOTAL	108.379	TOTAL	39.712	TOTAL	36.809
MODE1	81.521	MODE1	84.209	MODE1	25.127	MODE1	20.732

UNITS OF ALL VARIANCES (CM/SEC)**2

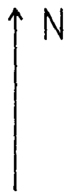
KEY ———————— REAL PART

----------- IMAGINARY PART

B3

TOTAL VARIANCE 287.720

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1
VARIANCE
205.998

MOORING B4

Set	28-VIII-82	Position:	58° 08.3'N 09° 41.2'W
Recovered	11- II-83	Water Depth:	1082m

Depth (m)	Variables	Samp. Int. (hours)	Comments
169	Sp,D,T,P	0.5	
477	Sp,D,T	0.5	
784	Sp,D,T	0.5	Rotor missing on recovery
1035	Sp,D,T	0.5	

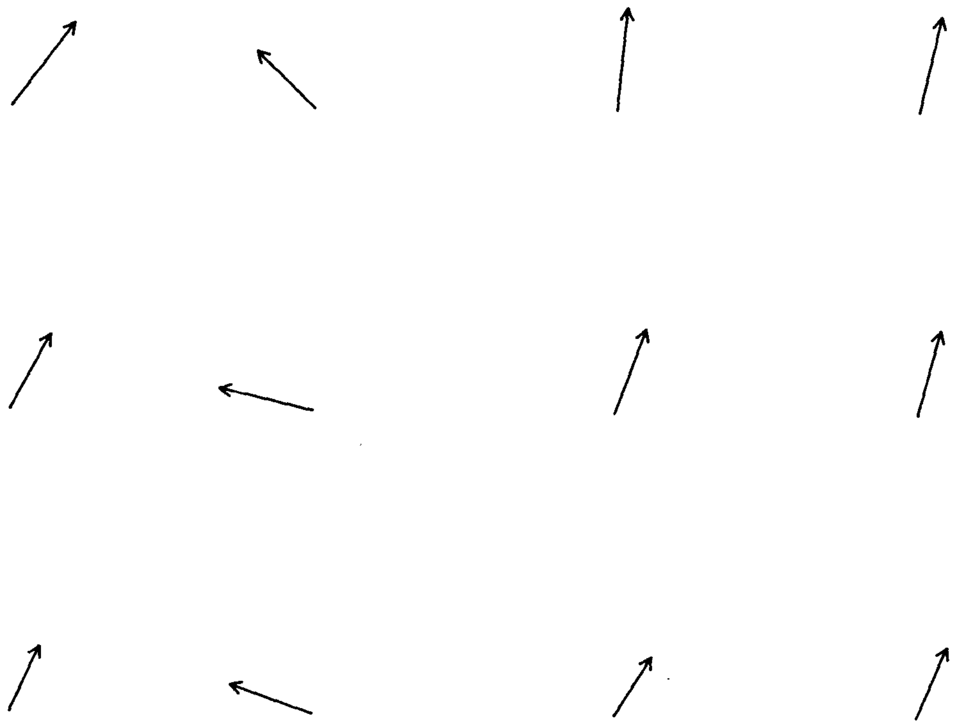
Comments

B3

↑ N

EVENT DURATION SHOWN BY DAY
NUMBER IN 1982. 1 JAN 1982 = 1

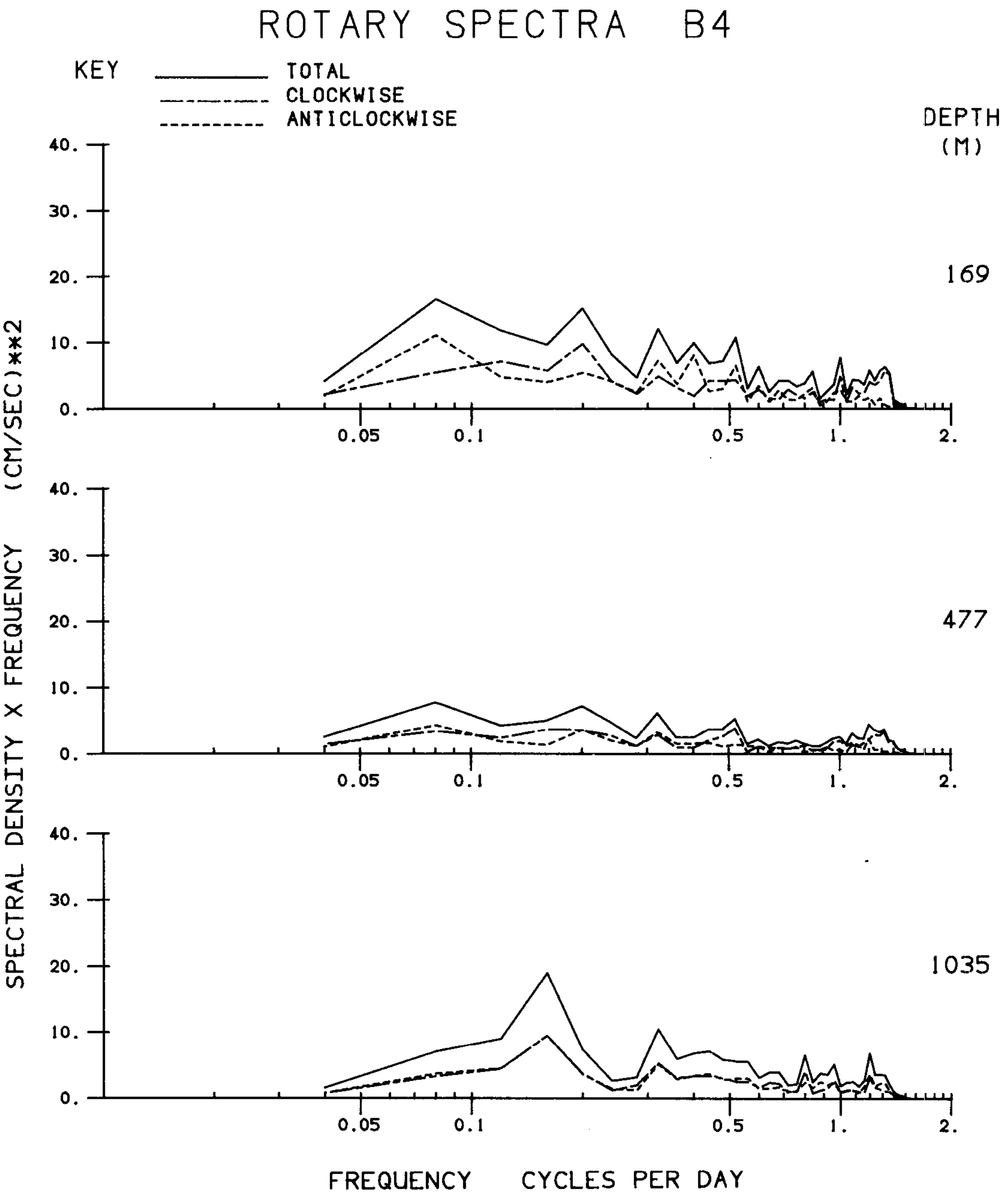
EVENT 1 295-305 LOW FREQUENCY	EVENT 1 295-305 HIGH FREQUENCY	EVENT 2 365-380	EVENT 3 393-410

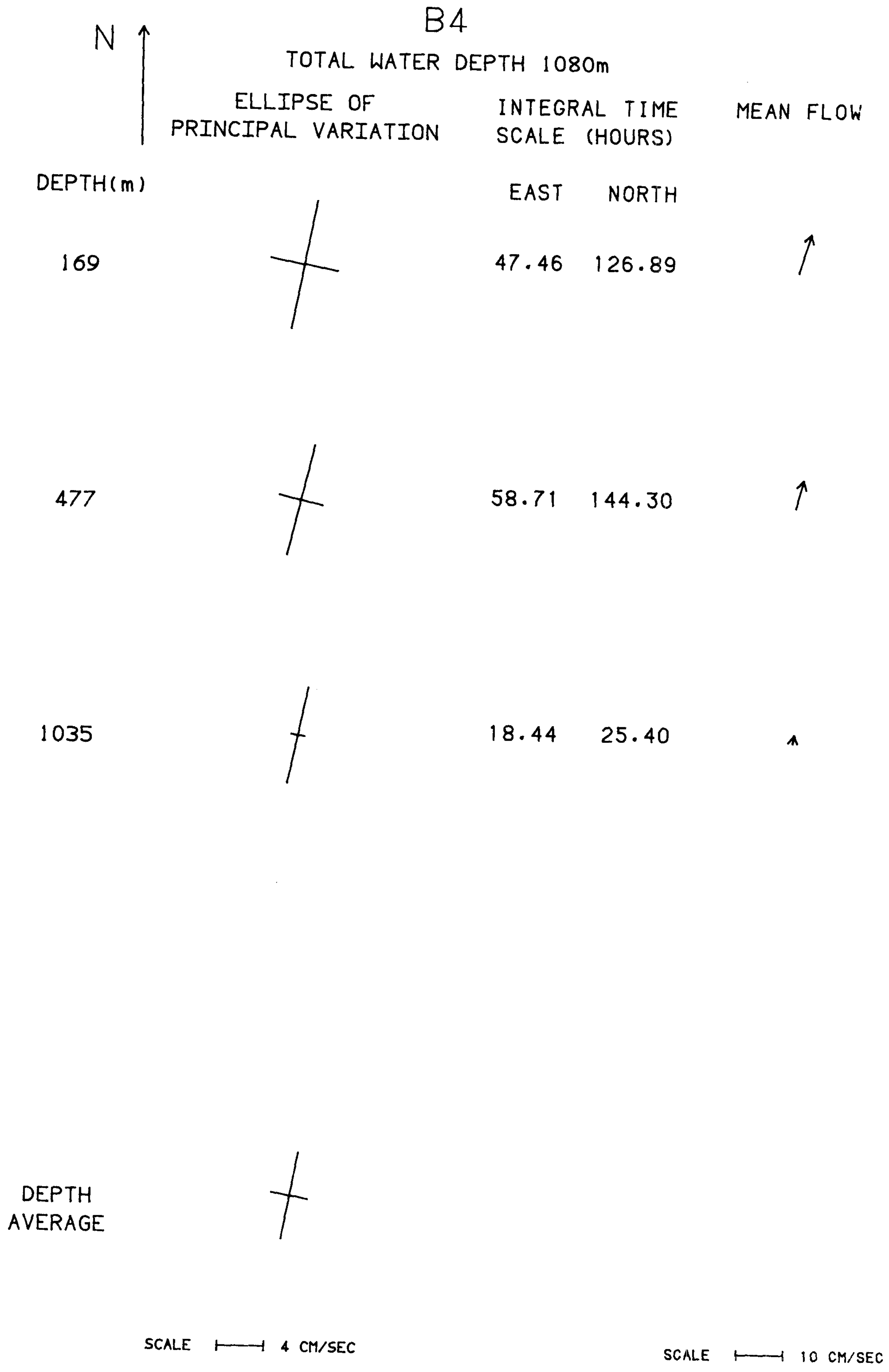


VARIANCES	VARIANCES	VARIANCES	VARIANCES
TOTAL 280.108	TOTAL 35.667	TOTAL 314.997	TOTAL 444.044
MODE 1 247.287	MODE 1 22.206	MODE 1 208.601	MODE 1 314.019

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
----- MODE 2


ROTARY SPECTRA B4
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
169
477
1035
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

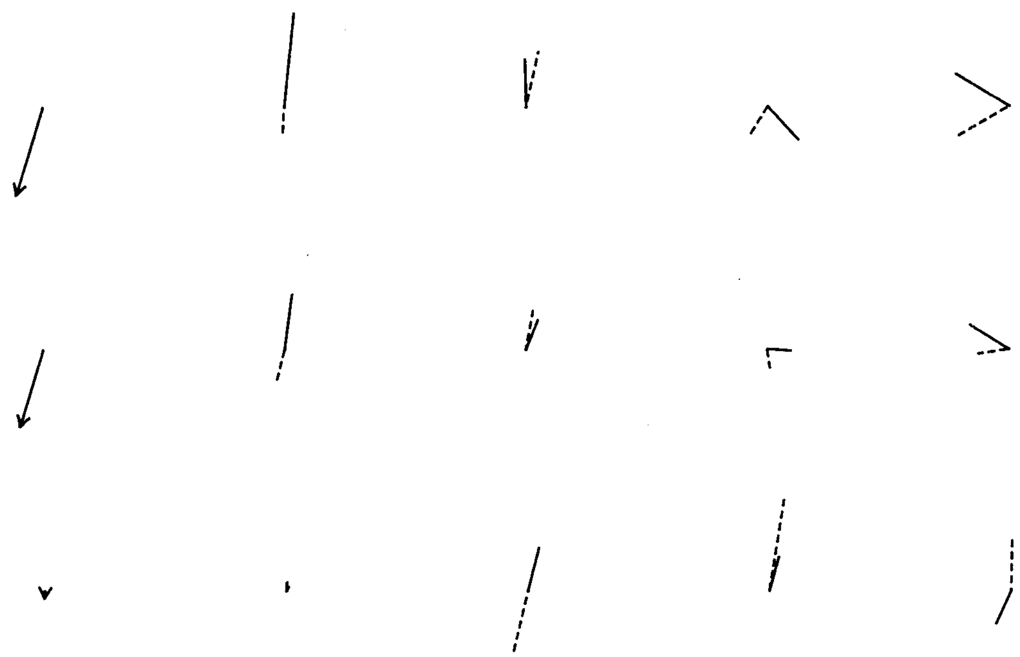

B4
N
TOTAL WATER DEPTH 1080m
ELLIPSE OF
PRINCIPAL VARIATION
INTEGRAL TIME
SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
169
47.46
126.89
477
58.71
144.30
1035
18.44
25.40
DEPTH
AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

B4

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.30	2 0.30-0.58	3 0.58-0.94	4 0.94-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	124.584	TOTAL	117.361	TOTAL	29.028	TOTAL	10.122	TOTAL	10.234
MODE1	101.177	MODE1	55.576	MODE1	14.909	MODE1	4.458	MODE1	4.706

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———————— REAL PART

------------ IMAGINARY PART

B4

TOTAL VARIANCE 333.940

UNITS OF ALL VARIANCES (CM/SEC)**2

MODE 1

VARIANCE

202.469

MOORING C2

Set	24-VIII-82	Position:	59° 05.4'N 07° 27.0'W
Recovered	12- II-83	Water Depth:	514m

Depth (m)	Variables	Samp. Int. (hours)	Comments
115	Sp,D,T,P	0.5	
266	Sp,D,T	0.5	
468	Sp,D,T	0.5	

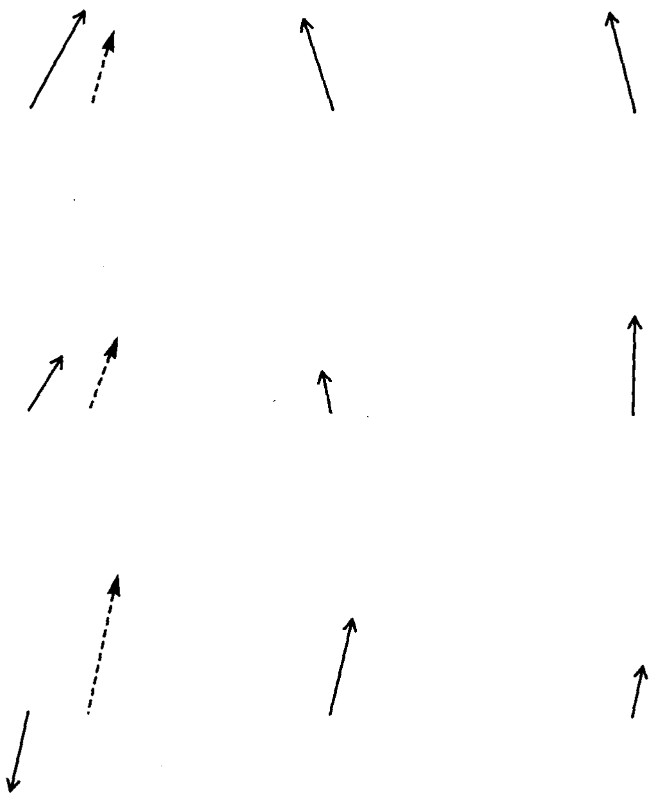
Comments

B4

Event duration shown by day number in 1982. 1 Jan 1982 = 1

N

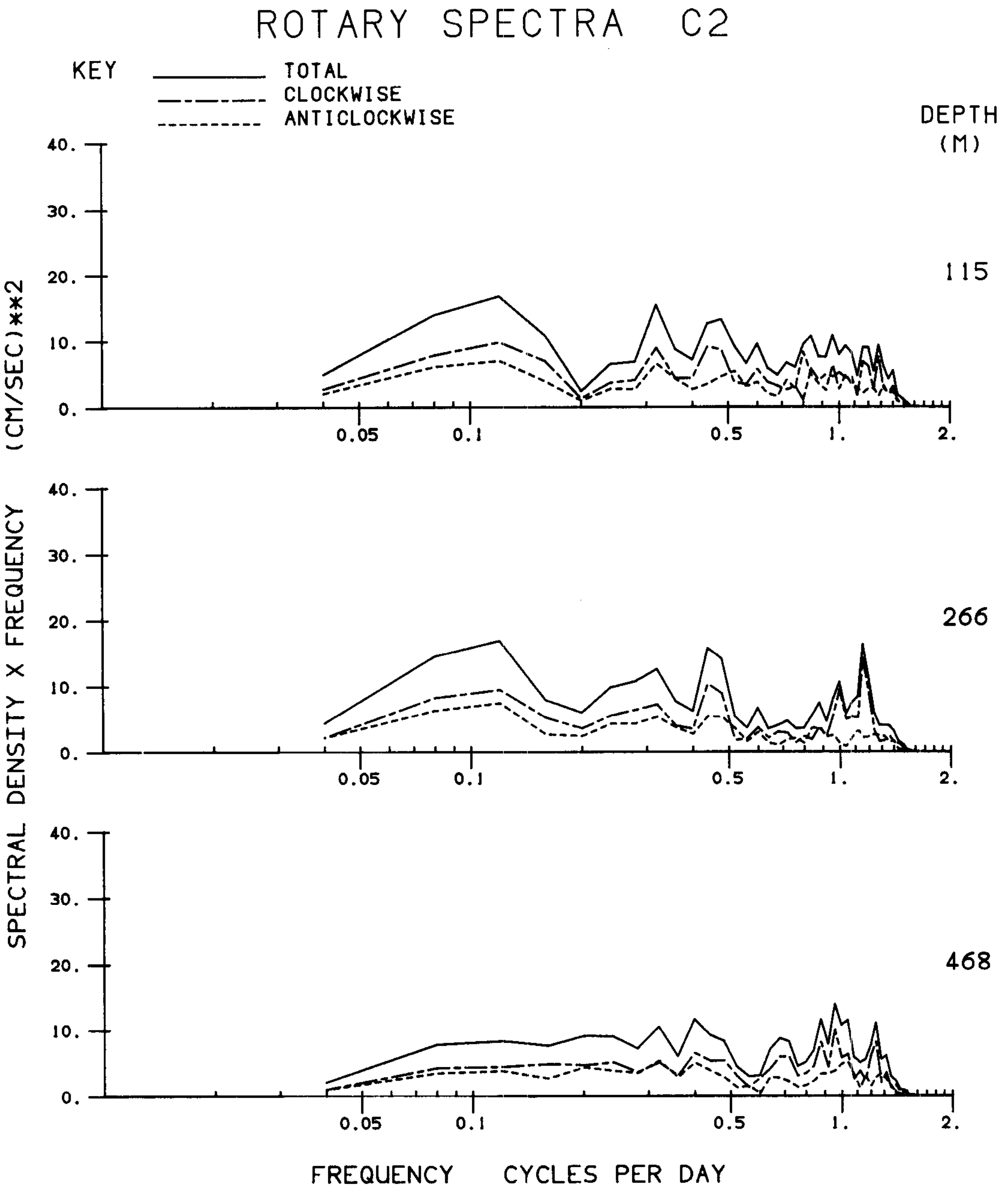
EVENT 1	EVENT 2	EVENT 3
260-280	295-305	393-410

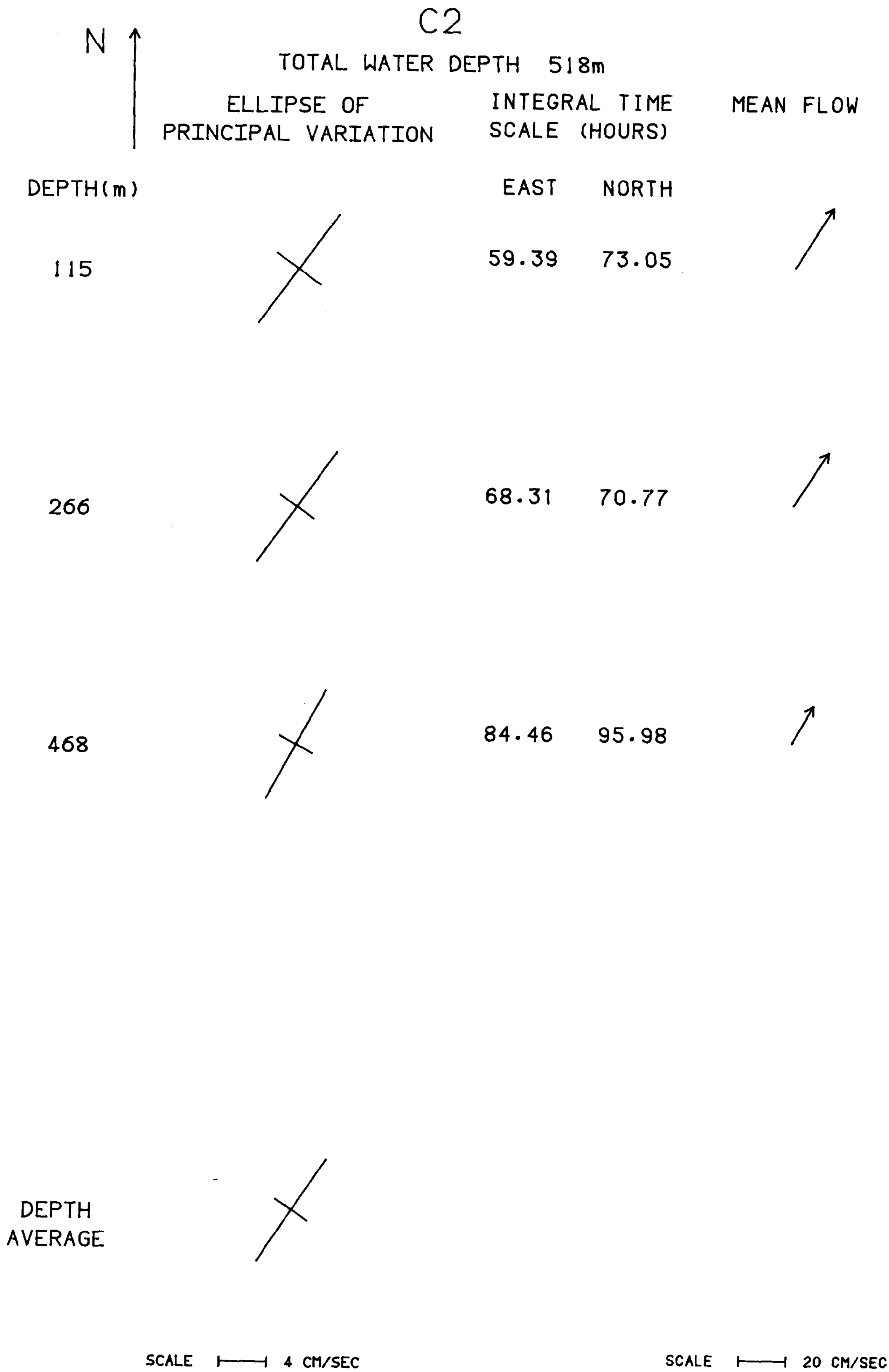


VARIANCES	VARIANCES	VARIANCES
TOTAL 306.598	TOTAL 195.682	TOTAL 593.575
MODE 1 186.193	MODE 1 106.300	MODE 1 363.850
MODE 2 95.436		

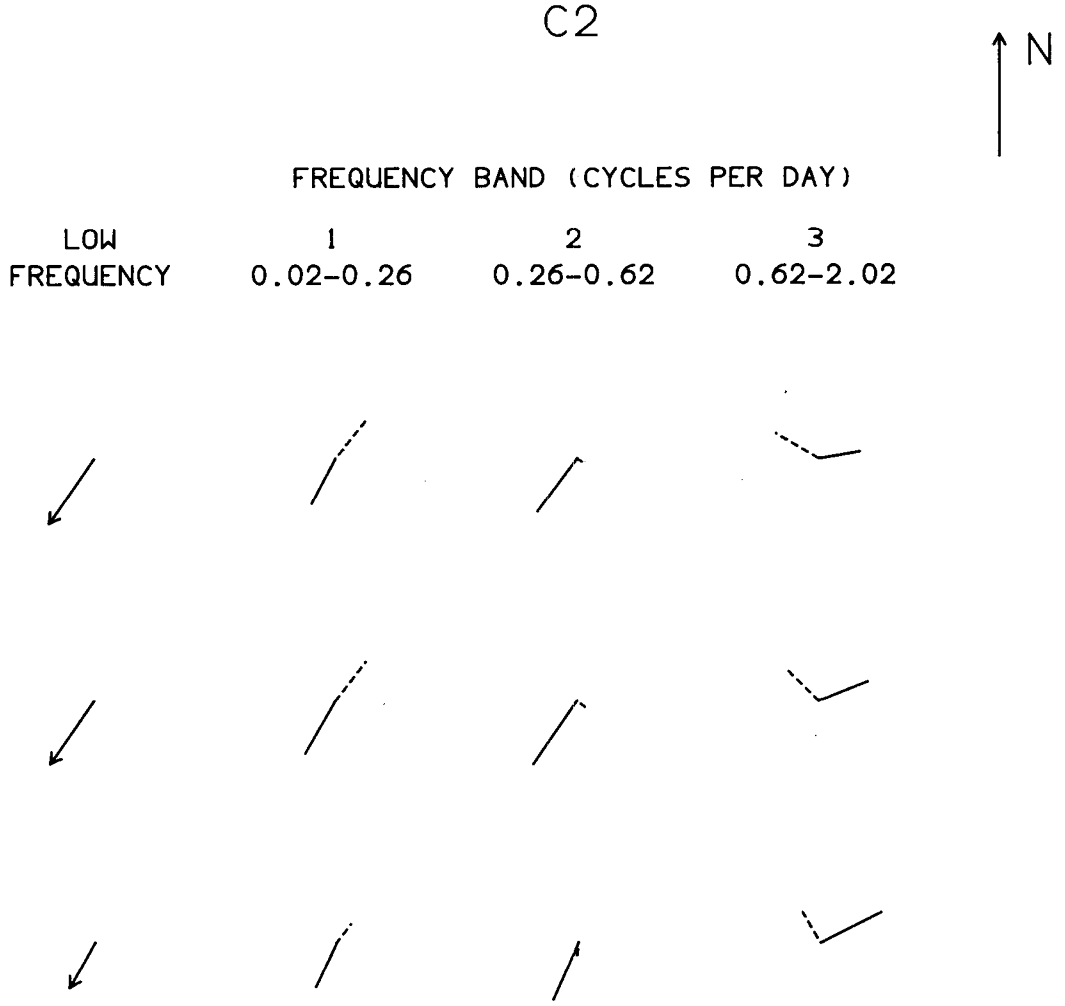
UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2


ROTARY SPECTRA C2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
115
266
468
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY


C2
TOTAL WATER DEPTH 518m
N
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
115
59.39
73.05
266
68.31
70.77
468
84.46
95.98
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 20 CM/SEC

C2



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	112.752	TOTAL	133.655	TOTAL	53.841	TOTAL	40.889
MODE1	102.561	MODE1	112.932	MODE1	36.070	MODE1	16.937

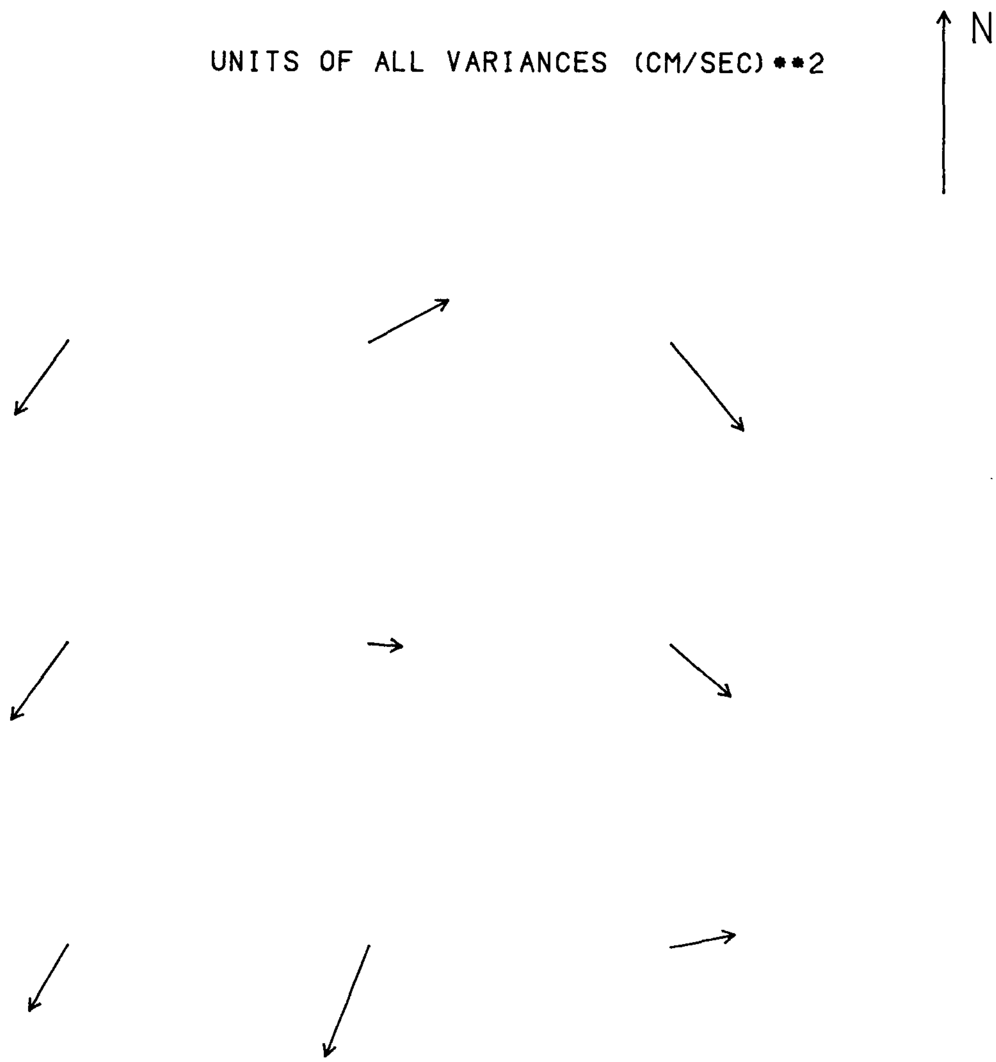
UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———————— REAL PART
----------- IMAGINARY PART

C2

TOTAL VARIANCE 411.012

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1	MODE 2	MODE 3
VARIANCE	VARIANCE	VARIANCE
319.106	42.790	30.285

MOORING C3

Set	23-VIII-82	Position:	59° 08.5'N 07° 42.4'W
Recovered	12- II-83	Water Depth:	998m

Depth (m)	Variables	Samp. Int. (hours)	Comments
104	Sp,D,T,P	0.5	
403	Sp,D,T	0.5	
703	Sp,D,T	0.5	No data, encoder fault
951	Sp,D,T	0.5	

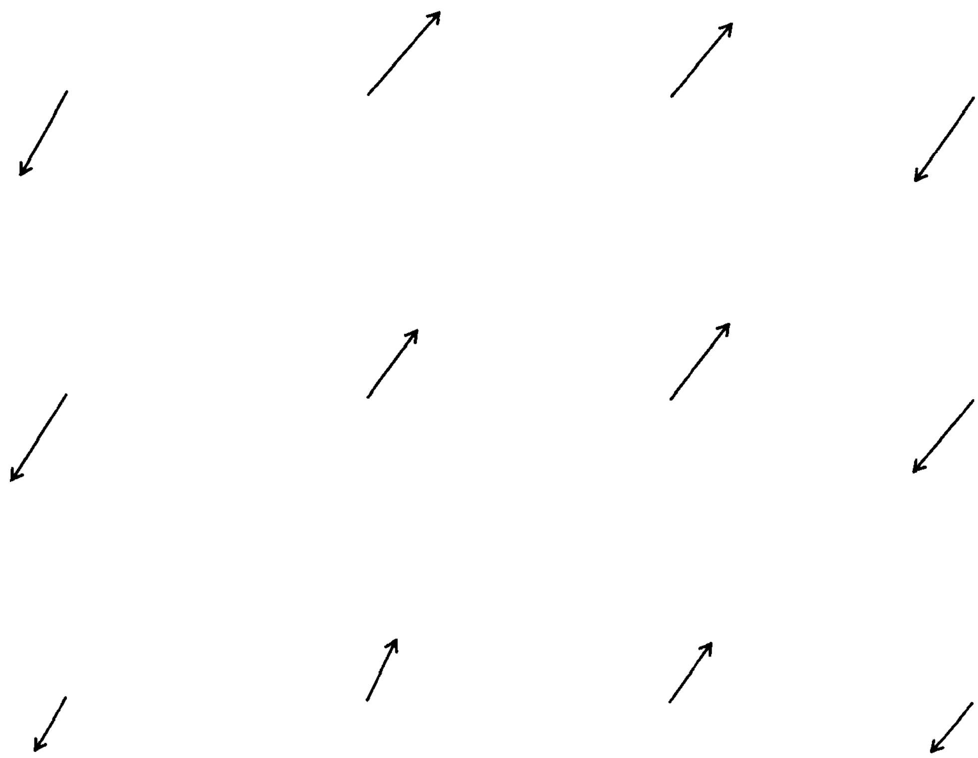
Comments

C2

Event duration shown by day number in 1982. 1 Jan 1982 = 1

N

EVENT 1	EVENT 2	EVENT 3	EVENT 4
277-291	339-350	353-362	393-410

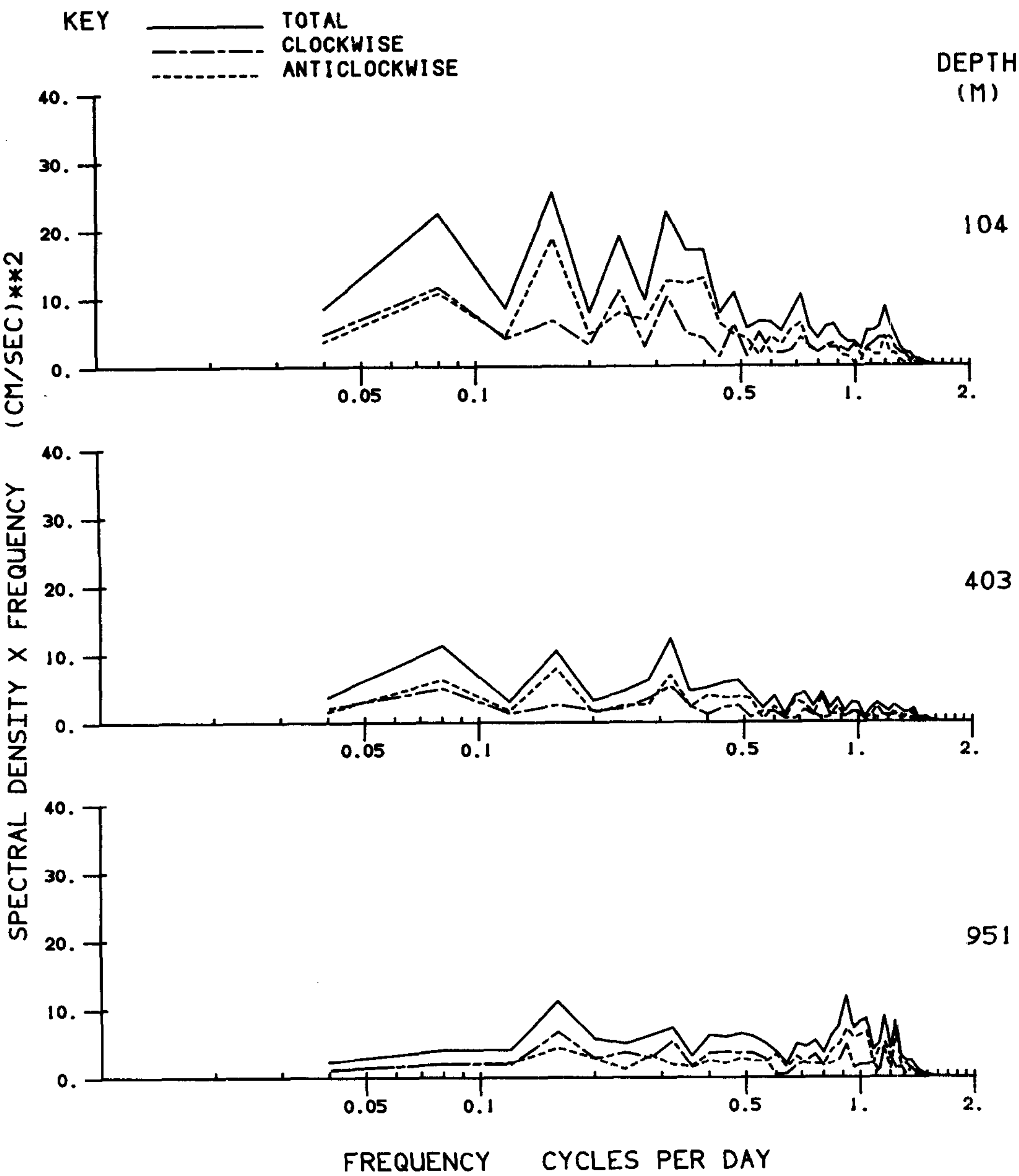


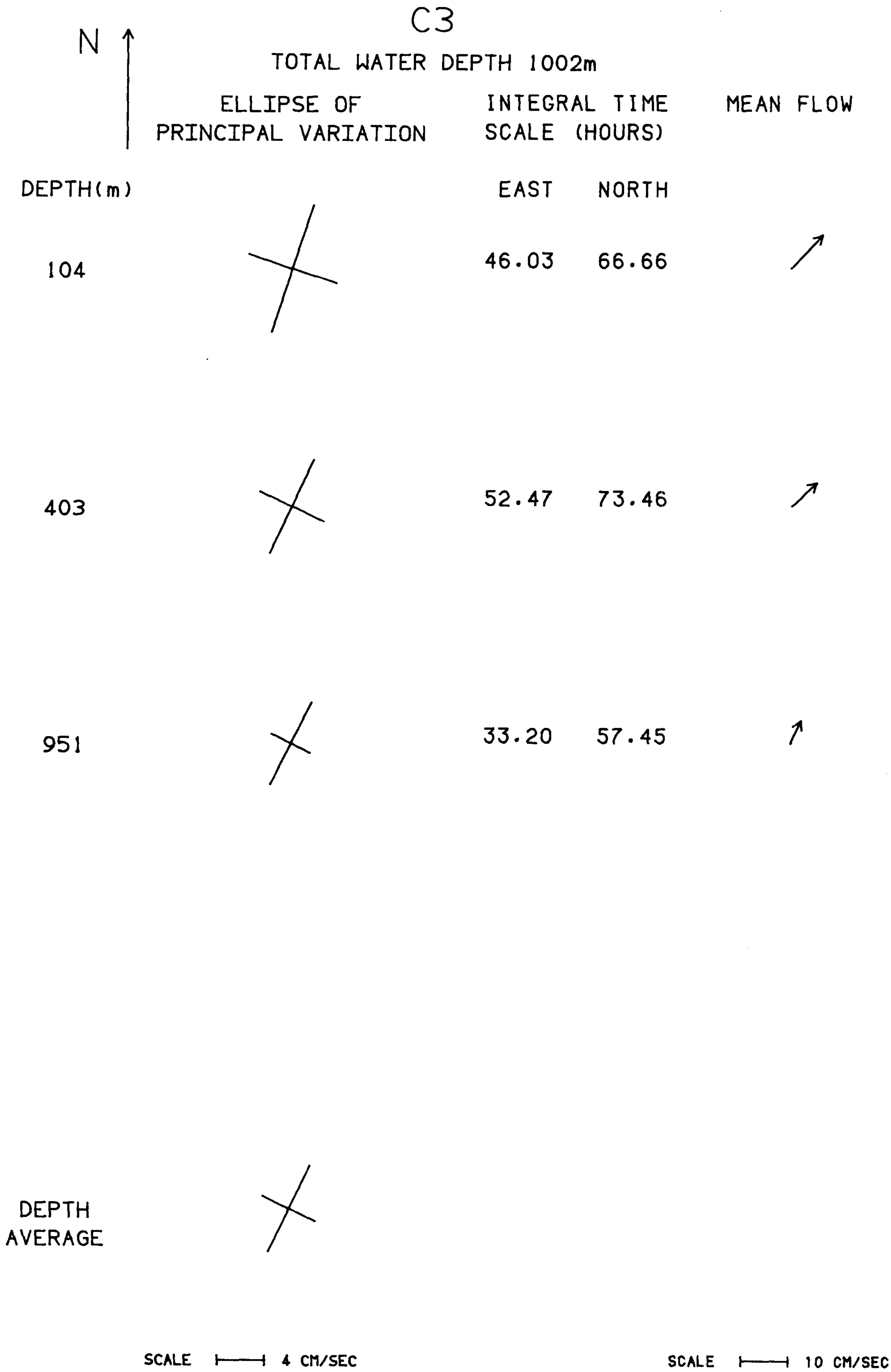
VARIANCES	VARIANCES	VARIANCES	VARIANCES
TOTAL 565.572	TOTAL 375.408	TOTAL 463.403	TOTAL 586.552
MODE 1 487.919	MODE 1 279.674	MODE 1 315.960	MODE 1 461.747

UNITS OF ALL VARIANCES (CM/SEC)**2

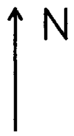
—— MODE 1
------ MODE 2

ROTARY SPECTRA C3




C3
N
TOTAL WATER DEPTH 1002m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
104
46.03
66.66
403
52.47
73.46
951
33.20
57.45
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

C3



FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.26	2 0.26-0.62	3 0.62-2.02

VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	80.648	TOTAL	134.940	TOTAL	47.833	TOTAL	25.642
MODE1	54.331	MODE1	65.478	MODE1	22.303	MODE1	8.497

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ——————— REAL PART

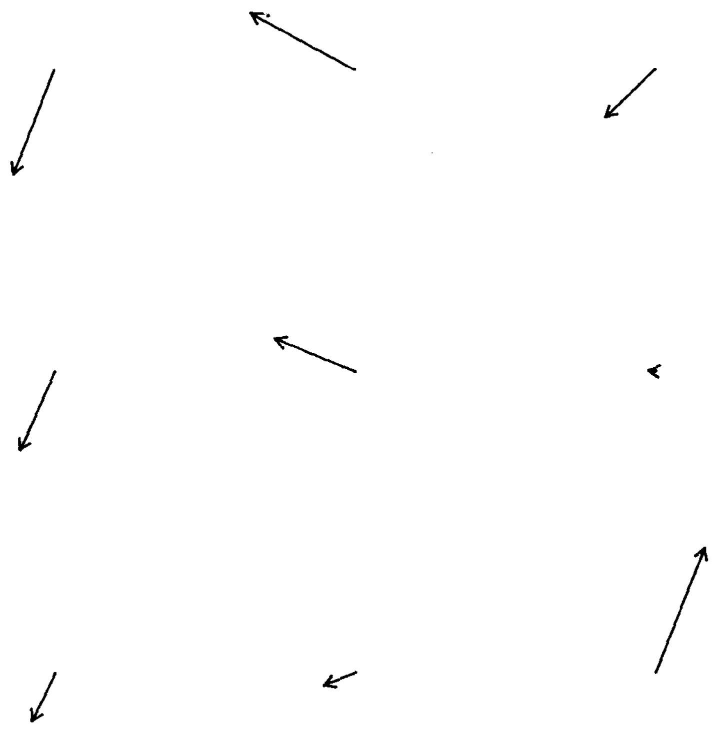
----------- IMAGINARY PART

C3

TOTAL VARIANCE 373.935

UNITS OF ALL VARIANCES (CM/SEC)**2

N



MODE 1	MODE 2	MODE 3
VARIANCE	VARIANCE	VARIANCE
215.758	94.949	37.493

MOORING D1

Set	27-VIII-82	Position:	59° 38.8'N 06° 00.5'W
	29- IX-82		59° 39.8'N 06° 02.5'W
Recovered	3- IX-82	Water Depth:	210m
	13- II-83		237m

Depth (m)	Variables	Samp. Int. (hours)	Comments
60	Sp,D,T,P	0.5	
87	Sp,D,T,P	0.5	
185			Meter not recovered
212	Sp,D,T,P	0.5	

Comments

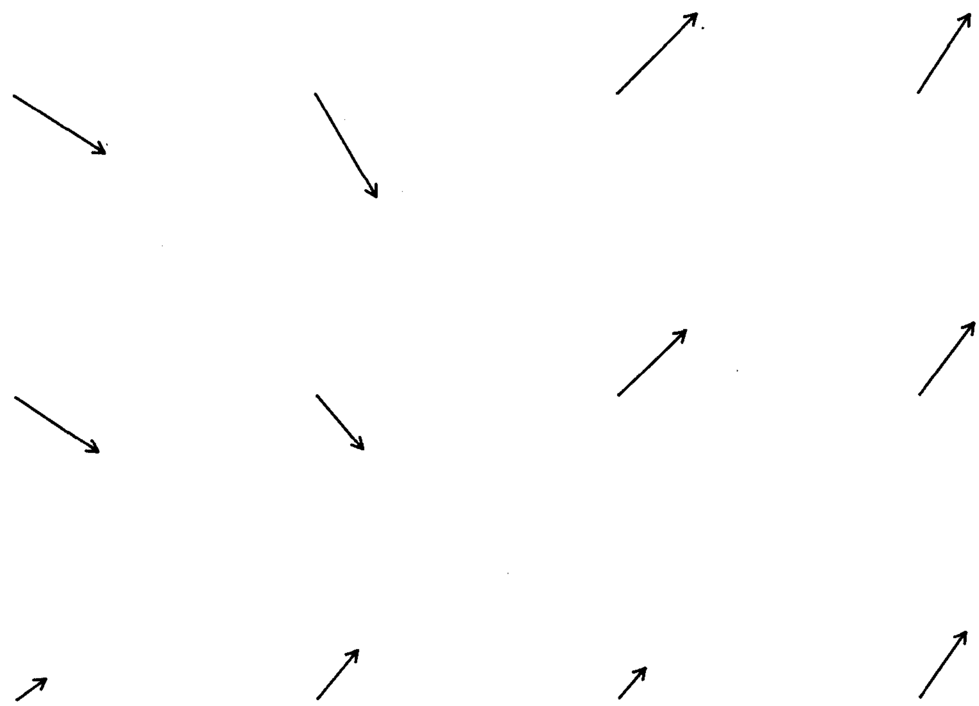
Repeated dates, position, depths and other values refer to second deployment. The first rig was damaged by trawlers on 3-IX-82, leaving a gap in the records until 29-IX-82, when the replacement rig was set.

C3

Event duration shown by day number in 1982. 1 Jan 1982 = 1

↑ N

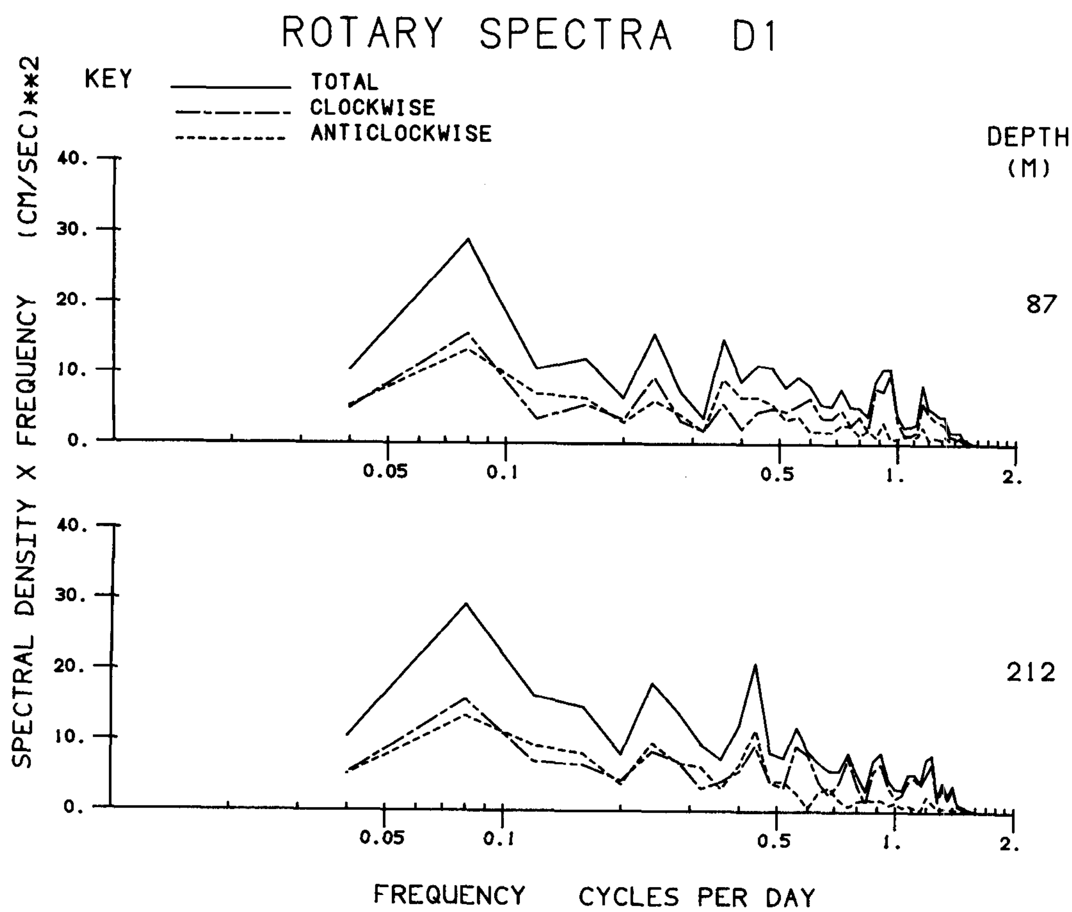
EVENT 1	EVENT 2	EVENT 3	EVENT 4
339-350	353-362	380-395	393-410



VARIANCES	VARIANCES	VARIANCES	VARIANCES
TOTAL 369.926	TOTAL 411.549	TOTAL 807.515	TOTAL 467.993
MODE 1 201.520	MODE 1 208.519	MODE 1 596.006	MODE 1 363.874

UNITS OF ALL VARIANCES (CM/SEC)**2

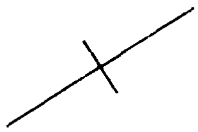
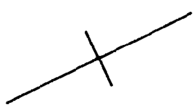
——— MODE 1
------ MODE 2


ROTARY SPECTRA D1
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
87
212
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
0.
10.
20.
30.
40.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

D1

N 

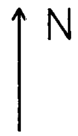
TOTAL WATER DEPTH 237m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	INTEGRAL TIME SCALE (HOURS) NORTH	MEAN FLOW
87		56.87	44.35	
212		51.84	53.45	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

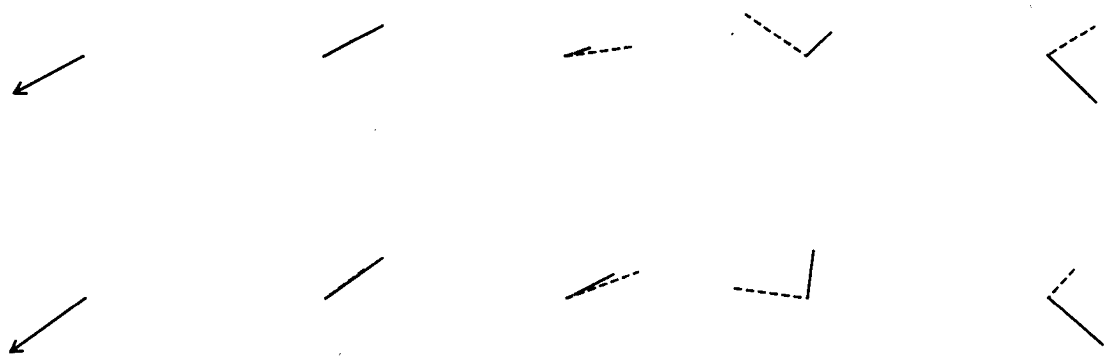
SCALE ⊢—⊣ 10 CM/SEC

D1



FREQUENCY BAND (cycles per day)

LOW FREQUENCY	1	2	3	4
	0.02-0.22	0.22-0.54	0.54-0.86	0.86-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	87.718	TOTAL	157.084	TOTAL	47.414	TOTAL	14.887	TOTAL	12.589
MODE1	81.350	MODE1	148.328	MODE1	38.802	MODE1	9.163	MODE1	7.193

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

------------ IMAGINARY PART

D1

TOTAL VARIANCE 351.028

UNITS OF ALL VARIANCES (CM/SEC)**2

MODE 1
VARIANCE
301.198

MOORING D2

Set	27-VIII-82	Position:	59° 46.7'N 06° 10.8'W
Recovered	13- II-83	Water Depth:	370m

Depth (m)	Variables	Samp. Int. (hours)	Comments
120	Sp,D,T,P	0.5	
270	Sp,D,T	0.5	
345	Sp,D,T,P	0.5	

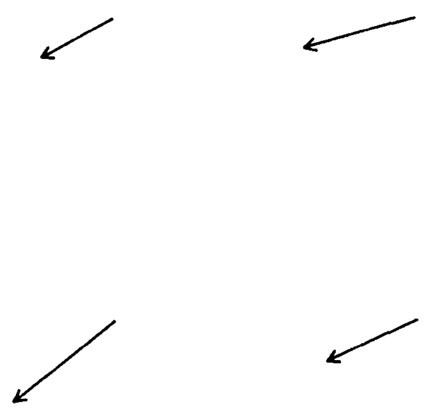
Comments

D1

↑ N

Event duration shown by day
number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 2
277-291	393-410

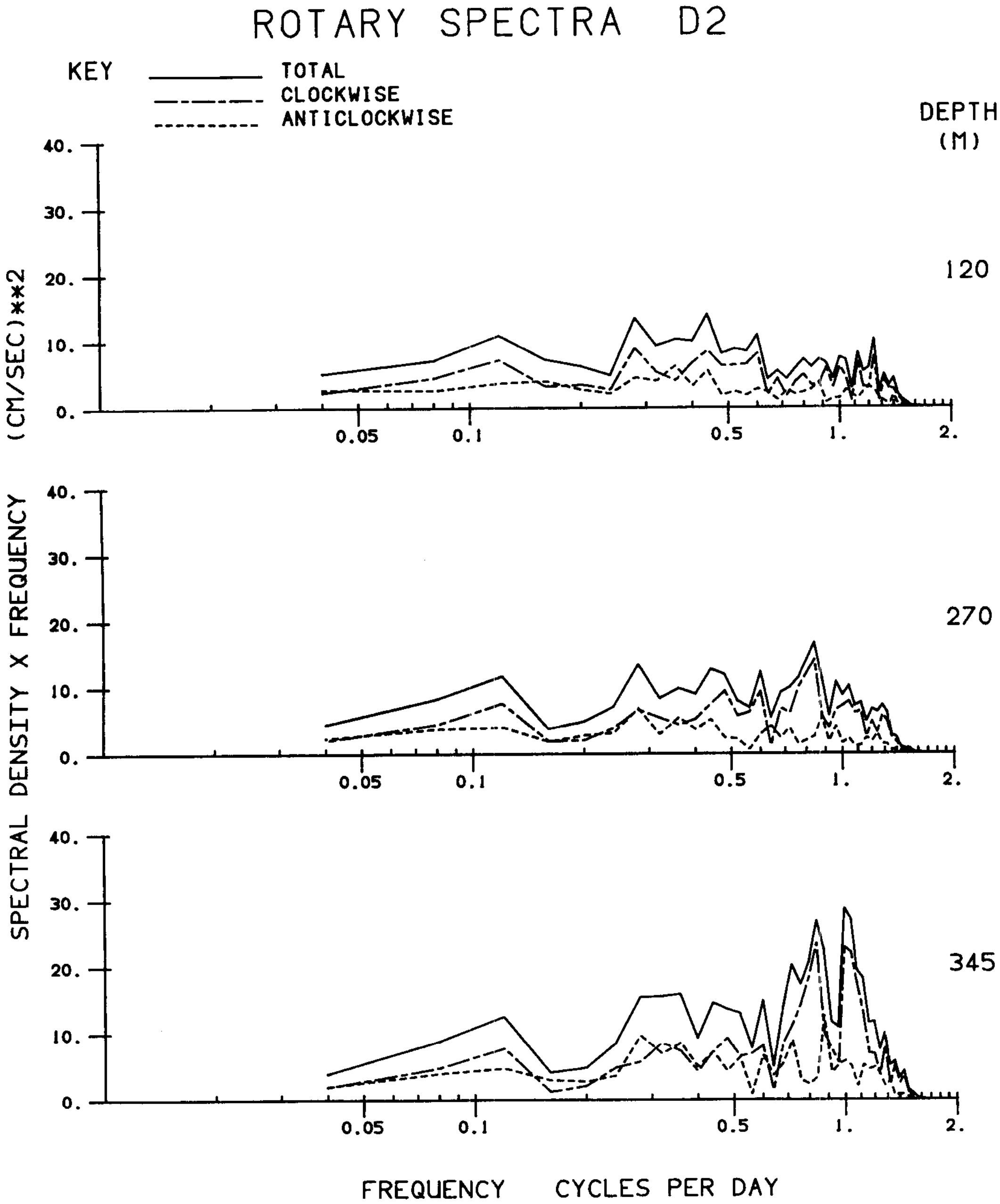


VARIANCES		VARIANCES	
TOTAL	416.906	TOTAL	322.863
MODE 1	360.617	MODE 1	253.560

UNITS OF ALL VARIANCES (CM/SEC)**2

——— MODE 1
------ MODE 2

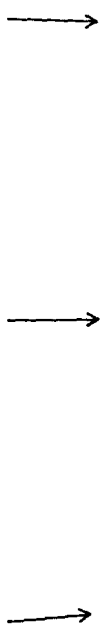
SCALE ├──┤ 10 CM/SEC


ROTARY SPECTRA D2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
120
270
345
40.
30.
20.
10.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

D2

TOTAL VARIANCE   432.137

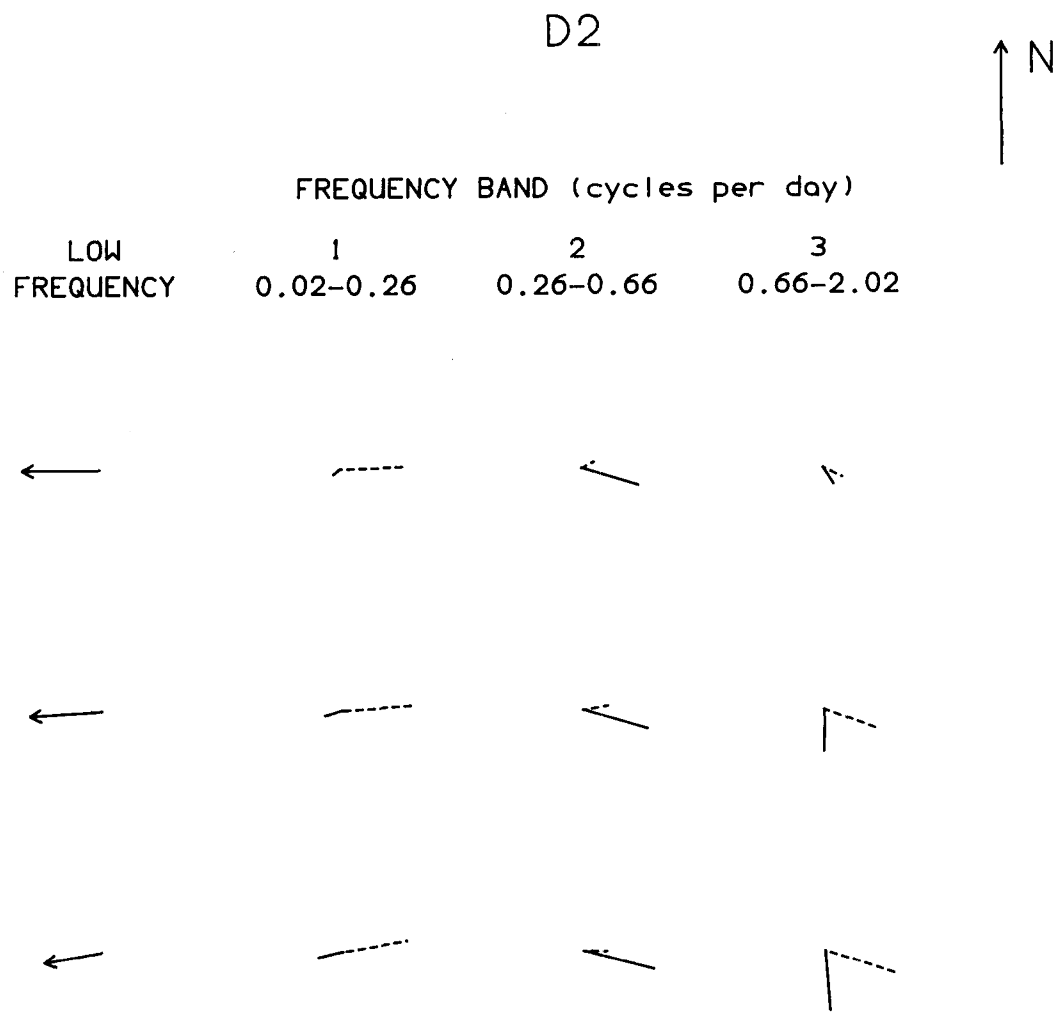
UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1

VARIANCE

335.692



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	183.223	TOTAL	110.438	TOTAL	71.130	TOTAL	55.562
MODE1	175.778	MODE1	90.307	MODE1	49.231	MODE1	32.063

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

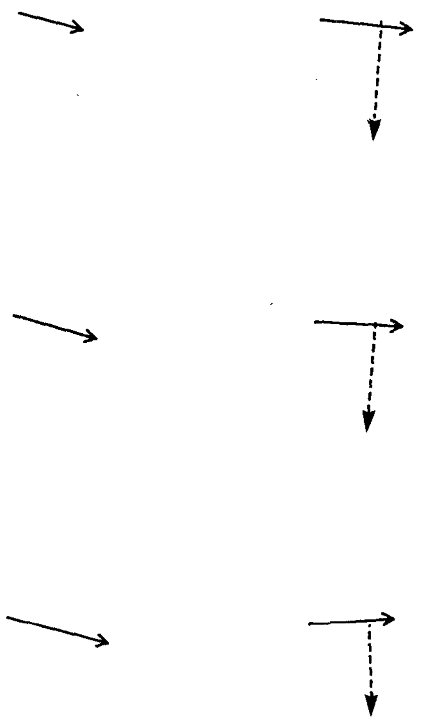
------------ IMAGINARY PART

D2

Event duration shown by day number in 1982. 1 Jan 1982 = 1

N

EVENT 1	EVENT 2
277-291	393-410



VARIANCES		VARIANCES	
TOTAL	177.124	TOTAL	480.241
MODE 1	89.797	MODE 1	378.971
		MODE 2	79.675

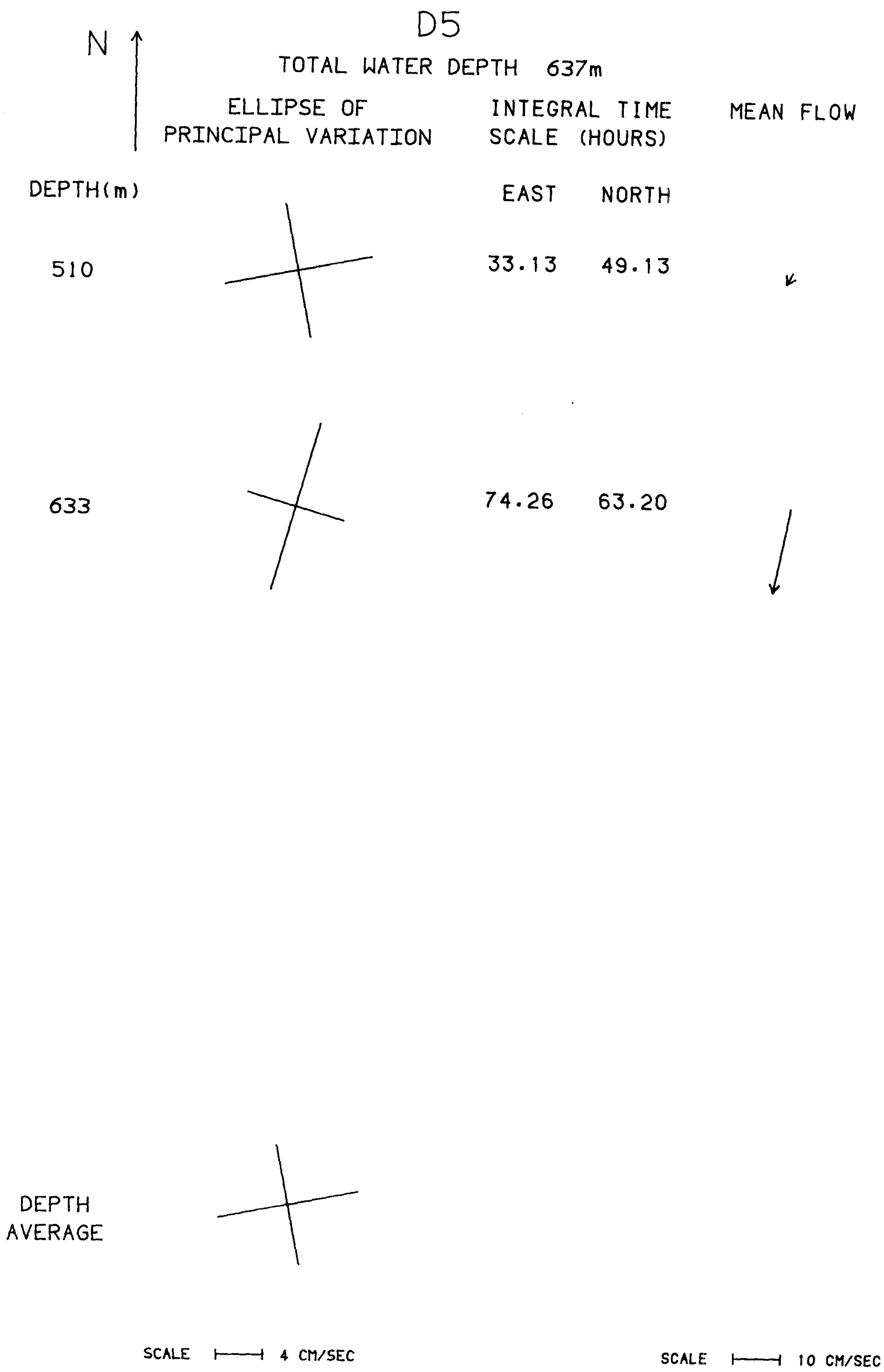
UNITS OF ALL VARIANCES (CM/SEC)**2

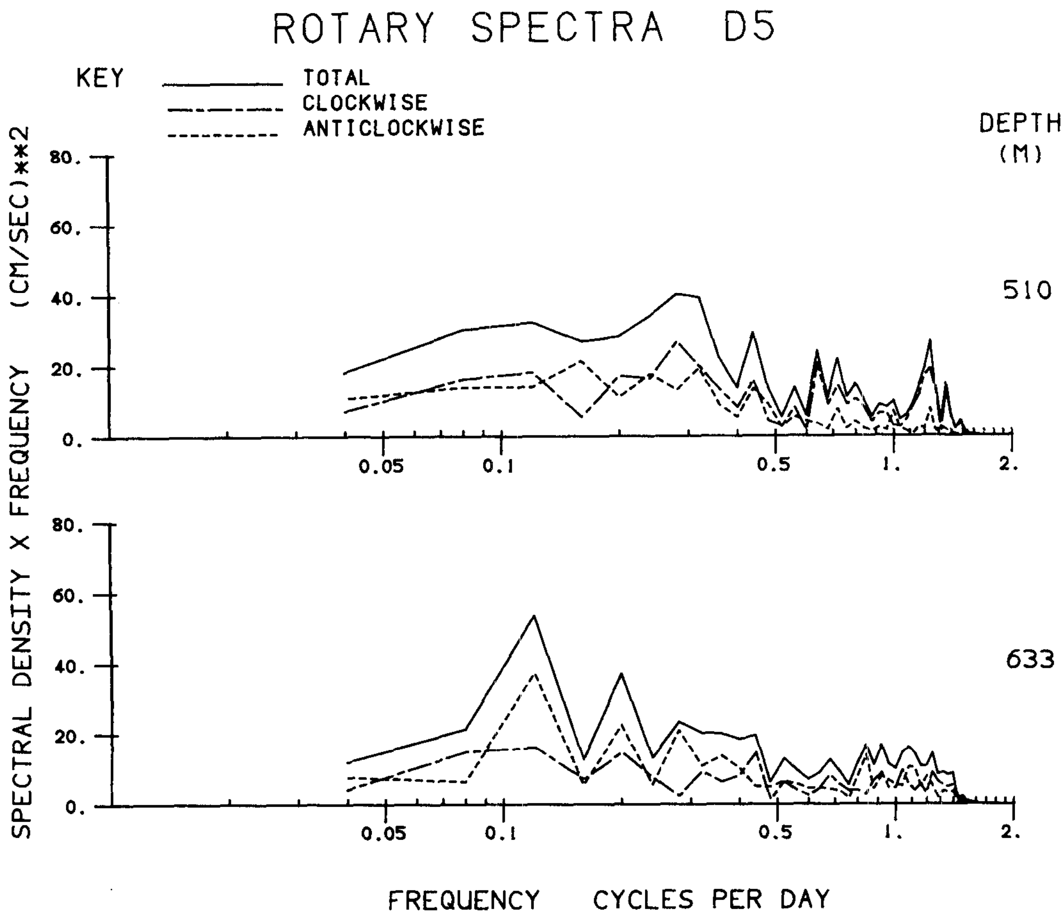
—— MODE 1
------ MODE 2

MOORING D5

Set	21- XI-82	Position:	60° 09.9'N 07° 44.5'W
Recovered	27- V-83	Water Depth:	637m

Depth (m)	Variables	Samp. Int. (hours)	Comments
102	Sp,D,T	1	Tape jammed
510	Sp,D,T	1	
633	Sp,D,T	1	

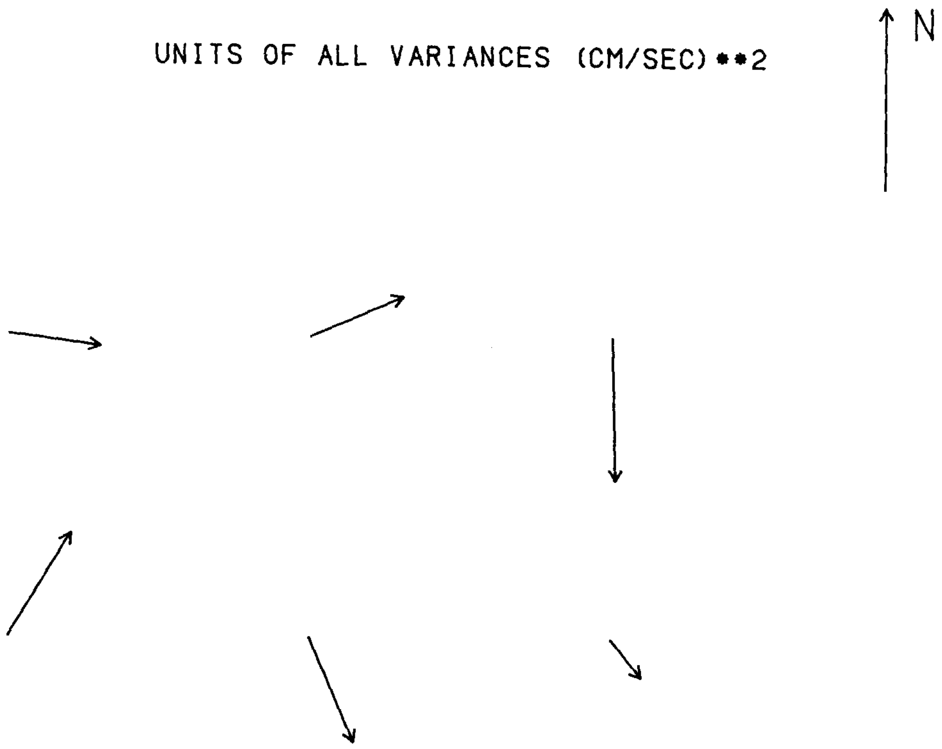

D5
N
TOTAL WATER DEPTH 637m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
510
33.13
49.13
633
74.26
63.20
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC


ROTARY SPECTRA D5
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH
(M)
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
510
0.05
0.1
0.5
1.
2.
633
FREQUENCY CYCLES PER DAY

D5

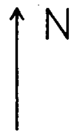
TOTAL VARIANCE 580.317

UNITS OF ALL VARIANCES (CM/SEC)**2



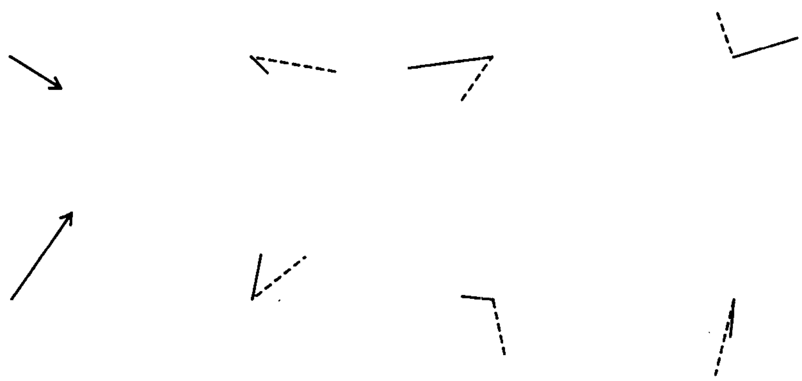
MODE 1	MODE 2	MODE 3
VARIANCE	VARIANCE	VARIANCE
270.756	147.394	134.747

D5



FREQUENCY BAND (cycles per day)

LOW FREQUENCY	1 0.02-0.42	2 0.42-0.90	3 0.90-2.02



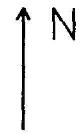
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	149.432	TOTAL	324.424	TOTAL	45.237	TOTAL	25.257
MODE1	105.454	MODE1	146.576	MODE1	20.951	MODE1	11.699

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
----------- IMAGINARY PART

D5

Event duration shown by day
number in 1982. 1 Jan 1982 = 1



EVENT 1
393-410

VARIANCES
TOTAL 813.748
MODE 1 413.807
MODE 2 259.439

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

MOORING I2

Set	18- III-82	Position:	60° 12.3'N 09° 12.6'W
Recovered	27- III-83	Water Depth:	1463m

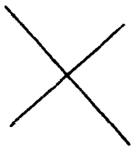
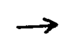
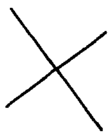
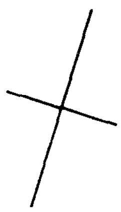
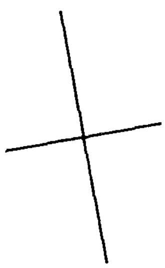
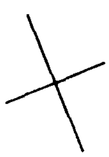
Depth (m)	Variables	Samp. Int. (hours)	Comments
251	Sp,D,T,P	1.0	
654	Sp,D,T	1.0	
1055	Sp,D,T	1.0	
1440	Sp,D,T	1.0	

Comments

I2

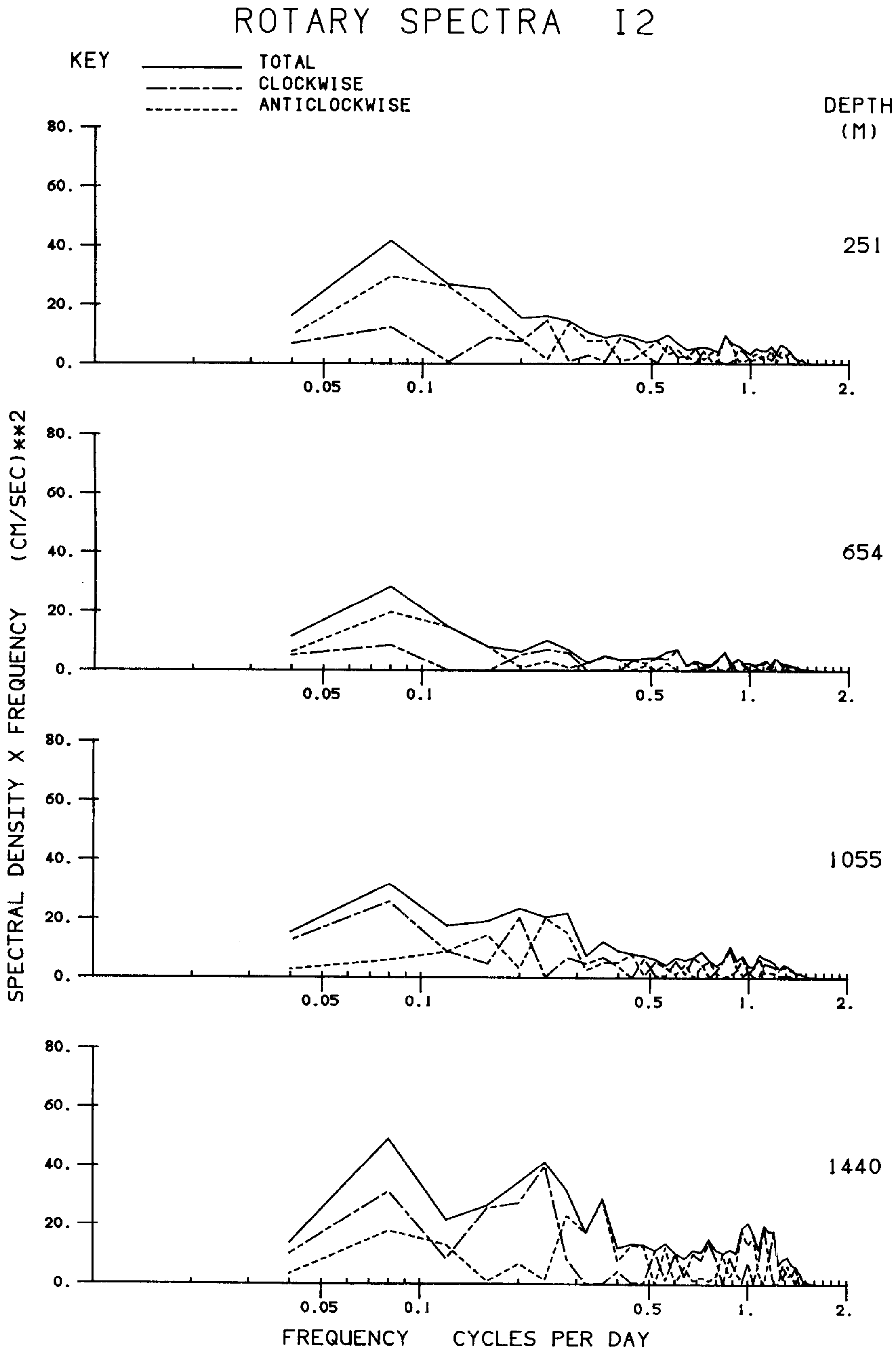
N ↑

TOTAL WATER DEPTH 1463m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
251		51.23	39.22	
654		57.15	45.67	
1055		37.37	56.74	
1440		82.89	53.59	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

SCALE ⊢—⊣ 10 CM/SEC

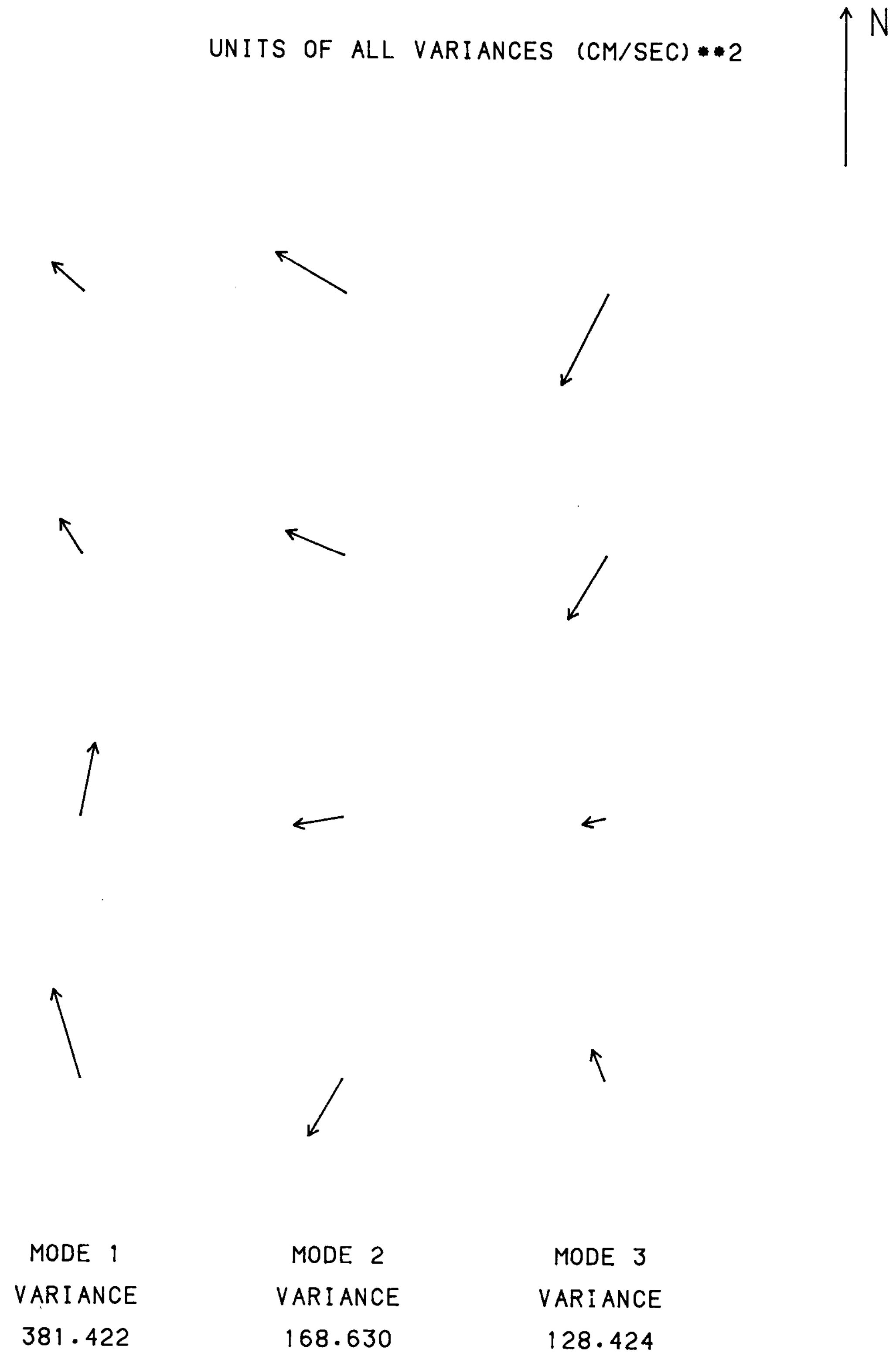


ROTARY SPECTRA I2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
251
654
1055
1440
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

I2

TOTAL VARIANCE 834.936

UNITS OF ALL VARIANCES (CM/SEC)**2



I2

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.42	2 0.42-0.82	3 0.82-2.02

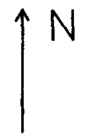
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	207.238	TOTAL	541.315	TOTAL	45.606	TOTAL	34.766
MODE1	120.236	MODE1	287.278	MODE1	13.681	MODE1	12.221

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

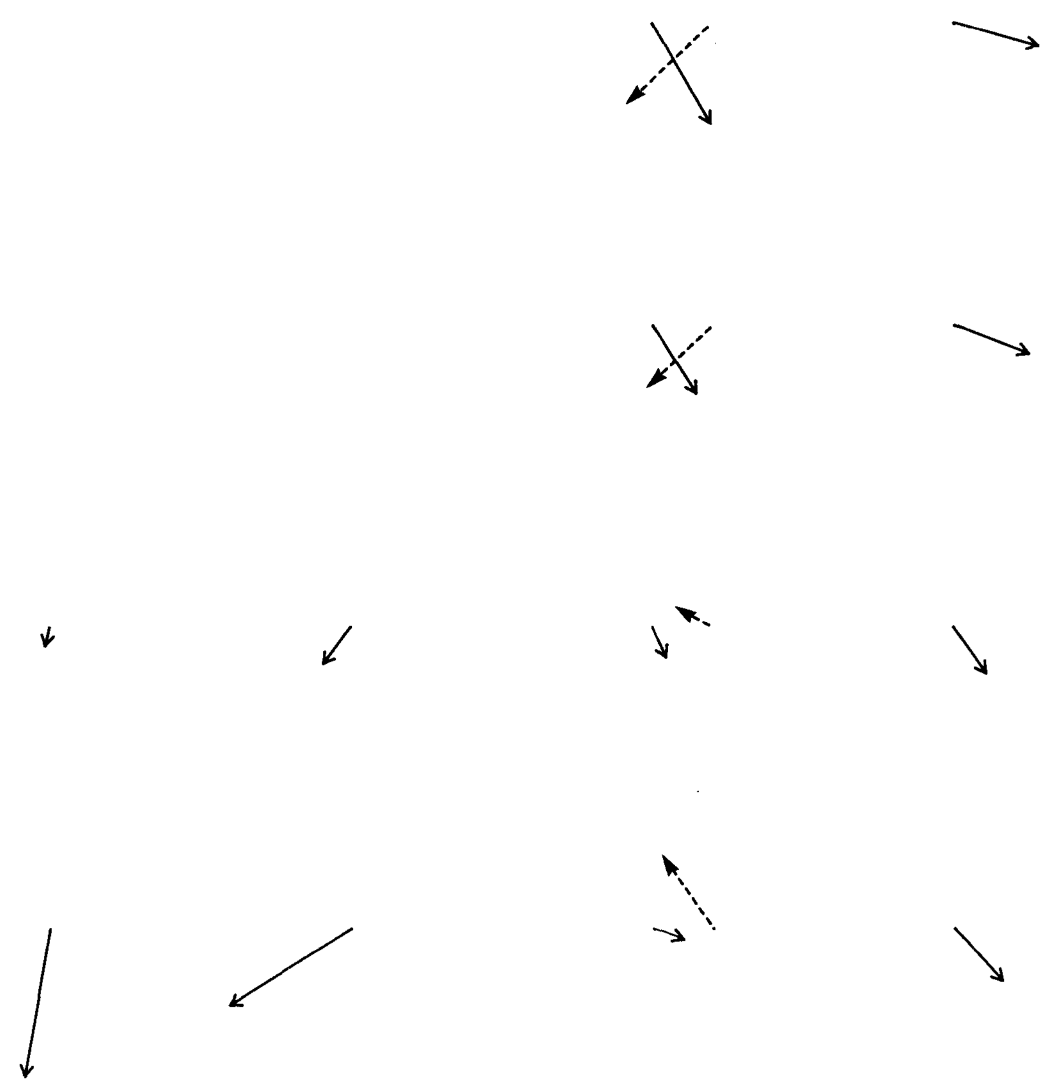
------------ IMAGINARY PART

I2



EVENT DURATION SHOWN BY DAY
NUMBER IN 1982. 1 JAN 1982 = 1

EVENT 1	EVENT 1	EVENT 2	EVENT 3
341-351	341-351	393-410	410-441
LOW FREQUENCY	HIGH FREQUENCY		



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	373.531	TOTAL	97.042	TOTAL	970.905	TOTAL	1006.911
MODE1	281.561	MODE1	66.159	MODE1	408.667	MODE1	489.732
				MODE2	296.379		

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

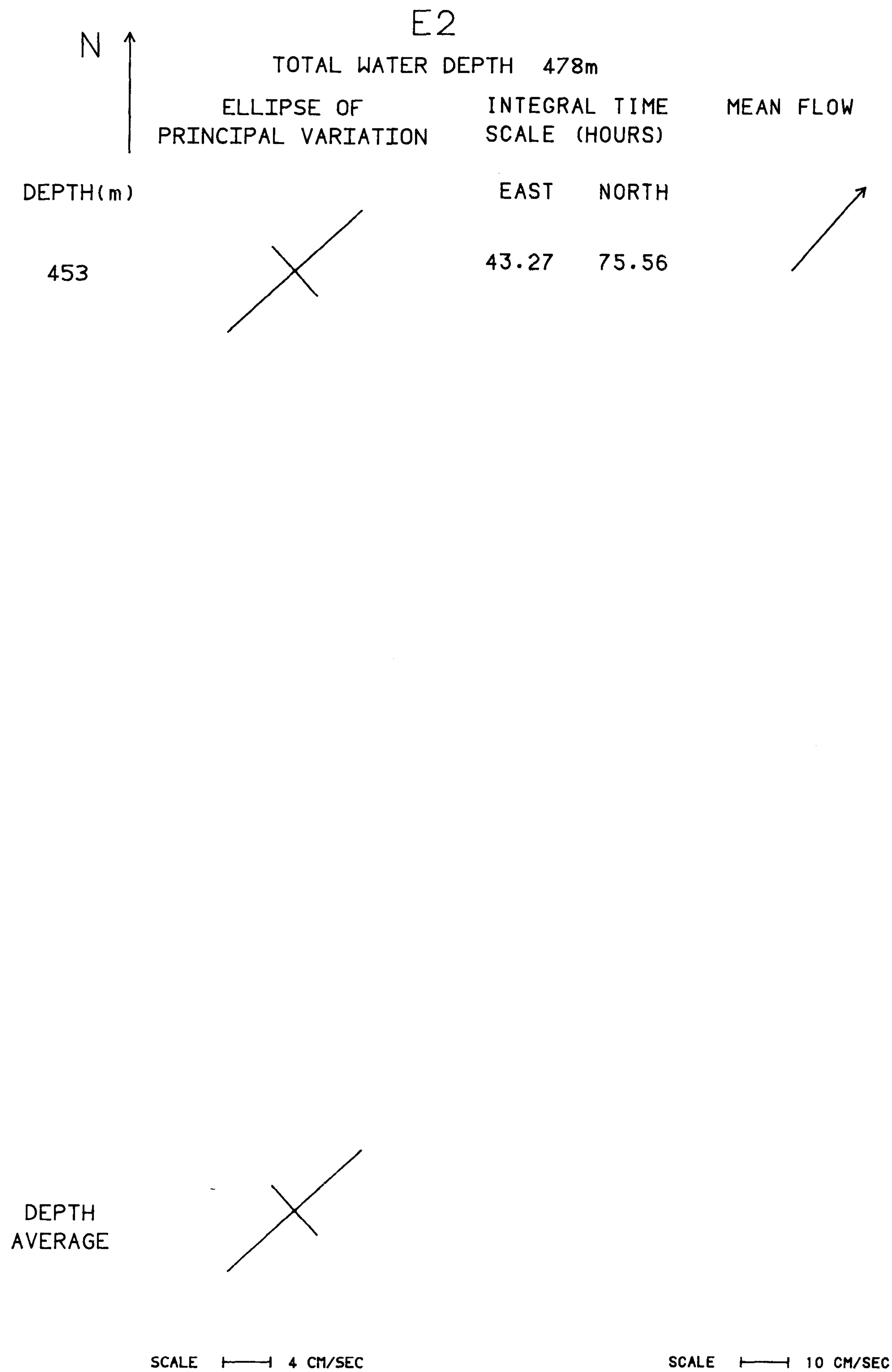
MOORING E2

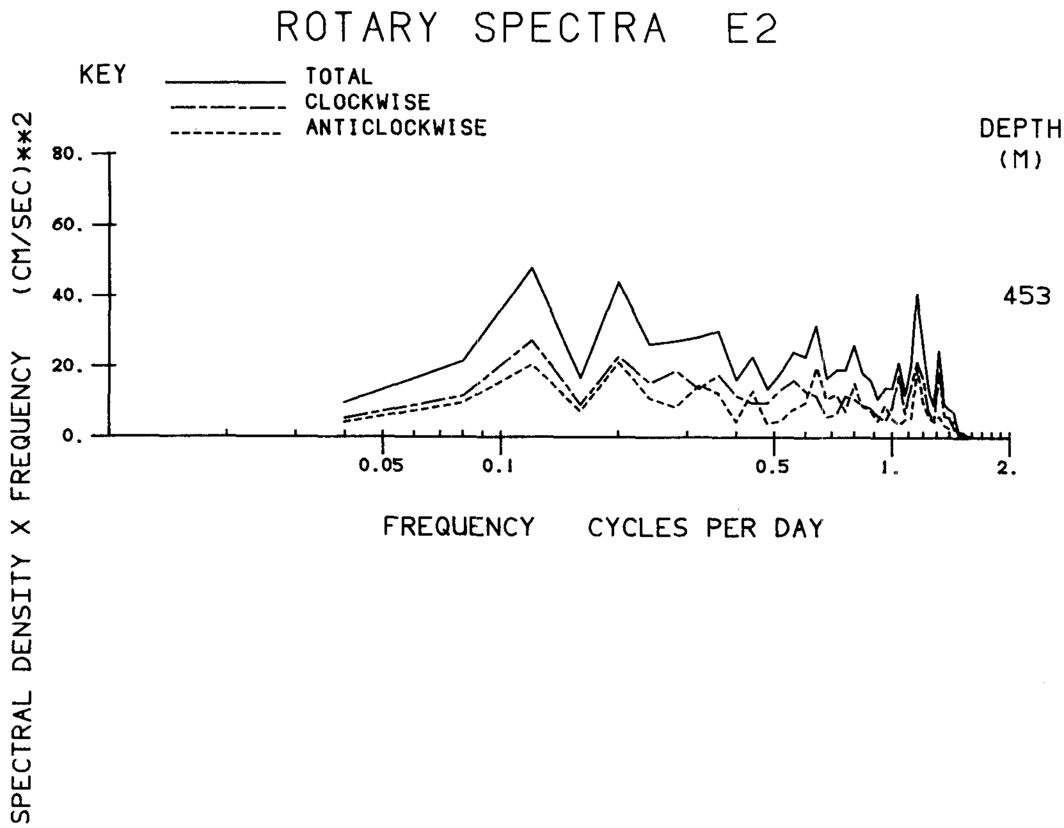
Set	10- X-82	Position:	60° 13.3'N 04° 31.8'W
Recovered	2-VIII-83	Water Depth:	478m

Depth (m)	Variables	Samp. Int. (hours)	Comments
453	Sp,D,T	1.0	See below

Comments

Mooring lying on sea bed when recovery attempted in March 1983. Deepest instrument recovered by dragging in August 1984. Complete data record continues until tape ran out. Mooring apparently failed (due to trawling?) 36 hours prior to attempted recovery in March '83.


E2
N
TOTAL WATER DEPTH 478m
ELLIPSE OF
PRINCIPAL VARIATION
INTEGRAL TIME
SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
453
43.27
75.56
DEPTH
AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

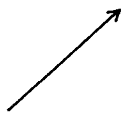

ROTARY SPECTRA E2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
453
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

E2

TOTAL VARIANCE 264.259

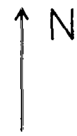
UNITS OF ALL VARIANCES (CM/SEC)**2

N



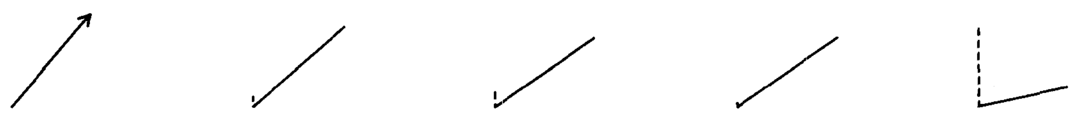
MODE 1
VARIANCE
232.979

E2



FREQUENCY BAND (CYCLES PER DAY)

LOW	1	2	3	4
FREQUENCY	0.02-0.26	0.26-0.50	0.50-0.94	0.94-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	61.327	TOTAL	124.871	TOTAL	35.887	TOTAL	30.291	TOTAL	17.909
MODE1	58.105	MODE1	118.767	MODE1	31.767	MODE1	23.514	MODE1	10.962

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

------------ IMAGINARY PART

E2

Event duration shown by day number in 1982. 1 Jan 1982 = 1

↑ N

EVENT 1	EVENT 2
350-370	410-440

VARIANCES		VARIANCES	
TOTAL	373.038	TOTAL	377.679
MODE 1	315.513	MODE 1	243.525

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

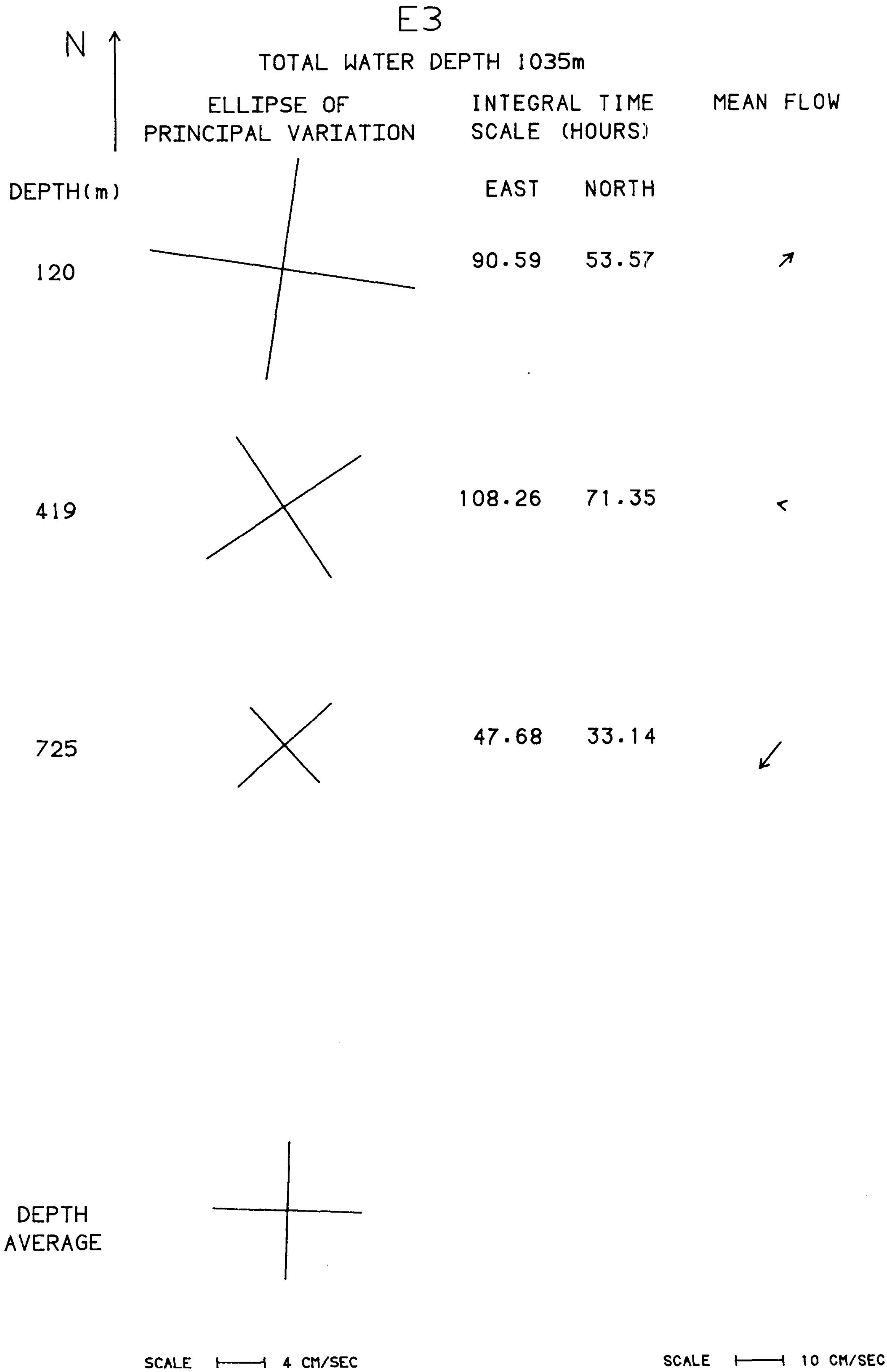
MOORING E3

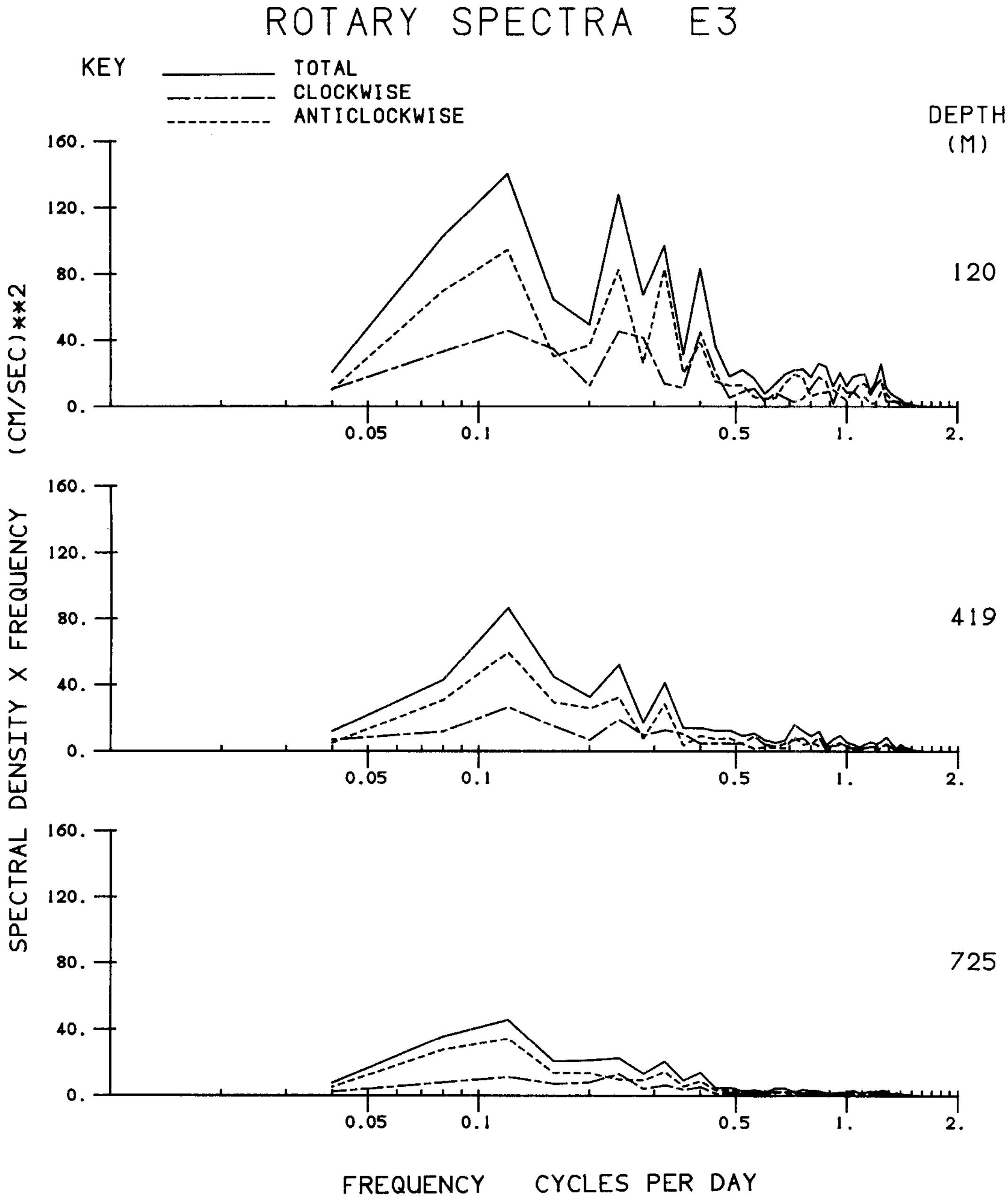
Set 9- X-82 Position: 60° 31.2'N 04° 56.8'W

Recovered 23- III-83 Water Depth: 1035m

Depth (m)	Variables	Samp. Int. (hours)	Comments
120	Sp,D,T,P	1.0	
419	Sp,D,T	1.0	
725	Sp,D,T	1.0	
980	Sp,D,T	1.0	Battery failure - no data

Comments

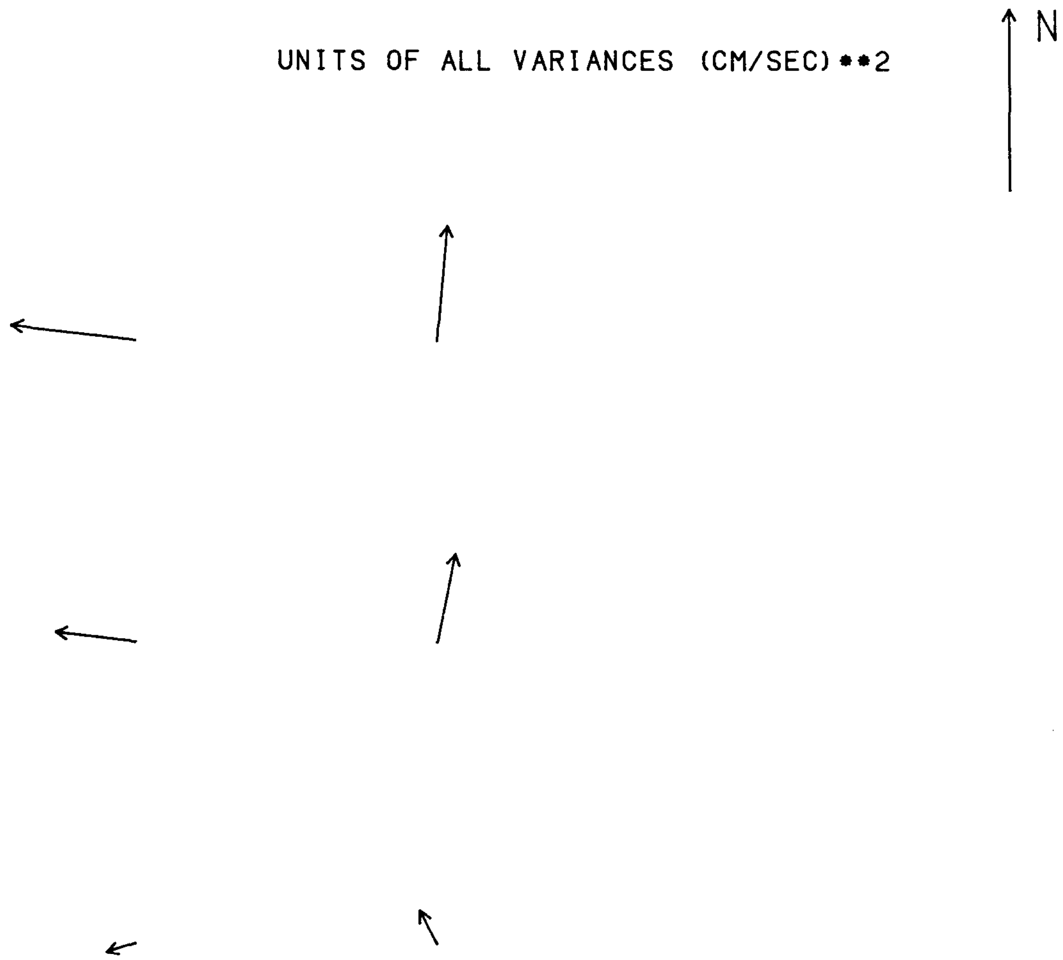

E3
N
TOTAL WATER DEPTH 1035m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
120
90.59
53.57
419
108.26
71.35
725
47.68
33.14
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC


ROTARY SPECTRA E3
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
120
419
725
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
160.
120.
80.
40.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

E3

TOTAL VARIANCE 1482.355

UNITS OF ALL VARIANCES (CM/SEC)**2



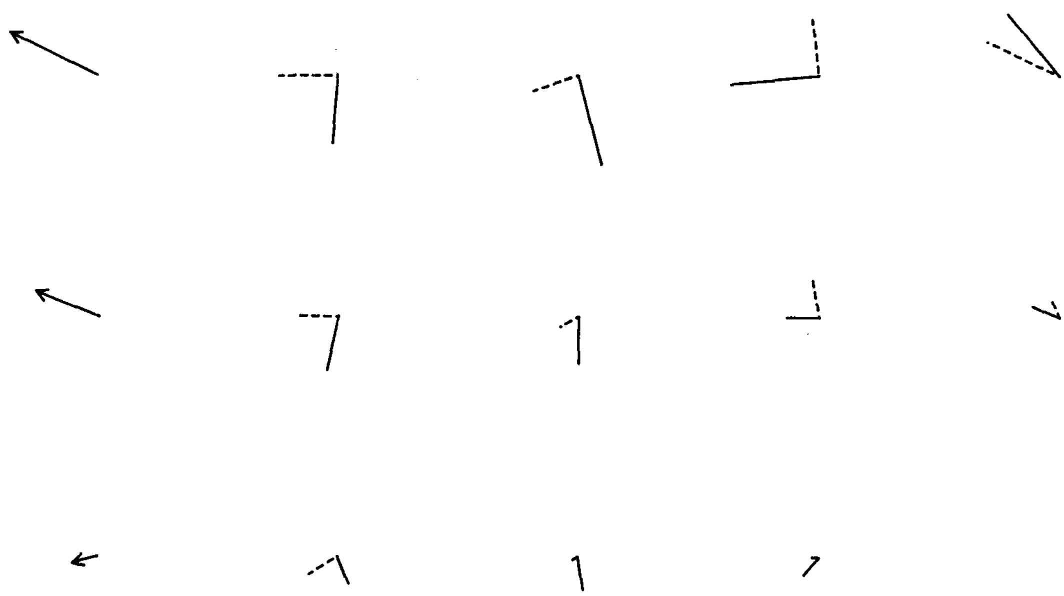
MODE 1	MODE 2
VARIANCE	VARIANCE
719.601	570.461

E3

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.30	2 0.30-0.62	3 0.62-0.90	4 0.90-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	524.212	TOTAL	742.581	TOTAL	116.615	TOTAL	28.428	TOTAL	23.946
MODE1	343.043	MODE1	427.826	MODE1	65.036	MODE1	12.756	MODE1	11.112

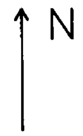
UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

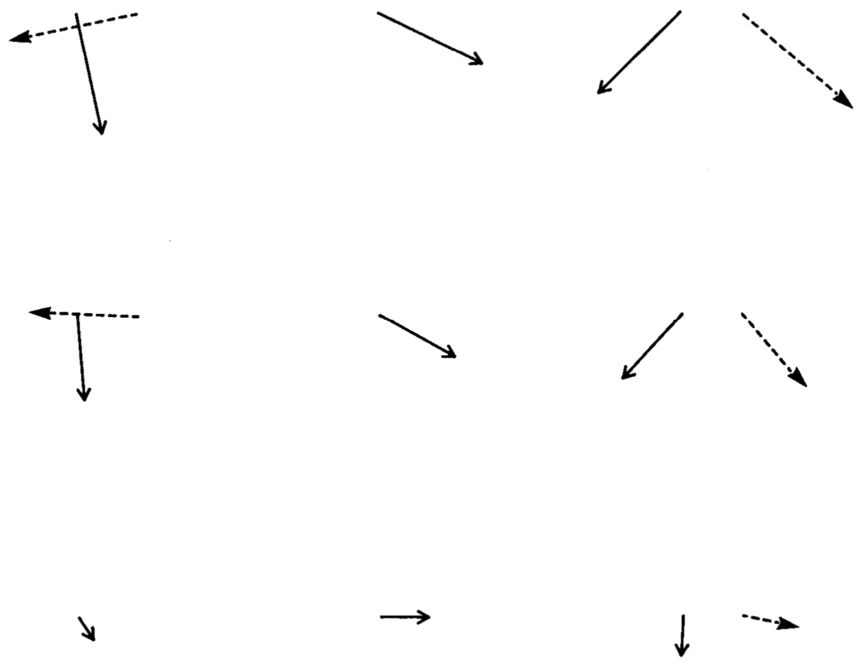
------------ IMAGINARY PART

E3

Event duration shown by day number in 1982. 1 Jan 1982 = 1



EVENT 1	EVENT 2	EVENT 3
350-370	370-390	410-440



VARIANCES	VARIANCES	VARIANCES
TOTAL 1408.663	TOTAL 1471.486	TOTAL 2903.771
MODE1 762.023	MODE1 787.104	MODE1 1603.859
MODE2 426.376		MODE2 825.090

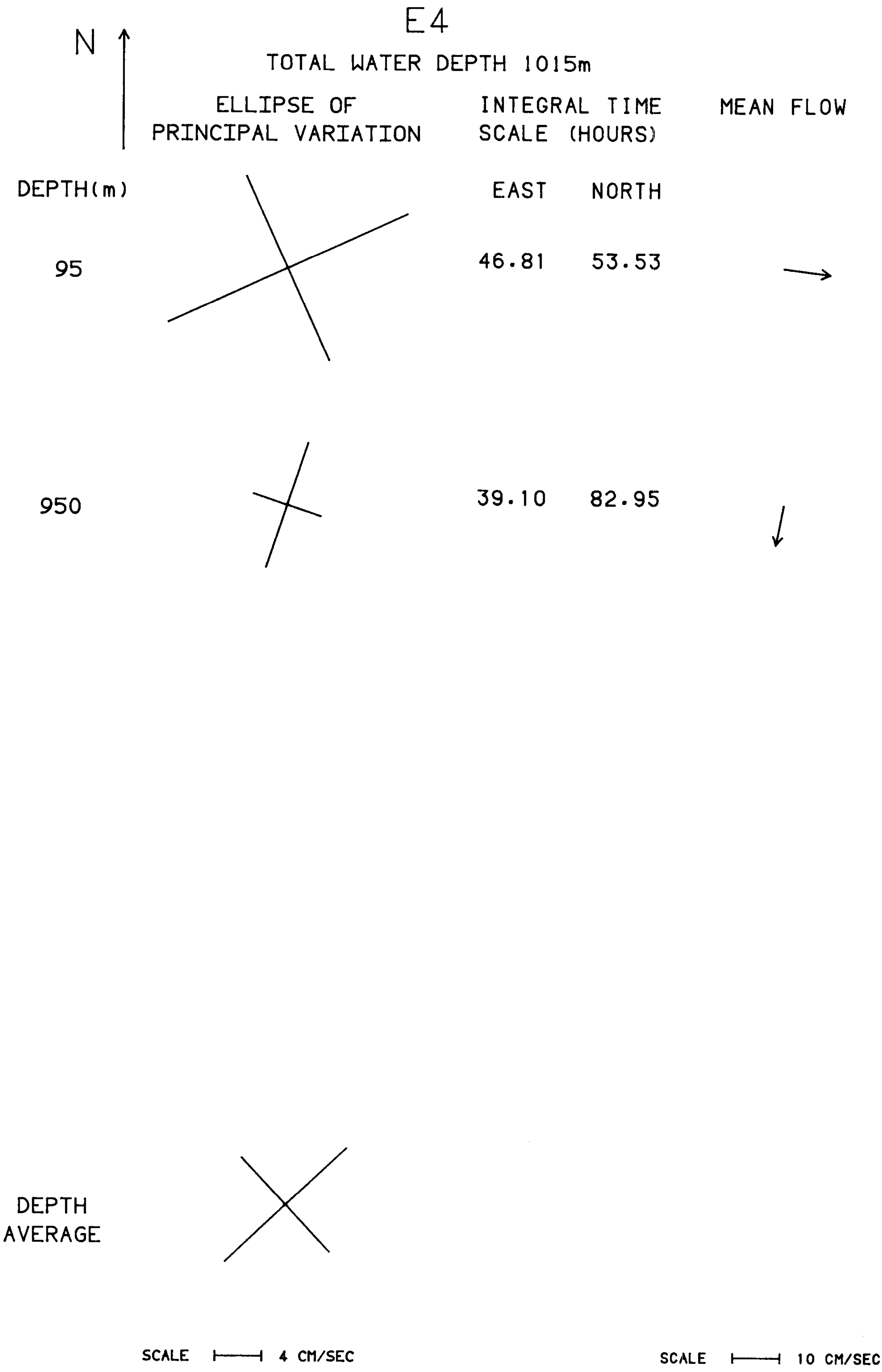
UNITS OF ALL VARIANCES (CM/SEC)**2

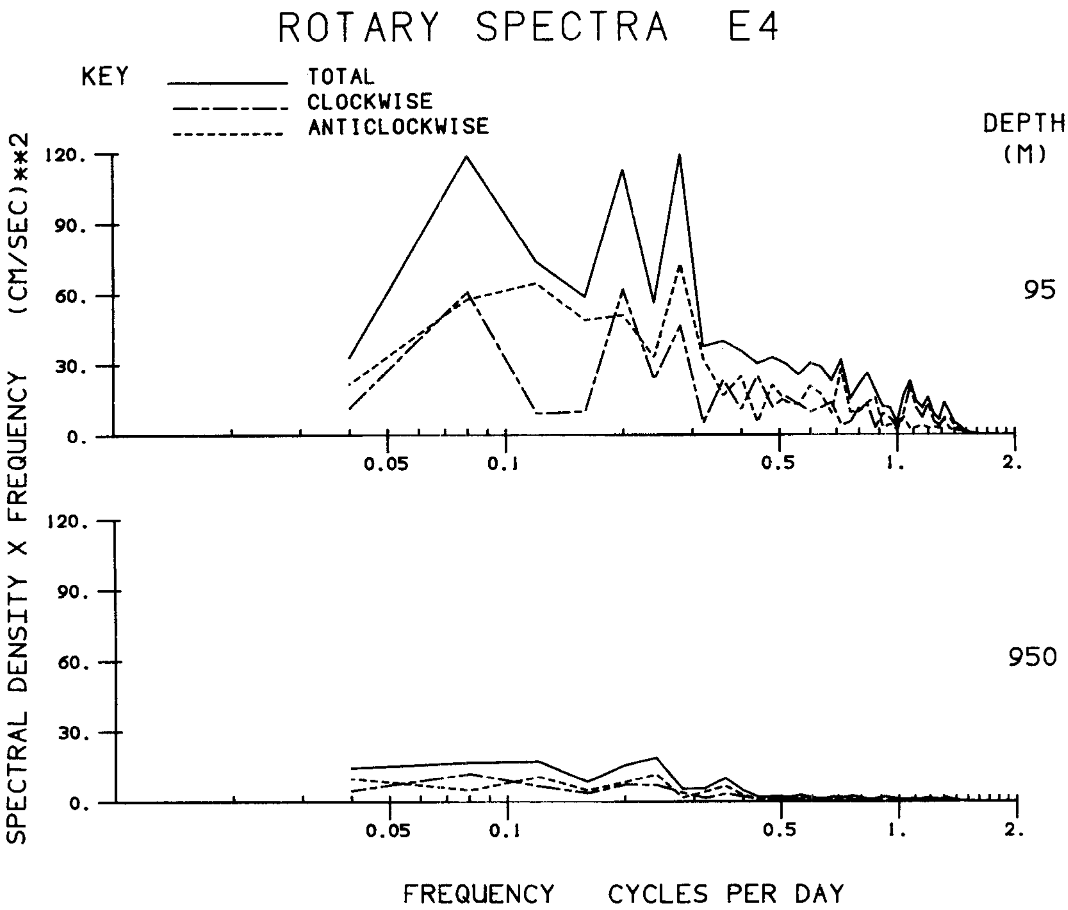
—— MODE 1
------ MODE 2

MOORING E4

Set	23- XI-82	Position:	60° 46.4'N 04° 49.4'W
Recovered	26- V-83	Water Depth:	1015m

Depth (m)	Variables	Samp. Int. (hours)	Comments
95	Sp,D,T	1	
950	Sp,D,T	1	65 hours missing

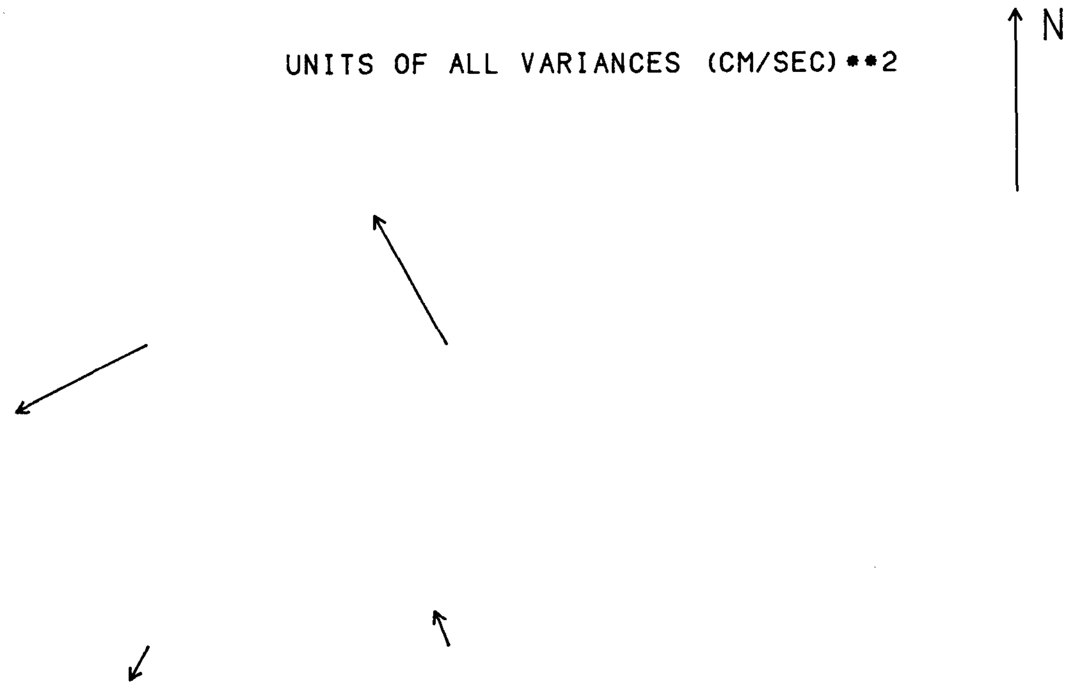

E4
TOTAL WATER DEPTH 1015m
N
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
95
46.81
53.53
950
39.10
82.95
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC


ROTARY SPECTRA E4
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
95
950
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
120.
90.
60.
30.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

E4

TOTAL VARIANCE 945.652

UNITS OF ALL VARIANCES (CM/SEC)**2

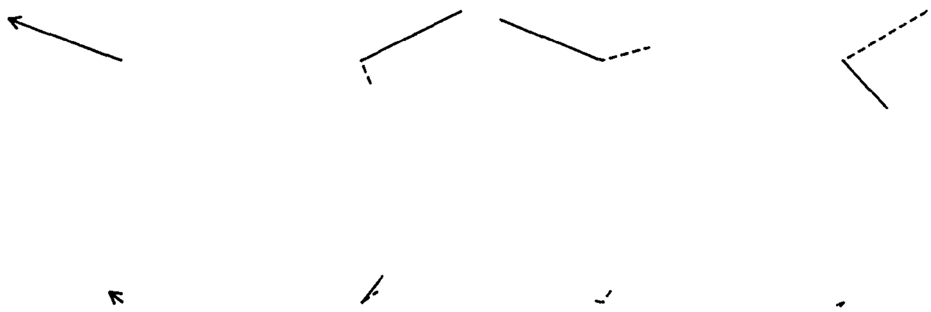


MODE 1	MODE 2
VARIANCE	VARIANCE
519.402	306.857

E4

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.34	2 0.34-1.02	3 1.02-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	245.328	TOTAL	515.088	TOTAL	75.158	TOTAL	10.986
MODE1	148.903	MODE1	335.570	MODE1	39.154	MODE1	7.452

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ——————— REAL PART

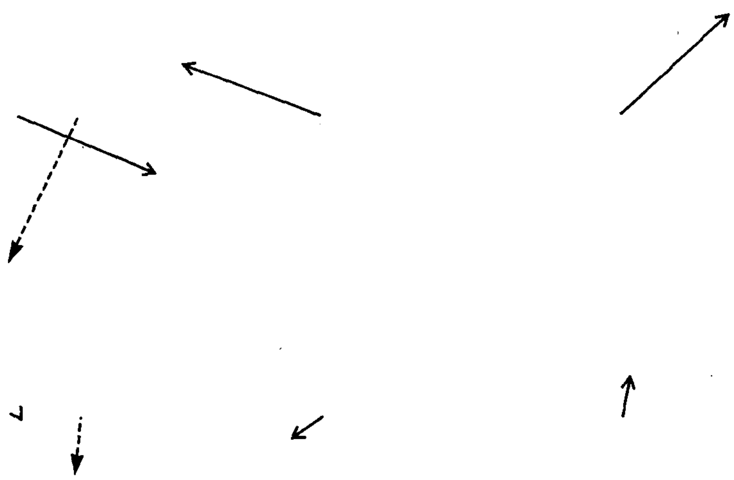
----------- IMAGINARY PART

E4

N

Event duration shown by day number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 2	EVENT 3
350-370	370-390	410-440



VARIANCES		VARIANCES		VARIANCES	
TOTAL	261.188	TOTAL	1195.217	TOTAL	1696.933
MODE1	125.705	MODE1	839.294	MODE1	1186.786
MODE2	105.606				

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

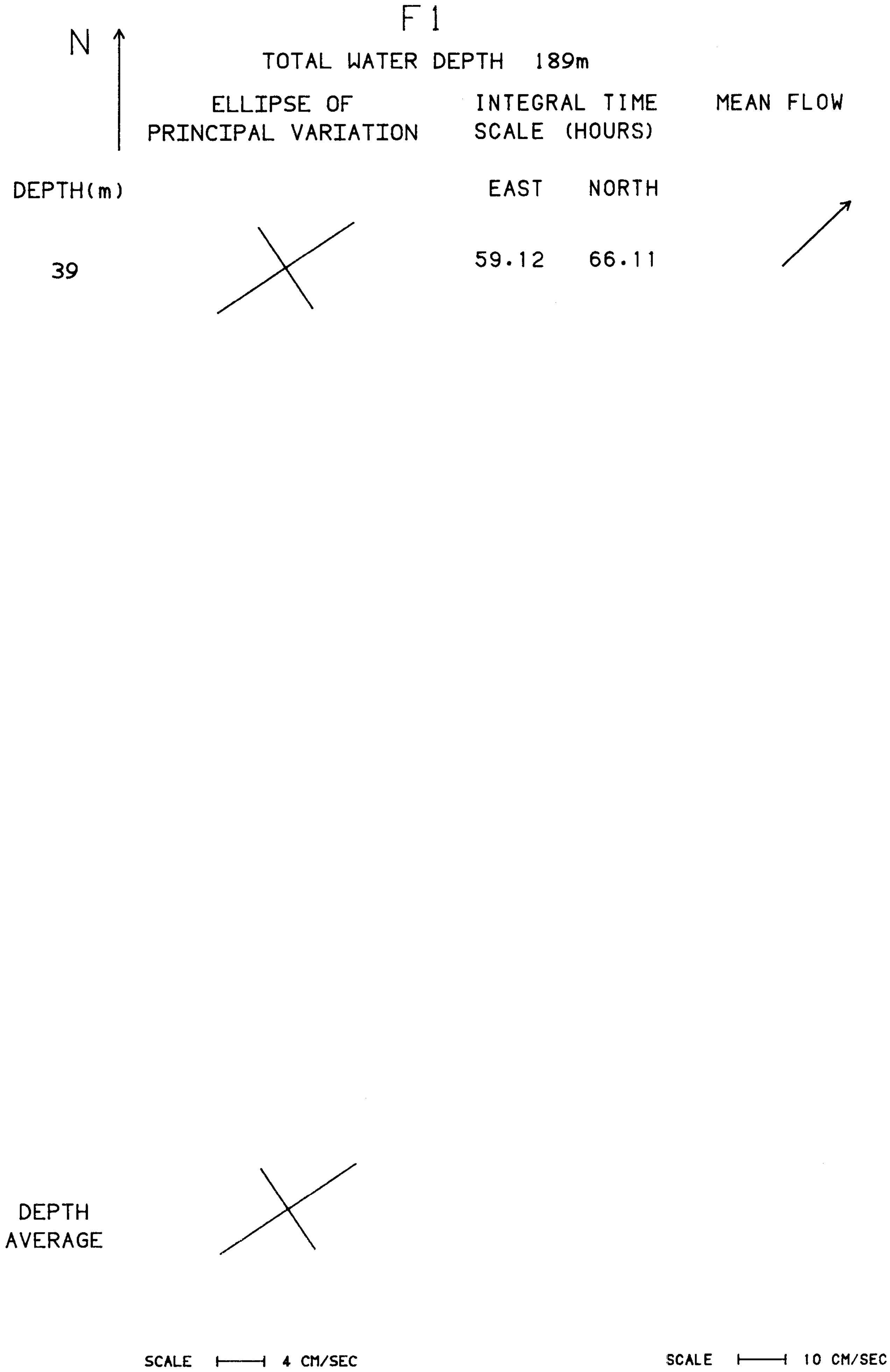
MOORING F1

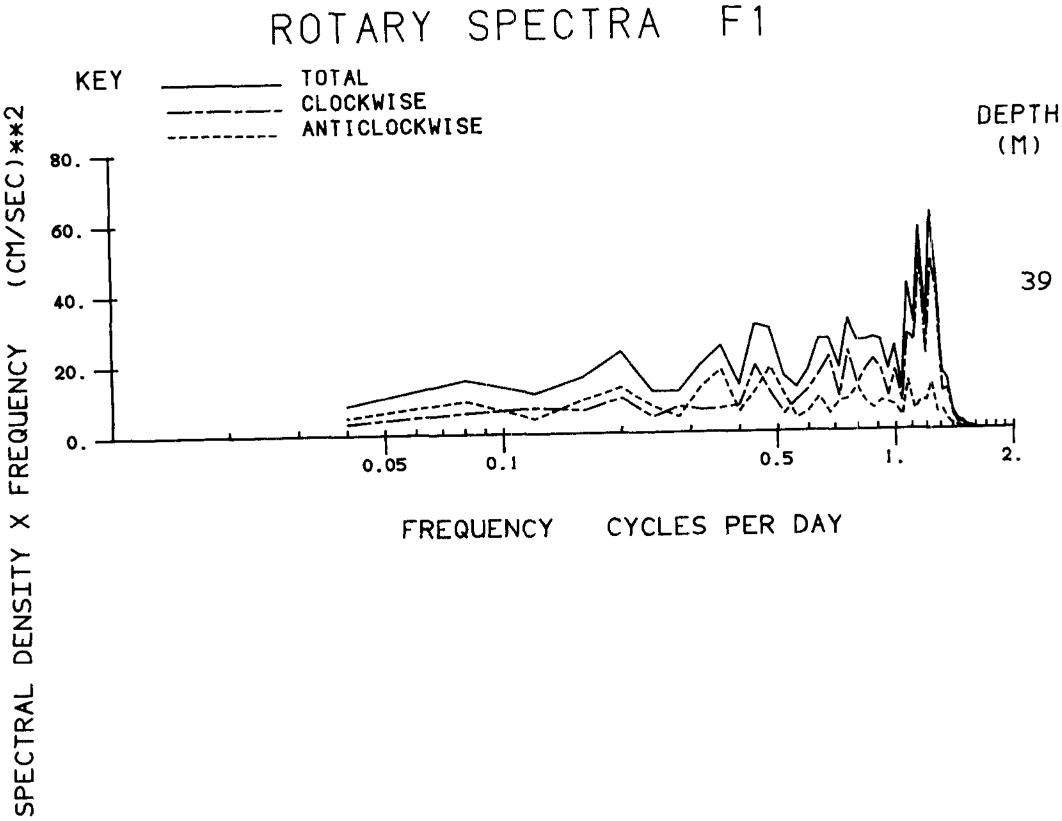
Set 3- X-82 Position: 61° 09.3'N 01° 31.7'W

Recovered 16- III-83 Water Depth: 189m

Depth (m)	Variables	Samp. Int. (hours)	Comments
39	Sp,D,T,P	0.5	
164	Sp,D,T	0.5	No temperature or direction

Comments

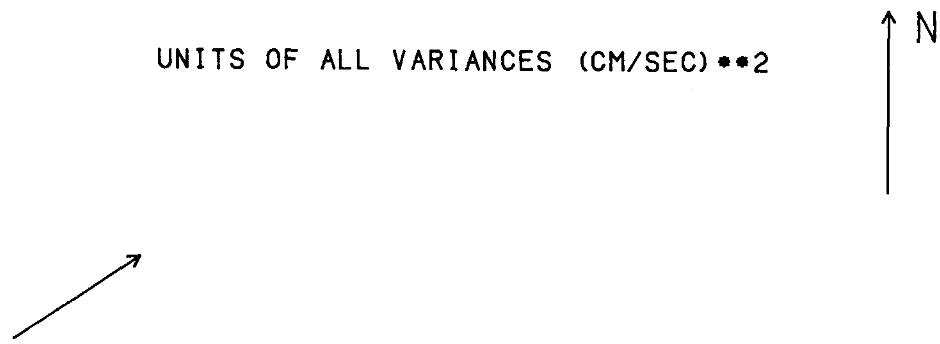

F1
N
TOTAL WATER DEPTH 189m
ELLIPSE OF
PRINCIPAL VARIATION
INTEGRAL TIME
SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
39
59.12
66.11
DEPTH
AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC


ROTARY SPECTRA F1
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH
(M)
39
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

F1

TOTAL VARIANCE 256.018

UNITS OF ALL VARIANCES (CM/SEC)**2

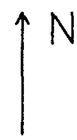


MODE 1

VARIANCE

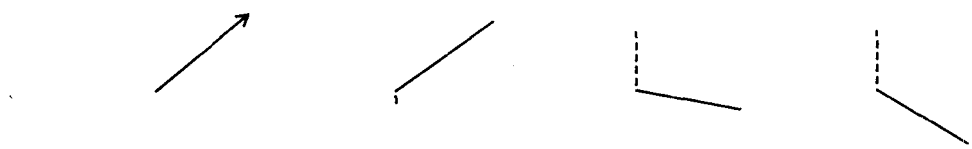
189.313

F1



FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.34	2 0.34-0.94	3 0.94-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	81.687	TOTAL	79.941	TOTAL	53.064	TOTAL	28.414
MODE1	79.351	MODE1	69.540	MODE1	30.673	MODE1	24.392

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ——————— REAL PART

----------- IMAGINARY PART

F1

Event duration shown by day number in 1982. 1 Jan 1982 = 1

N

EVENT 1	EVENT 2	EVENT 3
310-340	393-410	410-440

VARIANCES	VARIANCES	VARIANCES
TOTAL 192.109	TOTAL 297.423	TOTAL 260.312
MODE 1 120.840	MODE 1 206.866	MODE 1 183.414

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

MOORING F3

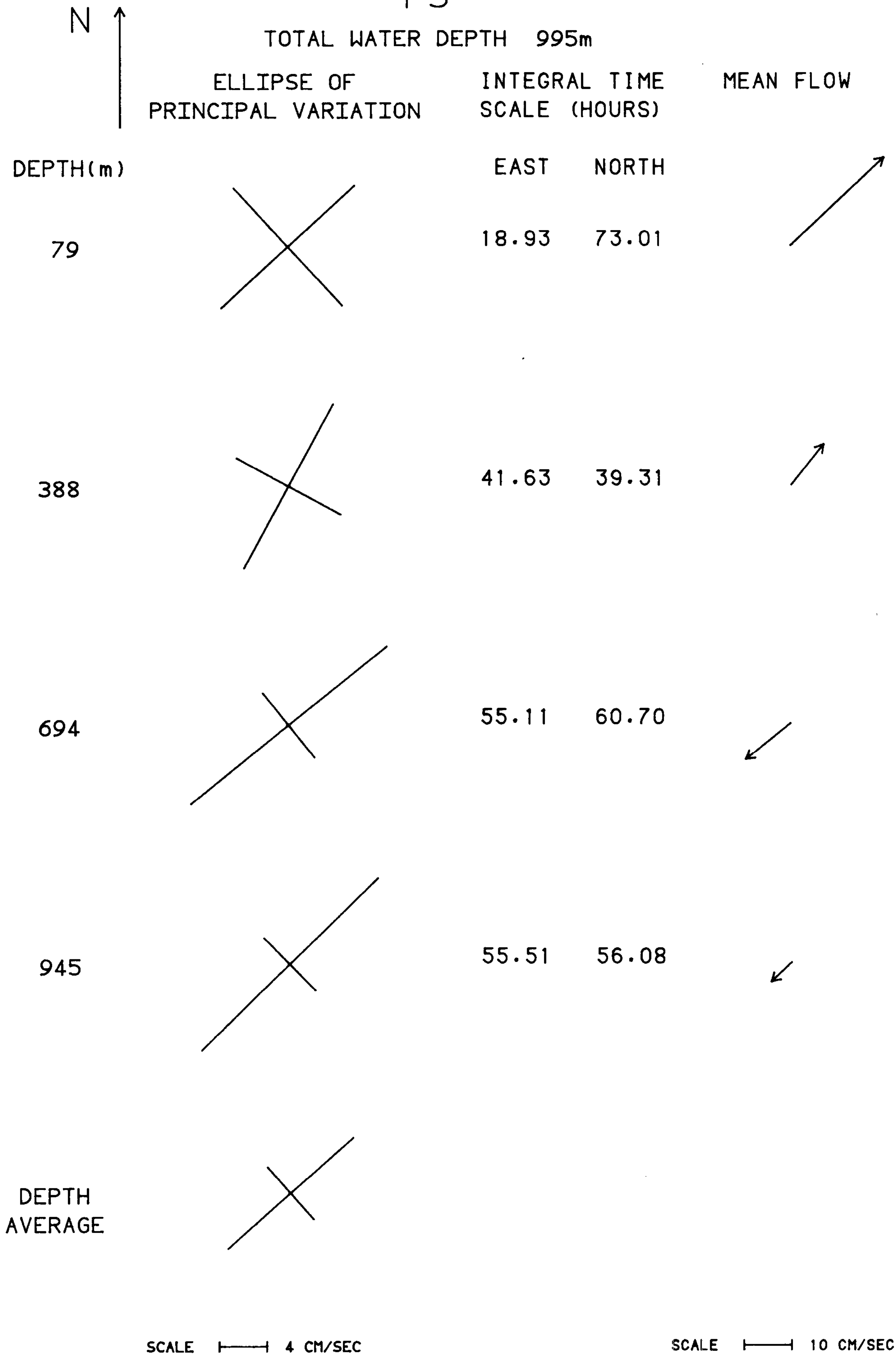
Set	4- X-82	Position:	61° 24.8'N 02° 06.1'W
Recovered	16- III-83	Water Depth:	995m

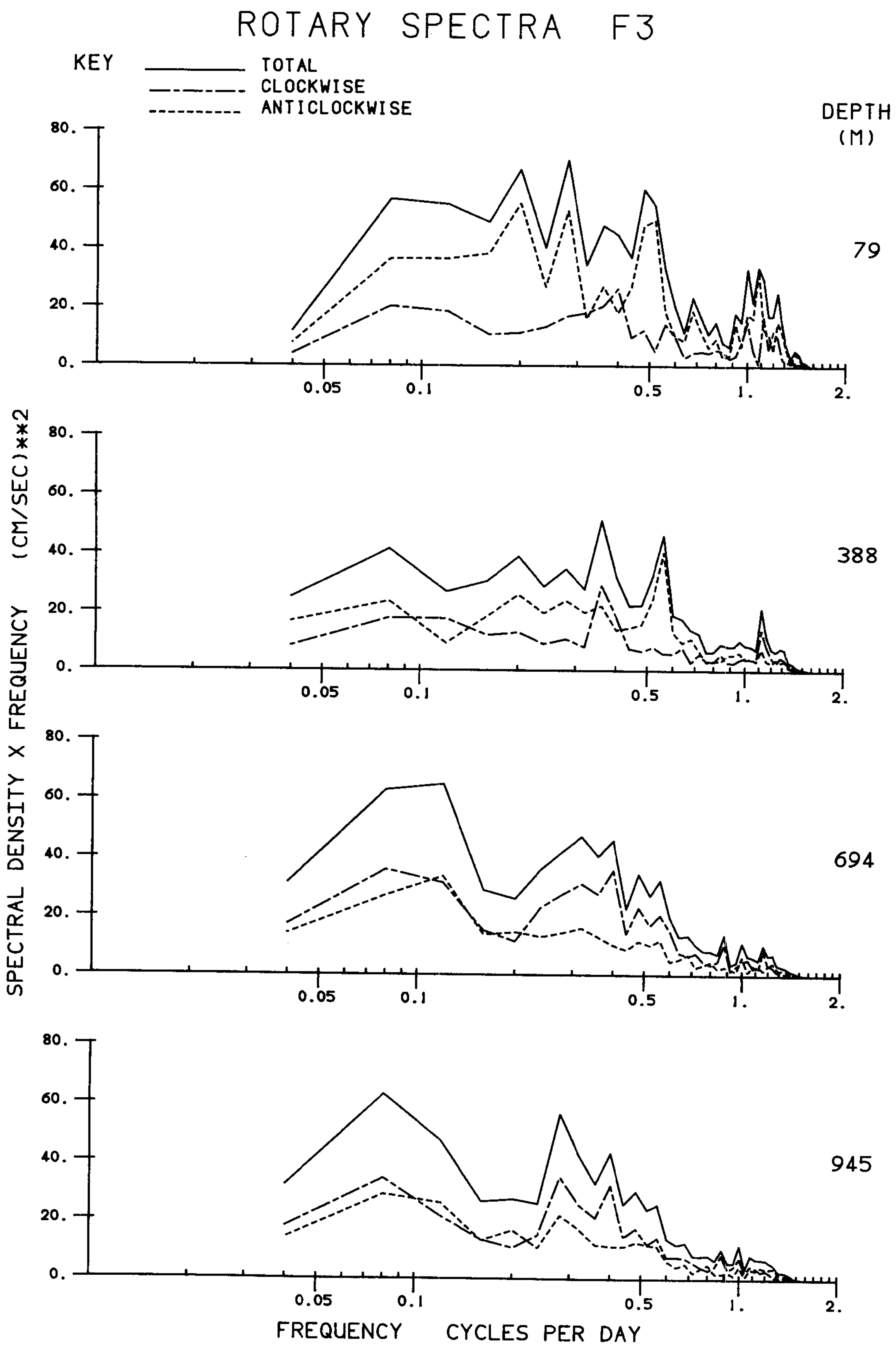
Depth (m)	Variables	Samp. Int. (hours)	Comments
79	Sp,D,T,P	1.0	Encoder fault short record
388	Sp,D,T	1.0	
694	Sp,D,T	1.0	
945	Sp,D,T	1.0	

Comments

Low frequency band covariance matrix not positive definite (0.8%).

F3

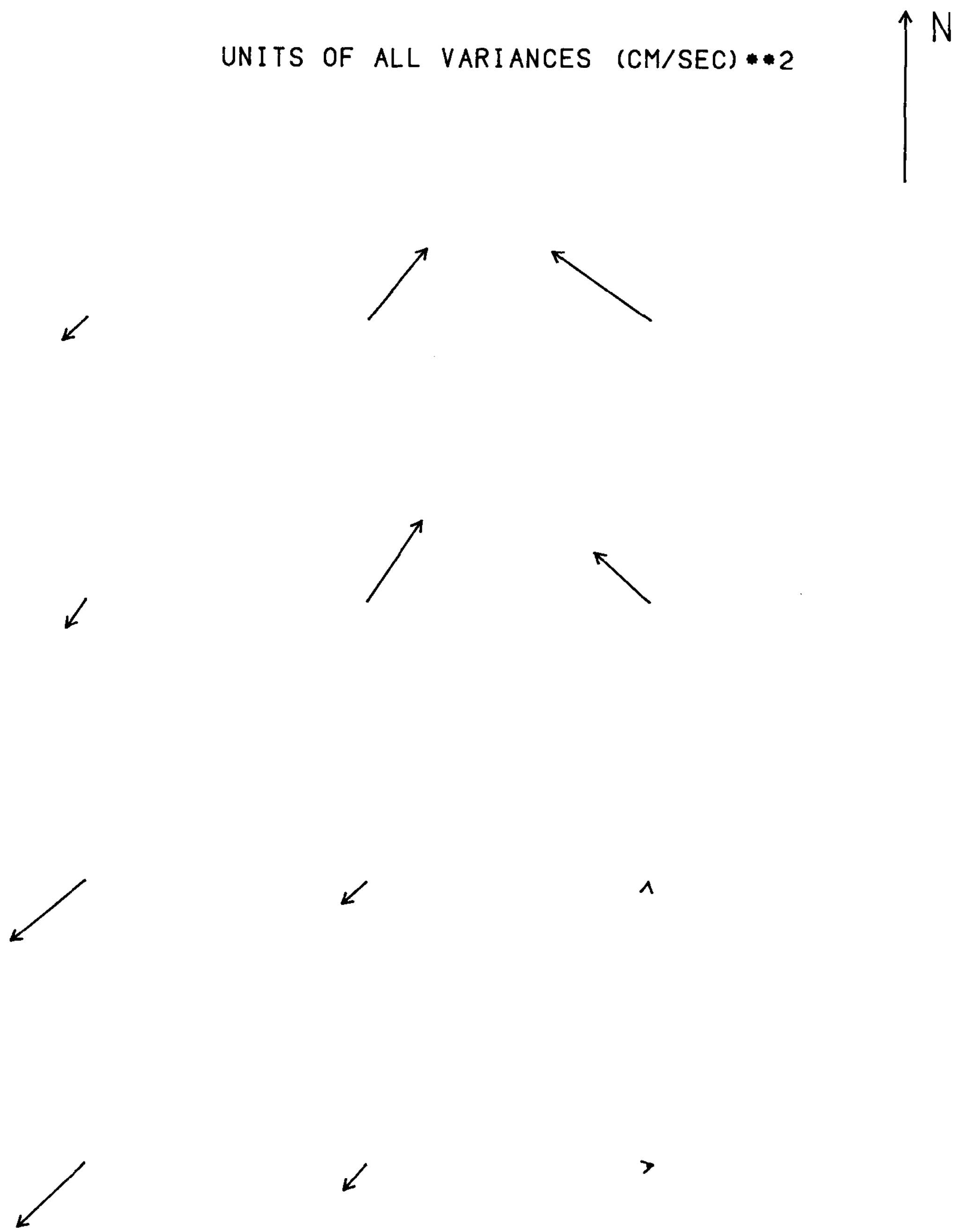

N
TOTAL WATER DEPTH 995m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
79
18.93
73.01
388
41.63
39.31
694
55.11
60.70
945
55.51
56.08
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC


ROTARY SPECTRA F3
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
79
388
694
945
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

F3

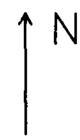
TOTAL VARIANCE 1710.106

UNITS OF ALL VARIANCES (CM/SEC)**2



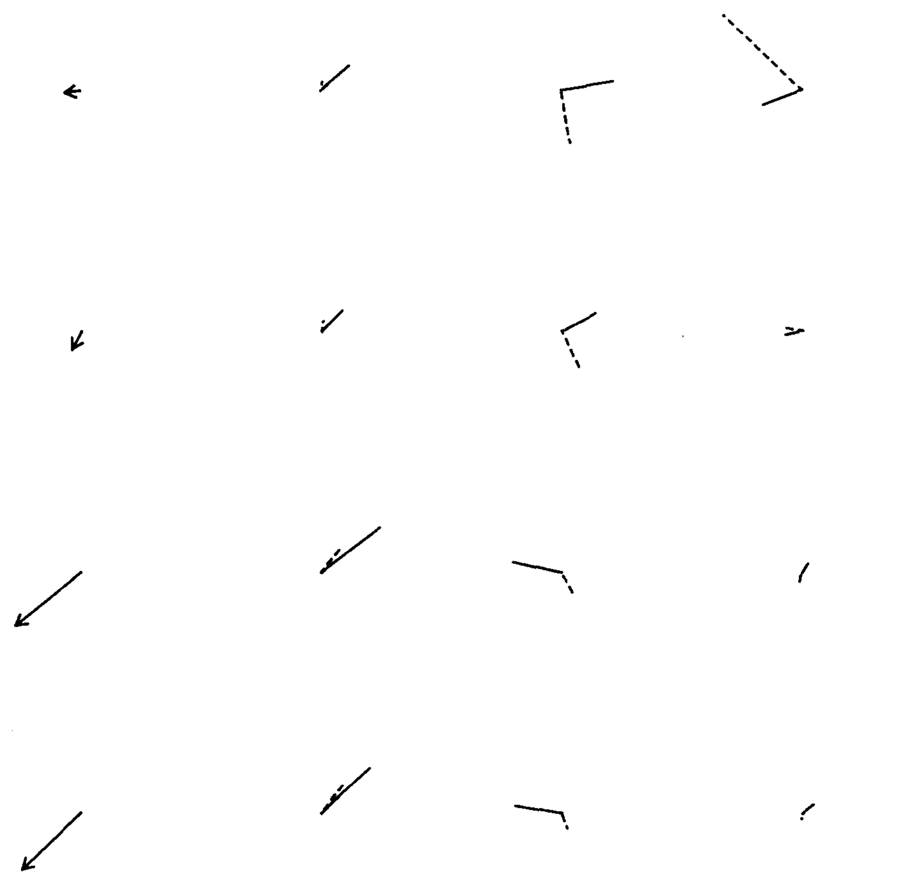
MODE 1	MODE 2	MODE 3
VARIANCE	VARIANCE	VARIANCE
927.781	300.281	225.134

F3



FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.42	2 0.42-0.90	3 0.90-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	460.084	TOTAL	1030.870	TOTAL	147.348	TOTAL	42.196
MODE1	318.848	MODE1	581.347	MODE1	62.077	MODE1	16.165

UNITS OF ALL VARIANCES (CM/SEC)**2

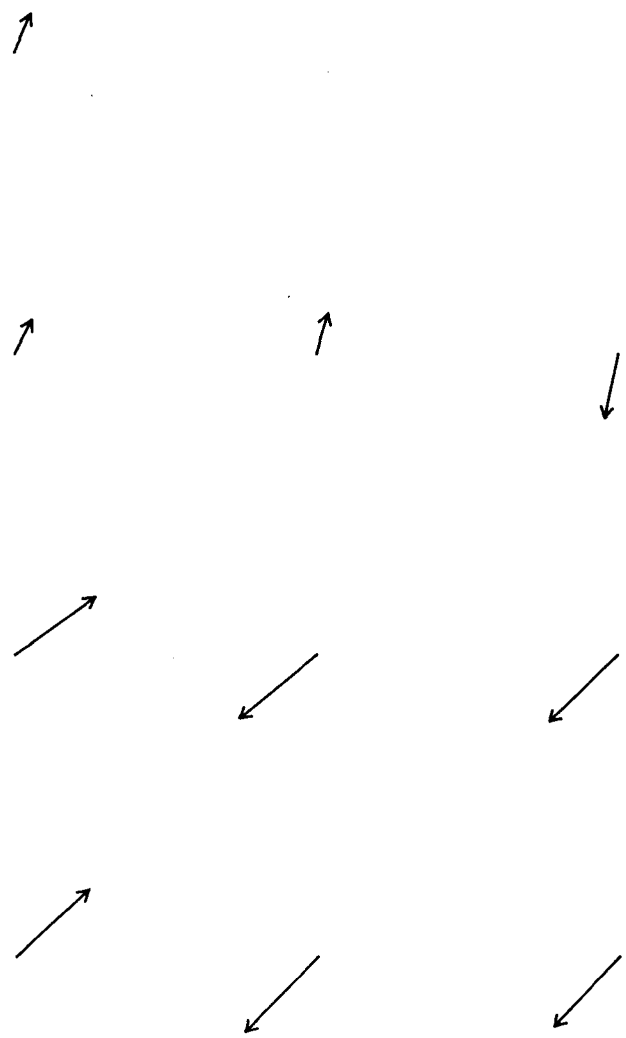
KEY ———— REAL PART

------------ IMAGINARY PART

F3

Event duration shown by day number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 2	EVENT 3
310-340	393-410	410-440



VARIANCES	VARIANCES	VARIANCES
TOTAL 1399.318	TOTAL 2485.471	TOTAL 1442.854
MODE1 924.528	MODE1 1443.158	MODE1 997.552

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

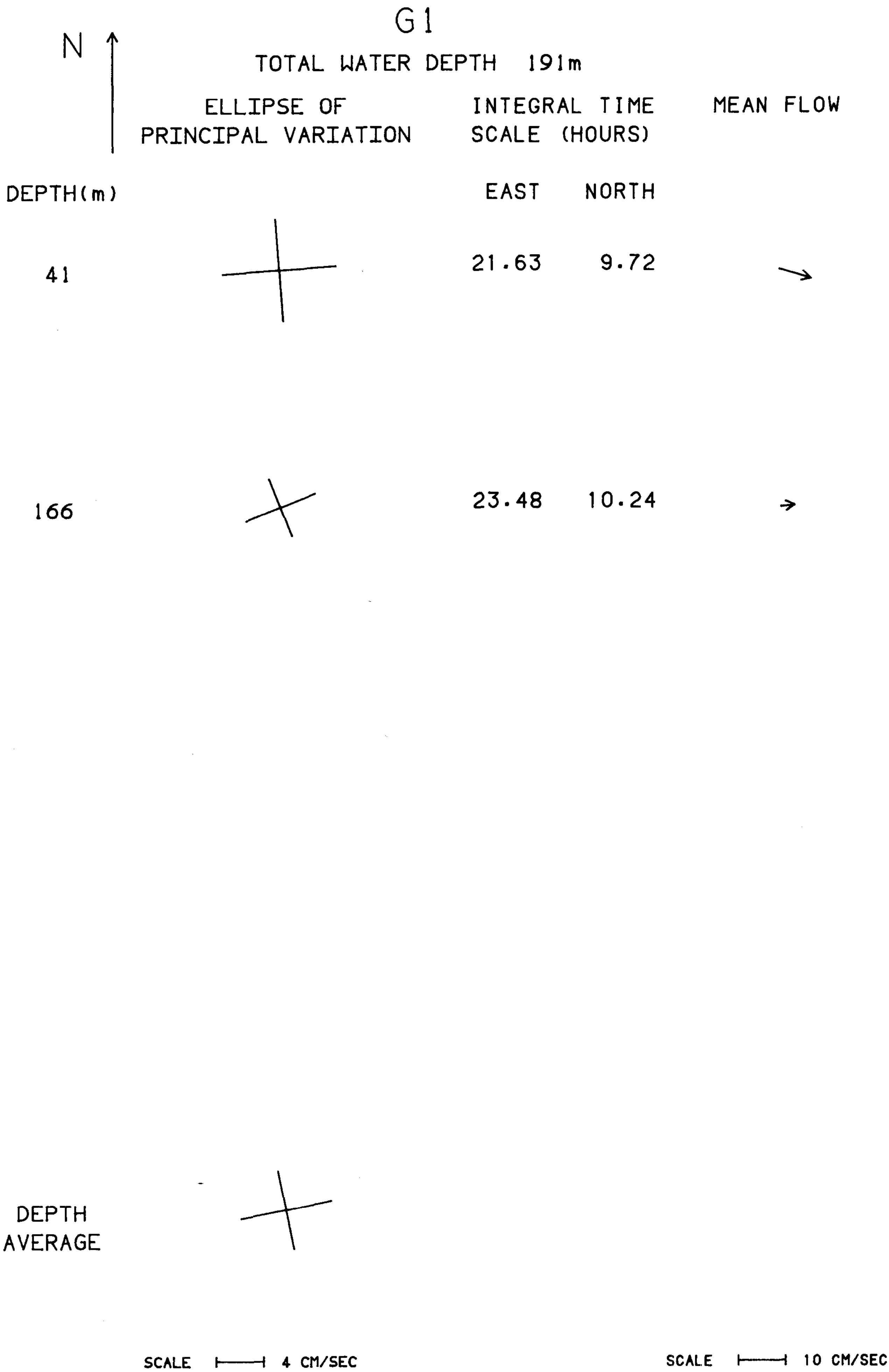
MOORING G1

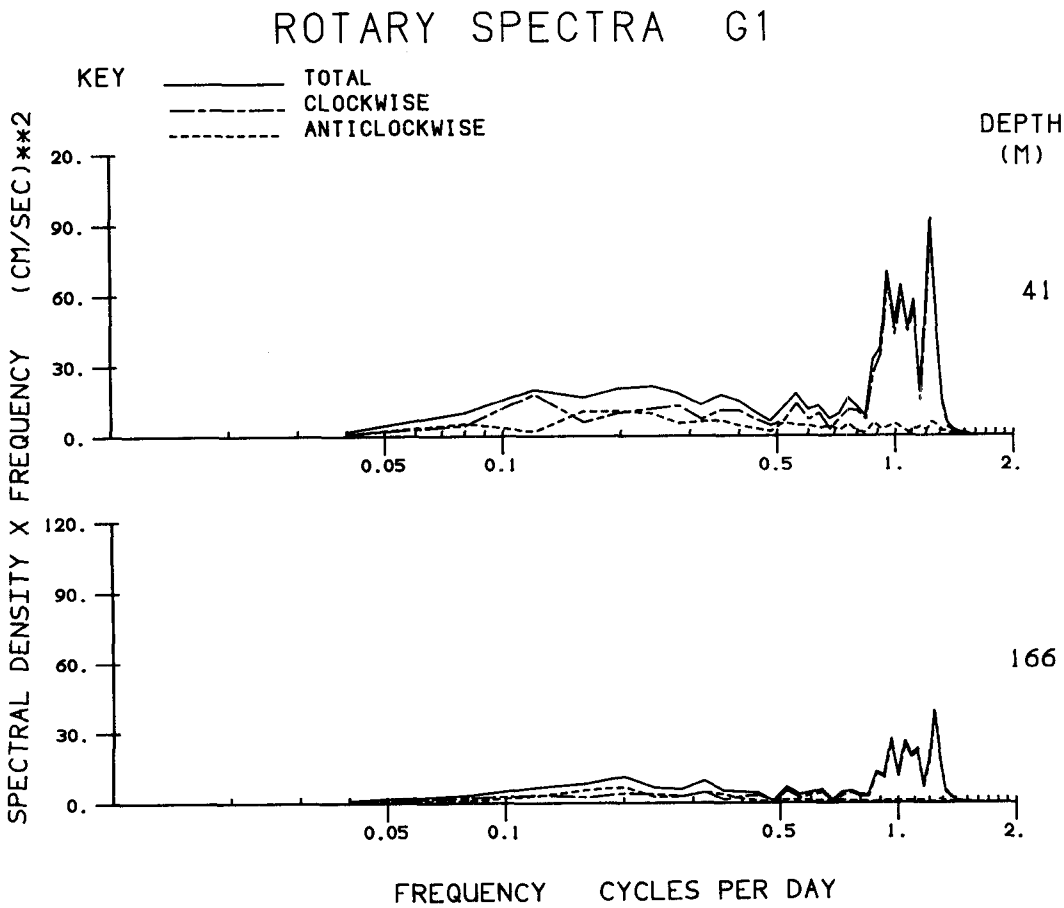
Set	5- X-82	Position:	61° 30.7'N 00° 02.5'E
	31- I-83		61° 31.7'N 00° 02.0'E
Recovered	31- I-83	Water Depth:	191m
	24- II-83		186m

Depth (m)	Variables	Samp. Int. (hours)	Comments
41	Sp,D,T,C,P	0.5	
35	Sp,D,T,C,P	0.5	No speed
166	Sp,D,T,C	0.5	
161	Sp,D,T,C	0.5	

Comments

Repeated dates, position, depths and other values refer to second deployment.
The second rig was trawled on 24-II-83, so that 21 days' data were lost.
Low frequency band covariance matrix not positive definite (1.2%).


G1
N
TOTAL WATER DEPTH 191m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
41
21.63
9.72
166
23.48
10.24
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 10 CM/SEC

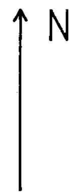


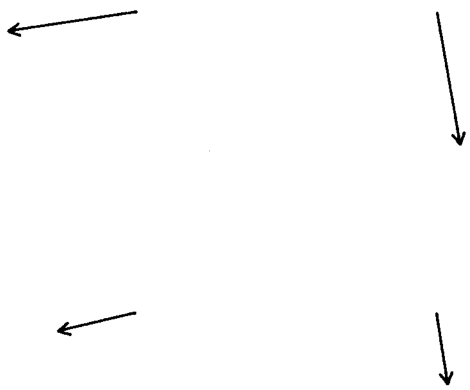
ROTARY SPECTRA G1
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
41
166
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
20.
90.
60.
30.
0.
120.
90.
60.
30.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

G1

TOTAL VARIANCE 232.850

UNITS OF ALL VARIANCES (CM/SEC)**2





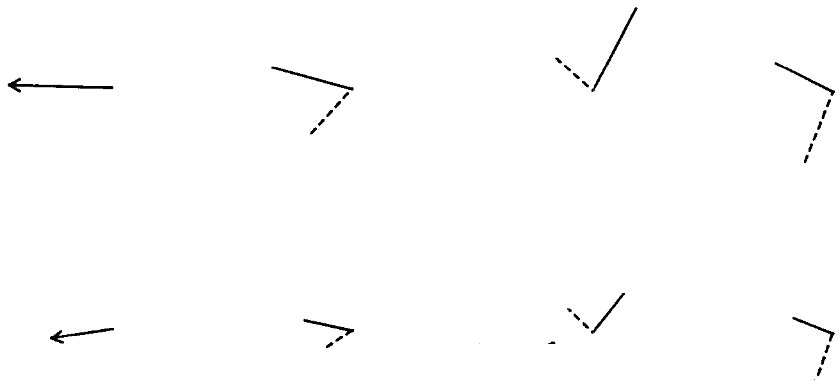
MODE 1	MODE 2
VARIANCE	VARIANCE
122.968	92.973

G1

N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.50	2 0.50-0.86	3 0.86-2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	36.793	TOTAL	112.387	TOTAL	20.763	TOTAL	70.052
MODE1	30.569	MODE1	62.187	MODE1	14.127	MODE1	64.737

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART
----------- IMAGINARY PART

MOORING G2

Set	5- X-82	Position:	62° 06.1'N 00° 03.9'E
Recovered	17- III-83	Water Depth:	550m

Depth (m)	Variables	Samp. Int. (hours)	Comments
151	Sp,D,T,P	1.0	
299	Sp,D,T	1.0	Gappy record - encoder fault
500	Sp,D,T	1.0	

Comments

Total covariance matrix not positive definite (2.1%).

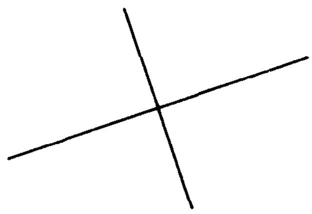
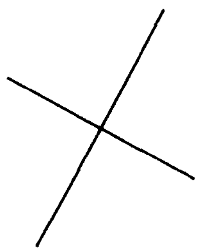
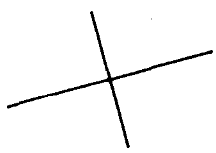
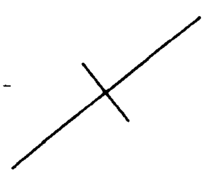
Low frequency band covariance matrix not positive definite (1.3%).

Bands 1, 2 and 3 cross-spectral matrices not positive definite (7.6%, 17%, 2.9%).

G2

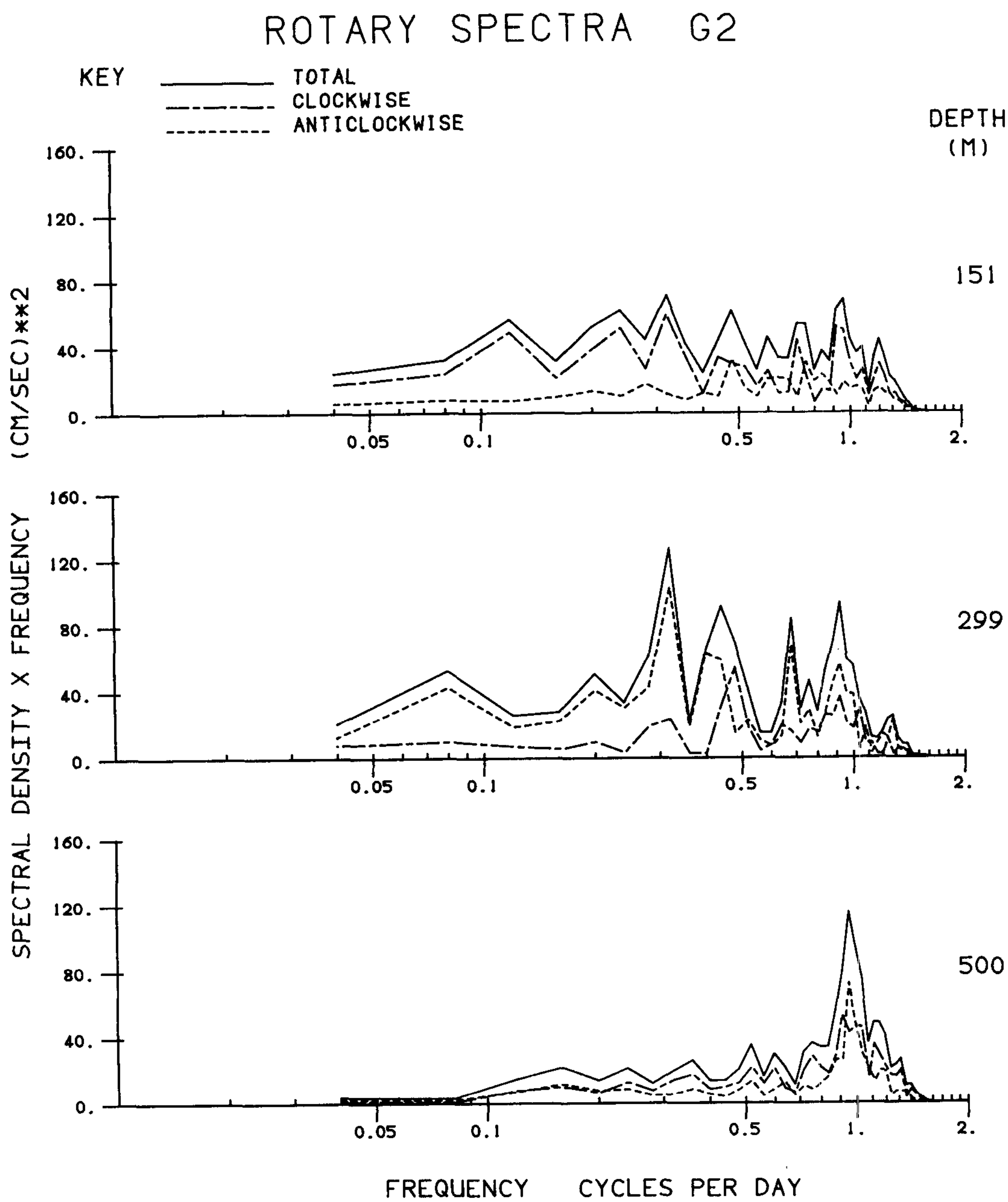
N ↑

TOTAL WATER DEPTH 550m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
151		48.18	60.44	
299		29.20	23.89	
500		84.77	4.87	
DEPTH AVERAGE				

SCALE ⊢—⊣ 4 CM/SEC

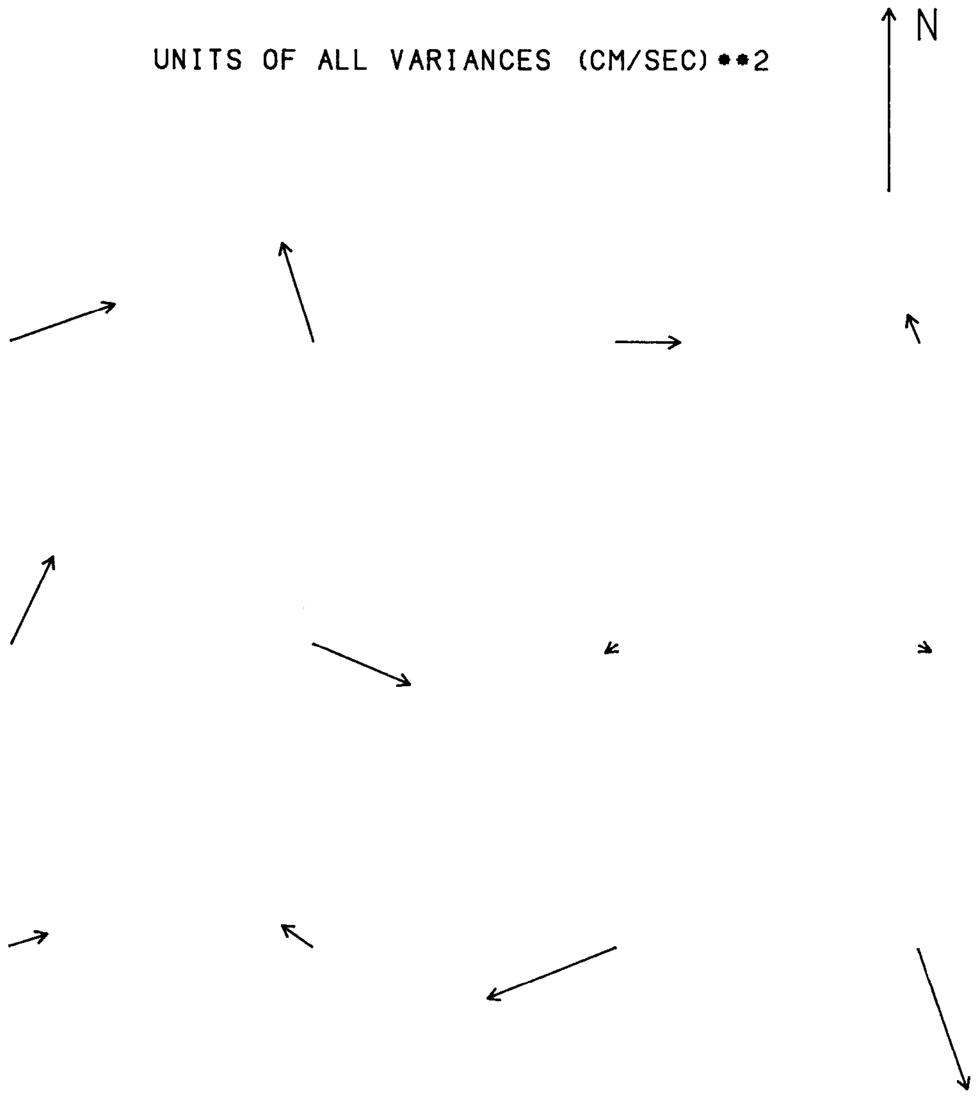
SCALE ⊢—⊣ 20 CM/SEC


ROTARY SPECTRA G2
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
151
299
500
160.
120.
80.
40.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

G2

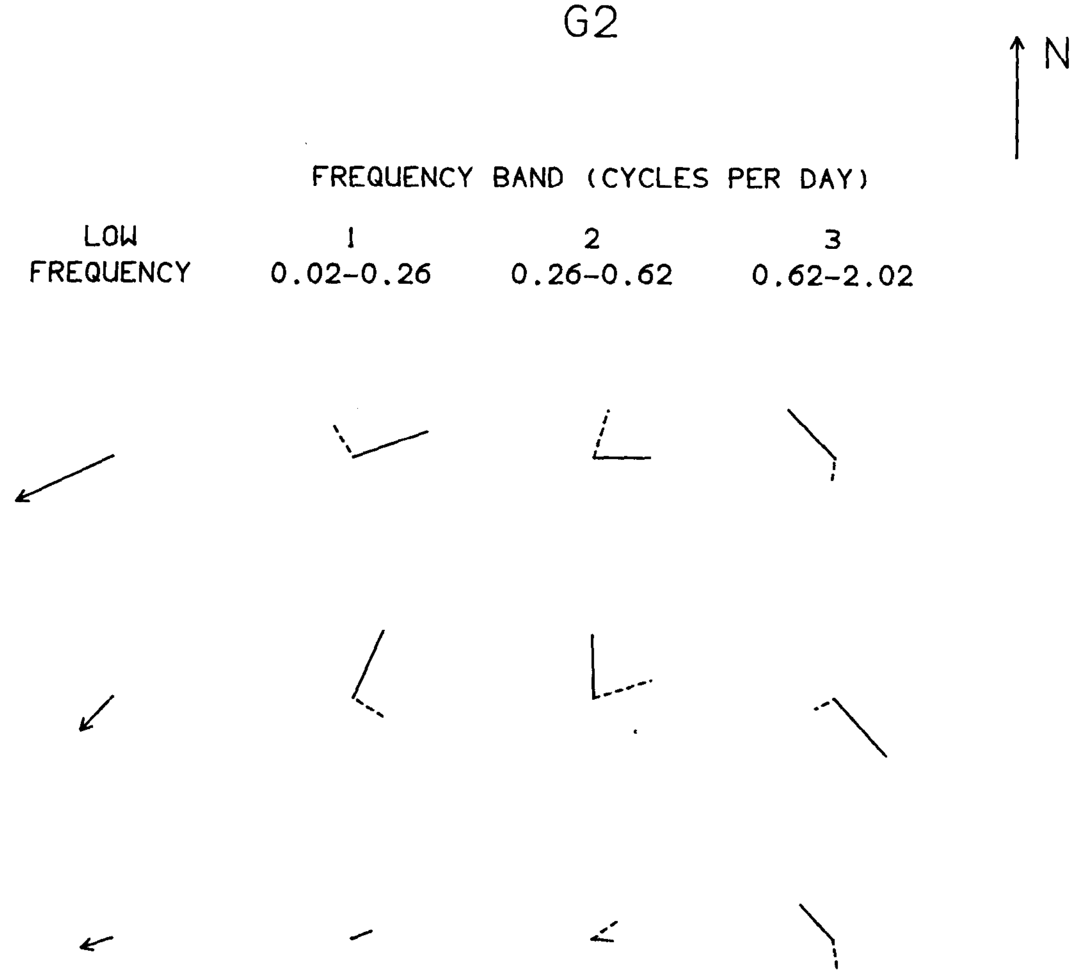
TOTAL VARIANCE 1129.132

UNITS OF ALL VARIANCES (CM/SEC)**2



MODE 1	MODE 2	MODE 3	MODE 4
VARIANCE	VARIANCE	VARIANCE	VARIANCE
619.039	343.671	132.379	57.263

G2

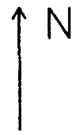


VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	220.664	TOTAL	434.677	TOTAL	251.965	TOTAL	228.652
MODE1	137.645	MODE1	362.651	MODE1	184.457	MODE1	119.312

UNITS OF ALL VARIANCES (CM/SEC)**2

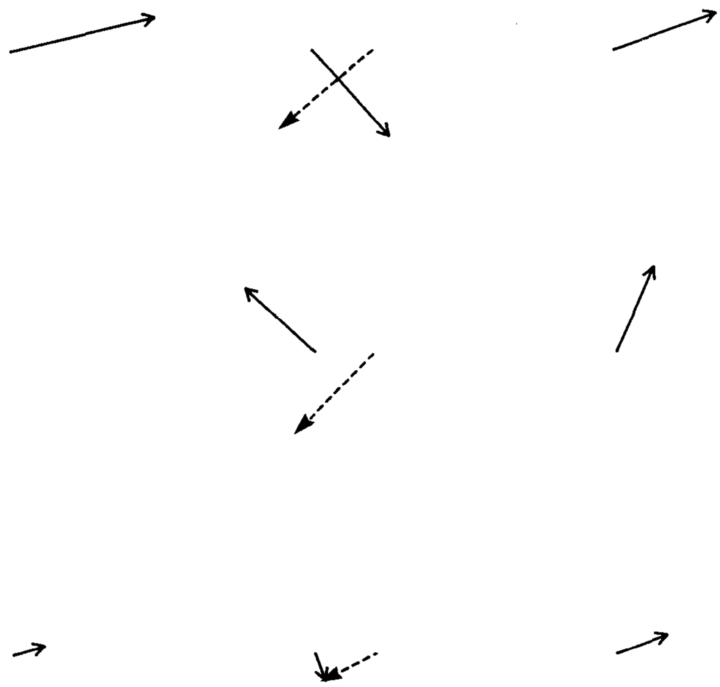
KEY ———— REAL PART
----------- IMAGINARY PART

G2



Event duration shown by day
number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 2	EVENT 3
348-353	393-410	410-440



VARIANCES		VARIANCES		VARIANCES	
TOTAL	1274.205	TOTAL	1306.523	TOTAL	1074.266
MODE1	837.066	MODE1	590.968	MODE1	655.499
		MODE2	505.742		

UNITS OF ALL VARIANCES (CM/SEC)**2

——— MODE 1
------ MODE 2

MOORING G4

Set	4- X-82	Position:	63° 08.8'N 00° 00.9'W
Recovered	18- III-83	Water Depth:	1611m

Depth (m)	Variables	Samp. Int. (hours)	Comments
195	Sp,D,T,P	1.0	
496	Sp,D,T	1.0	Rotor missing, short record
1104	Sp,D,T	1.0	
1554	Sp,D,T	1.0	

Comments

Total covariance matrix not positive definite (3.0%).

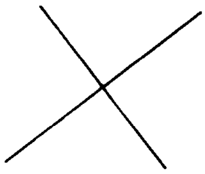
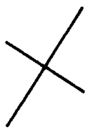
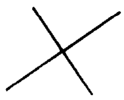
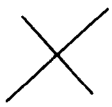
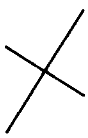
Low frequency band covariance matrix not positive definite (4.2%).

Bands 1 and 2 cross-spectral matrices not positive definite (12%, 4.1%).

G4

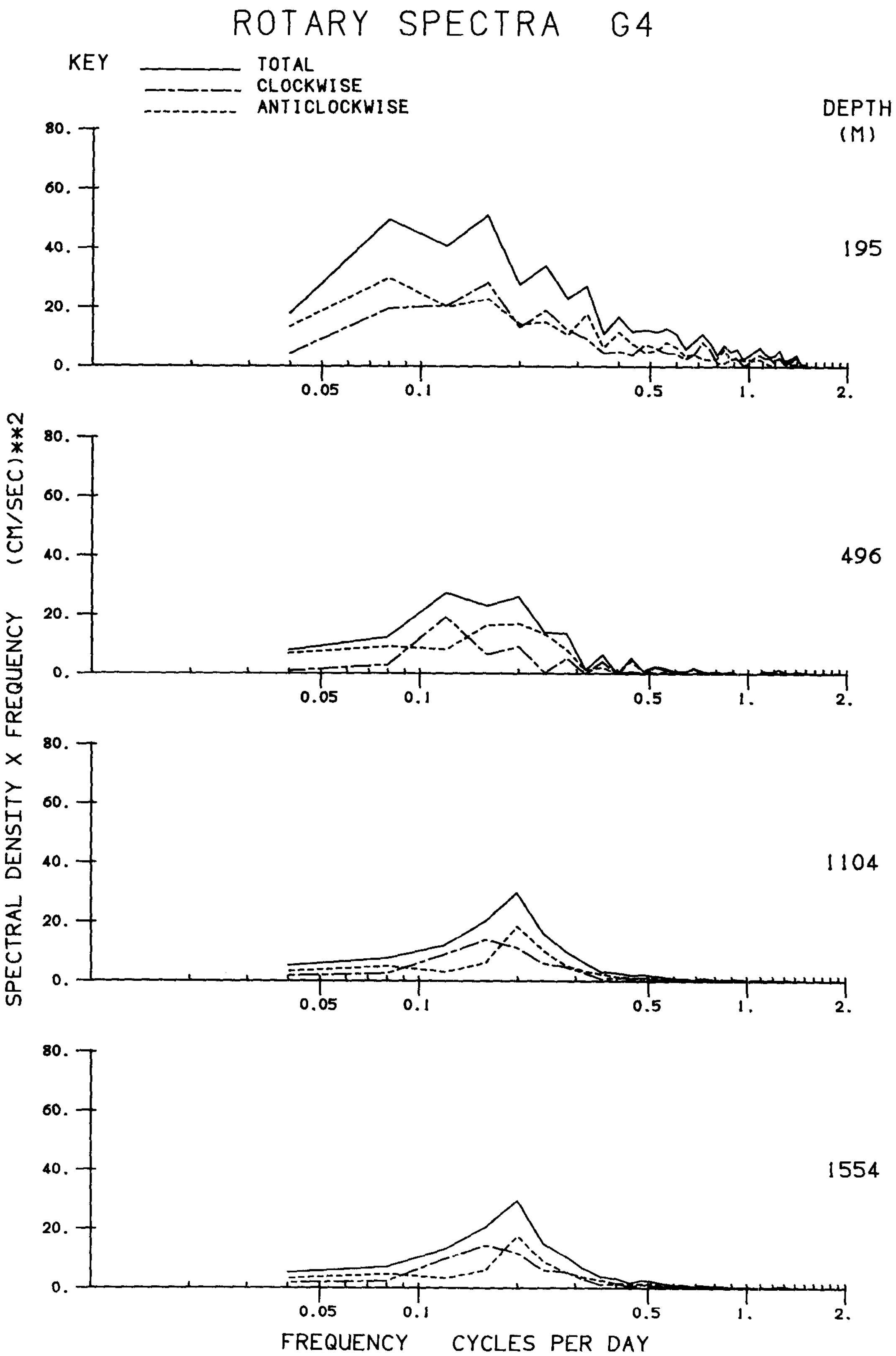
N 

TOTAL WATER DEPTH 1611m

DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
195		69.34	43.52	
496		39.51	23.25	
1104		63.80	23.39	
1554		56.09	25.17	
DEPTH AVERAGE				

SCALE ├──┤ 4 CM/SEC

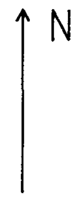
SCALE ├──┤ 10 CM/SEC

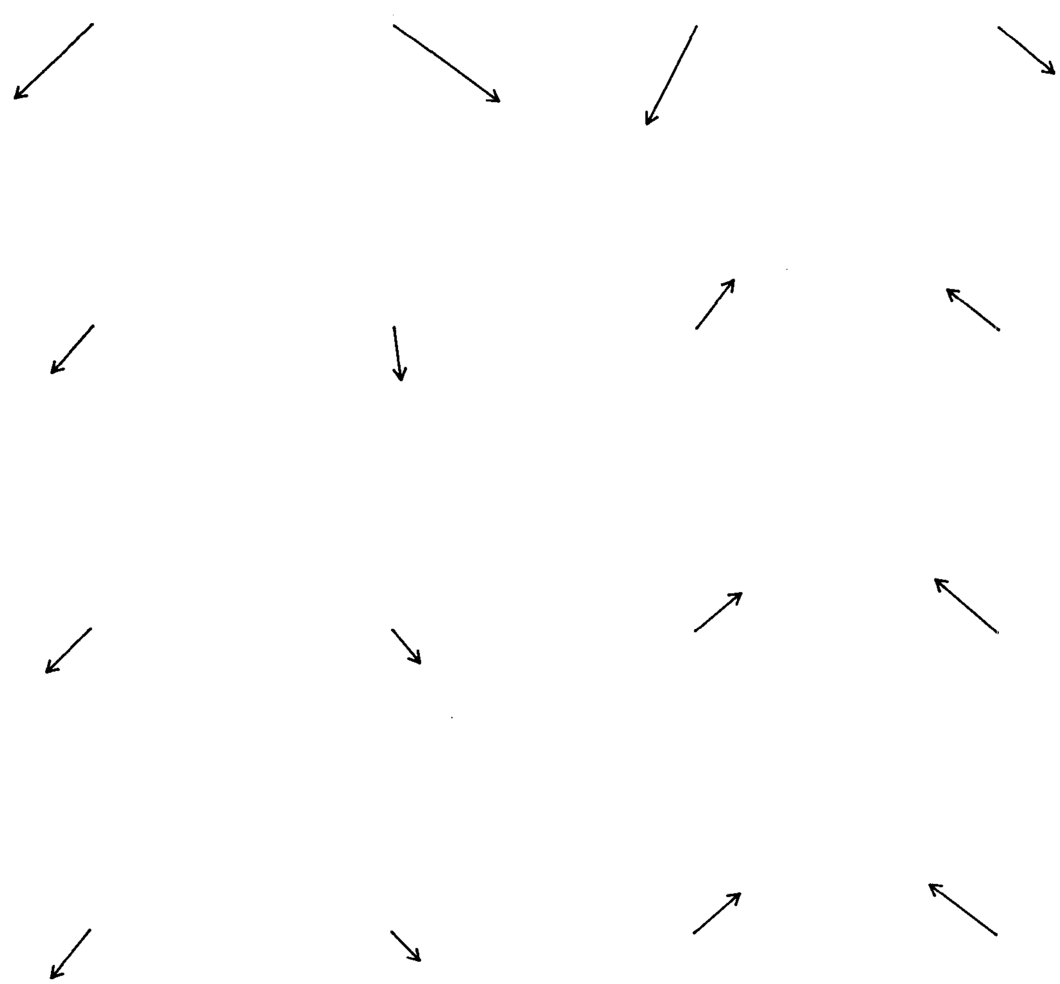

ROTARY SPECTRA G4
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (M)
195
496
1104
1554
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
80.
60.
40.
20.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

G4

TOTAL VARIANCE 658.508

UNITS OF ALL VARIANCES (CM/SEC)**2





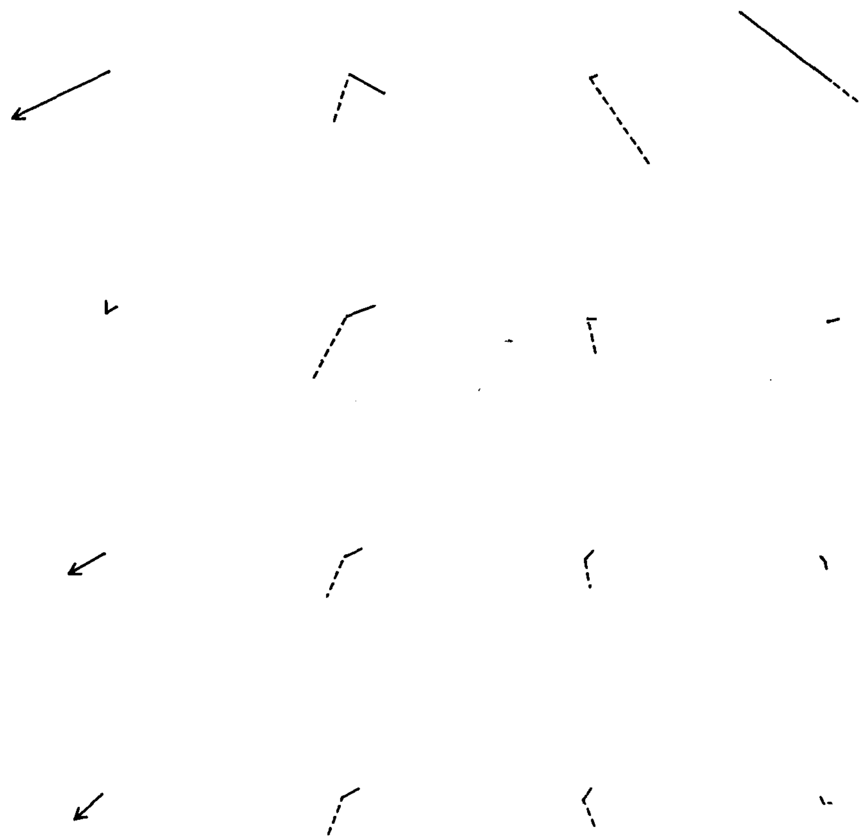
MODE 1	MODE 2	MODE 3	MODE 4
VARIANCE	VARIANCE	VARIANCE	VARIANCE
299.789	171.289	114.671	84.267

G4

↑ N

FREQUENCY BAND (CYCLES PER DAY)

LOW FREQUENCY	1 0.02-0.42	2 0.42-0.82	3 0.82-2.02



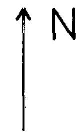
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	161.746	TOTAL	437.441	TOTAL	22.902	TOTAL	7.715
MODE1	91.934	MODE1	246.330	MODE1	9.698	MODE1	3.431

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

------------ IMAGINARY PART

G4



Event duration shown by day
number in 1982. 1 Jan 1982 = 1

EVENT 1
410-440

VARIANCES
TOTAL 743.801
MODE 1 513.482

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

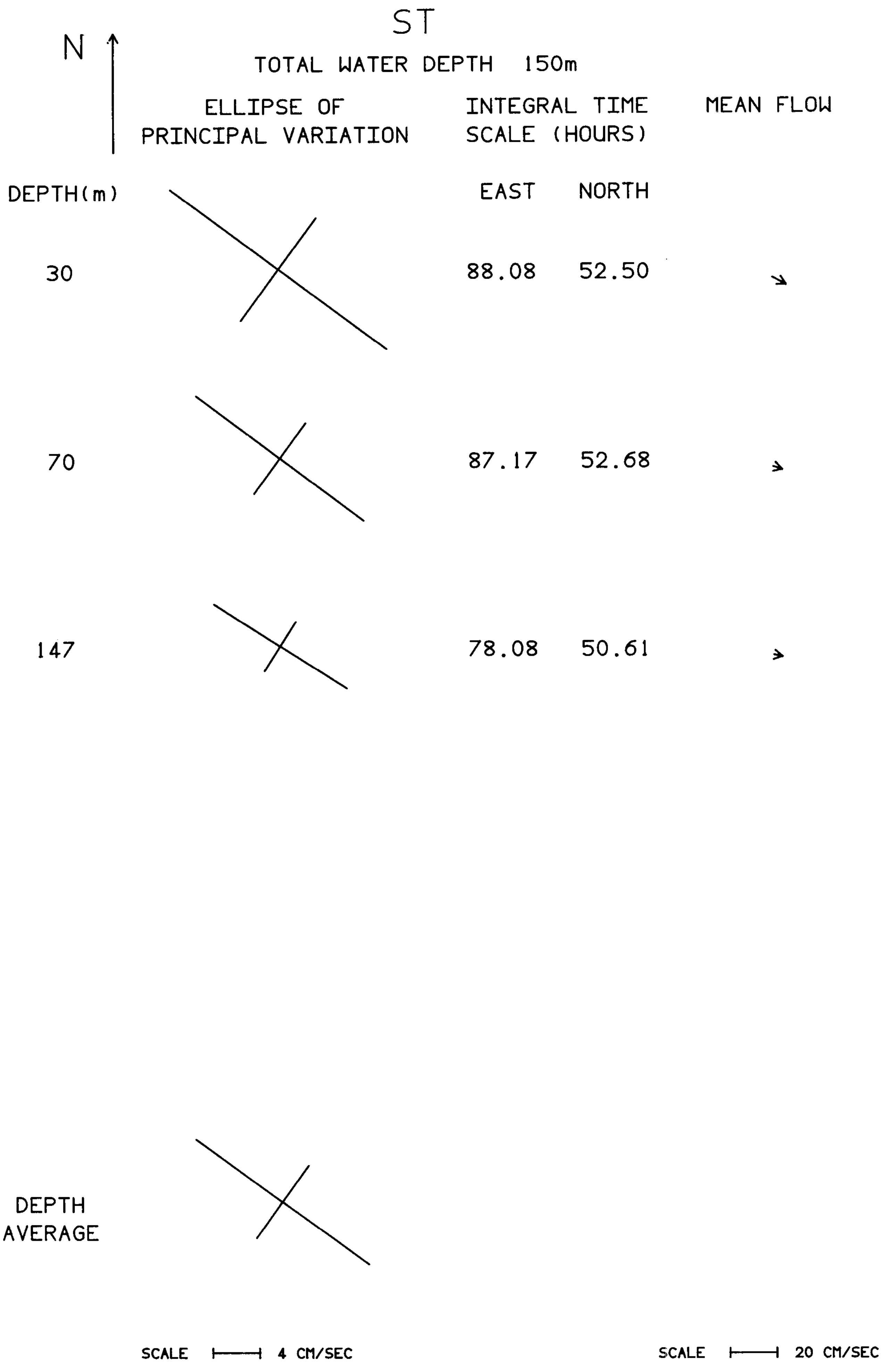
MOORING ST

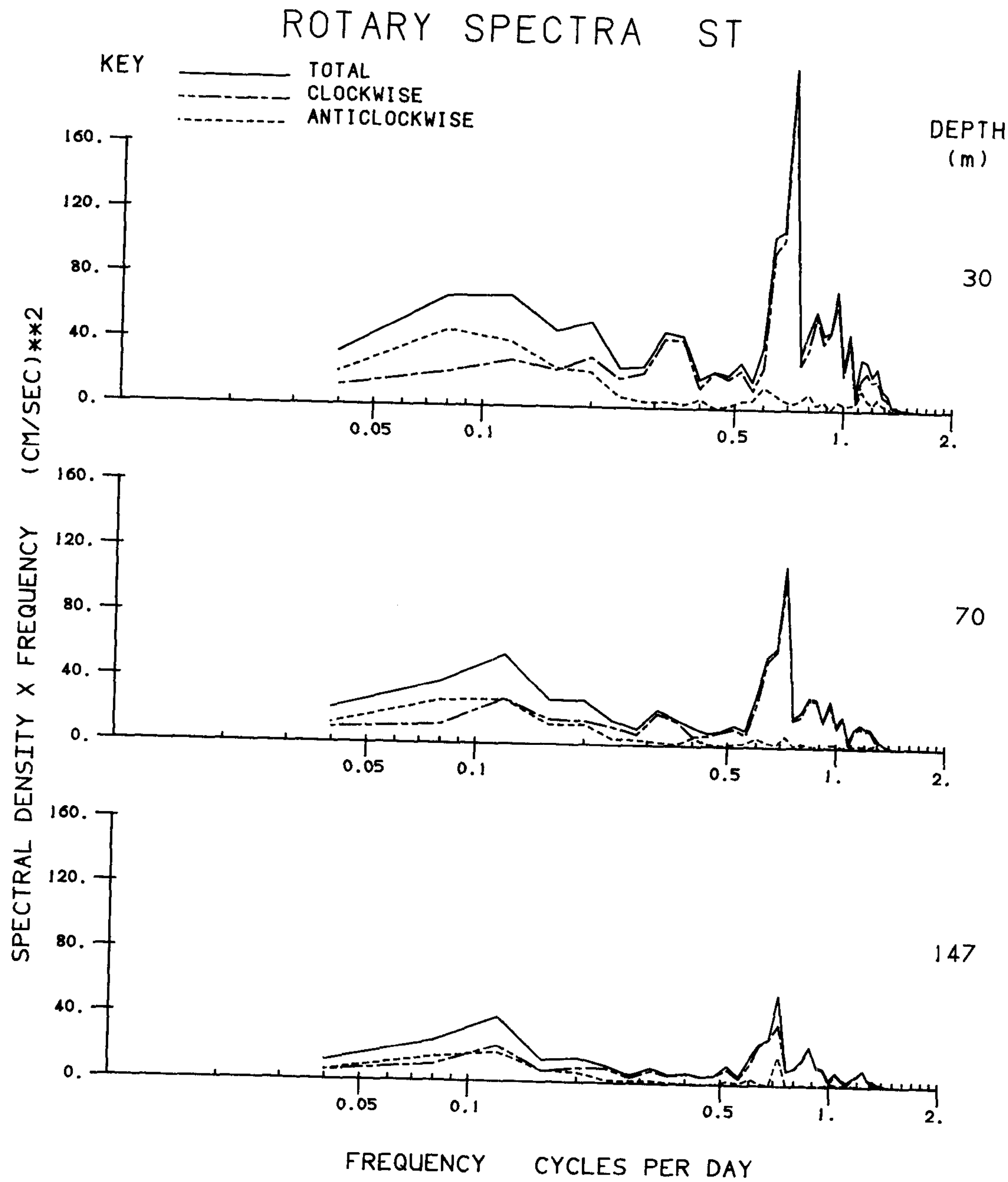
Set	1- XII-82	Position:	61° 19.54'N 01° 55.12'E
Recovered	9- III-83	Water Depth:	150m

Depth (m)	Variables	Samp. Int. (hours)	Comments
30	Sp,D	1	
70	Sp,D	1	
147	Sp,D	1	

Comments

There is a gap in the data for approximately 1 day on 28-I-83.

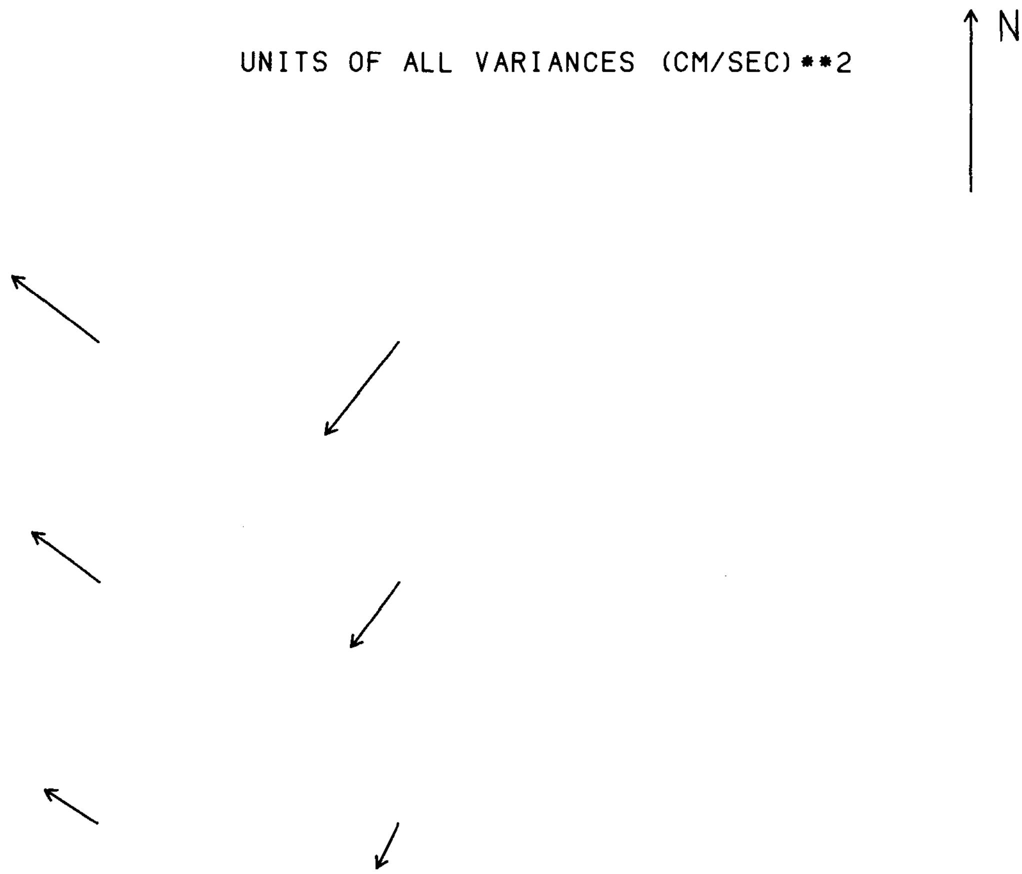

ST
N
TOTAL WATER DEPTH 150m
ELLIPSE OF PRINCIPAL VARIATION
INTEGRAL TIME SCALE (HOURS)
MEAN FLOW
DEPTH(m)
EAST
NORTH
30
88.08
52.50
70
87.17
52.68
147
78.08
50.61
DEPTH AVERAGE
SCALE 4 CM/SEC
SCALE 20 CM/SEC


ROTARY SPECTRA ST
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (m)
30
70
147
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
160.
120.
80.
40.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

ST

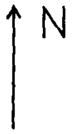
TOTAL VARIANCE 1213.481

UNITS OF ALL VARIANCES (CM/SEC)**2



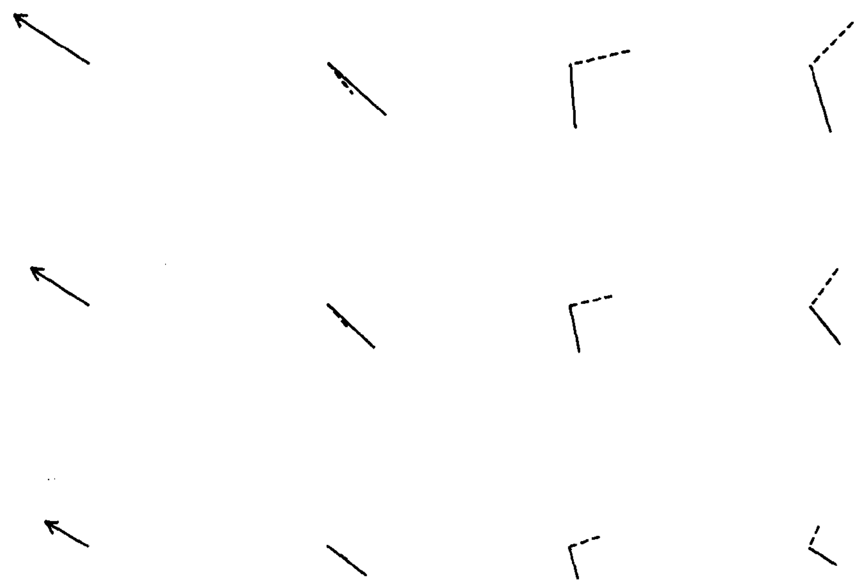
MODE 1	MODE 2
VARIANCE	VARIANCE
1004.351	187.953

ST



FREQUENCY BAND (cycles per day)

LOW FREQUENCY	1 0.02–0.42	2 0.42–1.10	3 1.10–2.02



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	441.485	TOTAL	600.280	TOTAL	213.517	TOTAL	18.520
MODE1	438.200	MODE1	522.208	MODE1	193.569	MODE1	14.701

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

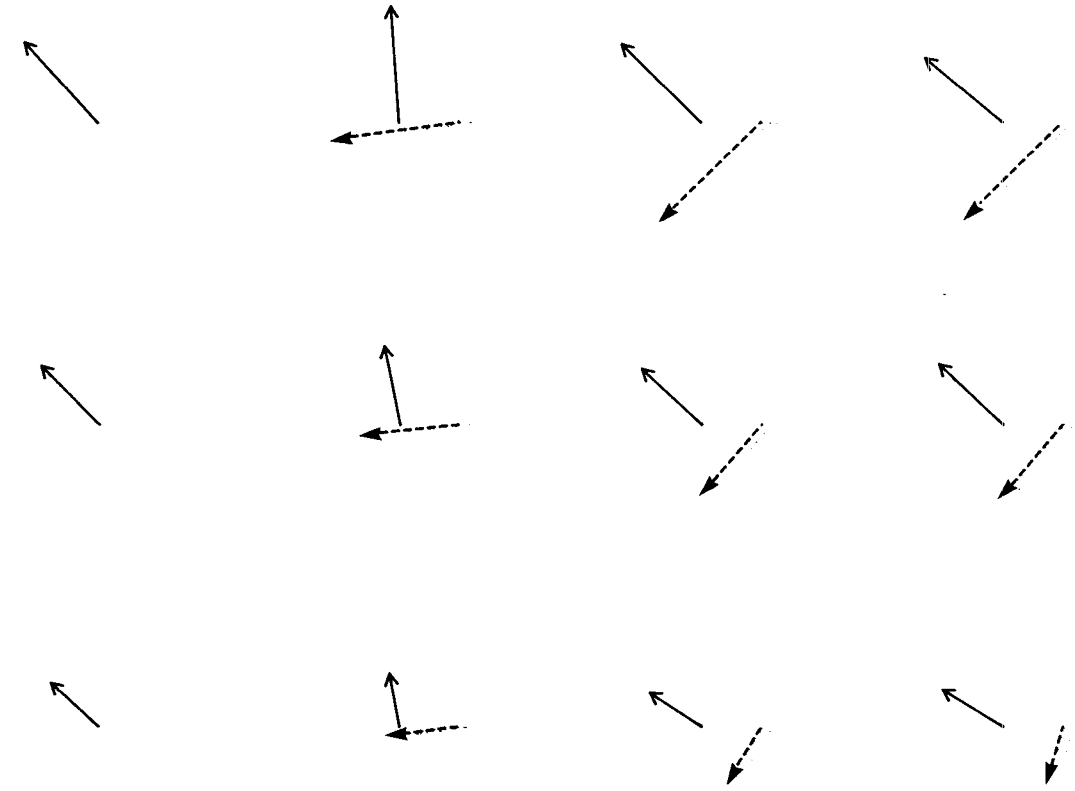
----------- IMAGINARY PART

ST

↑ N

Event duration shown by day number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 1	EVENT 2	EVENT 3
348-362	348-362	379-390	400-415
LOW FREQUENCY	HIGH FREQUENCY		



VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	987.227	TOTAL	442.223	TOTAL	773.119	TOTAL	1194.158
MODE1	931.822	MODE1	253.053	MODE1	556.755	MODE1	930.074
		MODE2	177.891	MODE2	196.443	MODE2	236.762

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

MOORING OS

Set	07- X-82	Position:	60° 33.9'N 02° 47.7'E
Recovered	07- X-83	Water Depth:	102m

Depth (m)	Variables	Samp. Int. (hours)	Comments
2	Sp,D	1	Nil Records 07-X-82 to 07-XII-82, 15-I-83 to 21-II-83, 01-IV-83 to 27-IV-83.
12	Sp,D	1	Nil Records 15-I-83 to 21-II-82, 15-V-83 to 07-X-83 (not replaced).
25	Sp,D	1	Nil Records 15-VI-83 to 12-VIII-83, 12-IX-83 to 07-X-83.
50	Sp,D	0.166	Nil Records 9-VI-83 to 6-VII-83.
99	Sp,D	0.166	

Comments

There were several gaps in the records at various depths, see comments above. The mooring was recovered 12-II-83 and re-set 21-II-83, leaving a gap in the records at all depths.

Total covariance matrix not positive definite (0.3%)

Low frequency band covariance matrix not positive definite (1.5%)

Bands 1, 2 and 3 cross-spectral matrices not positive definite (4.9%, 8.4%, 2.8%)

Event 2 covariance matrix not positive definite.

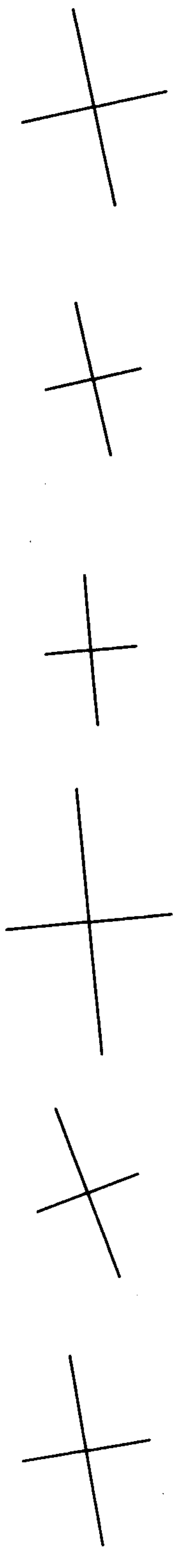
(For band 2 and event 2 the exaggerated mode 1 and mode 2 variances then exceed the total, as flagged by a star on the plots).

OS

N ↑

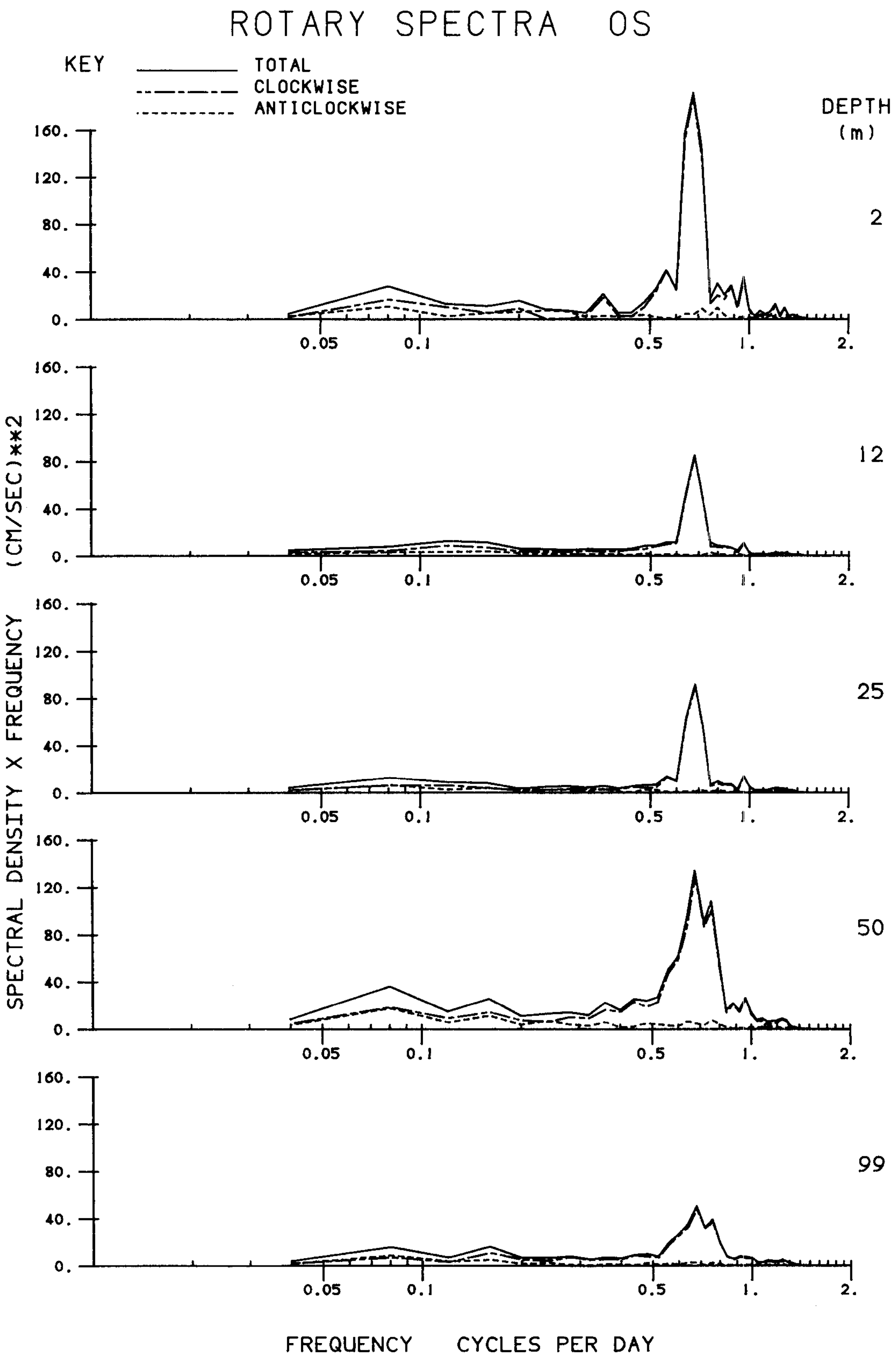
TOTAL WATER DEPTH 102m

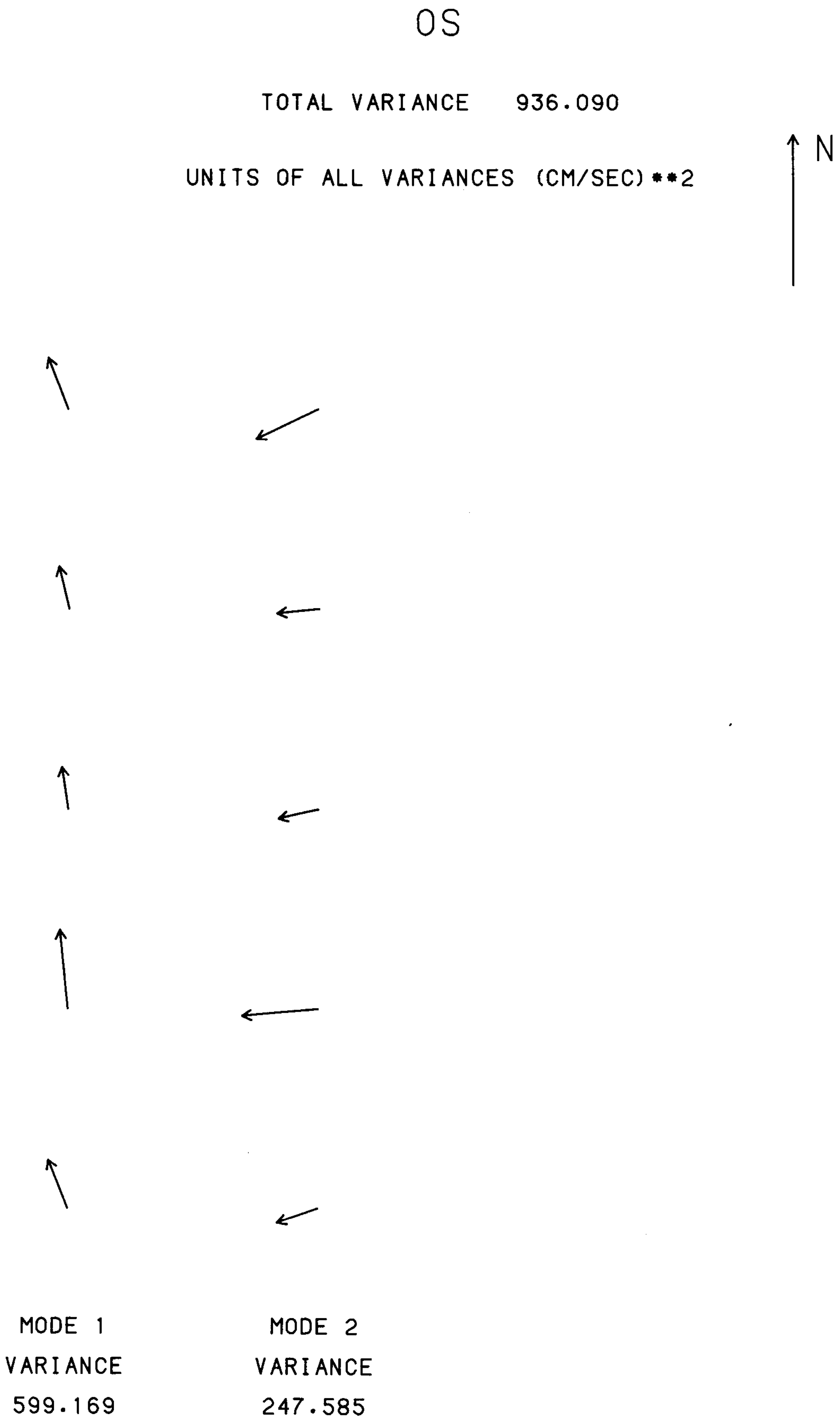
DEPTH(m)	ELLIPSE OF PRINCIPAL VARIATION	INTEGRAL TIME SCALE (HOURS) EAST	NORTH	MEAN FLOW
2		8.17	26.05	
12		7.92	42.56	
25		6.74	30.41	
50		6.55	43.36	
99		8.17	43.36	
DEPTH AVERAGE				



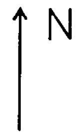
SCALE ⊢⊣ 4 CM/SEC

SCALE ⊢⊣ 20 CM/SEC


ROTARY SPECTRA OS
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
DEPTH (m)
2
12
25
50
99
160.
120.
80.
40.
0.
0.05
0.1
0.5
1.
2.
SPECTRAL DENSITY X FREQUENCY (CM/SEC)**2
FREQUENCY CYCLES PER DAY

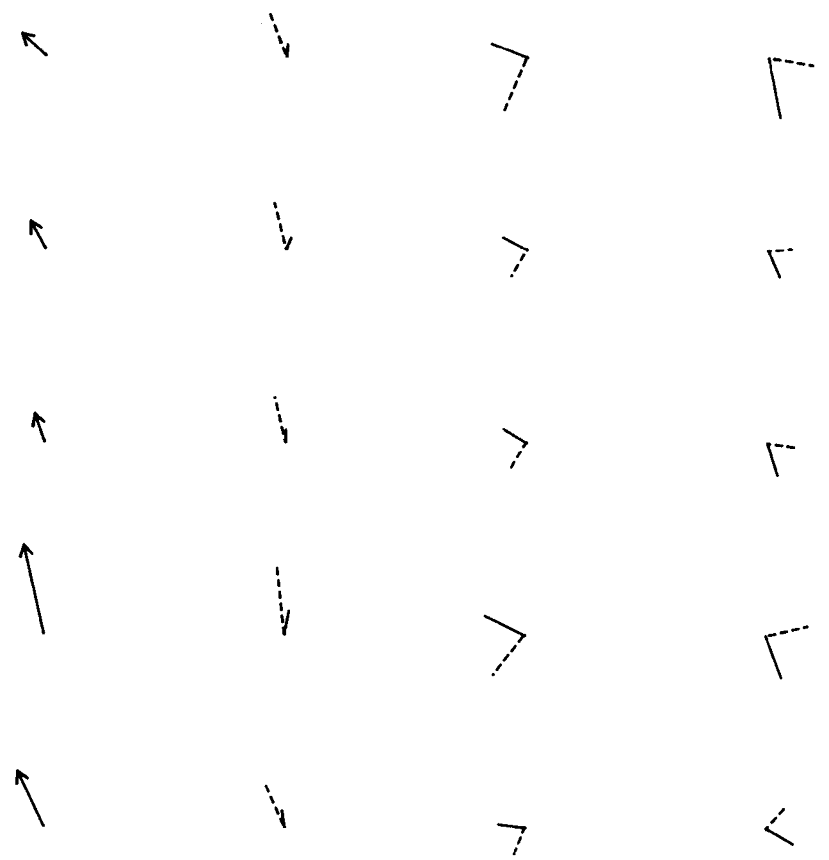

OS
TOTAL VARIANCE 936.090
UNITS OF ALL VARIANCES (CM/SEC)**2
N
MODE 1
VARIANCE
599.169
MODE 2
VARIANCE
247.585

OS



FREQUENCY BAND (cycles per day)

LOW FREQUENCY	1 0.02-0.34	2 0.34-1.06	3 1.06-2.02



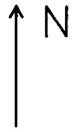
VARIANCES		VARIANCES		VARIANCES		VARIANCES	
TOTAL	189.765	TOTAL	324.606	TOTAL	353.998★	TOTAL	14.069
MODE1	155.323	MODE1	259.723	MODE1	357.908	MODE1	9.203

UNITS OF ALL VARIANCES (CM/SEC)**2

KEY ———— REAL PART

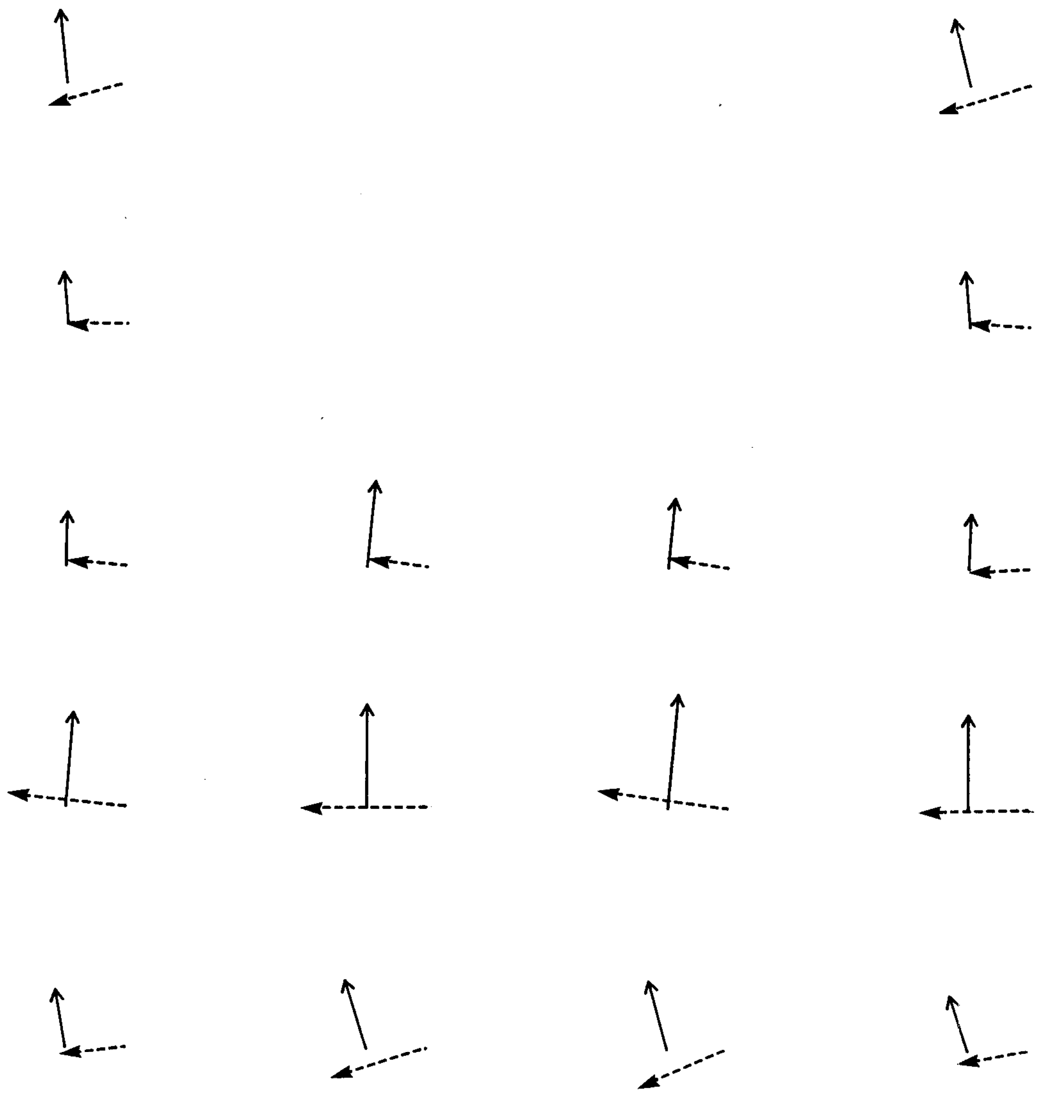
------------ IMAGINARY PART

OS



Event duration shown by day number in 1982. 1 Jan 1982 = 1

EVENT 1	EVENT 2	EVENT 3	EVENT 4
348-362	379-390	390-402	422-448



	VARIANCES		VARIANCES		VARIANCES		VARIANCES
TOTAL	1566.793	TOTAL	714.049★	TOTAL	764.216	TOTAL	651.512
MODE1	897.505	MODE1	520.317	MODE1	469.122	MODE1	363.195
MODE2	575.659	MODE2	210.966	MODE2	230.936	MODE2	212.919

UNITS OF ALL VARIANCES (CM/SEC)**2

—— MODE 1
------ MODE 2

APPENDIX 2. OTHER SPECTRA

The following plots show autospectra for other data from the CONSLEX period. They were calculated in the same way as described in Appendix 1, from 3-hrly time series obtained as in section 2 of the main text. The order is

sea level

bottom pressure

bottom temperature

thermistor chain temperatures B2, G1

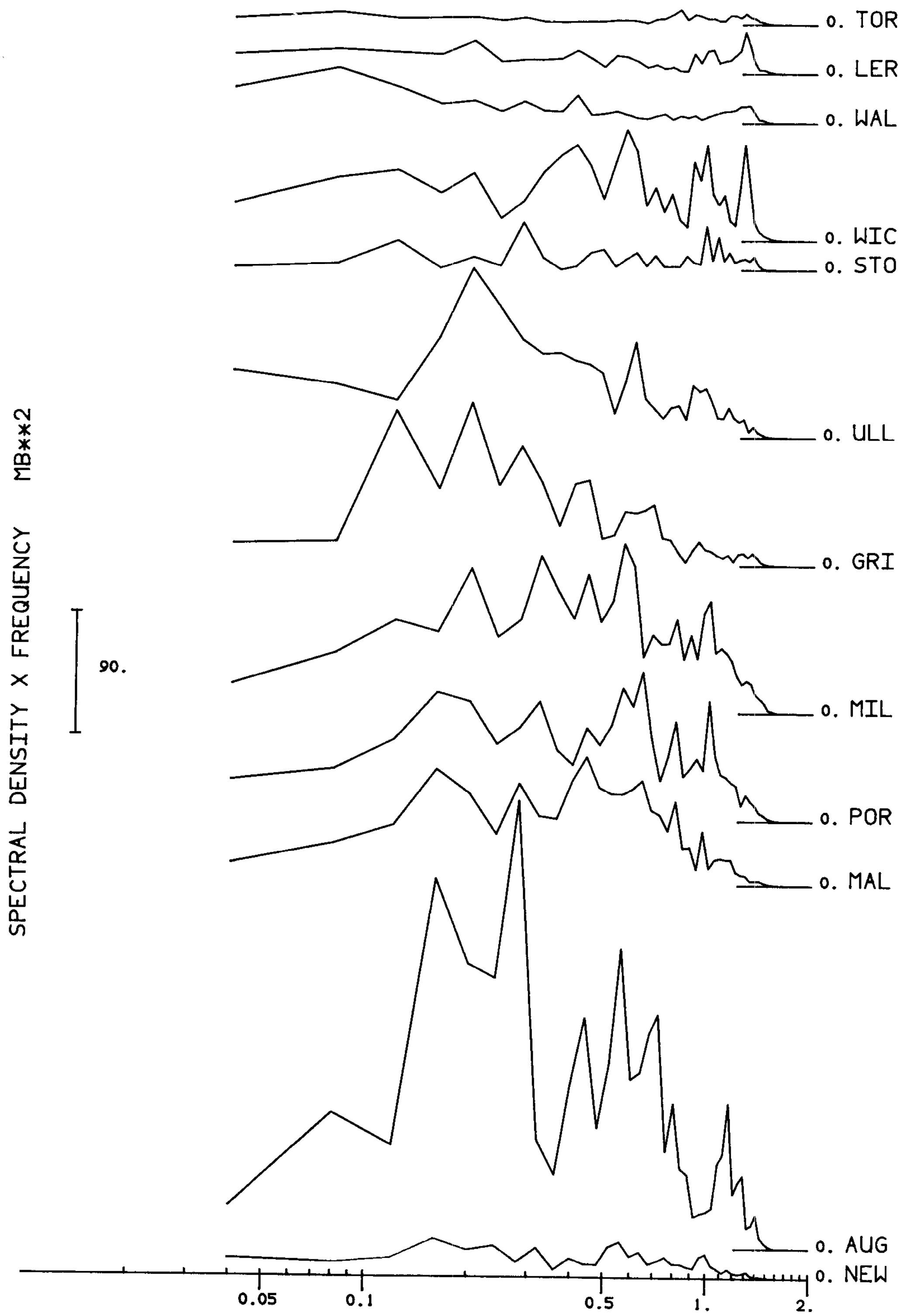
current meter temperatures, sections 'L', A, B, C, D, E, F, G

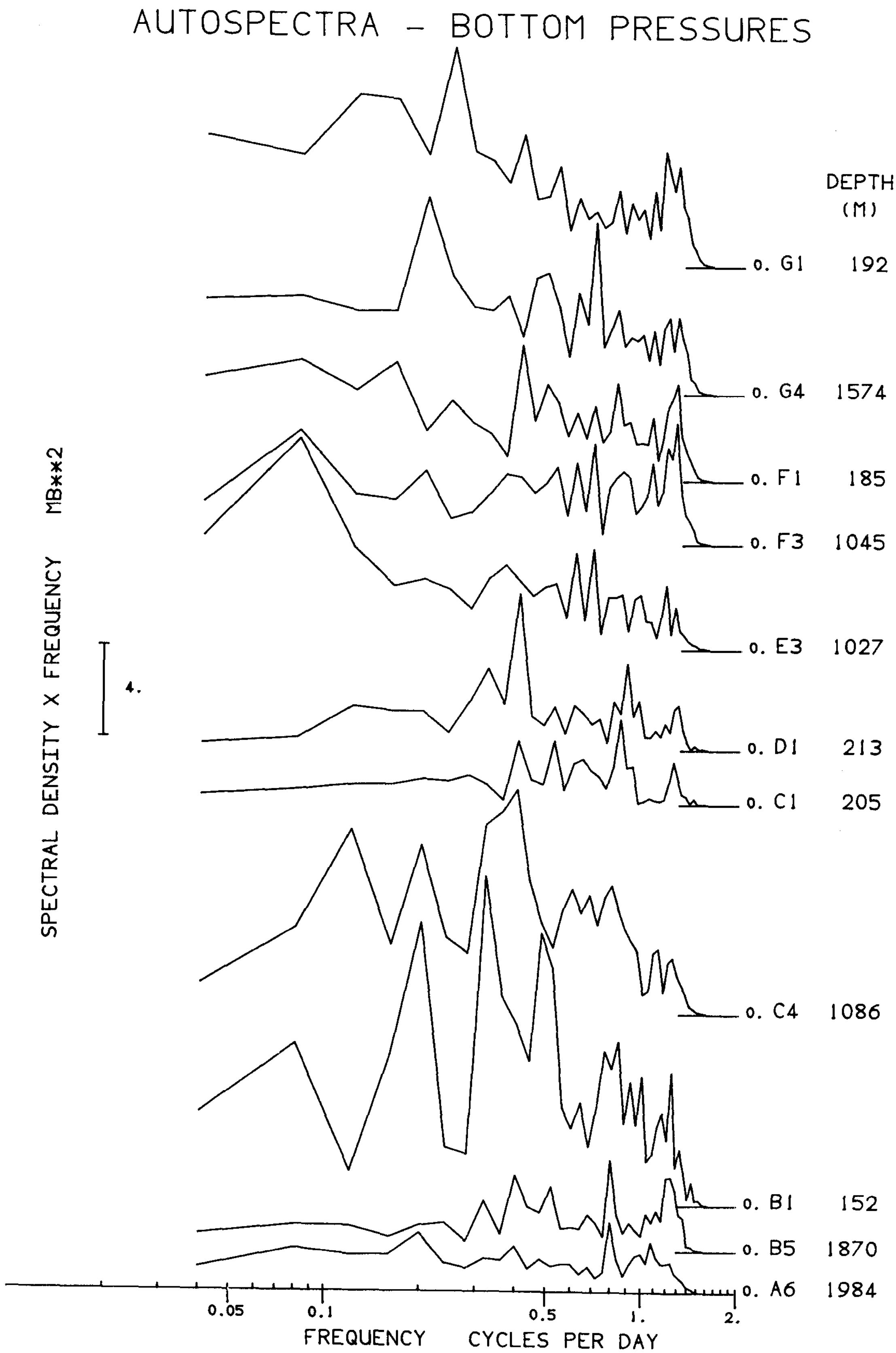
atmospheric pressure

winds

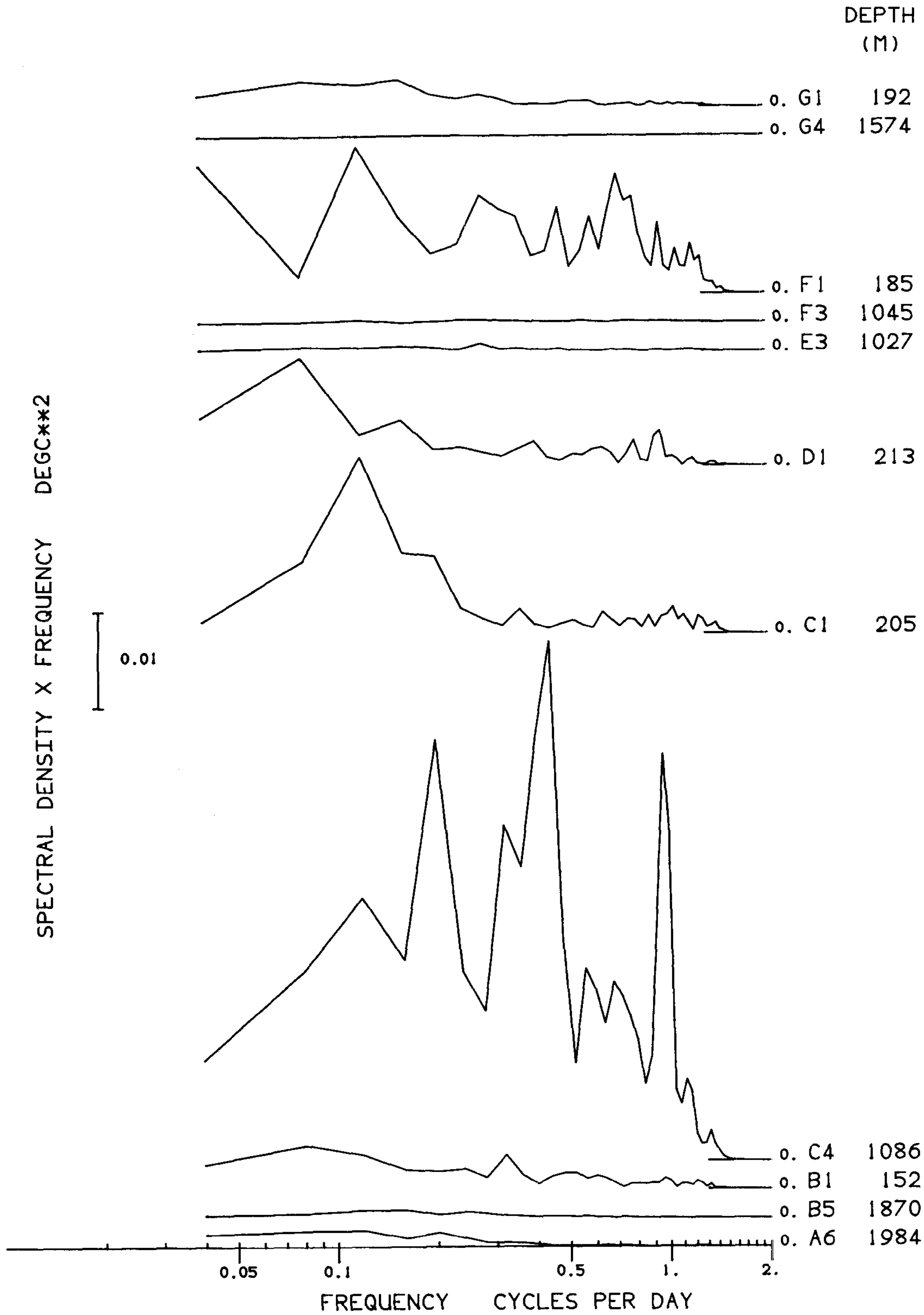
wind stress

AUTOSPECTRA - SEA LEVEL

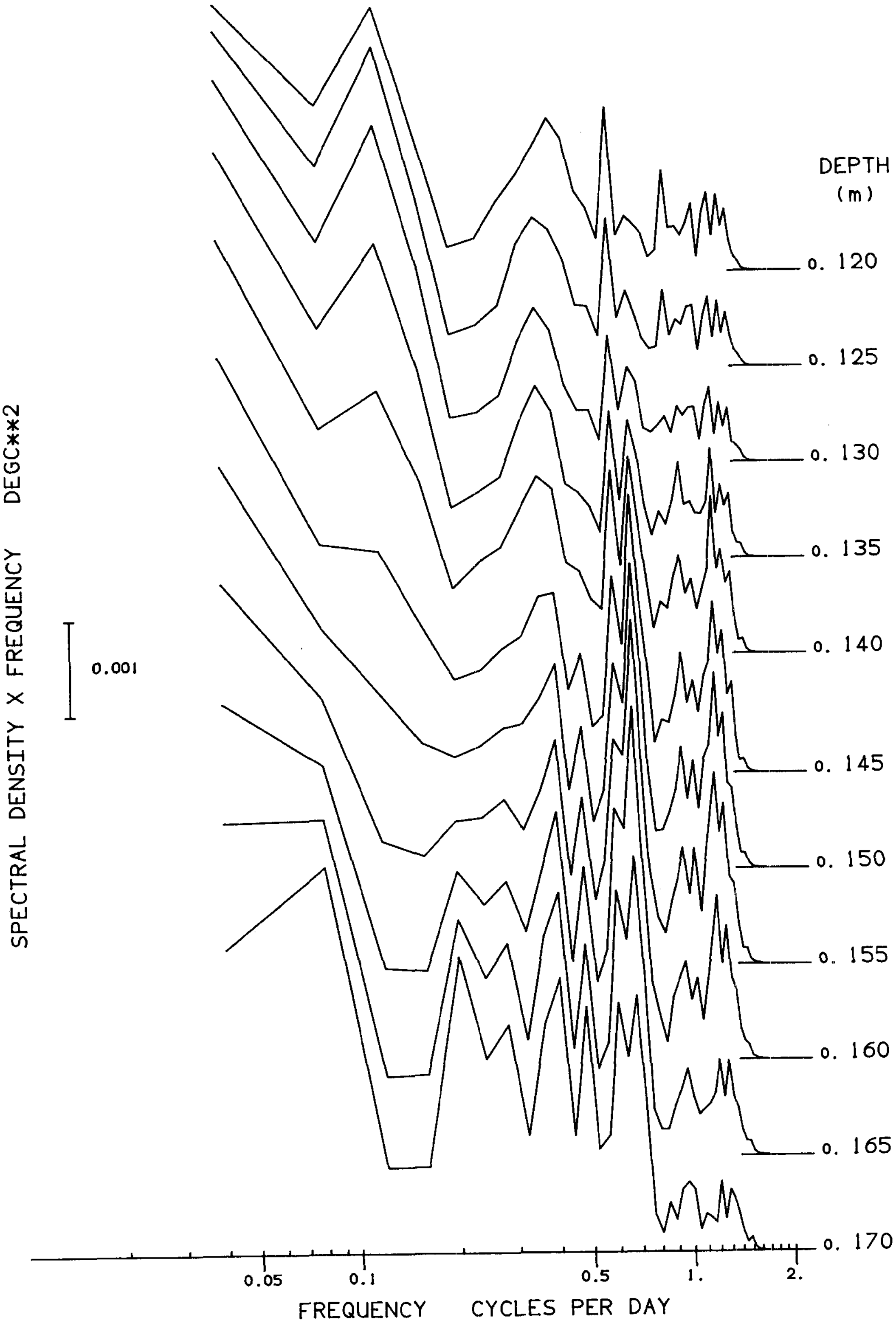



AUTOSPECTRA - BOTTOM PRESSURES
DEPTH (M)
o. G1 192
o. G4 1574
o. F1 185
o. F3 1045
o. E3 1027
o. D1 213
o. C1 205
o. C4 1086
o. B1 152
o. B5 1870
o. A6 1984
SPECTRAL DENSITY X FREQUENCY MB**2
4.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

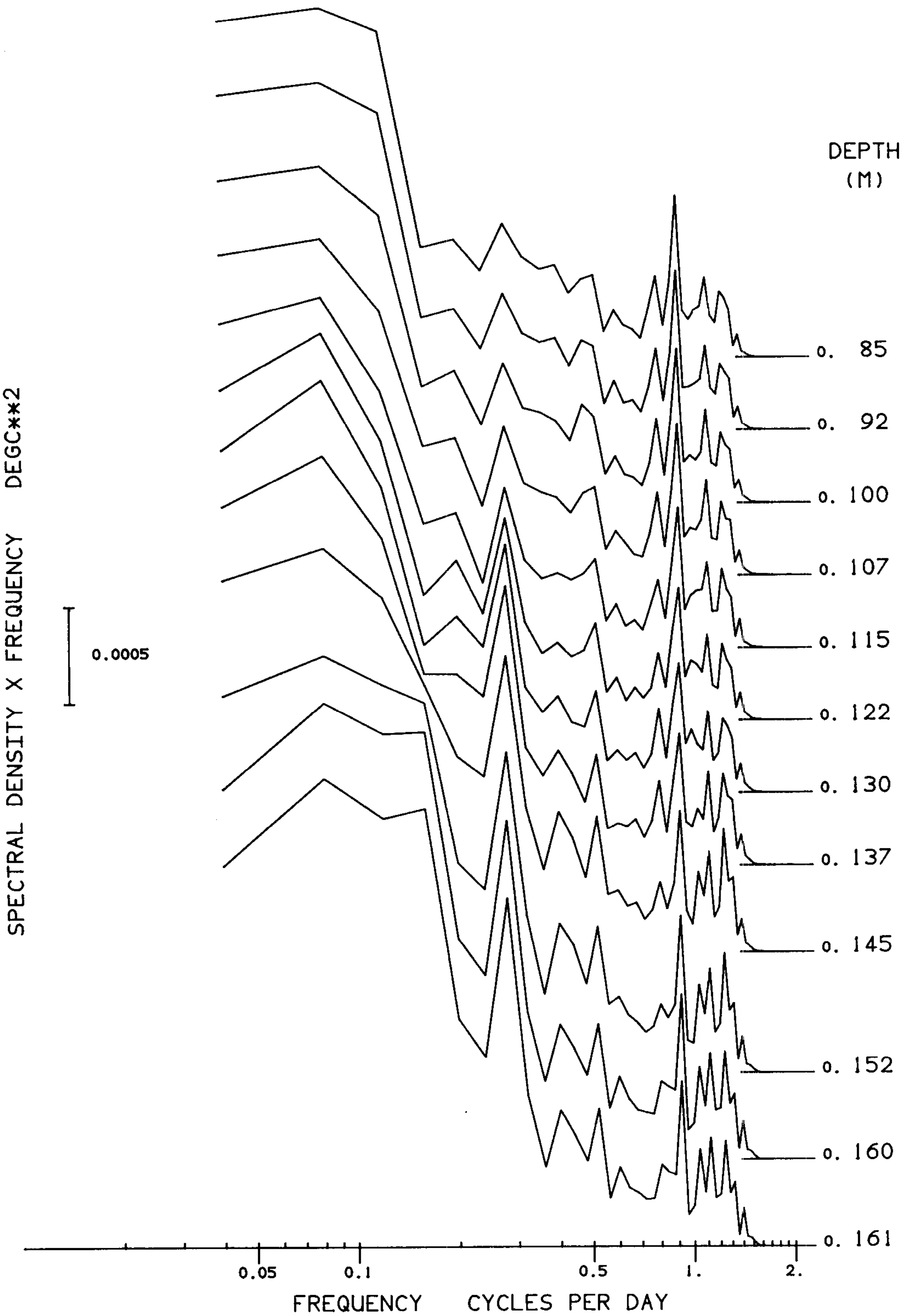
AUTOSPECTRA - BOTTOM TEMPERATURES

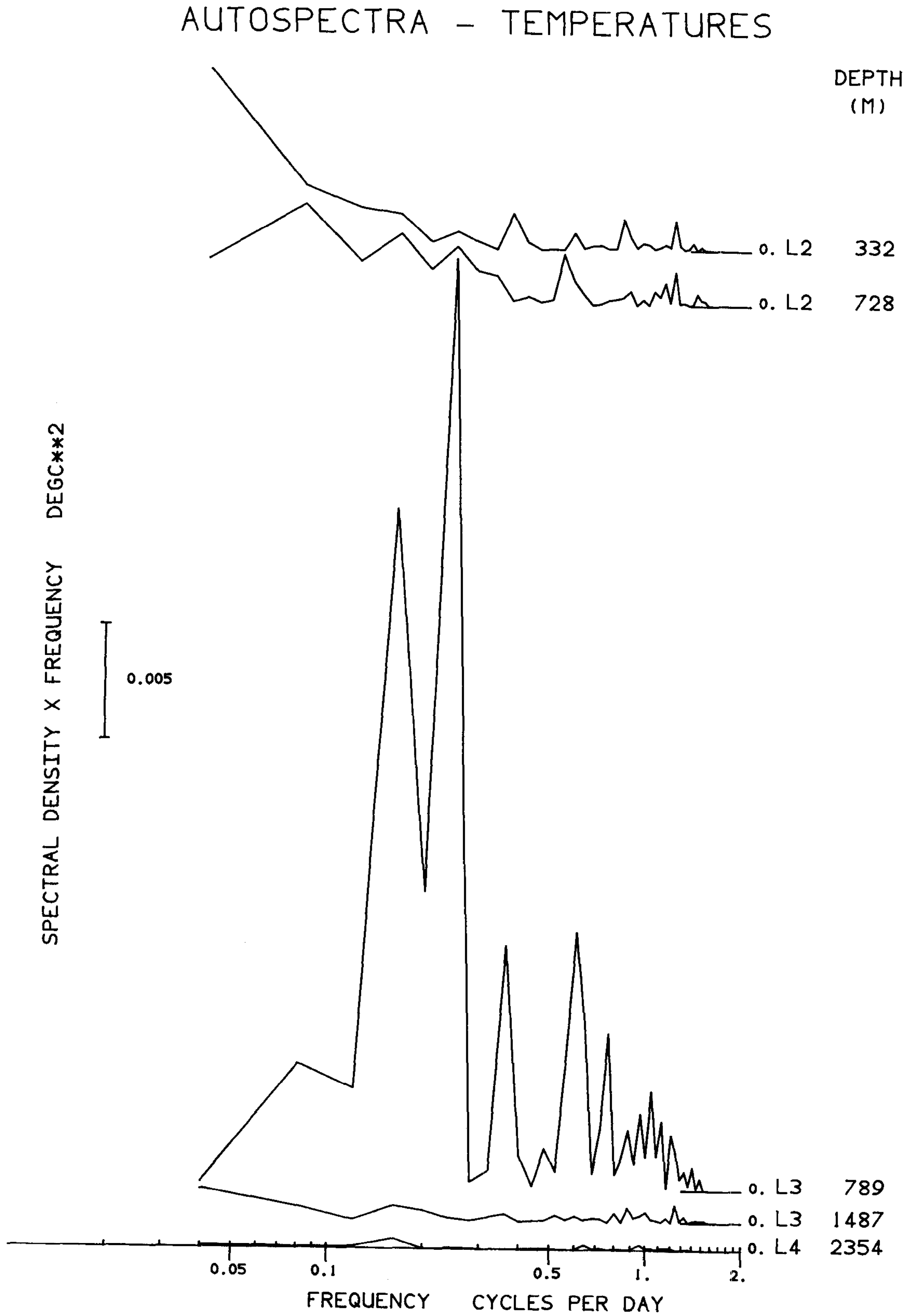


AUTOSPECTRA - THERMISTOR CHAIN B2

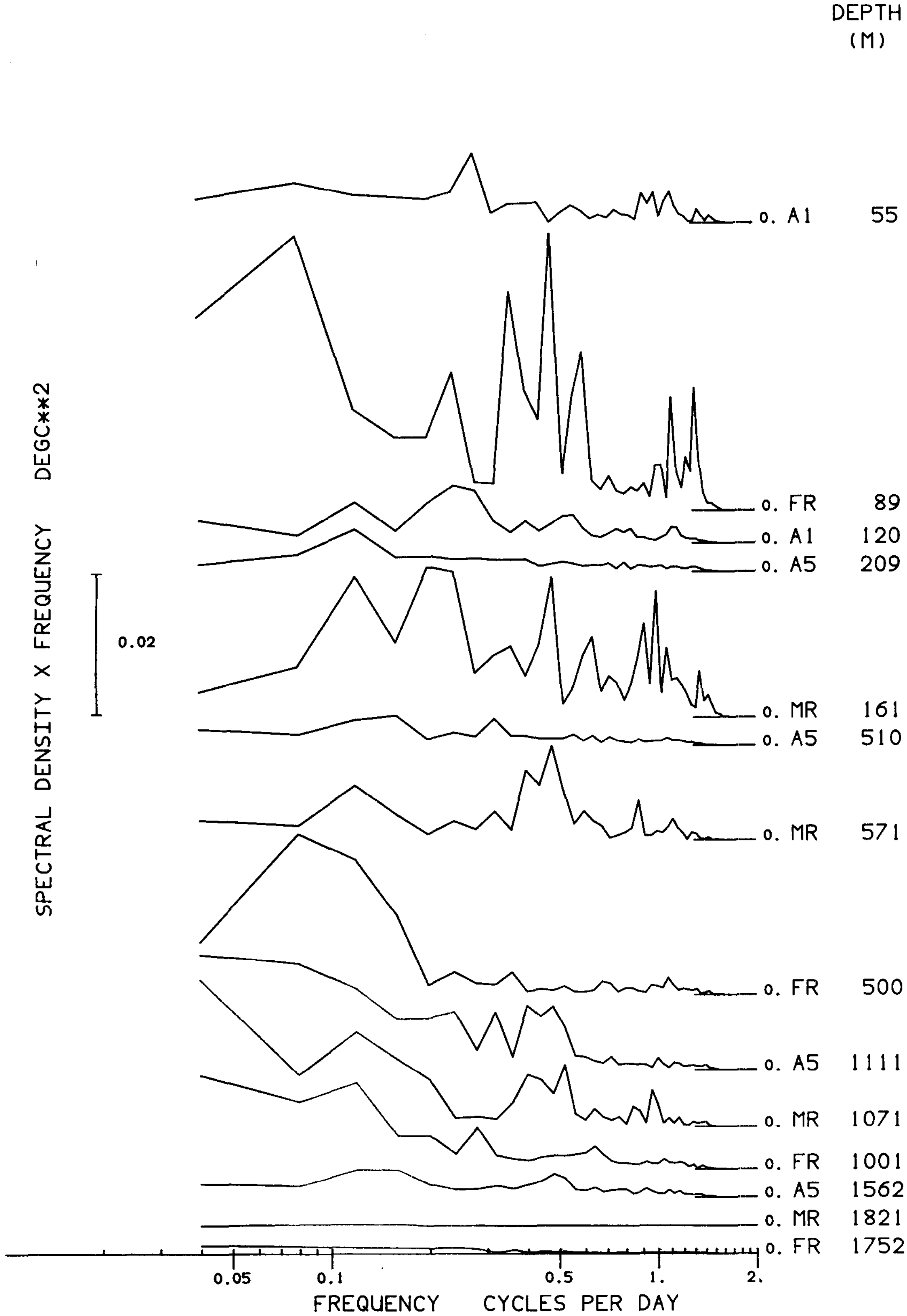


AUTOSPECTRA - THERMISTOR CHAIN G1

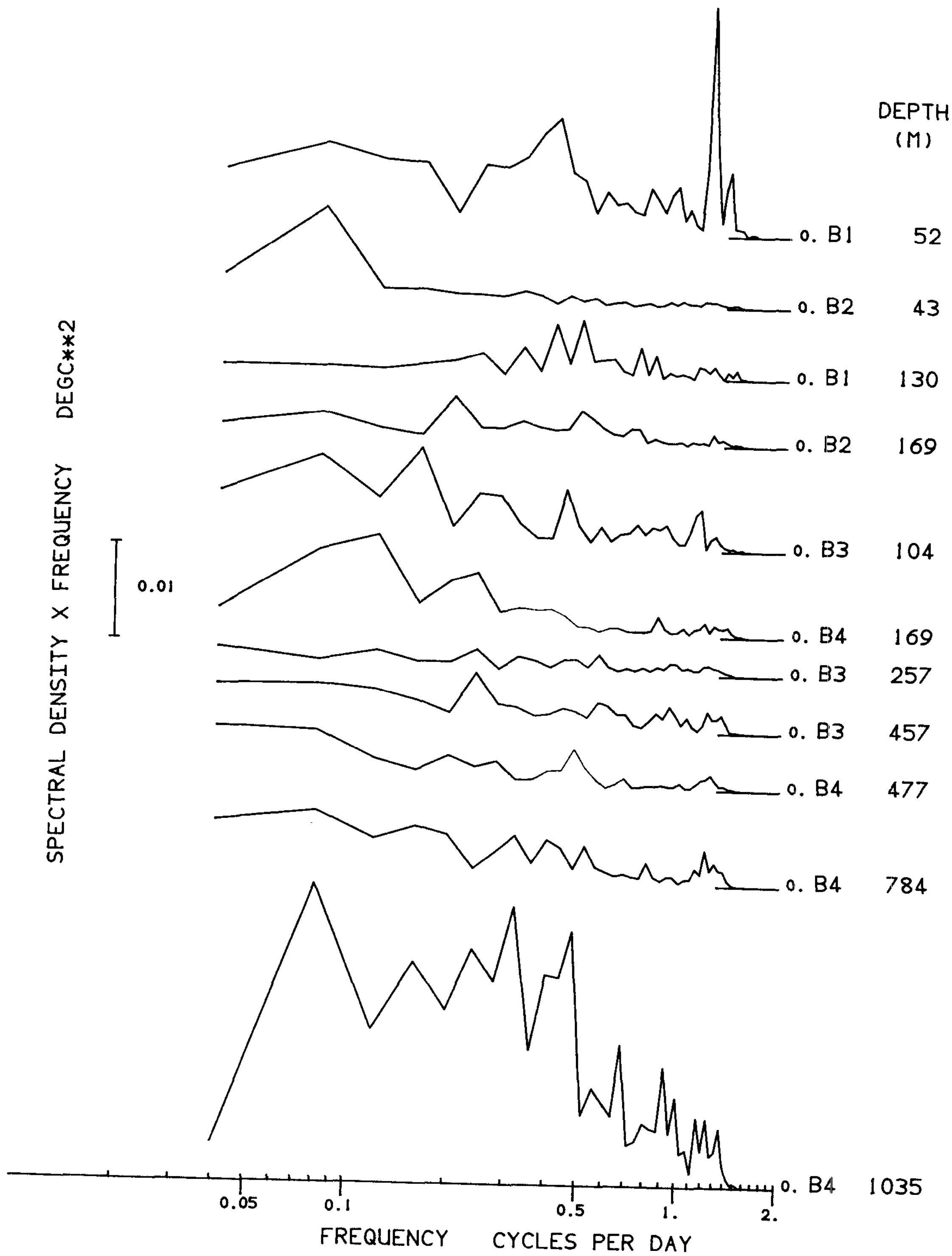



AUTOSPECTRA - TEMPERATURES
DEPTH (M)
0. L2 332
0. L2 728
0. L3 789
0. L3 1487
0. L4 2354
SPECTRAL DENSITY X FREQUENCY DEGC**2
0.005
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

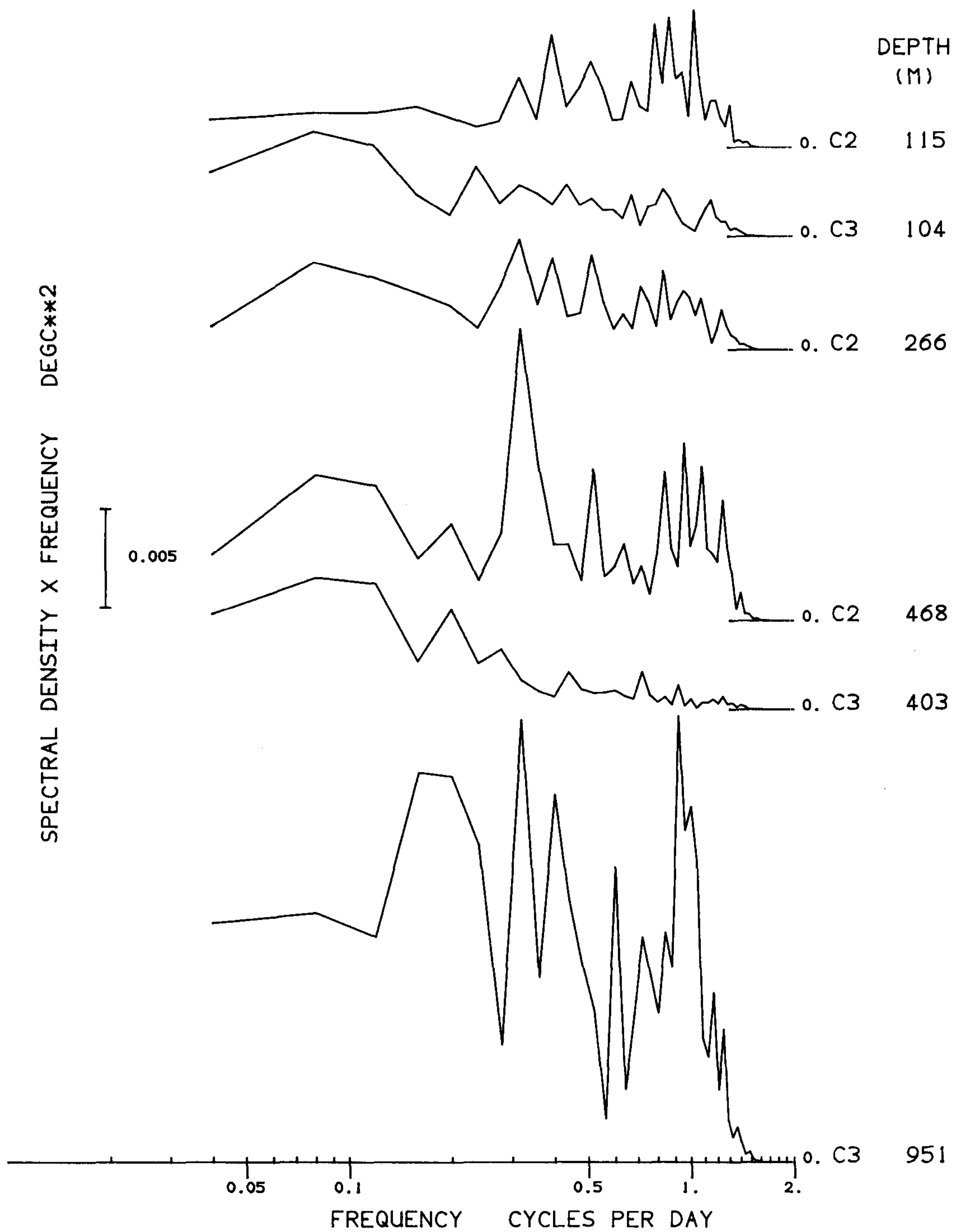
AUTOSPECTRA - TEMPERATURES

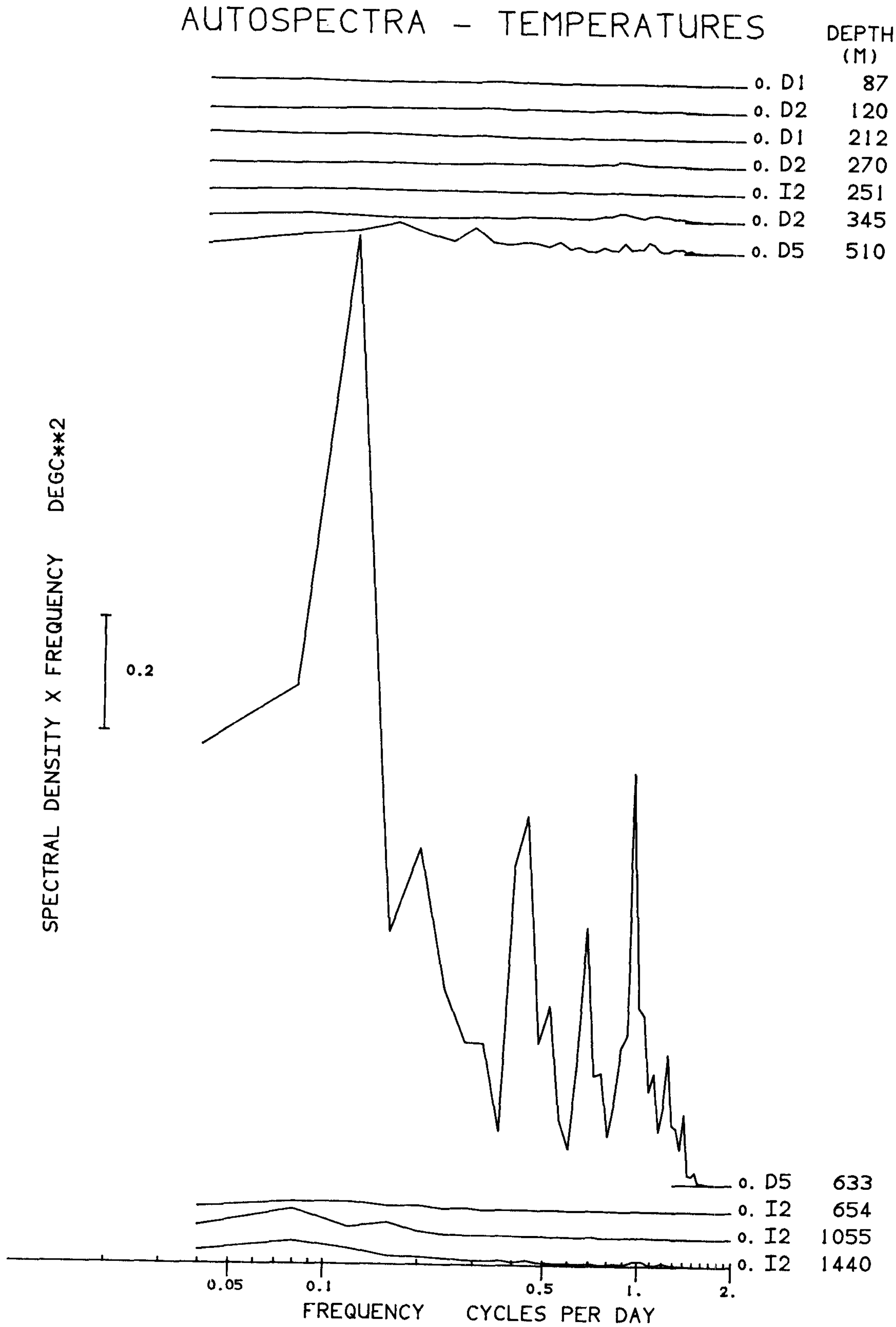


AUTOSPECTRA - TEMPERATURES

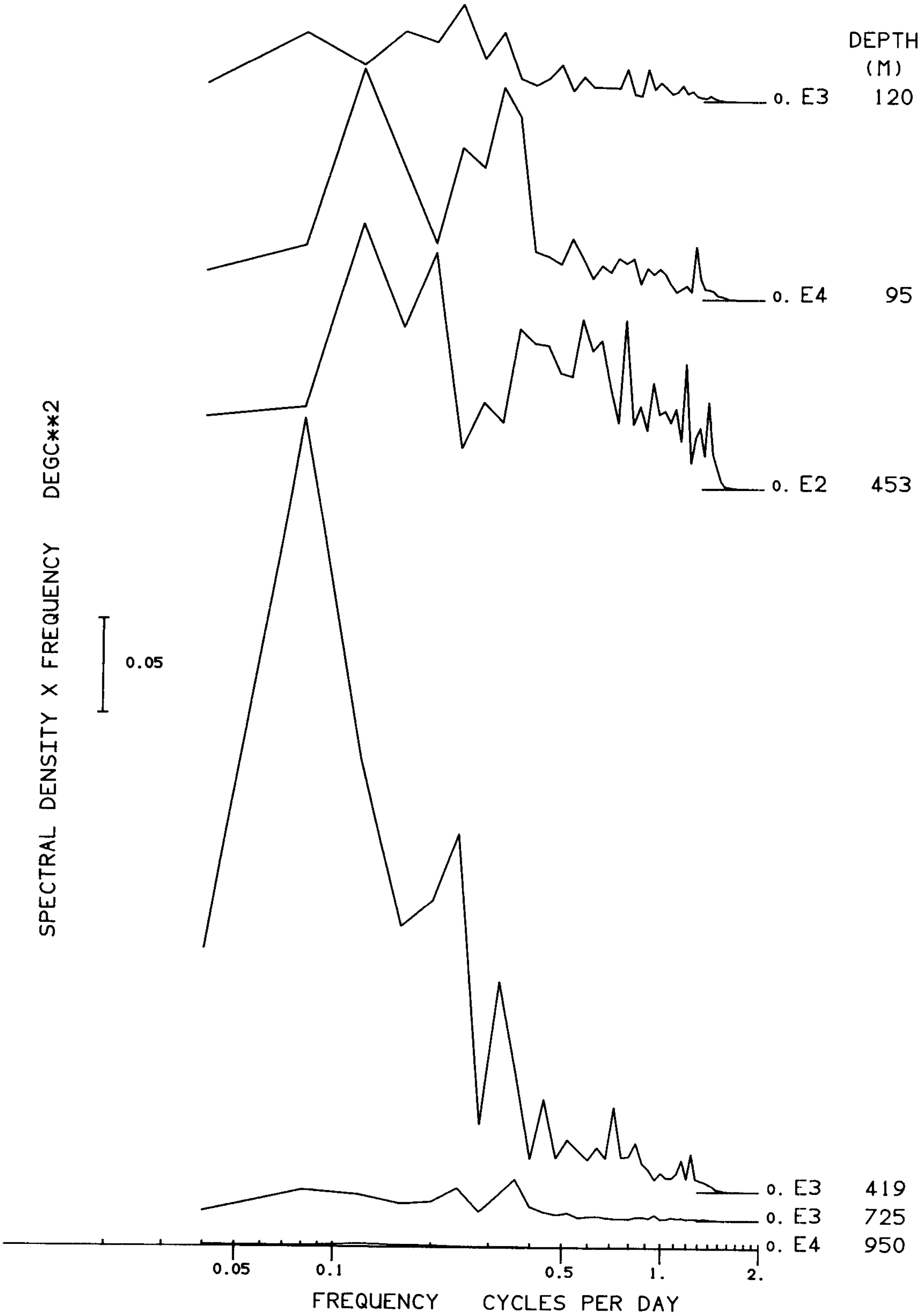


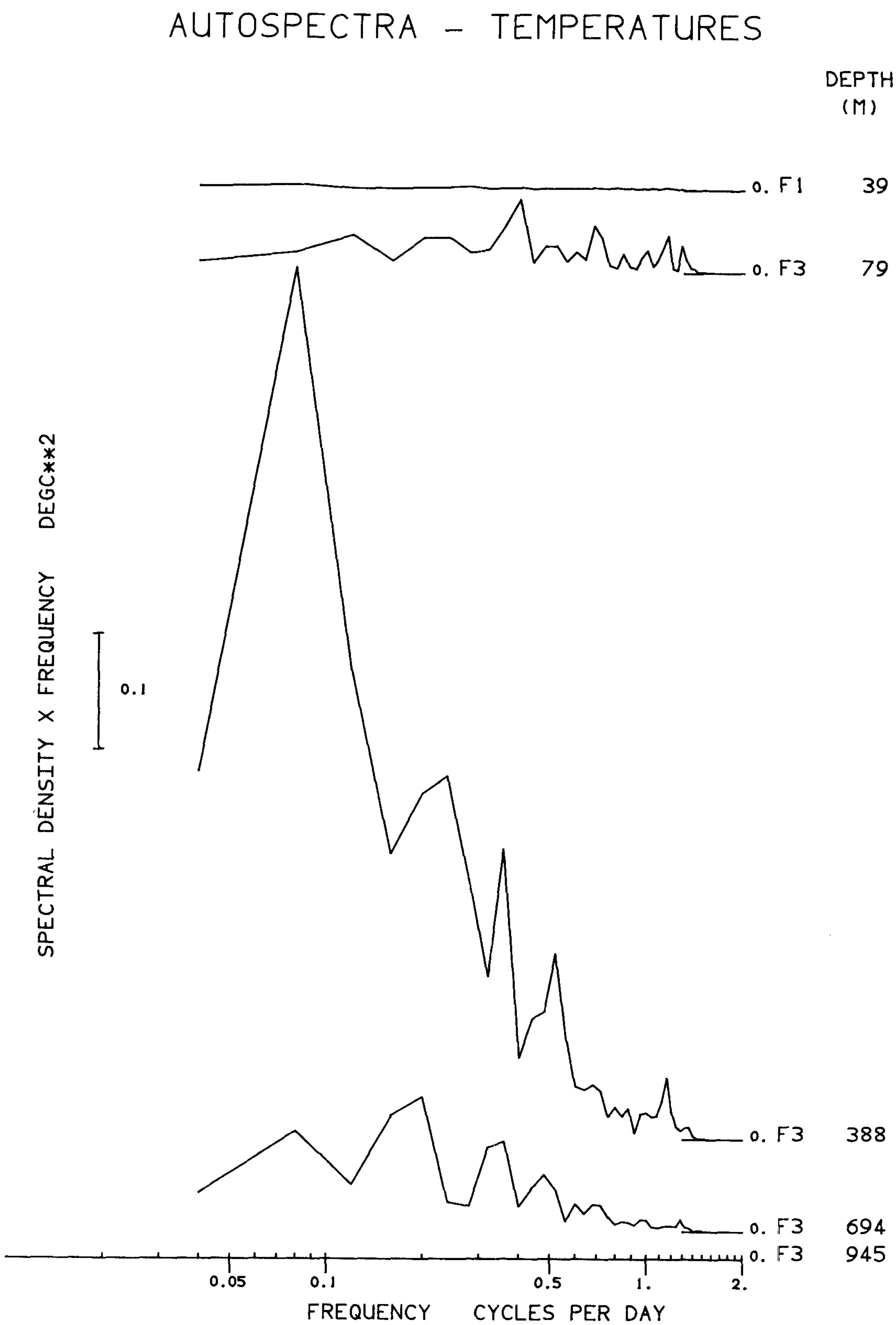
AUTOSPECTRA - TEMPERATURES

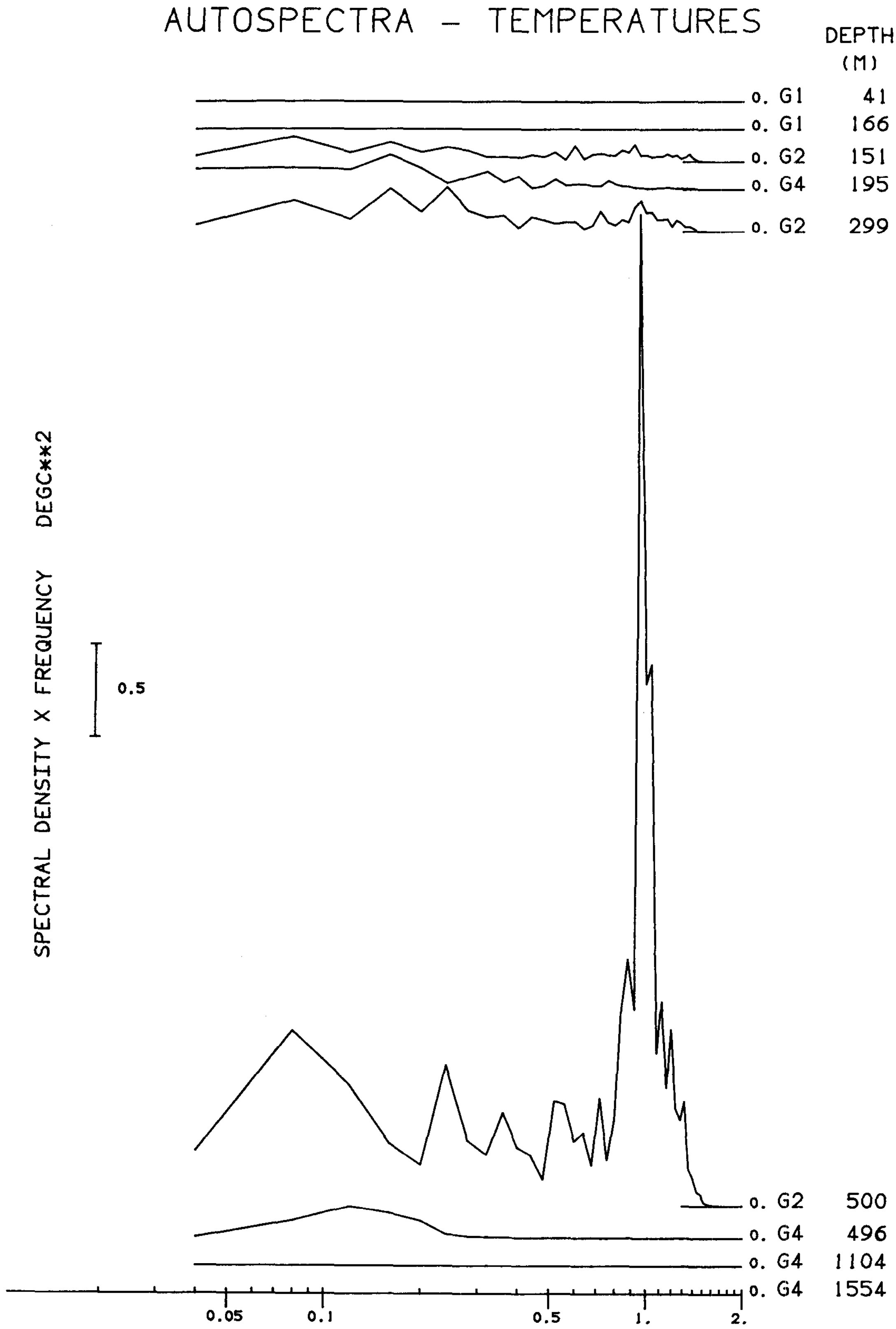



AUTOSPECTRA - TEMPERATURES
DEPTH (M)
o. D1 87
o. D2 120
o. D1 212
o. D2 270
o. I2 251
o. D2 345
o. D5 510
o. D5 633
o. I2 654
o. I2 1055
o. I2 1440
SPECTRAL DENSITY X FREQUENCY DEGC**2
0.2
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

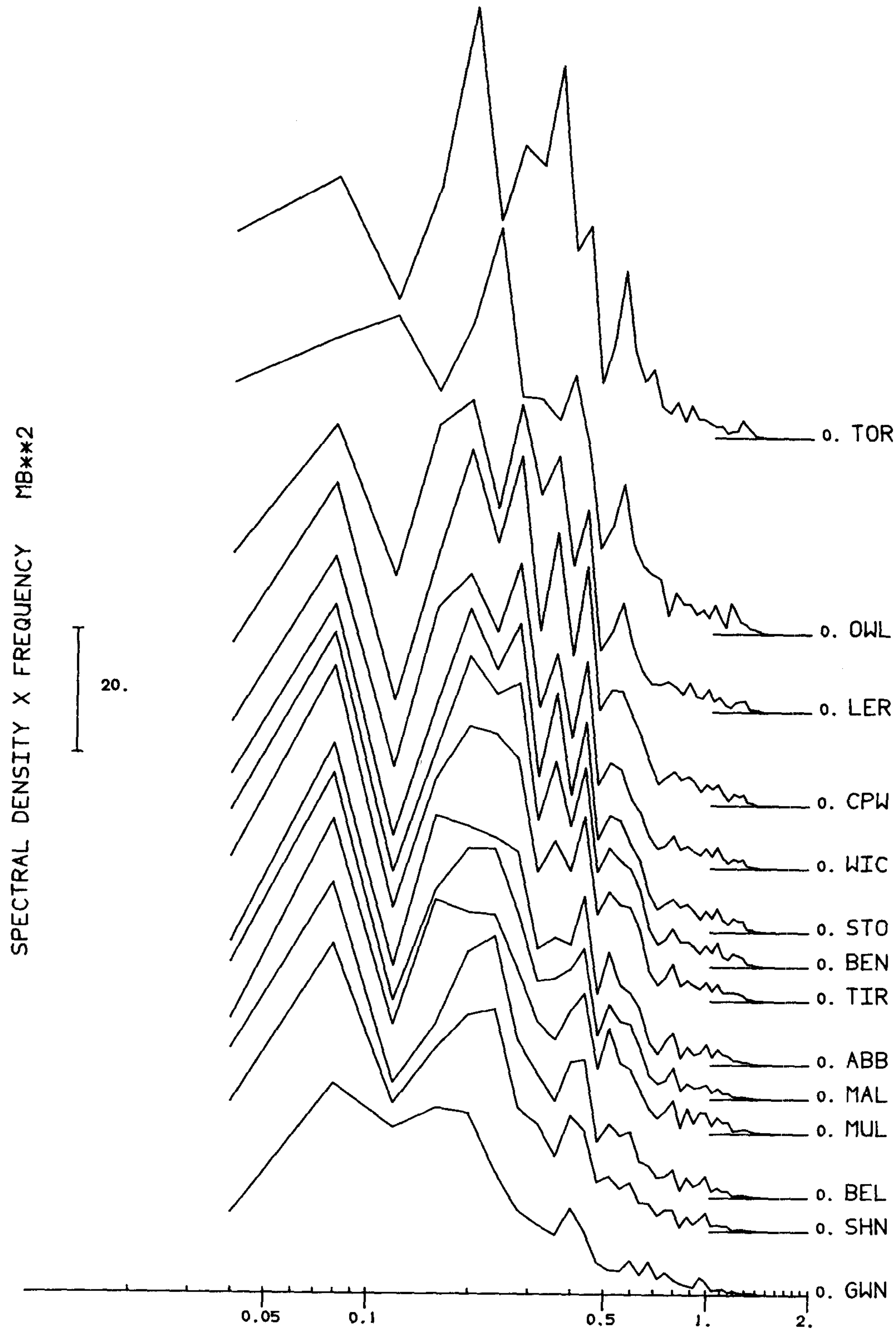
AUTOSPECTRA - TEMPERATURES

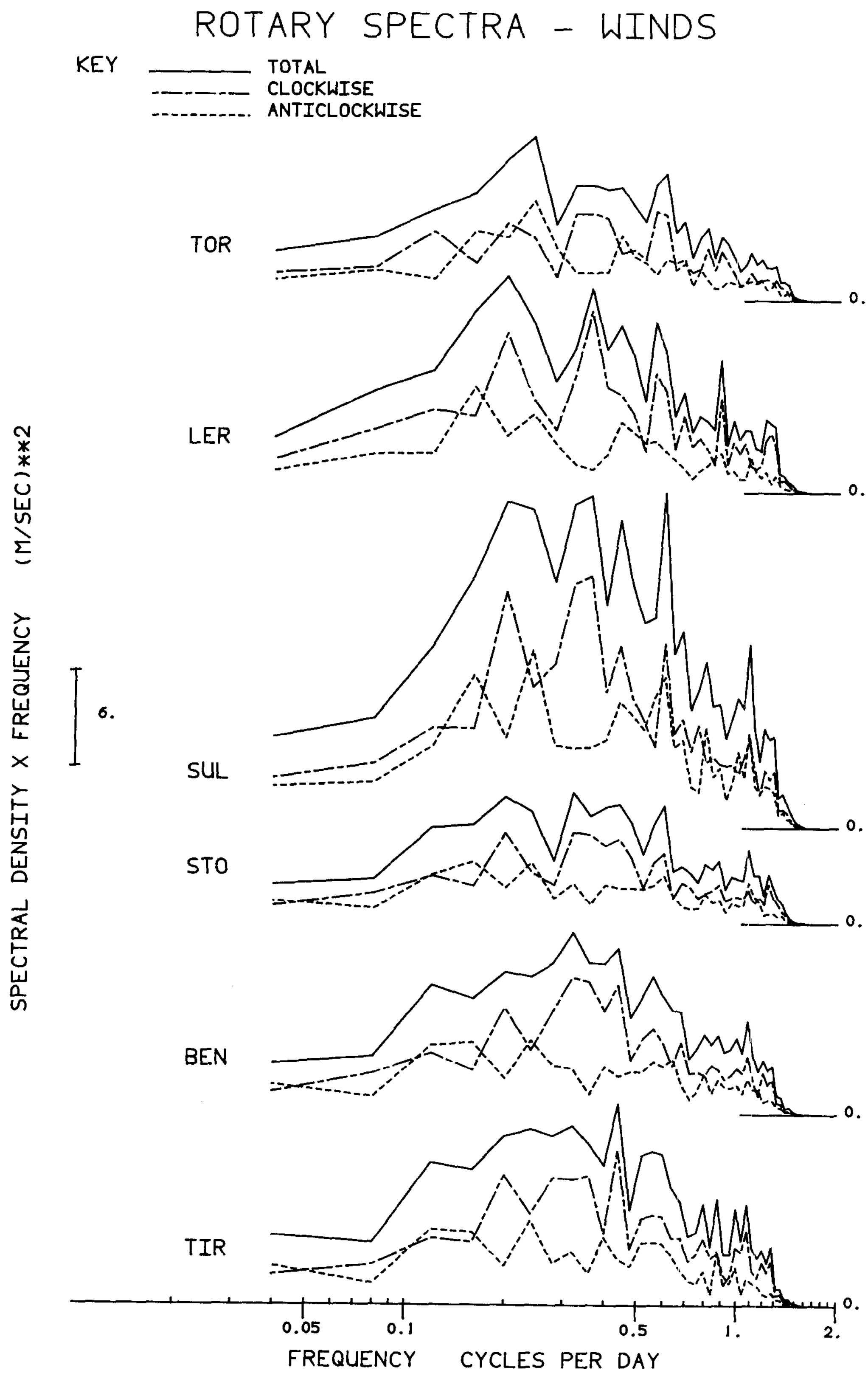


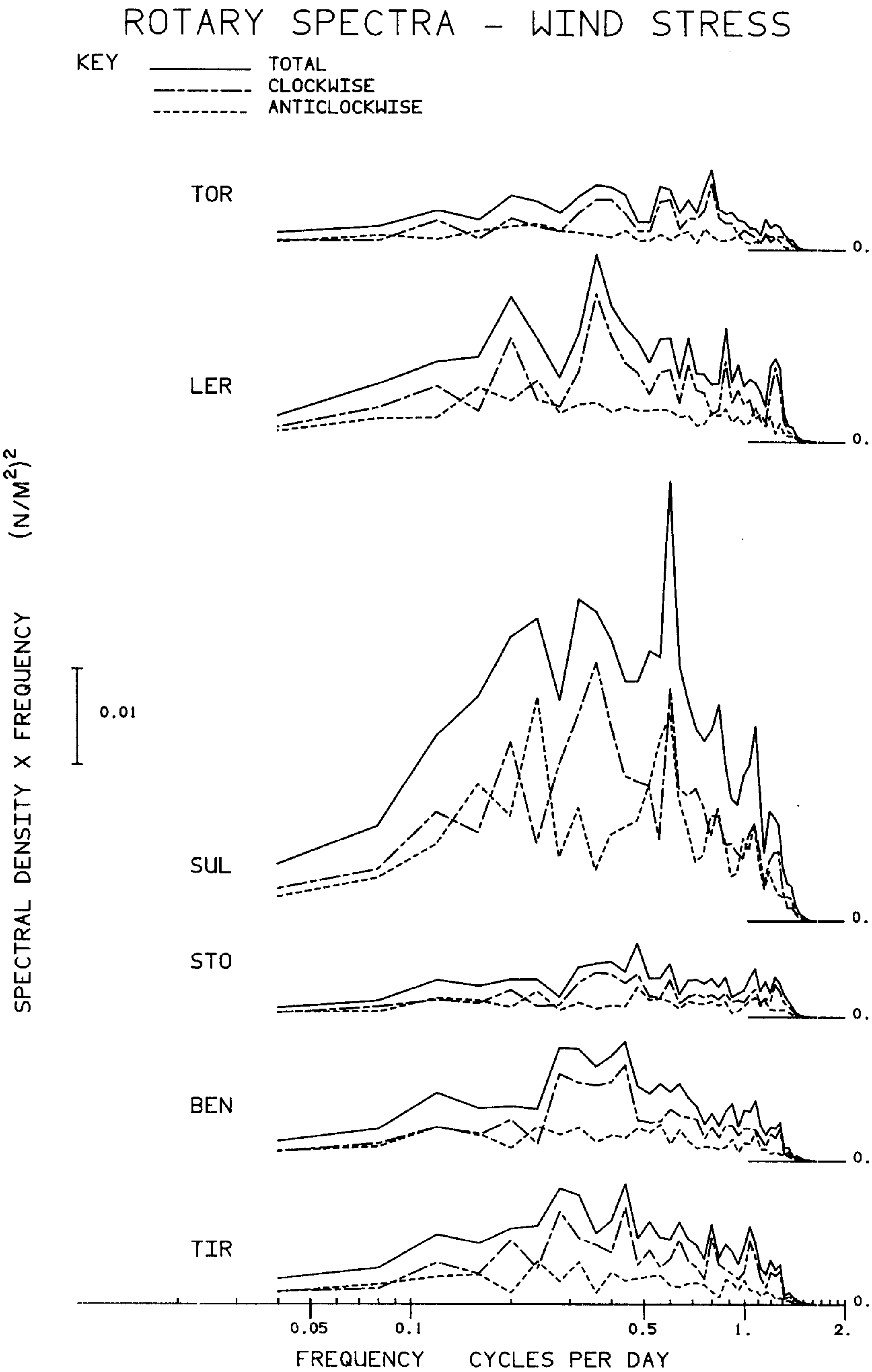

AUTOSPECTRA - TEMPERATURES
DEPTH (M)
0. F1 39
0. F3 79
0. F3 388
0. F3 694
0. F3 945
SPECTRAL DENSITY X FREQUENCY DEGC**2
0.1
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY


AUTOSPECTRA - TEMPERATURES
DEPTH (M)
0. G1 41
0. G1 166
0. G2 151
0. G4 195
0. G2 299
0. G2 500
0. G4 496
0. G4 1104
0. G4 1554
SPECTRAL DENSITY X FREQUENCY DEGC**2
0.5
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY

AUTOSPECTRA - PRESSURES




ROTARY SPECTRA - WINDS
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
TOR
LER
SUL
STO
BEN
TIR
SPECTRAL DENSITY X FREQUENCY (M/SEC)**2
6.
0.
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY


ROTARY SPECTRA - WIND STRESS
KEY
TOTAL
CLOCKWISE
ANTICLOCKWISE
TOR
LER
SUL
STO
BEN
TIR
0.
0.01
SPECTRAL DENSITY X FREQUENCY (N/M²)²
0.05
0.1
0.5
1.
2.
FREQUENCY CYCLES PER DAY