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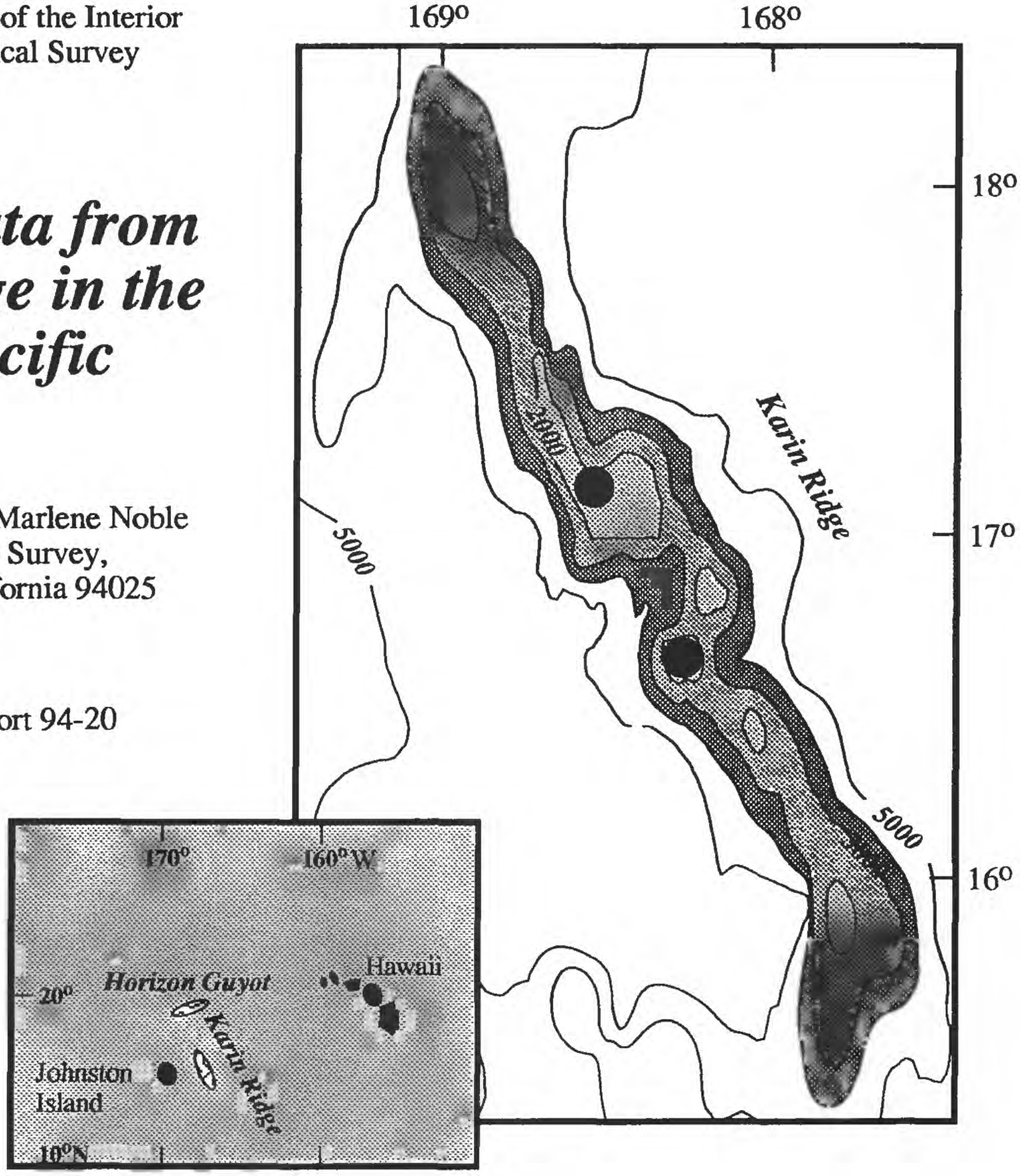

Current data from Karin Ridge in the Central Pacific

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Open-File Report 94-20

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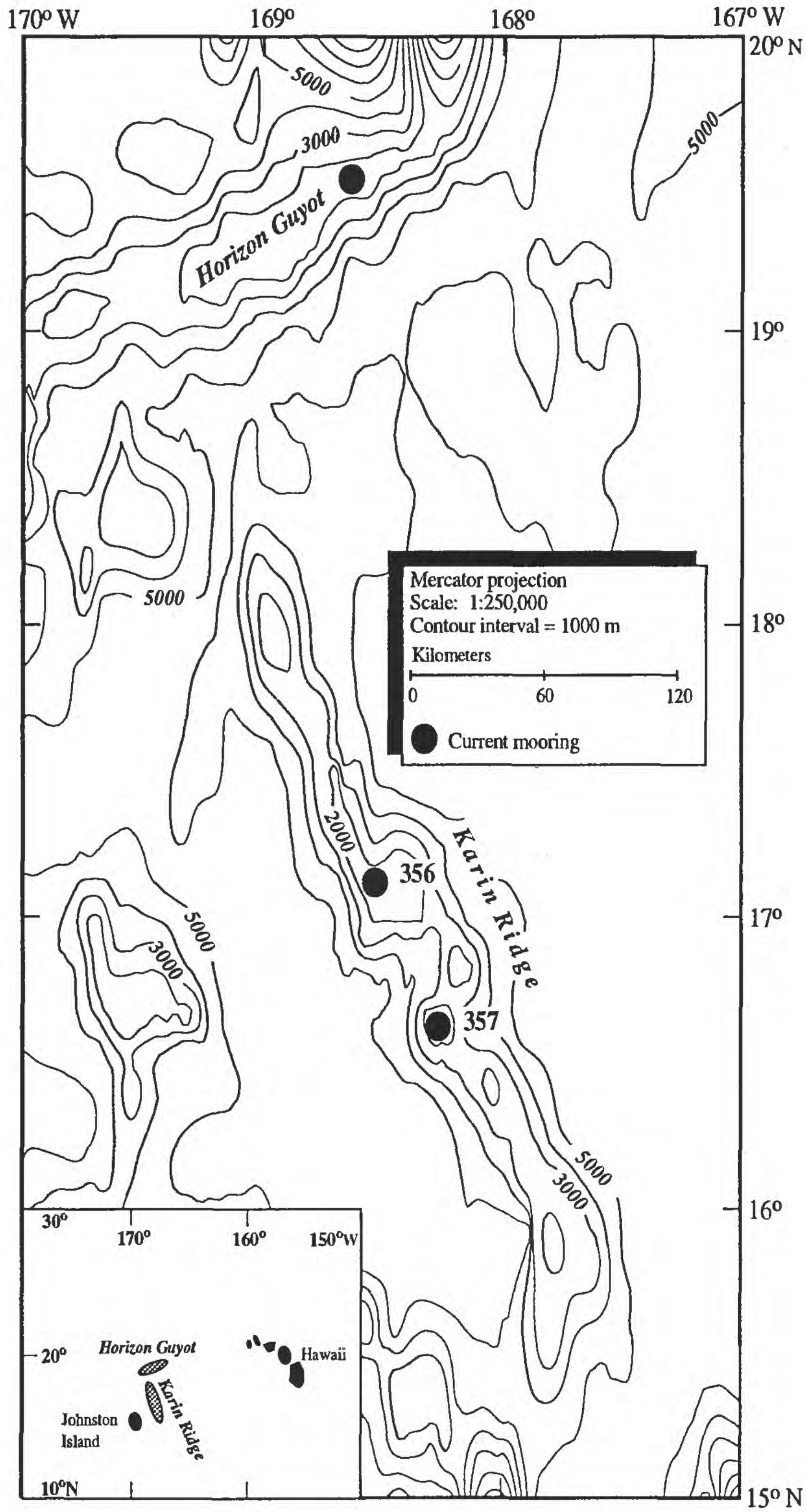

Figure 1. Location map of moorings on Karin Ridge and Horizon Guyot

ABSTRACT

A nine month-long program to study internal tides over Karin Ridge was begun in October, 1990. As part of this program, 2 moorings (Figure 1) that measured current and temperature were deployed on the ridge. This report is a description of the data that were collected during this experiment.

INTRODUCTION

A previous year-long study of currents over Horizon Guyot, a long, narrow, deep seamount located in the central Pacific suggested that strong internal tides were present over the guyot (Noble et al., 1988). It is likely that these internal tides were generated over the crest of the guyot. However, the exact characteristics of internal tides could not be determined because only a single current meter was deployed on Horizon Guyot. In addition, historical data about how internal tides are generated over deeply submerged guyots is sparse. Therefore, a new program to study internal tides generated over guyots was developed.

In October 1990, a 9 month-long study of currents and temperature over Karin Ridge was begun to determine additional characteristics of internal tides over seamounts in the central Pacific Ocean. Karin Ridge is very similar to Horizon Guyot. It is located in the same region of the Pacific and is a long narrow feature. However, Karin Ridge is oriented perpendicular to Horizon Guyot. Hence, the study can also address whether the orientation of this topographic feature had any effect on the generation or propagation of internal tides.

As part of this program, current-meter moorings were deployed at two sites on Karin Ridge (Figure 1). This report describes the data set collected by the moored current meters. A detailed description of the moored array and the instruments on each mooring is given in the next section. The principal data collected in this study include records of current velocity and water temperature. The appendices of the report list the statistical quantities of the entire data set and depict the characteristics of the hour-averaged and subtidal records.

Instrumentation

The EG&G vector-averaging current meter (VACM) was used on both moorings. A detailed description of the design and measurement characteristics is provided by McCullough (1975), Mero (1982) and Beardsley et al. (1987). These instruments measured the average current direction and speed every 450 seconds. All instruments at a site were attached to a single mooring. A dual acoustic release package was used to connect the mooring to the anchor.

Water temperature was measured with temperature sensors installed in the VACM's. All temperature sensors were calibrated by the manufacturer's specifications before deployment. The sample rate was the same as for the current meter (Table 1). CTD casts were made at sites over and adjacent to the crest of the ridge when the moorings were deployed. The data from these casts were used to estimate isotherm deflection from the measurements of temperature changes.

Description of the moored array

This field program consisted of several elements. The moored current observations were collected over Karin Ridge from October 1990 to May 1991. Two moorings (Figure 1) were deployed at sites (referred to as the northern and southern sites) of similar depths on the top of the ridge. An attempt was made to locate instrument packages at common depths on each mooring, instruments were placed at approximately 10, 50 and 200 meters above the sea floor.

Several criteria were used to determine the mooring locations. The array was designed to provide both a basic description of the current field and also a better understanding of the internal wave structure over large mid-oceanic topographic features. It was important to determine the spatial structure over the ridge and how that structure changed with time, depth and horizontal location. Primarily, the locations were chosen at the top of the ridge where the topography was flat enough to place the moorings. Because internal tides have wavelengths on the order of 50 - 100 km, it was thought that a 60 km separation would be sufficient to show changes in the internal tidal field. In addition, at 60 km the sites would not be so far apart that the measured internal tides would be totally independent of one another Hence, the moorings were deployed along the ridge crest, at sites 63 km apart.

Each mooring in the array had 3 instrument packages that measured current and temperature (Table 1, Figure 2). The instrument location at each site was designed to resolve the expected vertical structure of the physical parameters of the water column.

Site	Mooring	Water Depth (m)	Start time (M/D/Y)	Stop time (M/D/Y)	Position Latitude	Position Longitude	Sensor Depth (m)	Data Type	Current Sample interval (seconds)	Temperature Sample interval (seconds)
north	356-1	1560	10/04/90	05/12/91	17 08.65 N	168 30.23 W	1360	C, T,	450	450
north	356-2	1560	10/04/90	04/27/91	17 08.65 N	168 30.23 W	1510	C, T	450	450
north	356-3	1560	10/04/90	05/12/91	17 08.65 N	168 30.23 W	1550	C, T	450	450
south	357-1	1615	10/05/90	05/12/91	16 37.58 N	168 15.81 W	1415	C, T	450	450
south	357-2	1615	10/05/90	05/12/91	16 37.58 N	168 15.81 W	1565	C, T	450	450
south	357-3	1615	10/05/90	05/12/91	16 37.58 N	168 15.81 W	1605	C, T	450	450

Table 1. - Data availability for Karin Ridge moorings. (C = current data, T = sea temperature)

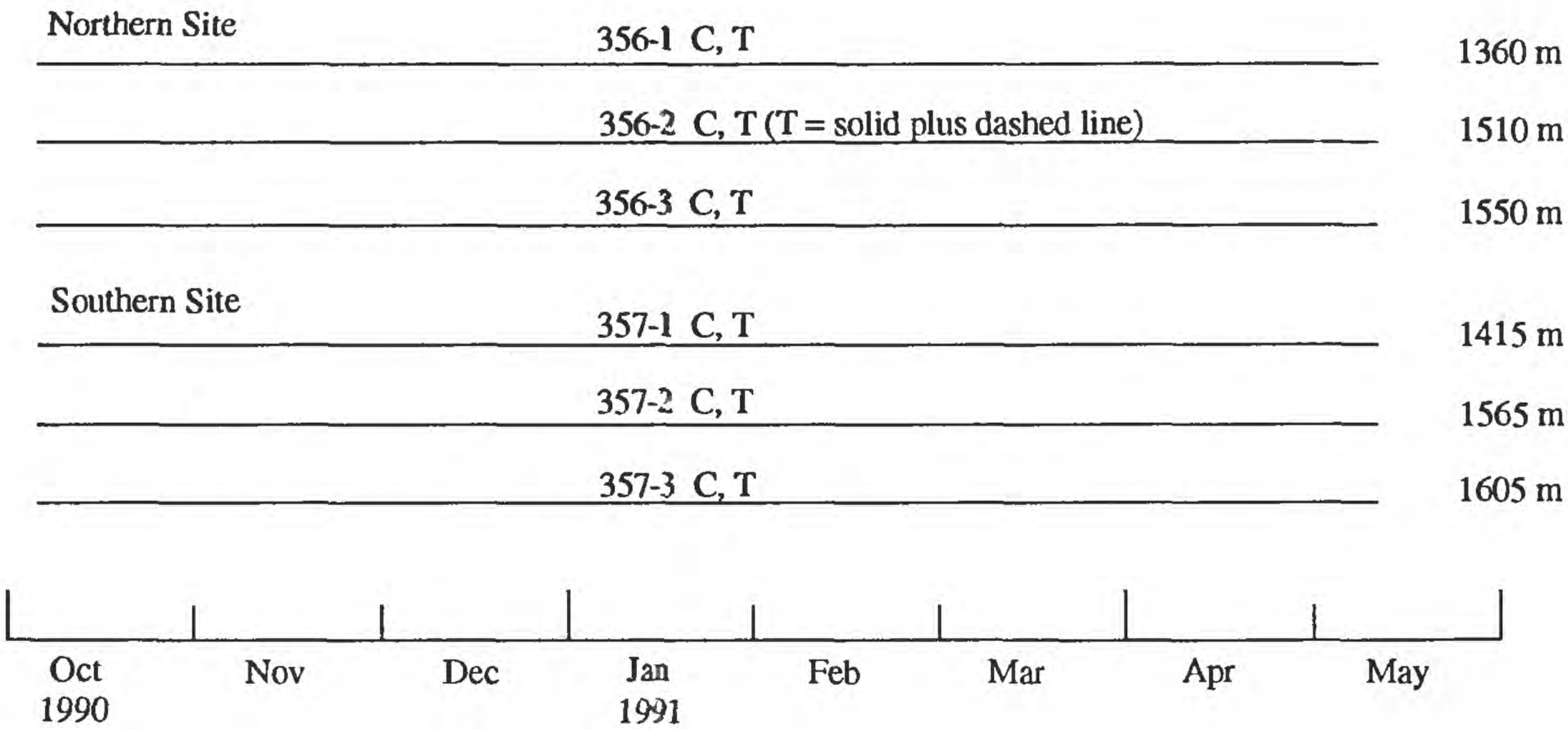

Figure 2. Timelines showing dates when valid data from the current meters exist

Data sets and statistical methods

This report is a statistical and pictorial description of the data collected and contains a series of figures that display characteristics of the measured currents. The data sets from each instrument package were decoded. transcribed into scientific units and passed through several processing steps. The data were checked for quality and errors caused by instrument noise or failures, using programs developed at Woods Hole Oceanographic Institute (Tarbell et al., 1988). The data were then analyzed using standard time series and statistical procedures. These procedures included making temporal plots, and calculating means, standard deviations, maximum values. minimum values and spectra for each data variable (Appendix A, B, and D). In addition, correlation and coherence statistics were calculated to provide information on the relationships between the various data sets. All times are in Greenwich mean time (GMT). The units for the currents are centimeters per second (cm/s) and temperature degrees Celsius (^{o}C).

The basic sample interval for all variables was 450 seconds (Table 1). All data in this report have been averaged into records that have an hour sampling interval (denoted hour-averaged records). In addition, the data were low-pass filtered to remove oscillations with periods shorter than 66 hours. Hence tides, with periods of 26 hours or less, and inertial oscillations which have a 41 hour period, are removed from the records. Since the majority of the variability at the shorter periods is due to tidal forcing, these lowpass-filtered records are referred to as subtidal records. The currents at all the mooring sites have been rotated into a coordinate system that is aligned with, or perpendicular to, the along-axis isobath of the seamount. The positive along-axis direction is 150^{o}; positive cross-axis is 60^{o}. The time series plots of the hour-averaged and subtidal along and cross-axis currents are in Appendix B. The time axes are the same for all current sites so that comparisons can easily be made between the instruments. The hour-averaged currents are shown first (Appendix B, pgs. B1-B4), the subtidal currents follow (pgs. B5-B8). In addition, vector plots of the subtidal currents are shown in Appendix C. These figures display the direction and amplitude of the current vectors simultaneously.

The mean currents and error bars for the mean at the 95% confidence level have been calculated for the mean along and cross-axis currents. The error bars around the mean value indicate how stable the calculated mean is. In order for a reliable mean direction to be established, the error bars around the mean can not span an interval that includes zero. Significant mean directions have been highlighted in tables A1, A2 and A3.

The formula for the error bar around the mean is:

$$\frac{\Phi t_{m;\alpha/2}}{\sqrt{m+1}} \qquad (1)$$

where $t_{m;\alpha/2}$ is the student t statistic with m degrees of freedom at the $100(1-\alpha)\%$ confidence level. Φ is the standard deviation of the subtidal data set. The degrees of freedom of a record is the record length divided by the autocorrelation scale. The autocorrelation scale for both the along and cross-axis currents is 22 days.

The characteristics of the major diurnal (O_1 and K_1) and semidiurnal (M_2 and S_2) tidal constituents are calculated for all measurement sites (Tables A4 and A5) using a standard tidal analysis based on programs developed by Foreman (1978). In the standard analysis, tidal amplitudes and phases are calculated via a least-squares fit. Subsequently, corrections are made to account for interference from unresolved tidal frequencies and for nodal modulations. The tidal amplitudes are calculated for the existing record length of each data set (Table D1).

The energy in the currents at each measurement site is depicted as a function of the frequency of the process (Appendix D). A variance-conserving autospectra is calculated for the along and cross-axis currents. We chose a variance-conserving spectra in order to highlight those frequencies that had the largest energies; the dominant processes occupy the biggest areas on the plots. The tidal frequencies generally have a large fraction of the energy; these large spectral peaks are found at frequencies above 10^{-5} hertz (1.2 days).

All spectra for the two moorings are calculated with similar Fourier transform parameters. Each record was divided into pieces 1104 hours long that overlapped each other by 50% (Table D1). Each piece was windowed with a Hanning window shape in order to reduce leakage of energy from the dominant frequencies into the less energetic frequency bands. The spectra for all pieces at one location were averaged together.

Moored current observations

The mean currents are not spatially uniform. At the northern site the mean current flows toward the east while at the southern site the mean current flows toward the west (Figure 3). This might suggest that a mean eddy exists over the ridge, but there was not enough data to definitely determine this.

At both sites, the semidiurnal tidal currents are fairly uniform relative to depth, although at the southern site this is less apparent near the bottom. The S2 tidal current and M2 tidal current have similar characteristics at both sites. However, the actual amplitudes of each semidiurnal constituent changes significantly between sites. The M2 tides at the southern site are two times larger than the M2 tides at the northern site. The S_2 tides are smallest at the southern site. These changing amplitudes make the S_2/M_2 ratios very different at the two moorings. The ratio for the major axis of the S_2/M_2 component is 0.8 at the northern site. At the southern site the ratio for the major axis for the S_2/M_2 component is between 0.2 to 0.3.

At the northern site the diurnal tidal currents (K_1) are fairly uniform with depth, with a range of 3-4 cm/s. At the southern site, however, the K1 tidal current is larger at the middle (1565 m) and bottom (1605 m) instruments. The other diurnal constituents, O1 and P_1 are fairly uniform with depth. The O_1/K_1 ratios vary somewhat between moorings. The ratio for the major axis of the O1/K1 component at the northern mooring is 0.5 and at the southern mooring it is between 0.3-0.4. These changing tidal characteristics suggest that significant internal tides are present in both semidiurnal and diurnal tidal bands.

Moored temperature and isotherm deflection observations

Measurements of temperature were obtained at all sites in the moored array (Table 1, Figure 2). The mean, standard deviation, minimum and maximum values for the hour-averaged data are listed in Table A3. Plots of the data are located in Appendix E.

Isotherm deflection

The isotherm displacements are calculated from the temperature record at each measurement site. The isotherm deflections are defined to be:

$$I = \frac{(t - \bar{t})}{\frac{\partial t}{\partial z}} \qquad (2)$$

where I is the isotherm deflection, t is the temperature and $\frac{\partial t}{\partial z}$ is the temperature gradient. The temperature gradient was calculated using two different methods. One temperature gradient was calculated from temperature profiles between 1300 m and 1700 m measured by a CTD taken at a site off the seamount when the moorings were deployed. A second temperature gradient was calculated from the mean temperature at each instrument depth. Both methods showed that the temperature decreased linearly with depth (Pg. E-1). The squared correlation indicated that the linear fit accounted for over 99% of the variations in temperature. The measured gradients had slightly different amplitudes, so the gradient used in the calculation was the average of the two measurements, -0.002372 degrees/meter. The value was within 7% of either measured temperature gradient.

The mean, standard deviation, minimum and maximum values for the hour-averaged data are listed in Table A3. Plots of the data are located in Appendix E.

ACKNOWLEDGMENTS

We would like to thank William Strahle, Kevin O'Toole, Walter Olson, Ransom Rideout and Jim Vaughan for preparing, deploying and recovering the many types of instruments used in this project. Francis Hotchkiss decoded and cleaned up the raw data sets. The crews of the research vessels *Farnella* and *Vinagradov* ably assisted in the deployment and recovery of instruments during the program. This research was sponsored by the Pacific Marine Geology Branch of the U.S. Geological Survey.

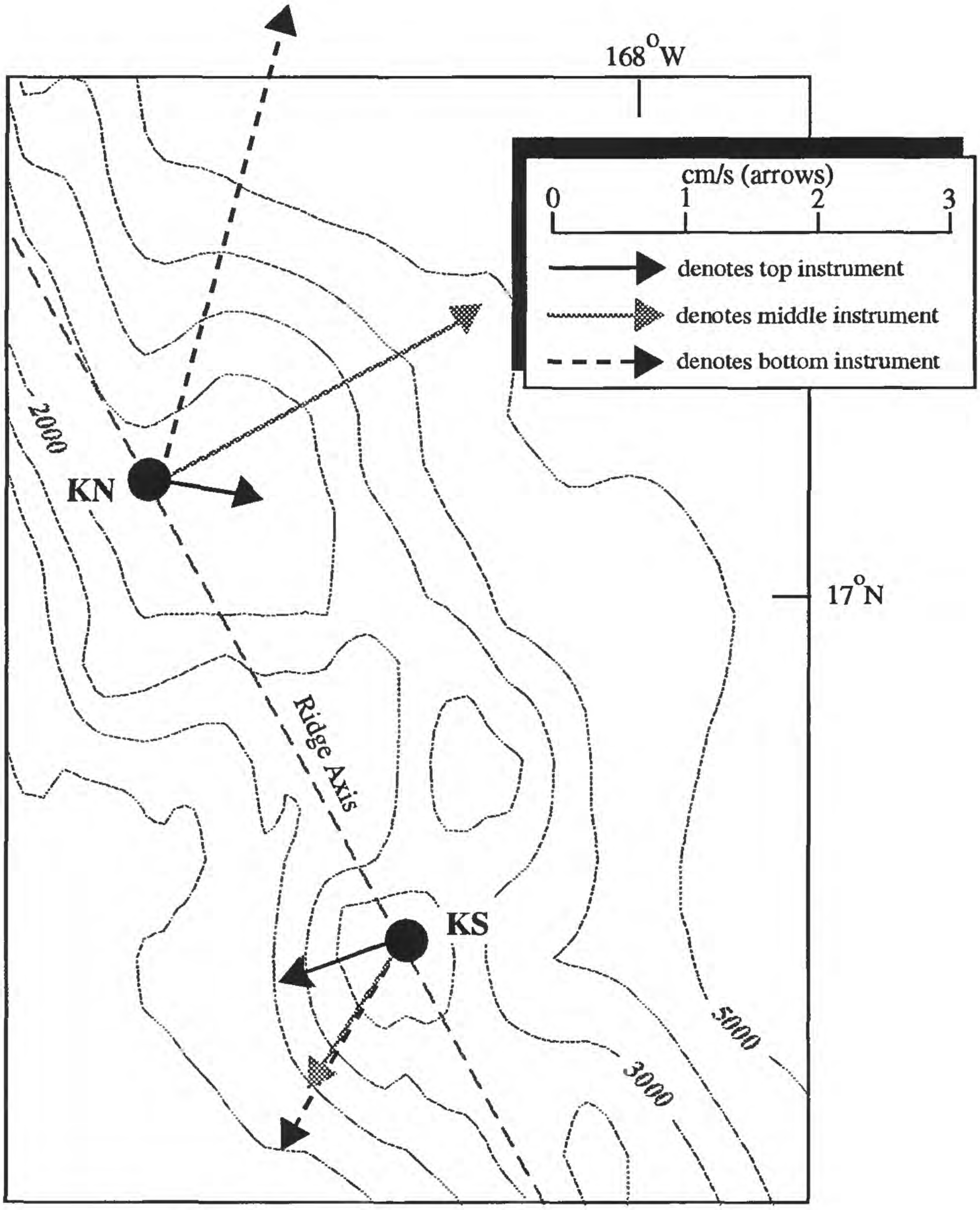

Figure 3. Mean currents on Karin Ridge

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Appendix A - Tables

Table A1. - Hour-averaged horizontal current components A1

Table A2. - Low-passed horizontal current components A1

Table A3 - Hour-averaged temperature A1

Table A4. - Diurnal tidal currents A2

Table A5. - Semi-diurnal tidal currents A2

Site	Mooring	Water Depth (m)	Start Time GMT (M/D/Y)	Stop Time GMT (M/D/Y)	Sensor Depth (m)	Along-axis				Cross-axis				Max Speed
						Mean	SD	Max	Min	Mean	SD	Max	Min	
north	356-1	1560	10/04/90	05/11/91	1360	0.4 ±2.4	7.4	24.6	-24.5	0.5 ±2.6	7.9	27.2	-21.9	28.9
north	356-2	1560	10/04/90	04/27/91	1510	0.1 ±2.7	7.0	21.0	-26.7	2.6 ±3.3	0.2	33.5	-23.0	34.9
north	356-3	1560	10/05/90	05/11/91	1550	**-2.6 ±2.2**	6.7	21.8	-26.9	**2.6 ±2.5**	6.8	25.6	-16.4	28.9
south	357-1	1615	10/05/90	05/12/91	1415	0.0 ±2.5	6.9	23.2	-22.7	-0.5 ±2.9	9.3	23.2	-22.7	31.1
south	357-2	1615	10/05/90	05/12/91	1565	0.6 ±2.5	8.2	25.1	-21.1	-0.7 ±3.0	10.6	31.0	-30.6	31.8
south	357-3	1615	10/05/90	10/12/91	1605	0.9 ±2.7	7.5	24.7	-19.7	-1.2 ±2.9	8.7	30.3	-26.9	32.0

Table A1. - Karin Ridge hour-averaged horizontal current components (cm/s)

Site	Mooring	Water Depth (m)	Start Time GMT (M/D/Y)	Stop Time GMT (M/D/Y)	Sensor Depth (m)	Along-axis				Cross-axis			
						Mean	SD	Max	Min	Mean	SD	Max	Min
north	356-1	1560	10/04/90	05/11/91	1360	0.5 ±2.4	3.3	11.0	-9.0	0.5 ±2.6	3.6	12.6	-8.3
north	356-2	1560	10/04/90	04/27/91	1510	0.7 ±2.7	3.5	8.8	-15.6	2.5 ±3.3	4.4	20.5	-9.3
north	356-3	1560	10/05/90	05/11/91	1550	**-2.6 ±2.2**	3.1	5.5	-12.6	**2.6 ±2.5**	3.4	14.9	-7.1
south	357-1	1615	10/05/90	05/12/91	1415	0.0 ±2.5	3.4	11.6	-11.5	-0.5 ±2.9	4.0	12.1	-12.5
south	357-2	1615	10/05/90	05/12/91	1565	0.6 ±2.5	3.5	11.3	-10.9	-0.7 ±3.0	4.1	10.7	-12.5
south	357-3	1615	10/05/90	10/12/91	1605	0.9 ±2.7	3.8	12.1	-10.5	-1.2 ±2.9	4.0	12.7	-12.3

Table A2. - Karin Ridge low-passed horizontal current components (cm/s)

Site	Mooring	Water Depth (m)	Start Time GMT (M/D/Y)	Stop Time GMT (M/D/Y)	Sensor Depth (m)	Temperature (C)				Isotherm (m)		
						Mean	SD	Max	Min	SD	Max	Min
north	356-1	1560	10/04/90	05/11/91	1360	**3.1 ±0.1**	0.1	3.5	2.8	40.2	135.6	-143.1
north	356-2	1560	10/04/90	04/27/91	1510	**3.5 ±0.1**	0.1	3.7	3.3	31.3	94.5	-100.0
north	356-3	1560	10/05/90	05/11/91	1550	**2.7 ±0.1**	0.1	2.9	2.4	27.7	94.5	-92.6
south	357-1	1615	10/05/90	05/12/91	1415	**3.0 ±0.1**	0.1	3.4	2.6	46.4	163.8	-154.8
south	357-2	1615	10/05/90	05/12/91	1565	**2.6 ±0.1**	0.1	2.9	2.4	37.6	110.0	-117.2
south	357-3	1615	10/05/90	10/12/91	1605	**2.5 ±0.1**	0.1	2.2	2.8	35.8	11.1	-126.5

Table A3. - Karin Ridge hour-averaged temperature and isotherm deflection

Site	Mooring	Start time GMT (M/D/Y)	Stop time GMT (M/D/Y)	O_1 Major axis (cm/s)	O_1 Minor axis (cm/s)	O_1 Inclination (degrees)	P_1 Major axis (cm/s)	P_1 Minor axis (cm/s)	P_1 Inclination (degrees)	K_1 Major Axis (cm/s)	K_1 Minor axis (cm/s)	K_1 Inclination (degrees)
north	356-1	10/05/90	05/11/91	2.0	-0.5	68.0	1.3	-0.5	36.0	4.0	-2.1	50.0
north	356-2	10/05/90	04/27/91	2.1	-0.8	52.0	1.9	-1.1	42.0	3.8	-1.6	51.0
north	356-3	10/05/90	05/11/91	1.8	-1.0	64.0	1.2	-1.1	68.0	3.4	-1.6	61.0
south	357-1	10/05/90	05/11/91	1.0	-0.6	135.0	0.7	-0.3	176.0	2.2	-0.7	175.0
south	357-2	10/05/90	05/11/91	2.2	-1.0	174.0	1.7	-0.7	2.0	6.6	-2.7	9.0
south	357-3	10/05/90	05/11/91	1.9	-0.4	1.0	1.5	-0.7	7.0	6.0	-2.5	4.0

TableA4. - Karin Ridge diurnal tidal currents. A negative minor axis indicates a clockwise rotation for the tidal currents. The inclination angle is counterclockwise from east.

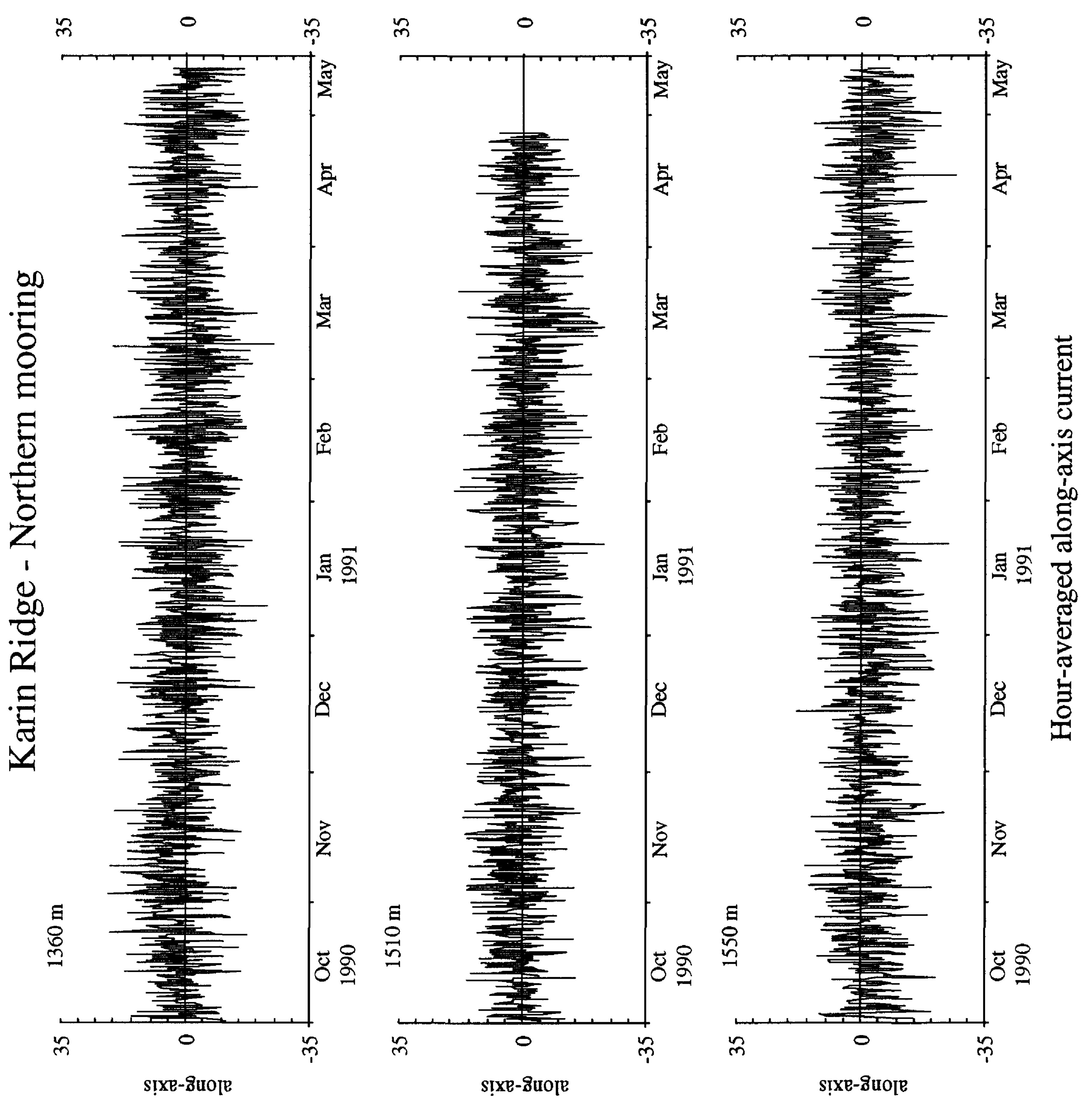
Site	Mooring	Start time GMT (M/D/Y)	Stop time GMT (M/D/Y)	M_2 Major axis cm/s	M_2 Minor axis cm/s	M_2 Inclination degrees	S_2 Major Axis cm/s	S_2 Minor axis cm/s	S_2 Inclination degrees
north	356-1	10/05/90	05/11/91	5.4	-5.1	29.0	4.2	-2.4	78.0
north	356-2	10/05/90	04/27/91	4.1	-3.1	102.0	3.3	-1.5	77.0
north	356-3	10/05/90	05/11/91	4.1	-3.2	99.0	3.1	-1.3	79.0
south	357-1	10/05/90	05/11/91	9.3	-5.2	30.0	2.6	-0.8	28.0
south	357-2	10/05/90	05/11/91	9.5	-6.7	11.0	2.1	-0.6	23.0
south	357-3	10/05/90	05/11/91	5.9	-5.1	13.0	1.3	-0.5	34.0

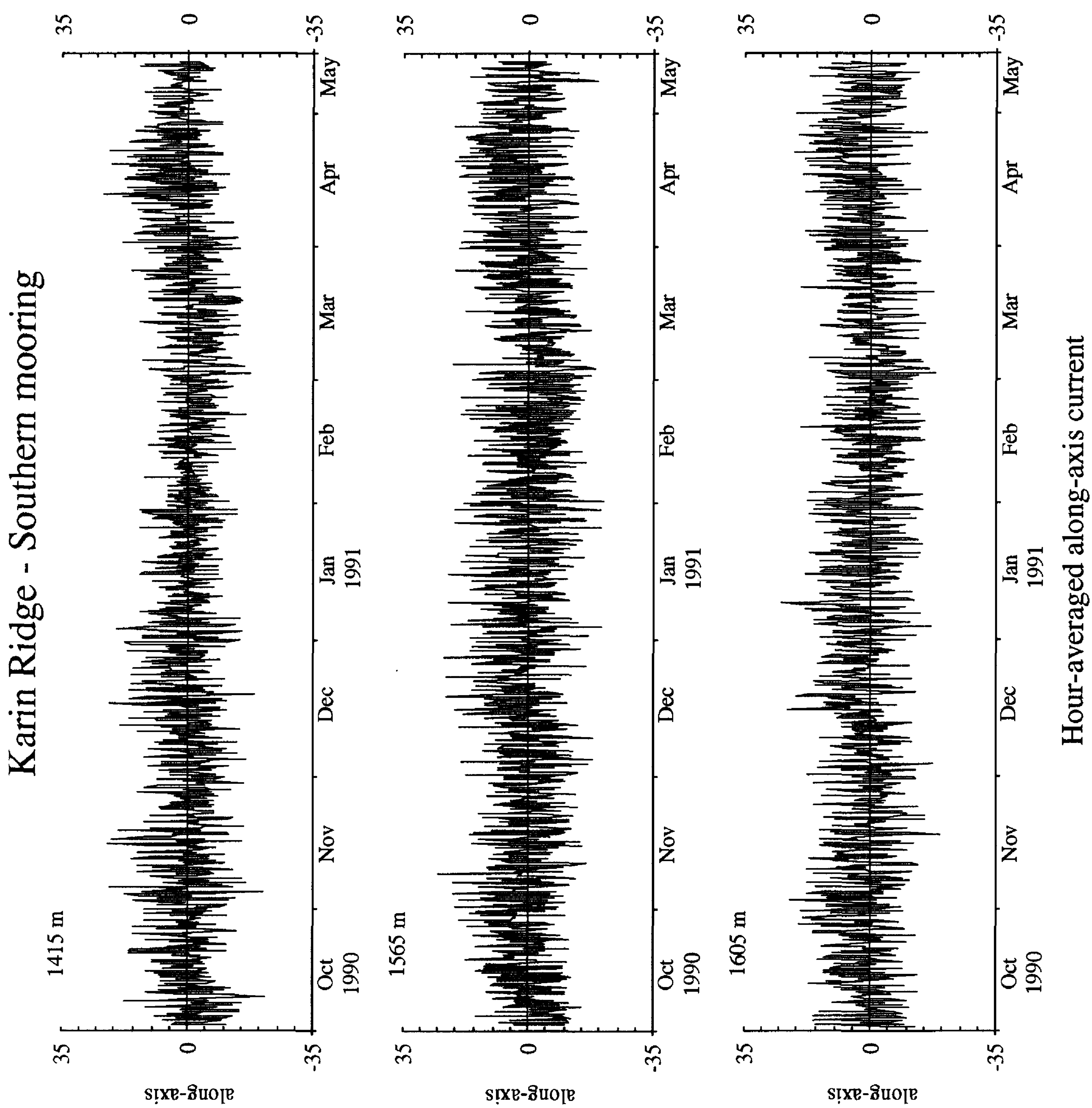
Table A5. - Karin Ridge semidiurnal tidal currents. A negative minor axis indicates a clockwise rotation for the tidal currents. The inclination angle is counterclockwise from east.

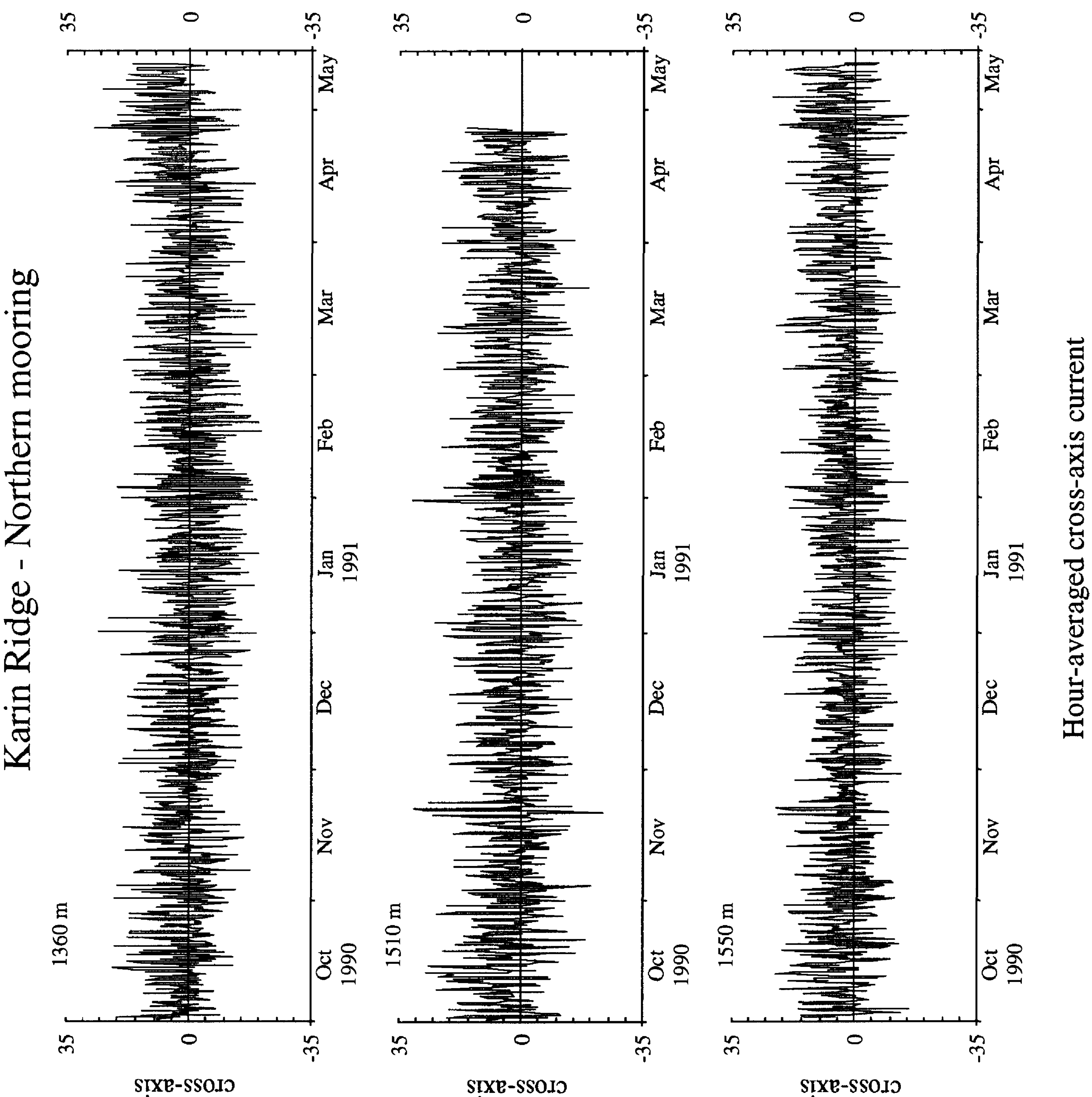
Appendix B - Time Series Plots

Plots of hour-averaged currents .... B 1 - B 4

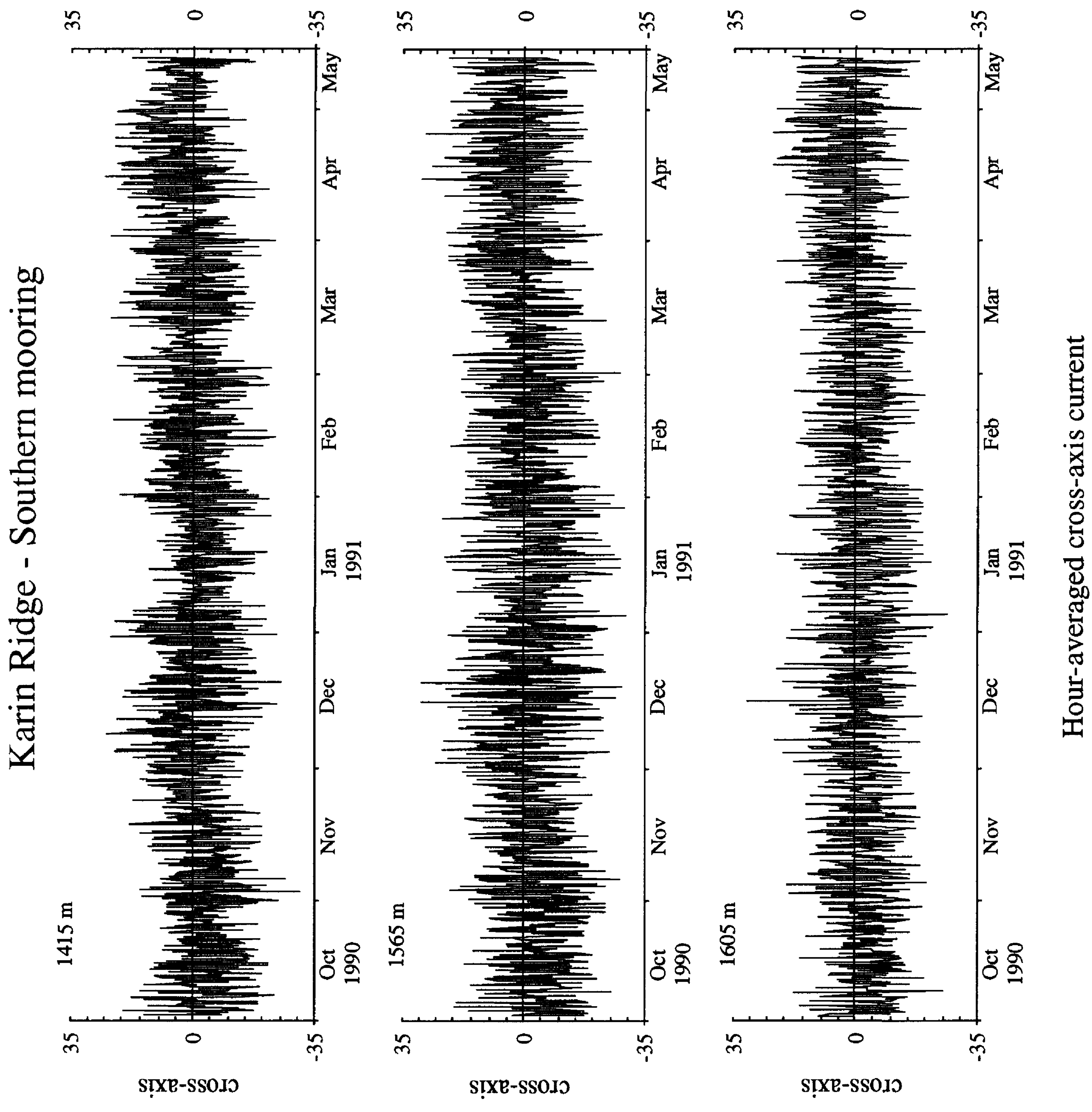
Plots of subtidal currents .... B 5 - B 8


Karin Ridge - Northern mooring
Hour-averaged along-axis current
1360 m
1510 m
1550 m
along-axis
35
0
-35
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May


Karin Ridge - Southern mooring
1415 m
1565 m
1605 m
along-axis
35
0
-35
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May
Hour-averaged along-axis current



Karin Ridge - Northern mooring
1360 m
1510 m
1550 m
cross-axis
35
0
-35
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May
Hour-averaged cross-axis current


Karin Ridge - Southern mooring
Hour-averaged cross-axis current
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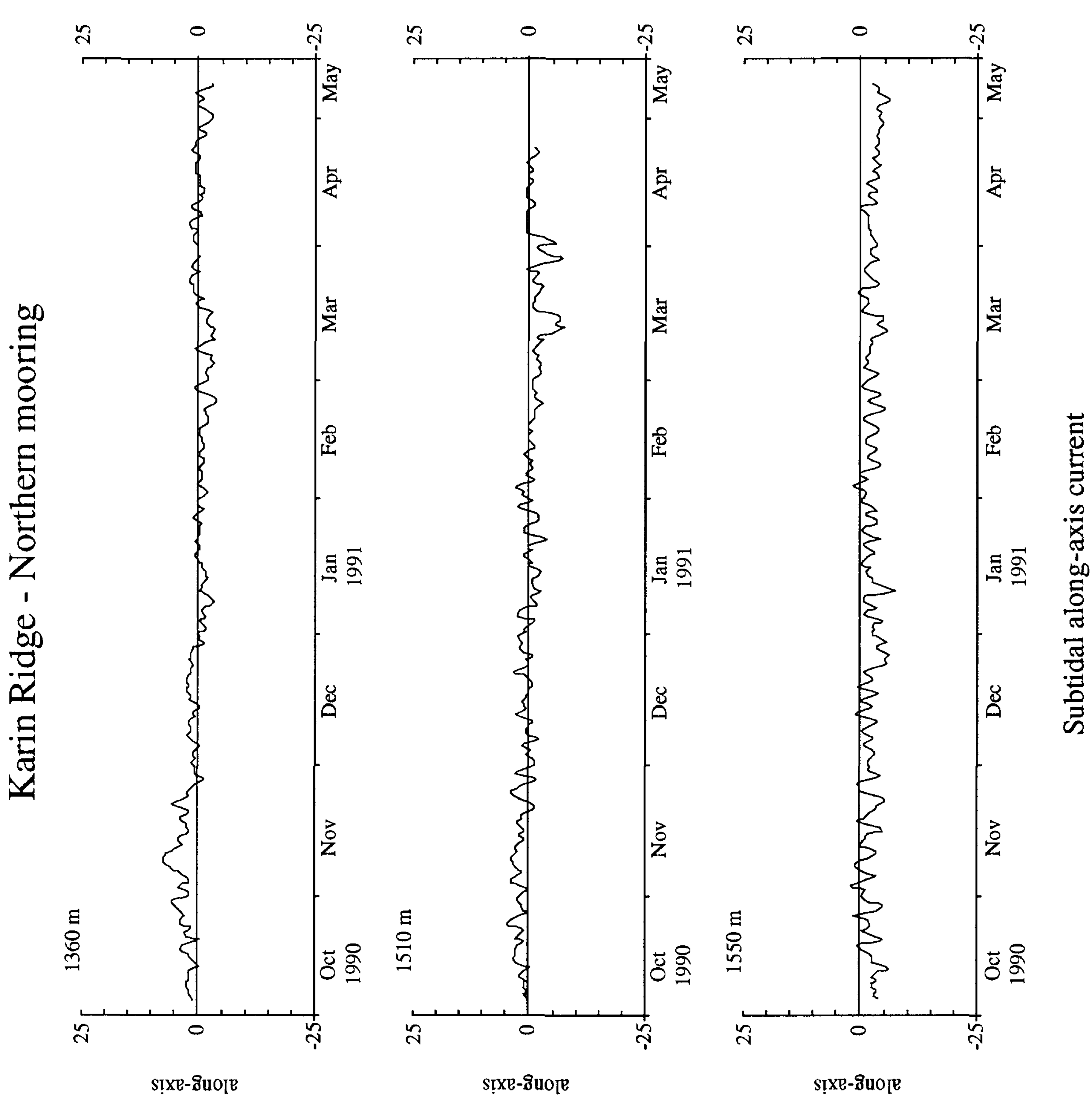
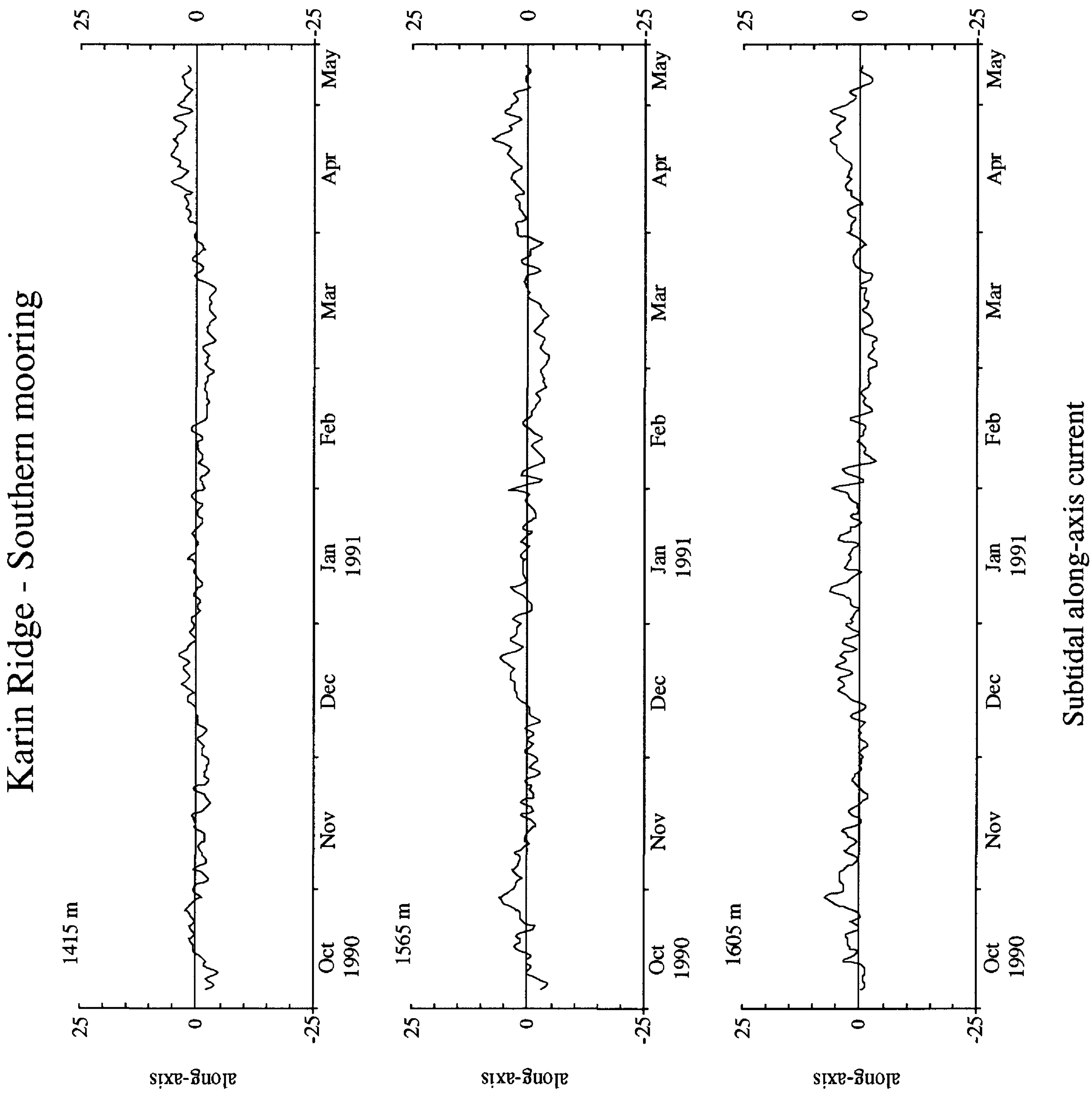
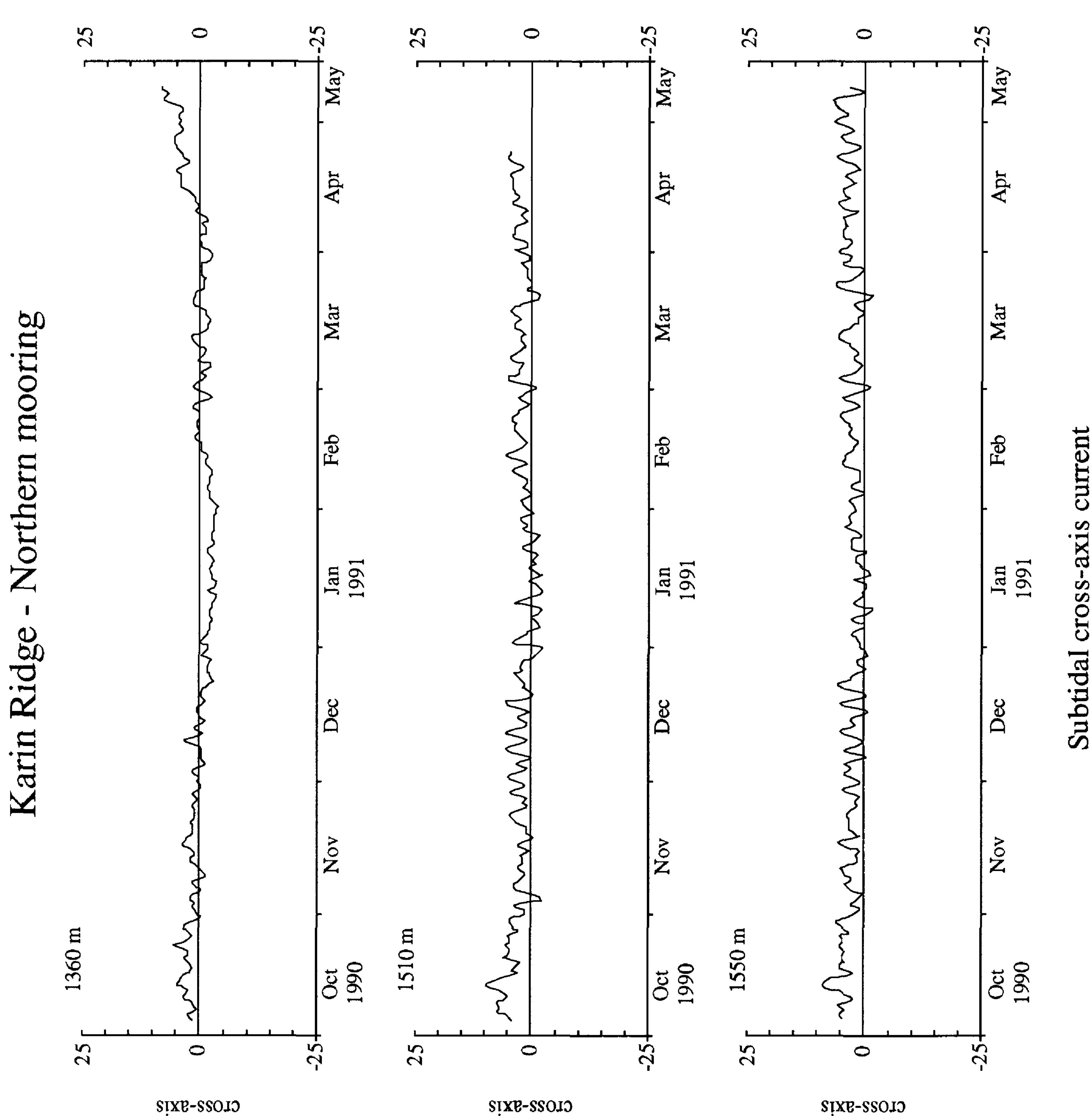
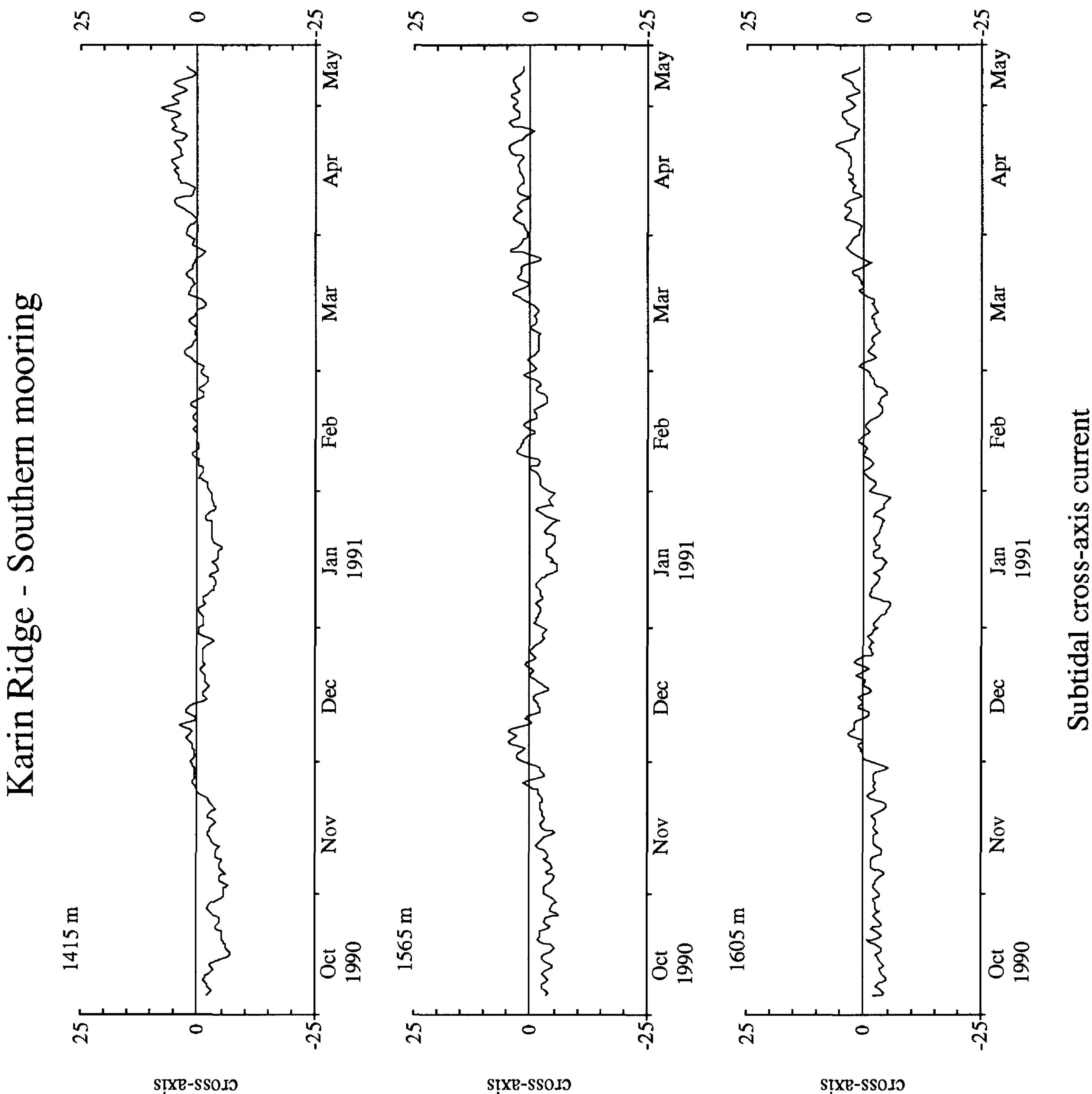
1565 m
1605 m
cross-axis
35
0
-35
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May


Karin Ridge - Northern mooring
1360 m
1510 m
1550 m
along-axis
25
0
-25
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May
Subtidal along-axis current



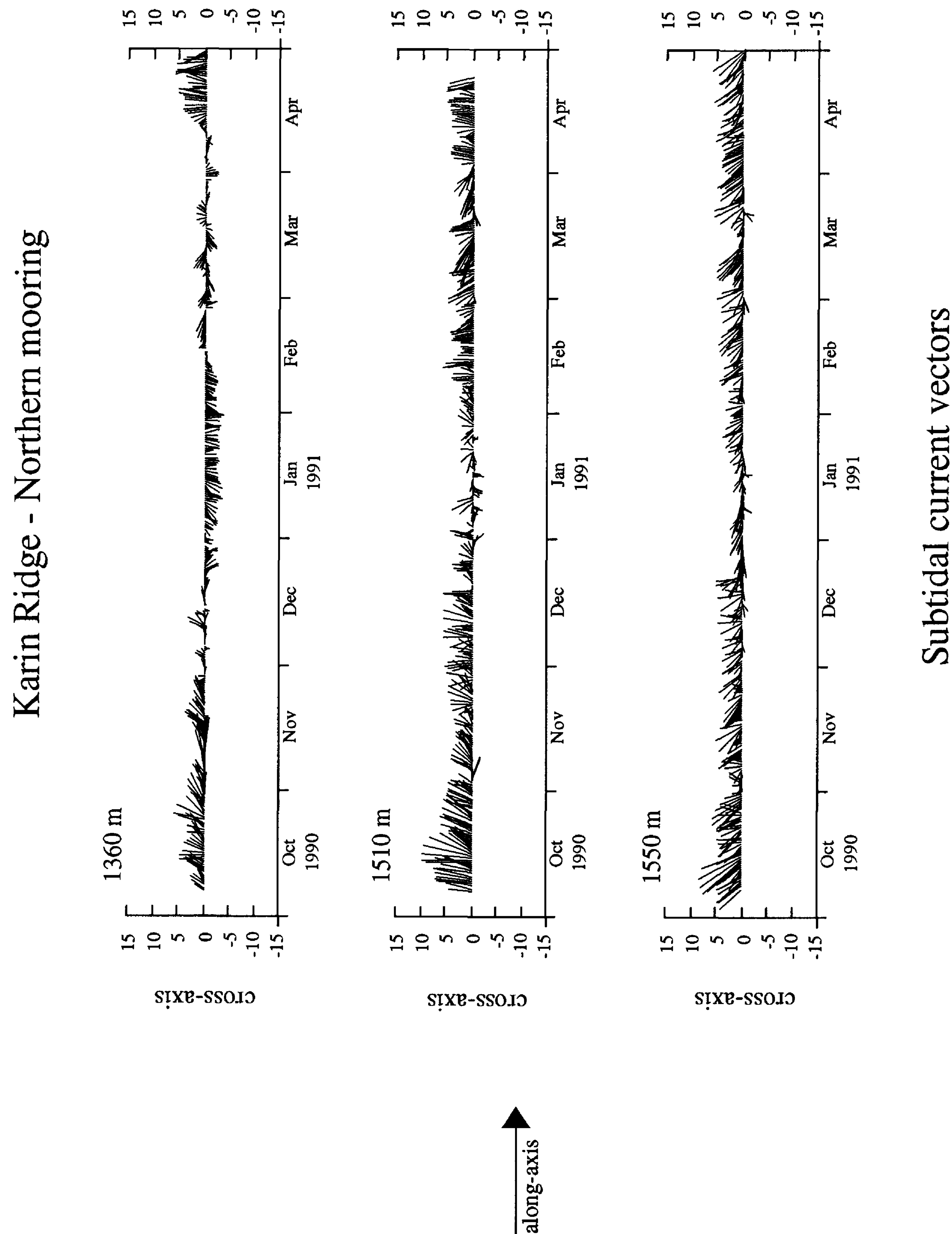
Karin Ridge - Southern mooring
1415 m
1565 m
1605 m
25
0
-25
along-axis
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May
Subtidal along-axis current

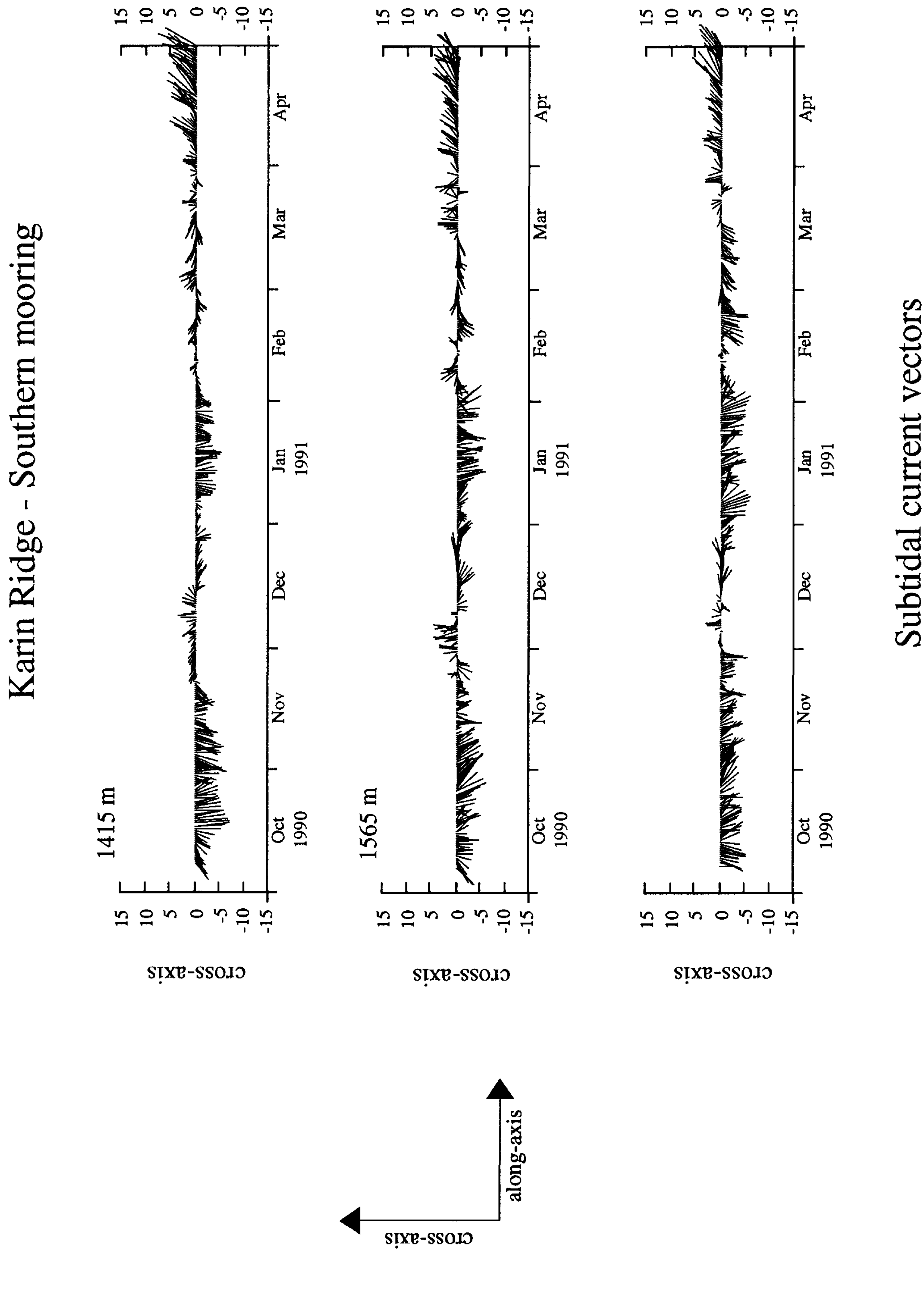

Karin Ridge - Northern mooring
1360 m
1510 m
1550 m
25
0
-25
cross-axis
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May
Subtidal cross-axis current


Karin Ridge - Southern mooring
1415 m
1565 m
1605 m
25
0
-25
cross-axis
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May
Subtidal cross-axis current

Appendix C - Subtidal current vectors

Plots of subtidal current vectors .... C 1 - C 2


Karin Ridge - Northern mooring
Subtidal current vectors
1360 m
1510 m
1550 m
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
15
10
5
0
-5
-10
-15
cross-axis
along-axis


Karin Ridge - Southern mooring
Subtidal current vectors
1415 m
1565 m
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
15 10 5 0 -5 -10 -15
cross-axis
along-axis

Appendix D - Variance-conserving auto spectra currents

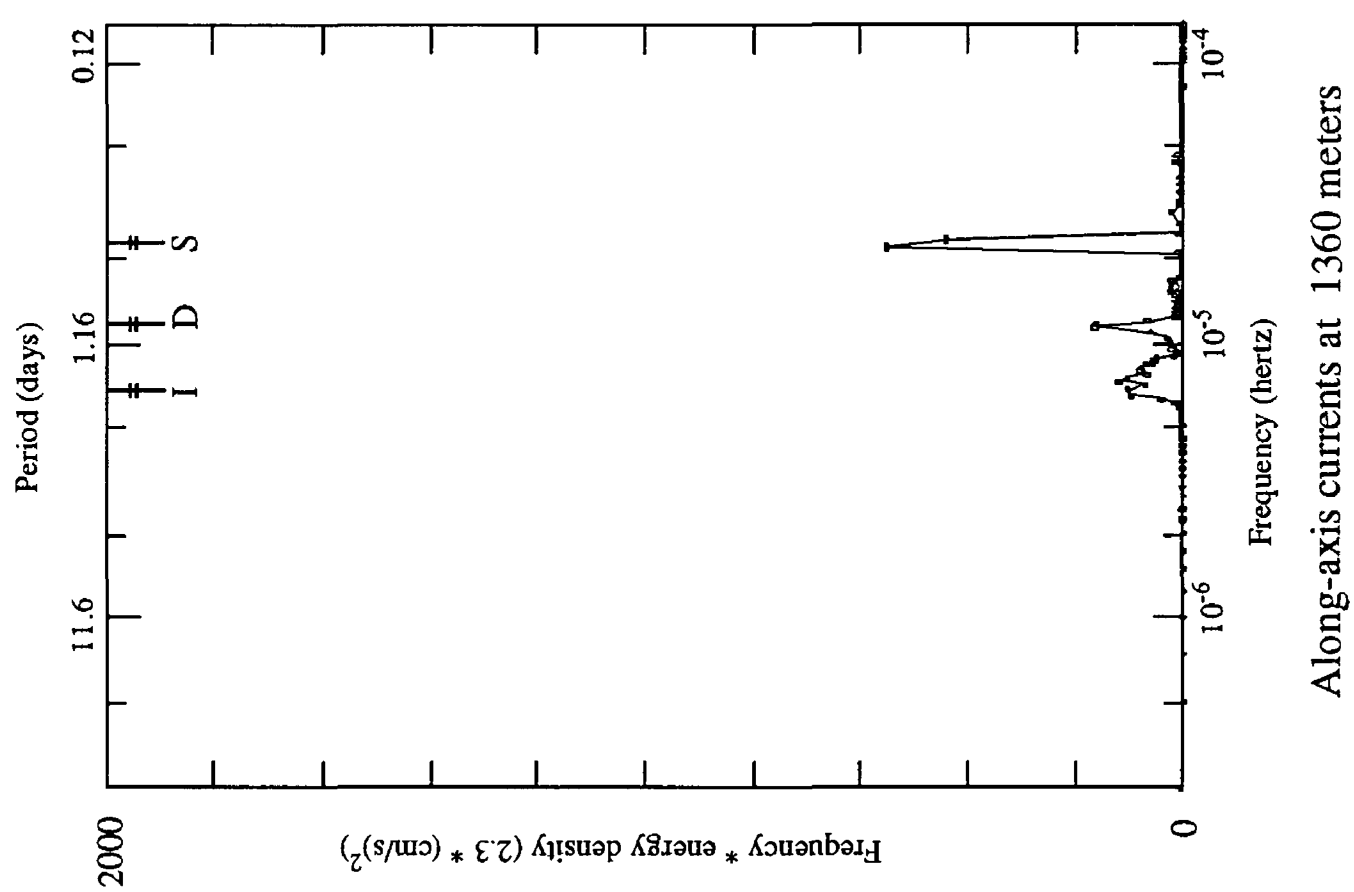
Table D1. - Dates and piece lengths used for current spectral plots D1

Variance-conserving auto spectra currents .... D2 - D7

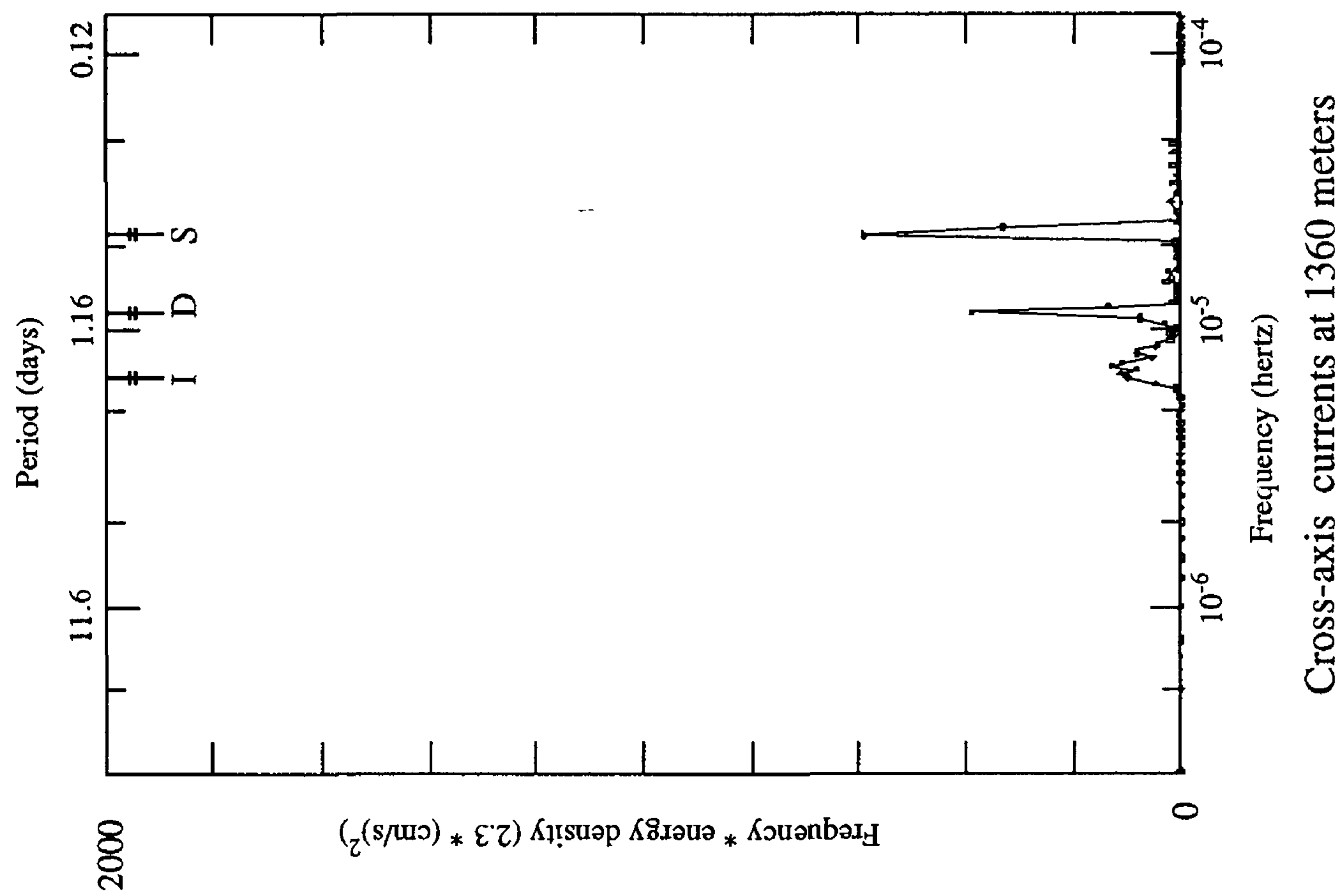
Site	Instrument depth	Mooring	Start time GMT (M/D/Y)	Stop time GMT (M/D/Y)	Piece length hours
north	1360	356-1	10/06/90	04/27/91	1104
north	1510	356-2	10/06/90	04/27/91	1104
north	1550	356-3	10/06/90	04/27/91	1104
south	1415	357-1	10/06/90	04/27/91	1104
south	1565	357-2	10/06/90	04/27/91	1104
south	1605	357-3	10/06/90	04/27/91	1104

Table D1. - Karin Ridge dates and piece lengths used for the spectral plots.

Northern mooring (356-1)



Along-axis currents at 1360 meters

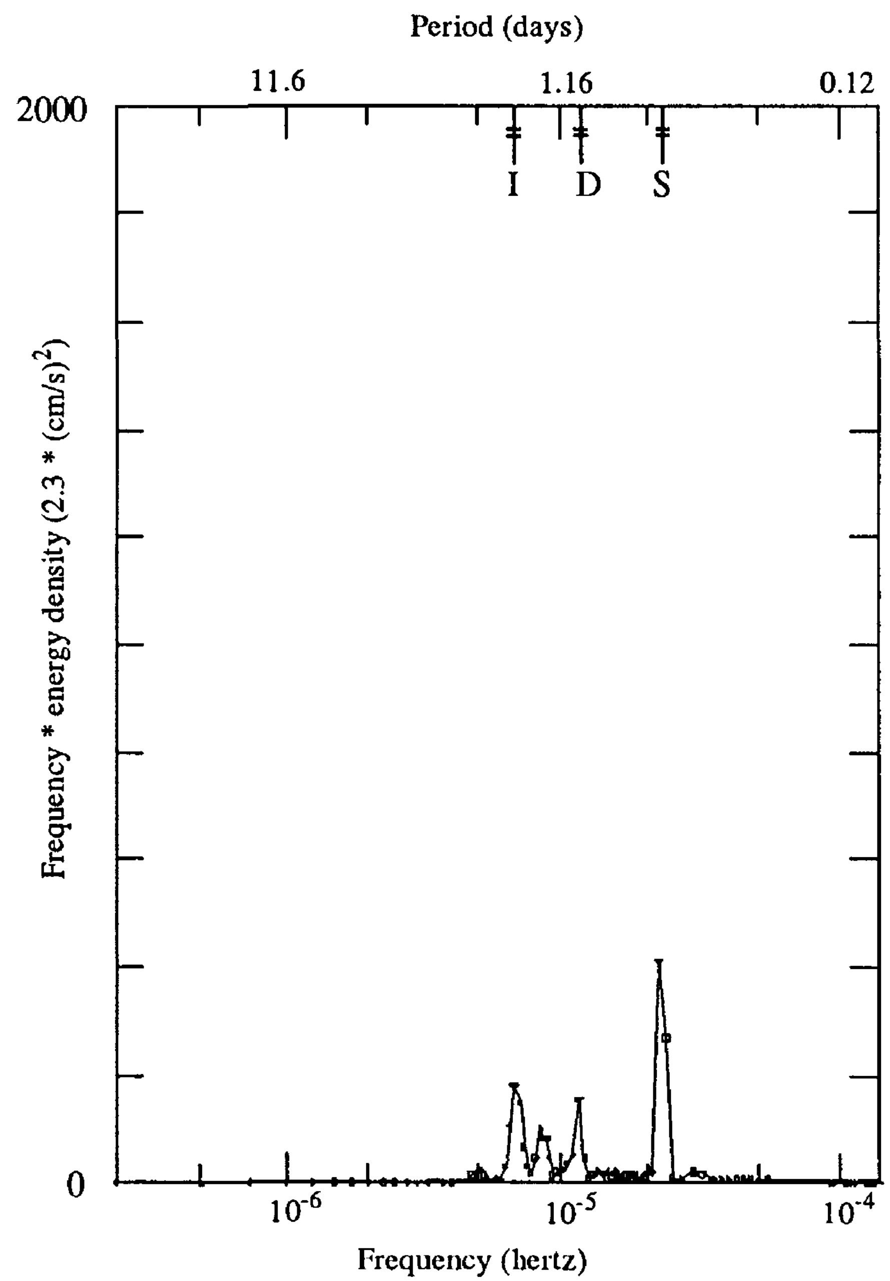


Cross-axis currents at 1360 meters

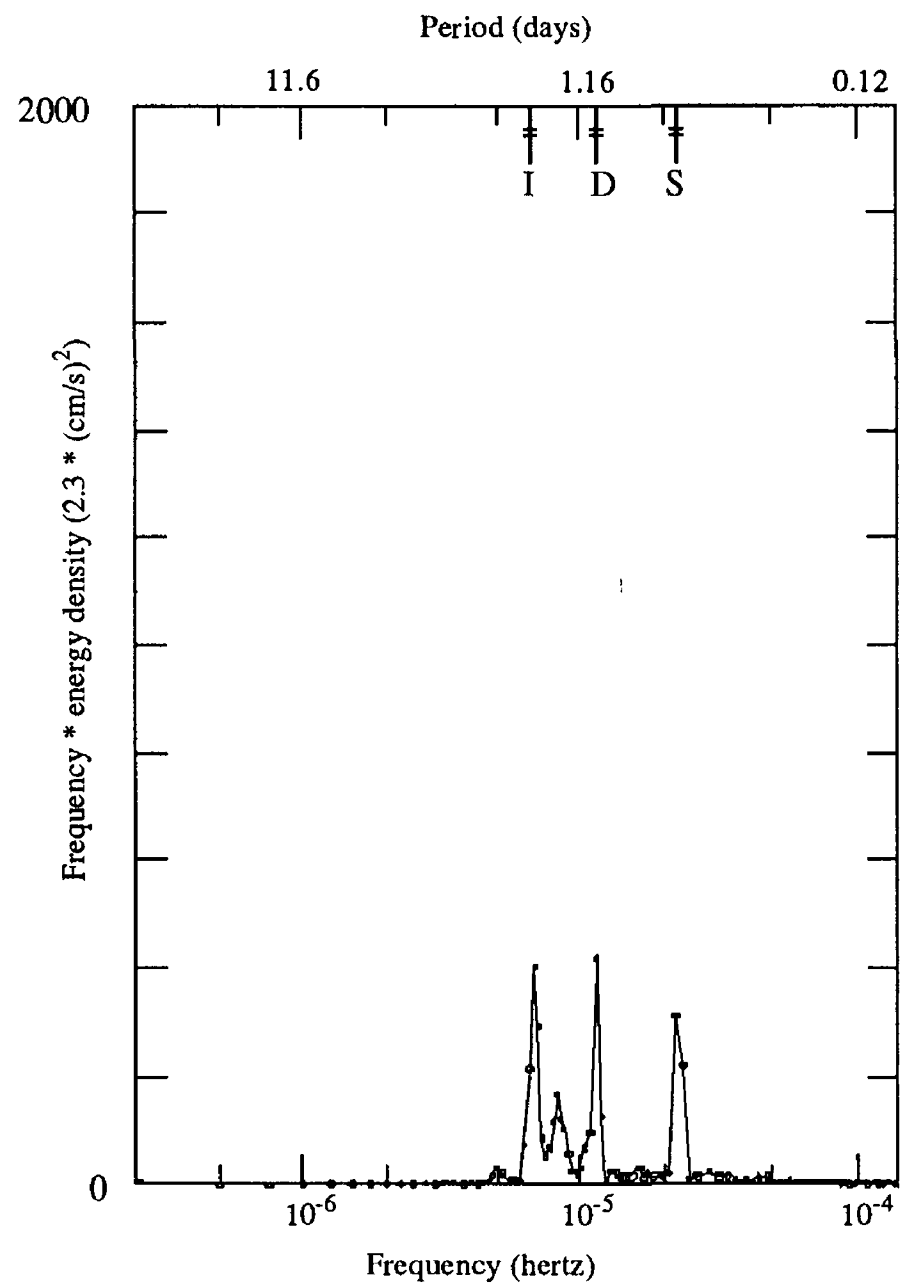
Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Northern mooring (356-2)



Along-axis currents at 1510 meters

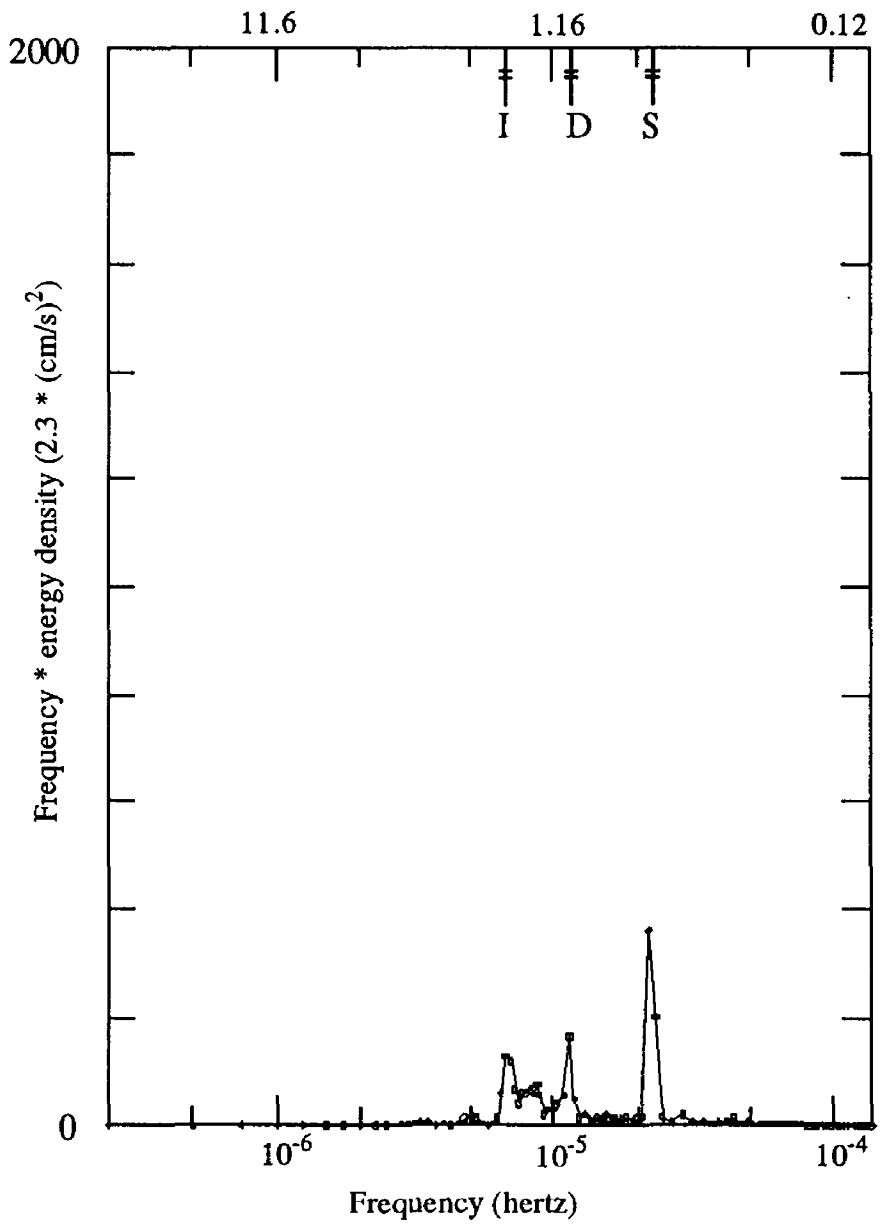


Cross-axis currents at 1510 meters

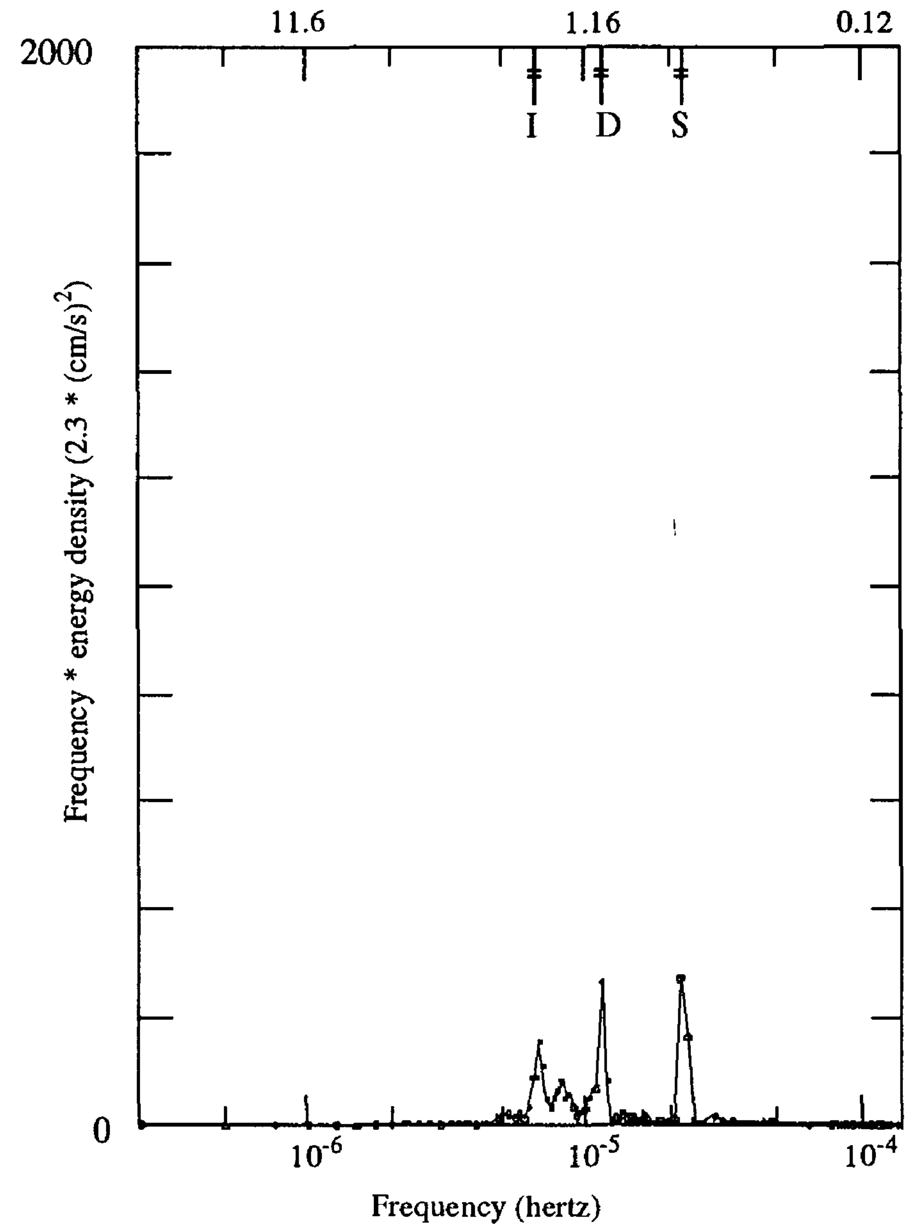
Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Northern mooring (356-3)



Along-axis currents at 1550 meters

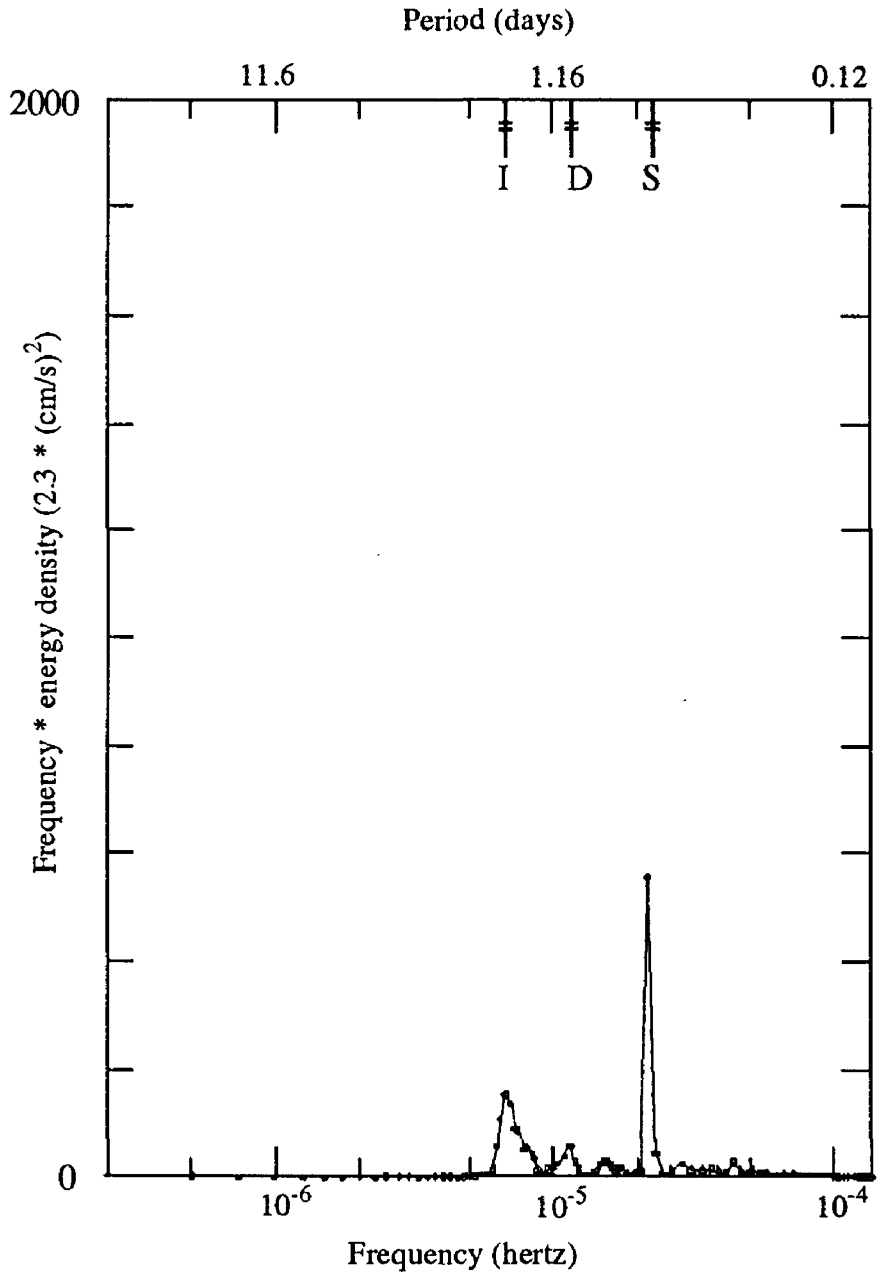


Cross-axis currents at 1550 meters

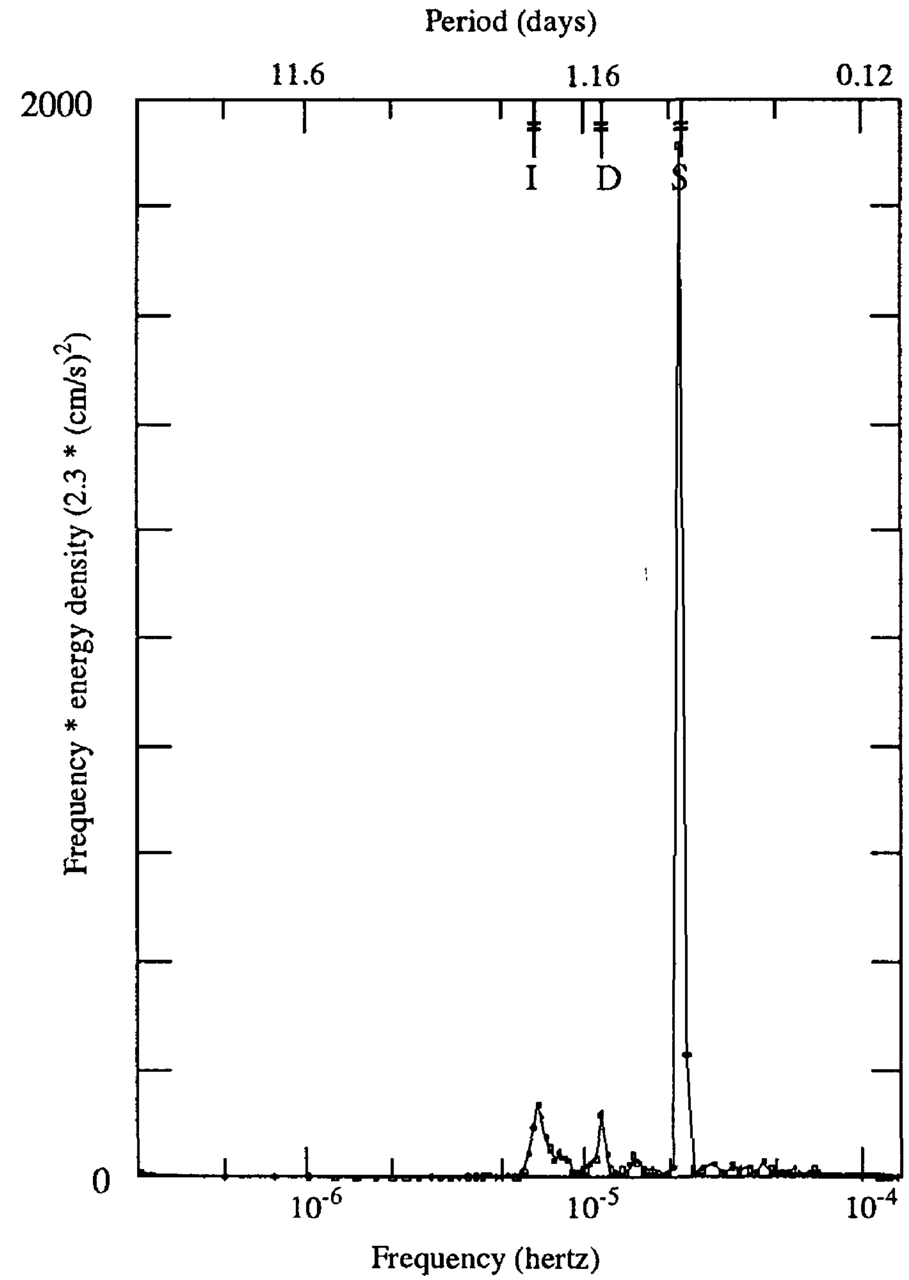
Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Southern mooring (357-1)



Along-axis currents at 1415 meters

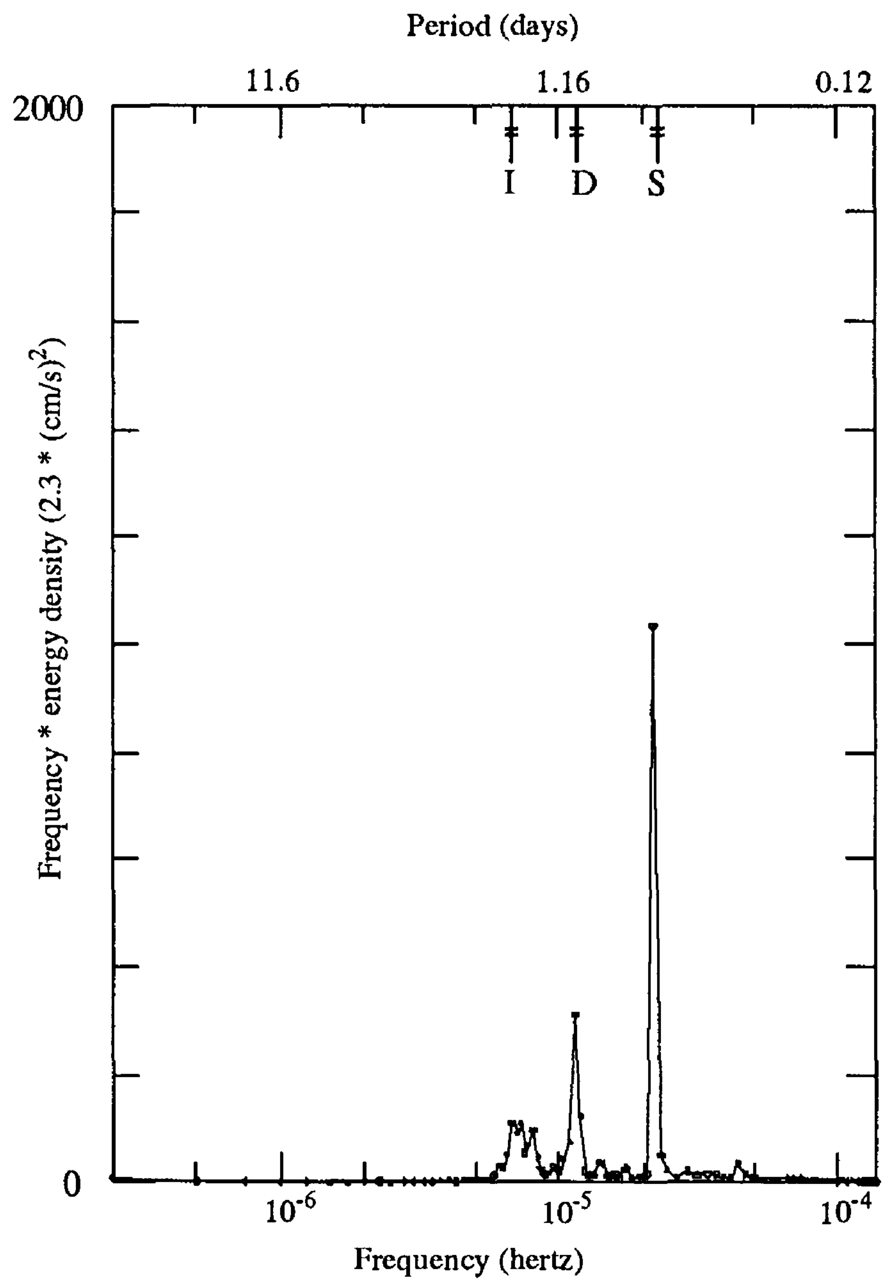


Cross-axis currents at 1415 meters

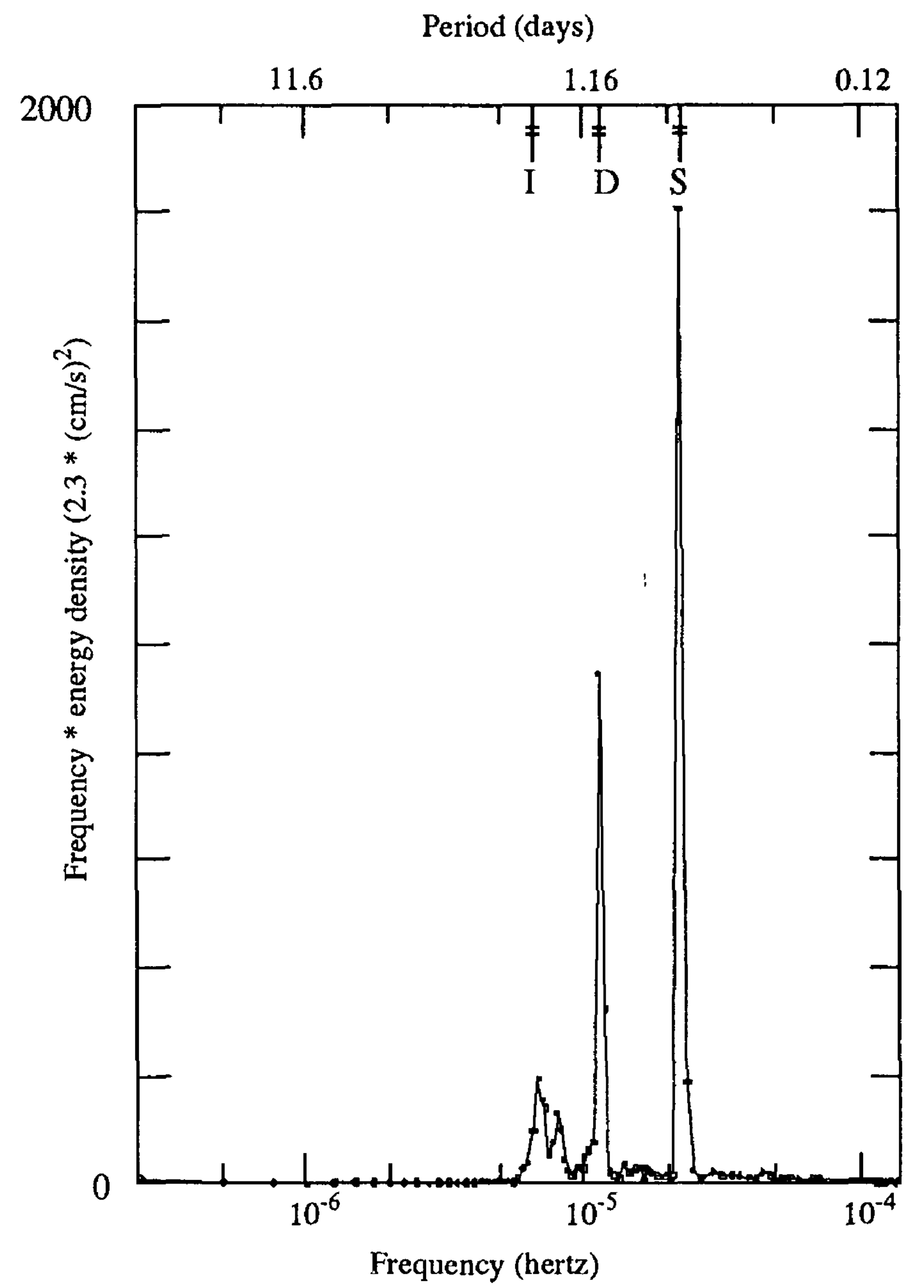
Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Southern mooring (357-2)



Along-axis currents at 1565 meters

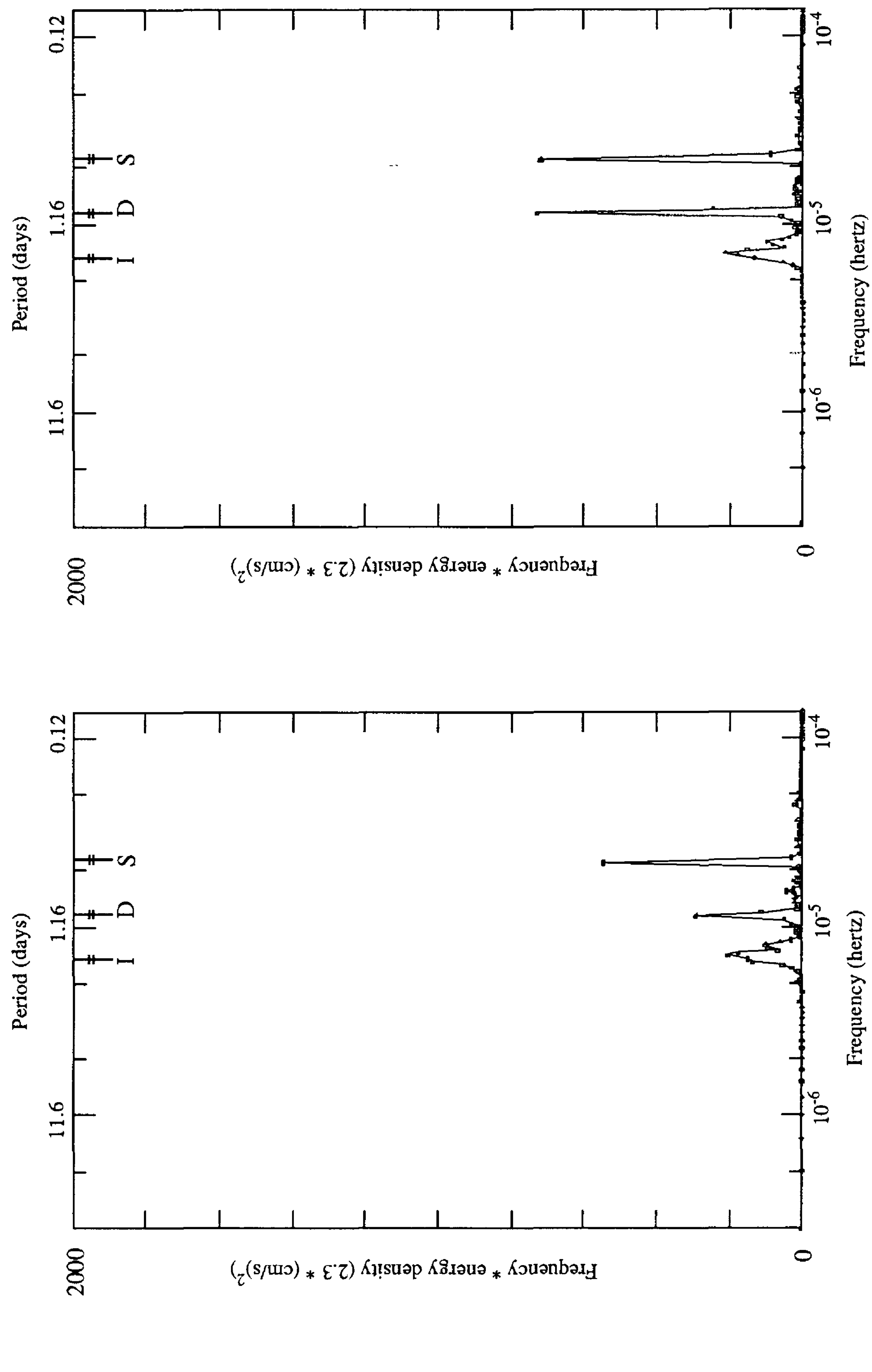


Cross-axis currents at 1565 meters

Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Southern mooring (357-3)



Along-axis currents at 1605 meters

Cross-axis currents at 1605 meters

Variance-conserving auto spectra for currents

(I = inertial, D = diurnal, S = semidiurnal)

Appendix E - Temperature

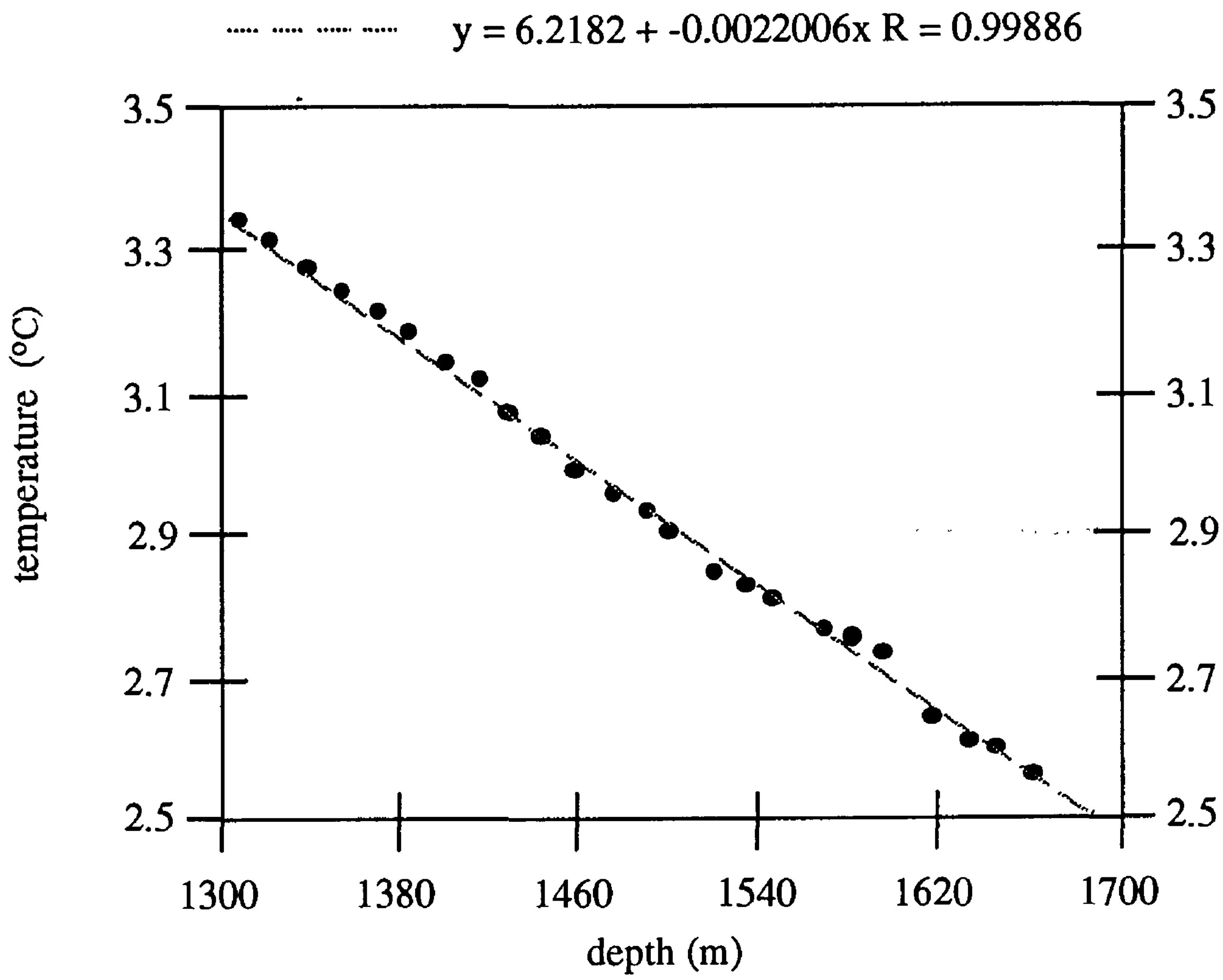
Temperature profiles E1

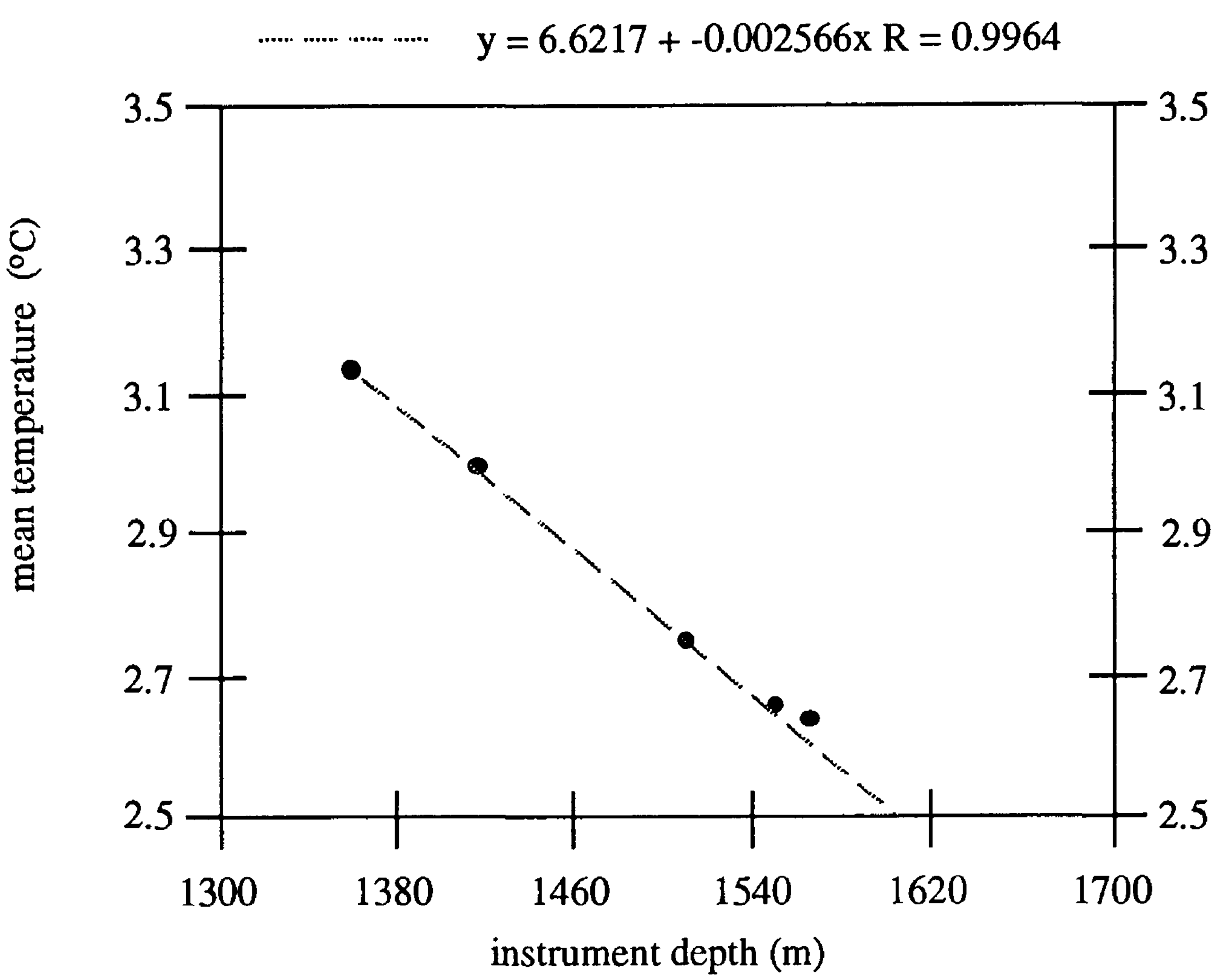
Plots of hour-averaged temperature .... E2 - E3

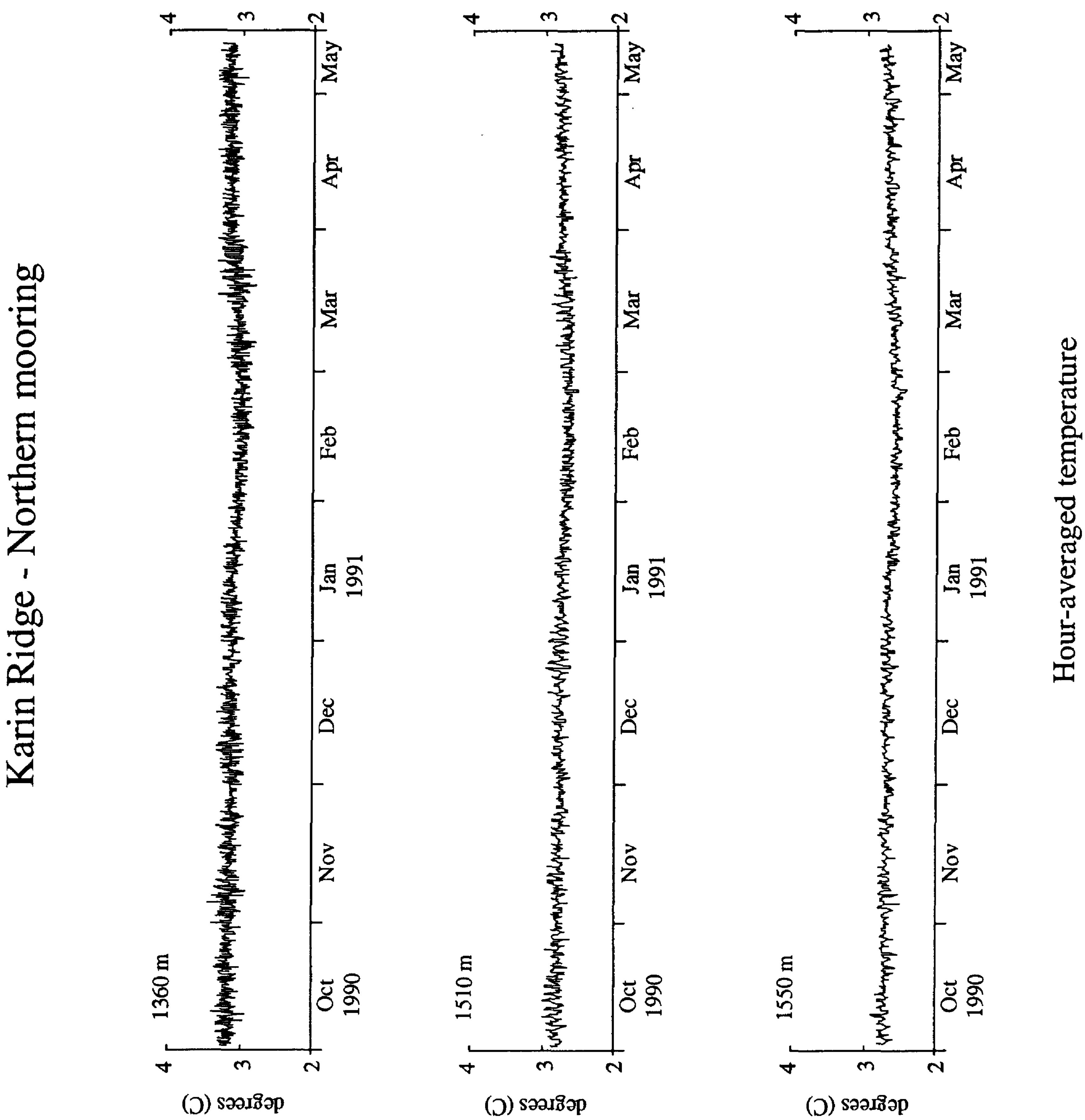
Variance-conserving auto spectra temperature .... E4 - E6

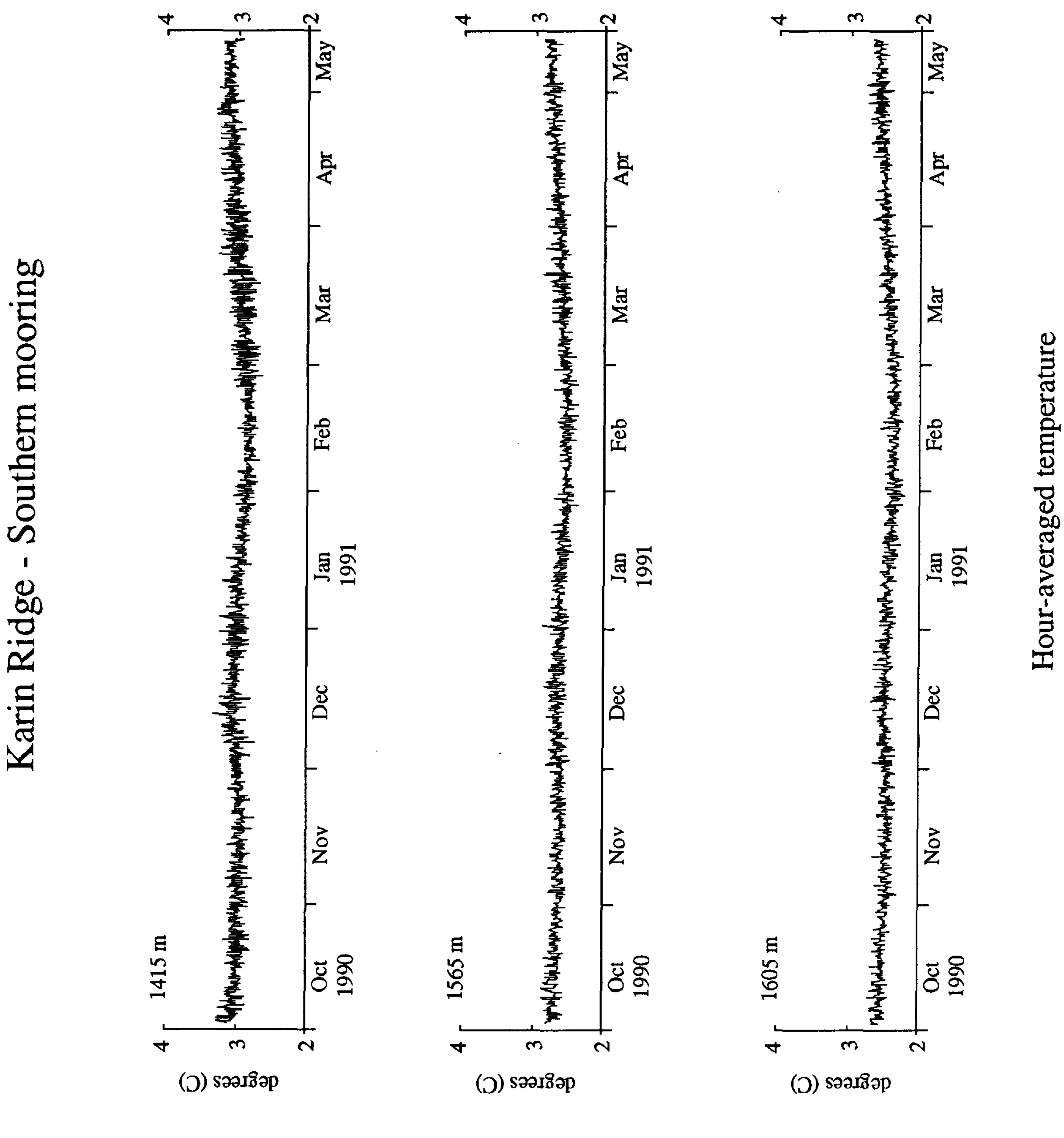
Plots of hour-averaged isotherm deflection .... E7 - E8

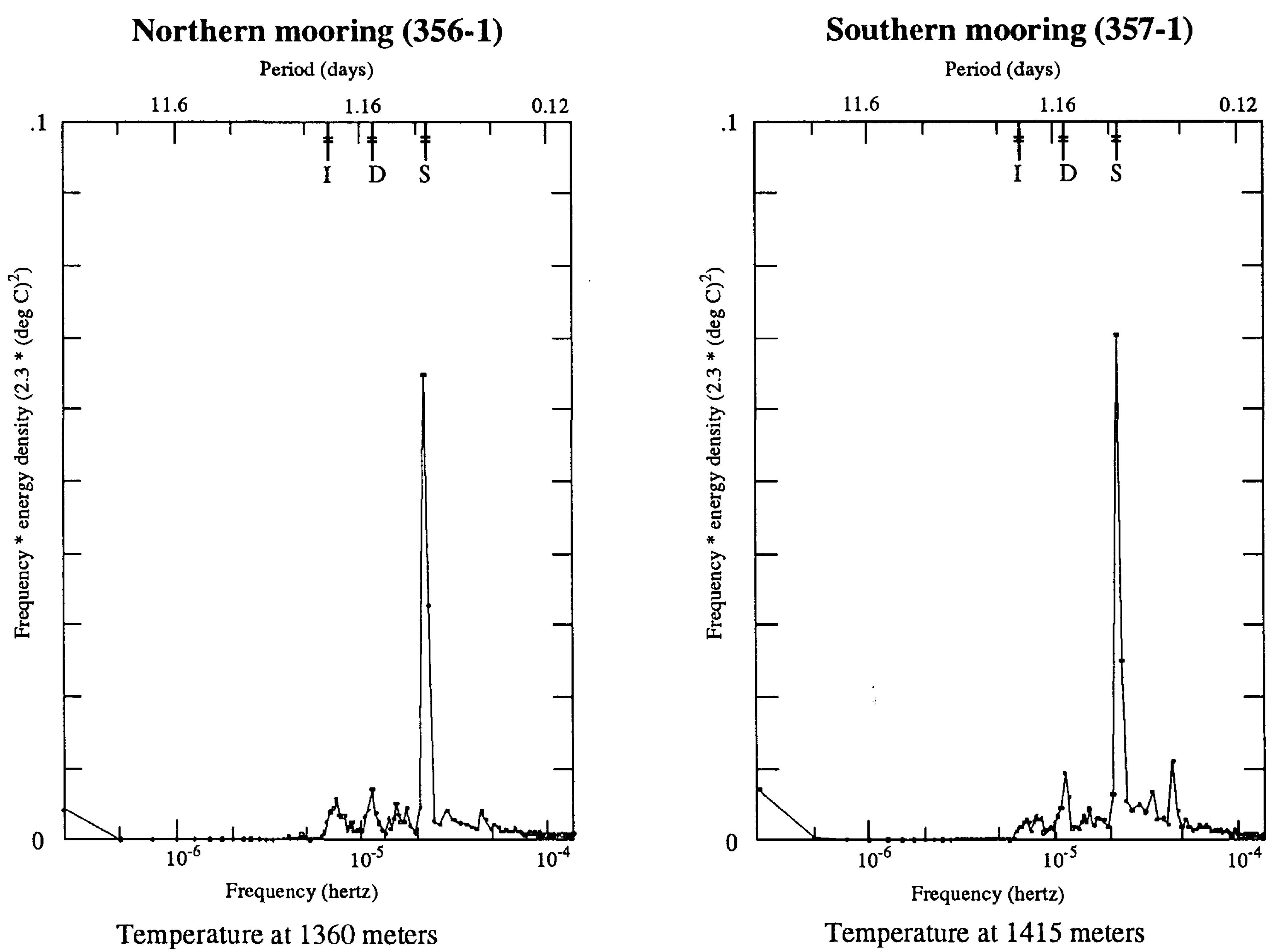
Temperature profiles





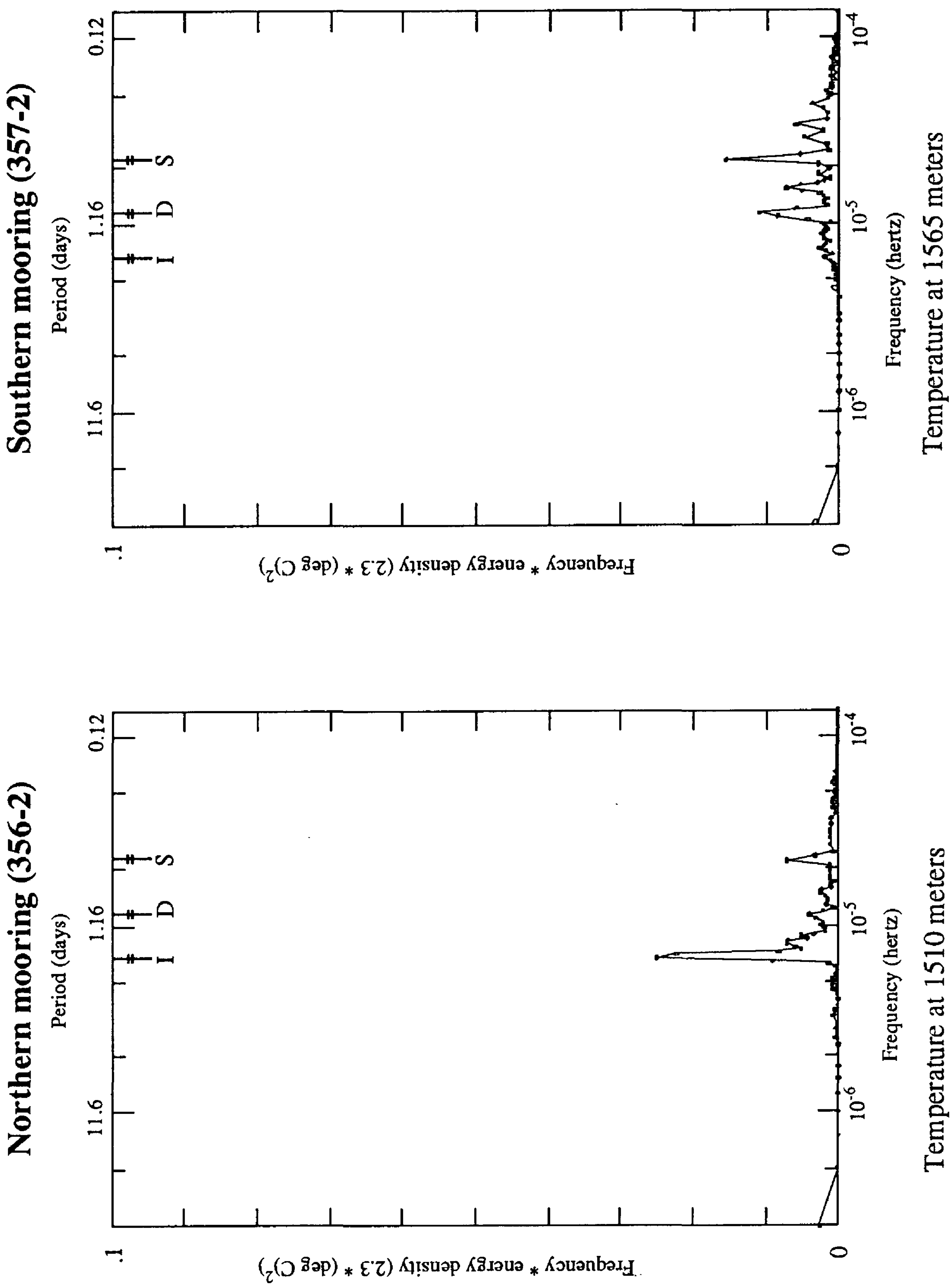

Karin Ridge - Northern mooring
1360 m
1510 m
1550 m
degrees (C)
4
3
2
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May
Hour-averaged temperature


Karin Ridge - Southern mooring
Hour-averaged temperature
1415 m
1565 m
1605 m
degrees (C)
4
3
2
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May



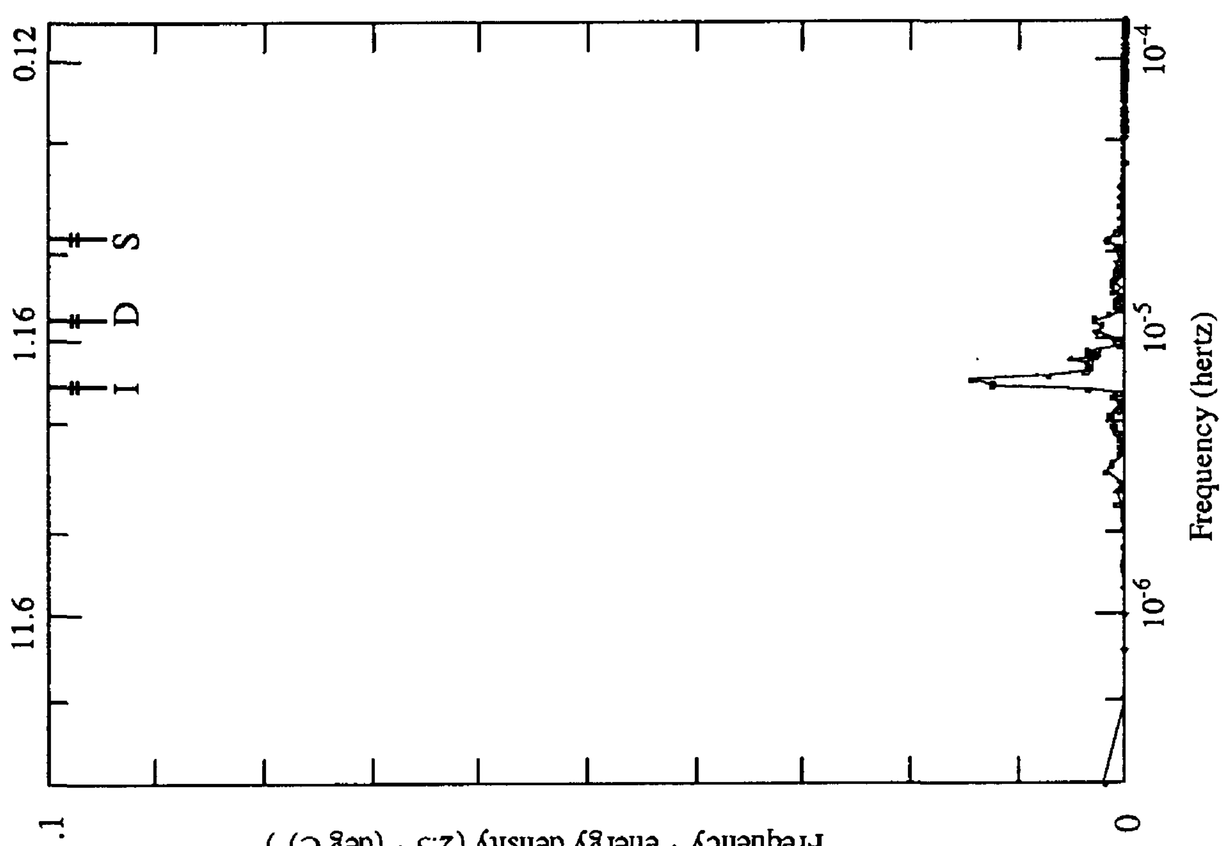
Variance-conserving auto spectra for temperature

(I = inertial, D = diurnal, S = semidiurnal)



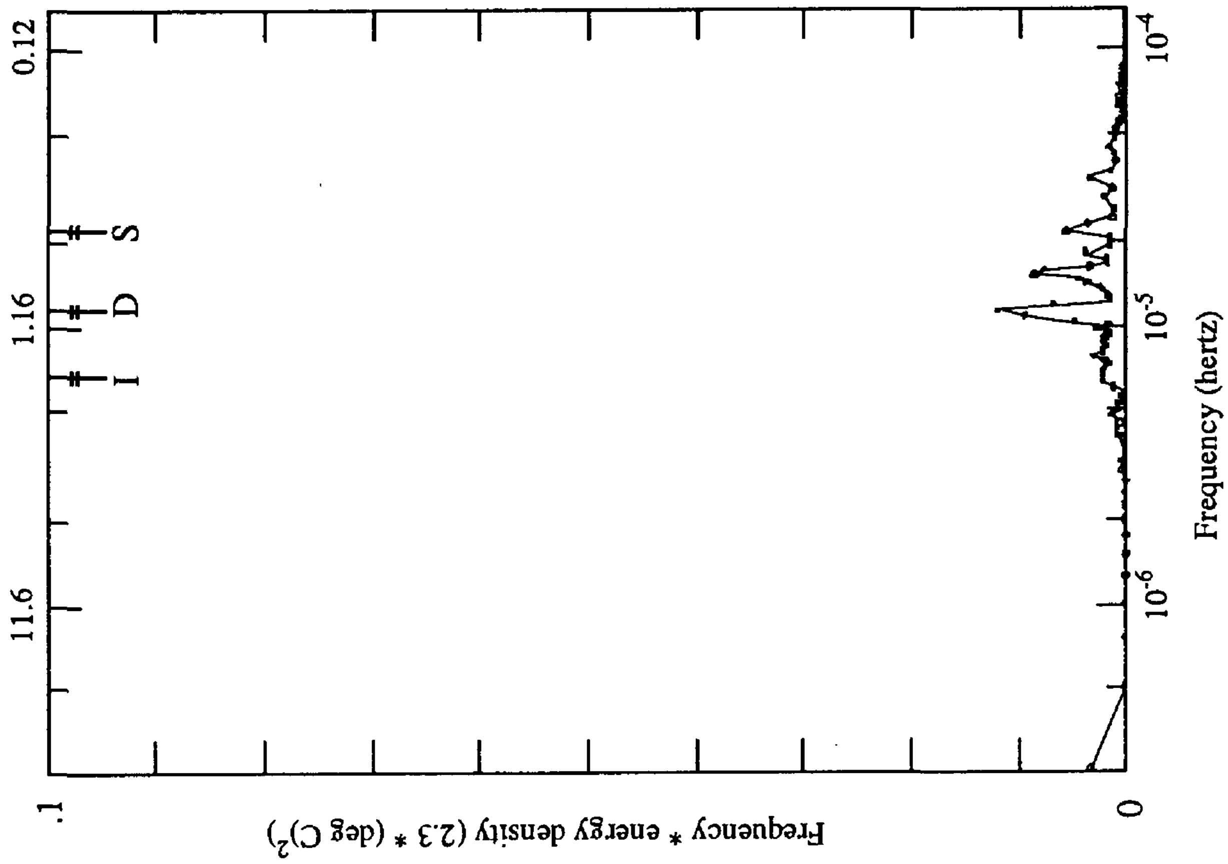
Variance-conserving auto spectra for temperature
(I = inertial, D = diurnal, S = semidiurnal)

Northern mooring (356-3)



Temperature at 1550 meters

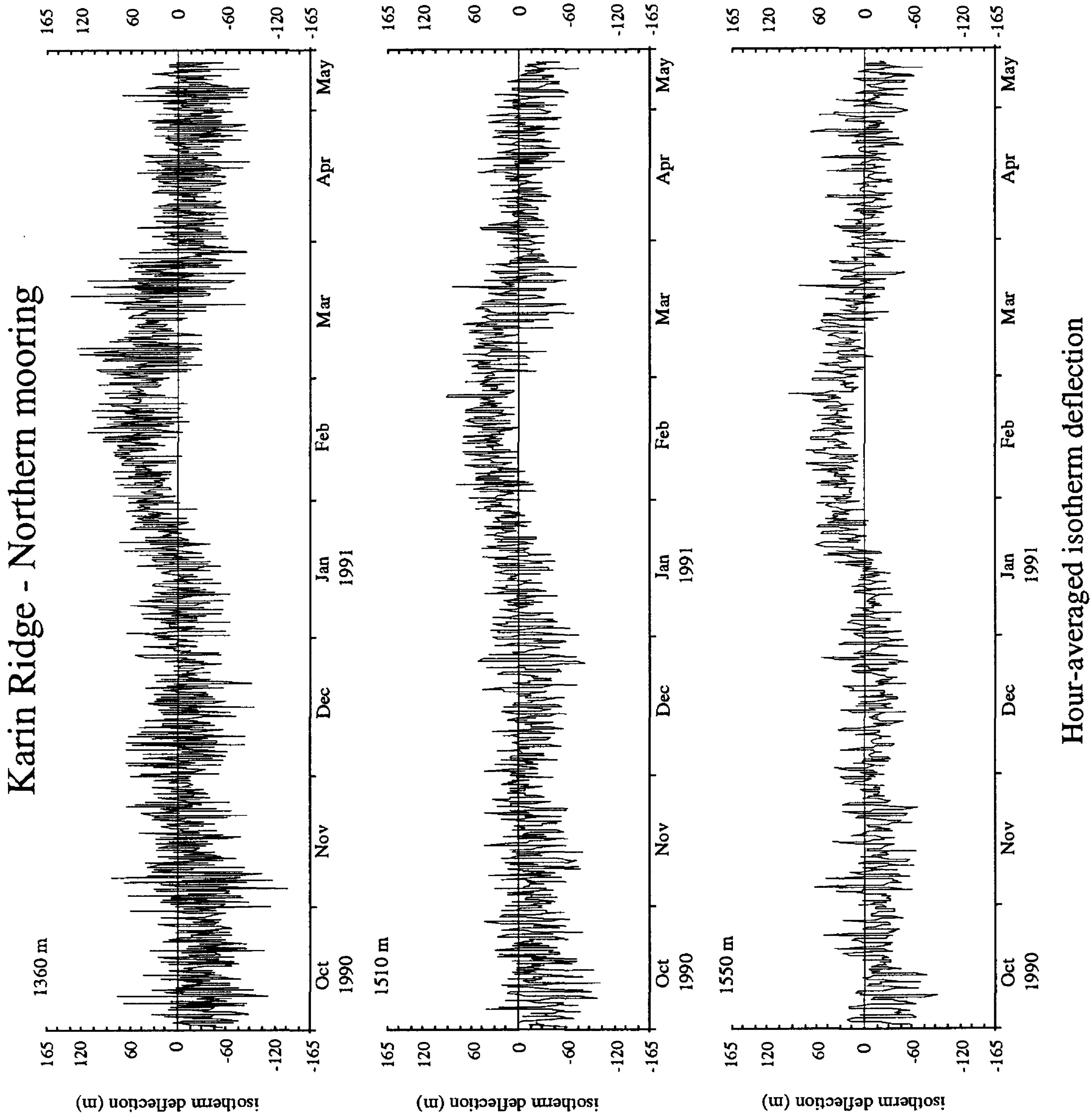
Southern mooring (357-3)

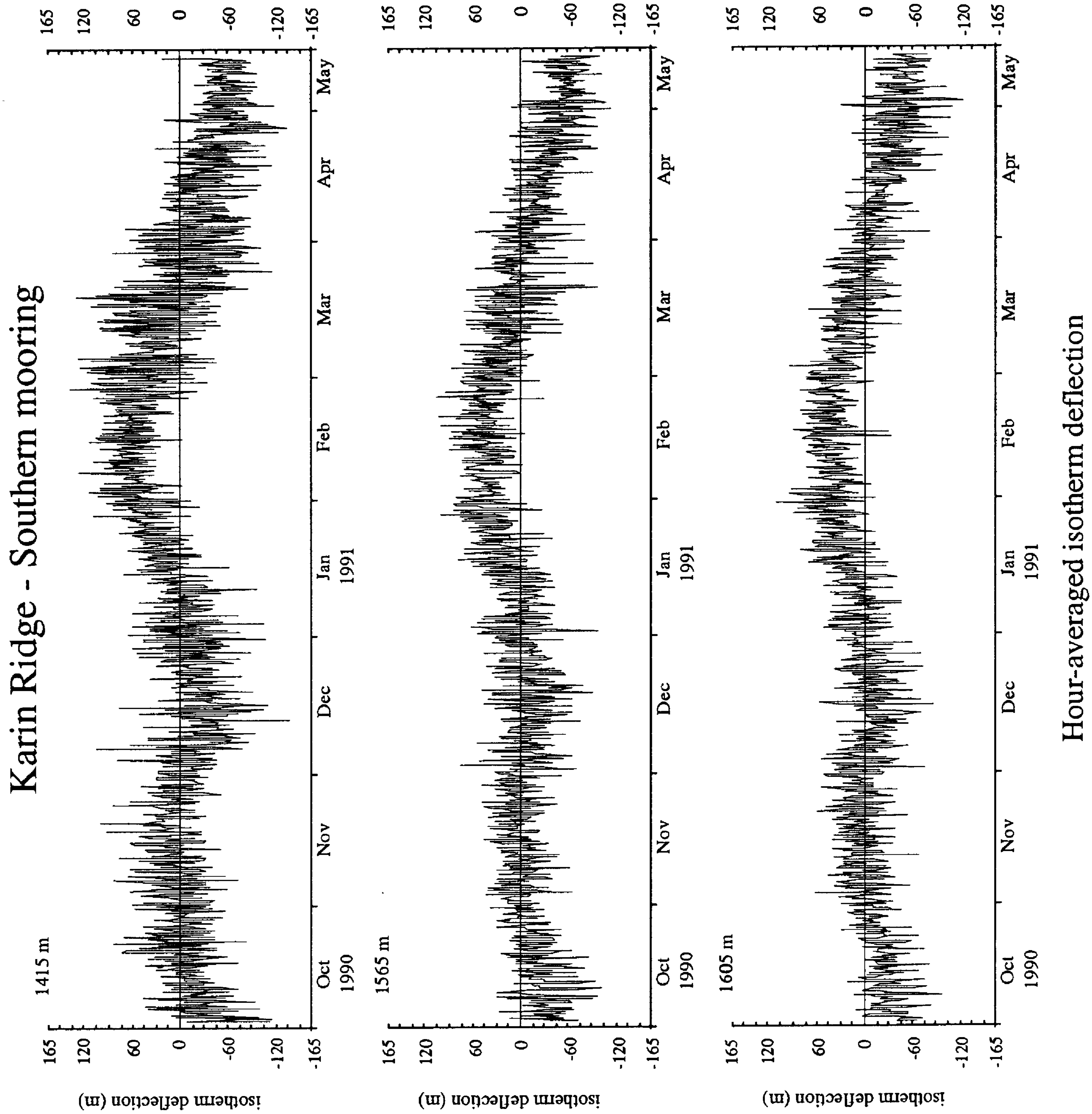


Temperature at 1605 meters

Variance-conserving auto spectra for temperature

(I = inertial, D = diurnal, S = semidiurnal)


Karin Ridge - Northern mooring
1360 m
1510 m
1550 m
isotherm deflection (m)
165
120
60
0
-60
-120
-165
Oct
1990
Nov
Dec
Jan
1991
Feb
Mar
Apr
May
Hour-averaged isotherm deflection


Karin Ridge - Southern mooring
Hour-averaged isotherm deflection
1415 m
1565 m
1605 m
isotherm deflection (m)
165
120
60
0
-60
-120
-165
Oct 1990
Nov
Dec
Jan 1991
Feb
Mar
Apr
May