School of OCEANOGRAPHY

OSU

OREGON STATE UNIVERSITY

A COMPILATION OF OBSERVATIONS FROM MOORED CURRENT METERS

Volume VI Oregon Continental Shelf
April-October 1972

by

R. D. Pillsbury, J. S. Bottero,
R. E. Still, W. E. Gilbert

National Science Foundation
Grant GX33502

Data Report 57 Reference 74-2

January 1974

School of Oceanography
Oregon State University
Corvallis, OR 97331

A COMPILATION OF OBSERVATIONS FROM MOORED CURRENT METERS
Volume VI

OREGON CONTINENTAL SHELF
April-October 1972

by

R. D. Pillsbury
J. S. Bottero
R. E. Still
W. E. Gilbert

Data Report 57
Reference 74-2
January 1974

National Science Foundation
Grant GX 33502

TABLE OF CONTENTS

ABSTRACT

Aanderaa recording current meters, moored in CUE-I off the Oregon coast at specific depths along both the Newport hydrographic line and perpendicular to the isobaths off Depoe Bay, were set to measure water temperature, current speed, current direction and, in some cases, pressure. In addition, surface buoy meteorological stations were moored at points along these same lines to measure wind speed, direction and air and water temperature. Data from each current meter string are shown by means of pertinent statistics, real time plots of hourly values, progressive vector diagrams and rotary spectra. The appendices describe the actual operation of the Aanderaa current meter and the methods used to process the data.

Introduction

During the summer of 1972 as a part of Coastal Upwelling Experiment Phase I (CUE-I), the Coastal Upwelling Group at Oregon State University (O.S.U.) undertook the measurement of currents and winds off the Oregon coast. CUE-I was a large multi-institutional field experiment with current meter measurements which were complimented by simultaneous collection of atmospheric and hydrographic data. The hydrographic data are published in a series of data reports (Anonymous, 1972a-e, and Halpern and Holbrook, 1972). The atmospheric data, including the wind data from the O.S.U. buoys, will be accomplished by publication in a two-volume atlas (O'Brien, 1972 and 1974). A special upper layer study using A.M.F. vector averaging current meters was done by the Pacific Oceanographic Laboratory, (Halpern, Holbrook, and Reynolds, 1973). Profiling current meters were deployed during CUE-I by the University of Miami. Vertical current meters were deployed by Woods Hole Oceanographic Institution. (Deckard, 1974).

This report is a final one giving error-free descriptions of the current meter data. An earlier version called a "quick look" report was distributed to participating scientists, (O'Brien and Tamura, 1972).

The Core Current Meter Program

The core array of current meters during CUE-I consisted of two lines of current meter strings. The first of these was along the Newport hydrographic line (Figure 1). This was chosen primarily for historical reasons. O.S.U. has monitored hydrographic conditions on this line for more than fifteen years, and these historical data would be relevant to the understanding of CUE-I data. The second line was perpendicular to the isobaths off Depoe Bay. Again this line has historical significance, since current meters had been

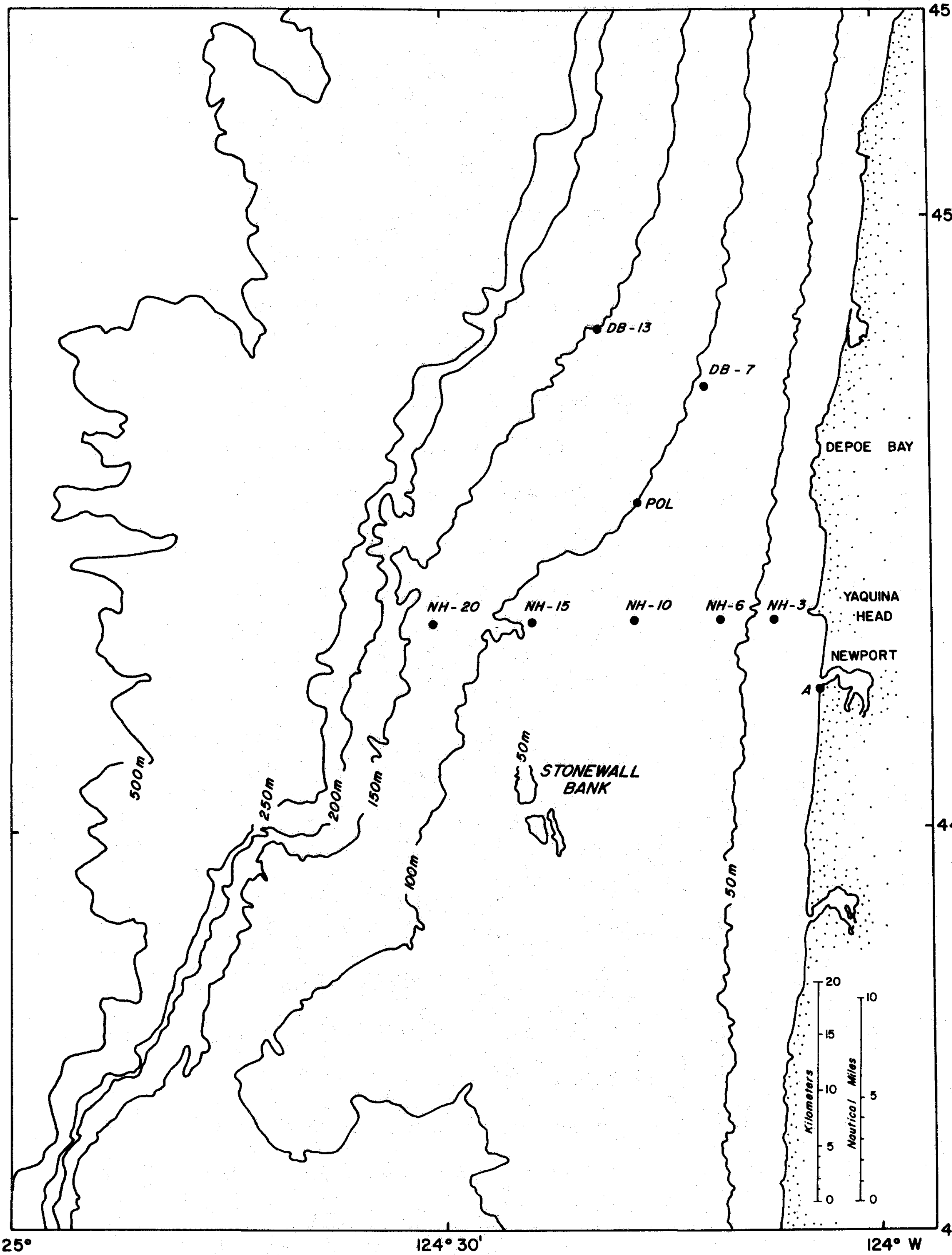
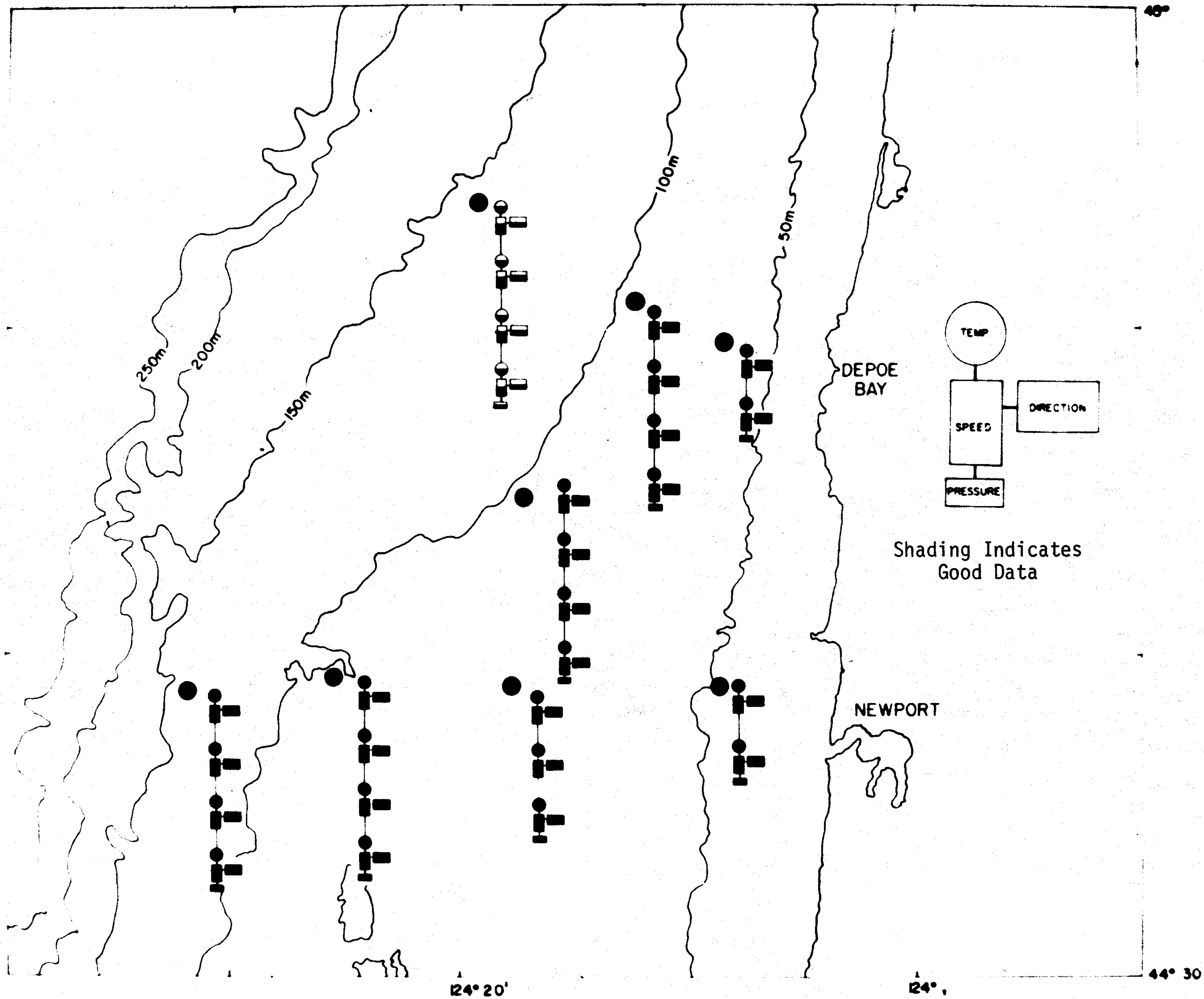

45° 10'
45° N
44° 30'
44° 10'
125°
124° 30'
124° W
DB-13
DB-7
POL
DEPOE BAY
NH-20
NH-15
NH-10
NH-6
NH-3
YAQUINA
HEAD
NEWPORT
A
STONEWALL
BANK
50m
500m
250m
200m
150m
100m
50m
Kilometers
Nautical Miles
20
15
10
5
0
10
5
0

Figure 1



45°
250m
200m
150m
100m
50m
DEPOE
BAY
NEWPORT
TEMP
SPEED
DIRECTION
PRESSURE
Shading Indicates
Good Data
124° 20'
124°
44° 30

Figure 2

placed there previously (Pillsbury, Smith, and Pattullo, 1970).

The distribution of instruments on these lines varied some during CUE-I, but the arrangement during late July is shown in Figure 2. The mooring was a subsurface taut wire, similar in design to that described by Pillsbury, Smith, and Tipper, (1969).

No current meters were lost. The percent of data recovery from the current meters defined as:

$$\text{percent data recovery} = \frac{\text{days of data (speed and direction)}}{\text{days of potential data}} \times 100\%$$

was 81%. The meters operated more than this figure implies, and a data recovery rate for temperature data would be larger. Figure 3 shows the specific times that current meters operated.

Description of Processed Data

The data from each string of current meters is presented separately. The header page gives the pertinent information about the location of the string, the data interval, and a general statement about the quality of the data. The depth of the instruments is given two ways. The intended depth is based on mooring wire length and intended water depth. The actual depth is based on the mean pressure from the pressure sensor or on the actual water depth when there was no pressure sensor on the string.

Each meter has a serial number assigned to it by the manufacturer. Each successive tape recorded by that machine is numbered with the serial number and the tape number. Thus, 485/10 indicates the tenth tape from machine number 485.

The table of statistics presented next gives the arithmetic mean, the standard deviation, the skewness, kurtosis, the maximum value, and the min-

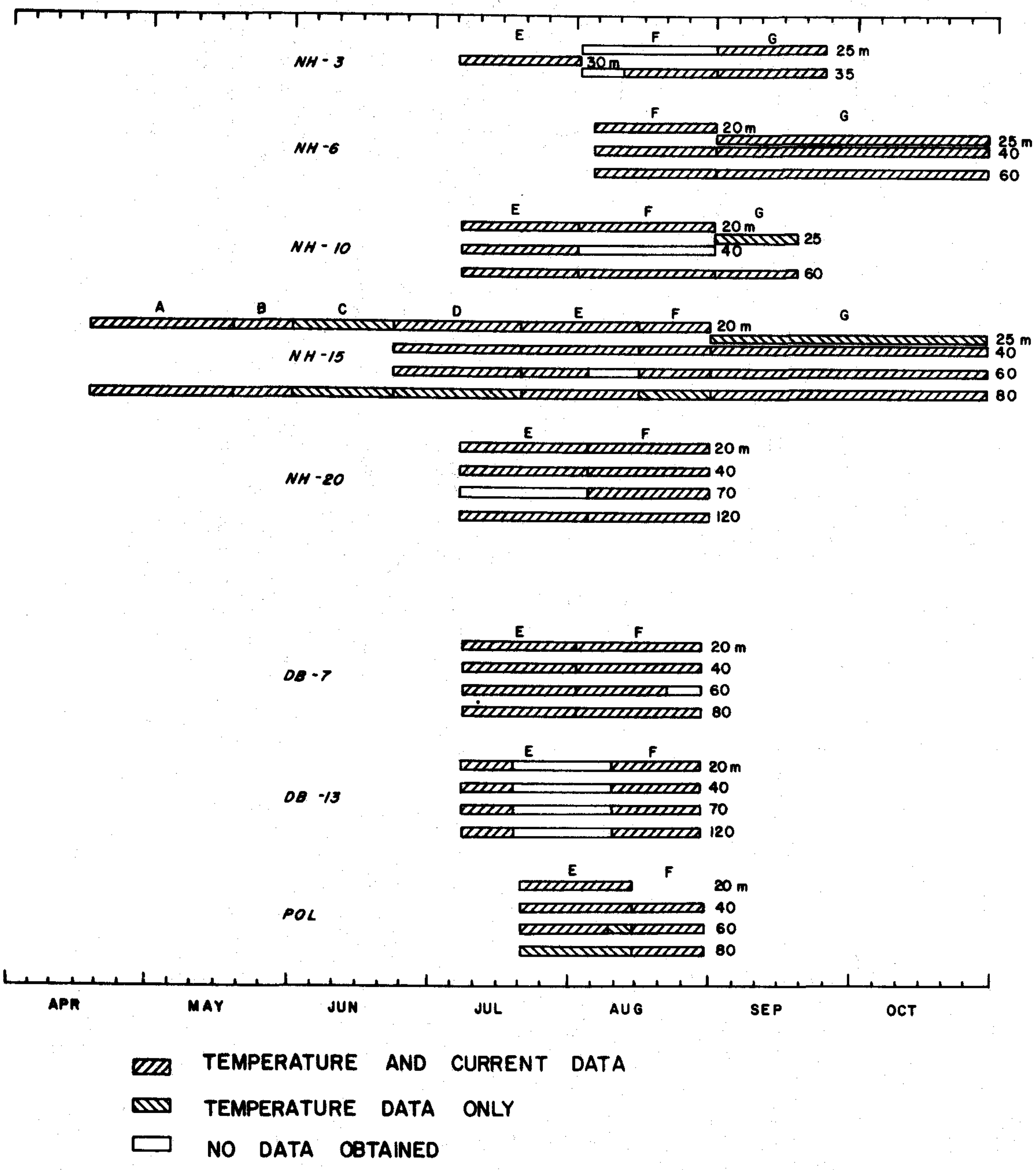

NH-3
E
F
G
25 m
30 m
35
NH-6
F
G
20 m
25 m
40
60
NH-10
E
F
G
20 m
25
40
60
NH-15
A
B
C
D
E
F
G
20 m
25 m
40
60
80
NH-20
E
F
20 m
40
70
120
DB-7
E
F
20 m
40
60
80
DB-13
E
F
20 m
40
70
120
POL
E
F
20 m
40
60
80
APR
MAY
JUN
JUL
AUG
SEP
OCT
TEMPERATURE AND CURRENT DATA
TEMPERATURE DATA ONLY
NO DATA OBTAINED

Figure 3

imum value. Each meter record is identified in this table by intended meter depth.

Real time plots of the hourly values follow the table of statistics. (For a discussion of the filter used to produce these hourly values, see the Appendix 2). For ease in comparison, the plots have been grouped by true east-west (U) components and true north-south (V) components where possible. Progressive vector diagrams (PVD's) are all scaled to page size, and all scale numbers are in kilometers. These plots represent a pseudotrajectory and each dot on the PVD is midnight of successive days. Spectra presented are rotary spectra as discussed by Mooers (1970) and Pillsbury (1972). Figure 4 shows the conversion from cycles/hour to cycles/day.

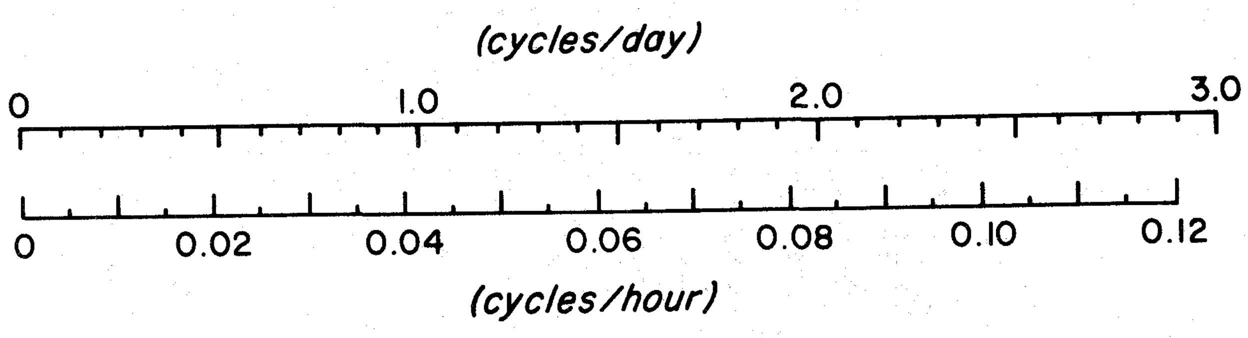


Figure 4

REFERENCES

Anonymous, 1972a. CUE-I Preliminary Hydrographic Data Report, YAQUINA cruise Y7206C, 19-23 June 1972. School of Oceanography, Oregon State University. CUEA Data Report No. 1. 96 pp.

________. 1972b. CUE-I Hydrographic Data Report, YAQUINA cruise Y7207A, 5-9 July 1972. School of Oceanography, Oregon State University. CUEA Data Report No. 2. 104 pp.

________. 1972c. CUE-I Hydrographic Data Report, YAQUINA cruise Y7207B, 10-18 July 1972. School of Oceanography, Oregon State University. CUEA Data Report No. 3. 93 pp.

________. 1972d. CUE-I Hydrographic Data Report, YAQUINA cruise Y7207E, 10-18 July-7 August 1972. School of Oceanography, Oregon State University. CUEA Data Report No. 5. 83 pp.

________. 1972e. CUE-I Hydrographic Data Report, YAQUINA cruise Y7208C, 22-23 August 1972. School of Oceanography, Oregon State University. CUEA Data Report No. 6. 50 pp.

Deckard, D. E. 1974. Vertical current measurement in the Oregon coastal upwelling region. Master's thesis. Oregon State University, Corvallis. 57 pp.

Halpern, D. and J. R. Holbrook. 1972. STD Measurements off the Oregon Coast, July-August 1972. Pacific Oceanographic Laboratory, University of Washington, Seattle. CUEA Data Report No. 4. 381 pp.

Halpern, D., J. R. Holbrook, and R. M. Reynolds. 1973. Physical oceanographic observations made by the Pacific Oceanographic Laboratory off the Oregon coast during July and August 1972. CUEA Technical Report No. 3. Reference M73-46, University of Washington, Department of Oceanography, Seattle. 205 pp.

O'Brien, J. J. 1972. CUE-1 Meteorological Atlas, Vol. I. Reference M7265, University of Washington, Seattle. 310 pp.

O'Brien, J. J. 1974. CUE-1 Meteorological Atlas, Vol. II. (In press, University of Washington, Seattle).

O'Brien, J. J. and K. J. Tamura, eds. 1972. CUE NOTES, A Record of Coastal Upwelling Experiment CUE-I Off Oregon, Summer 1972. Oregon State University, Corvallis. No. 6. 21 pp.

Mooers, C. N. K. 1970. The interaction of an internal tide with the frontal zone of a coastal upwelling region. Doctoral dissertation. Oregon State University, Corvallis. 480 pp.

Pillsbury, R. D. 1972. A description of hydrography, winds, and currents during the upwelling season near Newport, Oregon. Doctoral dissertation. Oregon State University, Corvallis. 163 pp.

Pillsbury, R. D., R. L. Smith, and J. G. Pattullo. 1970. A compilation of observations from moored current meters and thermographs. Vol. III: Oregon Continental Shelf, May-June 1967, April-September 1968. 102 pp. (Oregon State University, Department of Oceanography Data Report No. 40 on National Science Foundation Grants GA-1435, GA-295, Office of Naval Research Contracts 1286 (10) and N00014-67-A-0369-0007, Project NR 083-102. Reference 70-3.)

Pillsbury, R. D., R. L. Smith, and R. C. Tipper. 1969. A reliable low-cost mooring system for oceanographic instrumentation. Limnology and Oceanography 14 (2): 307-311.

1972 CUE Installation A

NH 15

Position: 44°42.0'N, 124°21.1'W
Depth of Water: 97 m
Set at 2200 GMT 17 April 1972 by R/V CAYUSE
Retrieved at 1800 GMT 18 May 1972 by R/V YAQUINA
Data Interval: 2227 GMT 17 April to 1632 GMT 18 May

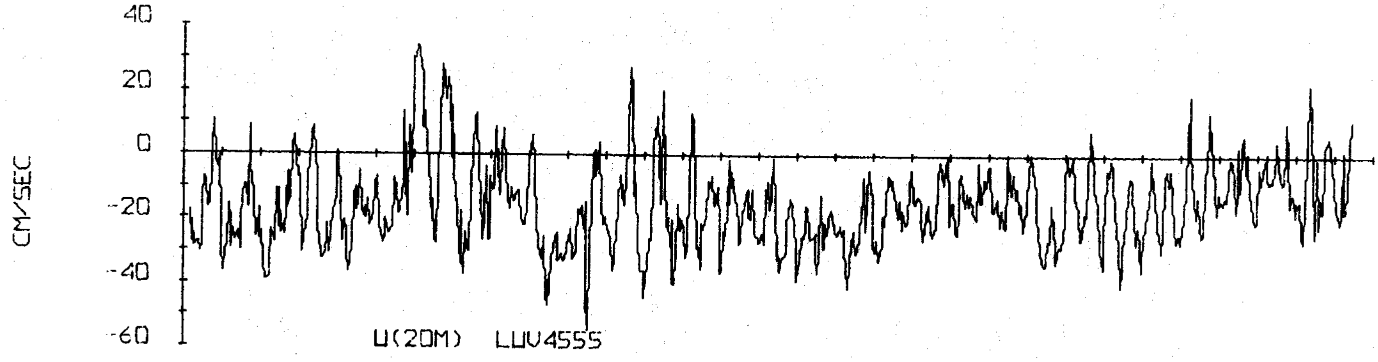
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	17 m	455/5
80 m	77 m	456/5

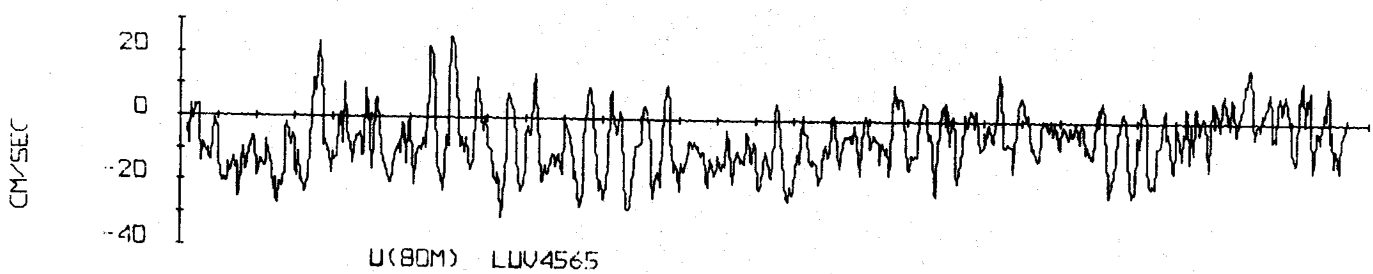
Data on speed, direction, and temperature were recorded every five minutes for the duration of the installation.

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	37.2	9.1	0.0	3.2	68.0	10.9
	U(cm/sec)	-15.2	13.3	0.7	3.9	33.9	-54.5
20m	V(cm/sec)	-30.7	10.9	0.8	6.0	30.8	-67.9
(4555)	T(C)	9.33	.26	0.80	4.84	10.50	8.65

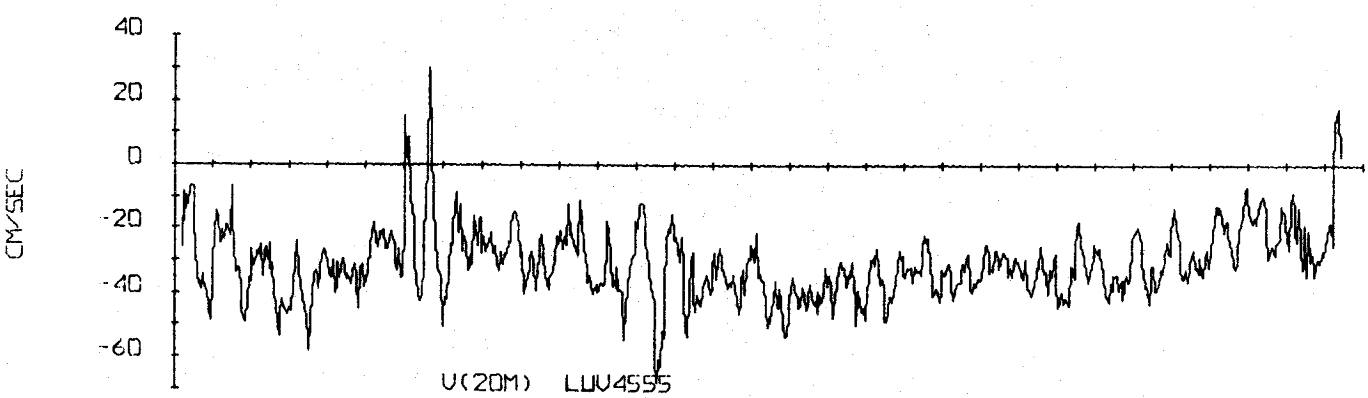
	S(cm/sec)	19.6	6.5	0.2	2.6	39.9	4.4
	U(cm/sec)	-6.8	9.5	0.3	2.9	25.4	-31.2
80m	V(cm/sec)	-14.2	9.4	0.8	4.4	20.9	-36.9
(4565)	T(C)	8.07	.14	0.52	2.60	8.50	7.80
	P	NONE					



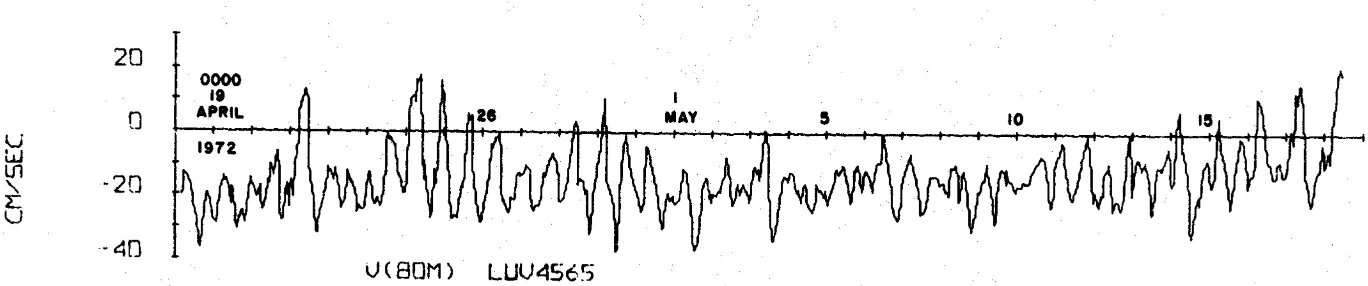
40
20
0
-20
-40
-60
CM/SEC
U(20M) LUV4555



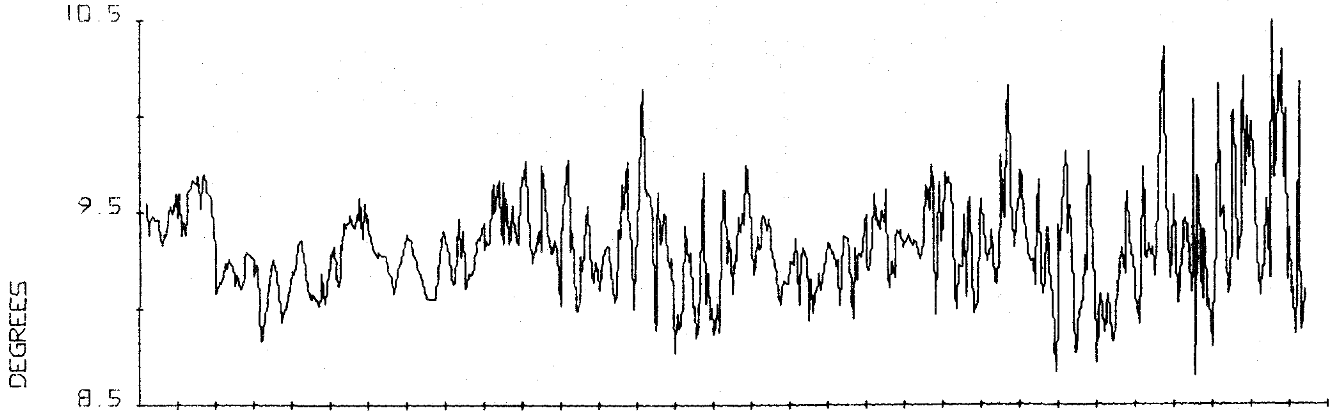
20
0
-20
-40
CM/SEC
U(80M) LUV4565



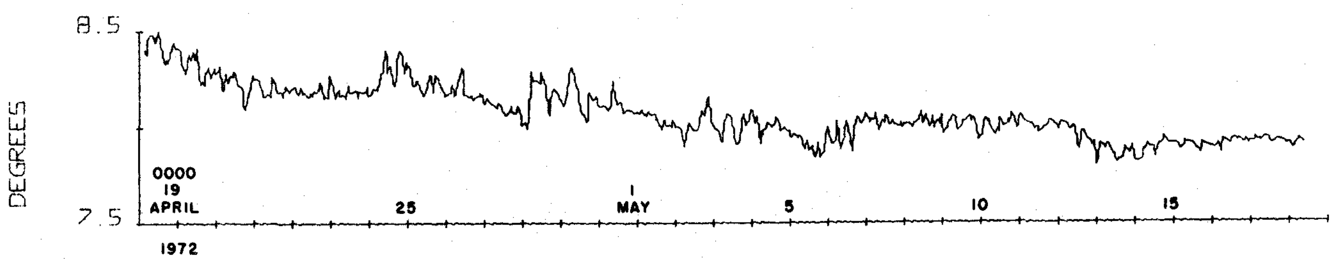
40
20
0
-20
-40
-60
CM/SEC
V(20M) LUV4555



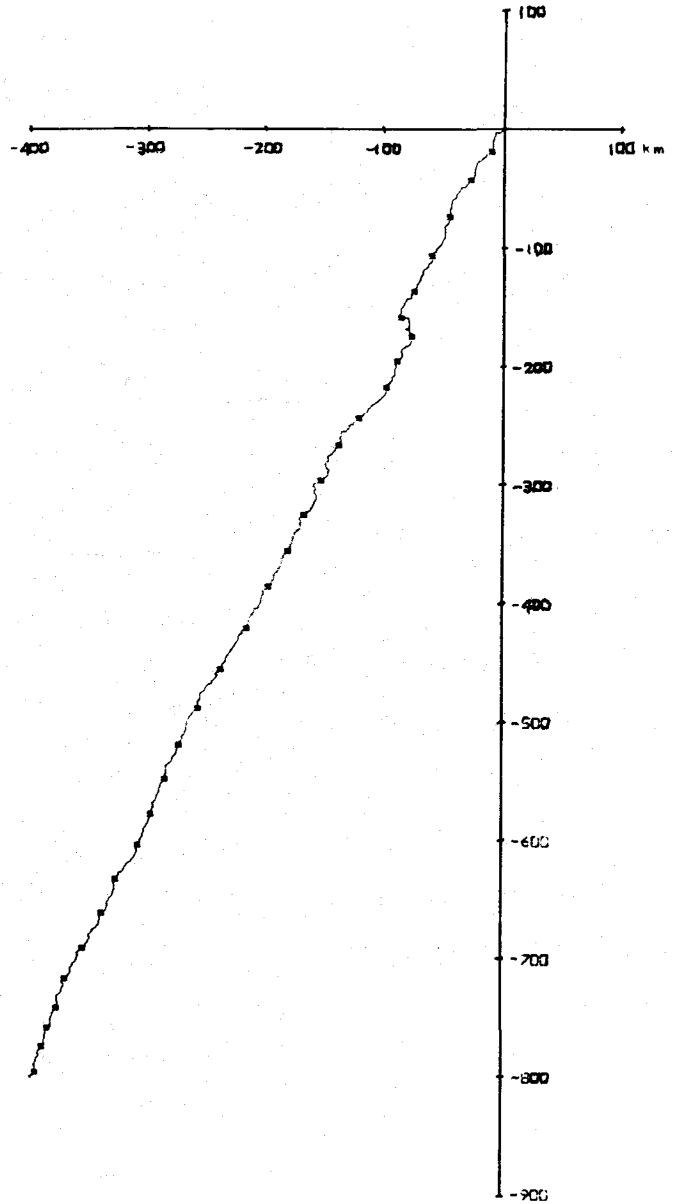
20
0
-20
-40
CM/SEC
0000
19
APRIL
1972
26
1
MAY
5
10
15
V(80M) LUV4565



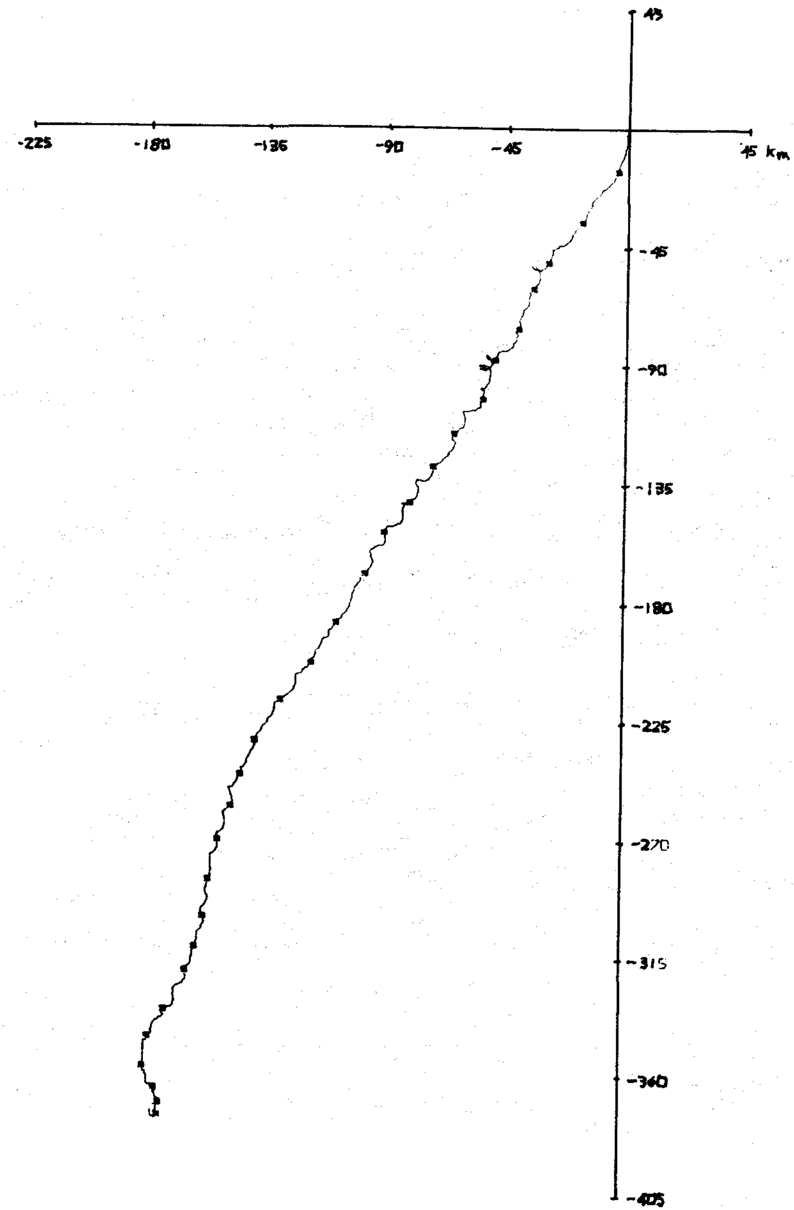
TEMP (20M) LT4555



TEMP (80M) LT4565

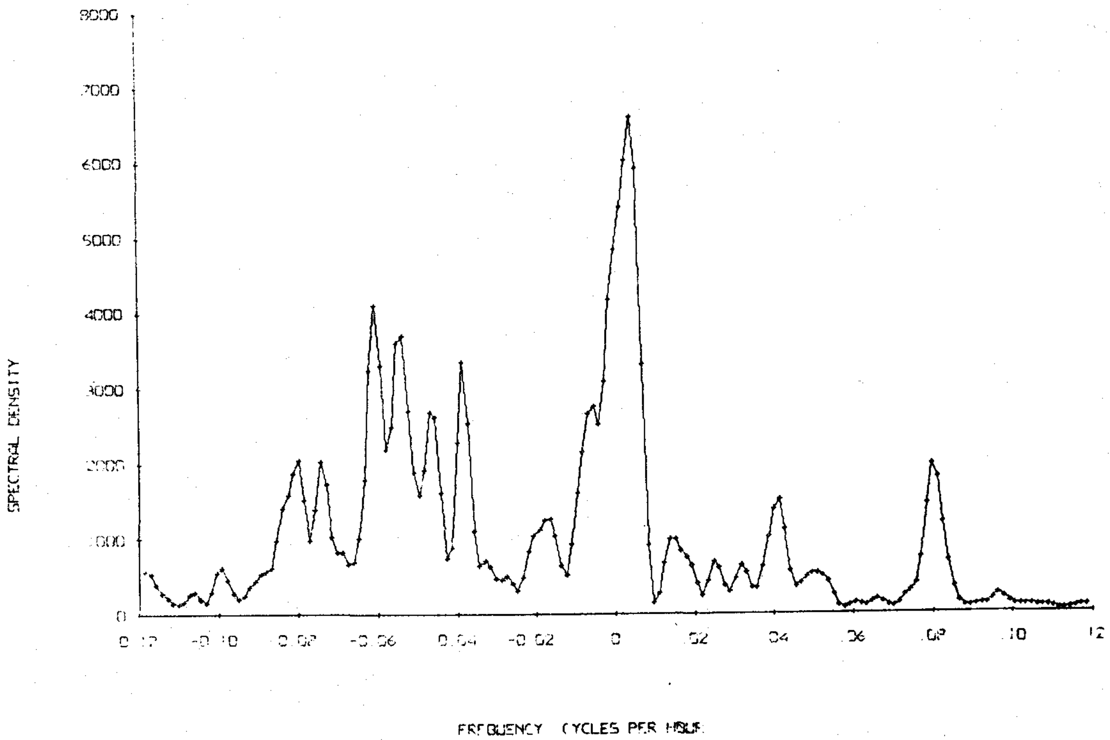


20M AT NH-15 30 DAYS STARTING 0432 4/18/72 GMT

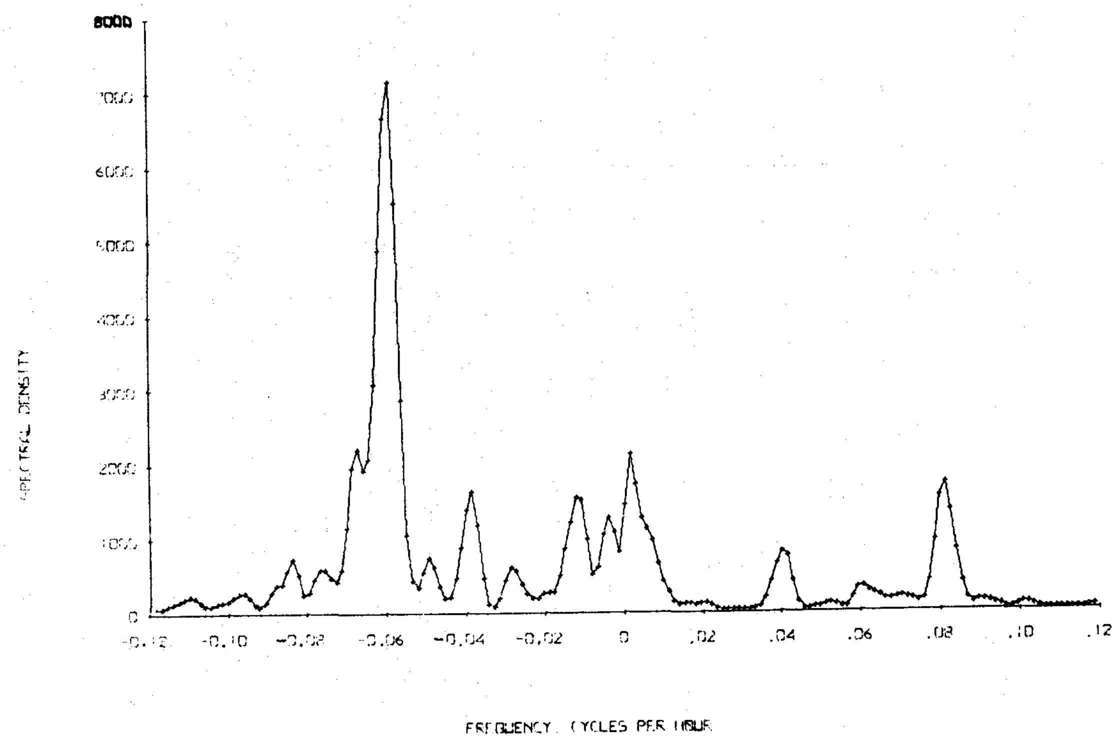


80M AT NH-15 30 DAYS STARTING 0432 4/18/72 GMT

ROTARY SPECTRUM
20M AT NH-15 4/17/72 TO 5/18/72 (TAPE 465/5)



ROTARY SPECTRUM
80M AT NH-15, 4/17/72 TO 5/18/72 (TAPE 466/5)



1972 CUE Installation B

NH 15

Position: 44°44.0'N, 124°20.0'W
Depth of Water: 96 m
Set at 0200 GMT 18 May 1972 by R/V YAQUINA
Retrieved at 2200 GMT 31 May 1972 by R/V CAYUSE
Data Interval: 0244 GMT 18 May to 2154 GMT 31 May

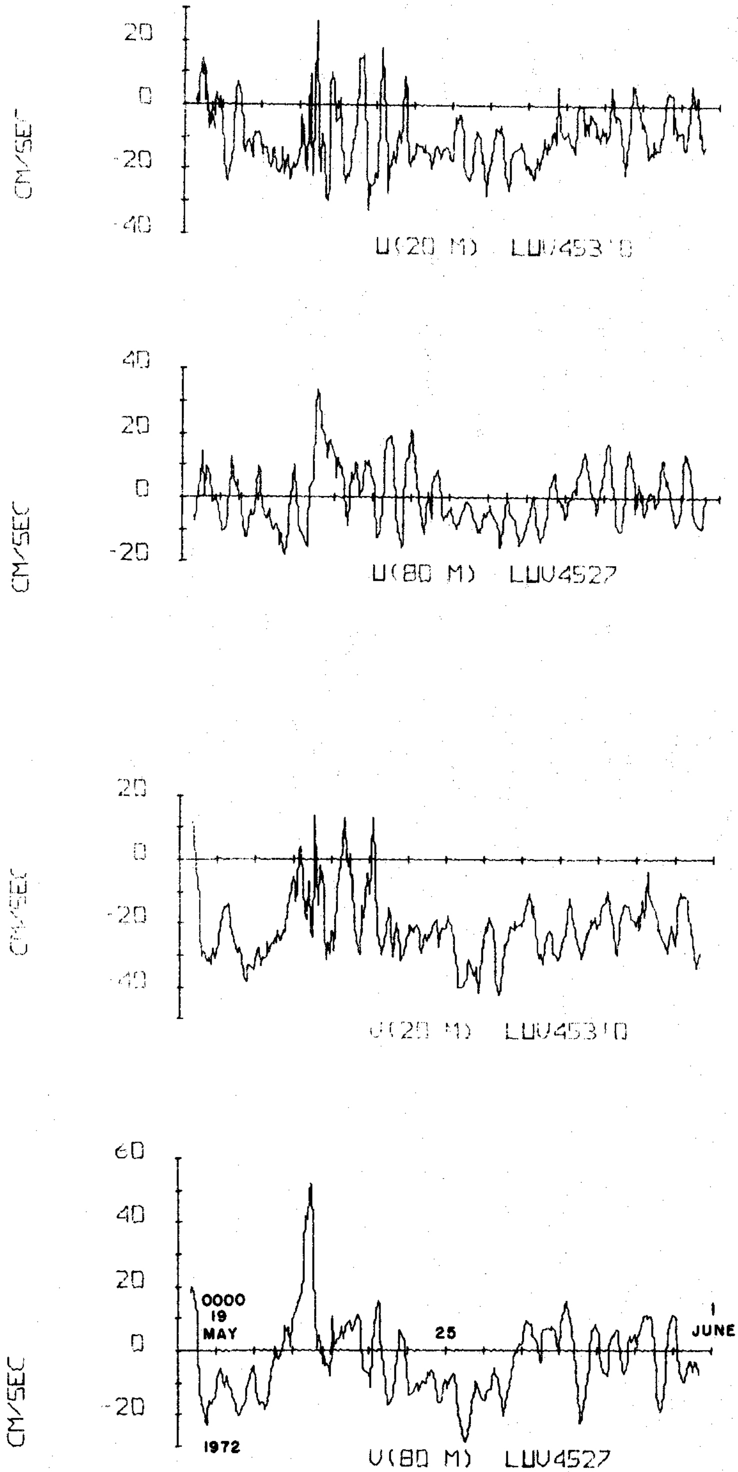
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	16 m	453/10
80 m	76 m	452/7

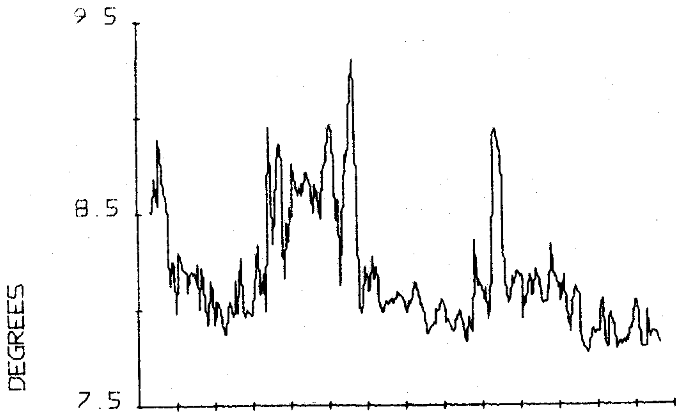
Data on speed, direction, and temperature were recorded every five minutes for the duration of the installation.

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	26.5	7.6	0.1	3.2	47.6	3.3
	U(cm/sec)	-10.5	9.3	0.6	3.6	26.1	-33.0
20m	V(cm/sec)	-21.5	10.0	0.9	4.3	13.6	-42.3
(45310)	T(C)	8.18	0.31	1.17	3.62	9.30	7.77

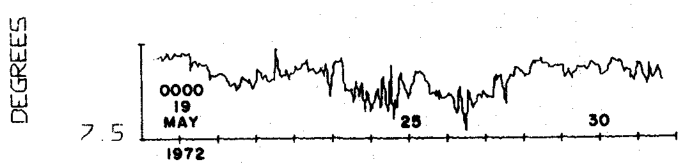
	S(cm/sec)	14.1	6.8	2.6	13.8	58.6	3.1
	U(cm/sec)	-0.0	9.4	0.7	3.4	33.8	-18.1
80m	V(cm/sec)	-2.7	12.2	0.8	5.1	52.0	-28.9
(4527)	T(C)	7.8	0.08	-0.69	3.11	7.97	7.54
	P	NONE					



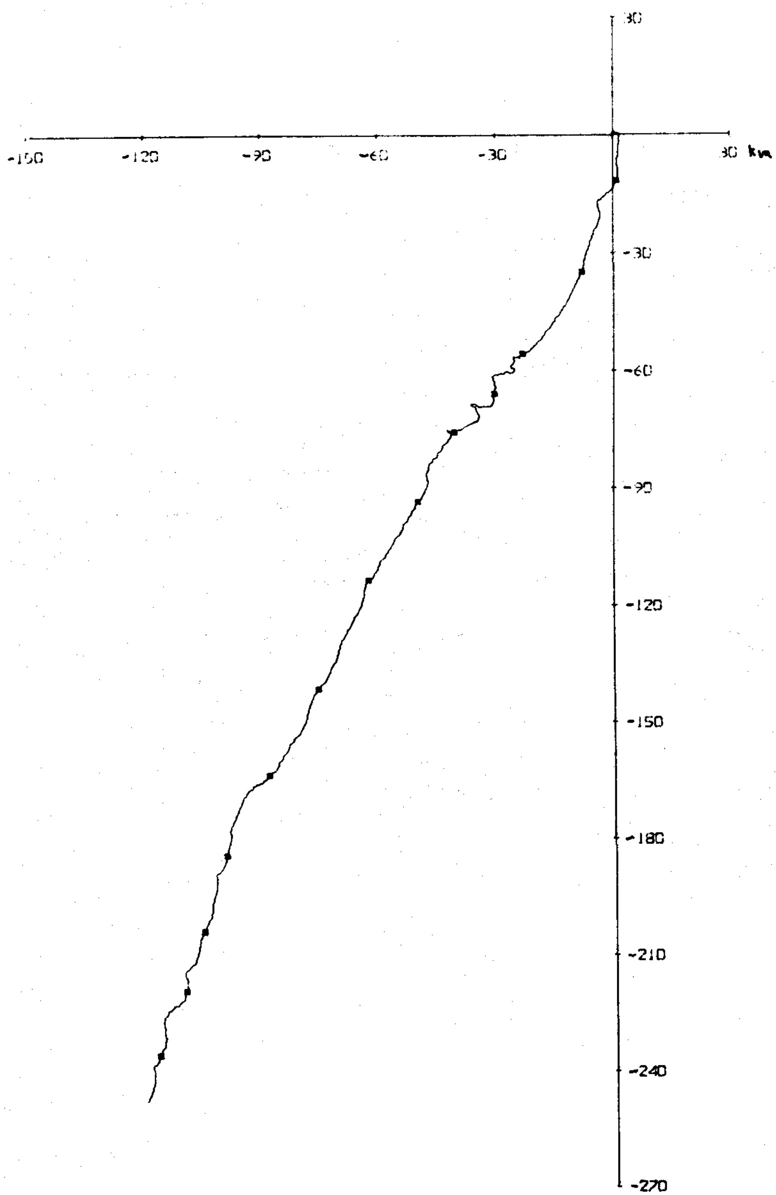
20
0
-20
-40
CM/SEC
40
20
0
-20
U(80 M) LUV4527
CM/SEC
60
40
20
0
-20
0000
19
MAY
25
1
JUNE
1972
V(80 M) LUV4527
CM/SEC



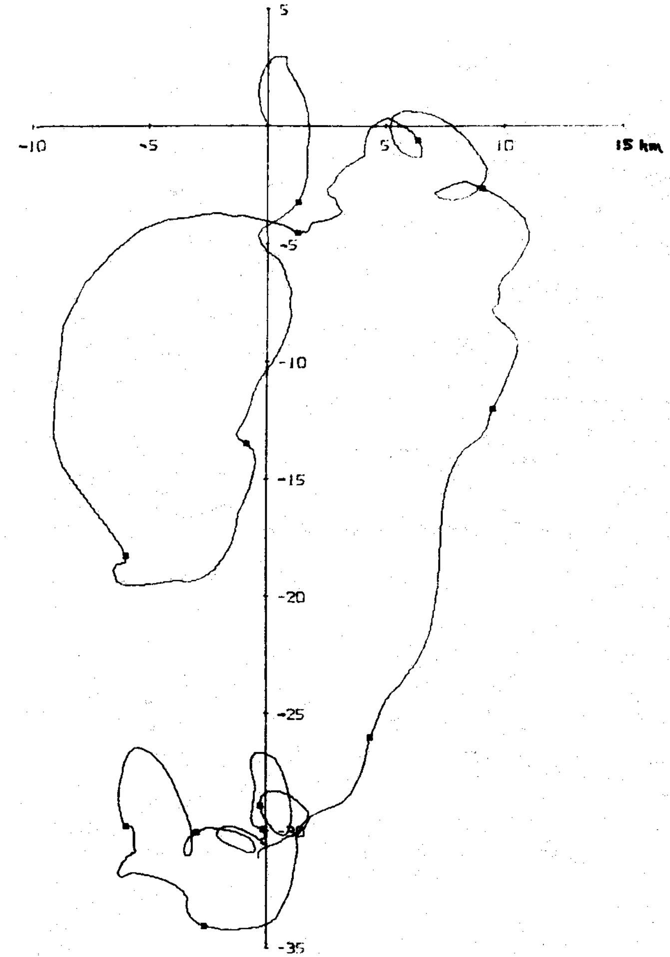
TEMP.(20 M) LT4531D



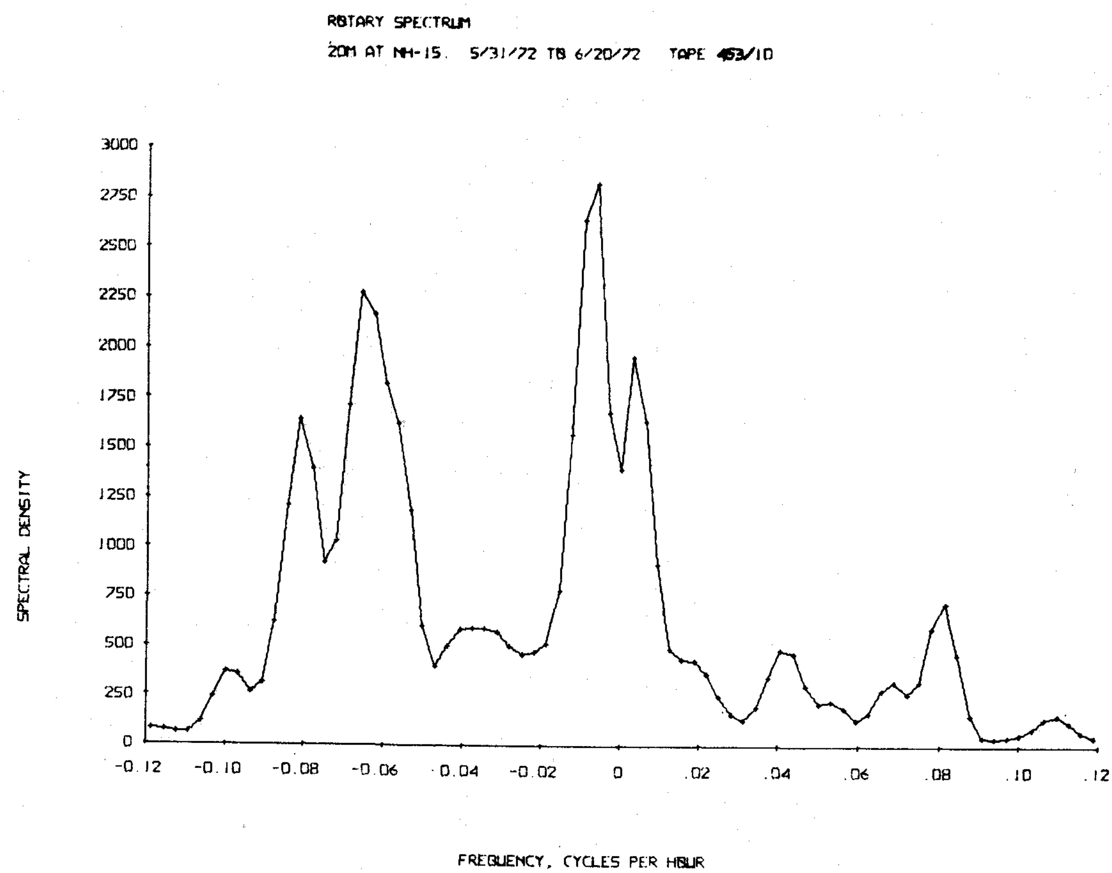
TEMP.(80 M) LT4527

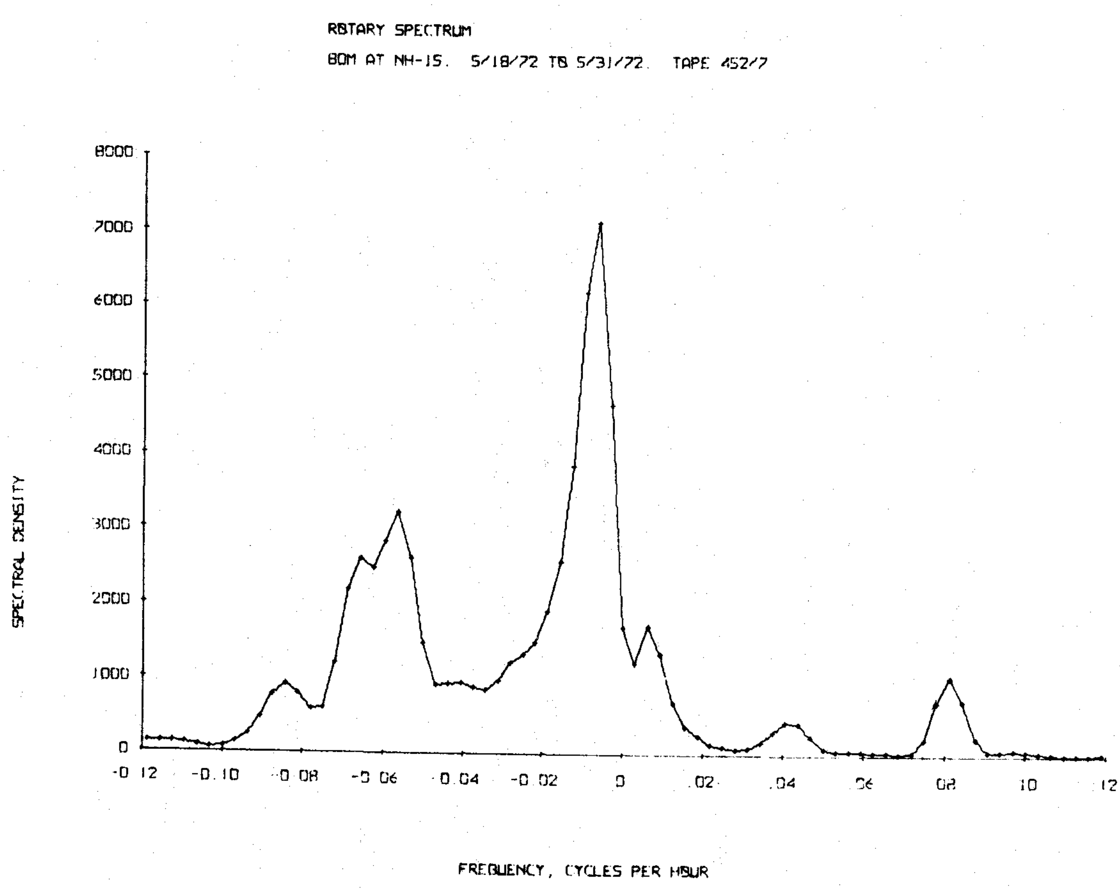


20M AT NH-15. 13 DAYS STARTING 0844 5/18/72



80M AT NH-15. 13 DAYS STARTING 0847 5/18/72


ROTARY SPECTRUM
20M AT NH-15. 5/31/72 TO 6/20/72 TAPE 453/10
SPECTRAL DENSITY
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR


ROTARY SPECTRUM
80M AT NH-15. 5/18/72 TO 5/31/72. TAPE 452/7
SPECTRAL DENSITY
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR

1972 CUE Installation C

NH 15

Position: 44°42.6'N, 124°22.8'W
Depth of Water: 99 m
Set at 2000 GMT 31 May by R/V CAYUSE
Retrieved at 2100 GMT 20 June by R/V YAQUINA
Data Interval: 2037 GMT 31 May to 2052 GMT 20 June

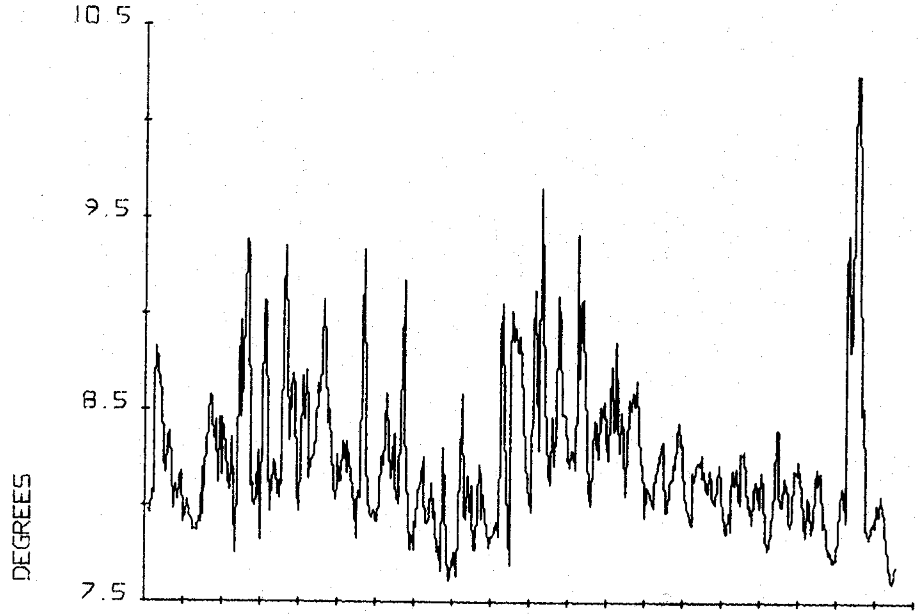
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	19 m	455/10
80 m	79 m	456/10

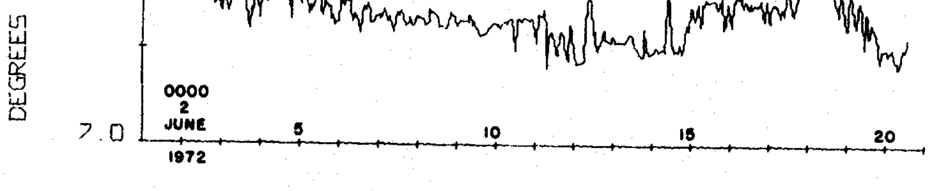
Speed and temperature were recorded every five minutes for the duration of the installation. Neither meter produced a usable direction record. The compass of the deep meter functioned correctly only for currents with directions ranging from 30° true clockwise to 200° true. The shallow meter may have become tangled in the mooring line; a nearly constant direction of 257° ± 5° was recorded,and the speeds were lower than expected, as they would have been had the meter been tilted from vertical.

(C-NH-15)

		MEAN	S.D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	NONE					
45510	U(cm/sec)	NONE					
(20m)	V(cm/sec)	NONE					
	T (C)	8.24	0.39	1.71	7.56	10.25	7.60
	S(cm/sec)	NONE					
45610	U(cm/sec)	NONE					
(80m)	V(cm/sec)	NONE					
	T (C)	7.67	0.11	-0.13	2.60	7.98	7.40
	P	NONE					



TEMP.(20 M) LT45510



TEMP.(80 M) LT45610

1972 CUE Installation D

NH 15

Position: 44°40.4'N, 124°25.4'W
Depth of Water: 96 m
Set at 1700 GMT 20 June 1972 by R/V YAQUINA
Retrieved at 1530 GMT 18 July 1972 by R/V CAYUSE
Data Interval: 1800 GMT 20 June to 1515 GMT 18 July

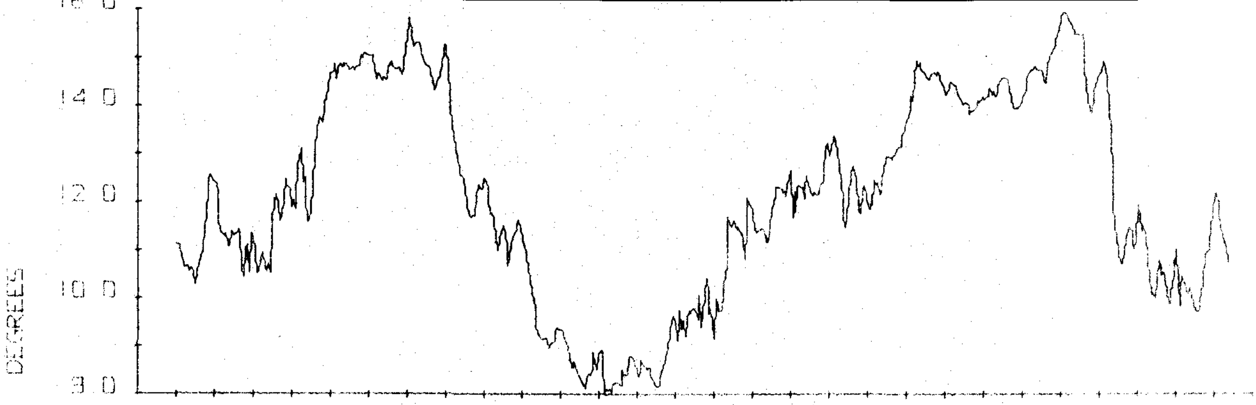
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D72/2
20 m	34 m	454/12
40 m	54 m	452/10
60 m	74 m	453/13
80 m	94 m	496/7

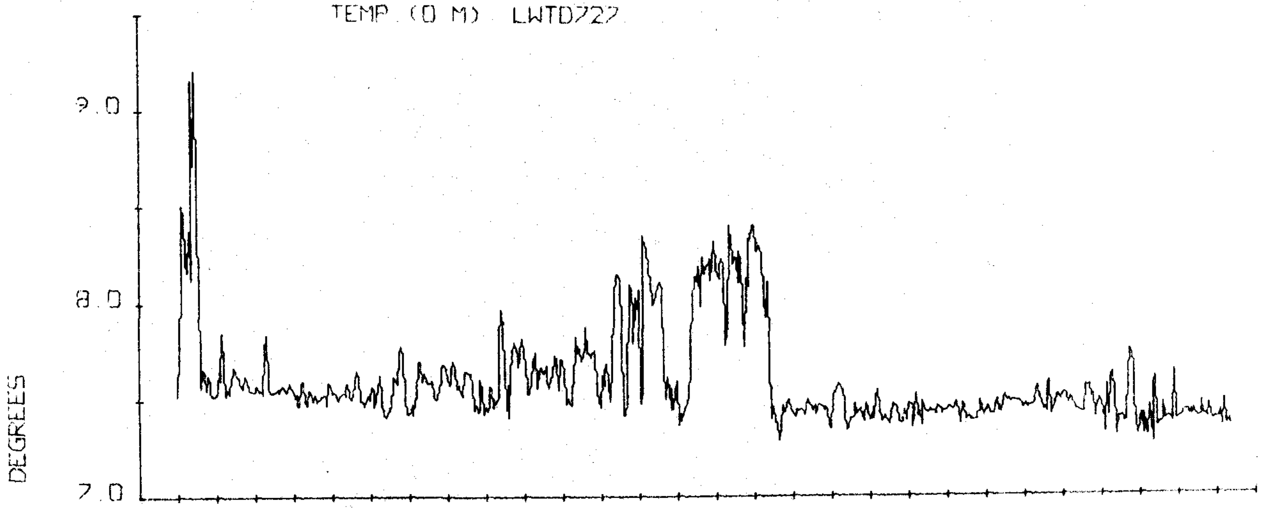
Data were recorded every 5 minutes. The surface instrument recorded wind speed and direction, air temperature,and surface water temperature. The wind direction and air temperature sensors failed for major portions of the installation, and data derived from them have not been included here. The 20 m, 40 m, 60 m,and 80 m instruments recorded speed, direction, and temperature. In addition, the 80 m instrument recorded pressure.

(D-NH-15)

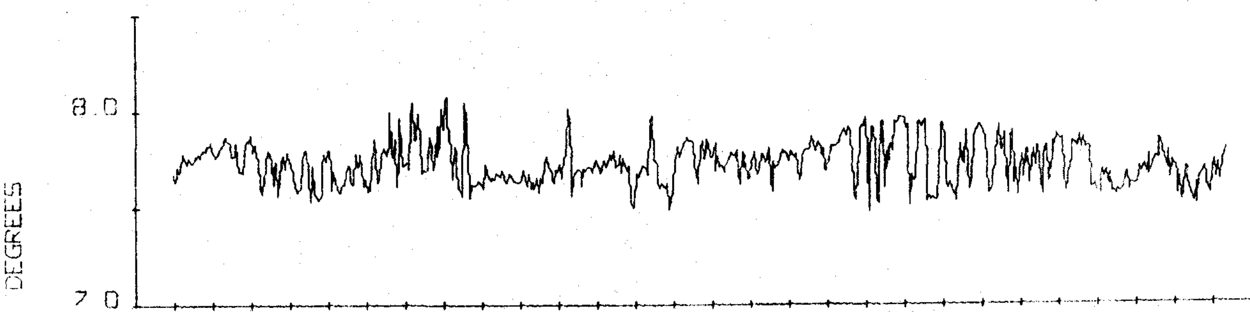
		MEAN	S.D.	SKEW	KURT	MAX	MIN
	S(m/sec)	5.3	2.5	0.3	2.4	12.8	0.4
n	U(m/sec)	NONE					
727)	V(m/sec)	NONE					
	T (C) water	12.11	2.13	-0.10	1.94	16.0	8.01
	S(cm/sec)	20.2	7.8	0.6	3.6	46.9	0.1
m	U(cm/sec)	- 8.0	8.8	0.2	3.2	18.9	-32.6
5412)	V(cm/sec)	-15.9	8.5	0.1	3.6	10.9	-43.0
	T (C)	7.60	0.26	2.15	8.60	9.21	7.27
	S(cm/sec)	14.1	5.7	0.3	2.8	32.9	0.4
m	U(cm/sec)	- 4.6	8.7	0.3	2.8	20.7	-23.4
5210)	V(cm/sec)	- 8.2	8.1	0.6	3.5	19.5	-28.3
	T (C)	7.73	0.11	0.33	2.81	8.08	7.48
	S(cm/sec)	13.7	4.4	0.2	3.2	30.5	0.4
m	U(cm/sec)	- 1.4	10.7	0.1	2.1	26.6	-29.7
5313)	V(cm/sec)	- 2.1	9.4	0.0	2.1	21.5	-25.3
	T (C)	7.66	0.08	0.09	2.62	7.89	7.46
	S(cm/sec)	9.6	5.4	1.1	4.8	34.8	0.4
m	U(cm/sec)	- 3.2	6.1	-1.0	4.1	13.6	-28.5
967)	V(cm/sec)	- 3.3	8.0	0.5	3.3	22.8	-27.6
	T (C)	7.41	0.10	-0.08	2.49	7.60	7.13
	$P(kg/cm^2)$	9.44	0.06	-0.51	2.46	9.54	9.29



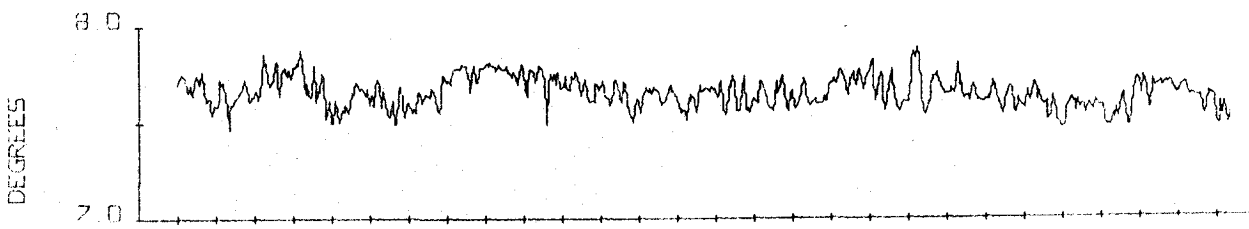
TEMP (0 M) LWTD727



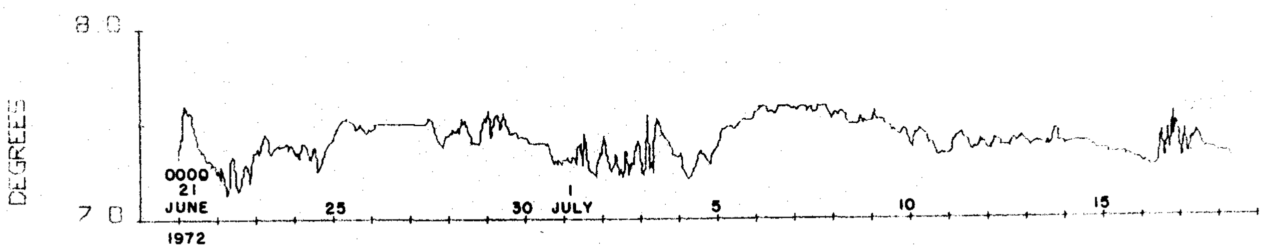
TEMP (20 M) LT45412



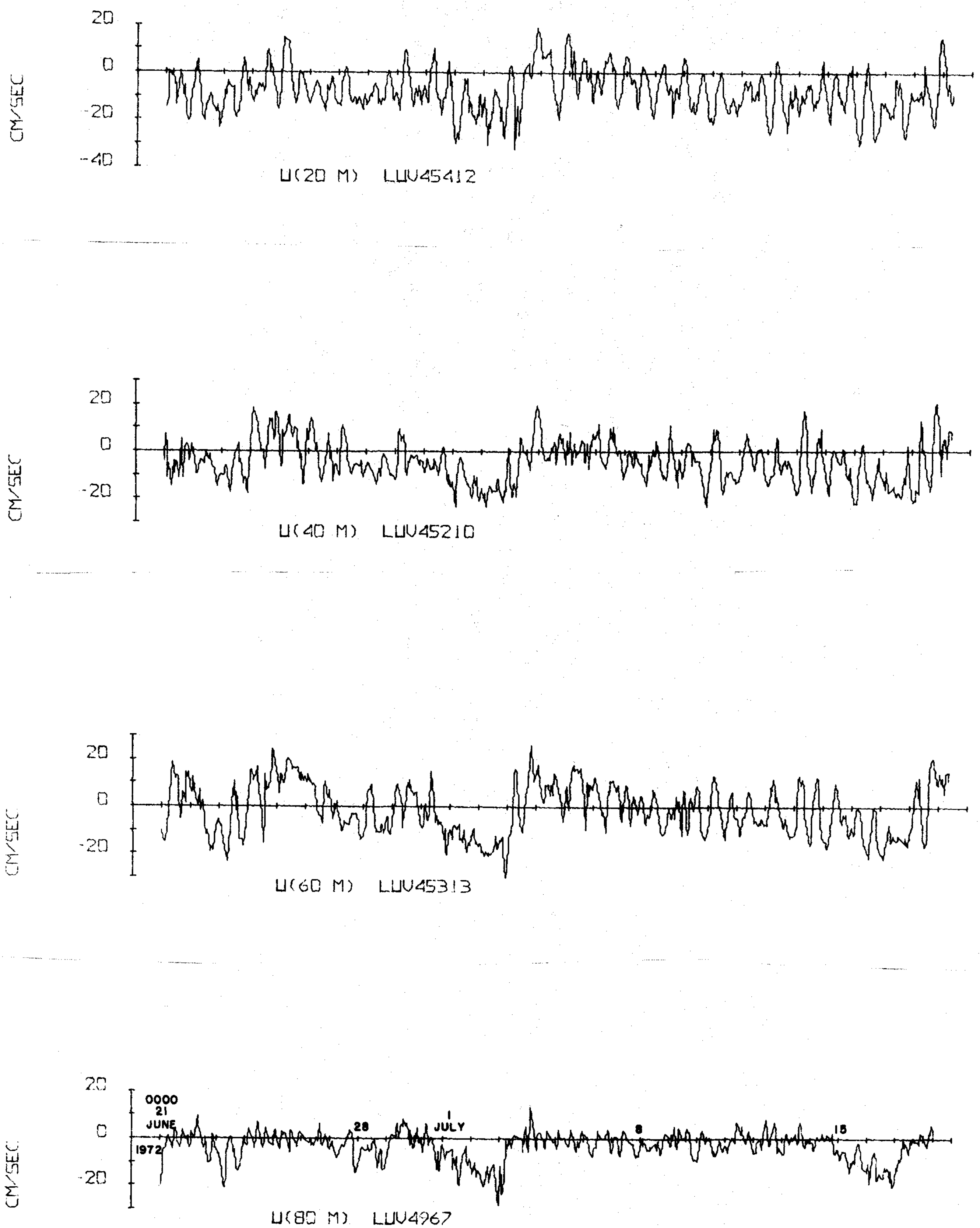
TEMP (40 M) LT45210



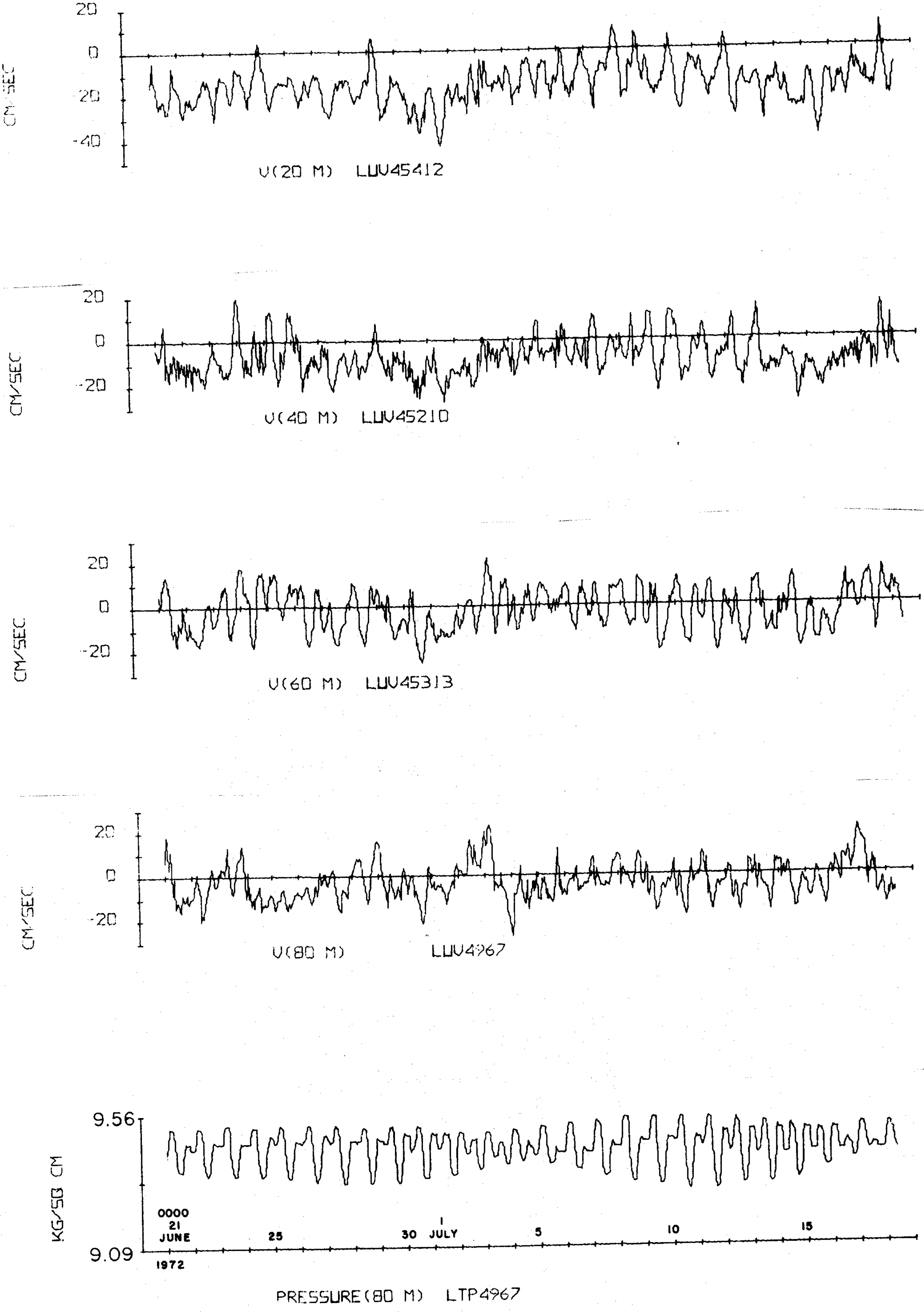
TEMP (60 M) LT45313



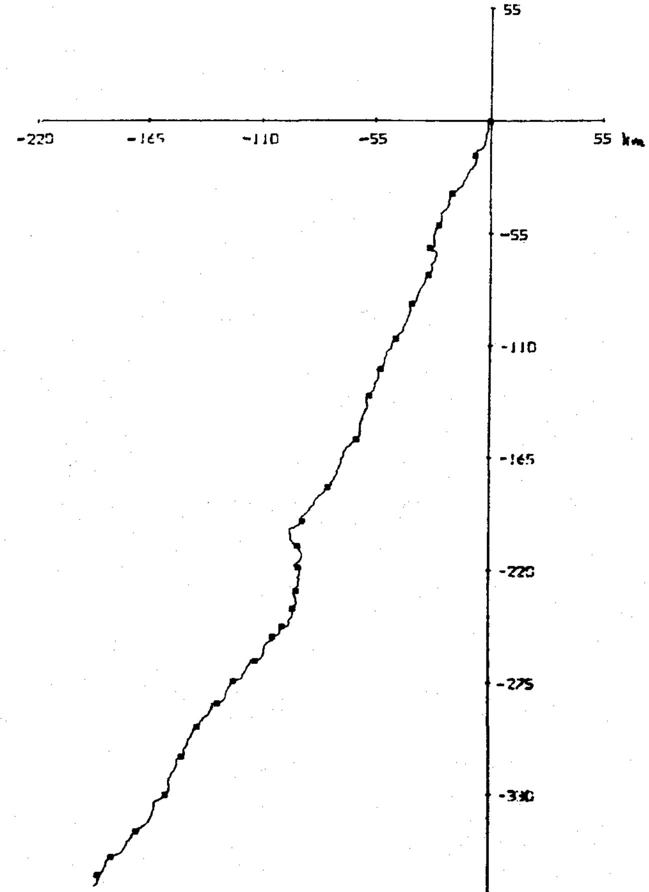
TEMP (80 M) LTP4967



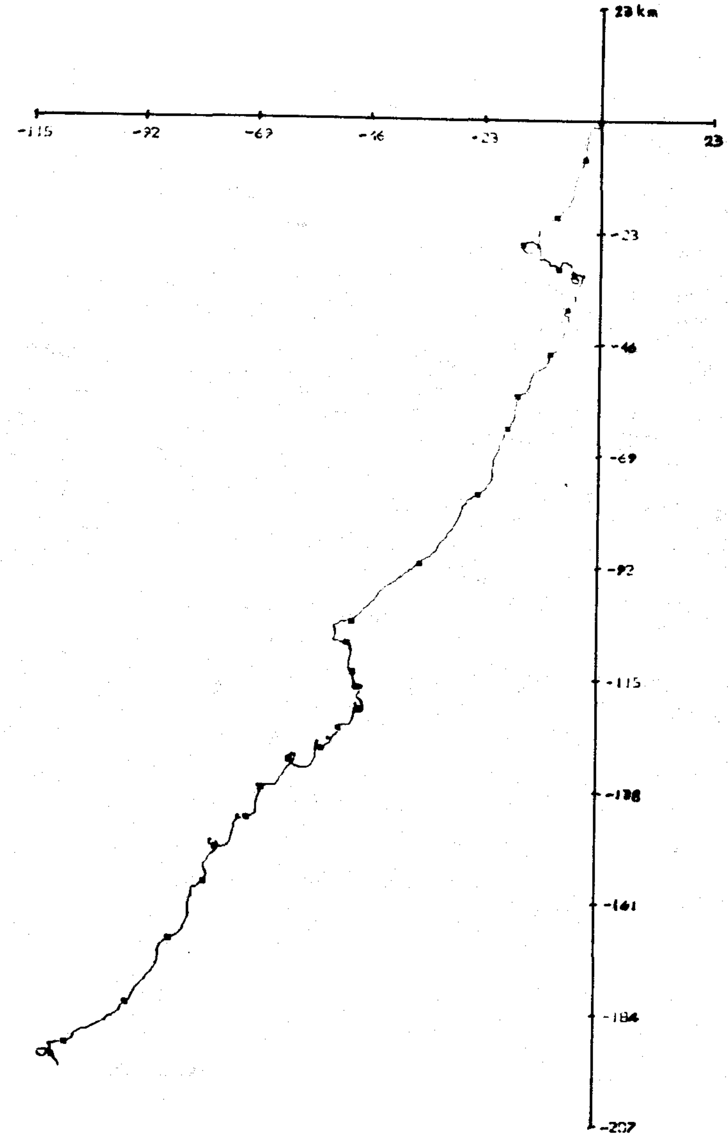
20
0
-20
-40
CM/SEC
U(20 M) LUV45412
20
0
-20
CM/SEC
U(40 M) LUV45210
20
0
-20
CM/SEC
U(60 M) LUV45313
20
0
-20
CM/SEC
0000
21
JUNE
1972
28
1
JULY
8
15
U(80 M) LUV4967



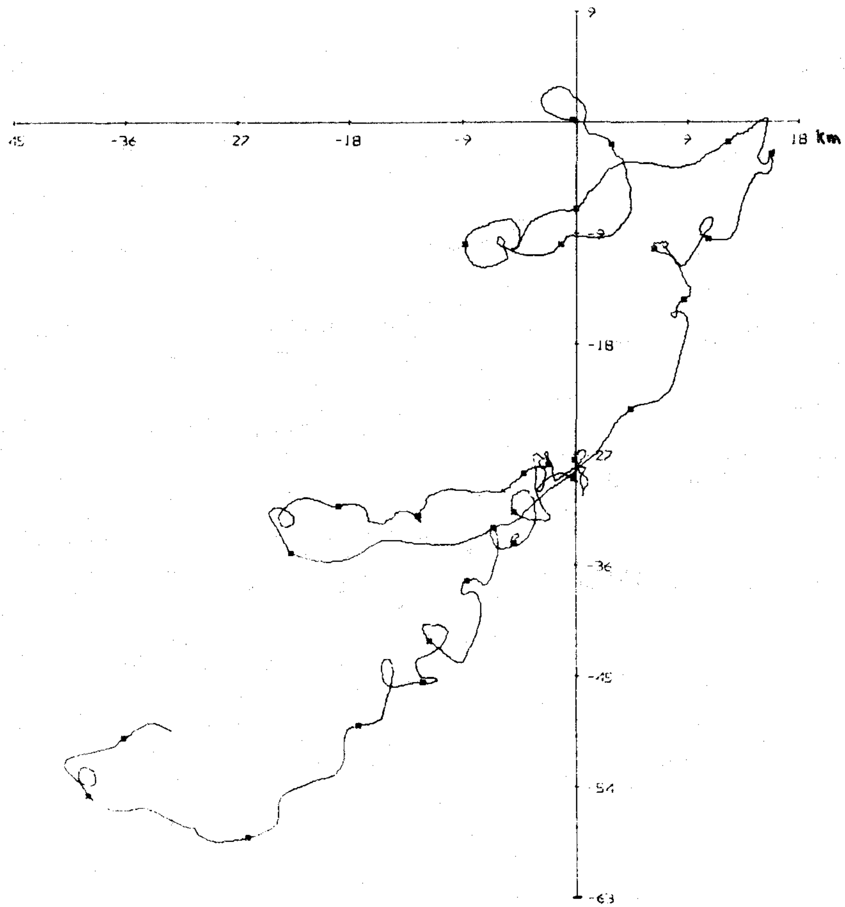
20
0
-20
-40
CM/SEC
V(20 M) LUV45412
20
0
-20
CM/SEC
V(40 M) LUV45210
20
0
-20
CM/SEC
V(60 M) LUV45313
20
0
-20
CM/SEC
V(80 M) LUV4967
9.56
9.09
KG/SQ CM
0000
21
JUNE
1972
25
30
1
JULY
5
10
15
PRESSURE(80 M) LTP4967



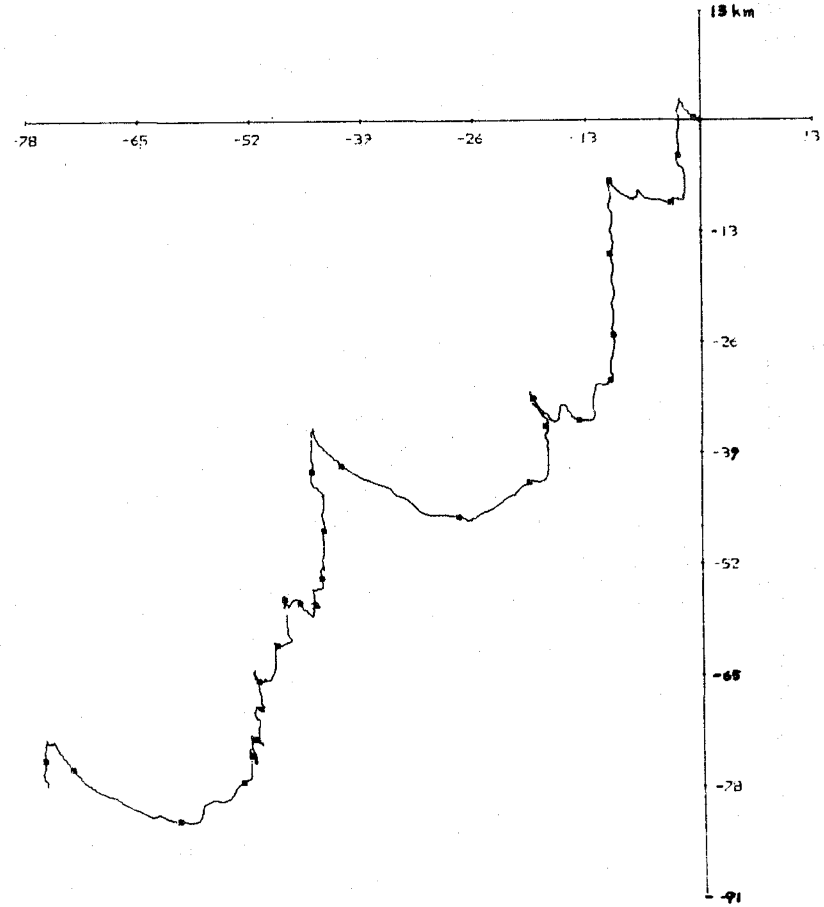
20M AT NH-15. 27 DAYS STARTING 2350 6/20/72



40M AT NH-15 27 DAYS STARTING 2353 6/20/72



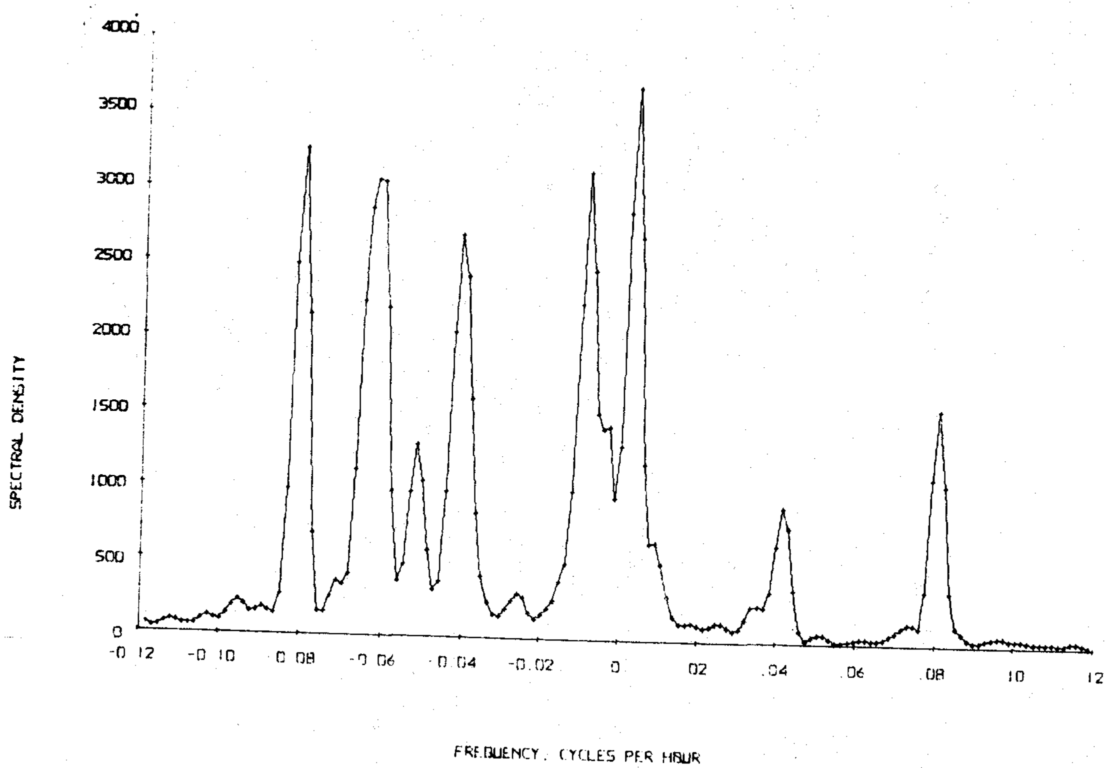
60M AT NH-15   27 DAYS STARTING 2354 6/20/72



80M AT NH-15.   22 DAYS STARTING 2352 6/20/72

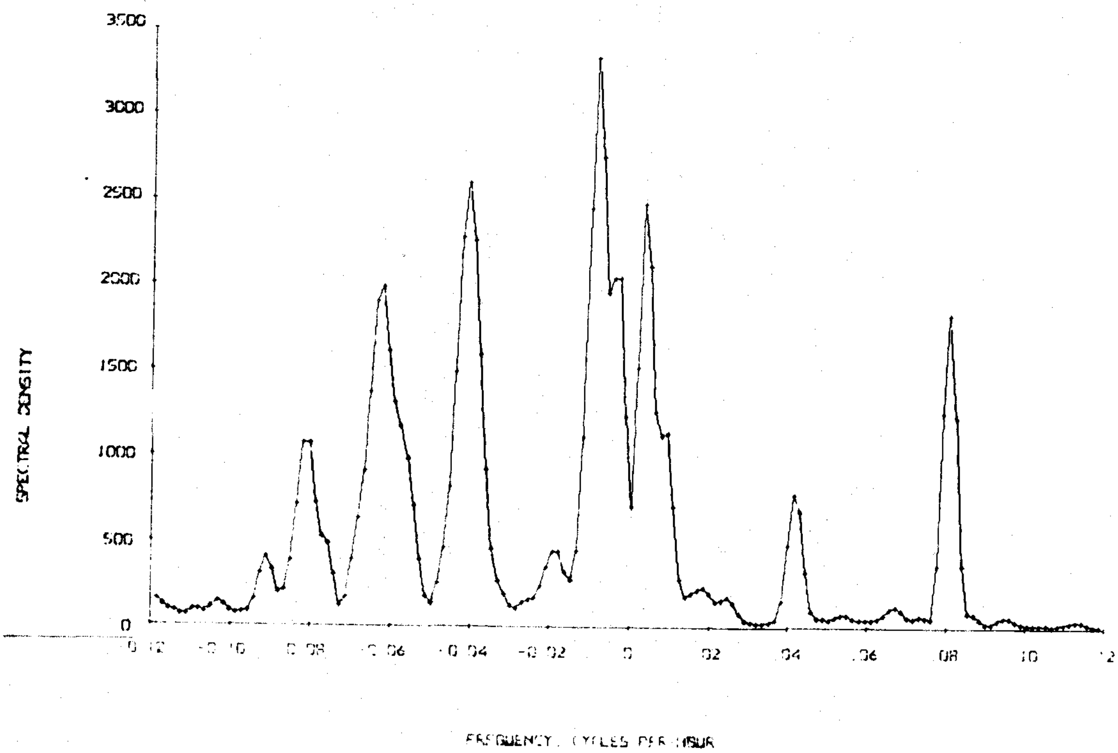
ROTARY SPECTRUM

20M AT NH-15, 6/20/72 TO 7/18/72, TAPE 454/12



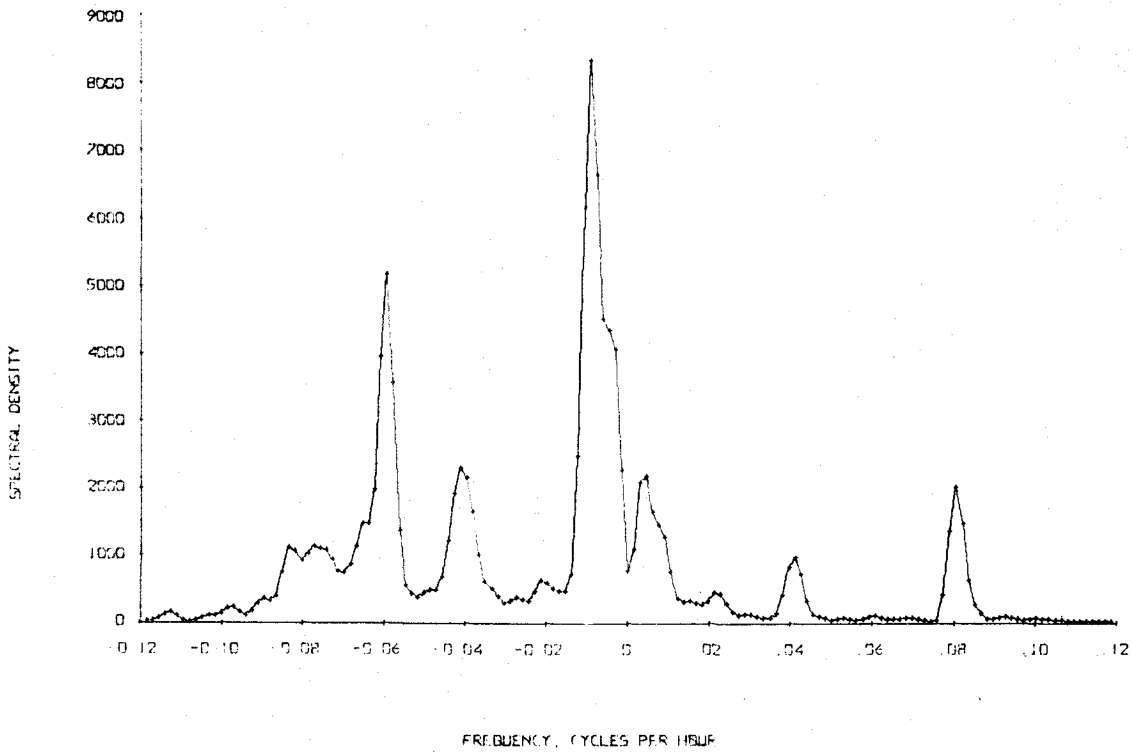
ROTARY SPECTRUM

40M AT NH-15, 6/20/72 TO 7/18/72, TAPE 452/10



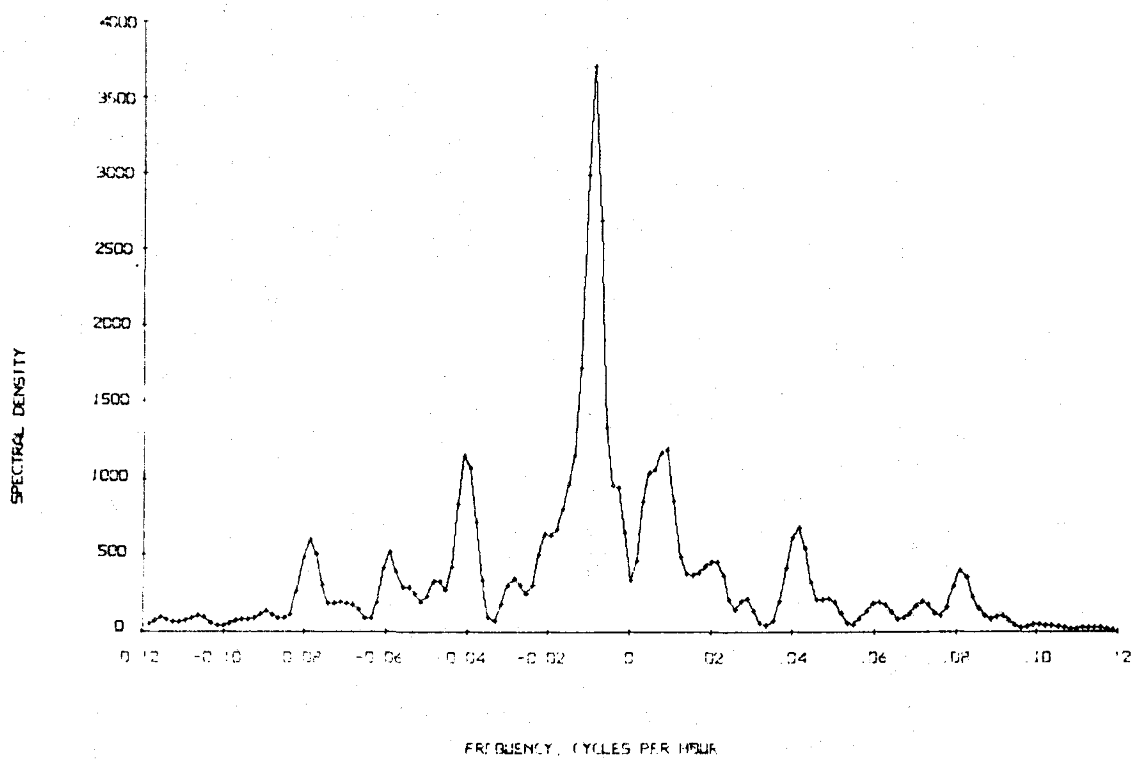
ROTARY SPECTRUM

40M AT NH-15 6/20/72 TO 7/18/72 TAPE 403/13



ROTARY SPECTRUM

80M AT NH-15. 6/20/72 TO 7/18/72. TAPE 426/7



1972 CUE Installation E

NH 3

Position: 44°39.0'N, 124°07.7'W
Depth of Water: 42 m
Set at 2125 GMT 5 July 1972 by R/V CAYUSE
Retrieved at 2105 GMT 1 August 1972 by R/V CAYUSE
Data Interval: 2125 GMT 5 July to 2100 GMT 1 August

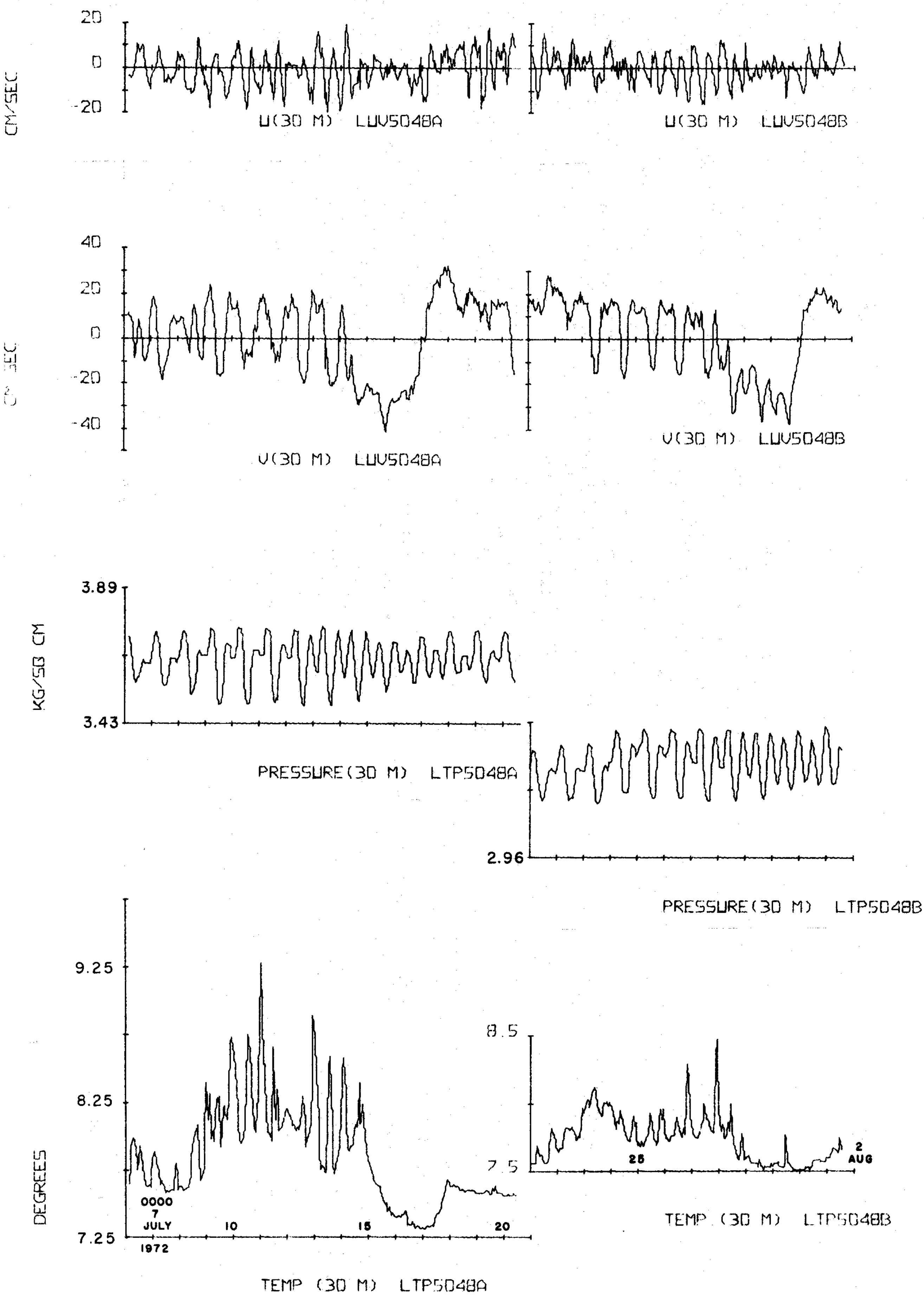
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	20 m	486/5
30 m	30 mA	504/8A
	25 mB	504/8B

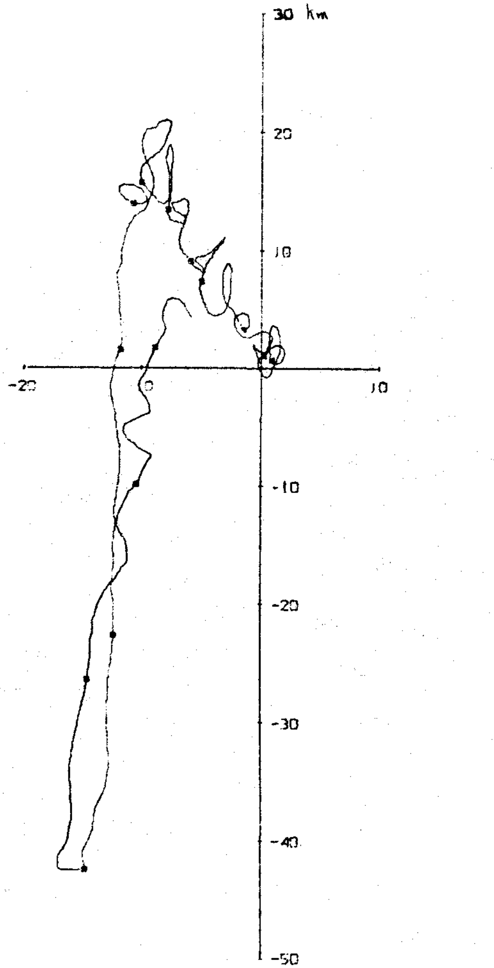
Data were recorded every 5 minutes. Both instruments measured temperature, current speed, and current direction. The 30 m instrument also recorded pressure. The 20 m instrument leaked and produced no usable data. The mooring was prematurely released on 20 July and was reset. As a result the 30 m record has been divided in part A and part B, of 16 days and 12 days duration respectively.

(E-NH-3)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	17.5	6.6	0.6	3.4	41.8	3.3
30 m	U (cm/sec)	- 0.5	8.0	-0.1	2.5	19.2	-19.6
(5048A)	V (cm/sec)	0.3	16.9	-0.3	2.0	32.3	-41.6
	T (C)	7.85	0.36	0.79	3.30	9.28	7.31
	P (kg/cm^2)	3.65	0.07	-0.41	2.46	3.76	3.48
	S (cm/sec)	17.4	6.0	1.1	4.5	38.0	3.3
30 m	U (cm/sec)	0.0	6.4	-0.3	2.7	15.5	-16.3
(5048B)	V (cm/sec)	1.6	17.2	-0.6	2.0	28.2	-38.0
	T (C)	7.74	0.17	0.84	3.99	8.46	7.51
	P (kg/cm^2)	3.29	0.08	-0.12	1.83	3.41	3.15

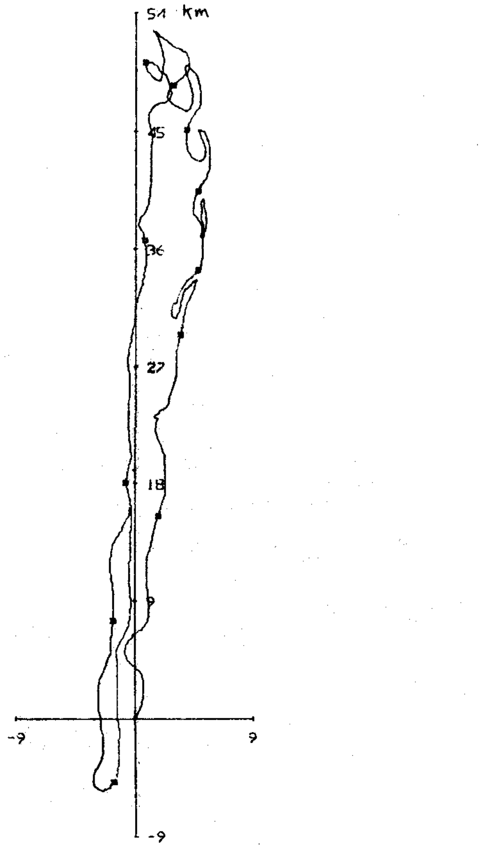


CM/SEC
20
0
-20
U(30 M) LUV5048A
U(30 M) LUV5048B
40
20
0
-20
-40
V(30 M) LUV5048A
V(30 M) LUV5048B
KG/SQ CM
3.89
3.43
PRESSURE(30 M) LTP5048A
2.96
PRESSURE(30 M) LTP5048B
DEGREES
9.25
8.25
7.25
0000
7
JULY
1972
10
15
20
TEMP (30 M) LTP5048A
8.5
7.5
25
2
AUG
TEMP (30 M) LTP5048B



30M AT NH-3 14 DAYS STARTING 0324 7/6/72

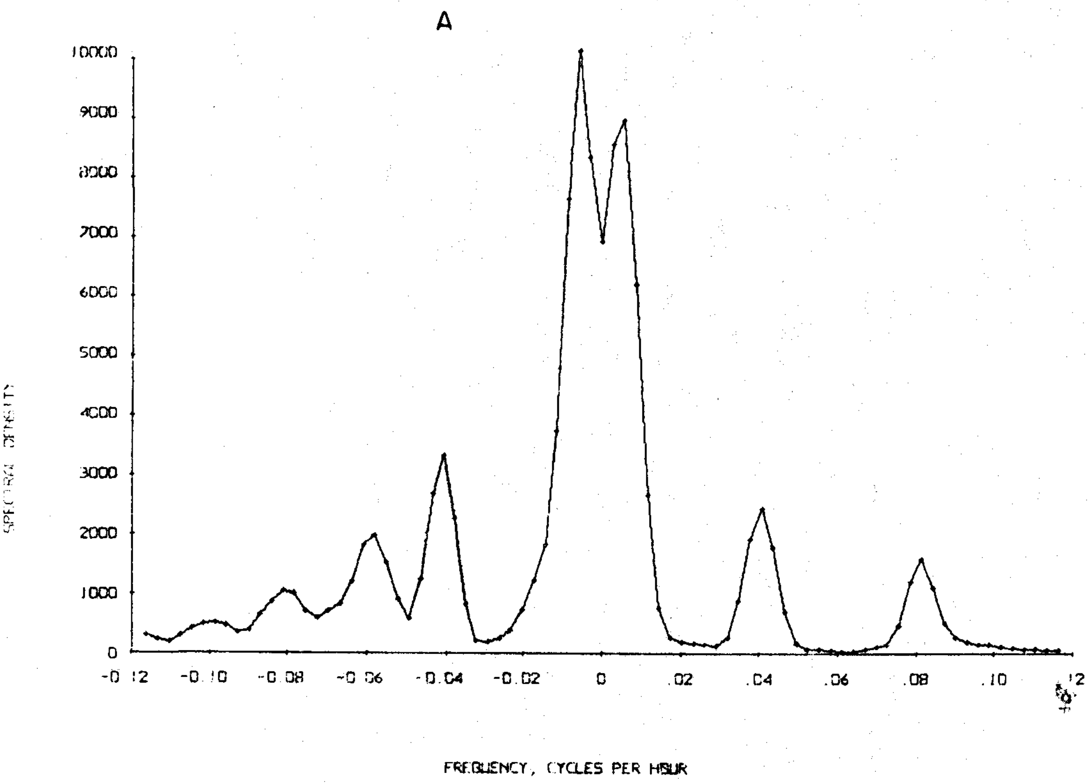
A



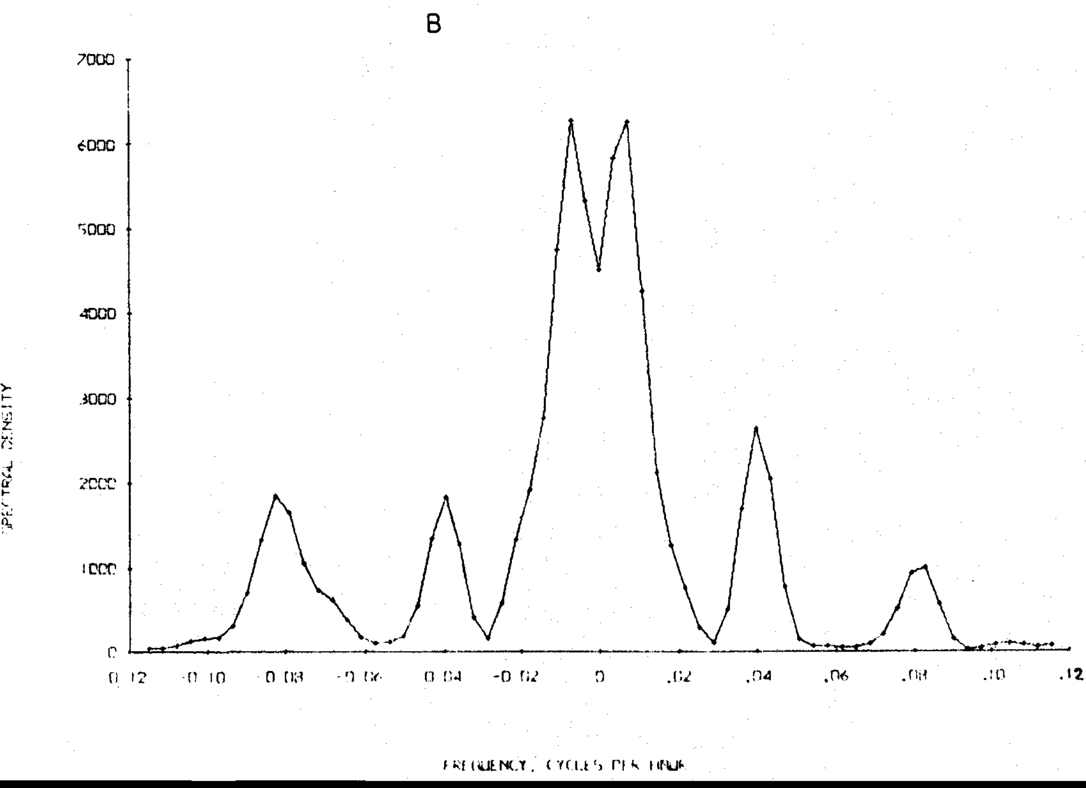
30M AT NH-3 11 DAYS STARTING 0019 7/21/72

B

ROTARY SPECTRUM
3DM AT NH-3. 7/5/72 TO 7/20/72. PART A OF TAPE 504/8



ROTARY SPECTRUM
3DM AT NH-3. 7/20/72 TO 8/1/72. PART B OF TAPE 504/8



1972 CUE Installation E

NH 10

Position: 44°39.0'N, 124°17.1'W
Depth of Water: 85 m
Set at 2100 GMT 6 July 1972 by R/V CAYUSE
Retrieved at 1600 GMT 2 August 1972 by R/V CAYUSE
Data Interval: 2115 GMT 6 July to 1530 GMT 2 August

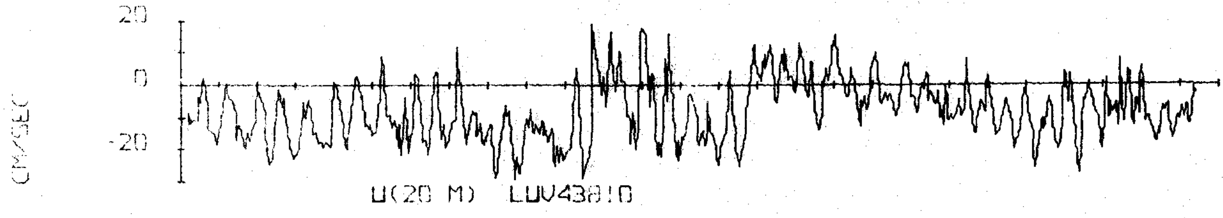
Instrumentation

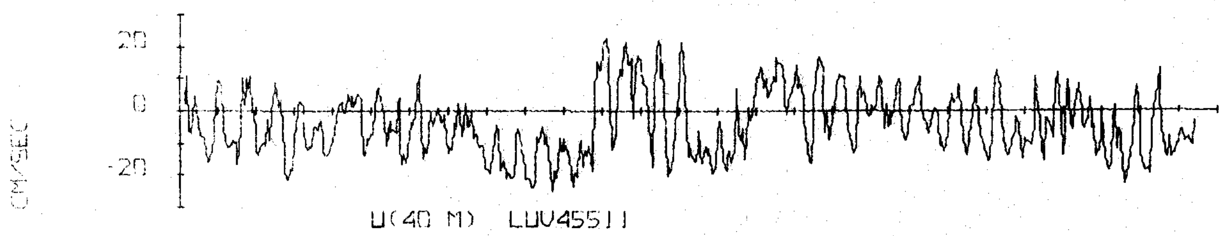
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D75/9
20 m	23 m	438/10
40 m	43 m	455/11
60 m	63 m	502/8

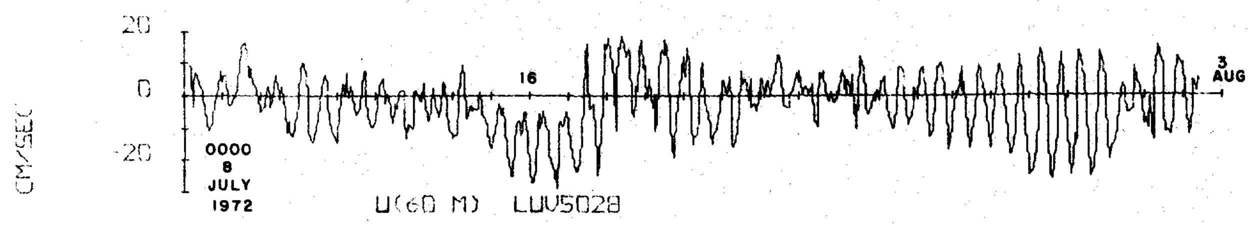
The subsurface meters recorded temperature, current direction, and current speed every 5 minutes. In addition, the 60 m instrument recorded pressure. The surface buoy recorded wind speed and direction, air temperature, and surface water temperature every 5 minutes. However, all sensors on the surface buoy except air temperature failed within a short time of installation, and only air temperature data are shown here.

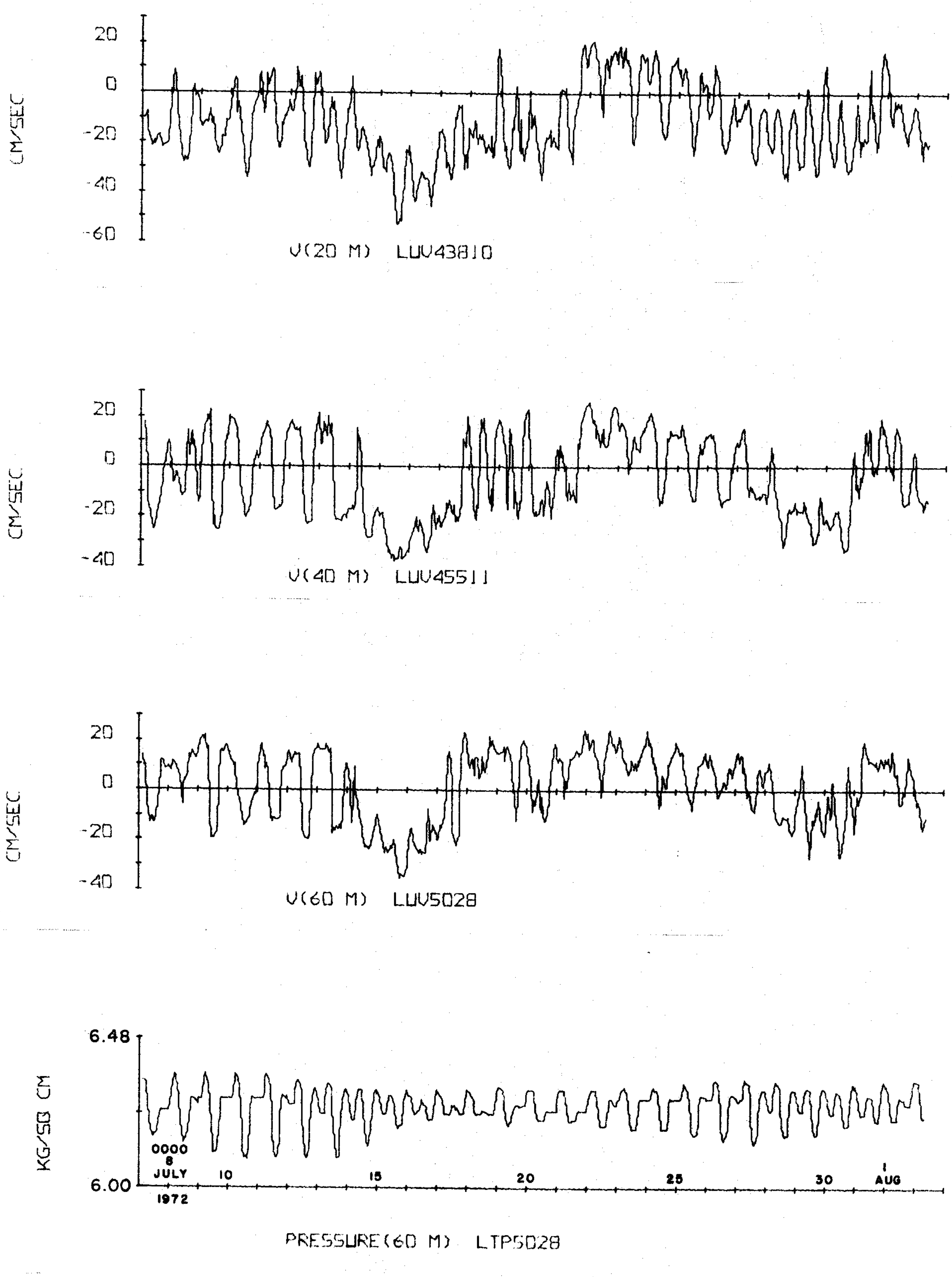
(E-NH-10)

		MEAN	S.D.	SKEW	KURT	MAX	MIN
0 m (D759)	T (C) air	12.47	1.38	0.26	2.41	15.81	9.67
	S (cm/sec)	20.6	8.8	0.9	4.5	58.6	0.5
20 m	U (cm/sec)	- 8.1	9.4	0.3	2.7	19.5	- 29.7
(43810)	V (cm/sec)	- 11.6	14.7	0.2	2.6	21.1	- 52.7
	T (C)	8.38	0.69	0.41	2.17	10.56	7.31
	S (cm/sec)	18.8	6.5	0.9	4.3	43.1	4.7
40 m	U (cm/sec)	-4.1	10.0	0.4	2.4	22.8	-25.0
(45511)	V (cm/sec)	- 4.5	16.1	0.0	1.8	26.5	- 37.8
	T (C)	7.79	0.26	1.47	6.54	8.94	7.42
	S (cm/sec)	16.0	5.9	1.0	4.4	36.6	0.6
60 m	U (cm/sec)	- 2.4	9.5	-0.3	2.6	18.7	- 28.6
(5028)	V (cm/sec)	1.7	13.8	- 0.5	2.2	24.8	- 35.2
	T (C)	7.49	0.14	1.23	6.35	8.25	7.09
	P (kg/cm^2)	6.26	0.06	- 0.76	3.37	6.36	6.10

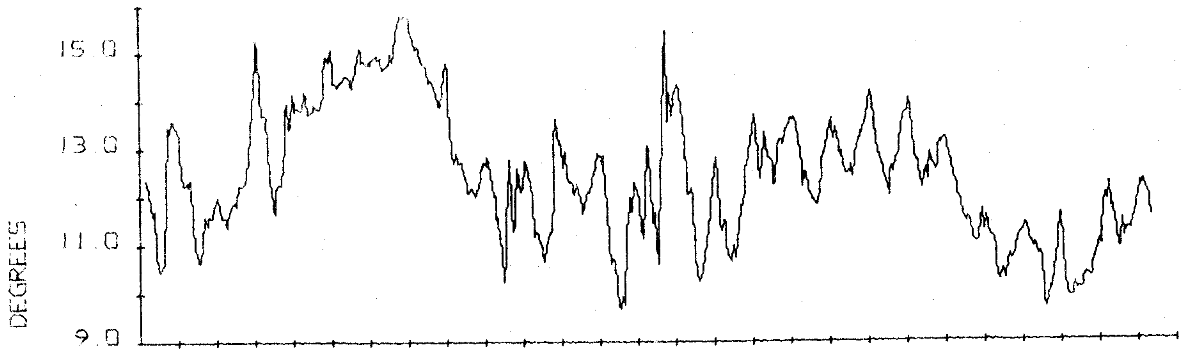

20
0
-20
CM/SEC
U(20 M) LUV43810


20
0
-20
CM/SEC
U(40 M) LUV4551

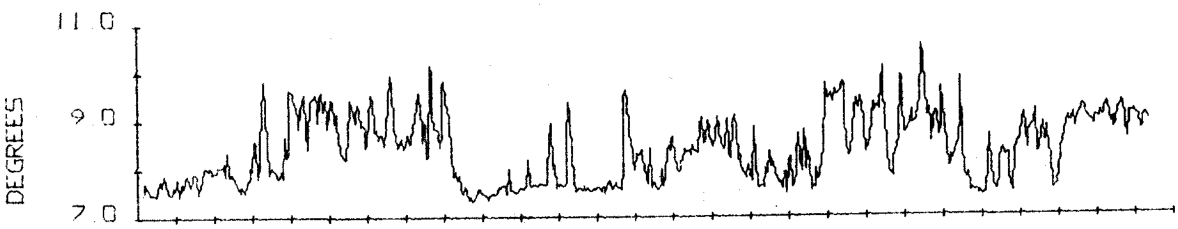

20
0
-20
CM/SEC
16
3
AUG
0000
8
JULY
1972
U(60 M) LUV5028



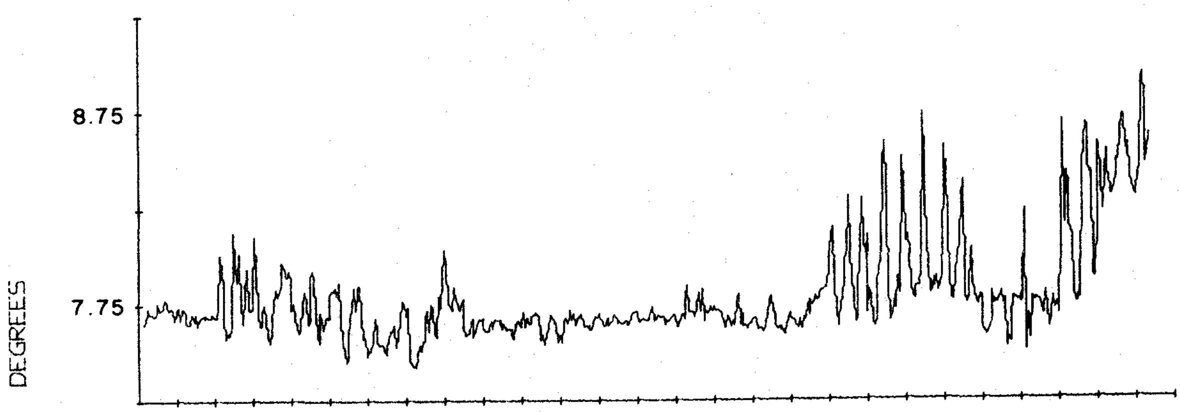
20
0
-20
-40
-60
CM/SEC
V(20 M) LUV43810
20
0
-20
-40
CM/SEC
V(40 M) LUV45511
20
0
-20
-40
CM/SEC
V(60 M) LUV5028
6.48
6.00
KG/SQ CM
0000
8
JULY
1972
10
15
20
25
30
1
AUG
PRESSURE(60 M) LTP5028



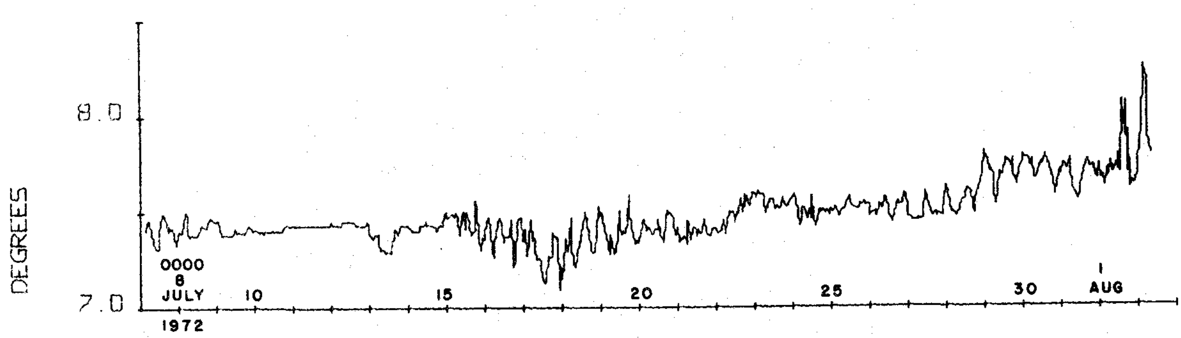
AIR TEMP(0 M) LATD759



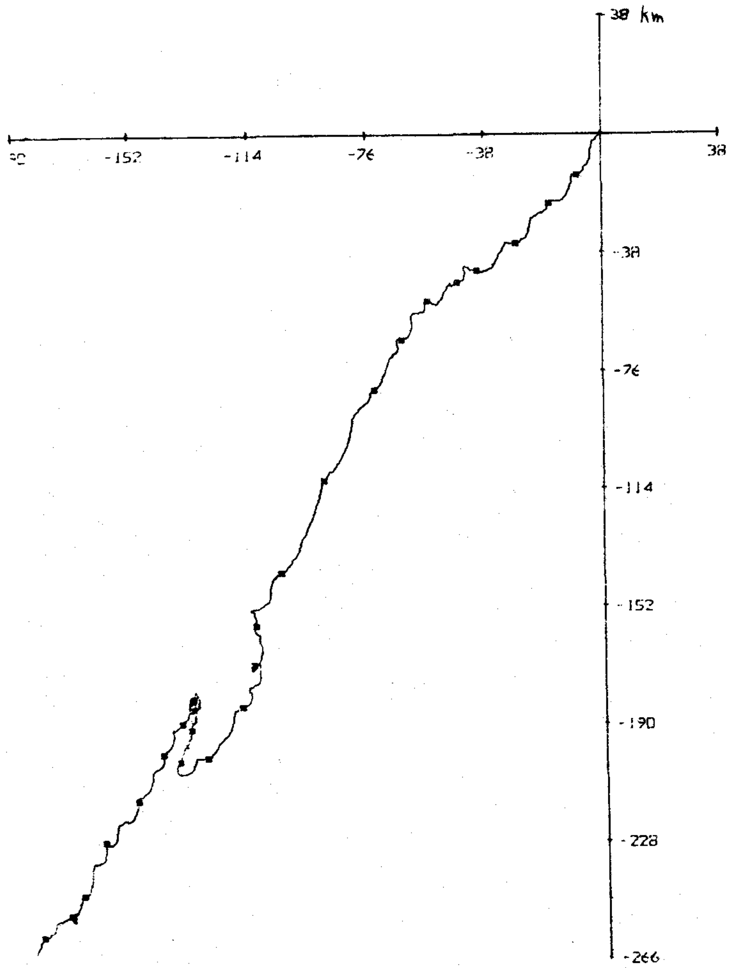
TEMP(20 M) LT43810



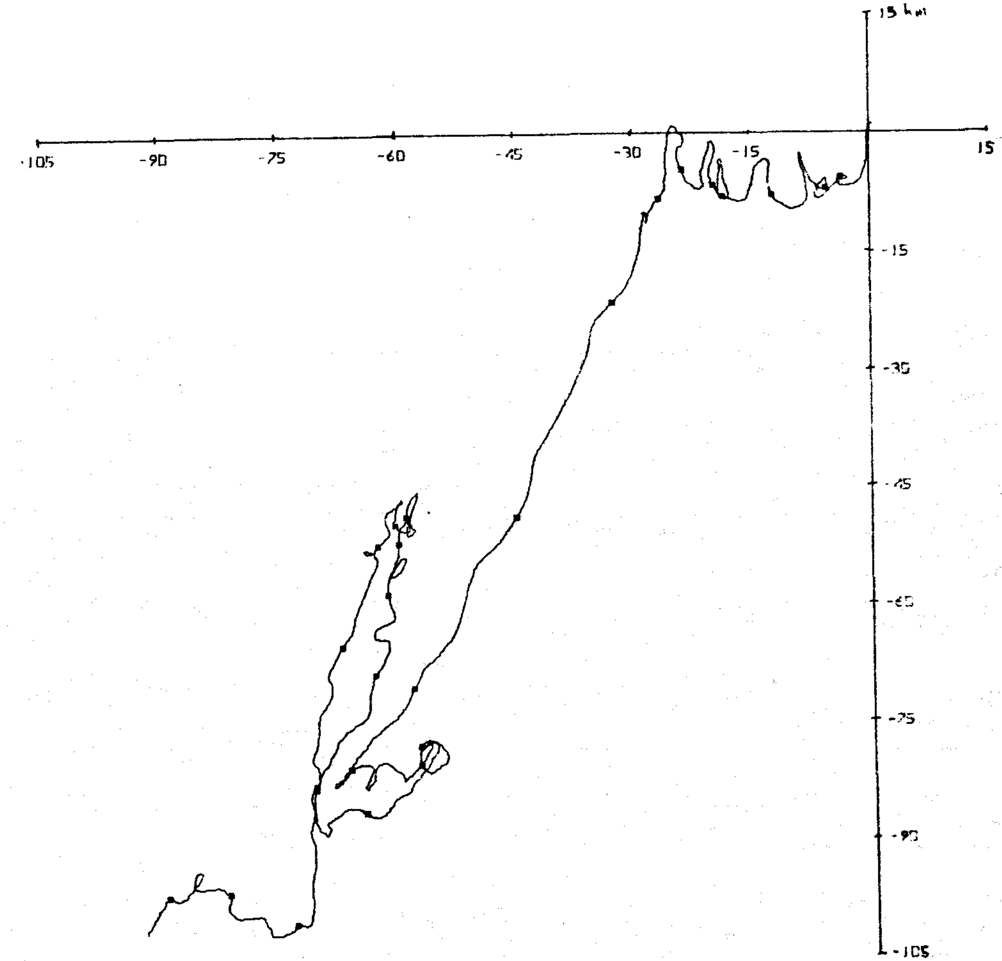
TEMP (40 M) LT45511



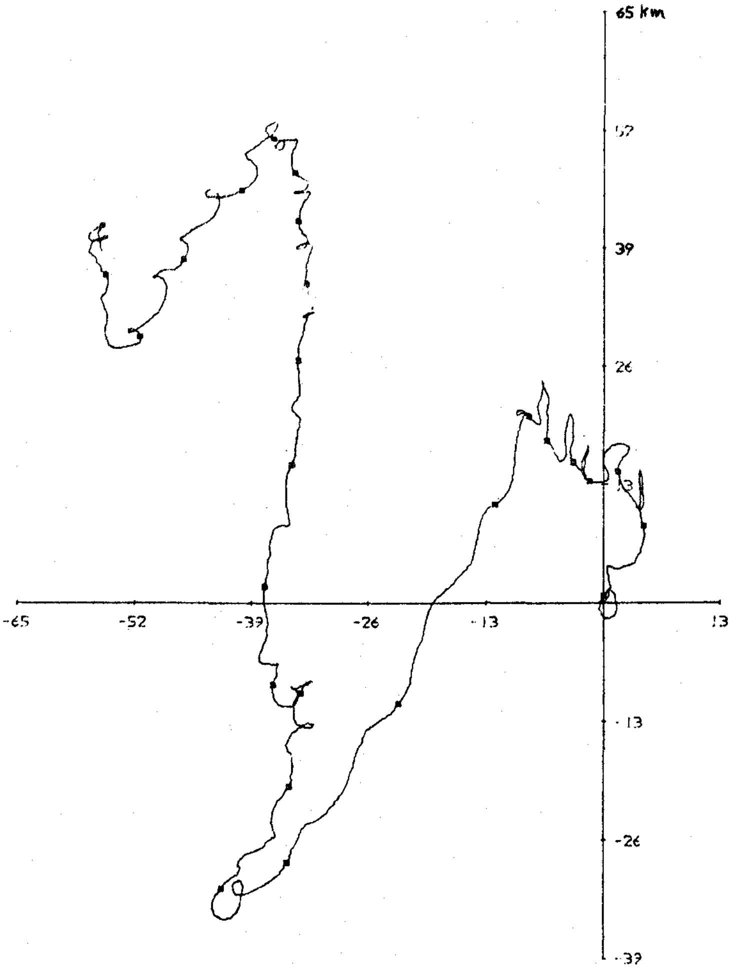
TEMP (60 M) LTP5028



2𝟎M AT NH-10. 26 DAYS STARTING 0318 7/7/72

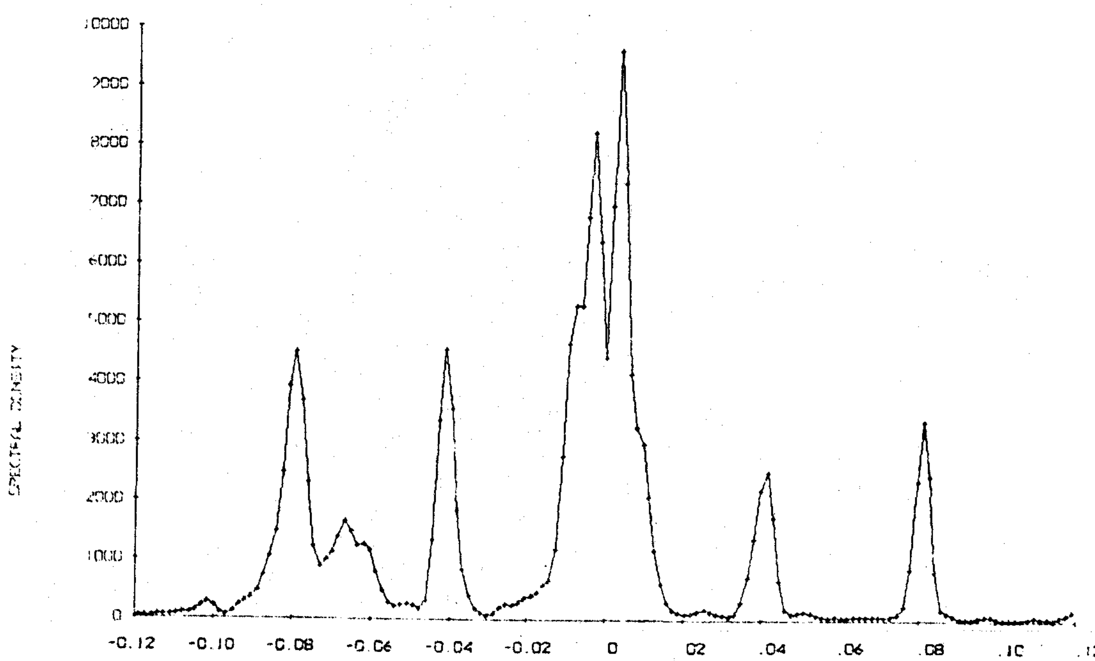


40M AT NH-10. 26 DAYS STARTING 0326 7/7/72



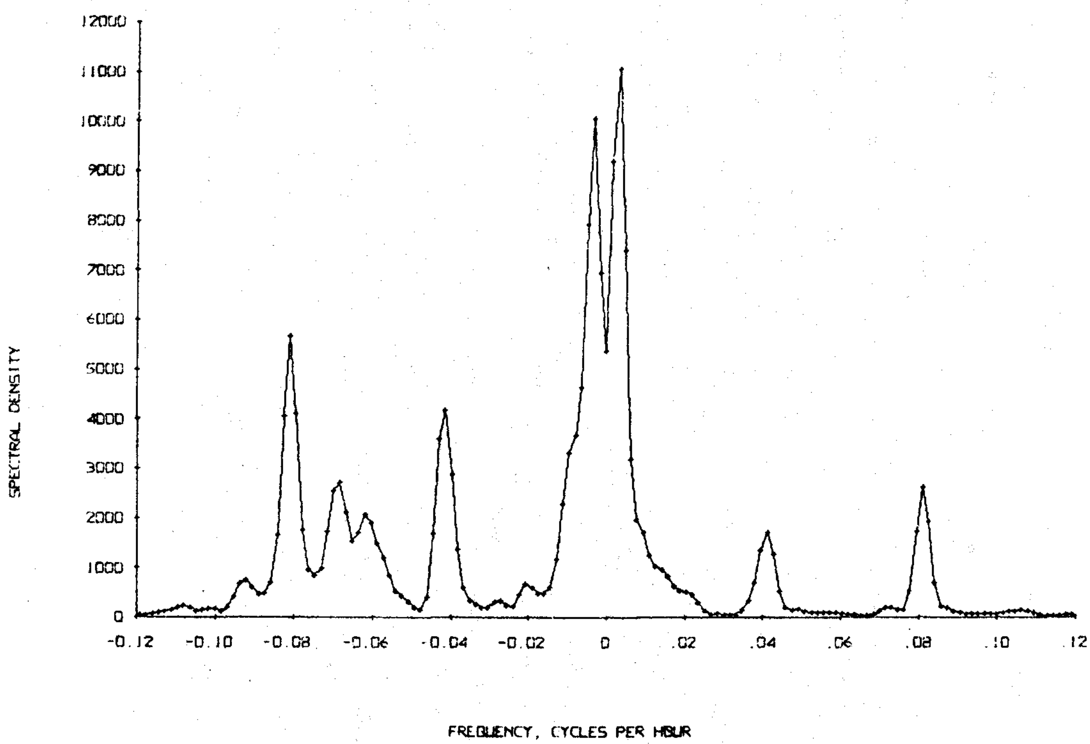
6DM AT NH-10. 26 DAYS STARTING 0330 7/7/72

ROTARY SPECTRUM
6DM AT NH-10. 7/6/72 TO 8/2/72. TAPE 502/8

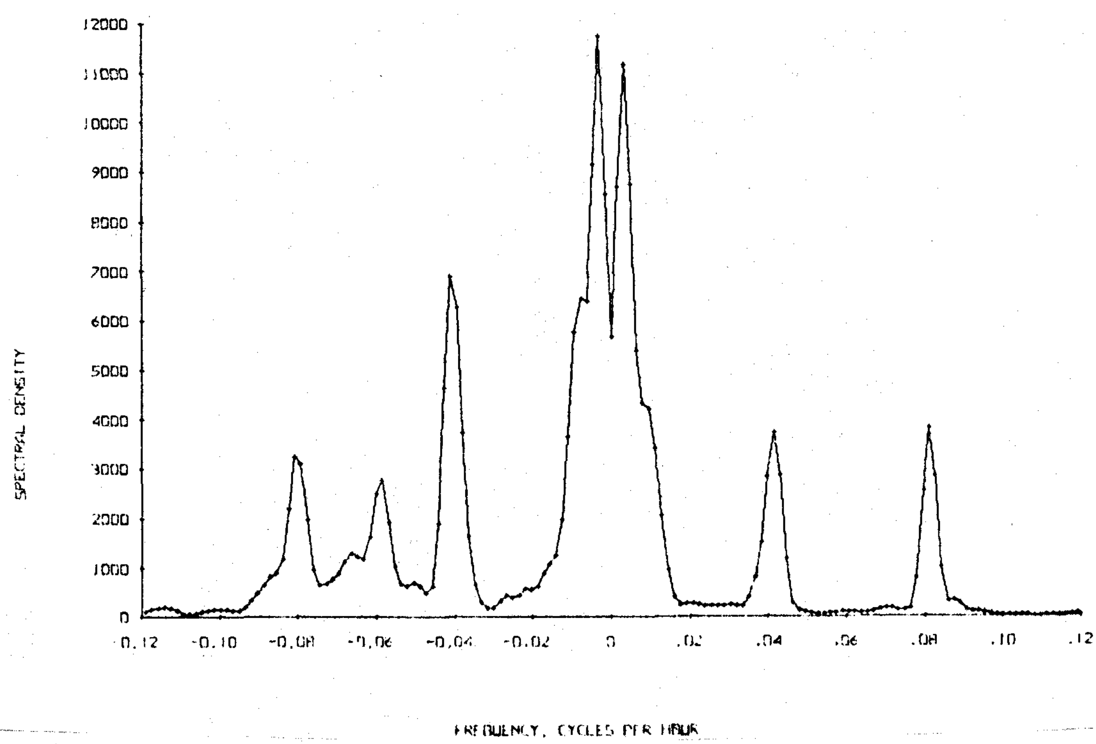


FREQUENCY, CYCLES PER HOUR

ROTARY SPECTRUM
20M AT NH-10. 7/6/72 TO 8/2/72. TAPE 438/10



ROTARY SPECTRUM
40M AT NH-10. 7/6/72 TO 8/2/72. TAPE 455/11



1972 CUE Installation E

NH 15

Position: 44°39.9'N, 124°25.1'W
Depth of Water: 95 m
Set at 2300 GMT 18 July 1972 by R/V CAYUSE
Retrieved at 1900 GMT 14 August 1972 by R/V CAYUSE
Data Interval: 2307 GMT 18 July to 1837 GMT 14 August

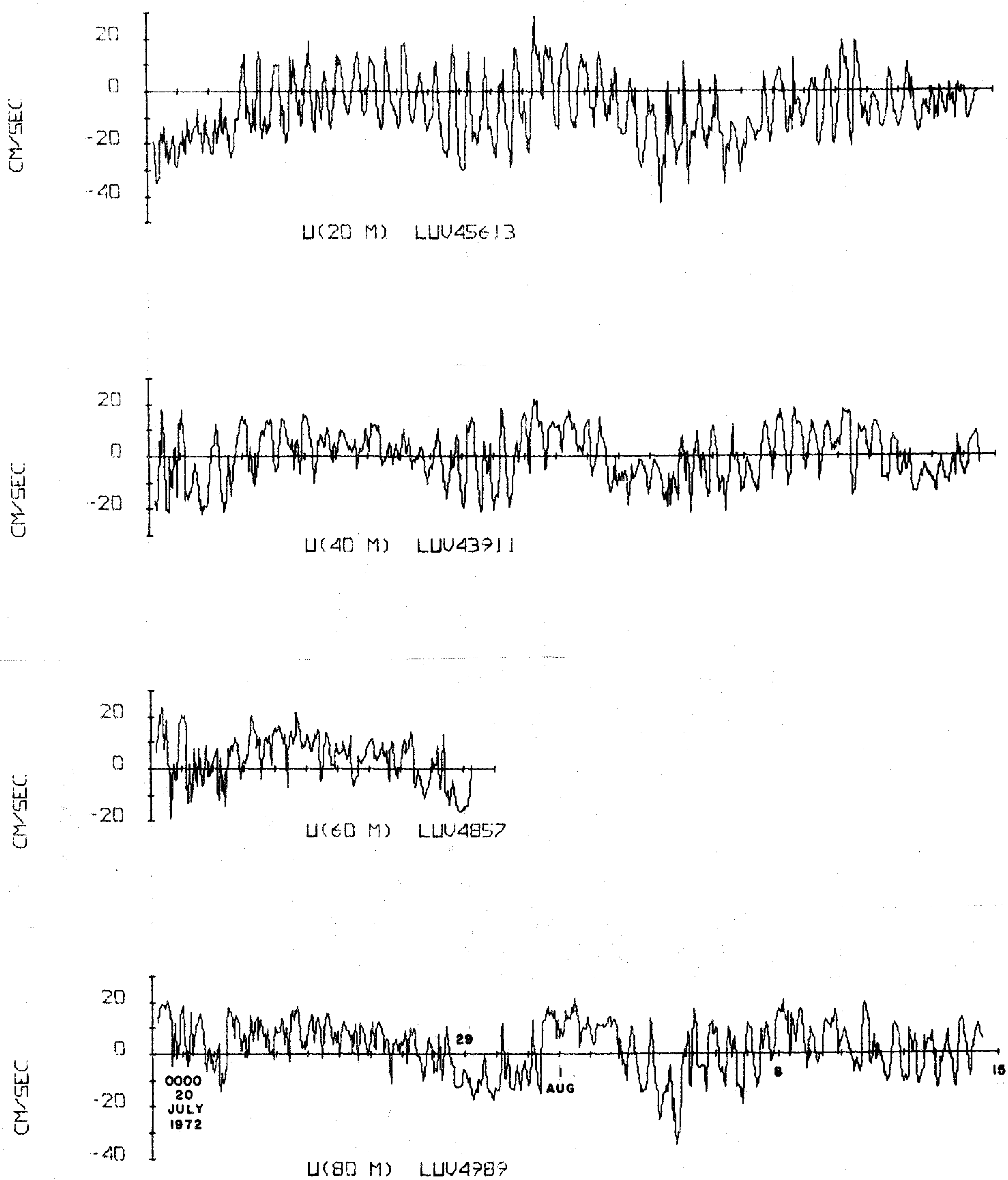
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	20 m	456/13
40 m	40 m	439/11
60 m	60 m	485/7
80 m	80 m	498/9

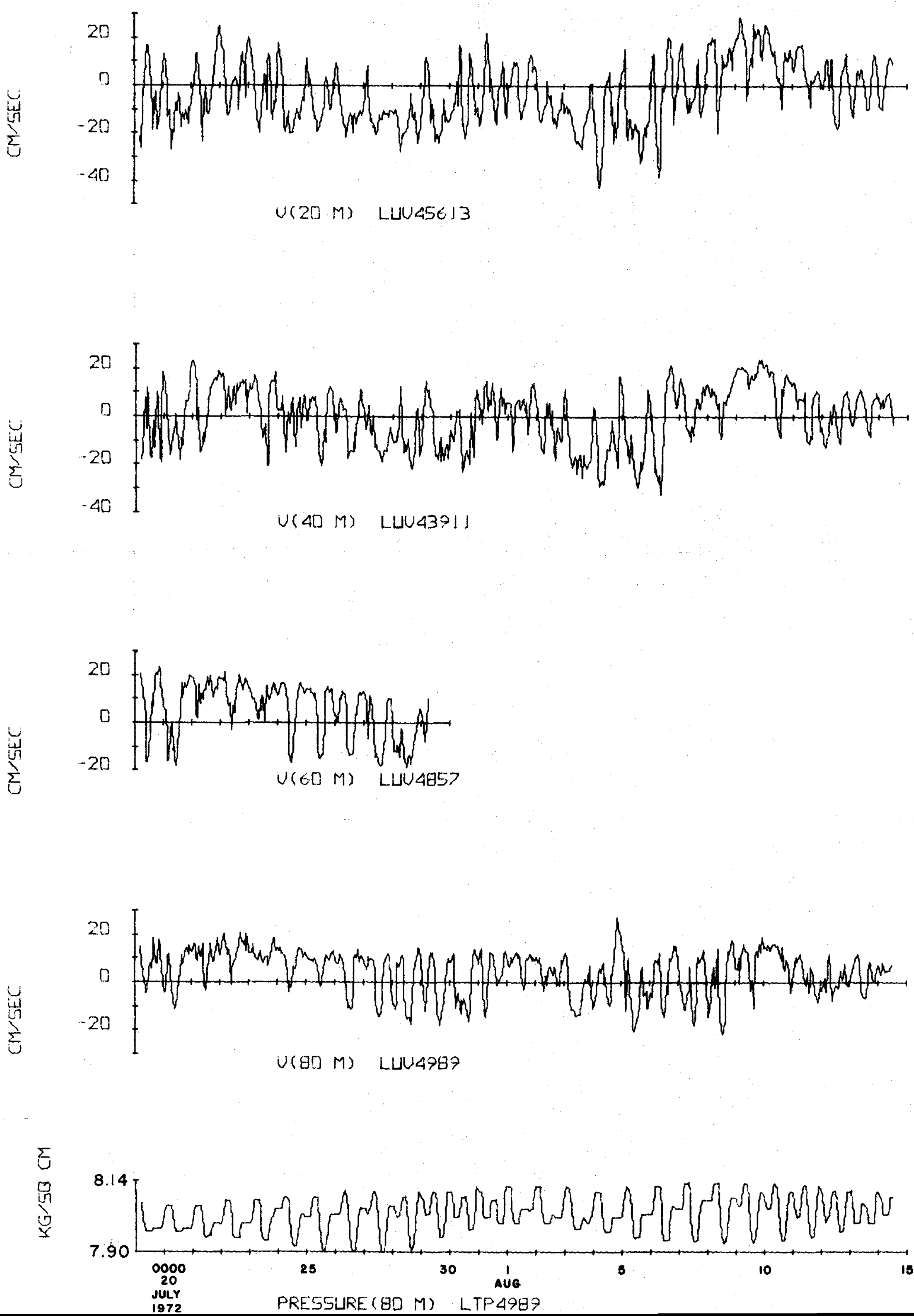
All meters recorded temperature, current direction, and current speed every 5 minutes. In addition, the deepest meter recorded pressure. All instruments worked well except RCM 485/7, which produced a data tape of poor quality. The best portion of RCM 485/7 through 1300 29 July is shown.

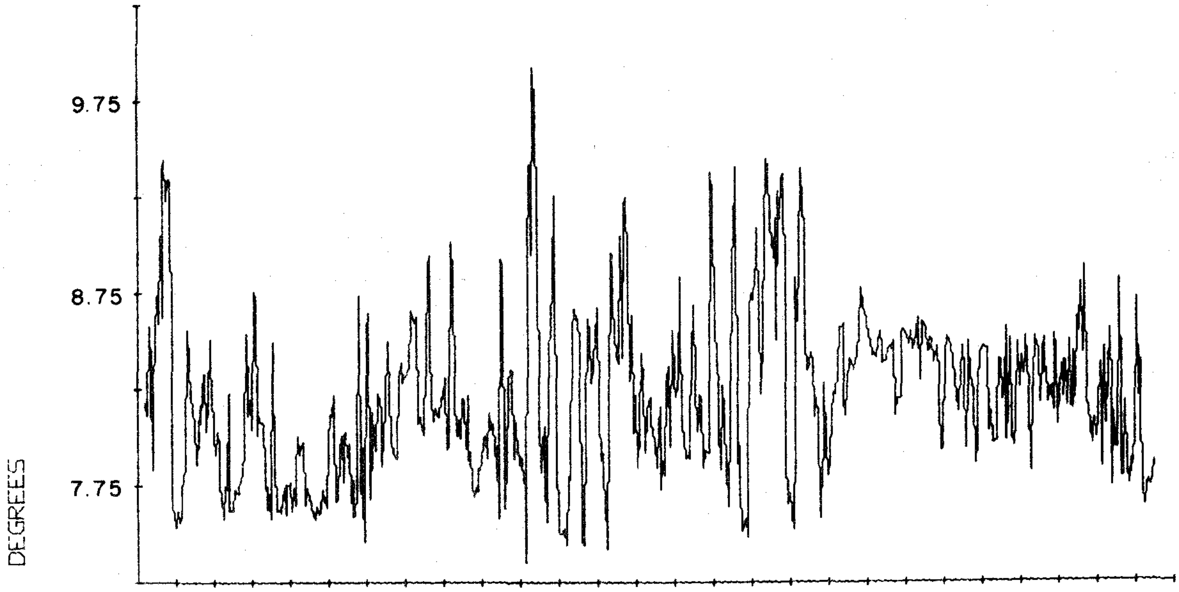
(E-NH-15)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	18.1	6.9	0.7	4.0	48.1	1.3
20 m (45613)	U (cm/sec)	- 6.8	12.1	0.2	2.6	29.0	-42.8
	V (cm/sec)	- 3.2	13.1	0.1	2.4	29.1	-42.9
	T (C)	8.21	0.43	0.73	3.68	9.93	7.35
	S (cm/sec)	14.6	5.6	0.2	2.8	33.4	1.8
40 m (43911)	U (cm/sec)	0.2	9.7	-0.1	2.2	22.3	-22.1
	V (cm/sec)	0.1	12.2	-0.3	2.1	24.2	-32.3
	T (C)	7.97	0.38	0.54	2.21	9.51	7.38
	S (cm/sec)	15.5	4.2	-0.3	3.3	25.1	2.4
60 m (4857)	U (cm/sec)	3.7	9.0	-0.3	2.5	23.4	-19.3
	V (cm/sec)	5.3	11.6	-0.6	2.1	23.5	-18.6
	T (C)	7.76	0.09	-0.44	2.20	7.88	7.53
	S (cm/sec)	13.7	4.4	0.7	6.7	41.0	1.0
80 m (4989)	U (cm/sec)	2.5	9.8	-0.5	2.8	21.6	-34.9
	V (cm/sec)	4.3	9.3	-0.6	2.6	27.8	-21.8
	T (C)	7.68	0.17	1.11	5.50	8.43	7.36
	P (kg/cm^2)	8.02	0.06	-0.13	2.23	8.12	7.90

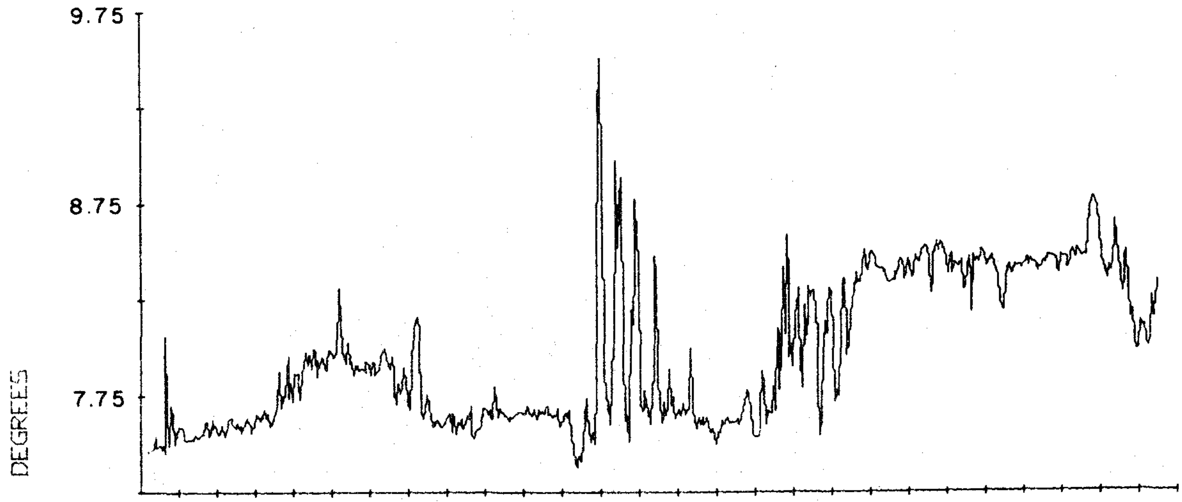


20
0
-20
-40
CM/SEC
U(20 M) LUV45613
20
0
-20
CM/SEC
U(40 M) LUV43911
20
0
-20
CM/SEC
U(60 M) LUV4857
20
0
-20
-40
CM/SEC
0000
20
JULY
1972
29
1
AUG
8
15
U(80 M) LUV4989

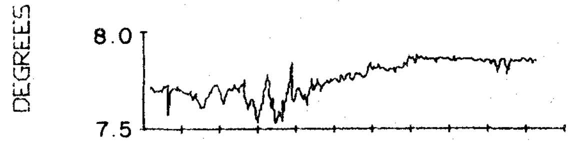

CM/SEC
20
0
-20
-40
V(20 M) LUV45613
CM/SEC
20
0
-20
-40
V(40 M) LUV43911
CM/SEC
20
0
-20
V(60 M) LUV4857
CM/SEC
20
0
-20
V(80 M) LUV4989
KG/SQ CM
8.14
7.90
0000
20
JULY
1972
25
30
1
AUG
5
10
15
PRESSURE(80 M) LTP4989



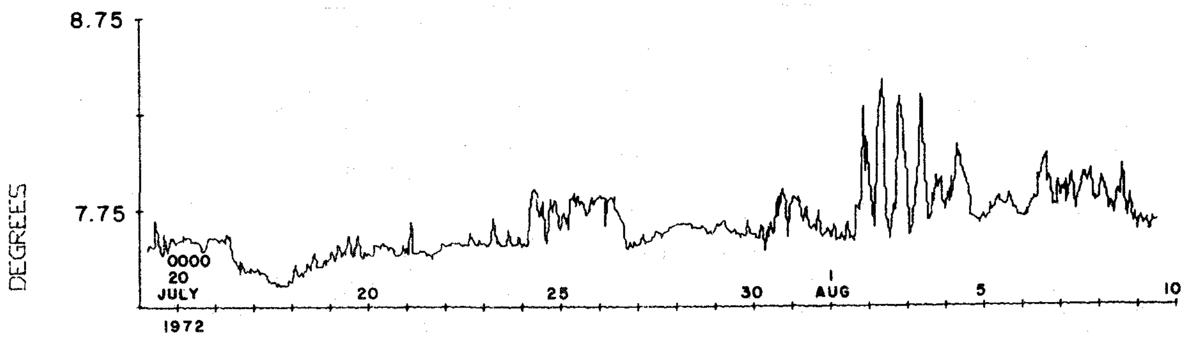
TEMP. (20 M) LT45613



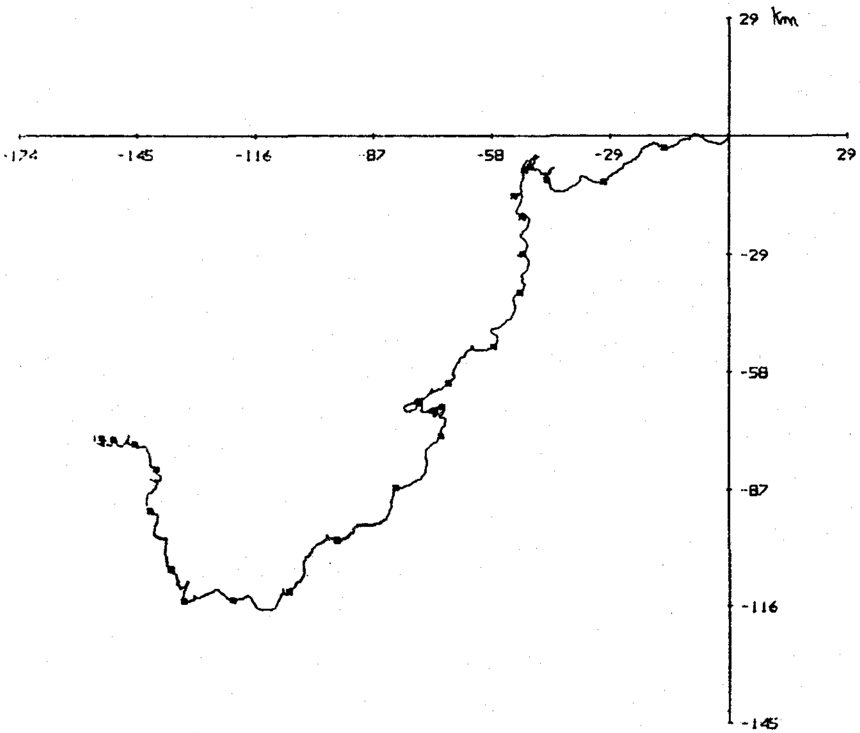
TEMP. (40 M) LT43911



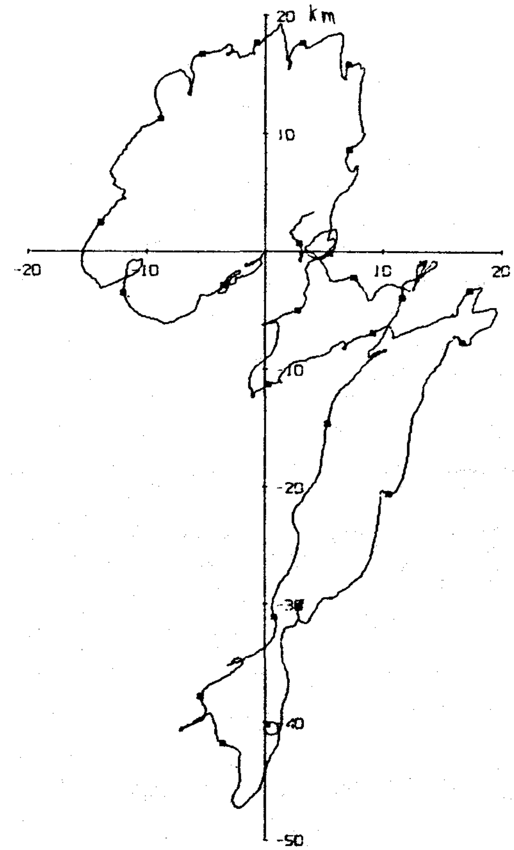
TEMP. (60 M) LT4857



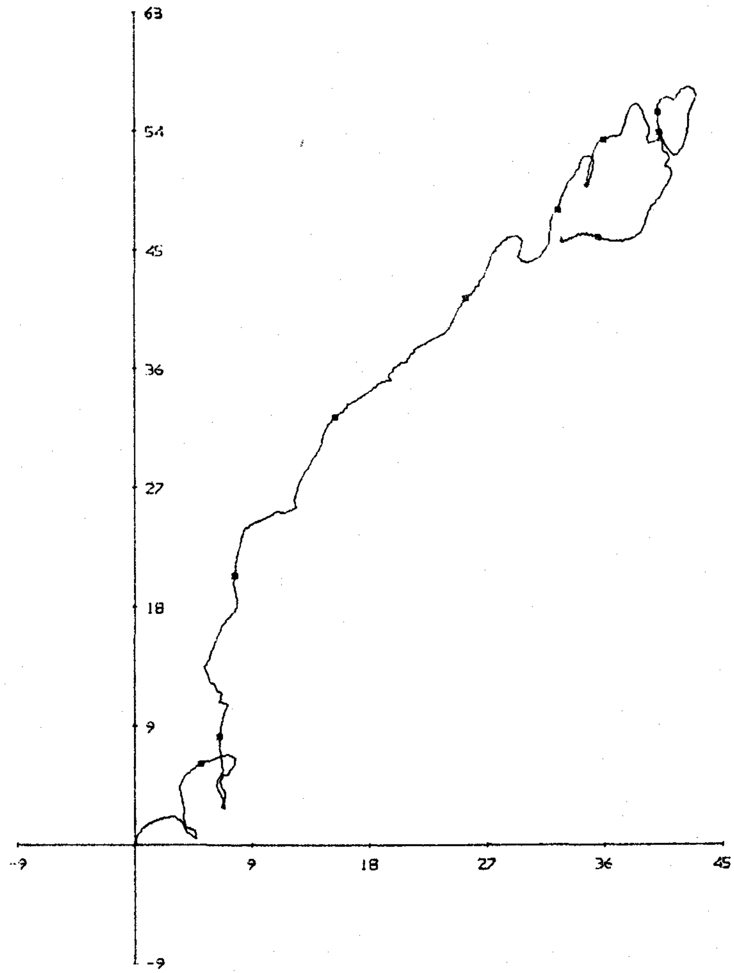
TEMP. (80 M) LTP4989



20M AT NH-15. 26 DAYS STARTING 0507 7/19/72



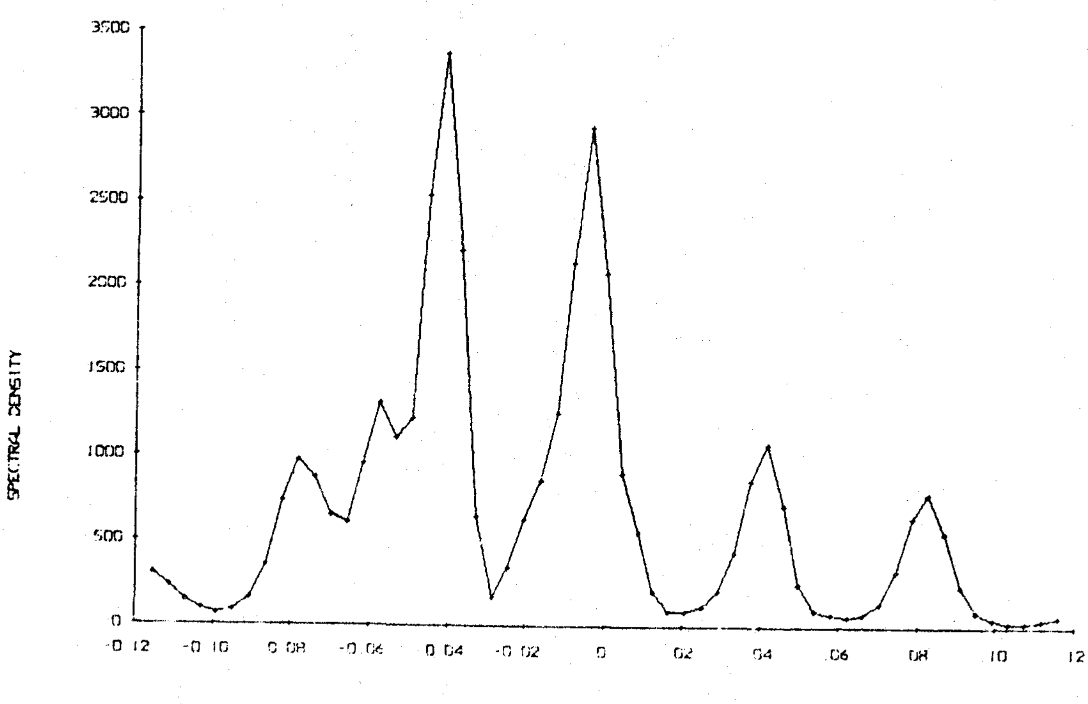
40M AT NH-15. 26 DAYS STARTING 0505 7/19/72

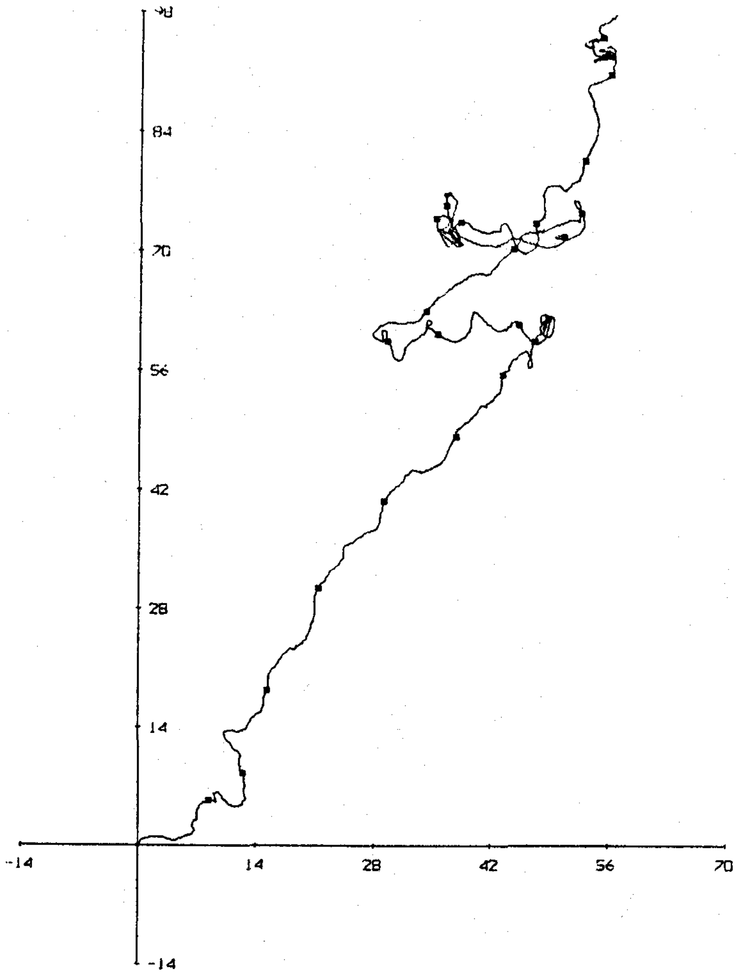


60 METERS AT NH-15. 10 DAYS STARTING 0505 7/19/72

ROTARY SPECTRUM

60 METERS AT NH-15. 7/18/72 TO 7/29/72. TAPE 485/7

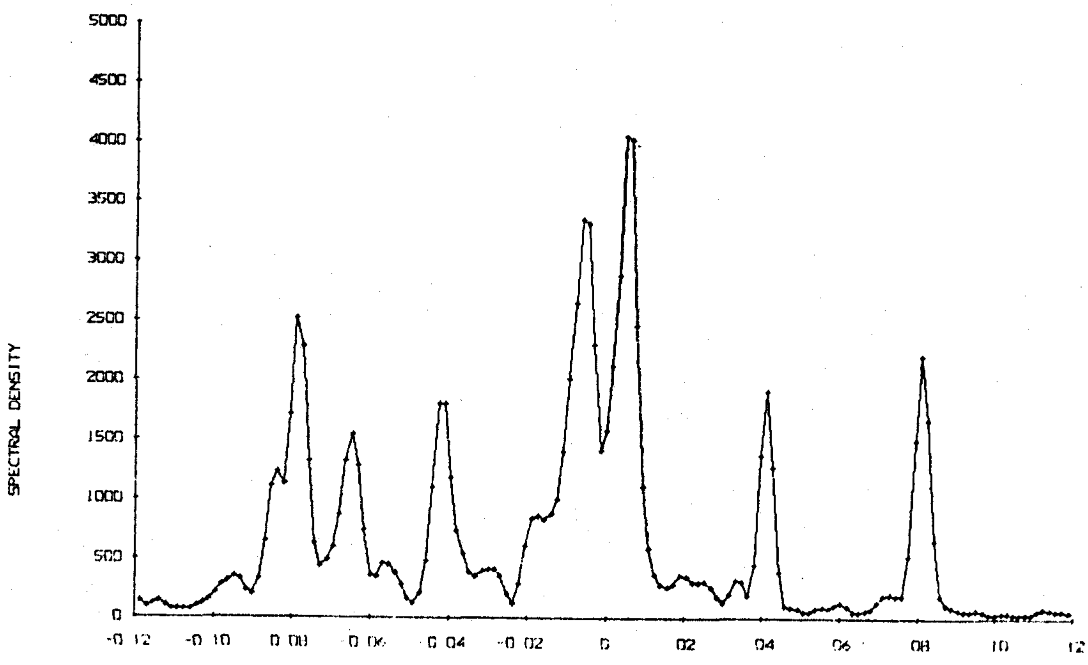




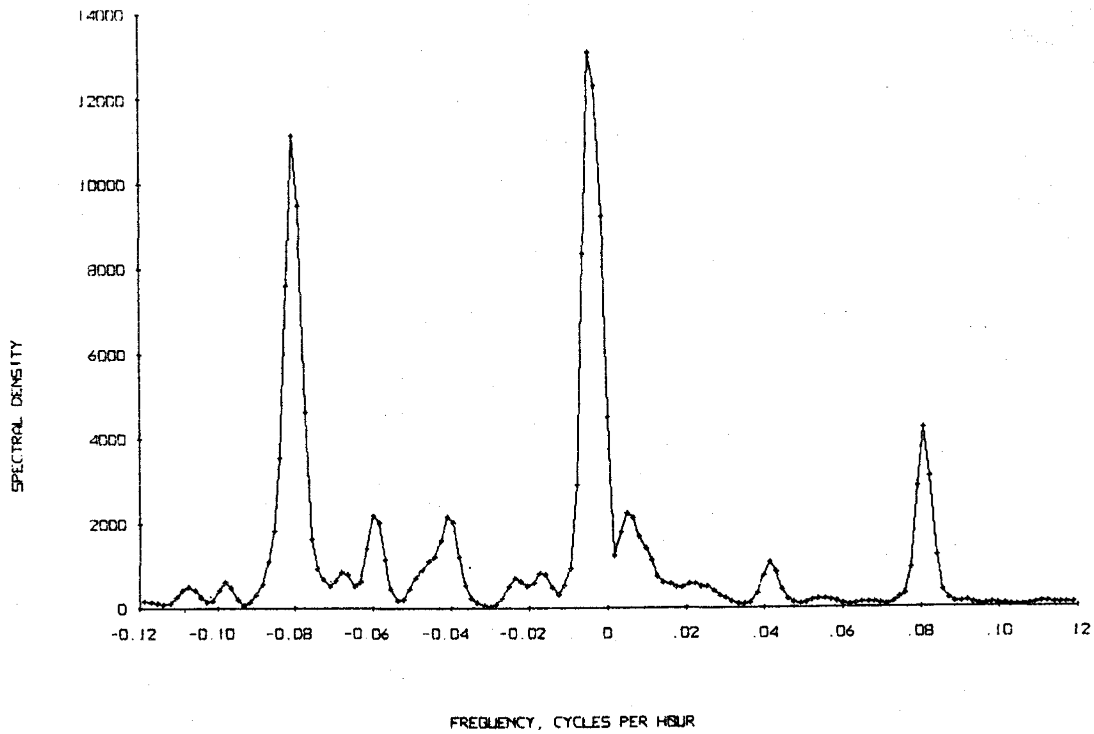
80 METERS AT NH-15. 26 DAYS STARTING 0504 7/19/72

ROTARY SPECTRUM

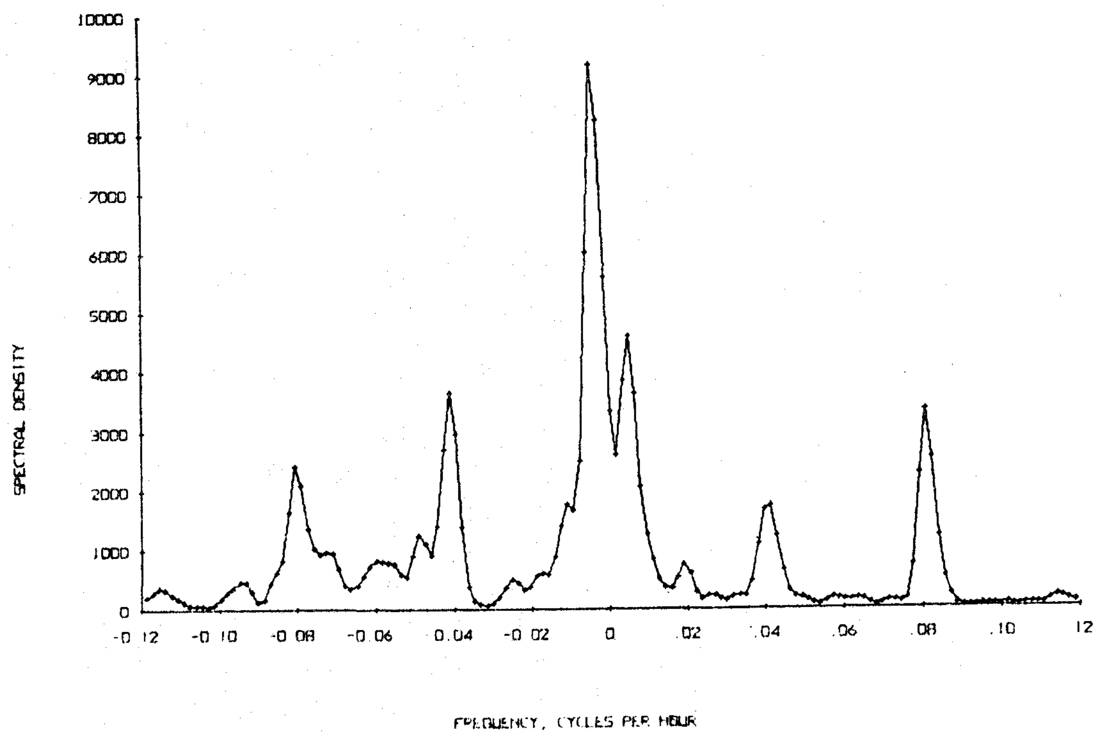
80 METERS AT NH-15. 7/18/72 TO 8/14/72. TAPE 498/9



ROTARY SPECTRUM
20M AT NH-15. 7/18/72 TO 8/14/72. TAPE [illegible]/13



ROTARY SPECTRUM
40M AT NH-15. 7/18/72 TO 8/14/72. TAPE 439/11



1972 CUE Installation E

NH 20

Position: 44°38.6'N, 124°31.5'W
Depth of Water: 142 m
Set at 0808 GMT 3 July 1972 by R/V CAYUSE
Retrieved at 1634 GMT 3 August 1972 by R/V CAYUSE
Data Interval: 1501 GMT 6 July to 1631 GMT 3 August

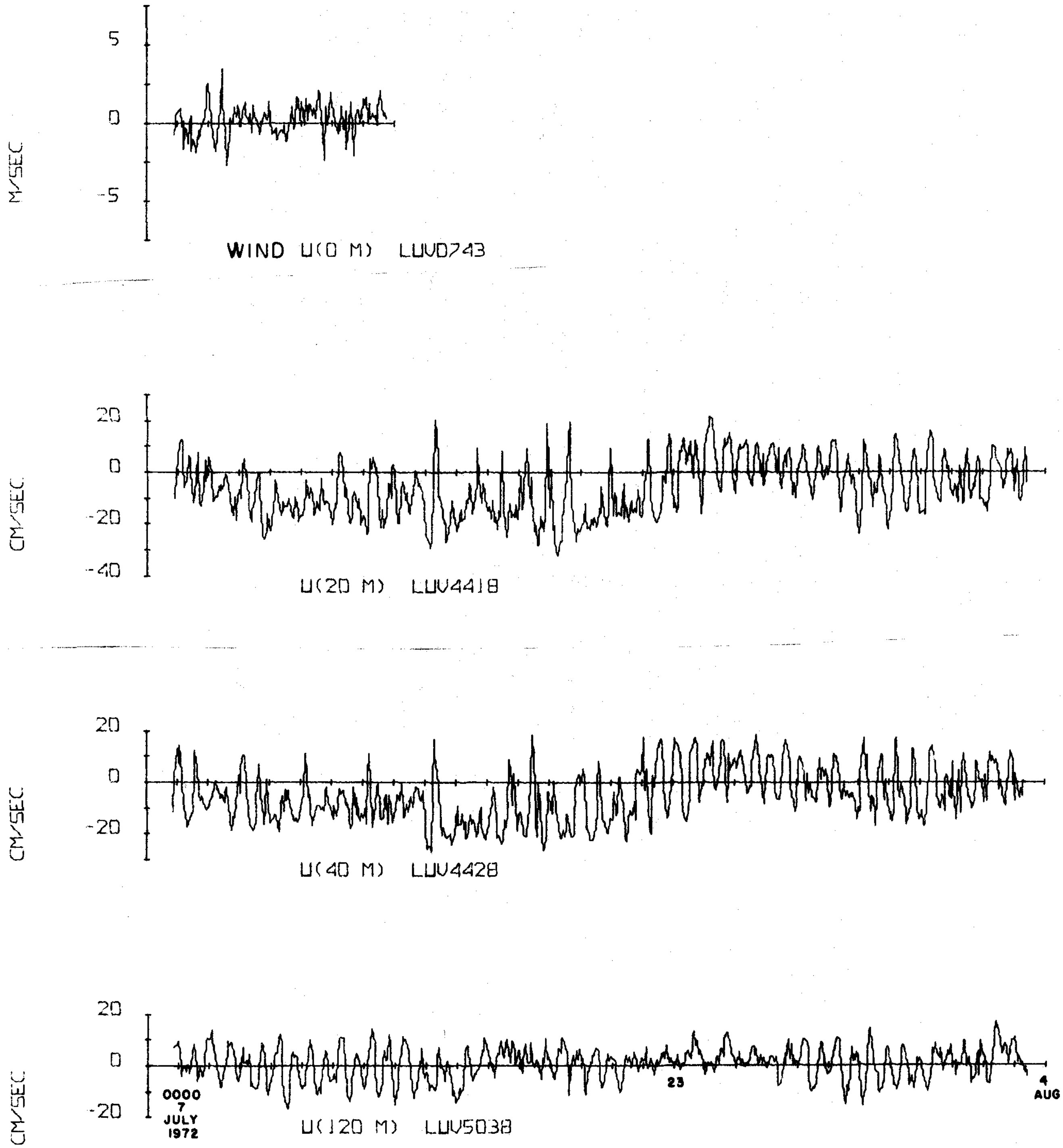
Instrumentation

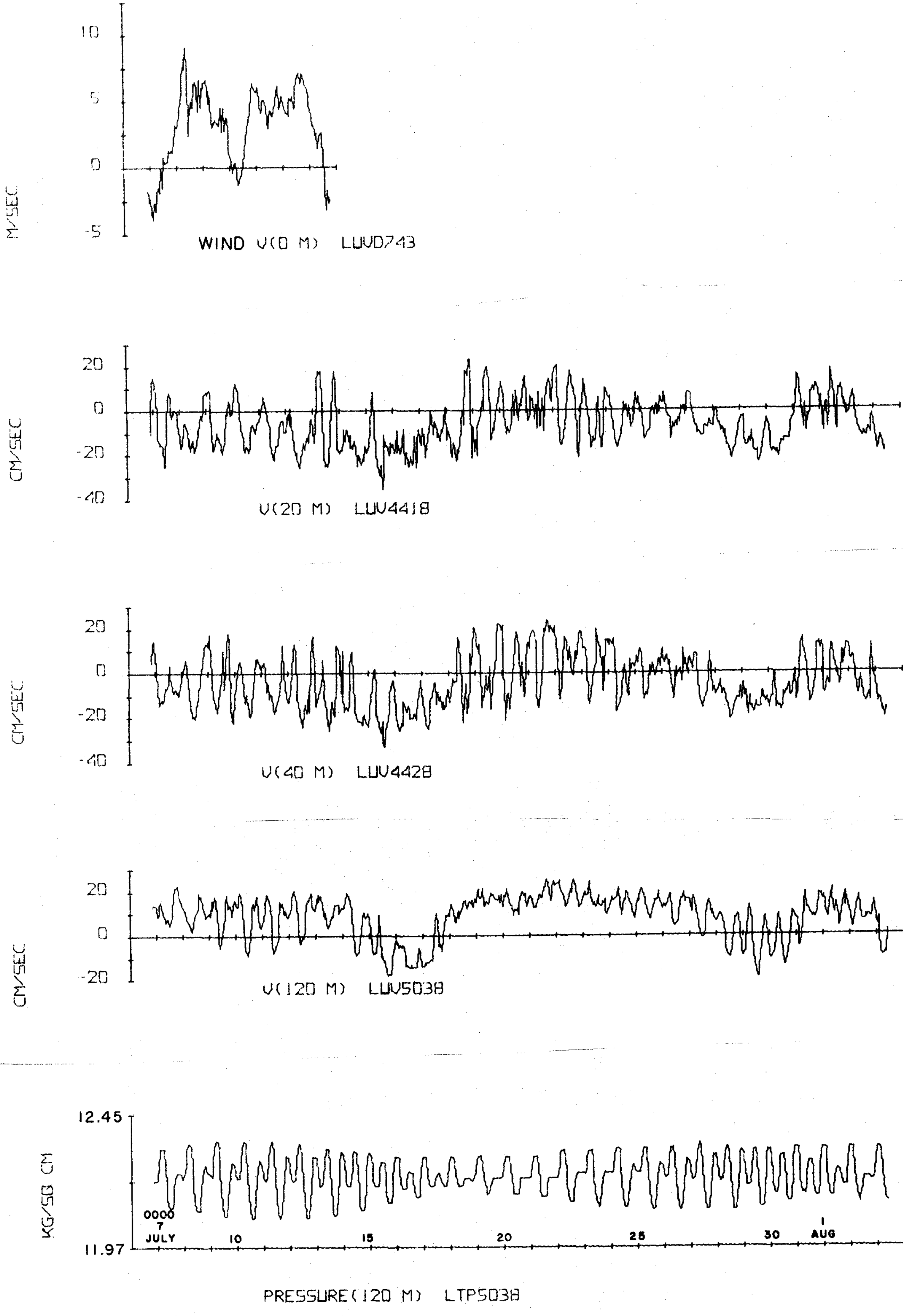
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D74/3
20 m	22 m	441/8
40 m	42 m	442/8
70 m	72 m	317/13
120 m	122 m	503/8

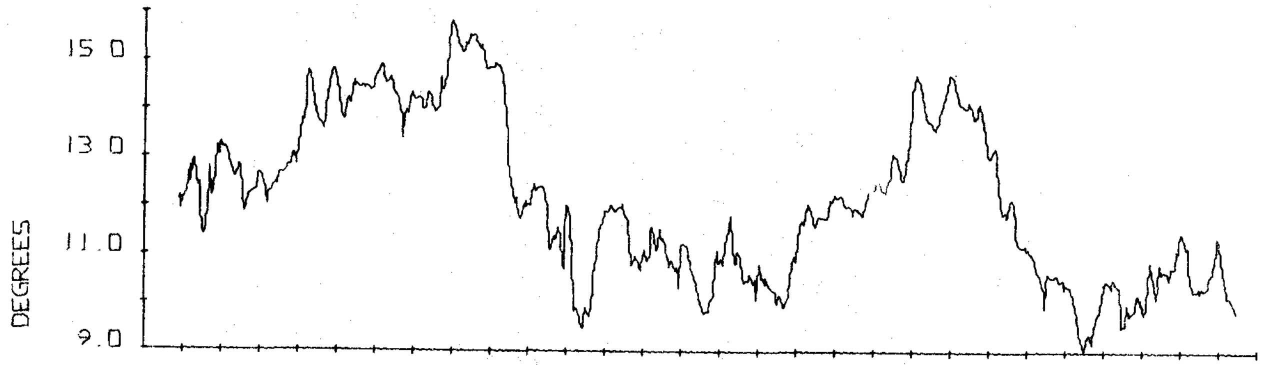
Data were recorded every 5 minutes. All sub-surface instruments measured temperature, current speed and current direction. In addition, the 120 m instrument recorded pressure. The 70 m instrument leaked and produced no usable data. Several sensors on the surface buoy also failed. Air temperatures were not obtained. The wind direction sensor failed after about a week, and the wind speed sensor a day later. Only the surface water temperature sensor worked for the entire installation.

(E-NH-20)

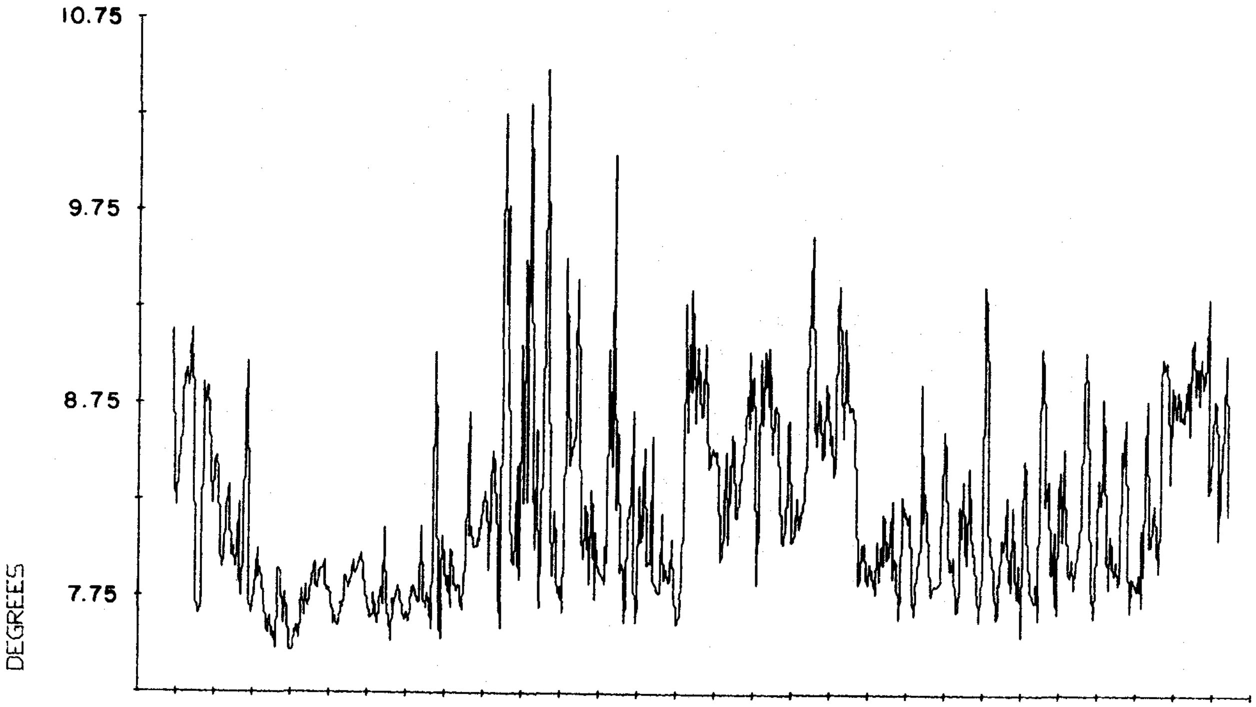
		MEAN	S.D.	SKEW	KURT	MAX	MIN
0m (D743)	S (m/sec)	3.9	1.9	0.4	2.2	9.2	0.1
	U (m/sec)	0.2	1.0	-0.1	3.4	3.5	- 2.6
	V (m/sec)	3.1	2.9	-0.6	2.5	9.1	- 3.9
	T (C) water	12.15	1.66	0.30	1.99	15.84	9.04
20m (4418)	S (cm/sec)	16.6	6.2	0.2	2.9	40.9	0.8
	U (cm/sec)	- 6.3	10.8	0.2	2.3	21.8	-32.2
	V (cm/sec)	- 6.4	10.7	0.4	2.6	23.6	-35.7
	T (C)	8.20	0.49	1.11	4.38	10.49	7.47
40m (4428)	S (cm/sec)	15.9	5.7	0.3	3.3	37.3	1.1
	U (cm/sec)	- 4.9	10.4	0.3	2.2	18.4	-26.9
	V (cm/sec)	- 4.0	11.7	0.3	2.2	23.7	-32.9
	T (C)	7.59	0.15	0.75	2.98	8.09	7.29
120m (5038)	S (cm/sec)	13.7	4.3	0.2	2.4	25.9	3.6
	U (cm/sec)	0.7	6.2	-0.3	2.6	16.7	-16.9
	V (cm/sec)	8.6	9.7	-0.9	3.0	25.3	-19.2
	T (C)	7.35	0.09	-0.01	2.08	7.57	7.16
	P (kg/cm^2)	12.23	0.07	-0.19	2.31	12.35	12.07


5
0
-5
M/SEC
WIND U(0 M) LUVD743
20
0
-20
-40
CM/SEC
U(20 M) LUV4418
20
0
-20
CM/SEC
U(40 M) LUV4428
20
0
-20
CM/SEC
0000
7
JULY
1972
23
4
AUG
U(120 M) LUV5038

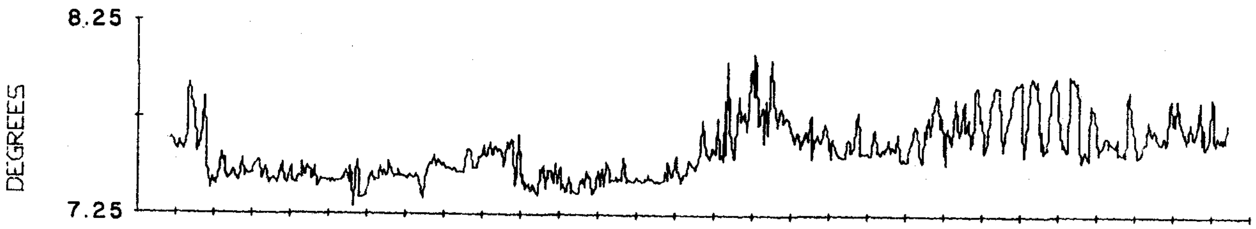

10
5
0
-5
M/SEC
WIND V(0 M) LUVD743
20
0
-20
-40
CM/SEC
V(20 M) LUV4418
20
0
-20
-40
CM/SEC
V(40 M) LUV4428
20
0
-20
CM/SEC
V(120 M) LUV5038
12.45
11.97
KG/SQ CM
0000
7
JULY
10
15
20
25
30
1
AUG
PRESSURE(120 M) LTP5038



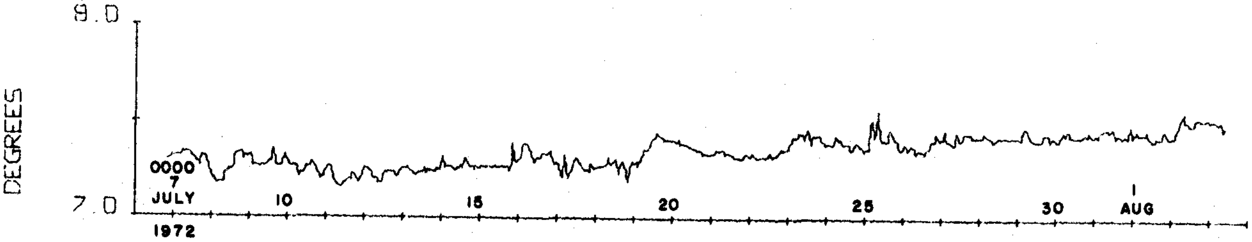
WATER TEMP (0 M) LWTD743



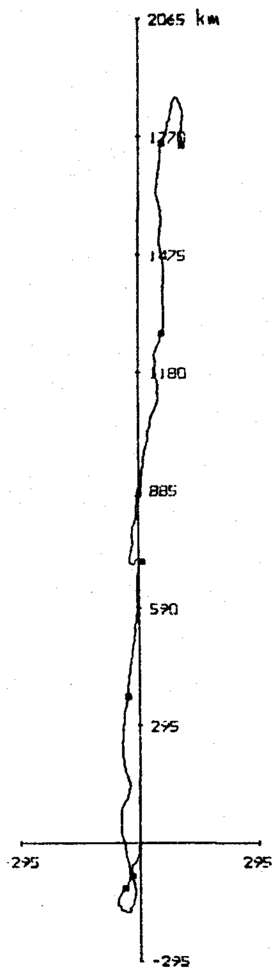
TEMP (20 M) LT4418



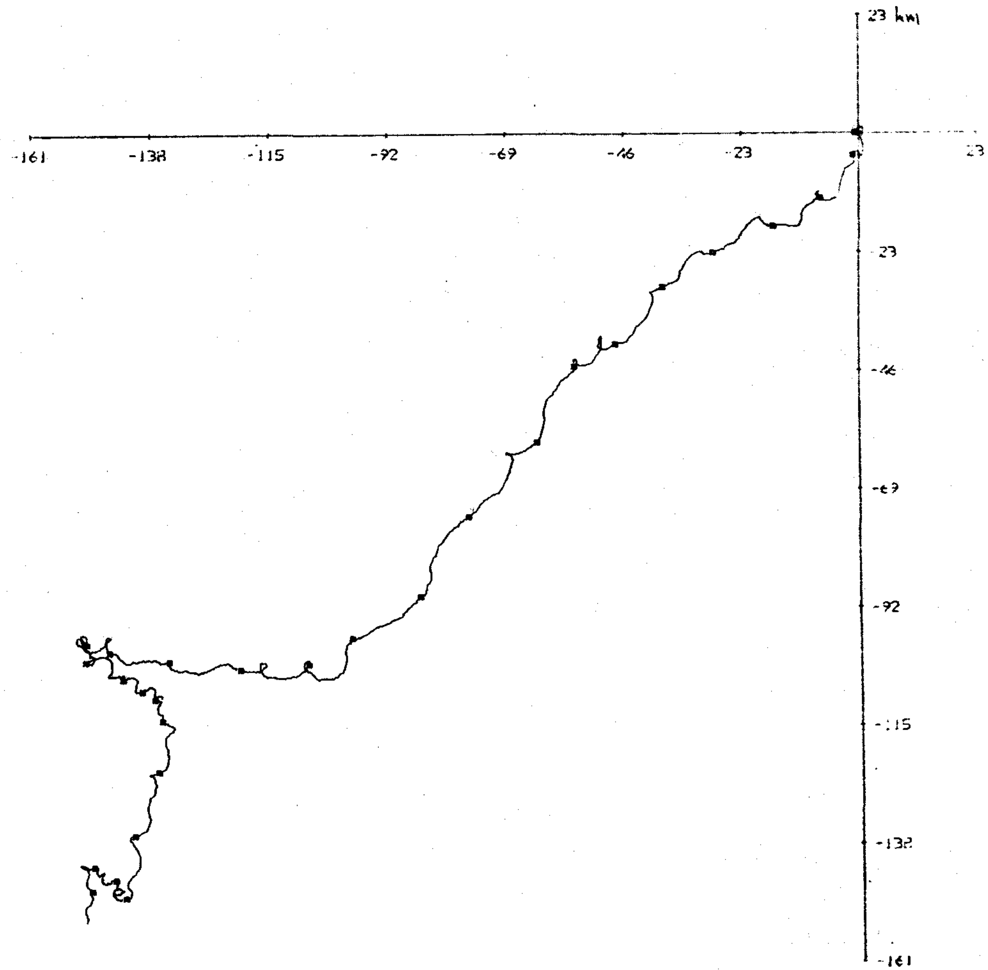
TEMP (40 M) LT4428



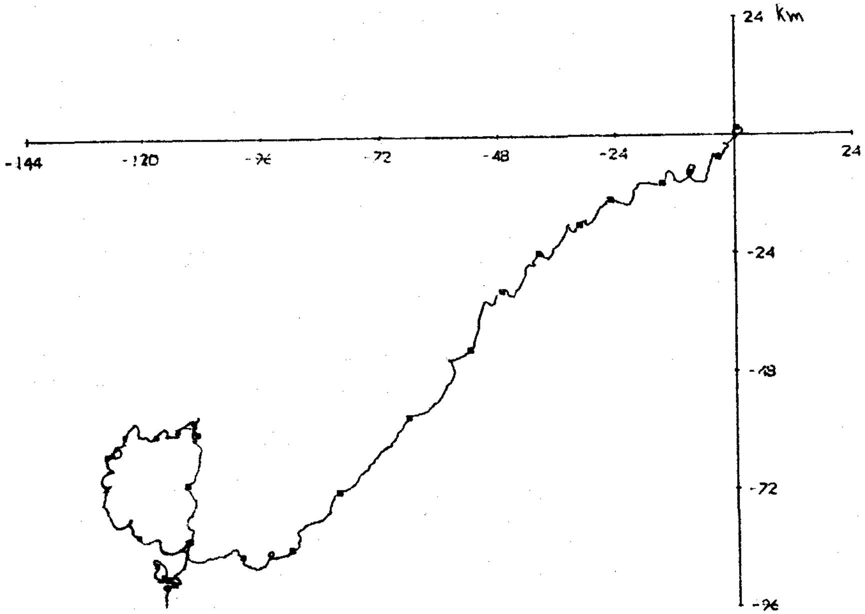
TEMP (120 M) LTP5038



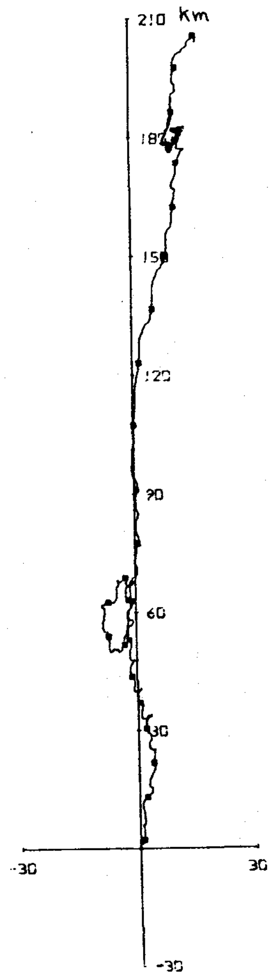
WIND AT NH-20. 7 DAYS STARTING 1540 7/6/72



20M AT NH-20. 28 DAYS STARTING 2101 7/6/72



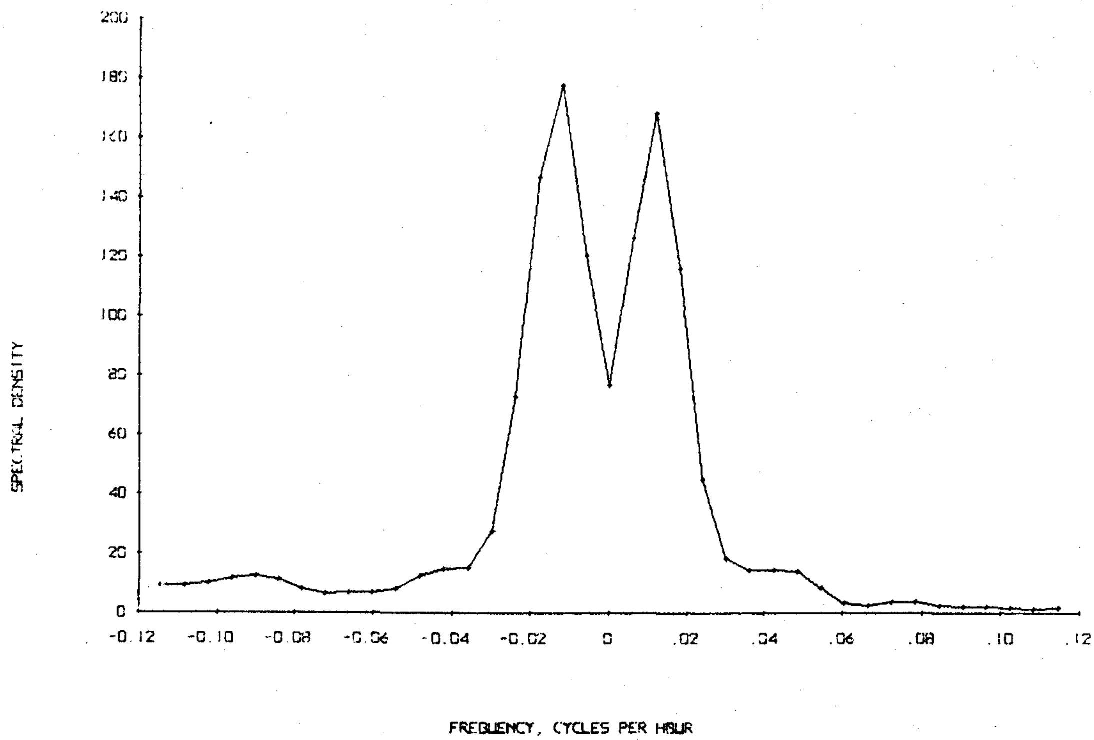
40M AT NH-20 28 DAYS STARTING 2048 7/6/72



120 METERS AT NH-20 28 DAYS STARTING 2058 7/6/72

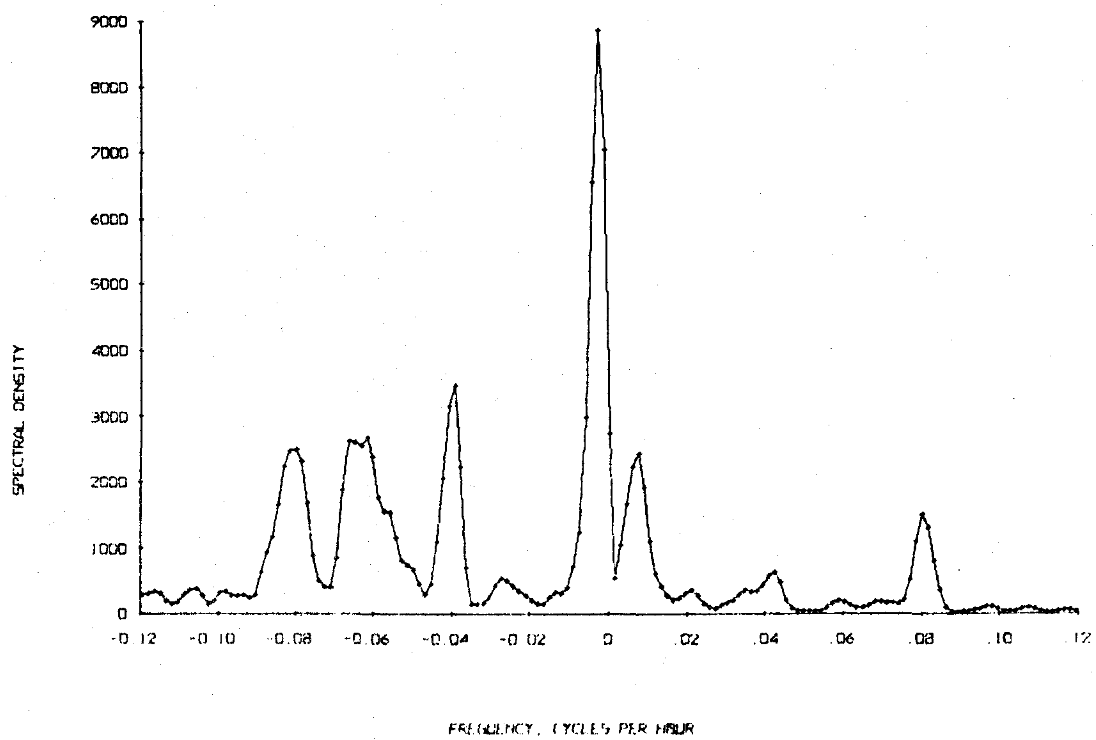
ROTARY SPECTRUM

WIND AT NH-20   7/6/72 TO 7/13/72.   TAPE 074/3

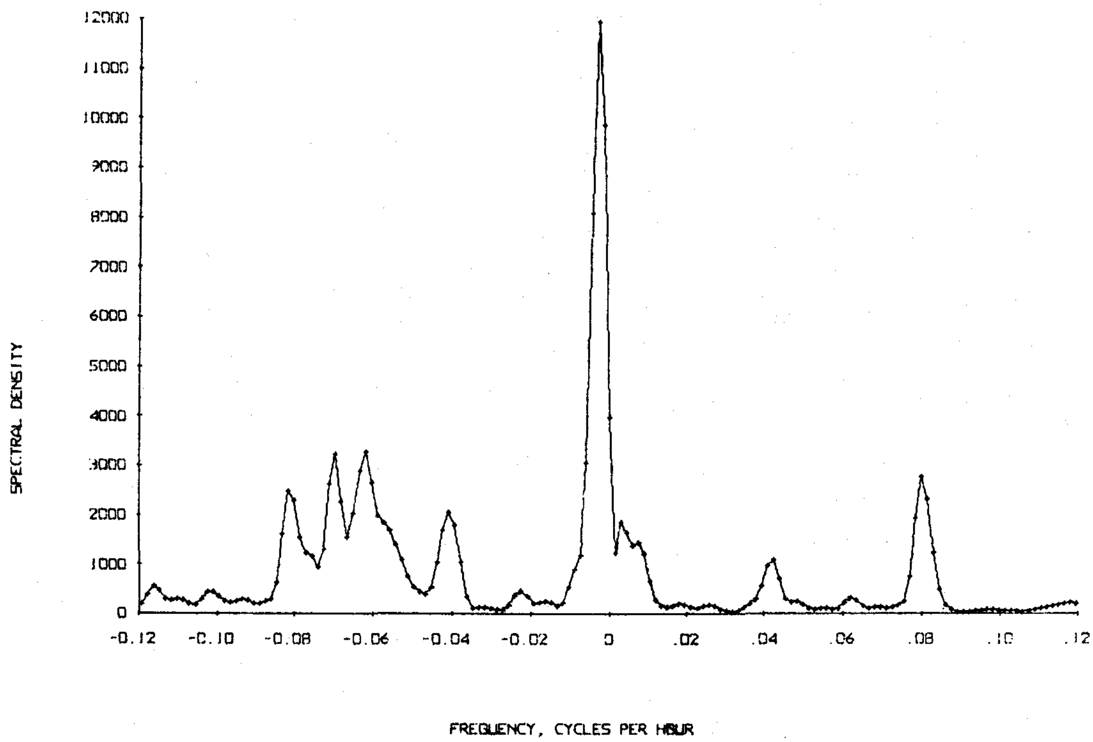


ROTARY SPECTRUM

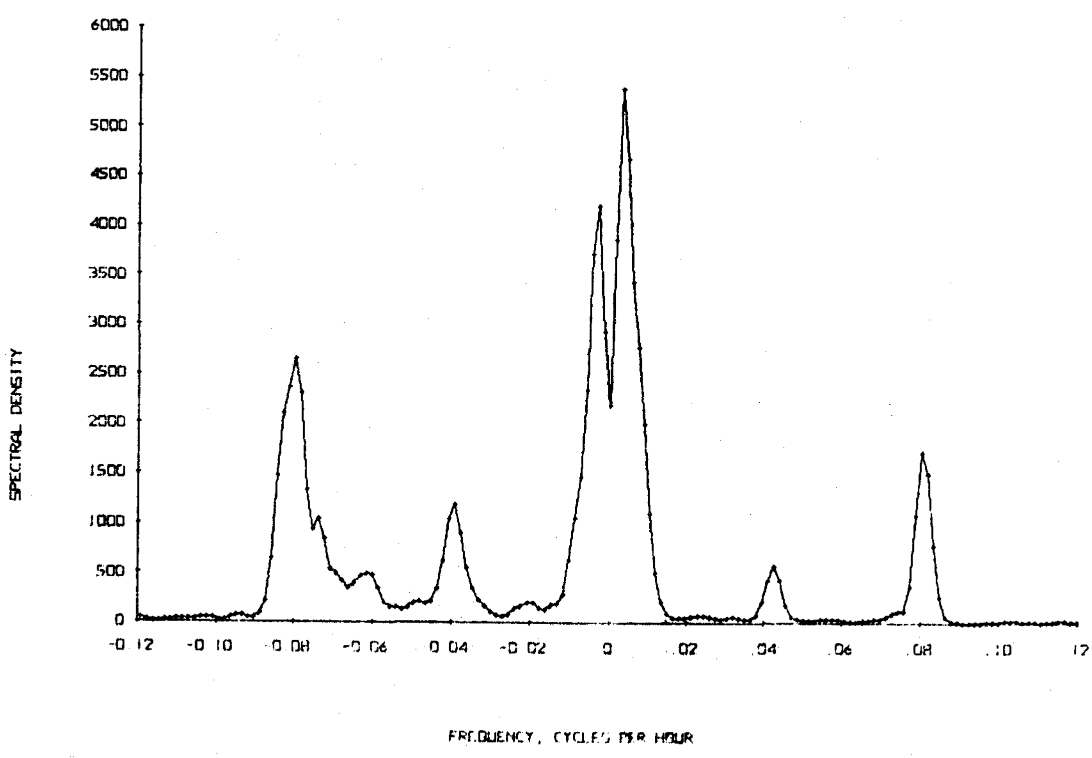
20M AT NH-20. 7/6/72 TO 8/3/72.   TAPE 441/8



ROTARY SPECTRUM
40M AT NH-20. 7/6/72 TO 8/3/72. TAPE 442/8



ROTARY SPECTRUM
120 METERS AT NH-20. 7/6/72 TO 8/3/72. TAPE 503/8



1972 CUE Installation E

DB 7

Position: 44°51.3'N, 124°12.0'W
Depth of Water: 100 m
Set at 1600 GMT 7 July 1972 by R/V CAYUSE
Retrieved at 1630 1 August 1972 by R/V CAYUSE
Data Interval: 1600 GMT 7 July to 1615 GMT 1 August

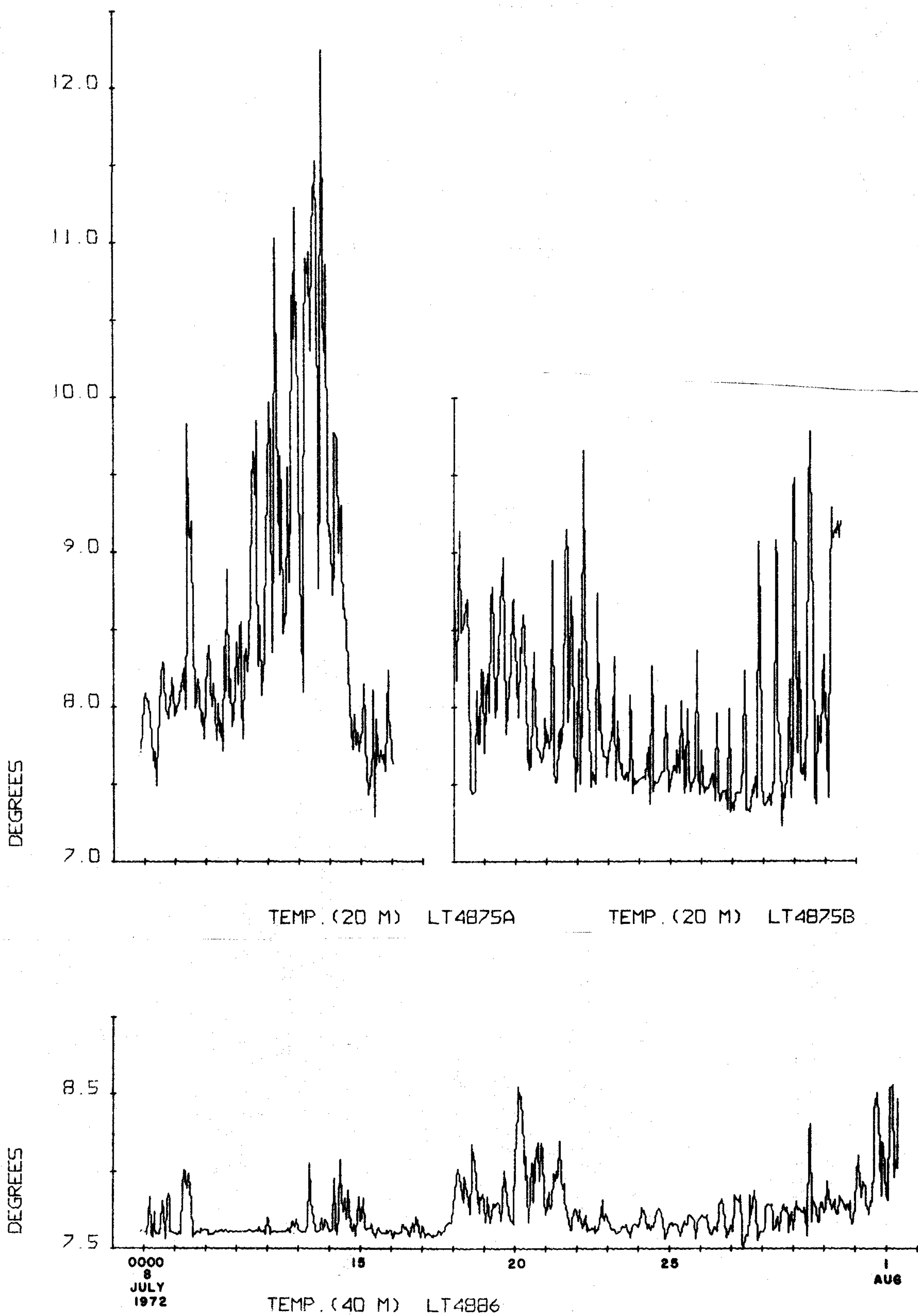
Instrumentation

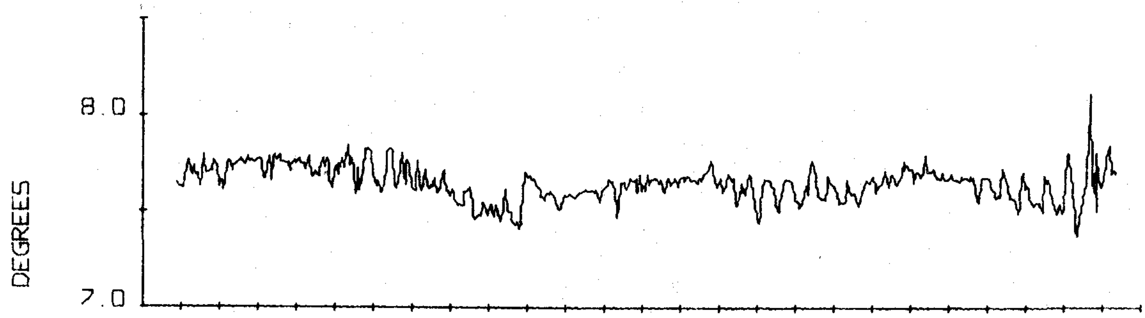
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	20 m	487/5
40 m	40 m	488/6
60 m	60 m	489/5
80 m	80 m	497/8

Data were recorded every 5 minutes. All instruments measured temperature, current speed,and current direction. In addition,the 80 m instrument recorded pressure. All meters operated normally except the 20 m instrument, which produced about a day of bad data near the middle of the installation and two days at the end. The 20 m record has been divided into Part A and Part B, of 8 days and 12 days duration respectively.

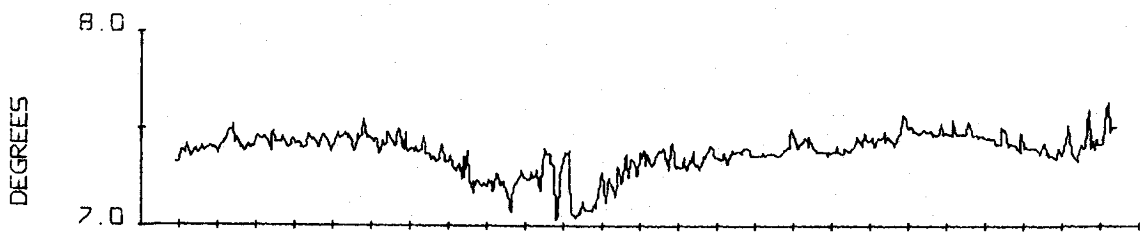
(E-DB-7)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	28.6	10.6	0.7	3.4	58.2	3.0
20 m)	U (cm/sec)	- 4.6	7.9	0.1	3.0	17.4	-27.9
4875A	V (cm/sec)	-26.9	11.1	-0.6	3.2	- 1.8	- 58.2
	T (C)	8.61	0.98	1.33	4.09	12.25	7.29
	S (cm/sec)	21.4	7.6	0.4	3.0	43.1	3.4
(20 m)	U (cm/sec)	0.6	11.3	0.2	2.1	28.1	-22.0
4875B	V (cm/sec)	-12.3	15.4	0.5	2.5	23.9	- 42.5
	T (C)	7.92	0.55	1.21	3.62	9.78	7.23
	S (cm/sec)	18.8	8.3	1.1	4.5	48.8	1.5
(40 m)	U (cm/sec)	2.8	8.6	- 0.2	2.4	21.3	- 22.3
4886	V (cm/sec)	-9.0	16.1	- 0.1	2.2	23.7	- 48.8
	T (C)	7.74	0.18	2.14	8.30	8.56	7.50
	S (cm/sec)	18.3	5.1	0.7	4.2	37.1	3.6
(60 m)	U (cm/sec)	3.0	9.2	-0.1	2.1	21.6	-19.6
4895	V (cm/sec)	2.0	16.3	-0.6	2.0	26.3	-36.9
	T (C)	7.65	0.09	-0.04	4.04	8.12	7.37
	S (cm/sec)	18.2	5.4	0.4	2.8	34.8	3.0
(80 m)	U (cm/sec)	2.3	8.8	- 0.4	2.5	20.6	- 23.9
4978	V (cm/sec)	7.4	15.0	- 0.8	2.6	34.8	- 32.5
	T (C)	7.38	0.10	- 1.14	4.74	7.64	7.03
	P (kg/cm^2)	8.04	0.06	- 0.60	4.06	8.17	7.88

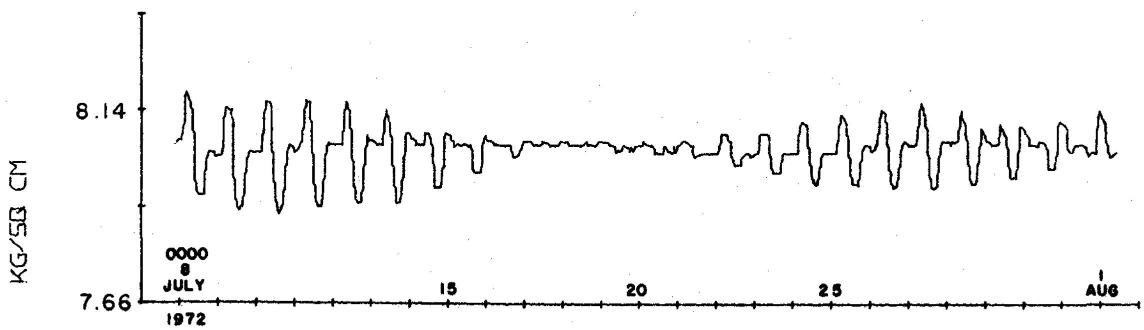

12.0
11.0
10.0
9.0
8.0
7.0
DEGREES
TEMP. (20 M) LT4875A
TEMP. (20 M) LT4875B
8.5
7.5
DEGREES
0000
8
JULY
1972
15
20
25
1
AUG
TEMP. (40 M) LT4886



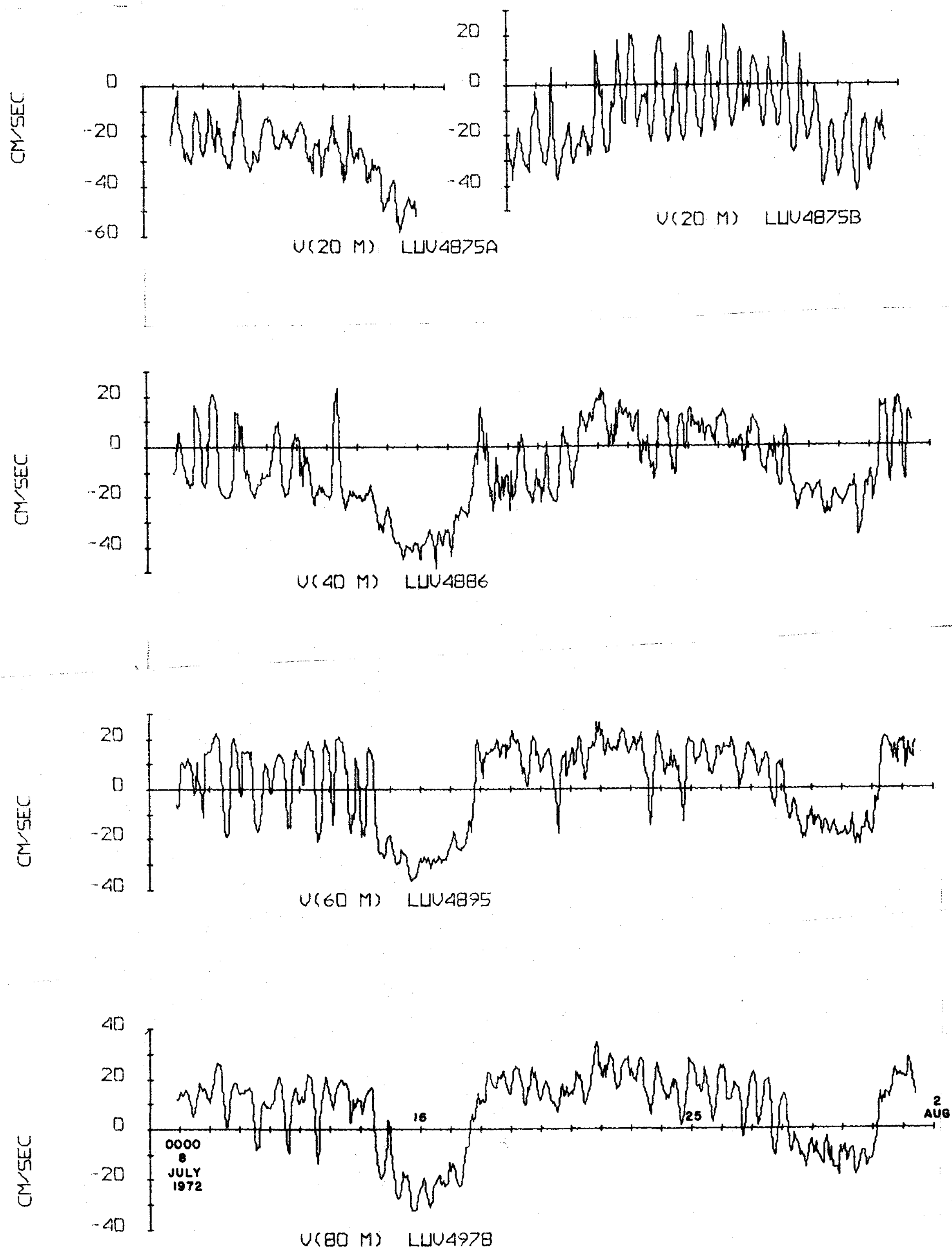
TEMP. (60 M) LULT4895

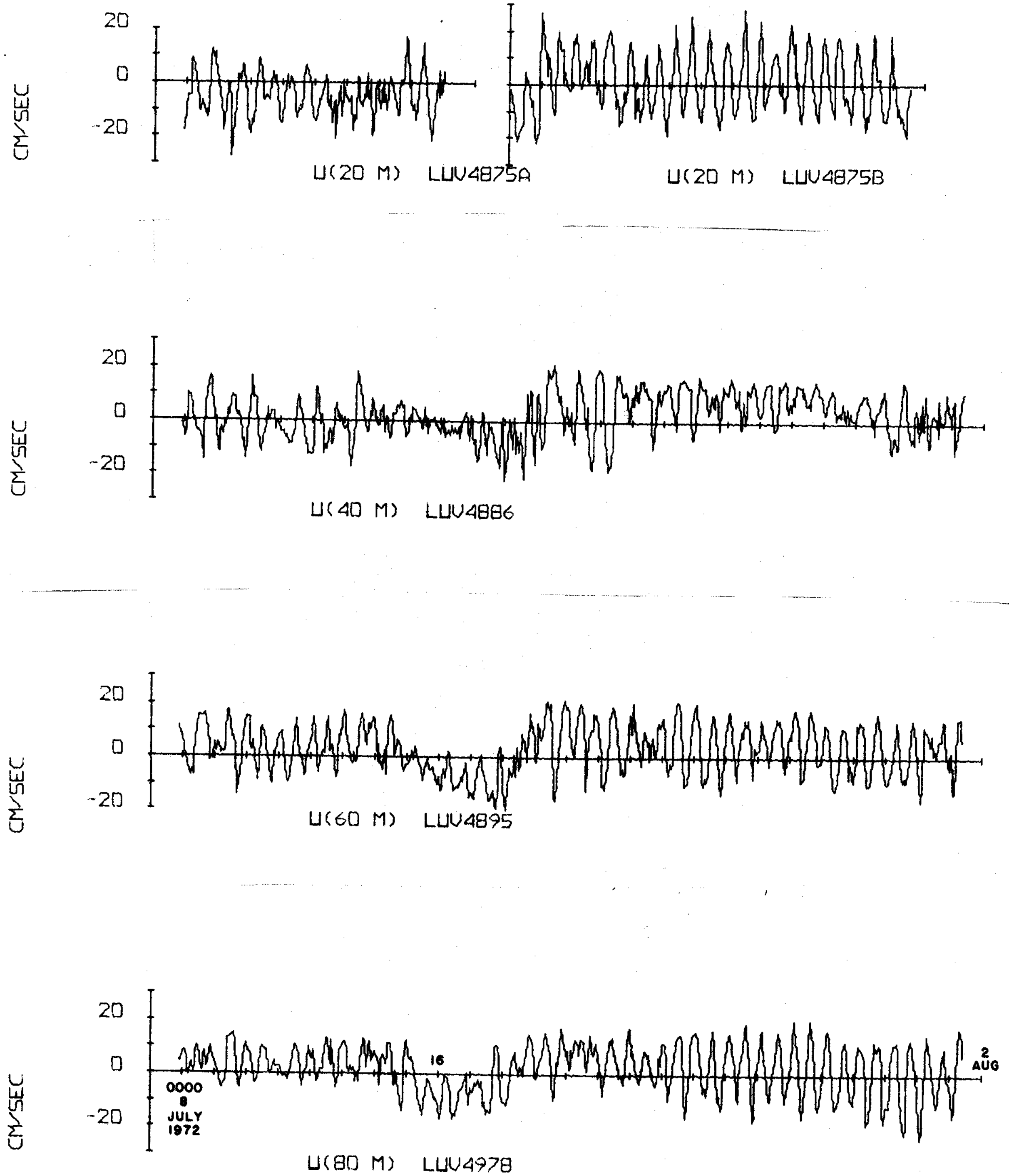


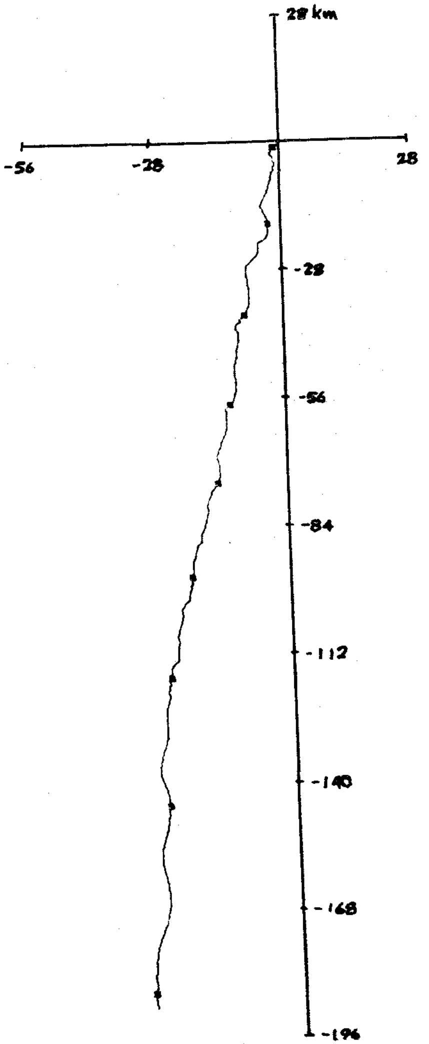
TEMP. (80 M) LTP4978



PRESSURE (80 M) LTP4978

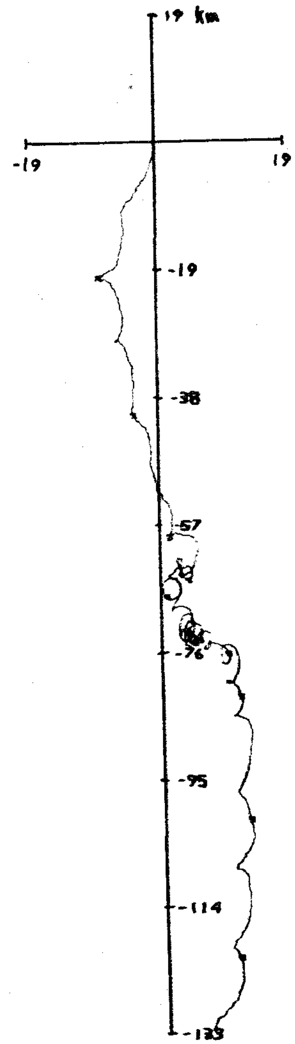

CM/SEC
0
-20
-40
-60
V(20 M) LUV4875A
20
0
-20
-40
V(20 M) LUV4875B
CM/SEC
20
0
-20
-40
V(40 M) LUV4886
CM/SEC
20
0
-20
-40
V(60 M) LUV4895
CM/SEC
40
20
0
-20
-40
0000
8
JULY
1972
16
25
2
AUG
V(80 M) LUV4978


CM/SEC
20
0
-20
U(20 M) LUV4875A
U(20 M) LUV4875B
20
0
-20
U(40 M) LUV4886
20
0
-20
U(60 M) LUV4895
20
0
-20
0000
8
JULY
1972
16
2
AUG
U(80 M) LUV4978



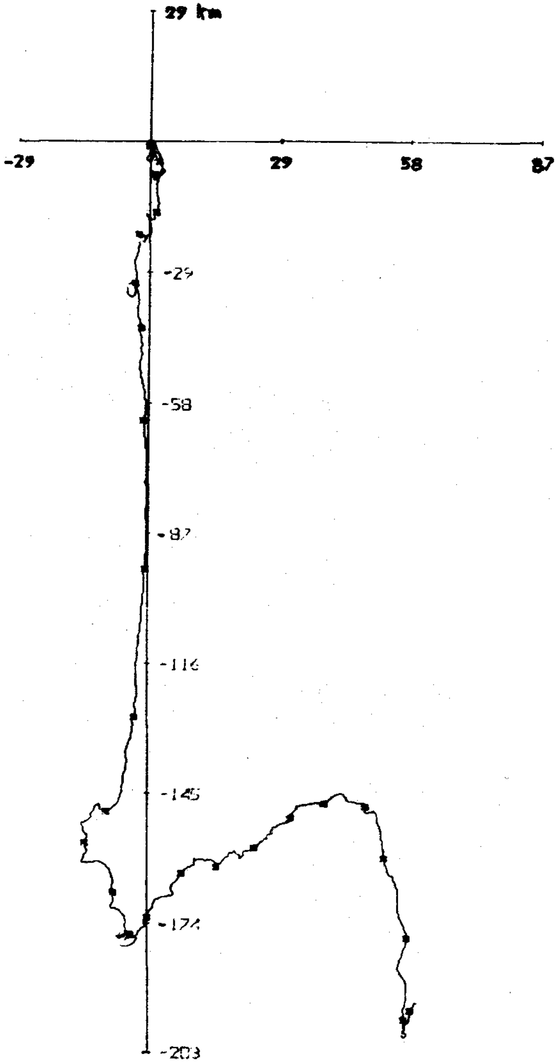
20M AT DS 7 8 DAYS STARTING 2203 7/7/72

A

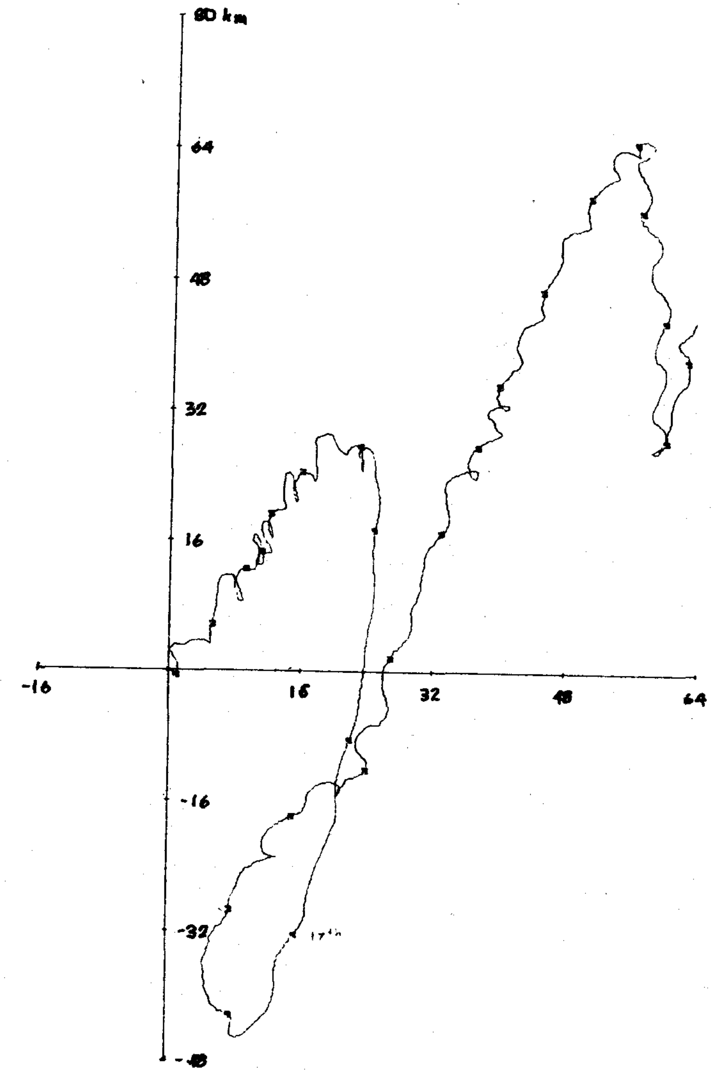


20M AT DS 7 12 DAYS STARTING 0123 7/18/72

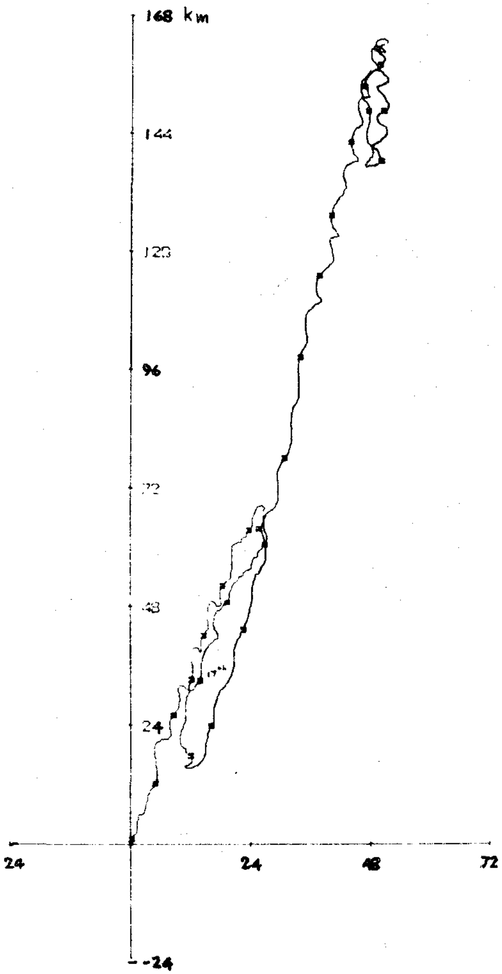
B



40 METERS AT DB-7. 24 DAYS STARTING 2158 7/7/72

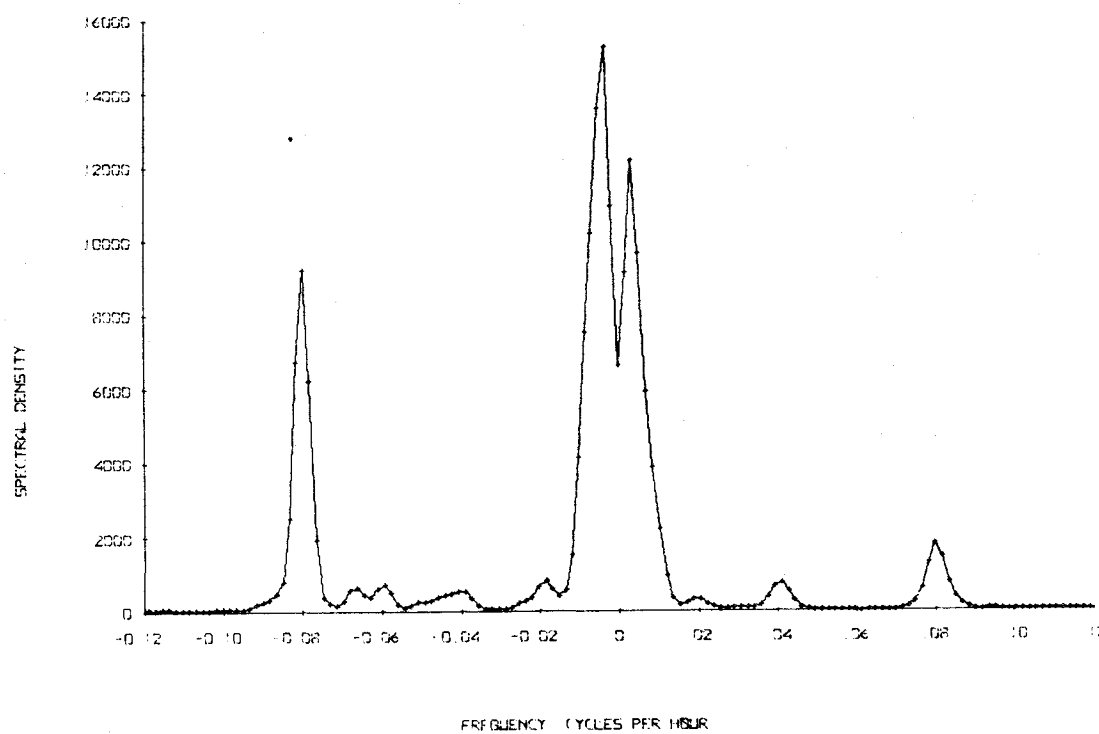


60M AT DB-7. 21 DAYS STARTING 2159 7/7/72



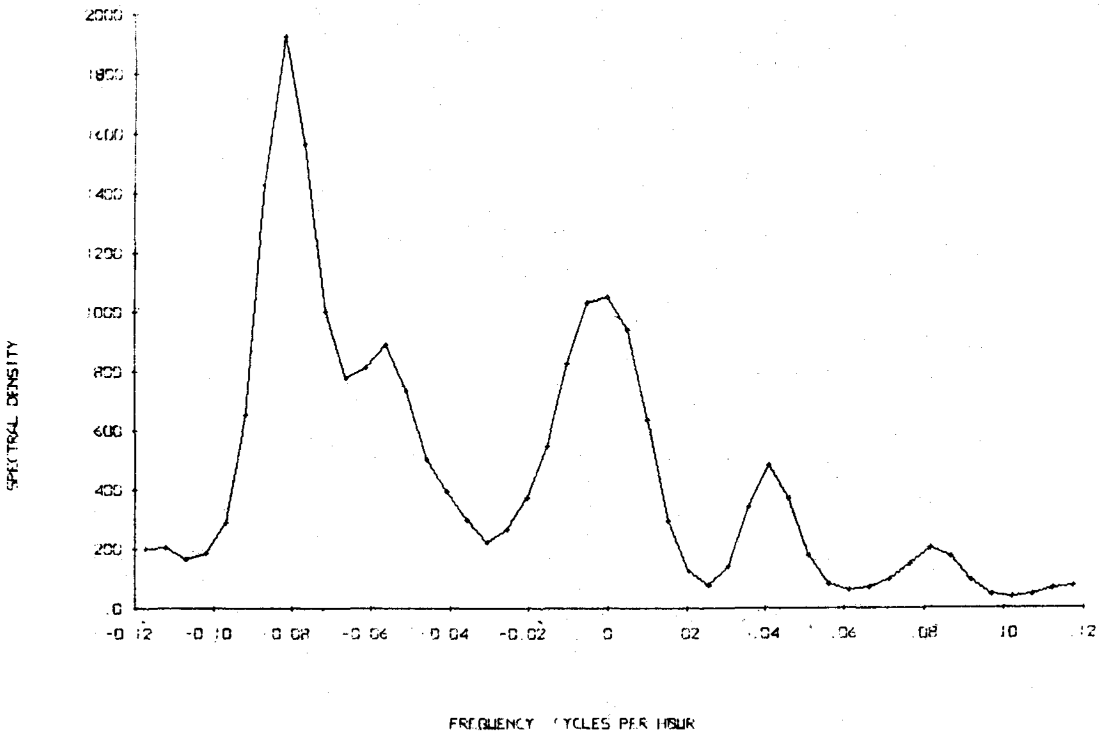
80M AT DB 2 24 DAYS STARTING 2202 2/7/72

ROTARY SPECTRUM
80M AT DB-2. 2/7/72 TO 8/1/72. TAPE 492/8



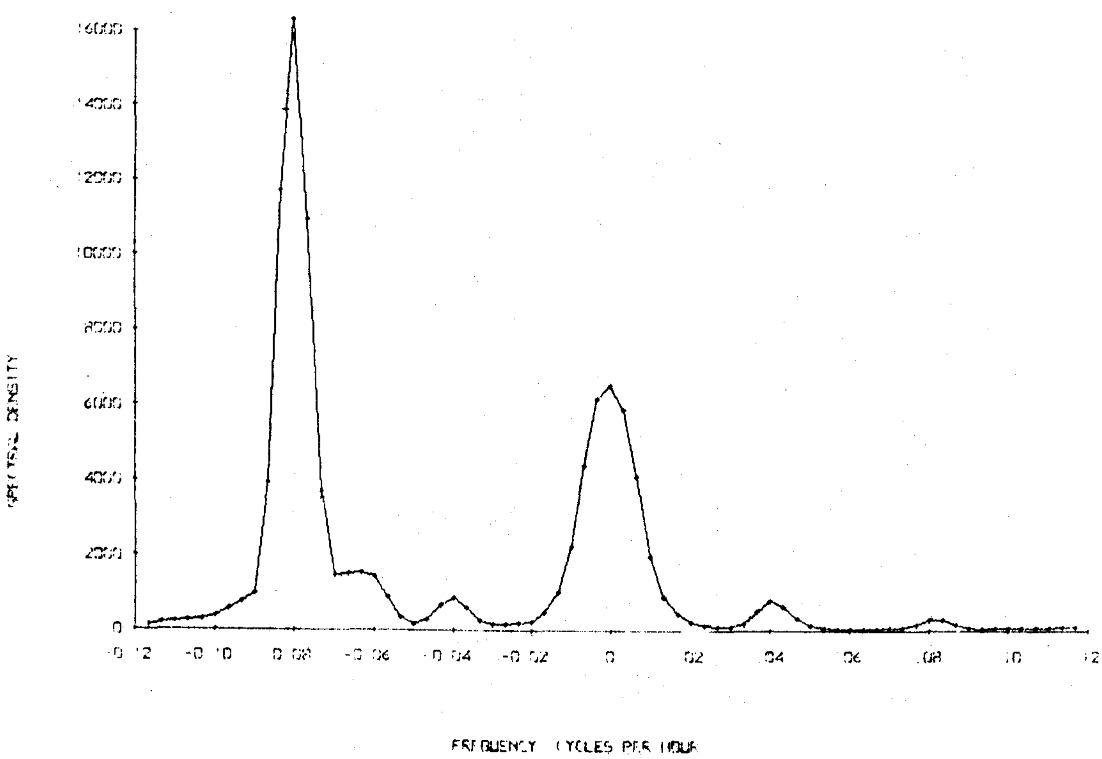
ROTARY SPECTRUM
20M AT DB-2 7/2/72 TO 7/16/72. PART A OF TAPE 482/5

A



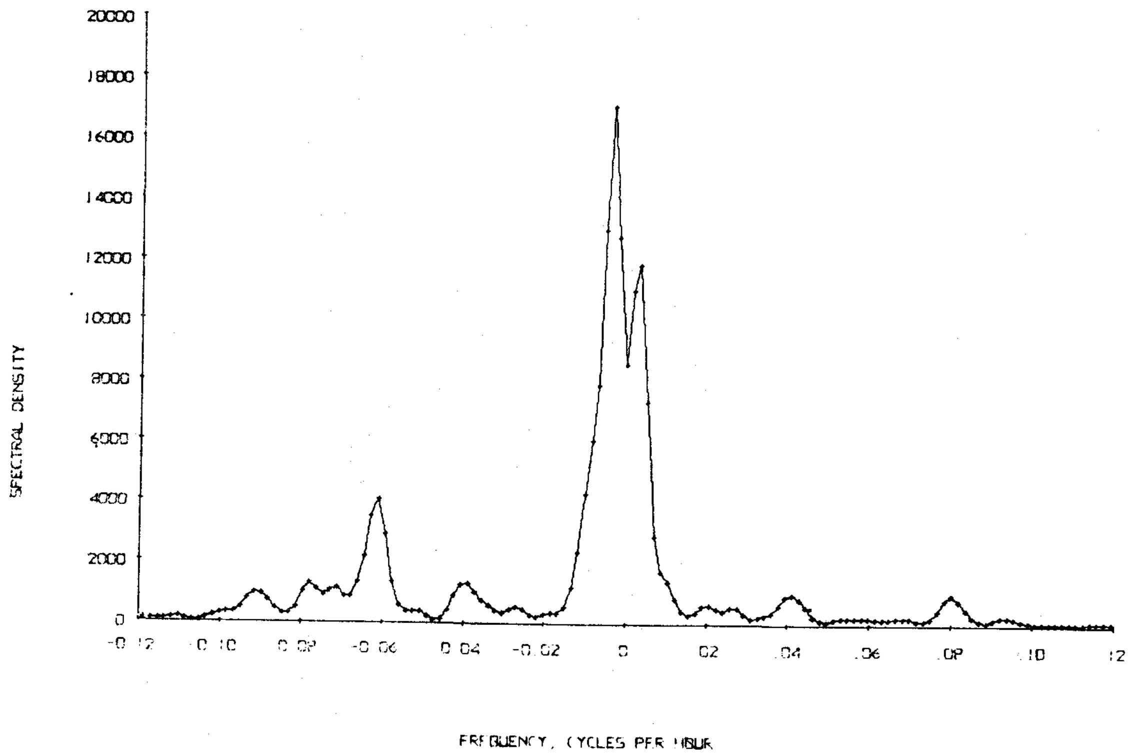
ROTARY SPECTRUM
20M AT DB-2 7/17/72 TO 7/30/72. PART B OF TAPE 482/5

B



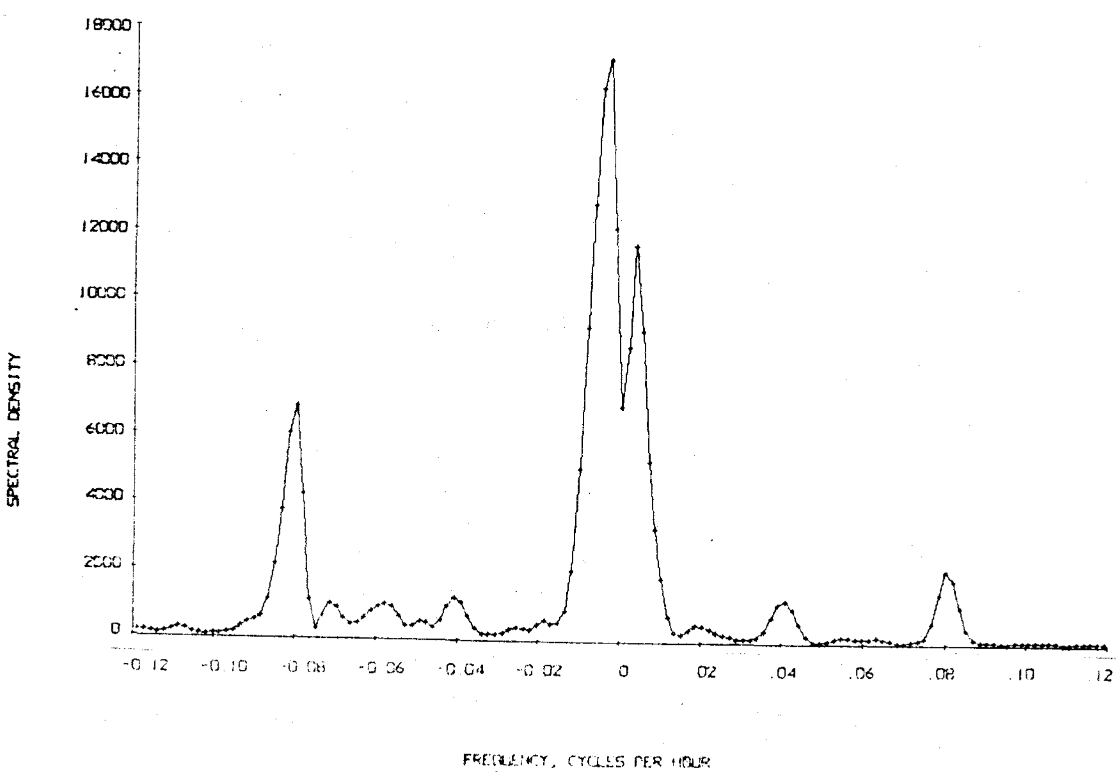
ROTARY SPECTRUM

40 METERS AT DB 2 7/2/72 TO 8/1/72 TAPE 482/6



ROTARY SPECTRUM

[illegible] AT DB 2. 7/2/72 TO 8/1/72 TAPE 482/5



1972 CUE Installation E

DB 13

Position: 44°54.1'N, 124°19.1'W
Depth of Water: 150 m
Set at 1400 GMT 7 July 1972 by R/V CAYUSE
Retrieved at 1800 GMT 9 August 1972 by R/V CAYUSE
Data Interval: 1430 GMT 7 July to 0930 GMT 18 July

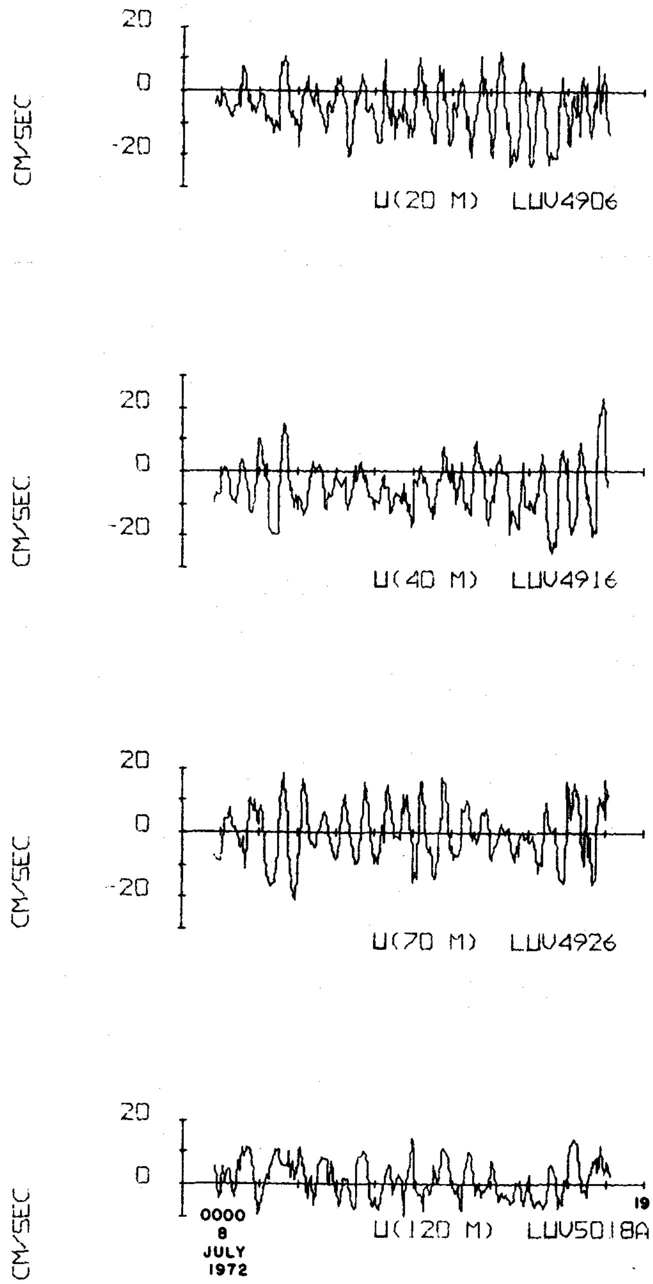
Instrumentation

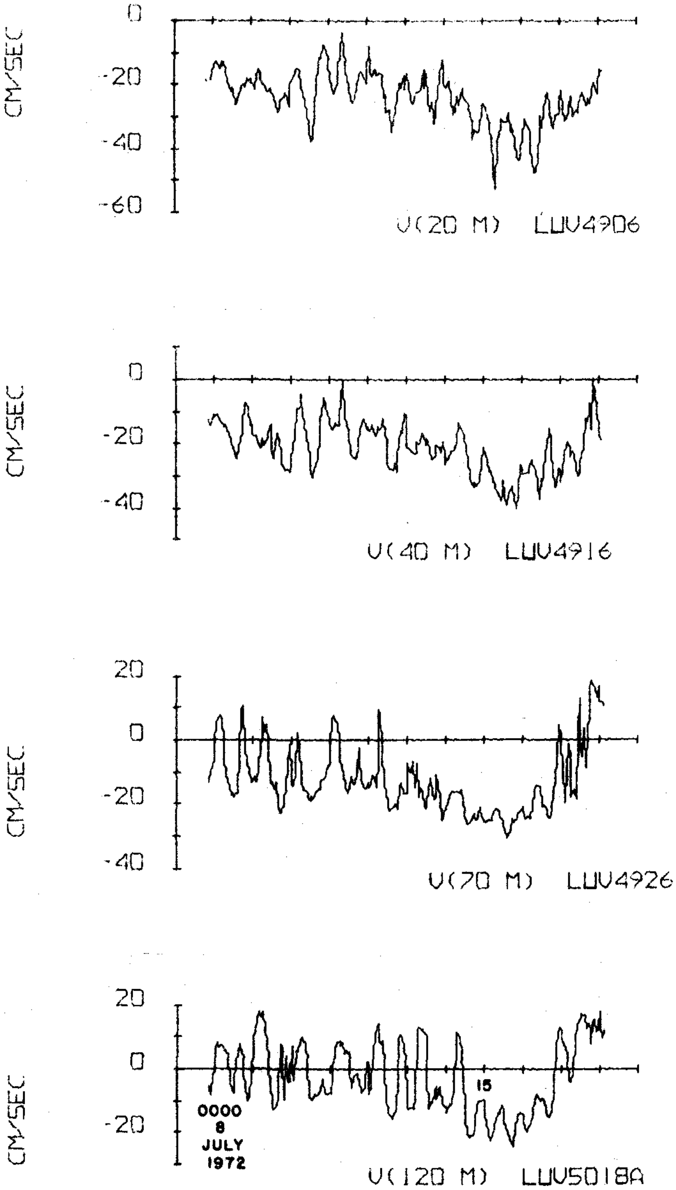
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	22 m	490/6
40 m	42 m	491/6
70 m	72 m	492/6
120 m	122 m	501/8

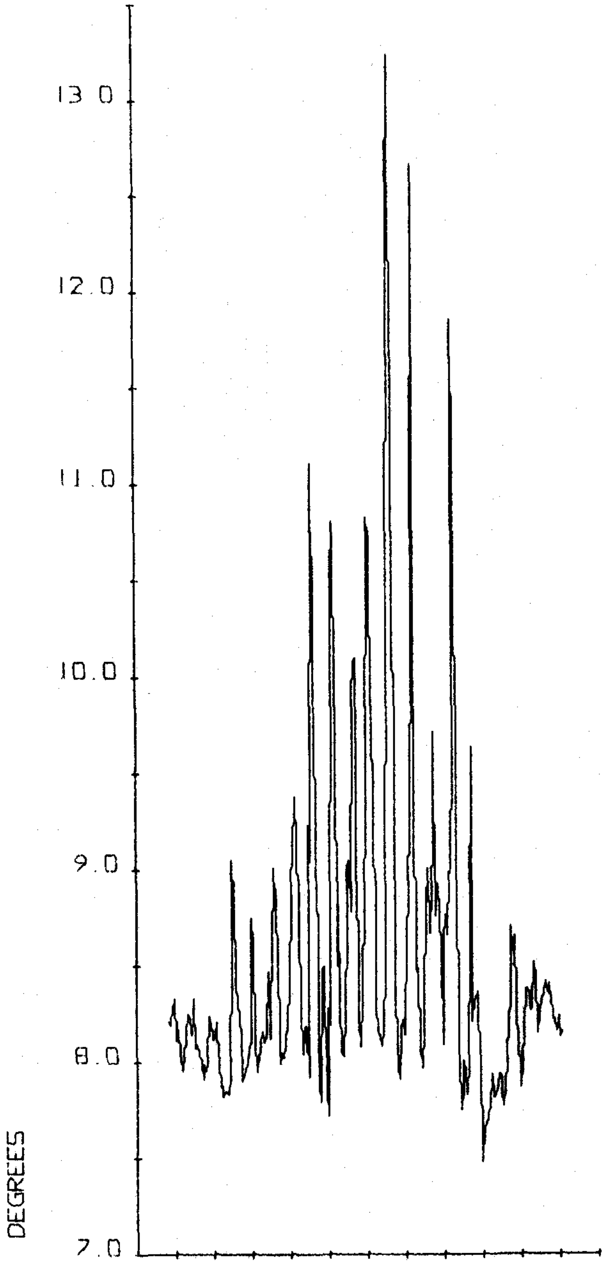
Data were recorded every 5 minutes. All meters recorded speed, direction,and temperature. In addition, the deepest meter recorded pressure. Although the instruments were in the water for 33 days, the acoustic release inadvertently fired on the 10th day, and only 10 days of useful data were obtained. There is a B part for 120 m instrument but it is not shown, as the depth varies and meter tilt was unknown.

(E-DB-13)

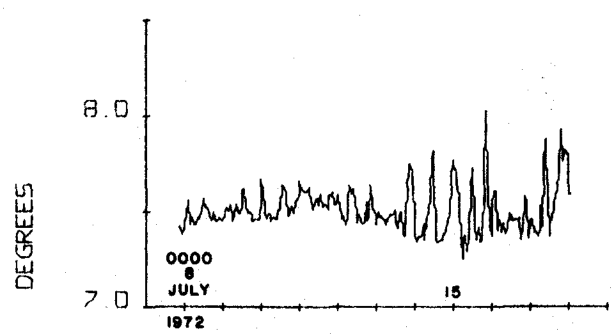
		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	26.0	8.0	0.6	3.3	52.9	9.6
4906	U(cm/sec)	- 5.5	7.9	-0.1	2.7	12.5	-23.7
(20m)	V(cm/sec)	-24.1	8.1	-0.6	3.6	- 3.6	-52.9
	T (C)	8.52	0.84	2.66	11.78	13.24	7.48
	S(cm/sec)	23.3	7.1	0.3	2.6	40.6	7.8
4916	U(cm/sec)	- 5.4	8.1	0.3	3.5	22.9	-25.9
(40m)	V(cm/sec)	-20.9	7.7	-0.1	2.7	0.7	-40.2
	T (C)	7.51	0.12	1.14	5.09	8.03	7.25
	S(cm/sec)	17.8	5.2	-0.0	2.6	31.3	3.8
4926	U(cm/sec)	- 0.1	8.6	0.0	2.4	18.7	-20.9
(70m)	V(cm/sec)	-12.6	10.6	0.9	3.3	18.4	-30.6
	T (C)	7.72	0.14	0.40	1.62	7.99	7.54
	S(cm/sec)	12.1	4.0	0.6	3.4	24.7	3.0
5018A	U(cm/sec)	1.6	5.7	0.1	2.1	14.2	-10.0
(120m)	V(cm/sec)	- 2.4	11.0	0.1	1.8	18.0	-24.6
	T (C)	7.30	0.07	-1.40	4.47	7.41	7.08
	P(kg/cm^2)	12.19	0.05	-1.11	3.77	12.28	12.05


20
0
-20
CM/SEC
U(20 M) LUV4906
20
0
-20
CM/SEC
U(40 M) LUV4916
20
0
-20
CM/SEC
U(70 M) LUV4926
20
0
CM/SEC
0000
8
JULY
1972
19
U(120 M) LUV5018A

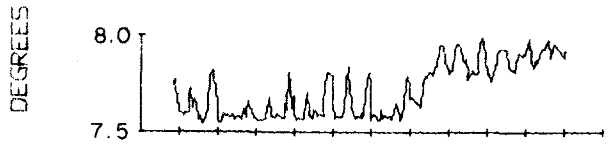

CM/SEC
0
-20
-40
-60
V(20 M) LUV4906
CM/SEC
0
-20
-40
V(40 M) LUV4916
CM/SEC
20
0
-20
-40
V(70 M) LUV4926
CM/SEC
20
0
-20
0000
8
JULY
1972
15
V(120 M) LUV5018A



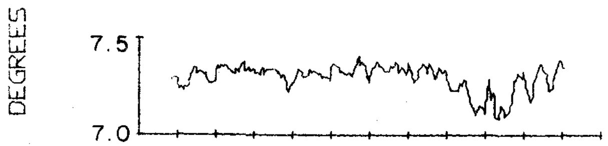
TEMP.(20 M) LT4906



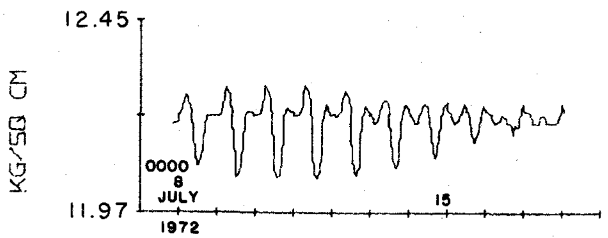
TEMP.(40 M) LT4916



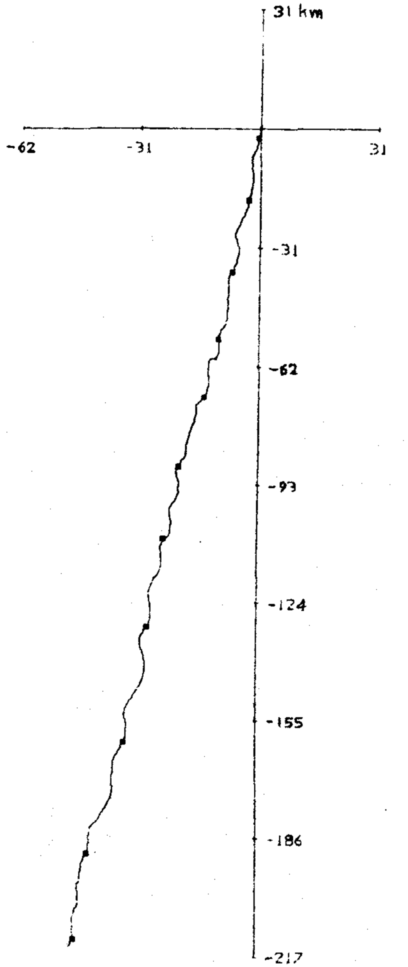
TEMP.(70 M) LT4926



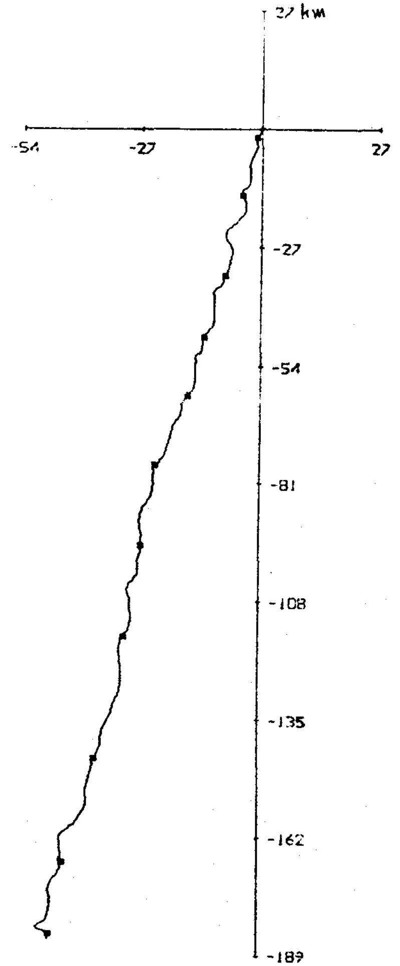
TEMP.(120 M) LTP5018A



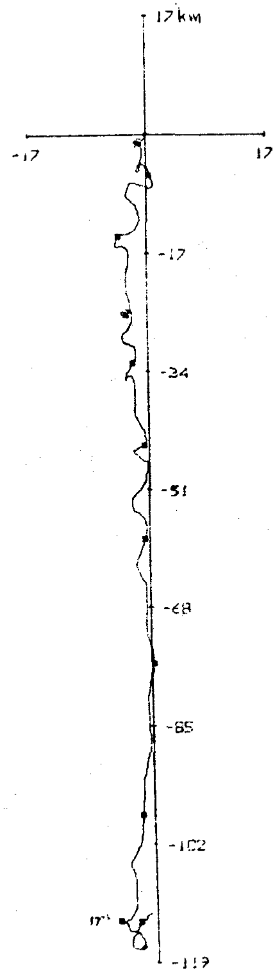
PRESSURE(120 M) LTP5018A



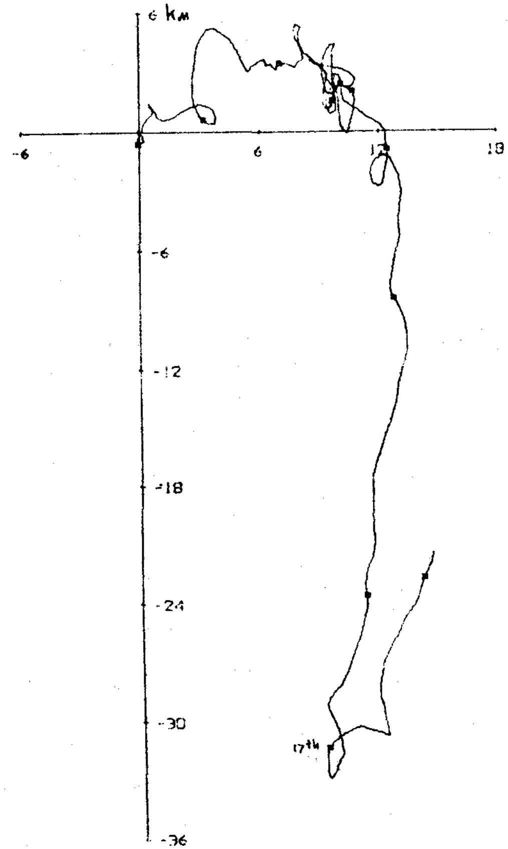
20M AT DB-13 10 DAYS STARTING 2031 7/2/72



40M AT DB-13. 10 DAYS STARTING 2032 7/2/72



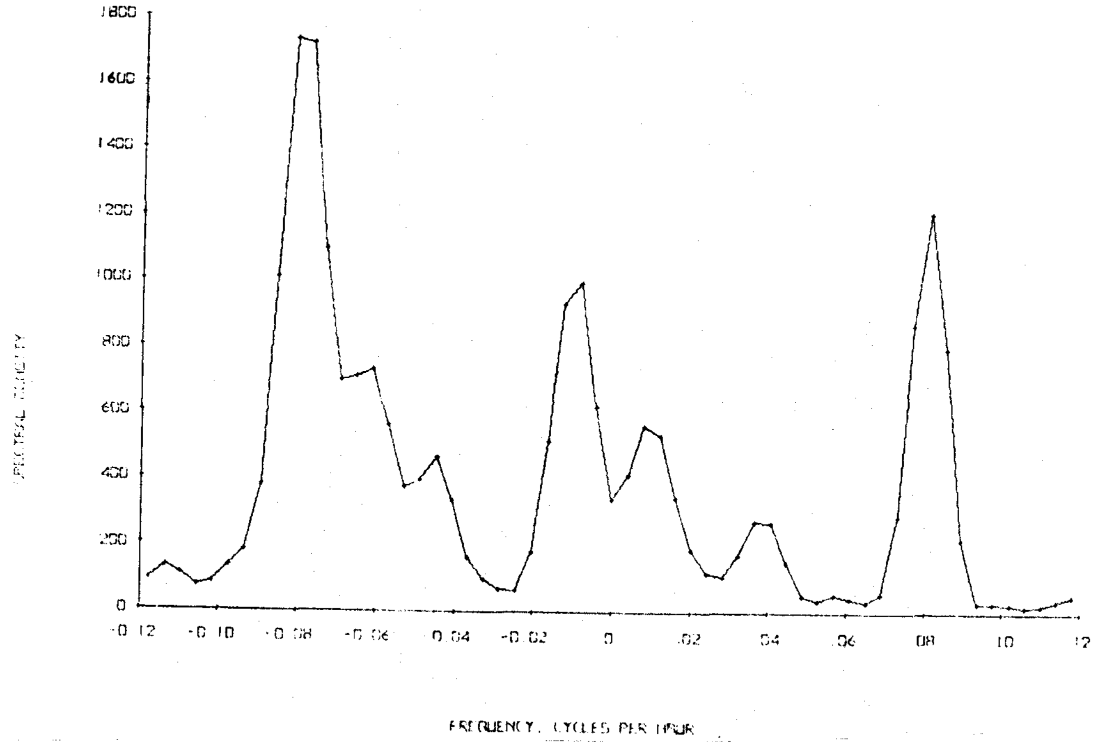
70 METERS AT DB-13.   10 DAYS STARTING 2033 7/7/72



120M AT DB-13.   10 DAYS STARTING 2036 7/7/72

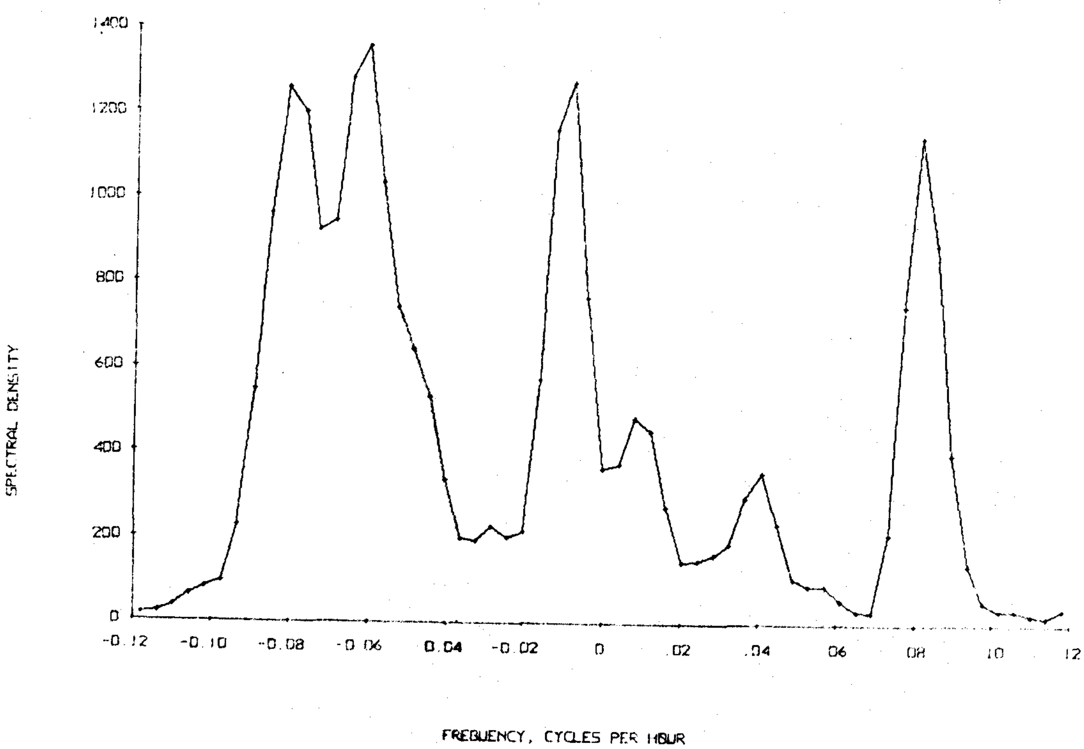
ROTARY SPECTRUM

20M AT DB-13 7/2/72 TO 7/18/72. TAPE 490/6

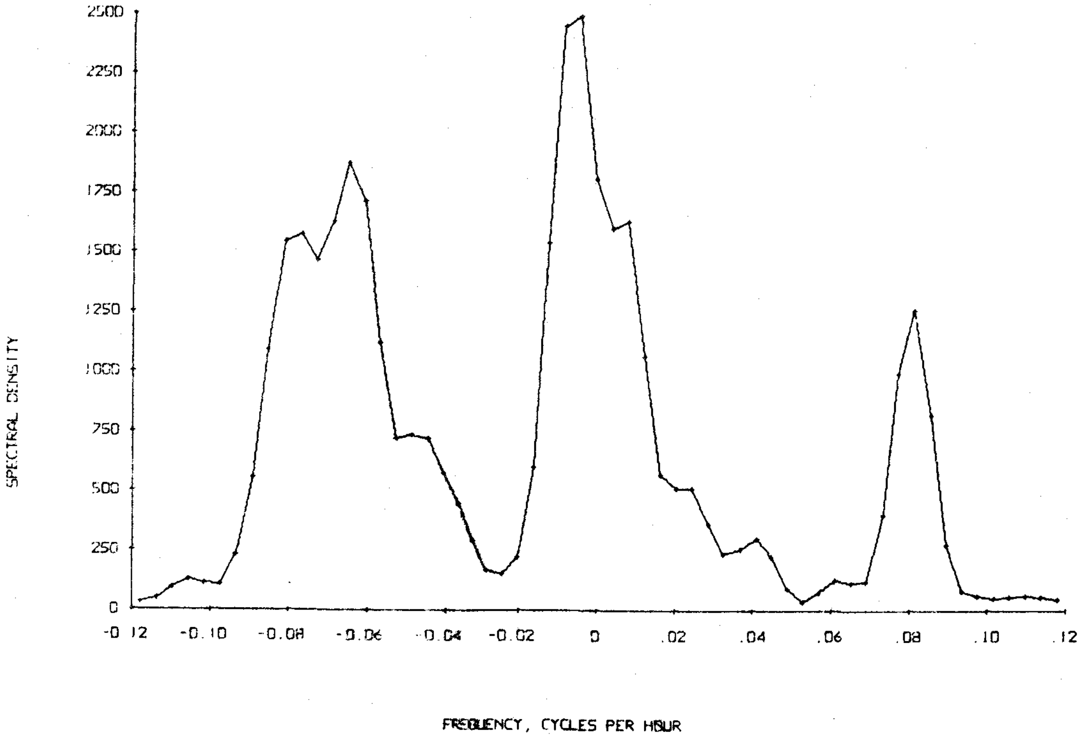


ROTARY SPECTRUM

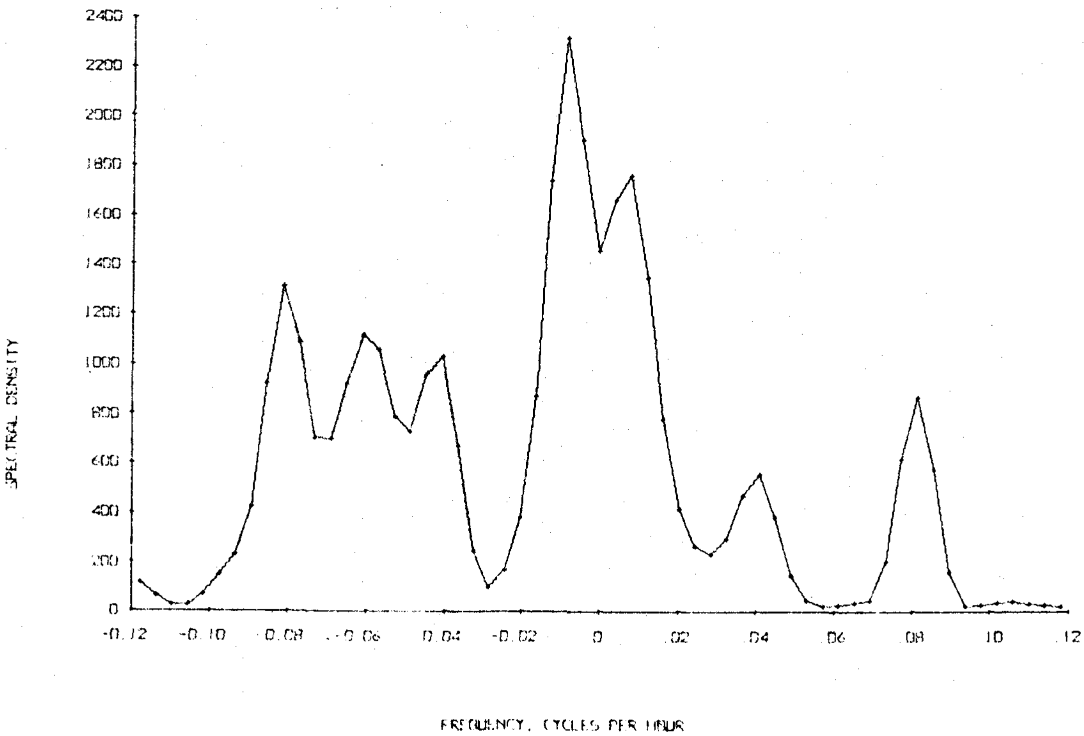
40M AT DB-13 7/2/72 TO 7/18/72. TAPE 491/6



ROTARY SPECTRUM
20 METERS AT DB-13 7/7/72 TO 7/18/72. TAPE 492/6



ROTARY SPECTRUM
120M AT DB-13. 7/7/72 TO 7/18/72. PART A OF TAPE 501/8



1972 CUE Installation E

POL Buoy

Position: 44°44.7'N, 124°17.2'W
Depth of Water: 102 m
Set at 1633 GMT 20 July 1972 by R/V CAYUSE
Retrieved at 1524 GMT 14 August 1972 by R/V CAYUSE
Data Interval: 1634 GMT 20 July to 1515 GMT 14 August

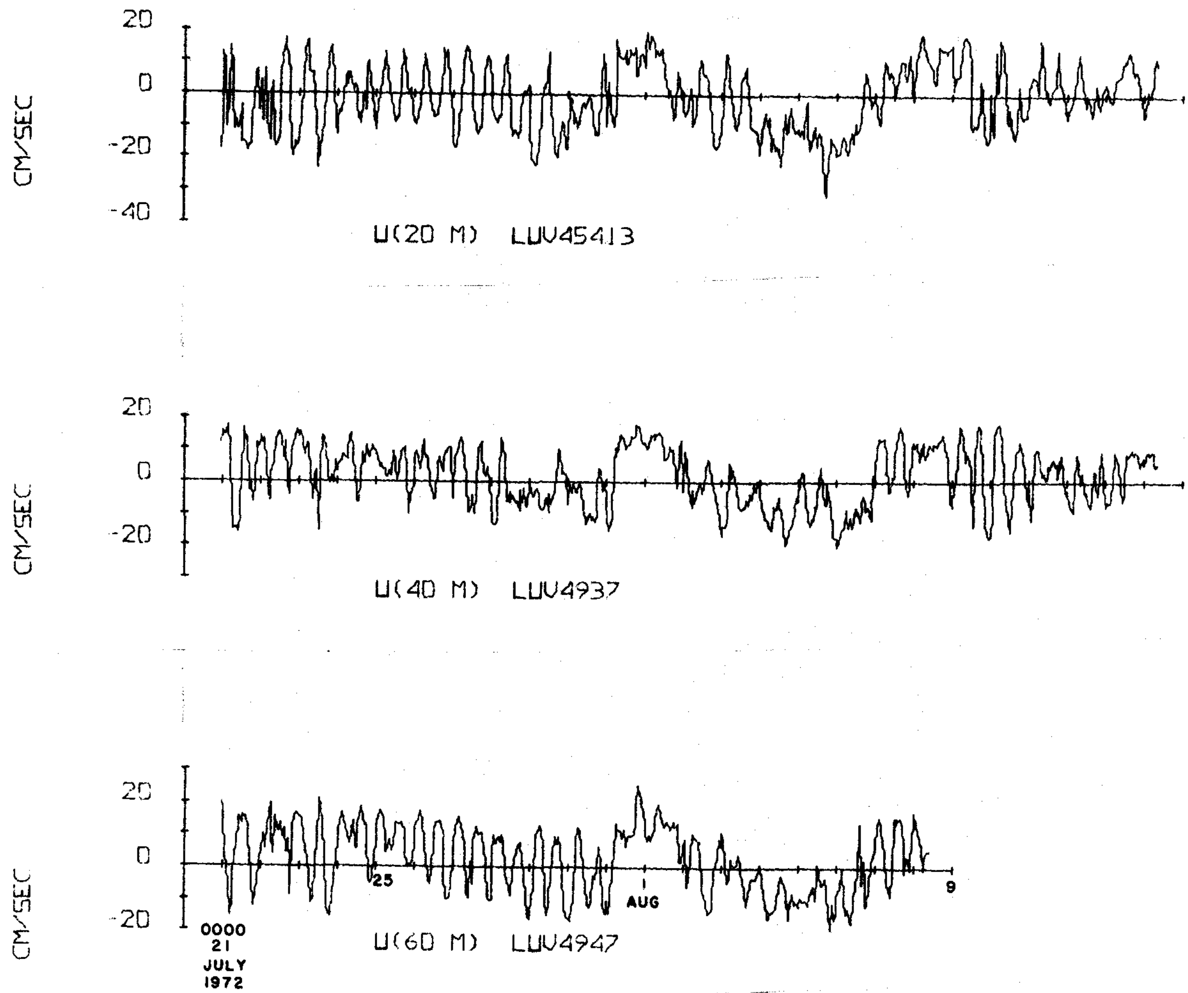
Instrumentation

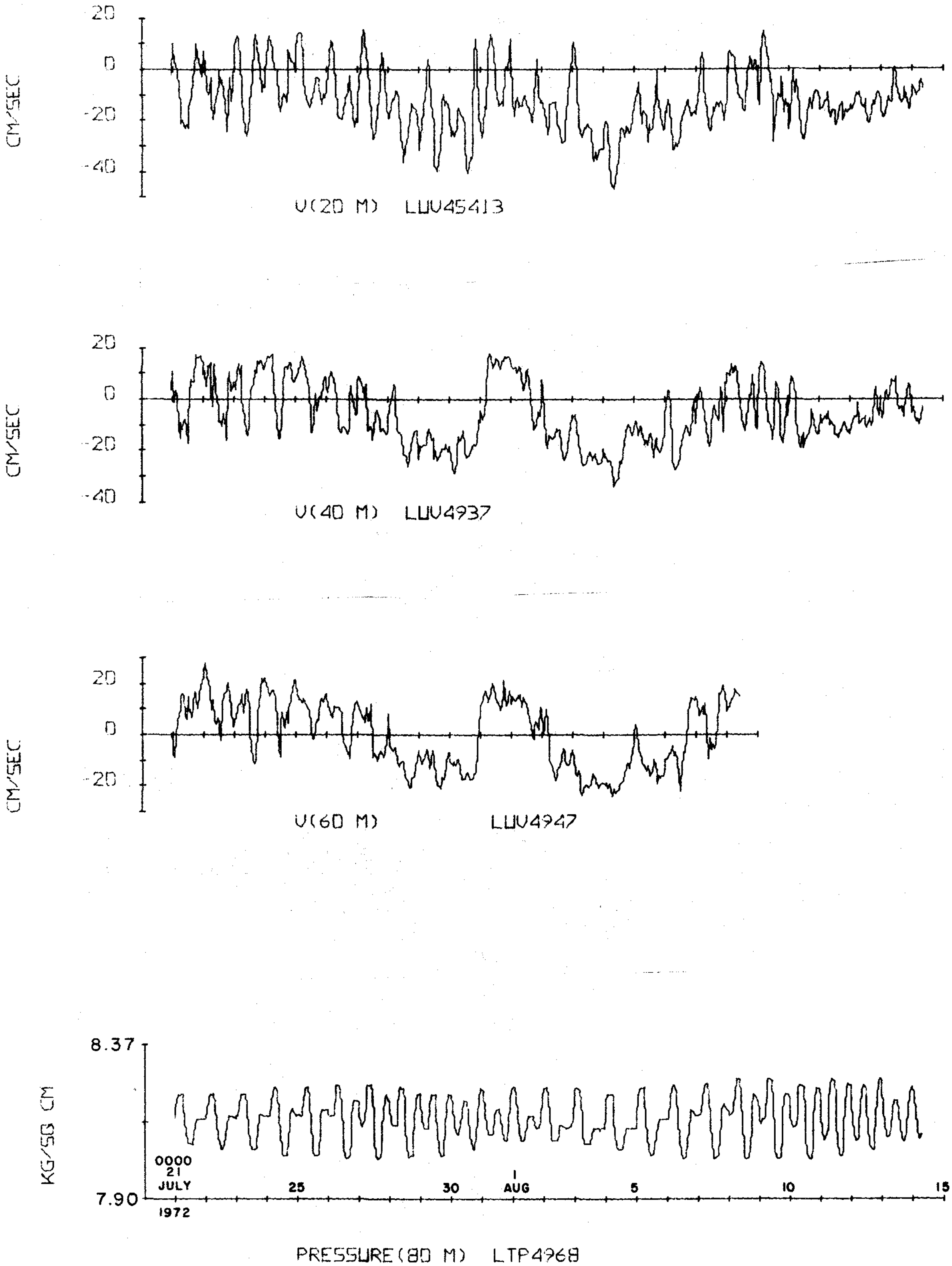
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	21 m	454/13
40 m	41 m	493/7
60 m	61 m	494/7
80 m	81 m	496/8

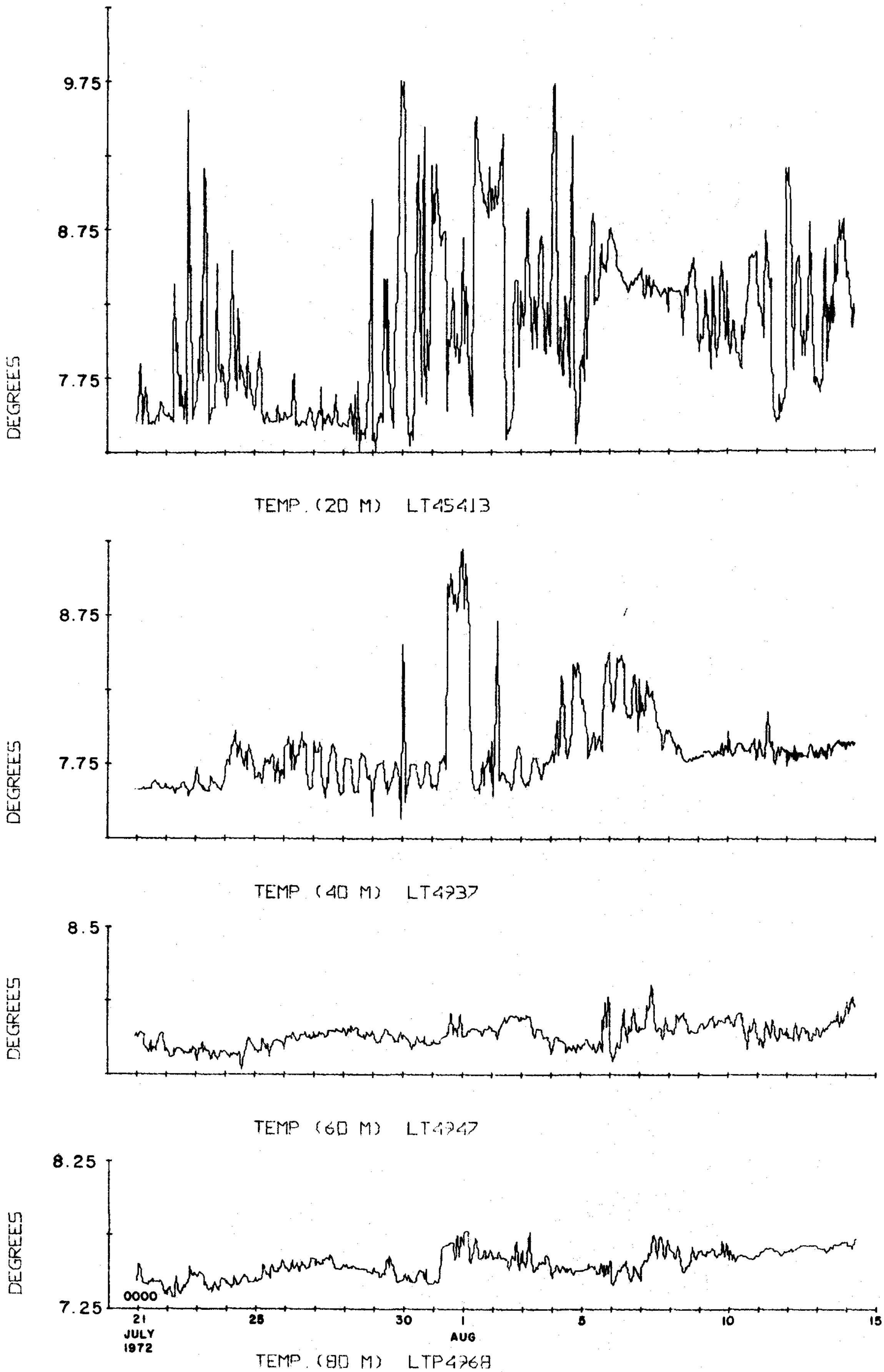
Data were recorded every 5 minutes. All instruments measured temperature, current speed, and current direction. In addition, the 80 m instrument recorded pressure. On the 20 m instrument the rotor fouled on 8 August 1972, recovered, then briefly fouled on 9 August 1972. The rotor was missing after 1545 GMT 8 August 1972 for the 60 m instrument. Direction for 80 m instrument, and hence U and V, appeared bad.

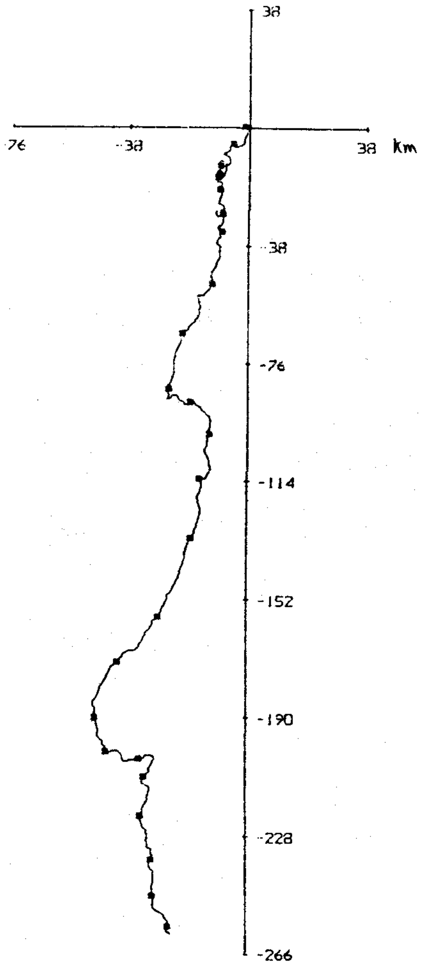
(E-POL)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
20 m (45413)	S (cm/sec)	18.4	7.7	1.0	4.3	48.9	0.6
	U (cm/sec)	- 1.1	10.3	-0.1	2.1	20.0	-31.5
	V (cm/sec)	-12.3	11.8	0.1	3.0	15.5	-46.9
	T (C)	8.08	0.54	0.62	2.83	9.76	7.25
40 m (4937)	S (cm/sec)	15.4	5.4	0.5	3.6	34.8	1.9
	U (cm/sec)	1.7	9.2	-0.2	2.0	18.0	-20.5
	V (cm/sec)	- 5.7	12.1	0.2	2.1	18.0	-34.0
	T (C)	7.85	0.28	2.17	8.72	9.21	7.38
60 m (4947)	S (cm/sec)	16.2	4.2	0.1	3.8	30.0	1.7
	U (cm/sec)	2.6	10.1	-0.2	1.9	25.7	-19.1
	V (cm/sec)	0.3	13.1	-0.1	1.6	28.2	-24.1
	T (C)	7.77	0.08	0.37	3.39	8.11	7.53
80 m (4968)	S (cm/sec)	NONE					
	U (cm/sec)	NONE					
	V (cm/sec)	NONE					
	T (C)	7.55	0.09	-0.01	2.25	7.78	7.33
	P (kg/cm^2)	8.14	0.07	-0.7	1.98	8.27	8.02

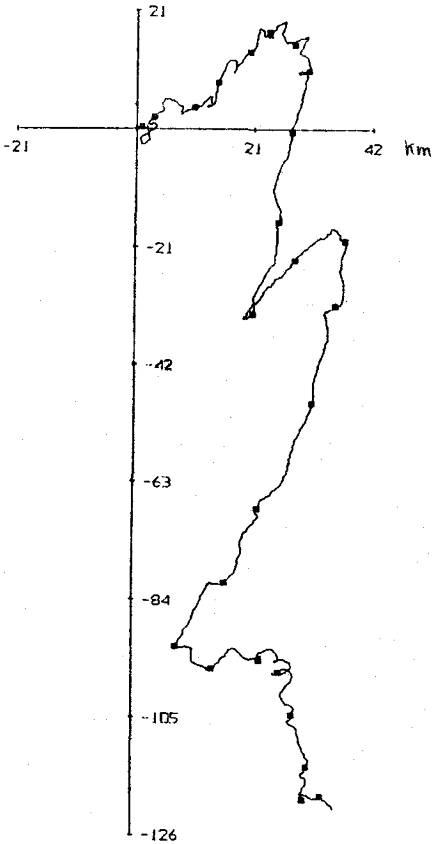

20
0
-20
-40
CM/SEC
U(20 M) LUV45413
20
0
-20
CM/SEC
U(40 M) LUV4937
20
0
-20
CM/SEC
25
AUG
9
0000
21
JULY
1972
U(60 M) LUV4947


20
0
-20
-40
CM/SEC
V(20 M) LUV45413
20
0
-20
-40
CM/SEC
V(40 M) LUV4937
20
0
-20
CM/SEC
V(60 M) LUV4947
8.37
7.90
KG/SQ CM
0000
21
JULY
1972
25
30
1
AUG
5
10
15
PRESSURE(80 M) LTP4968


9.75
8.75
7.75
DEGREES
TEMP. (20 M) LT45413
8.75
7.75
DEGREES
TEMP (40 M) LT4937
8.5
DEGREES
TEMP (60 M) LT4947
8.25
7.25
DEGREES
0000
21
JULY
1972
25
30
1
AUG
5
10
15
TEMP. (80 M) LTP4968



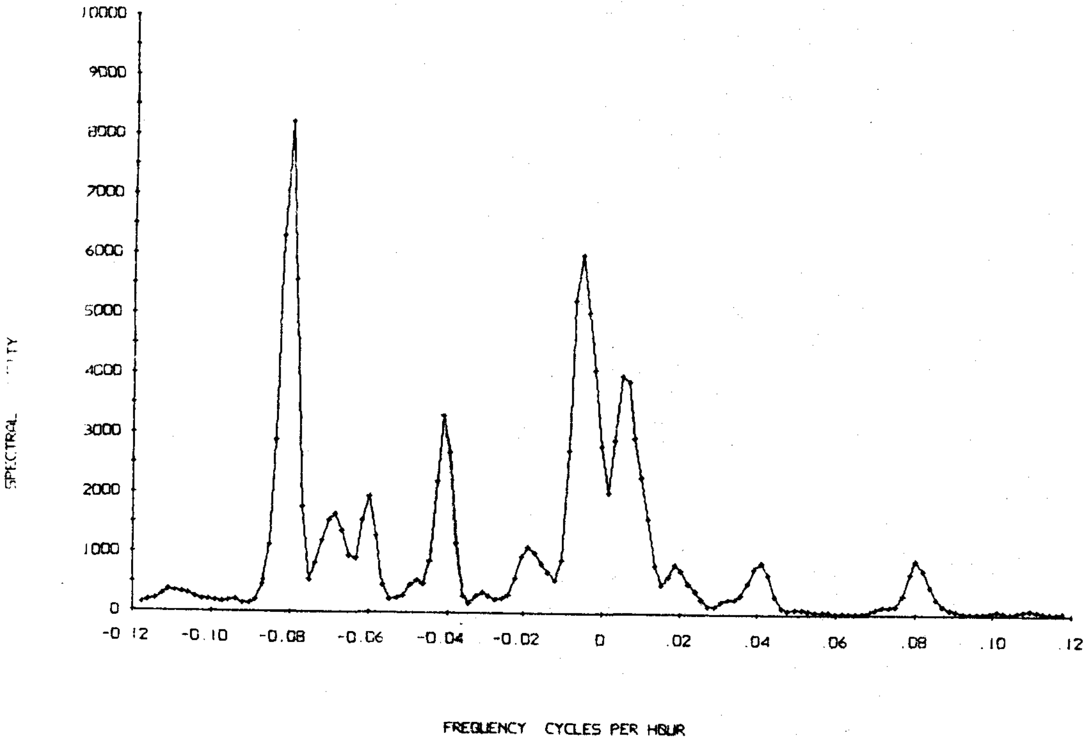
20 METERS AT PBL BUOY. 25 DAYS STARTING 2234 7/20/72



40M AT PBL BUOY 24 DAYS STARTING 2229 7/20/72

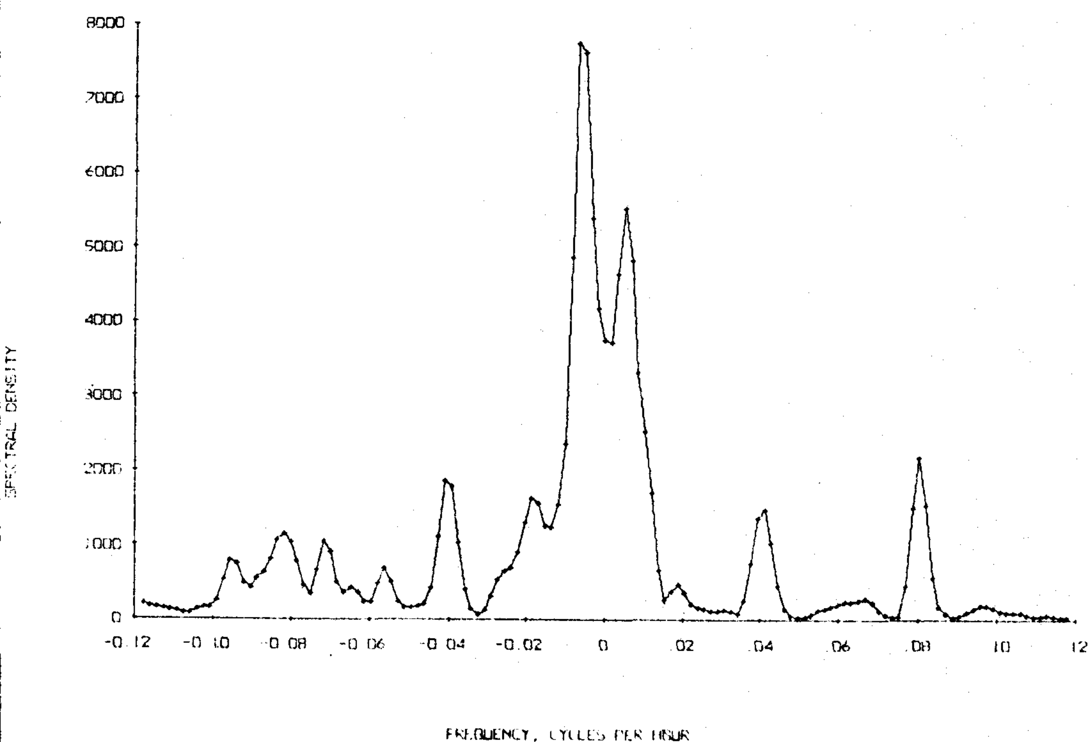
ROTARY SPECTRUM

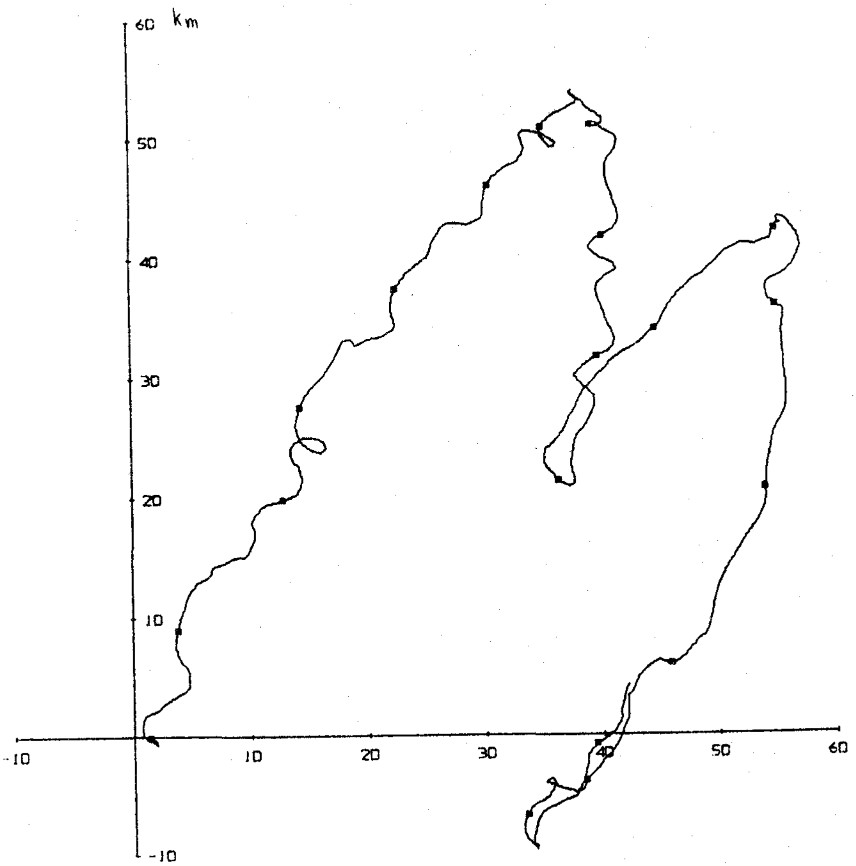
20 METERS AT PSL BUOY. 7/20/72 TO 8/14/72 TAPE 454/13



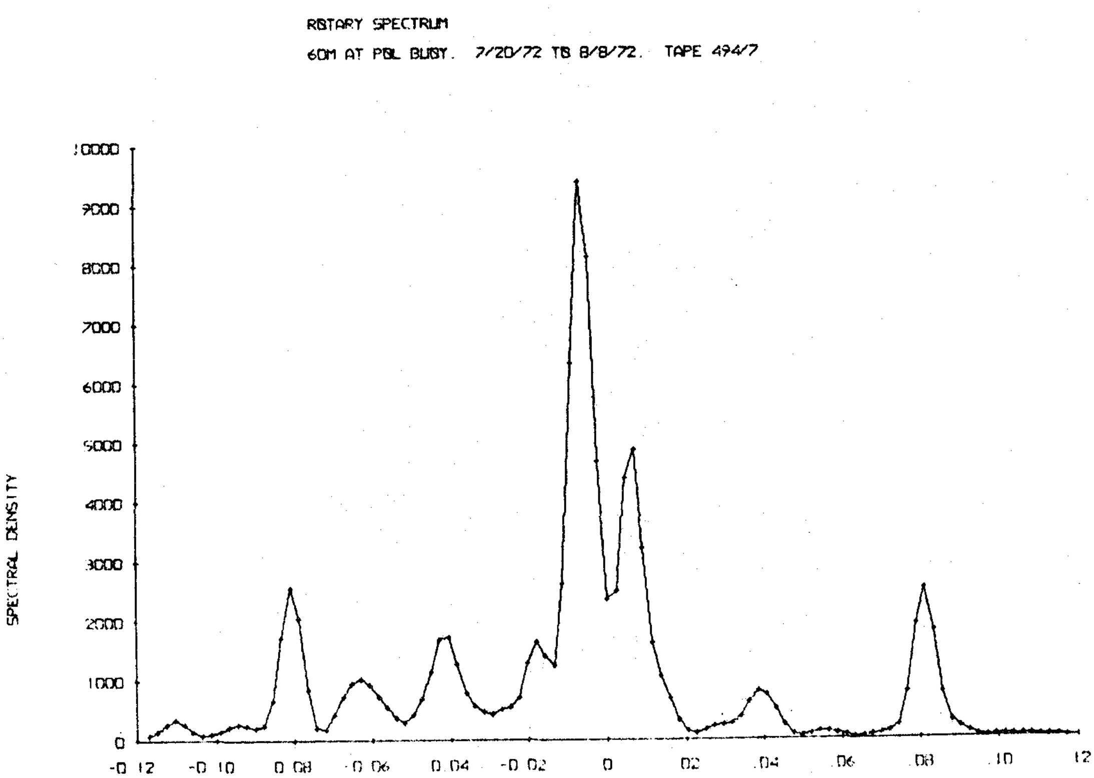
ROTARY SPECTRUM

40M AT PSL BUOY. 7/20/72 TO 8/14/72. TAPE 493/7





6DM AT PBL BUBY. 18 DAYS STARTING 2230 7/20/72



1972 CUE Installation F

NH 3

Position: 44°39.0'N, 124°07.0'W
Depth of Water: 42 m
Set at 2217 GMT 1 August 1972 by R/V CAYUSE
Retrieved at 1942 GMT 31 August 1972 by R/V CAYUSE
Data Interval: 0001 GMT 10 August to 1941 GMT 31 August

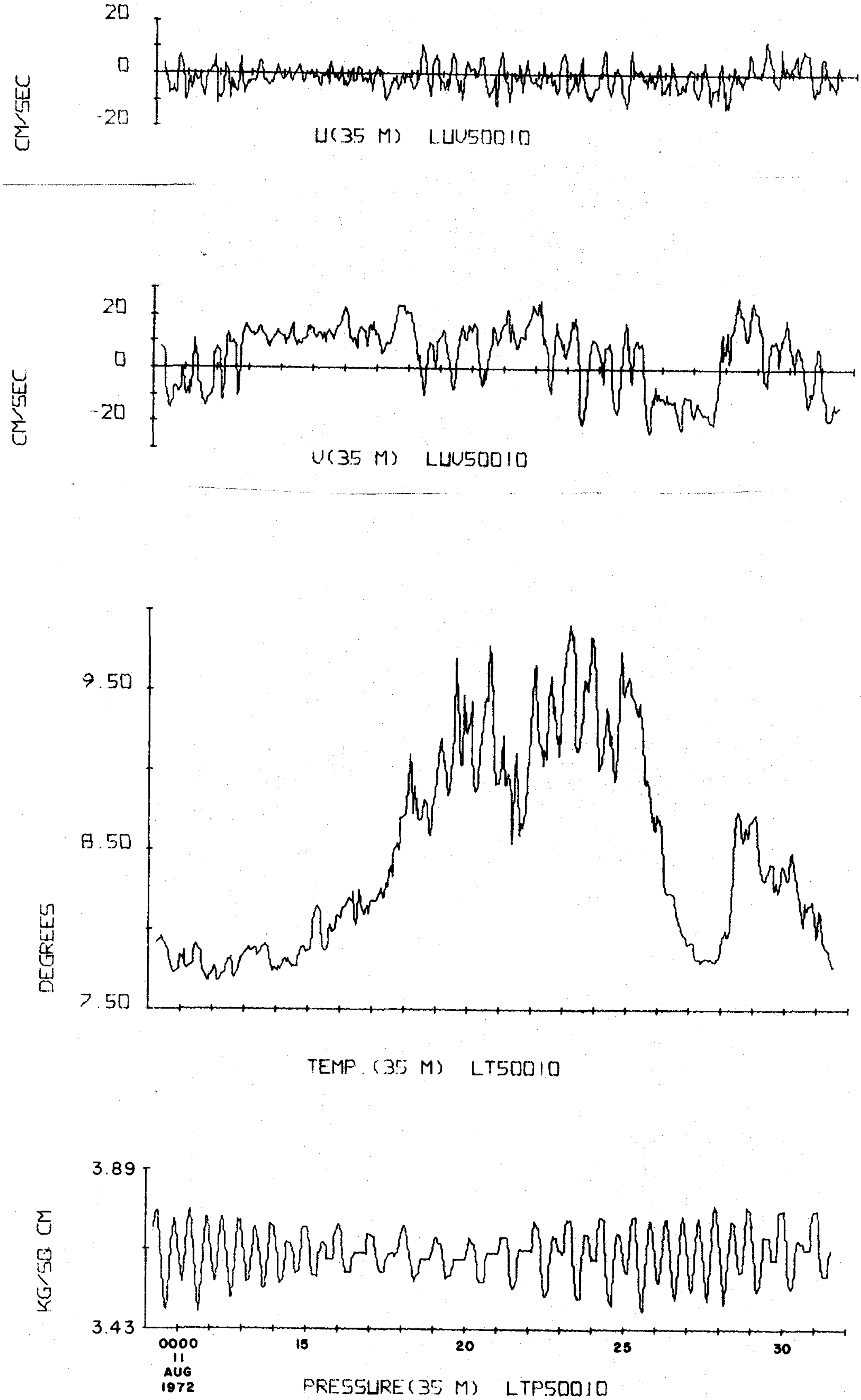
Instrumentation

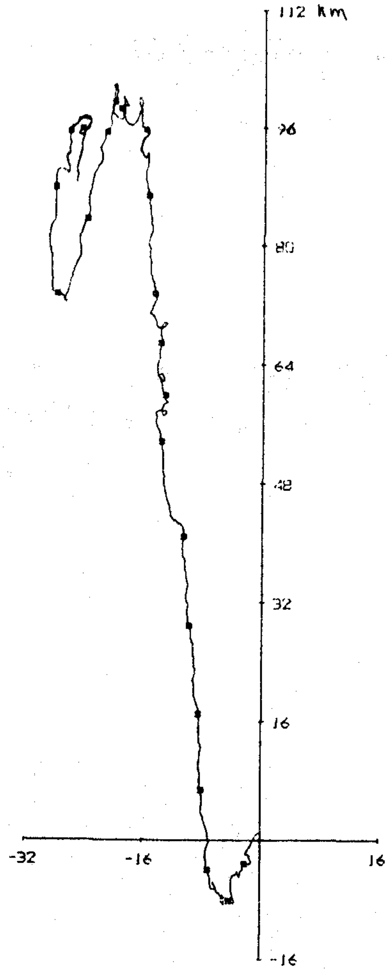
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	21 m	487/6
35 m	36 m	500/10

Data were recorded every 5 minutes. Both instruments measured temperature, current speed,and current direction. The 35 m instrument also recorded pressure. The 20 m instrument produced no usable data. The 35 m instrument had three days of bad data near the beginning. Data were processed for the 35 m instrument from 10 August 1972 to the end of the record.

(F-NH-3)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	12.9	4.6	0.6	3.1	27.1	2.7
35m	U(cm/sec)	- 1.4	4.5	0.2	2.9	12.9	-12.8
(50010)	V(cm/sec)	4.8	11.9	- 0.6	2.2	27.0	-24.1
	T (C)	8.47	0.62	0.51	1.97	9.90	7.68
	P(kg/cm2)	3.65	0.07	- 0.18	2.46	3.79	3.48

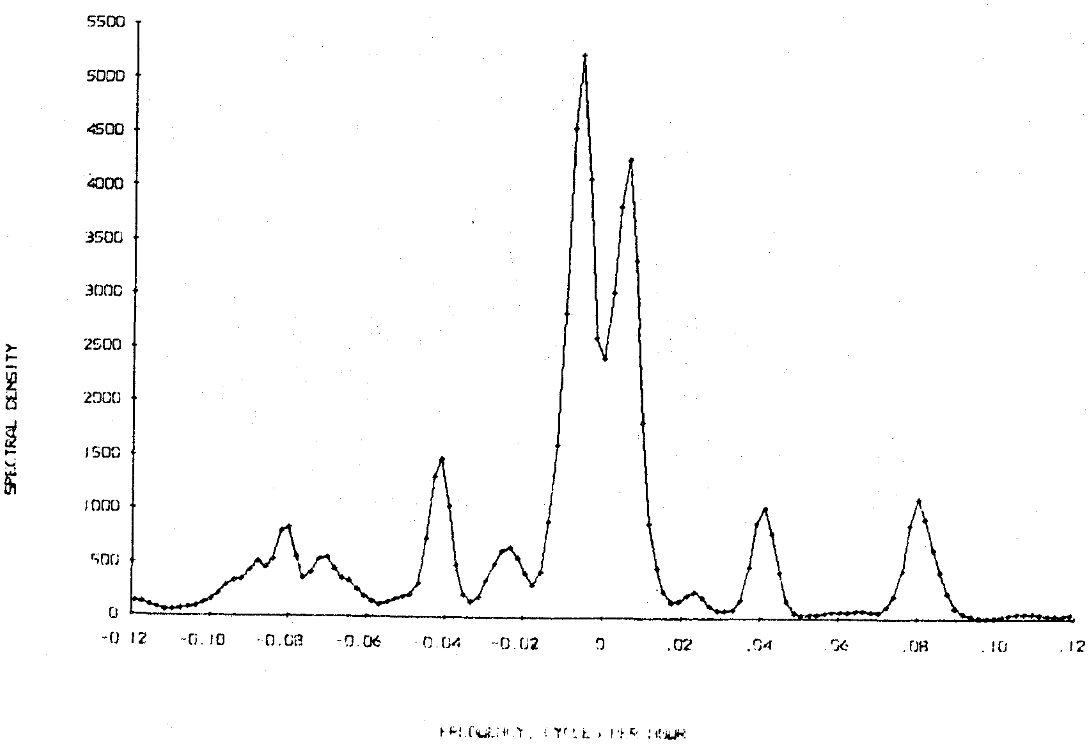

20
0
-20
CM/SEC
U(35 M) LUV50010
20
0
-20
CM/SEC
V(35 M) LUV50010
9.50
8.50
7.50
DEGREES
TEMP.(35 M) LT50010
3.89
3.43
KG/SQ CM
0000
11
AUG
1972
15
20
25
30
PRESSURE(35 M) LTP50010



35 METERS AN NH-3. 22 DAYS STARTING 0601 8/10/72

ROTARY SPECTRUM

35 METERS AT NH-3. 8/10/72 TO 8/31/72. TAPE 500/10



1972 CUE Installation F

NH 6

Position: 44°38.8'N, 124°12.2'W
Depth of Water: 66 m
Set at 1930 GMT 4 August 1972 by R/V CAYUSE
Retrieved at 1706 31 August 1972 by R/V CAYUSE
Data Interval: 1956 GMT 4 August to 1701 GMT 31 August

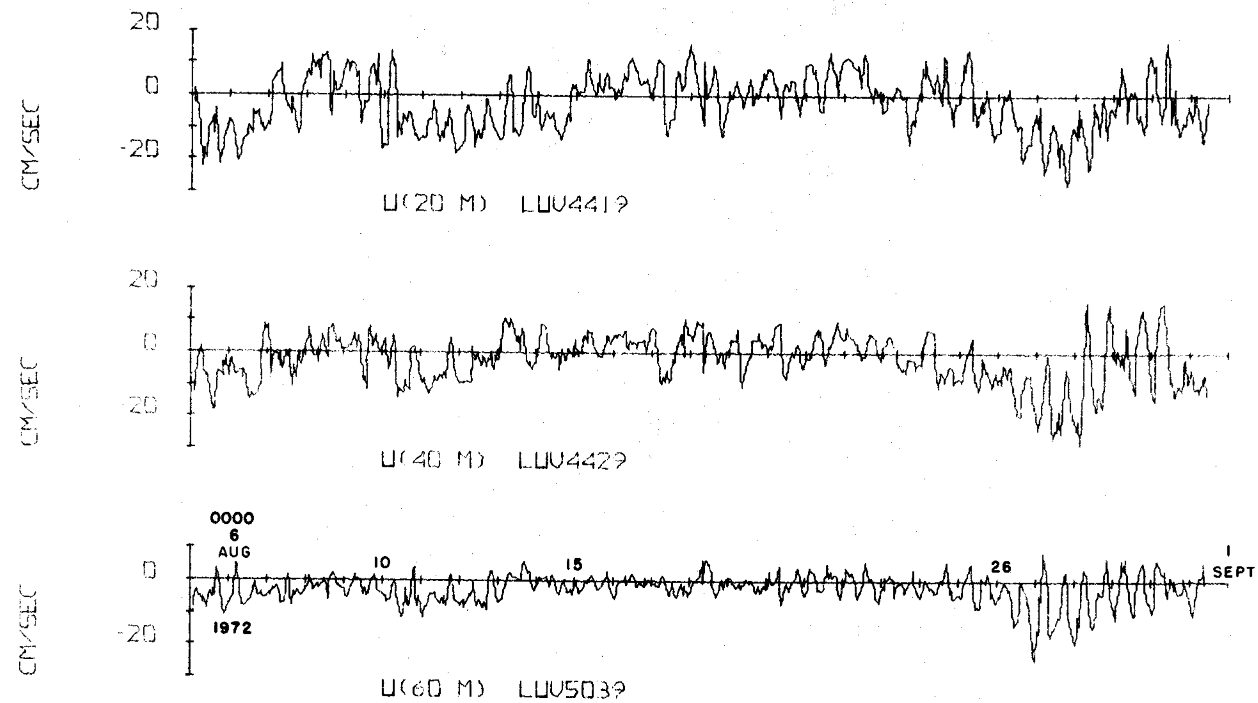
Instrumentation

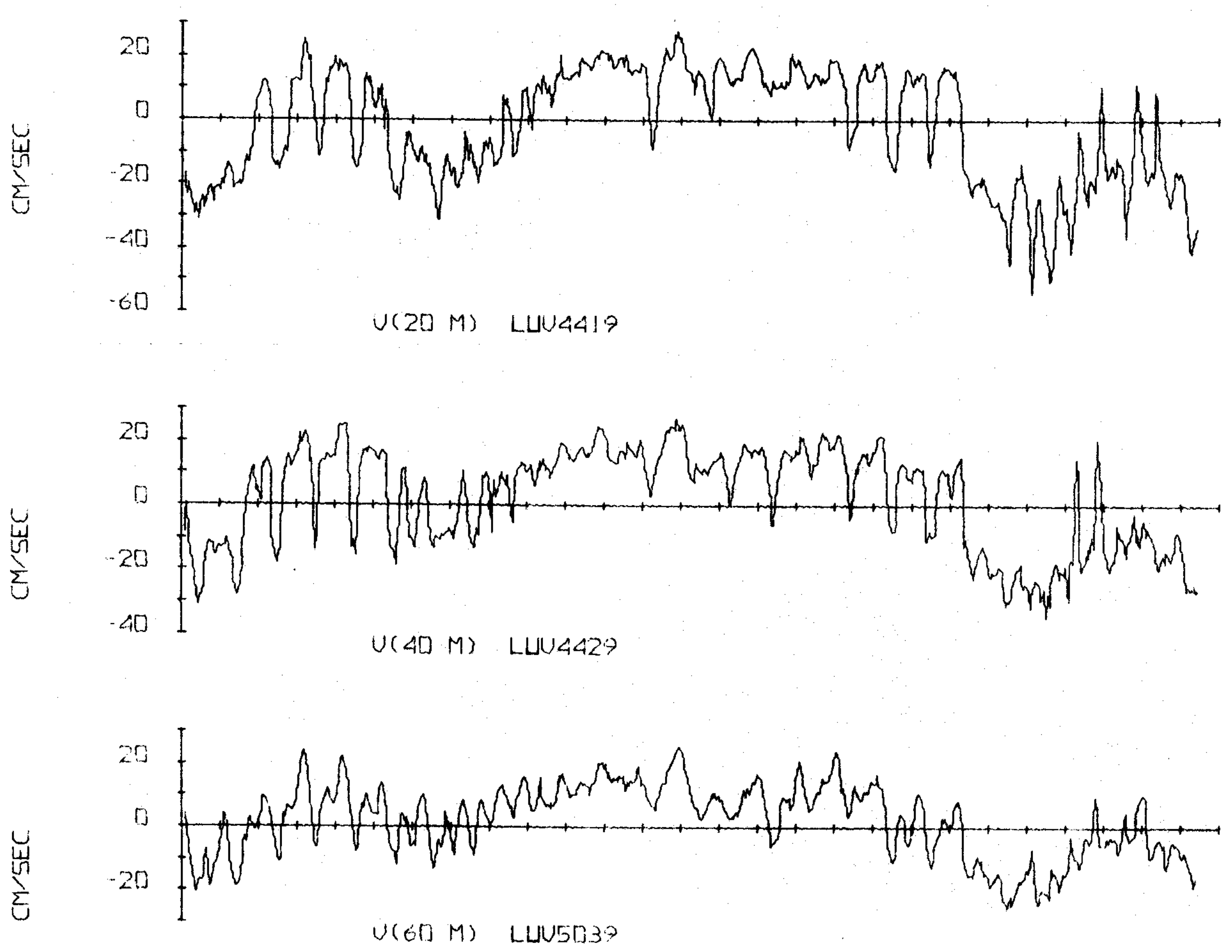
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	23 m	441/9
40 m	43 m	442/9
60 m	63 m	503/9

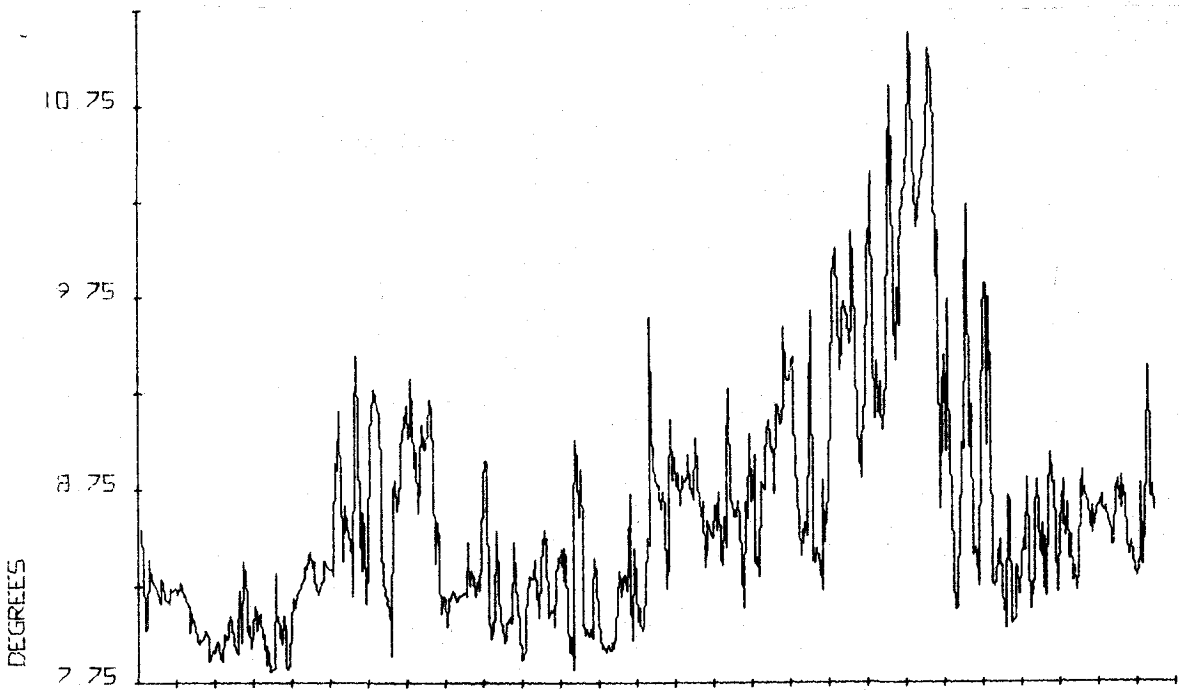
Data were recorded every 5 minutes. All instruments measured temperature, current speed,and current direction. In addition,the 60 m instrument recorded pressure.

(F-NH-6)

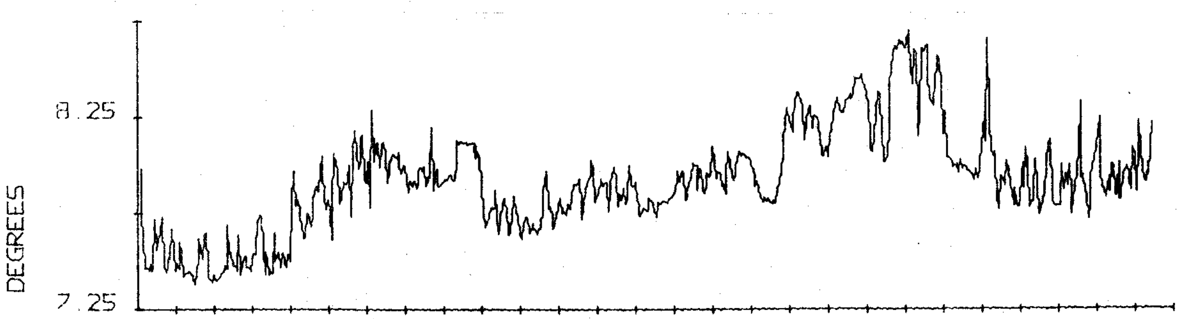
		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	18.6	7.5	1.6	6.9	56.2	3.8
20 m	U (cm/sec)	- 2.4	8.7	-0.1	2.3	17.1	-27.6
(4419)	V (cm/sec)	- 2.1	17.8	-0.4	2.0	27.3	-54.0
	T (C)	8.63	0.63	1.50	5.39	11.14	7.81
	S (cm/sec)	16.2	6.4	0.9	4.3	42.3	0.8
40 m	U (cm/sec)	- 2.2	7.6	-0.5	3.2	16.0	-28.9
(4429)	V (cm/sec)	1.8	15.5	-0.4	1.8	26.8	-34.9
	T (C)	7.92	0.27	0.41	3.36	8.70	7.38
	S (cm/sec)	11.3	5.5	0.8	3.0	28.4	1.8
60 m	U (cm/sec)	- 2.5	4.5	-0.8	5.0	8.7	-24.6
(5039)	V (cm/sec)	2.2	11.3	-0.4	2.3	25.5	-25.2
	T (C)	7.75	0.24	0.94	3.52	8.41	7.36
	P (kg/cm^2)	6.27	0.08	-0.07	2.10	6.42	6.13


CM/SEC
20
0
-20
U(20 M) LUV4419
CM/SEC
20
0
-20
U(40 M) LUV4429
0000
6
AUG
1972
10
15
26
1
SEPT
CM/SEC
0
-20
U(60 M) LUV5039

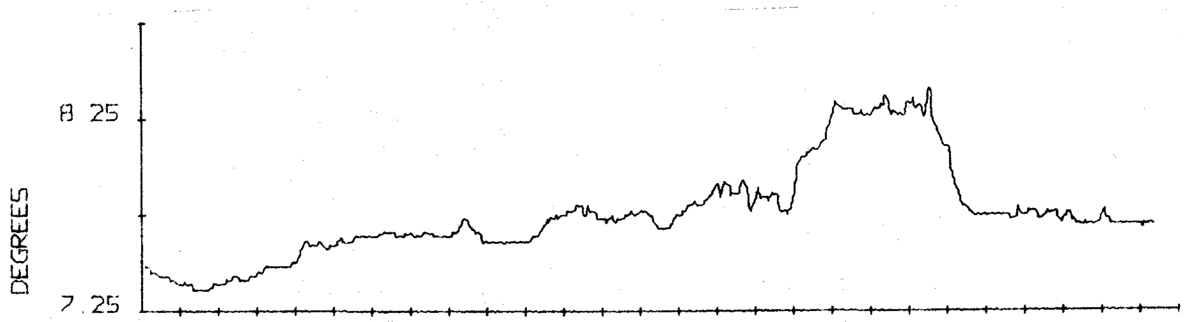

CM/SEC
20
0
-20
-40
-60
V(20 M) LUV4419
CM/SEC
20
0
-20
-40
V(40 M) LUV4429
CM/SEC
20
0
-20
V(60 M) LUV5039



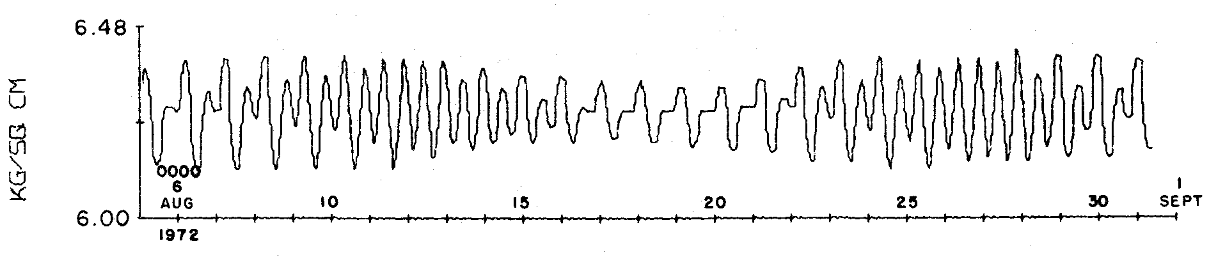
TEMP.(20 M) LT4419



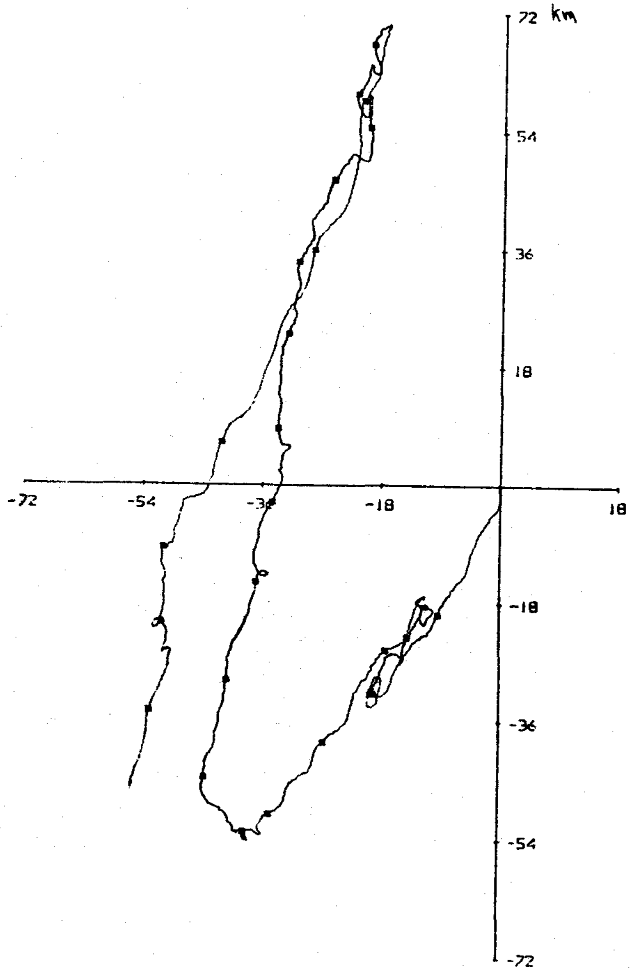
TEMP.(40 M) LT4429



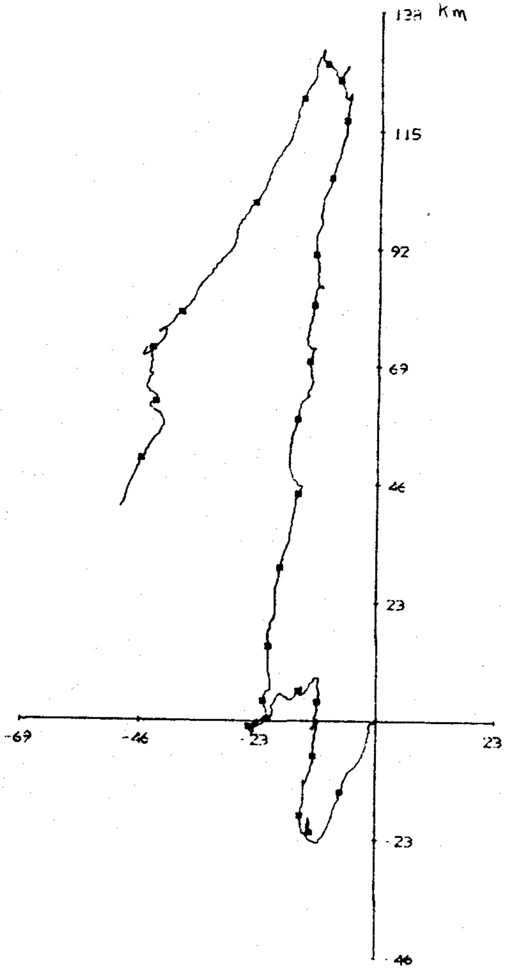
TEMP.(60 M) LT5039



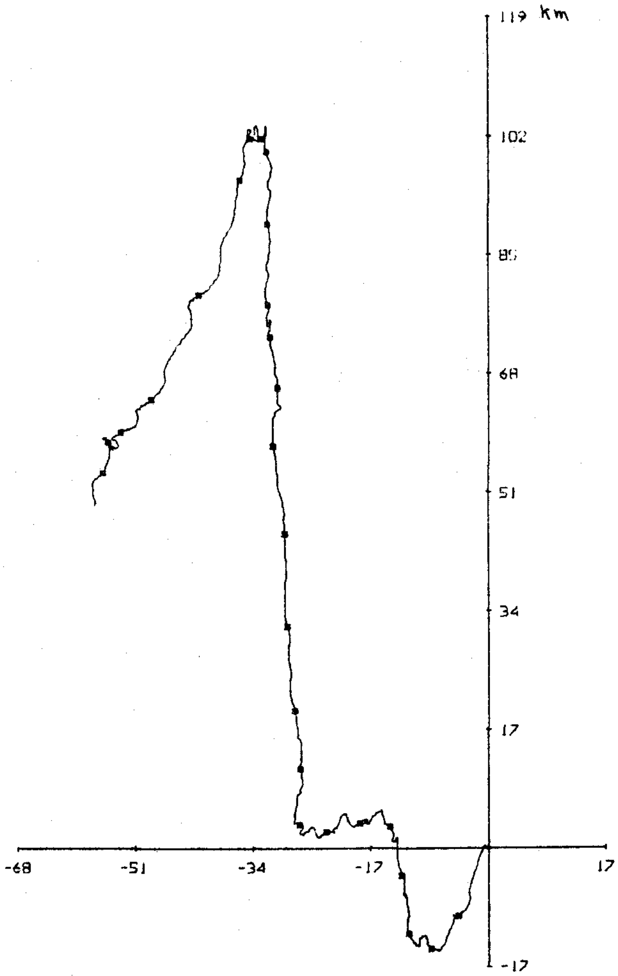
PRESSURE(60 M) LTP5039



20 METERS AT NH-6   26 DAYS STARTING D156 8/5/72



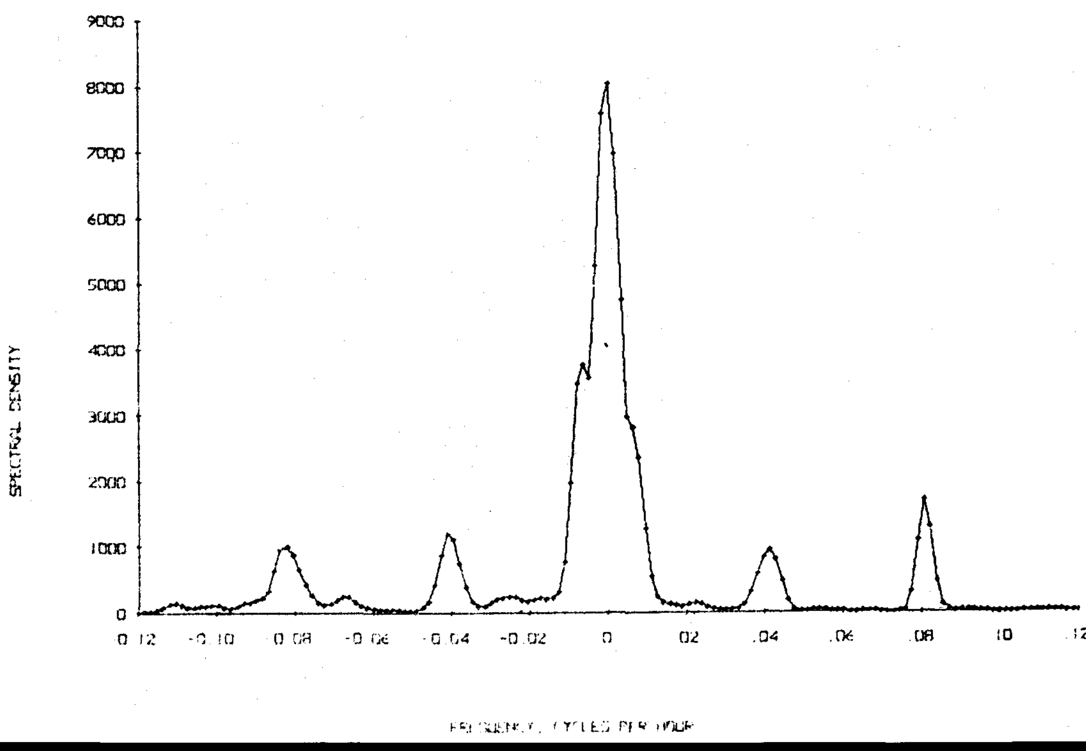
40 METERS AT NH-6   26 DAYS STARTING D157 8/5/72



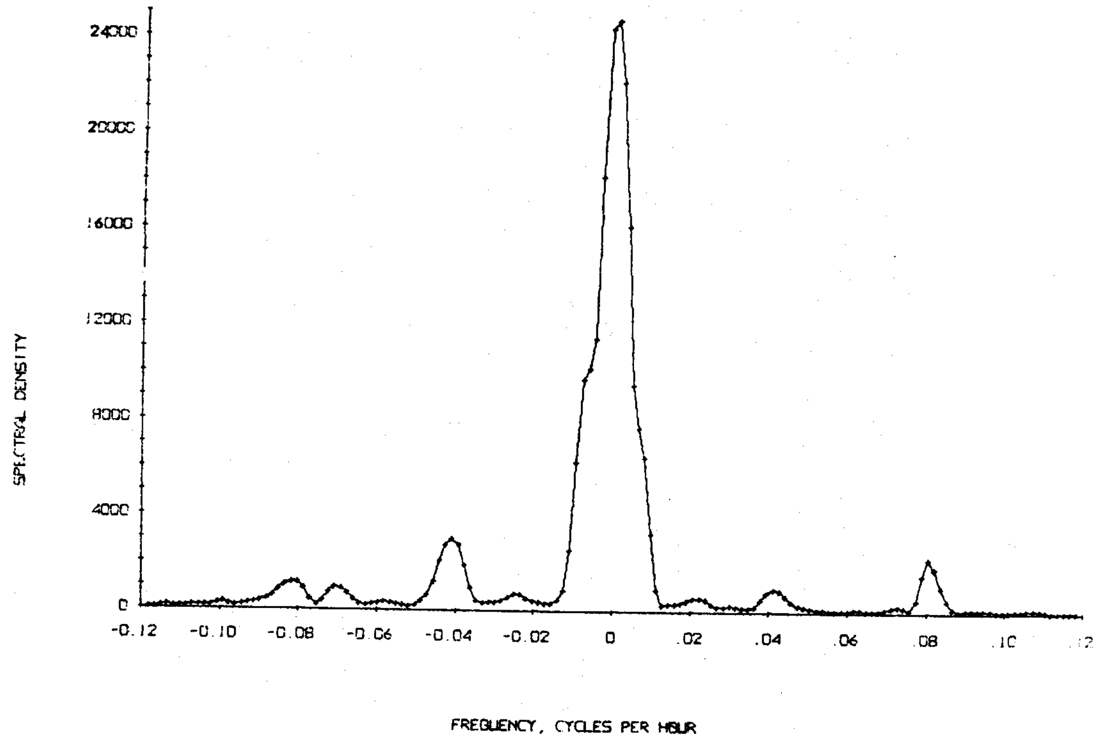
60 METERS AT NH-6. 27 DAYS STARTING 8/5/72

ROTARY SPECTRUM

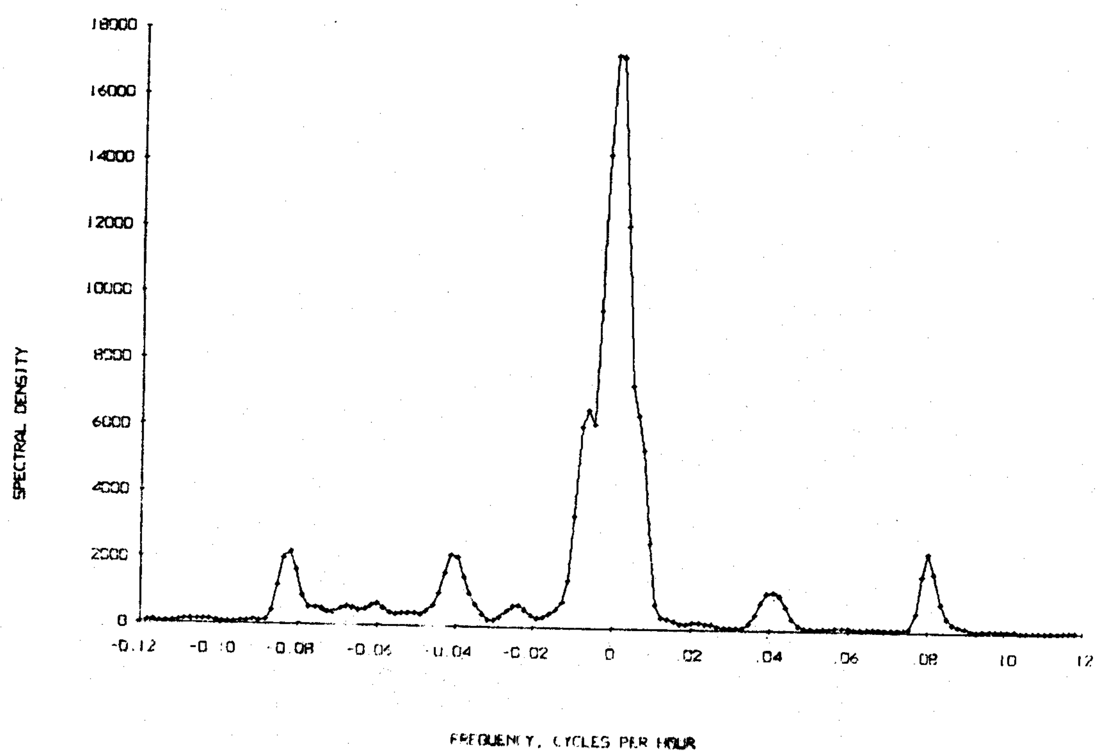
60 METERS AT NH-6. 8/4/72 TO 8/31/72. TAPE 503/9



ROTARY SPECTRUM
20 METERS AT NH-6. 8/4/72 TO 8/31/72. TAPE 441/9



ROTARY SPECTRUM
40 METERS AT NH-6. 8/4/72 TO 8/31/72. TAPE 442/9



1972 CUE Installation F

NH 10

Position: 44°39.1'N, 124°17.3'W
Depth of Water: 80 m
Set at 1709 GMT 2 August 1972 by R/V CAYUSE
Retrieved at 1624 GMT 31 August 1972 by R/V CAYUSE
Data Interval: 1733 GMT 2 August to 1618 GMT 31 August

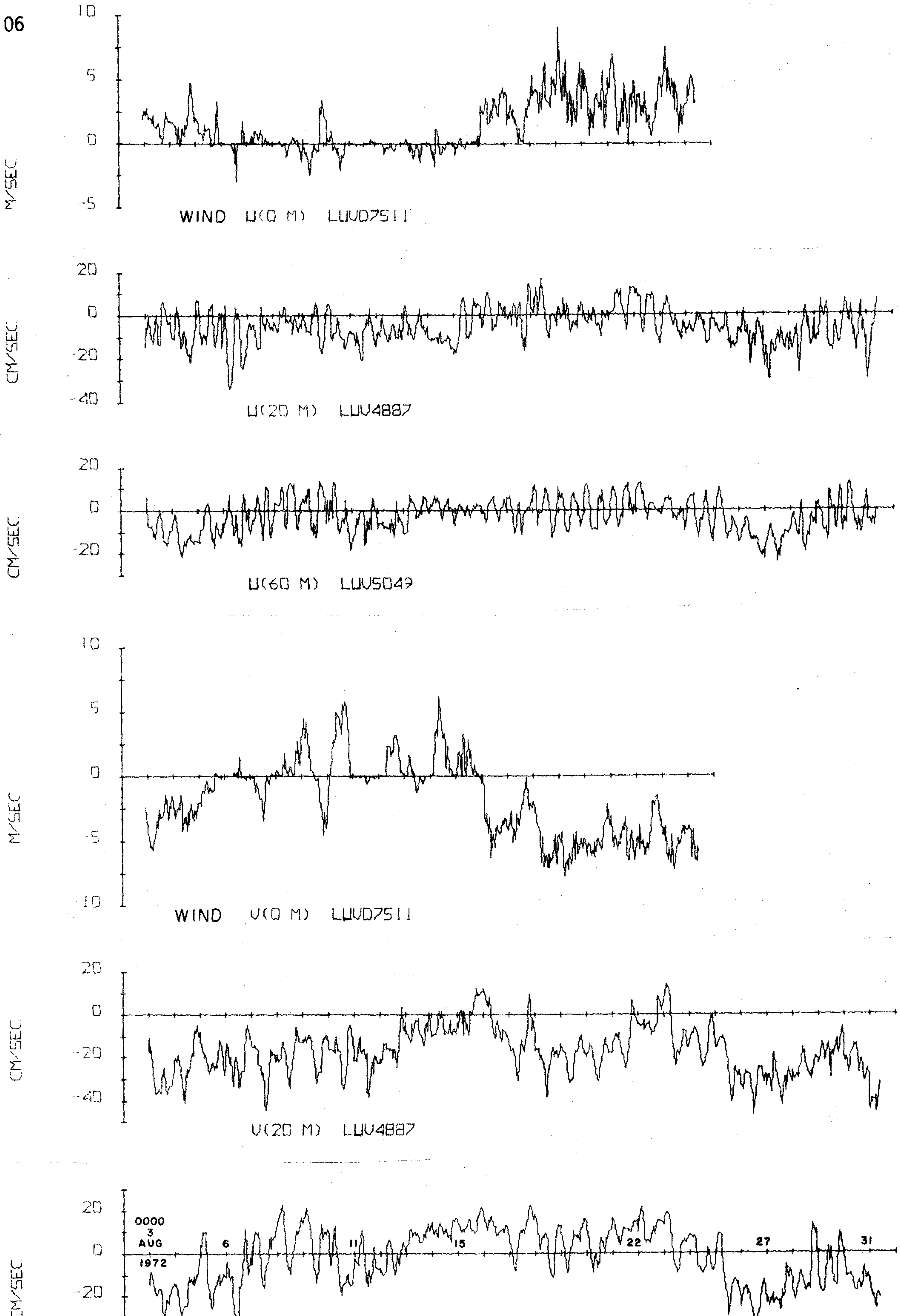
Instrumentation

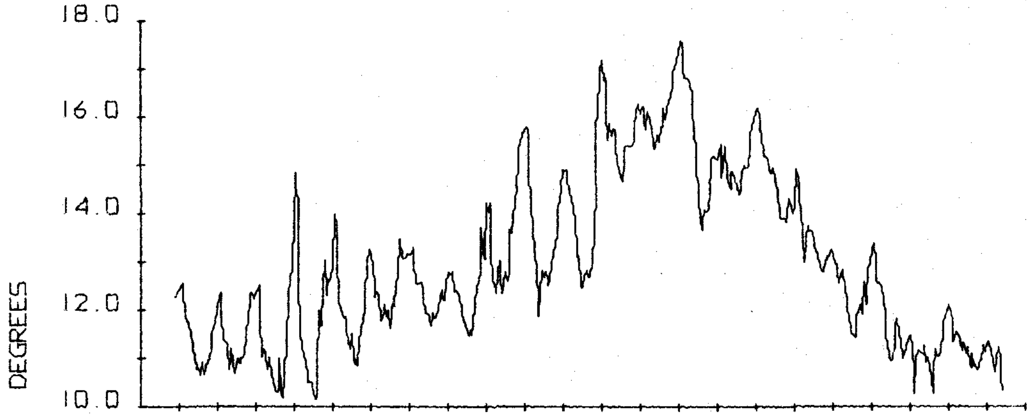
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D75/11
20 m	21 m	488/7
40 m	41 m	486/6
60 m	61 m	504/9

Data were recorded every 5 minutes. All subsurface instruments measured temperature, current speed,and current direction. In addition,the 60 m instrument recorded pressure. The 40 m instrument produced no usable data, and the water temperature sensor on the surface buoy failed after six days. The anemometer rotor appeared to have a very high starting speed, so that the wind record shows many more zero speeds than it probably should, particularly during the first half of the installation.

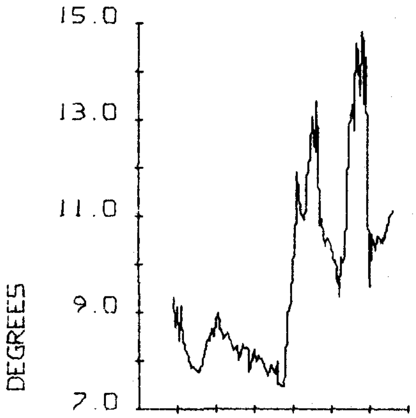
(F-NH-10)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	3.3	2.6	0.3	1.9	10.1	0.0
0m	U(cm/sec)	1.4	1.9	0.8	3.1	9.1	- 3.0
(D7511)	V(cm/sec)	- 1.8	2.9	0.2	2.3	6.2	- 7.7
	T (C) air	12.97	1.76	0.58	2.34	17.61	10.15
	T (C) water	9.71	1.89	0.89	2.90	14.85	7.47
	S(cm/sec)	21.0	9.1	0.7	2.9	53.5	3.7
20m	U(cm/sec)	- 5.4	8.0	-0.2	3.3	17.0	-34.1
(4887)	V(cm/sec)	-17.4	11.3	0.2	2.9	14.0	-46.5
	T (C)	8.61	0.63	1.16	5.30	11.62	7.50
	S(cm/sec)	14.4	6.2	1.1	4.3	38.6	2.2
60m	U(cm/sec)	- 3.0	7.6	-0.1	2.4	14.0	-24.1
(5049)	V(cm/sec)	- 1.8	13.3	-0.3	2.0	22.9	-37.0
	T (C)	7.81	0.17	0.23	2.43	8.21	7.40
	P(kg/cm^2)	6.14	0.05	0.03	2.31	6.24	6.02

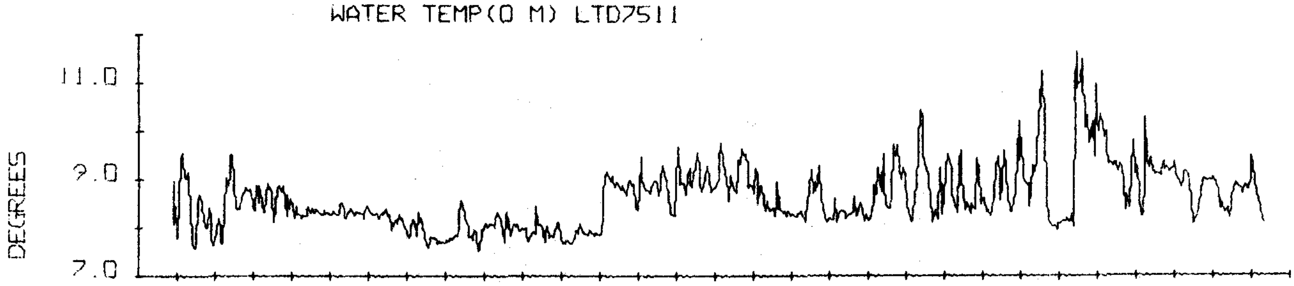

10
5
0
-5
M/SEC
WIND U(0 M) LUUD7511
20
0
-20
-40
CM/SEC
U(20 M) LUU4887
20
0
-20
CM/SEC
U(60 M) LUU5049
10
5
0
-5
-10
M/SEC
WIND V(0 M) LUUD7511
20
0
-20
-40
CM/SEC
V(20 M) LUU4887
20
0
-20
CM/SEC
0000
3
AUG
1972
6
11
15
22
27
31



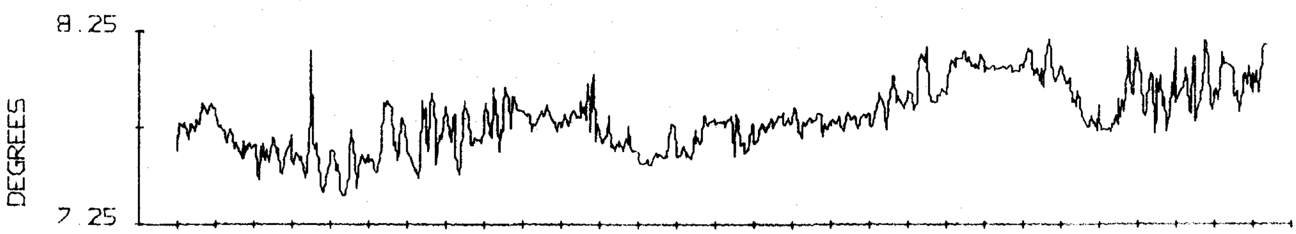
AIR TEMP.(0 M) LTD7511



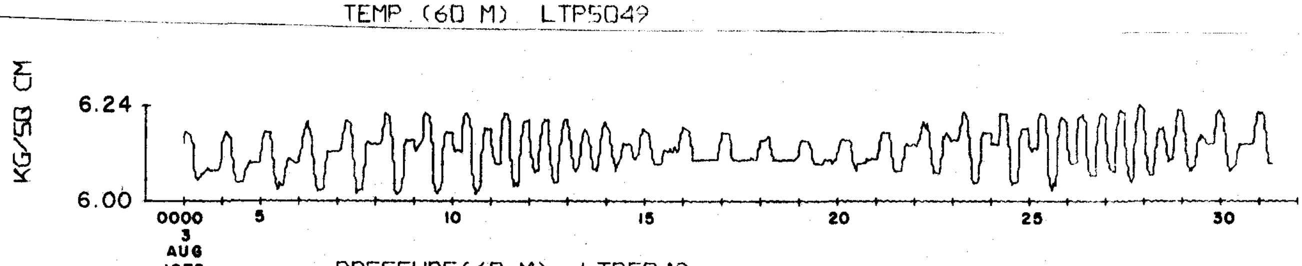
WATER TEMP(0 M) LTD7511



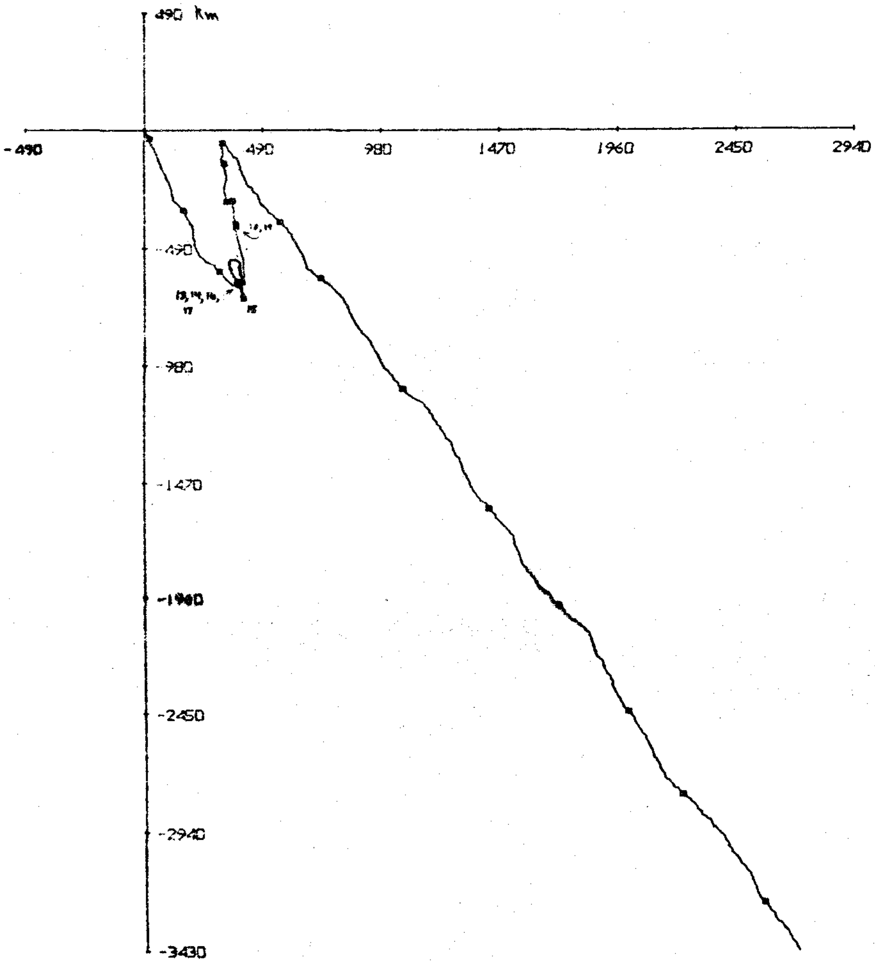
TEMP.(20 M) LT4887



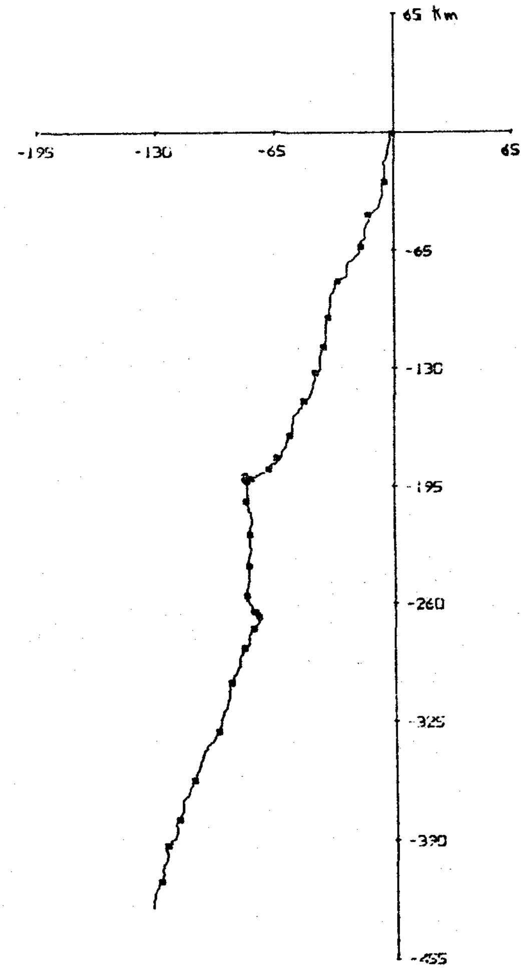
TEMP.(60 M) LTP5049



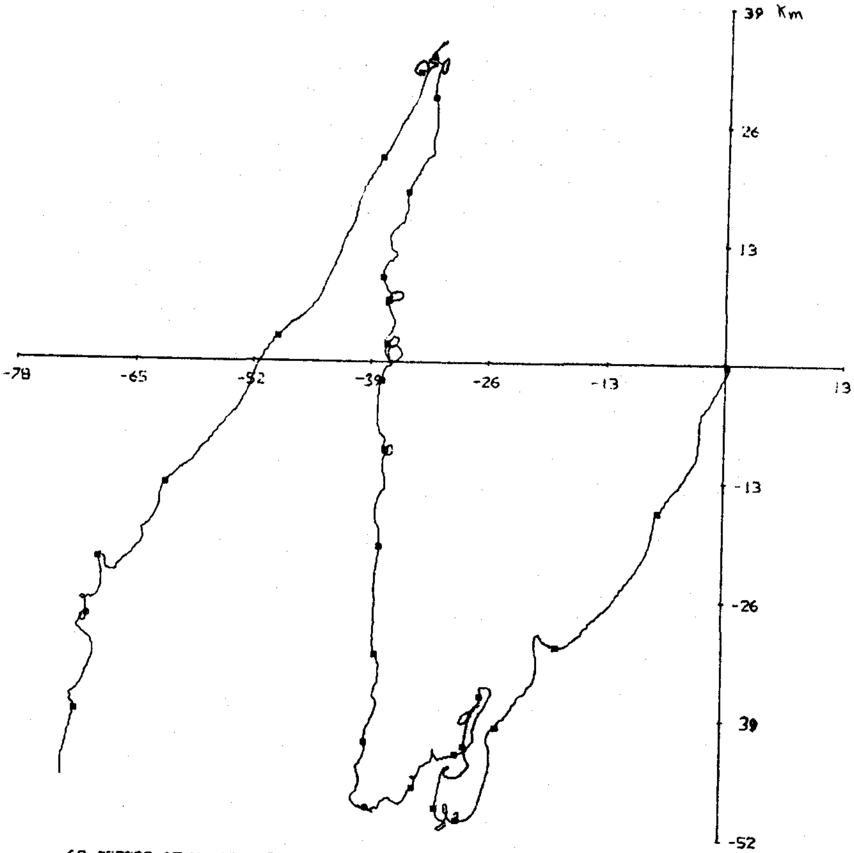
PRESSURE(60 M) LTP5049



WIND AT NH-10. 22 DAYS STARTING 2156 8/9/72

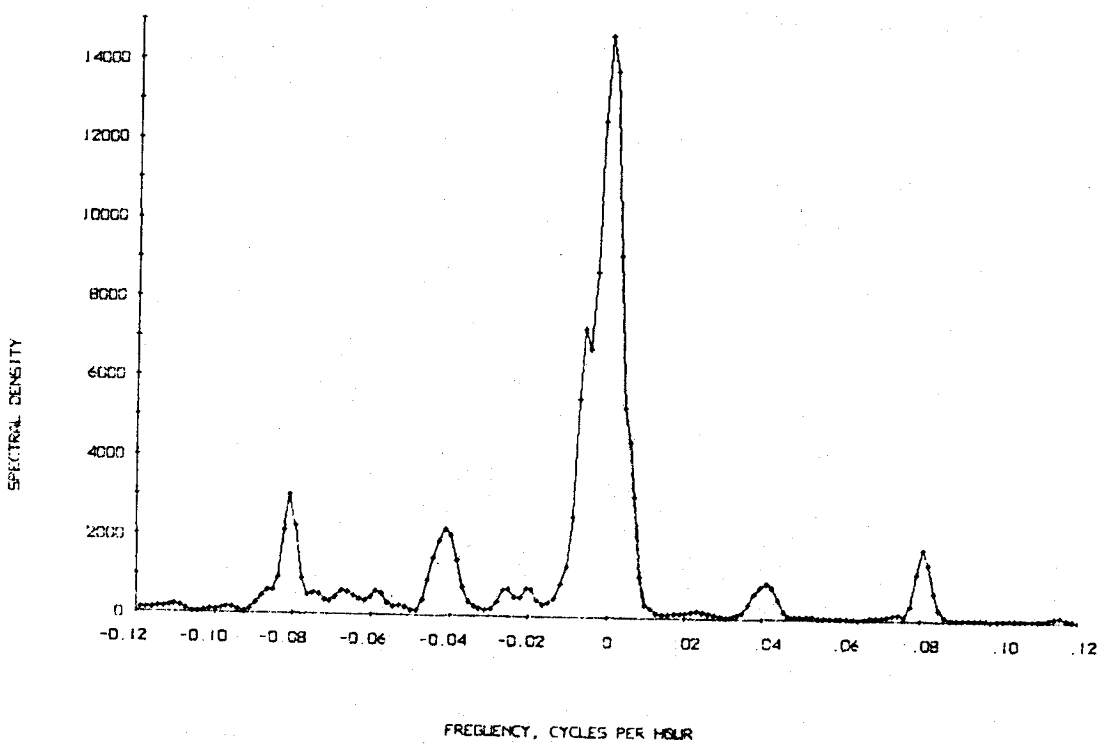


20 METERS AT NH-10. 28 DAYS STARTING 2333 8/2/72

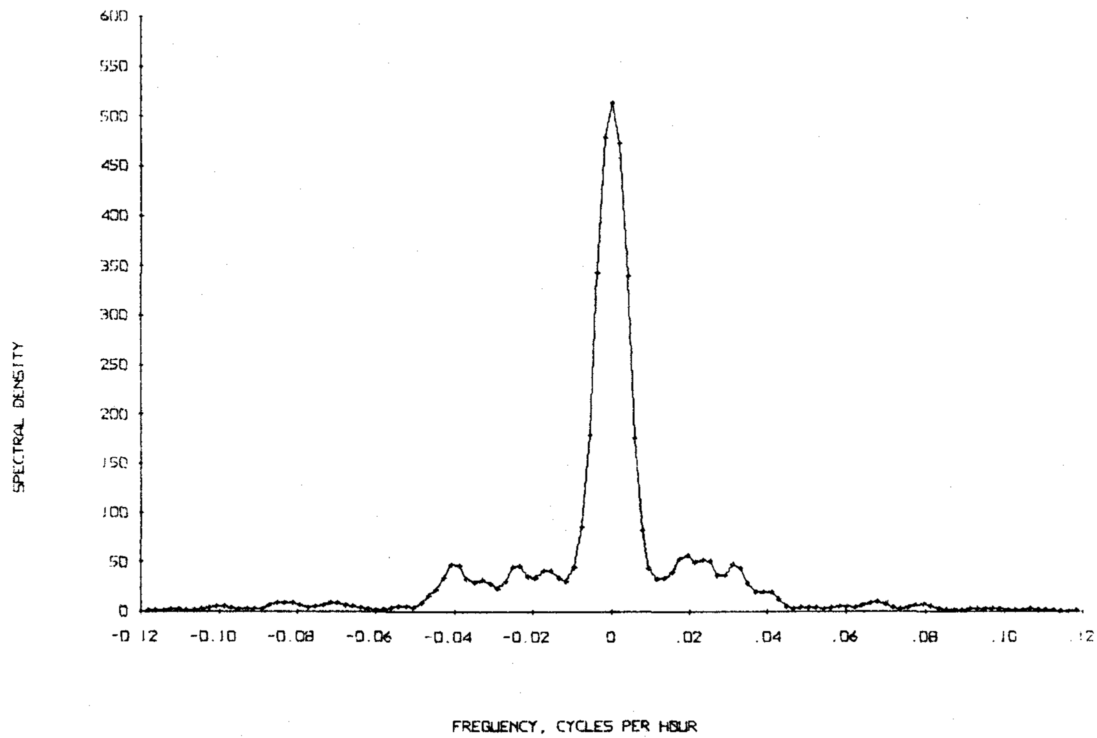


60 METERS AT NH-10. 28 DAYS STARTING 2330 8/2/72

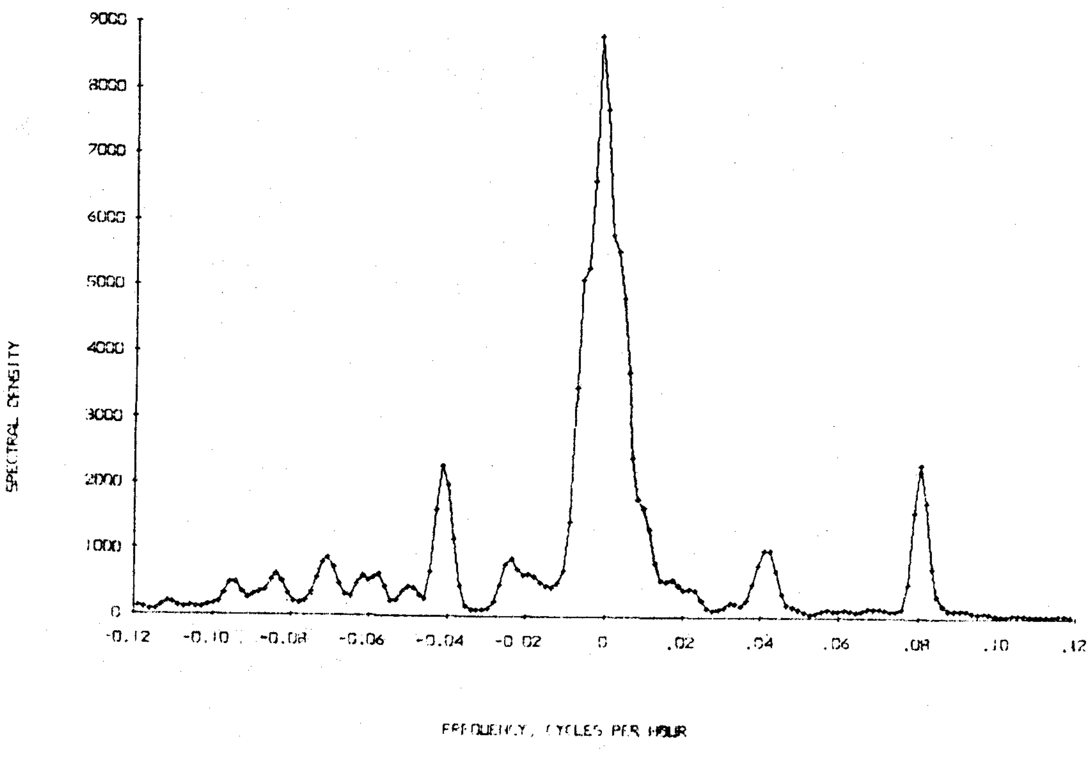
ROTARY SPECTRUM
60 METERS AT NH-10. 8/2/72 TO 8/31/72. TAPE 504/9



ROTARY SPECTRUM
WIND AT NH-10. 8/9/72 TO 8/31/72. TAPE 025/11



ROTARY SPECTRUM
20 METERS AT NH-10. 8/2/72 TO 8/31/72. TAPE 488/7



1972 CUE Installation F

NH 15

Position: 44°40.0'N, 124°25.0'W
Depth of Water: 95 m
Set at 2317 GMT 14 August 1972 by R/V CAYUSE
Retrieved at 1800 GMT 30 August 1972 by R/V CAYUSE
Data Interval: 2337 GMT 14 August to 1757 GMT 30 August

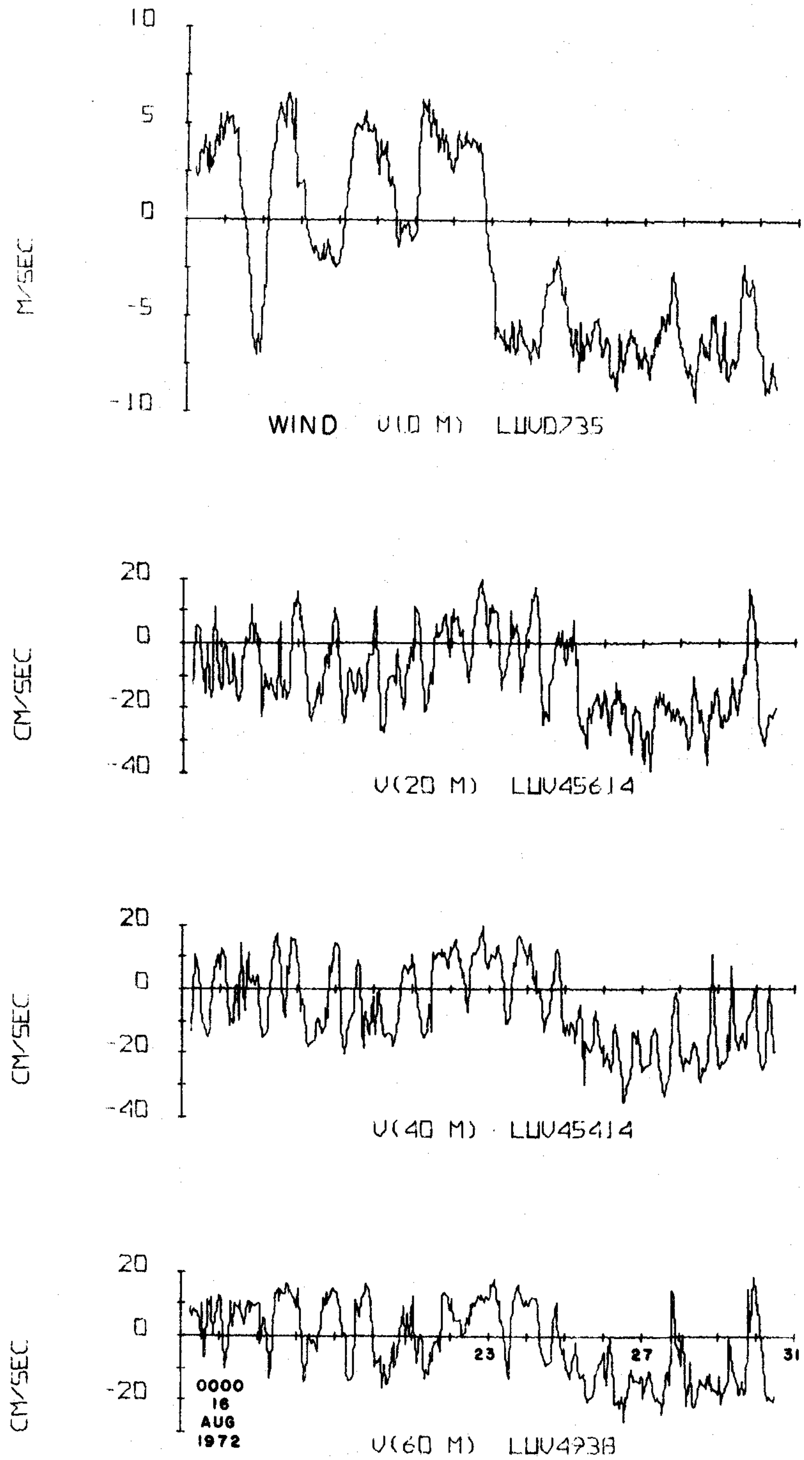
Instrumentation

Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D73/5
20 m	17 m	456/14
40 m	37 m	454/14
60 m	57 m	493/8
80 m	77 m	496/9

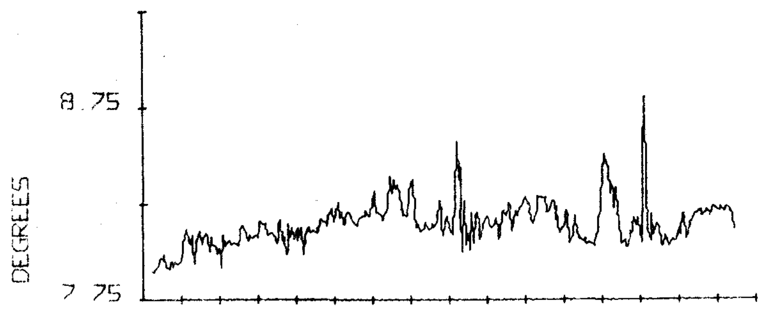
Data were recorded every 5 minutes. All subsurface instruments measured temperature, current speed,and current direction. In addition,the 80 m instrument recorded pressure. The surface buoy measured wind speed and direction, air temperature, and surface water temperature. Direction, and hence U and V,were bad in the 80 m instrument.

(F-NH-15)

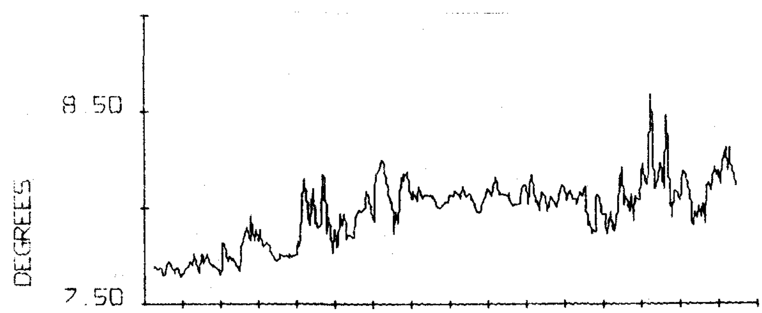
		MEAN	S.D.	SKEW	KURT	MAX	MIN
0 m (D735)	S(m/sec)	5.0	2.0	0.0	2.2	9.4	0.4
	U(m/sec)	- 0.1	1.6	-0.2	3.1	4.5	- 4.6
	V(m/sec)	- 1.9	4.8	0.3	1.6	6.6	- 9.4
	T(C) air	14.04	1.37	0.34	2.38	17.73	11.04
	T (C) water	13.33	1.98	- 0.31	1.99	16.29	9.16
20m (45614)	S(cm/sec)	20.6	9.9	0.6	3.0	51.2	2.2
	U(cm/sec)	- 9.1	13.6	0.1	2.4	23.3	-40.8
	V(cm/sec)	-10.0	12.5	0.3	2.2	20.0	-39.5
	T (C)	9.72	1.09	1.02	4.28	14.64	7.83
40m (45414)	S(cm/sec)	16.6	6.3	0.8	3.7	38.7	2.9
	U(cm/sec)	- 2.8	9.8	0.0	2.2	18.7	-23.6
	V(cm/sec)	- 6.4	13.1	0.1	1.9	19.8	-35.4
	T (C)	8.12	0.13	0.12	4.20	8.60	7.78
60m (4938)	S(cm/sec)	15.3	4.8	-0.1	3.1	28.1	1.7
	U(cm/sec)	0.6	11.0	-0.3	1.9	21.8	-22.7
	V(cm/sec)	- 1.7	11.6	-0.1	1.7	18.4	-26.2
	T (C)	8.15	0.11	0.96	6.71	8.81	7.89
80m (4969)	S(cm/sec)	NONE					
	U(cm/sec)	NONE					
	V(cm/sec)	NONE					
	T (C)	7.97	0.17	-0.15	2.79	8.59	7.64
	P(kg/cm^2)	7.72	0.06	-0.04	1.86	7.82	7.60


10
5
0
-5
-10
M/SEC
WIND V(10 M) LUVD735
20
0
-20
-40
CM/SEC
V(20 M) LUV45614
20
0
-20
-40
CM/SEC
V(40 M) LUV45414
20
0
-20
CM/SEC
0000
16
AUG
1972
23
27
31
V(60 M) LUV4938

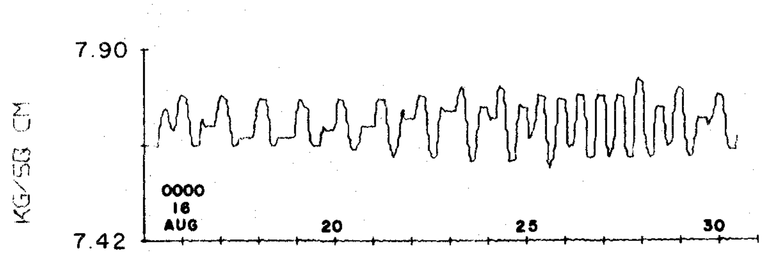
TEMP.(40 M) LT45414



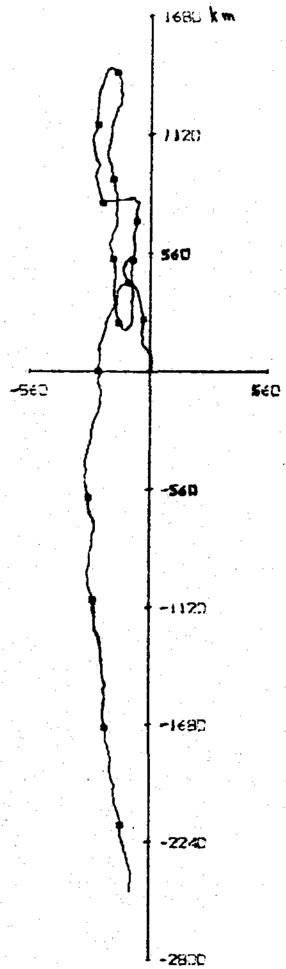
TEMP (60 M) LT4938



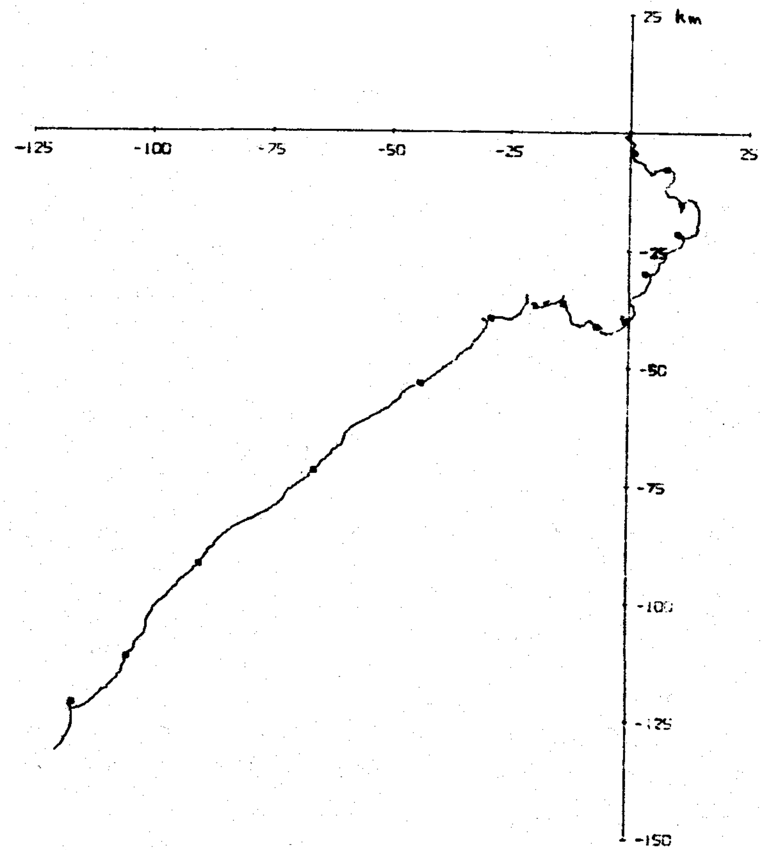
TEMP.(80 M) LTP4969



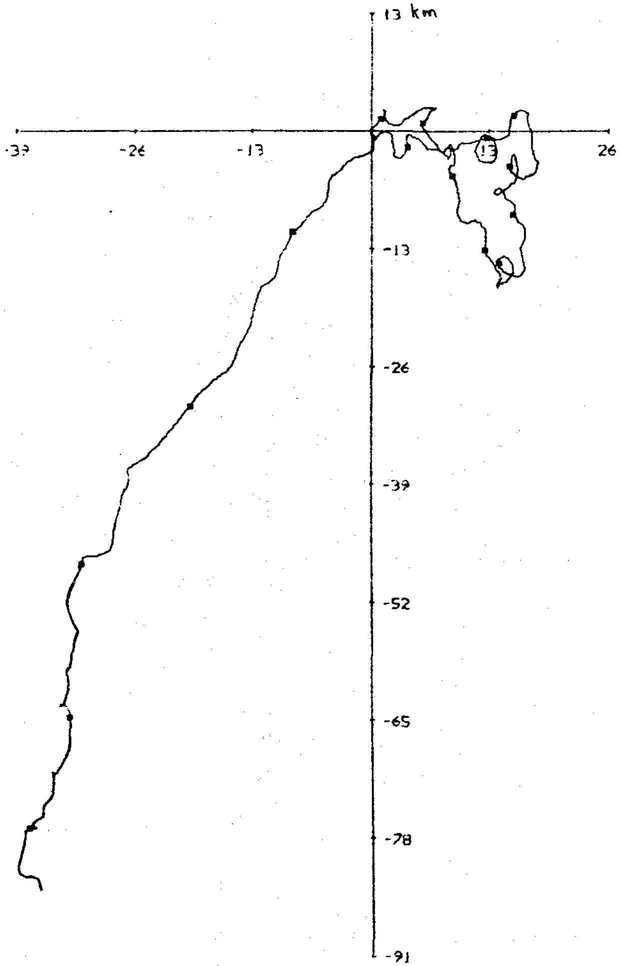
PRESSURE(80 M) LTP4969



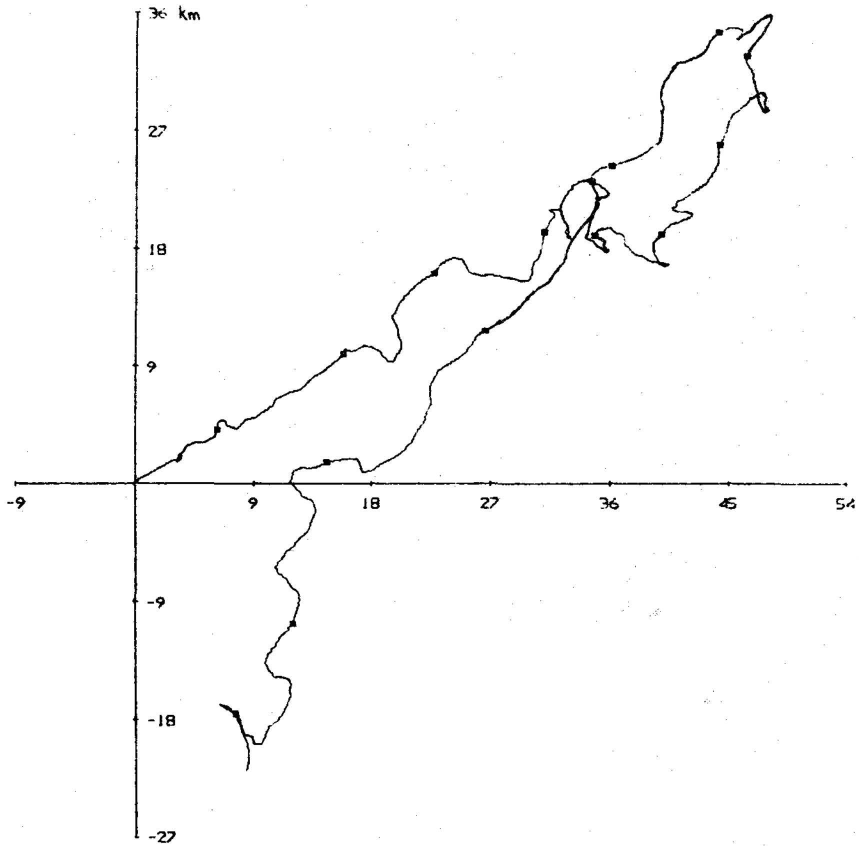
WIND AT NH-15. 15 DAYS STARTING 0554 8/15/72



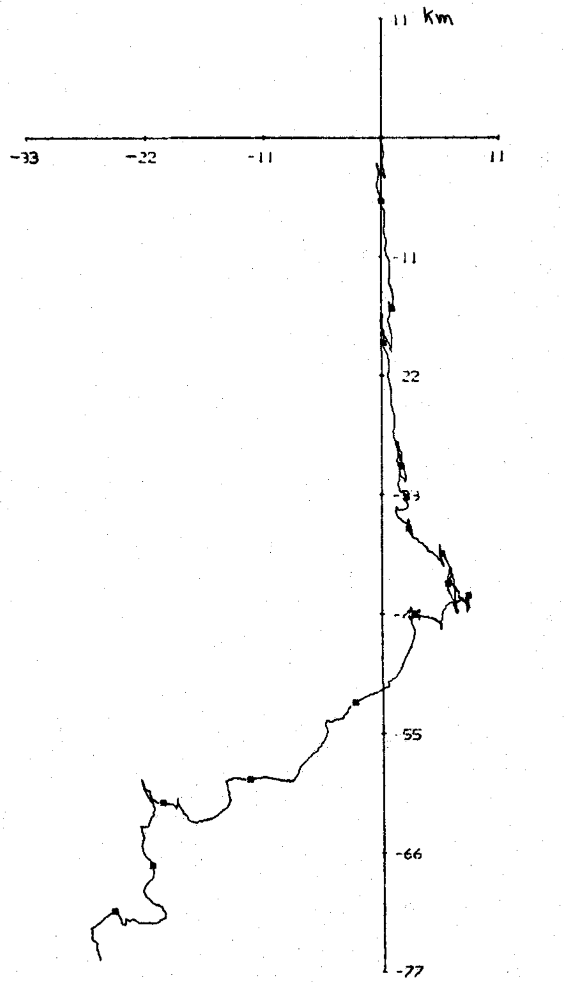
20 METERS AT NH-15. 16 DAYS STARTING 0537 8/15/72



40 METERS AT NH-15. 16 DAYS STARTING 0535 8/15/72



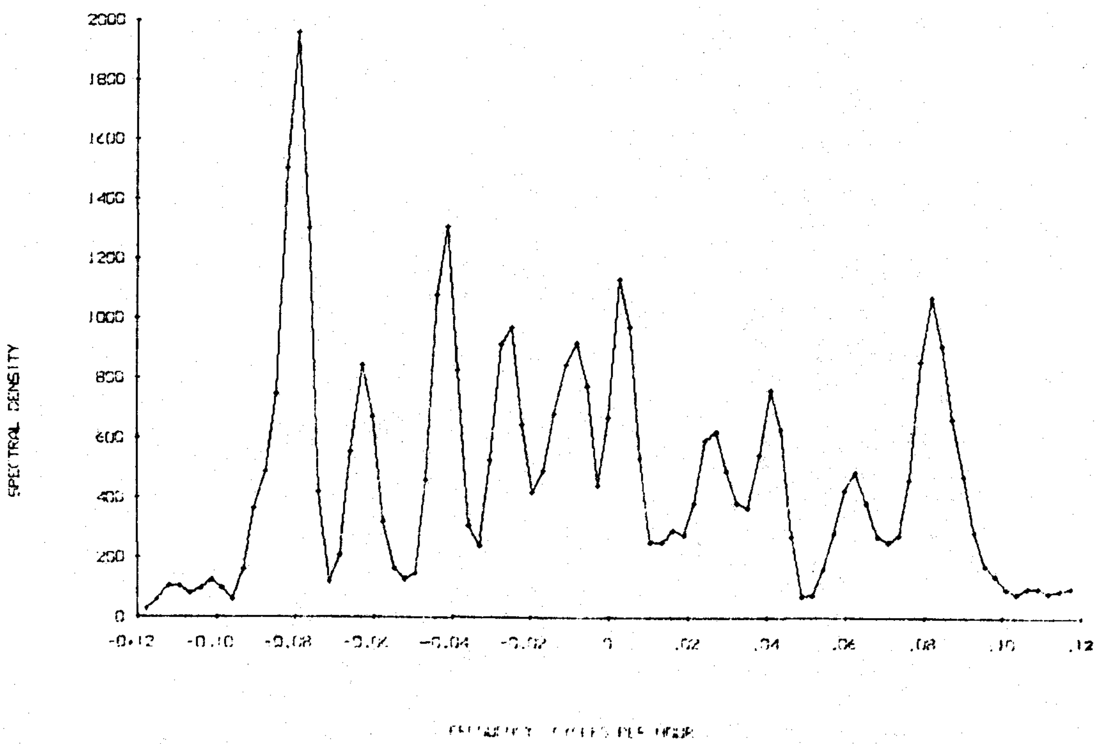
60 METERS AT NH-15. 16 DAYS STARTING 0539 8/15/72



80 METERS AT NH-15. 16 DAYS STARTING 0537 8/15/72

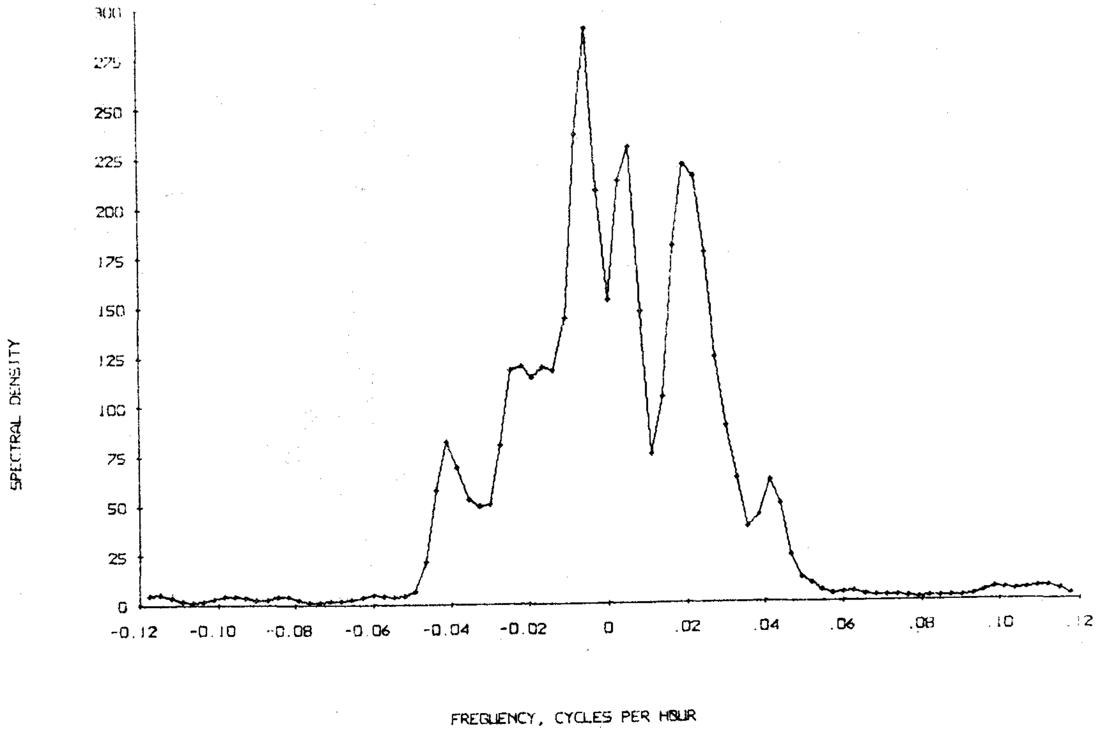
ROTARY SPECTRUM

80 METERS AT NH-15. 8/14/72 TO 8/30/72. TAPE 496/9



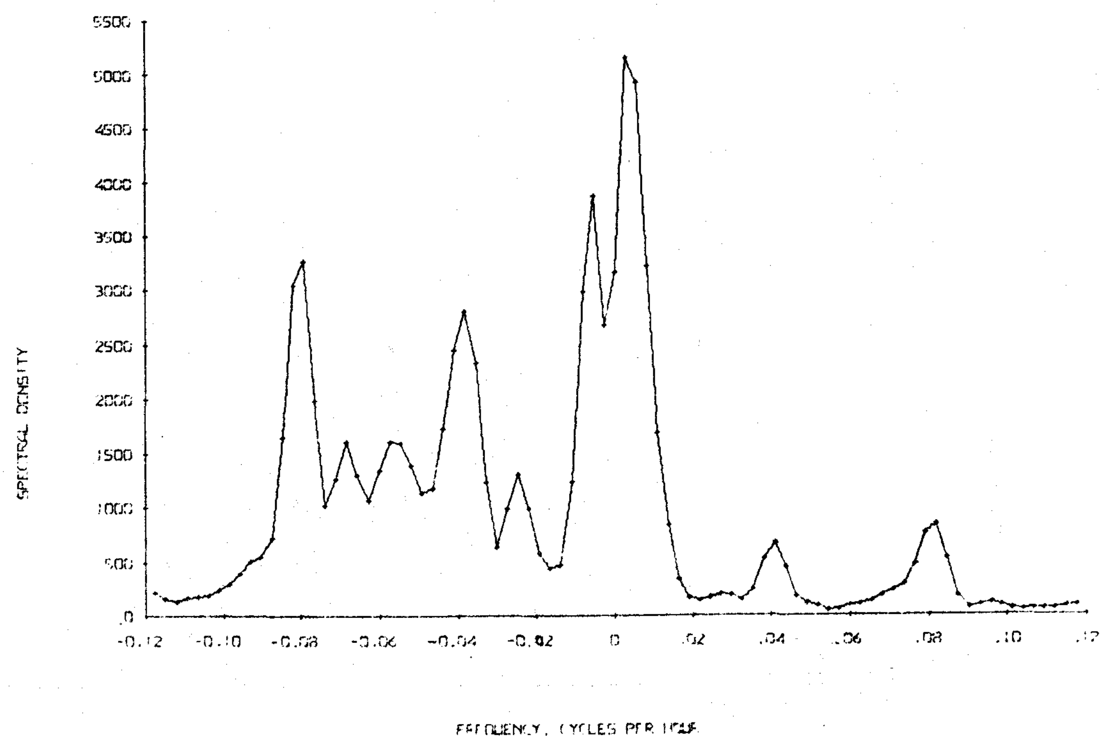
ROTARY SPECTRUM

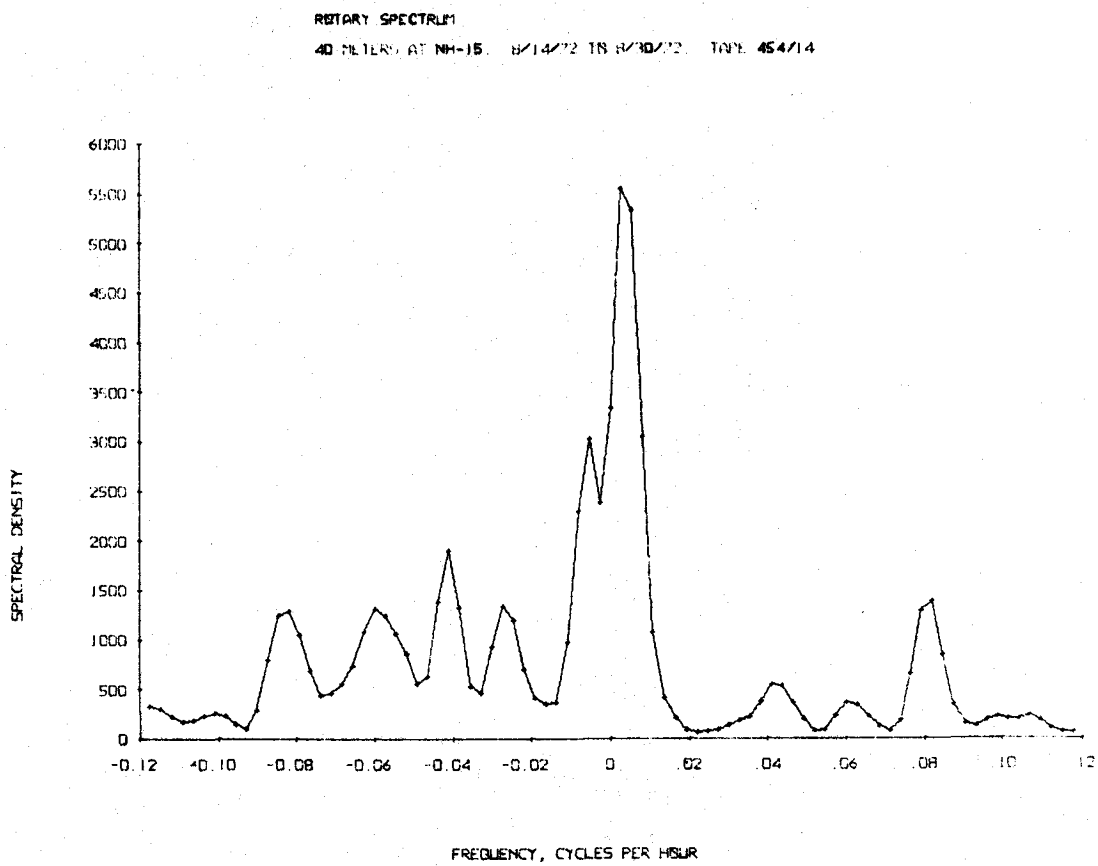
WIND AT NH-15 8/14/72 TO 8/30/72 TAPE D73/5

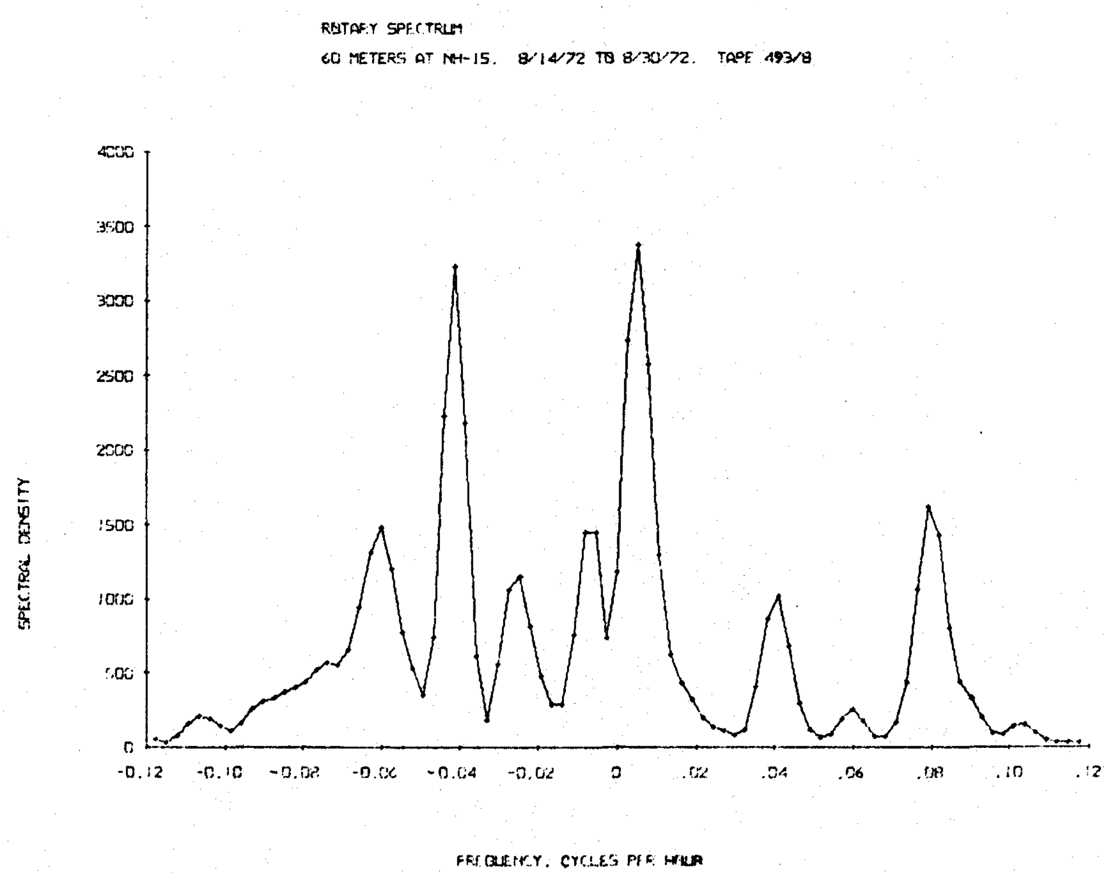


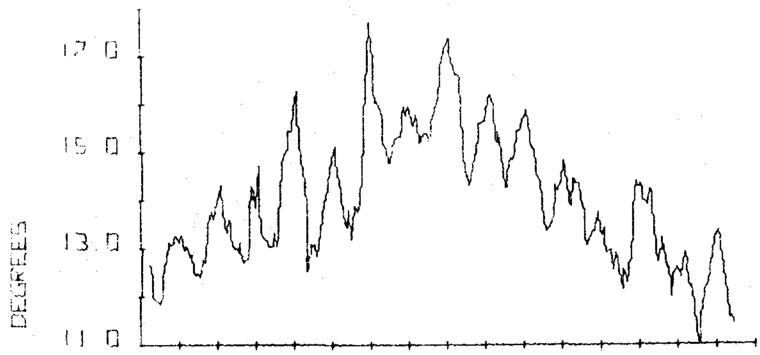
ROTARY SPECTRUM

20 METERS AT NH-15. 8/14/72 TO 8/30/72. TAPE 456/14

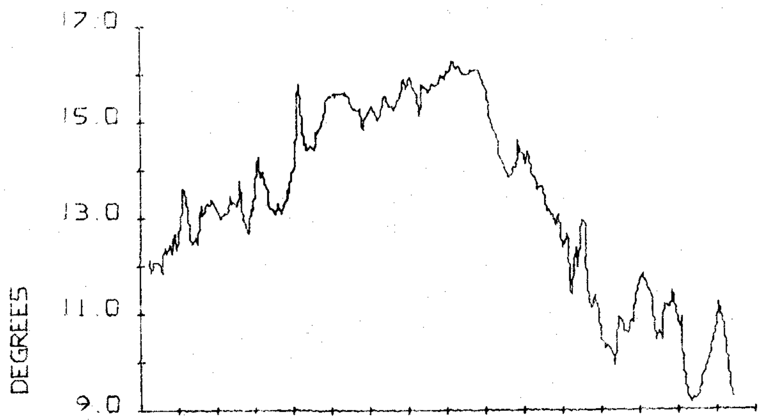



RBTARY SPECTRUM
40 METERS AT NH-15. 8/14/72 TO 8/30/72. TAPE 454/14
SPECTRAL DENSITY
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR

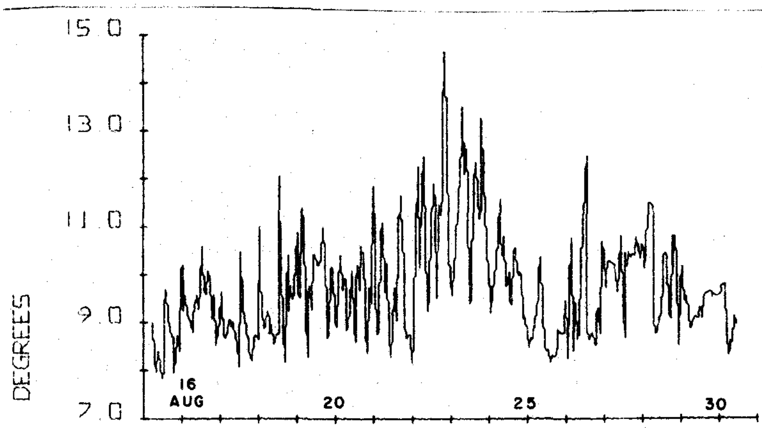

ROTARY SPECTRUM
60 METERS AT NH-15. 8/14/72 TO 8/30/72. TAPE 493/8
SPECTRAL DENSITY
4000
3500
3000
2500
2000
1500
1000
500
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR



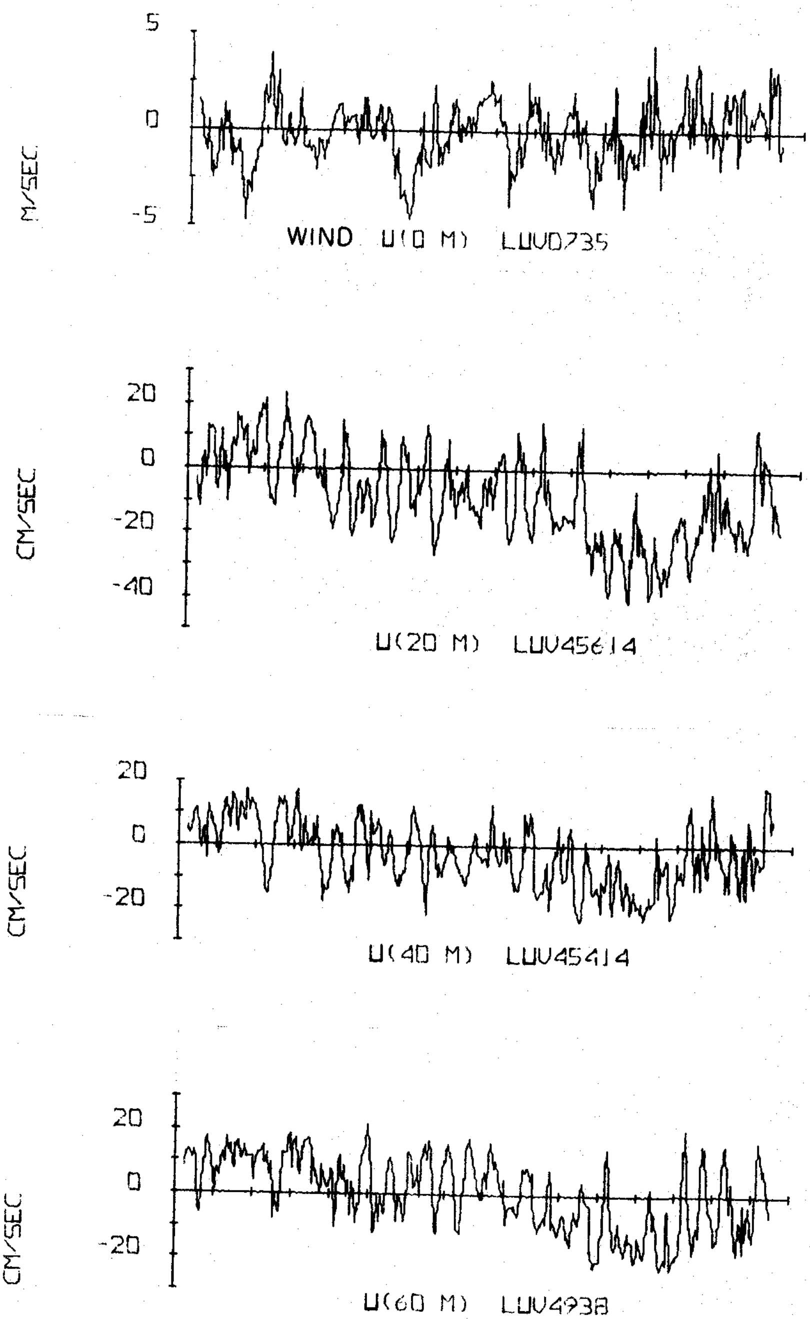
AIR TEMP (0 M) LTD735



WATER TEMP(0 M) LTD735



TEMP.(20 M) LT45614


5
0
-5
M/SEC
WIND U(0 M) LUV0735
20
0
-20
-40
CM/SEC
U(20 M) LUV45614
20
0
-20
CM/SEC
U(40 M) LUV45414
20
0
-20
CM/SEC
U(60 M) LUV4938

1972 CUE Installation F

NH 20

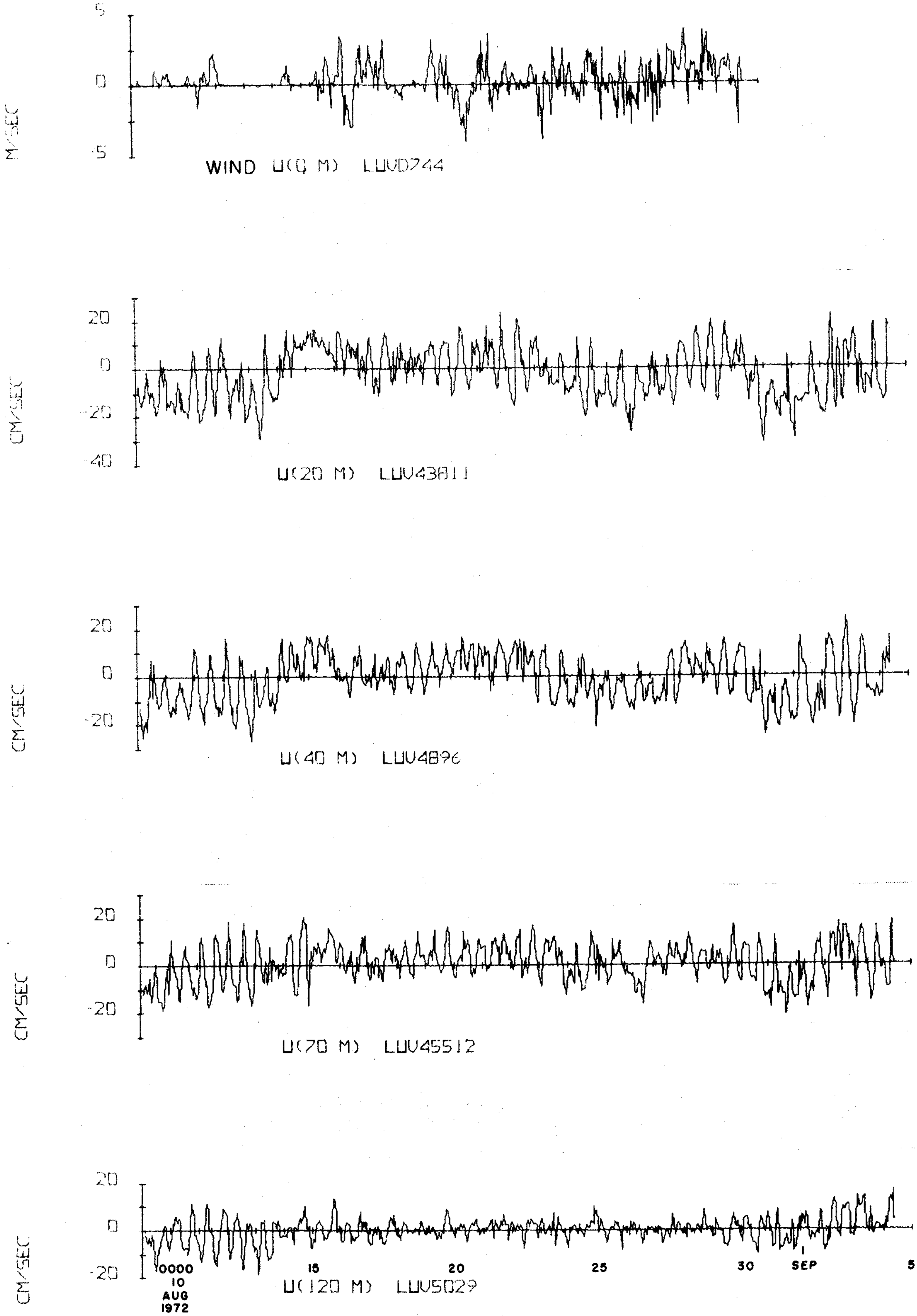
Position: 44°39.0'N, 124°31.8'W
Depth of Water: 142 m
Set at 1956 GMT 3 August 1972 by R/V CAYUSE
Retrieved at 1615 GMT 30 August 1972 by R/V CAYUSE
Data Interval: 2000 GMT 3 August to 1615 GMT 30 August

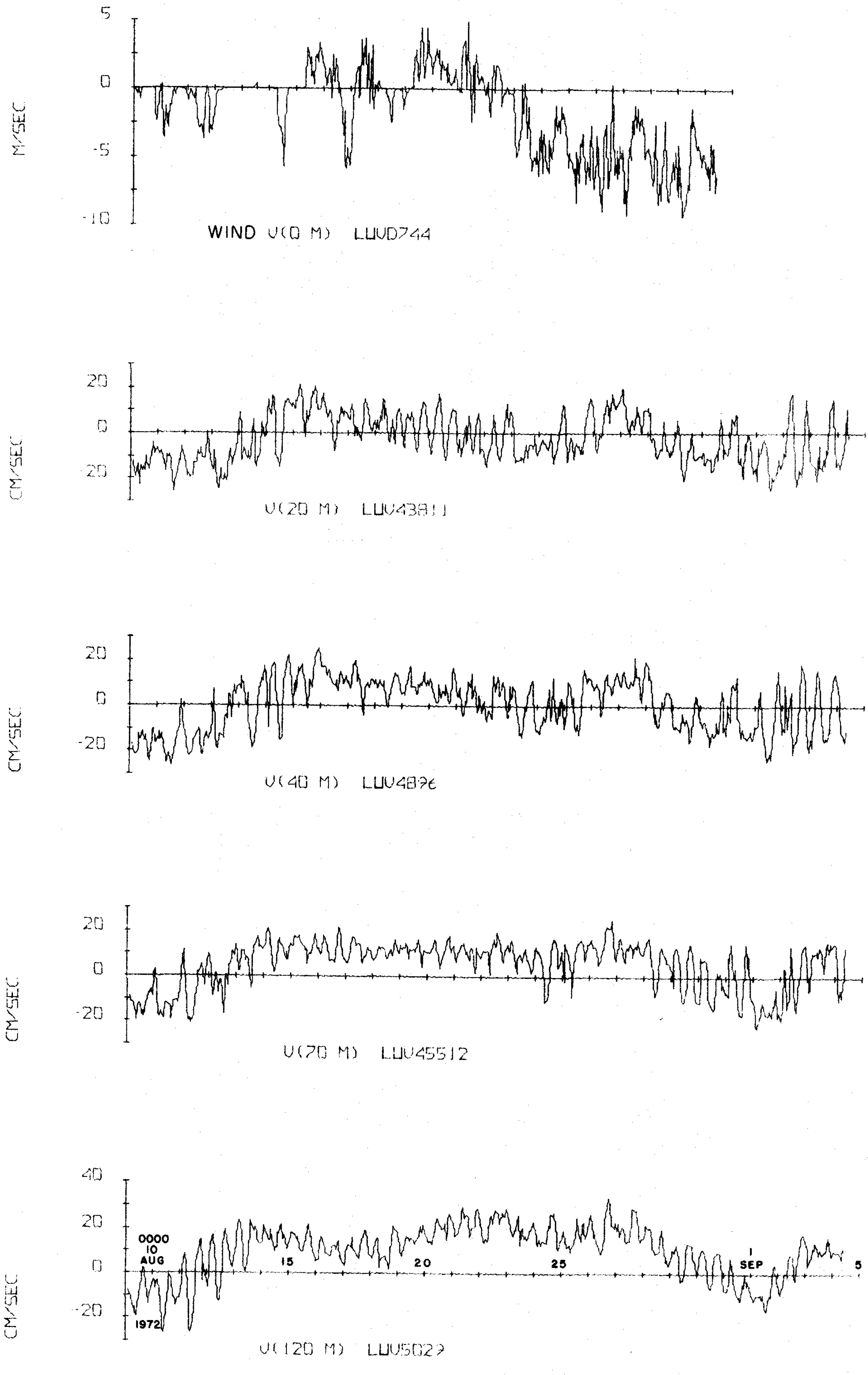
Instrumentation

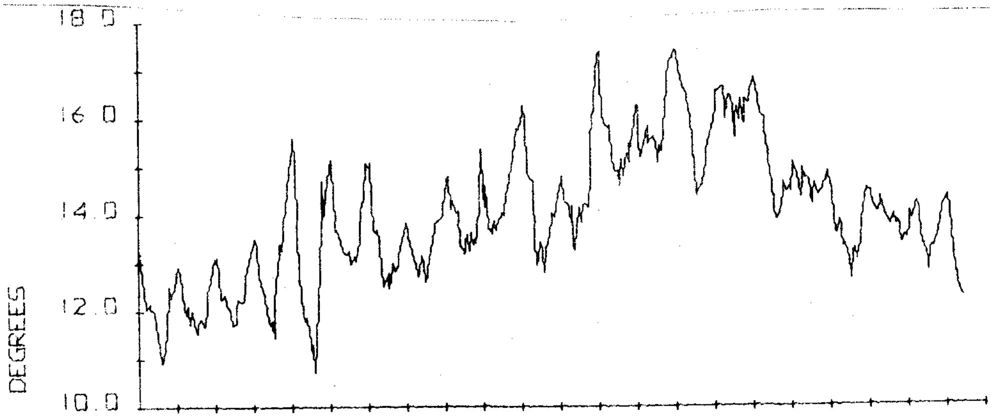
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D74/4
20 m	24 m	438/11
40 m	44 m	489/6
70 m	74 m	455/12
120 m	124 m	502/9

Data were recorded every 5 minutes. All subsurface instruments measured temperature, current speed,and current direction. The 120 m instrument also recorded pressure.

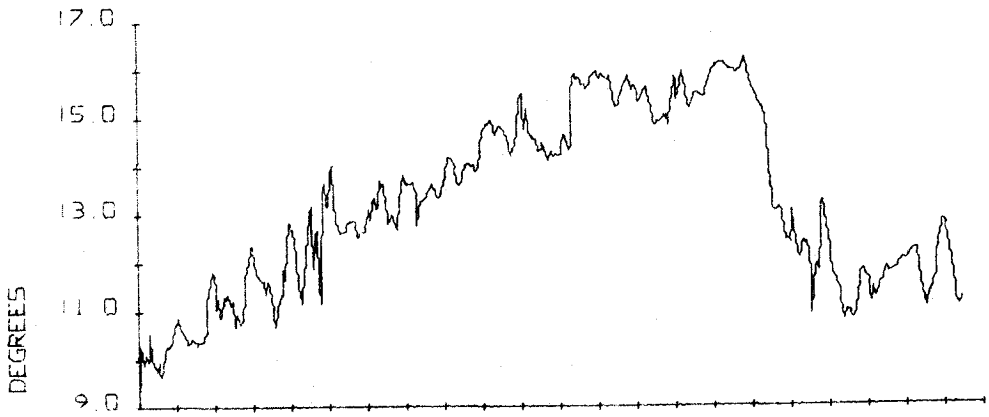
		MEAN	S. D.	SKEW	KURT	MAX	MIN
0m (D744)	S(m/sec)	2.6	2.4	0.7	2.6	10.0	0.0
	U(m/sec)	0.2	1.2	-0.1	4.6	3.8	- 4.0
	V(m/sec)	- 1.6	2.9	-0.6	2.5	5.0	- 9.3
	T (C) air	14.01	1.40	0.22	2.55	17.45	10.72
	T (C) water	13.21	1.82	0.02	1.80	16.22	9.38
20m (43811)	S(cm/sec)	14.4	5.5	0.6	3.3	33.2	1.0
	U(cm/sec)	- 2.8	10.7	-0.0	2.2	23.1	-32.0
	V(cm/sec)	- 2.8	10.4	0.2	2.0	20.9	-25.7
	T (C)	9.01	0.80	0.92	3.60	12.43	7.39
40m (4896)	S(cm/sec)	14.3	5.2	0.5	3.2	32.8	0.5
	U(cm/sec)	- 0.9	9.9	-0.1	2.2	24.8	-27.0
	V(cm/sec)	0.4	11.5	-0.3	2.0	24.9	-26.2
	T (C)	8.17	0.25	-0.18	3.77	8.98	7.51
70m (45512)	S(cm/sec)	13.7	4.0	0.2	3.2	27.3	2.8
	U(cm/sec)	0.7	8.3	-0.2	2.3	20.3	-21.0
	V(cm/sec)	5.1	10.5	-0.9	2.6	25.3	-21.9
	T (C)	8.01	0.18	0.42	2.00	8.48	7.62
120m (5029)	S(cm/sec)	14.7	6.0	0.5	2.6	33.5	1.6
	U(cm/sec)	- 0.1	5.1	-0.2	4.2	16.9	-18.5
	V(cm/sec)	9.8	11.4	-0.8	3.1	33.5	-26.5
	T (C)	7.60	0.14	-0.13	2.06	7.87	7.19
	P(kg/cm^2)	12.37	0.04	0.13	2.46	12.46	12.28


5
0
-5
M/SEC
WIND U(0 M) LUVD744
20
0
-20
-40
CM/SEC
U(20 M) LUV43811
20
0
-20
CM/SEC
U(40 M) LUV4896
20
0
-20
CM/SEC
U(70 M) LUV45512
20
0
-20
CM/SEC
0000
10
AUG
1972
15
20
25
30
1
SEP
5
U(120 M) LUV5029

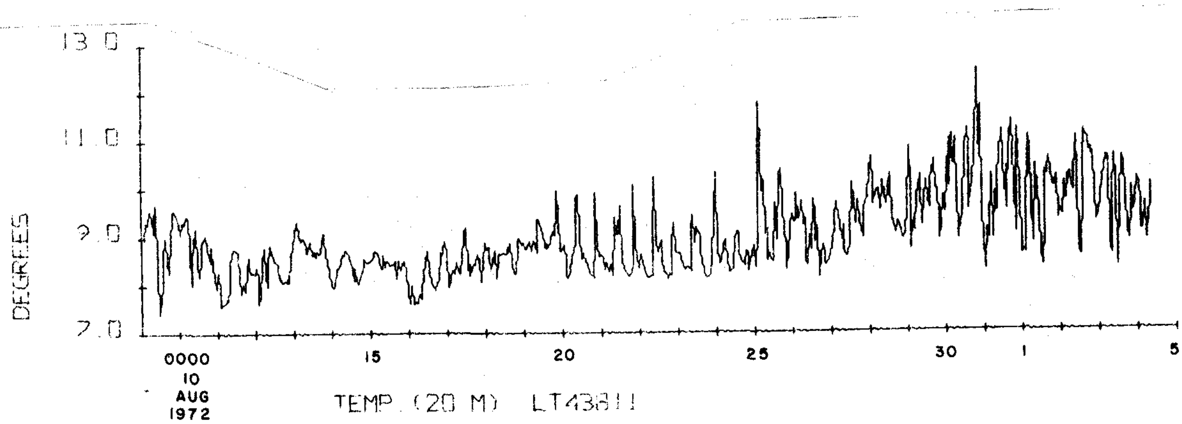

M/SEC
5
0
-5
-10
WIND V(0 M) LUVD744
CM/SEC
20
0
-20
V(20 M) LUV4381]
CM/SEC
20
0
-20
V(40 M) LUV4896
CM/SEC
20
0
-20
V(70 M) LUV45512
CM/SEC
40
20
0
-20
0000
10
AUG
1972
15
20
25
1
SEP
5
V(120 M) LUV5029



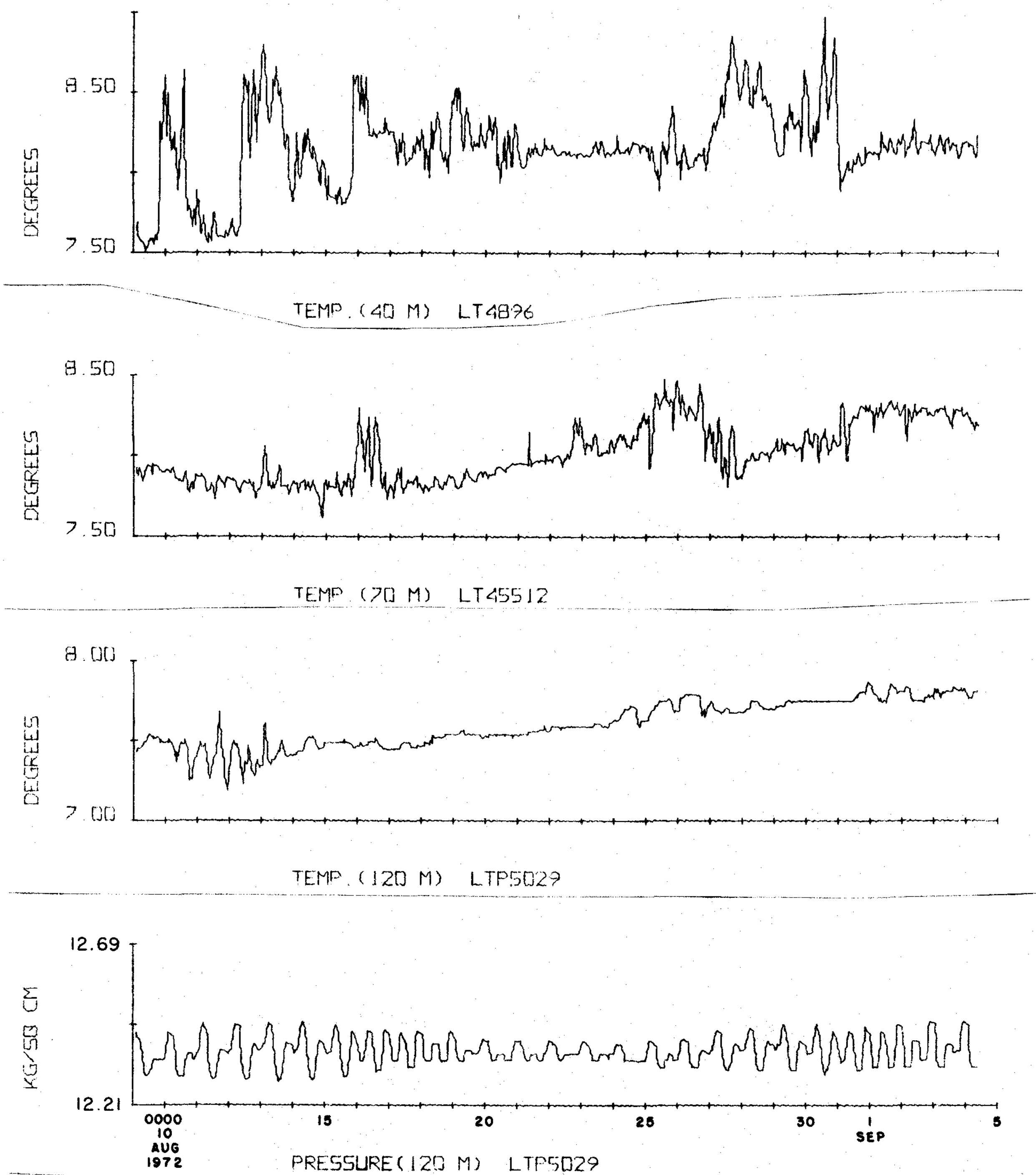
AIR TEMP (0 M) LTD744

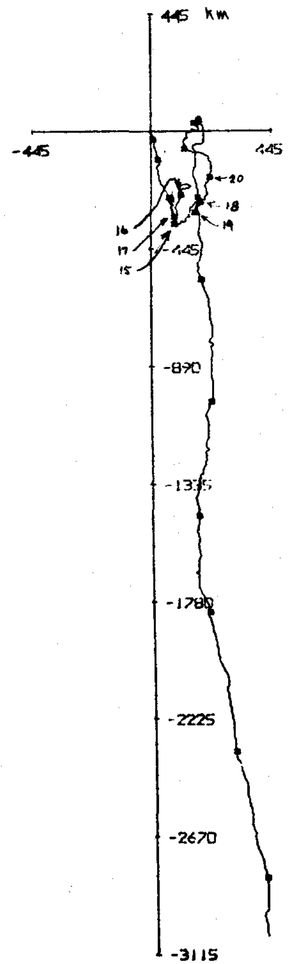


WATER TEMP(0 M) LTD744

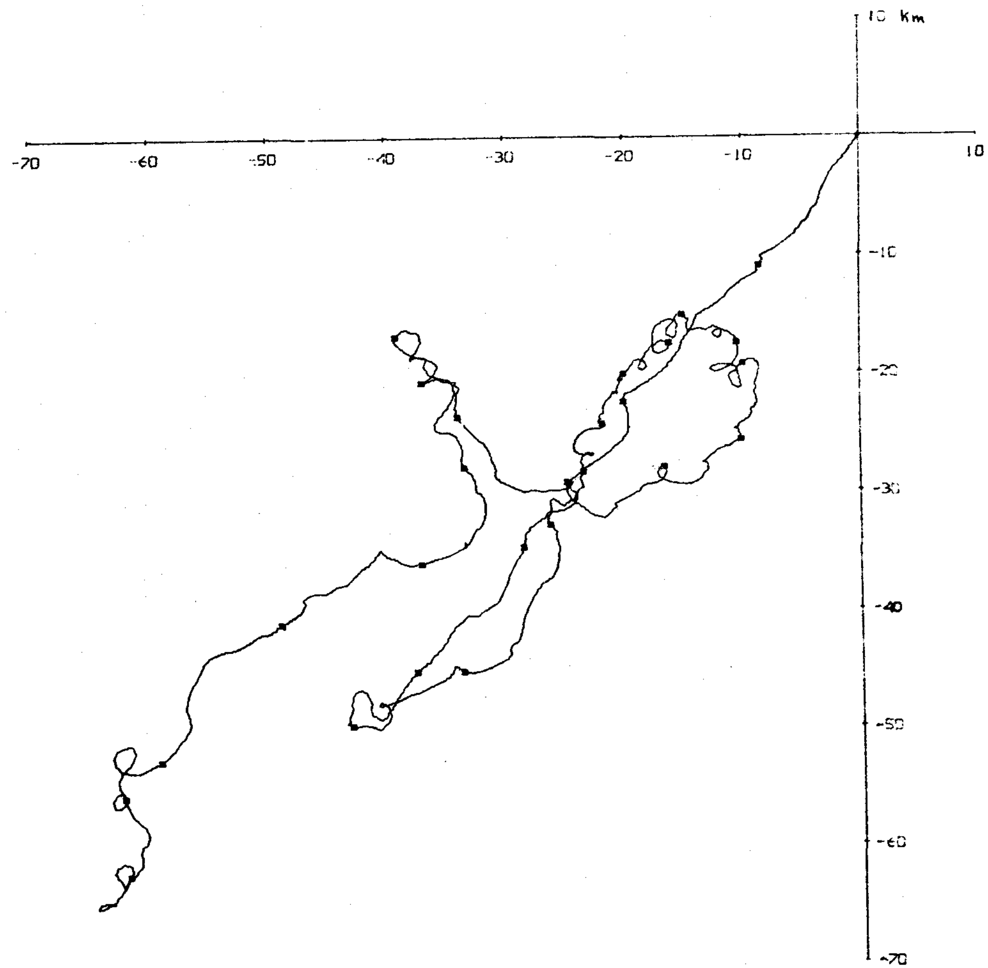


TEMP (20 M) LT4381

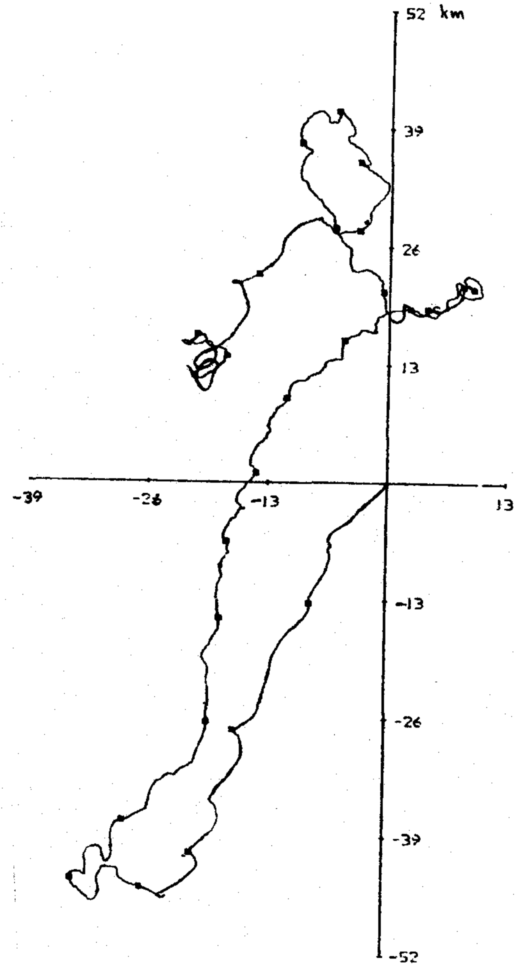

8.50
DEGREES
7.50
TEMP.(40 M) LT4896
8.50
DEGREES
7.50
TEMP.(70 M) LT45512
8.00
DEGREES
7.00
TEMP.(120 M) LTP5029
12.69
KG/SQ CM
12.21
0000
10
AUG
1972
15
20
25
30
1
SEP
5
PRESSURE(120 M) LTP5029



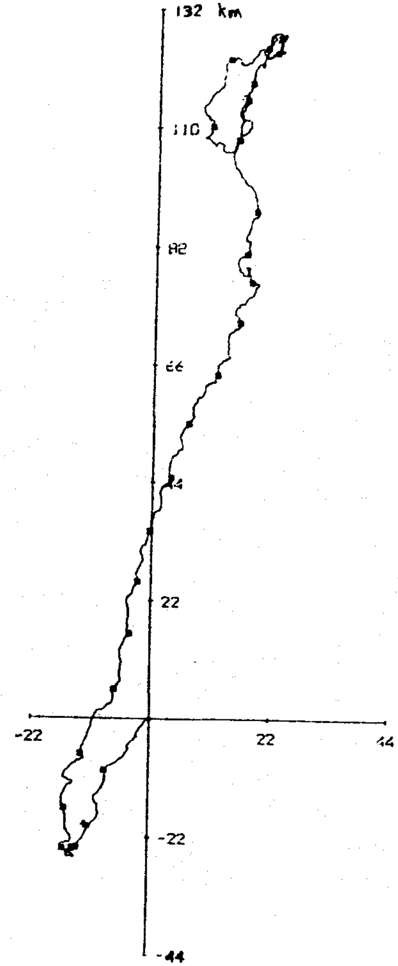
WIND AT NH-20. 21 DAYS STARTING 0045 8/9/72



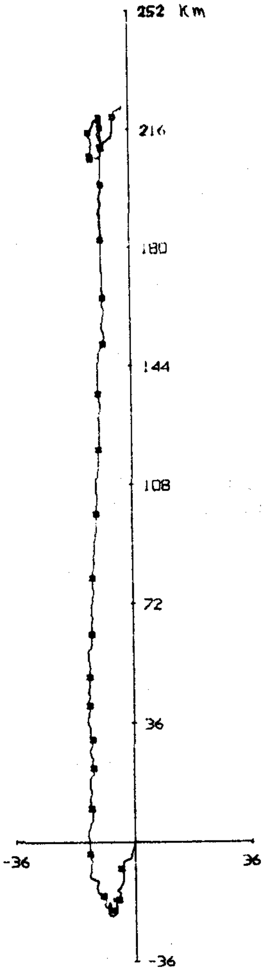
20M AT NH-20. 26 DAYS STARTING 0159 8/4/72



40M AT NH-20 26 DAYS STARTING 0200 8/4/72



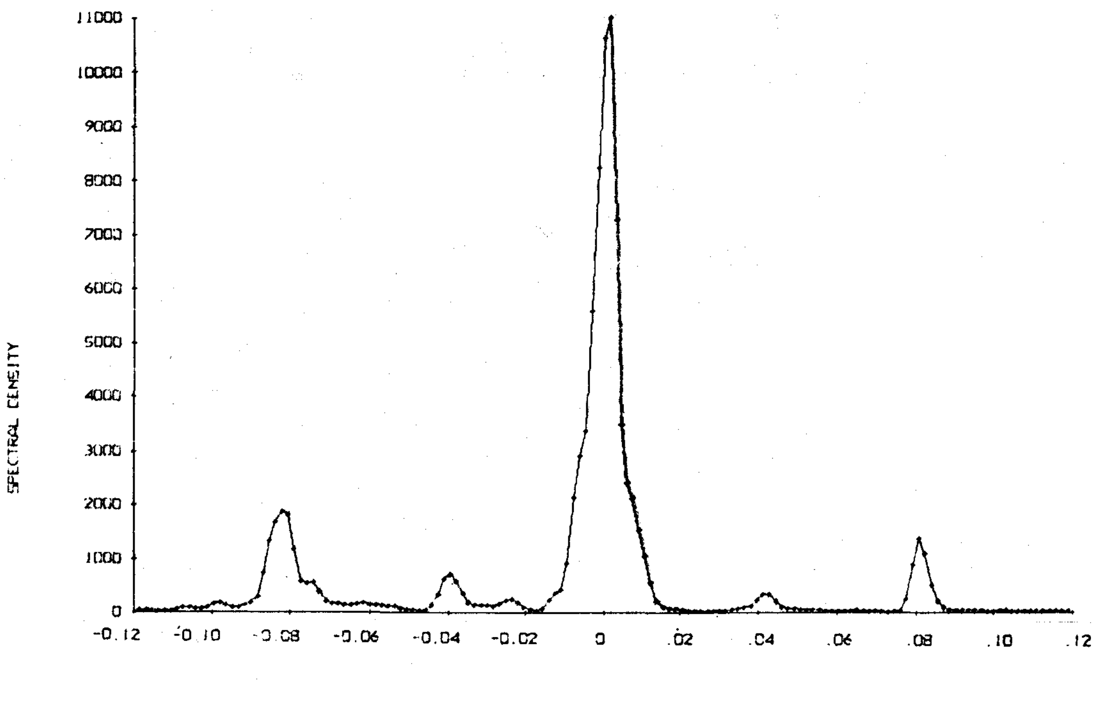
70M AT NH-20 26 DAYS STARTING 0200 8/4/72



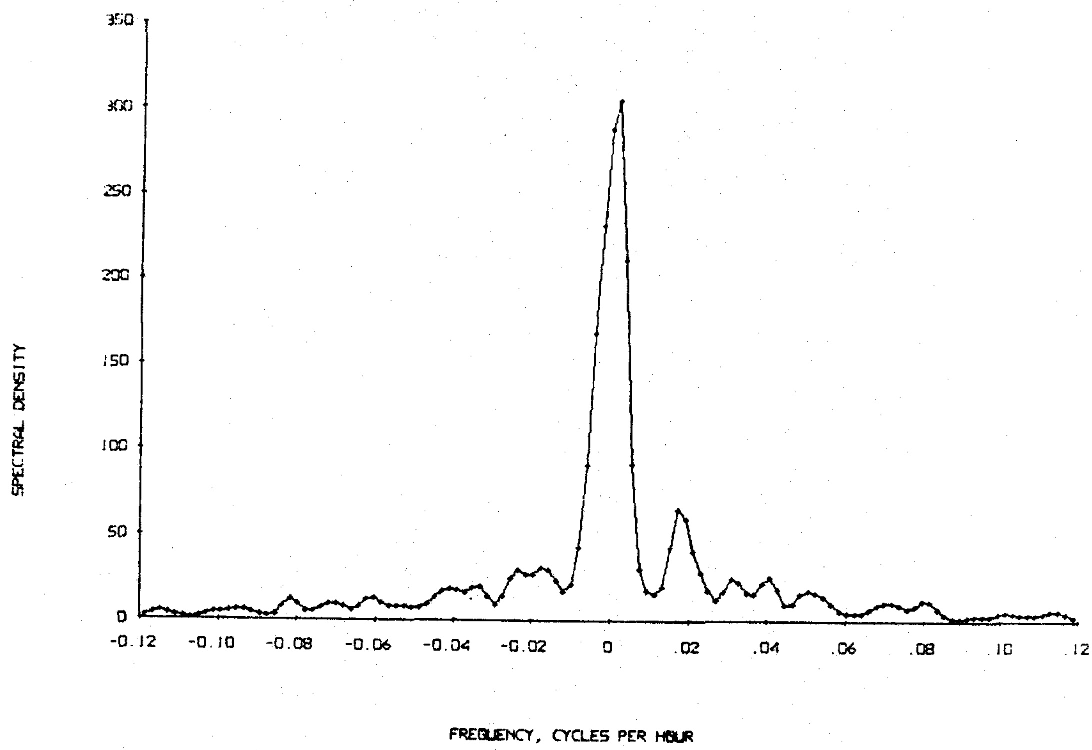
120M AT NH-20. 26 DAYS STARTING 0157 8/4/72

ROTARY SPECTRUM

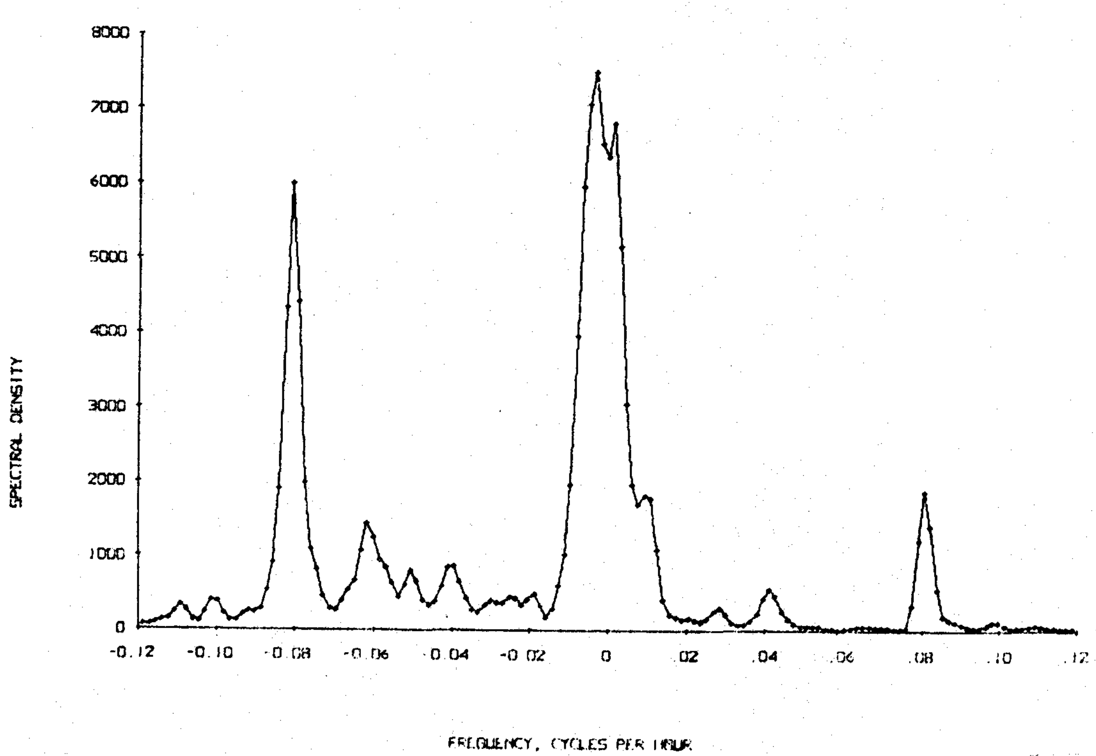
120M AT NH-20. 8/3/72 TO 8/30/72. TAPE 502/9

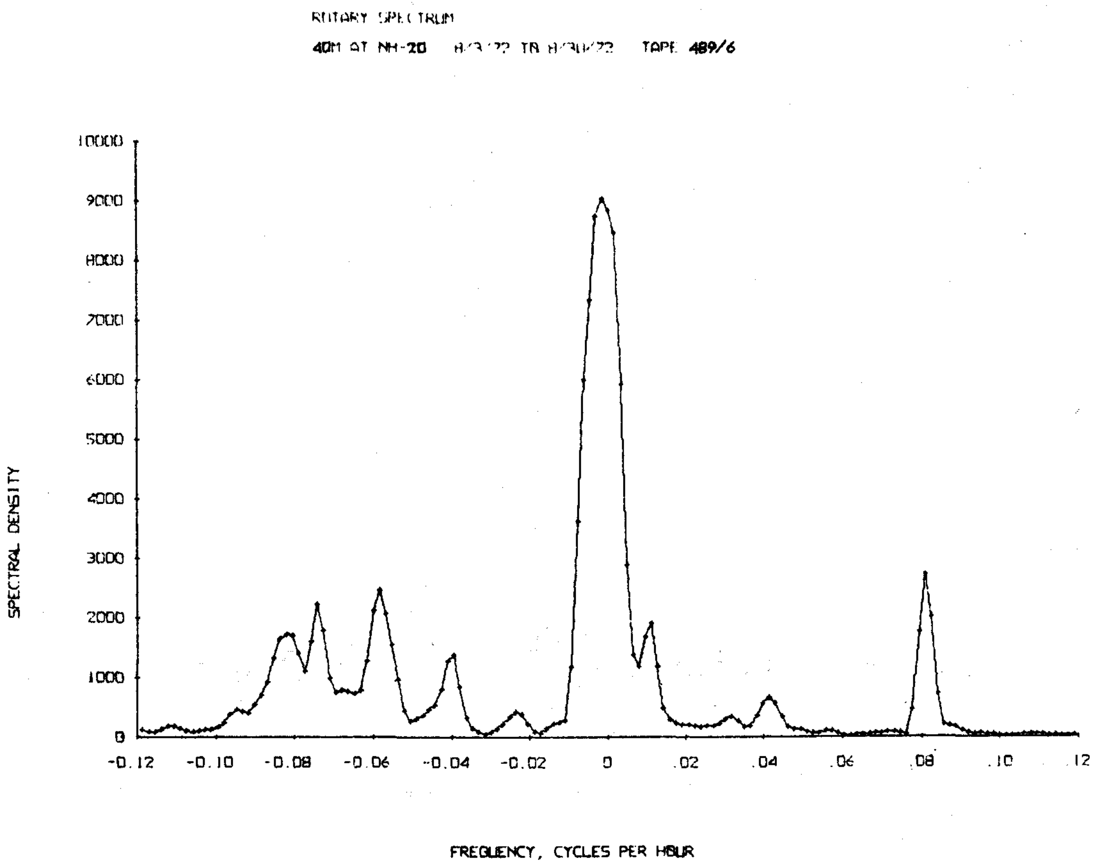


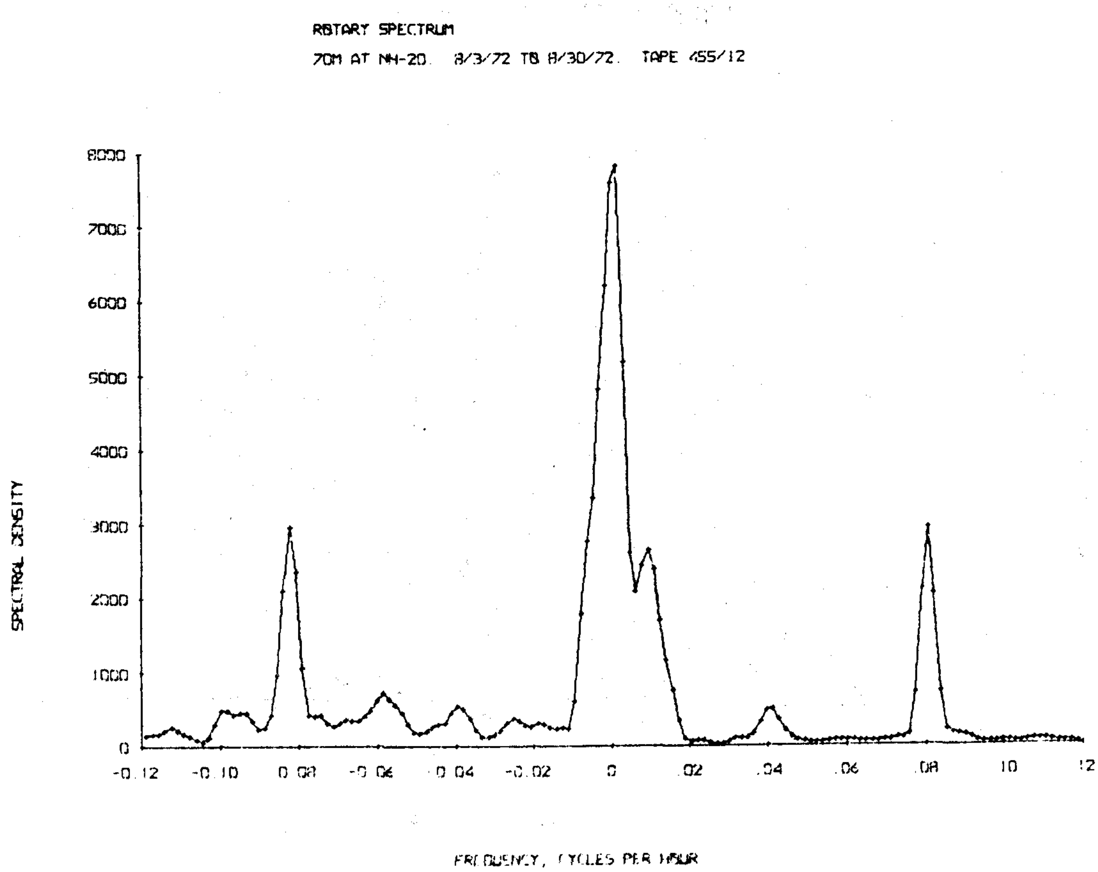
ROTARY SPECTRUM
WIND AT NH-20. 8/8/72 TO 8/30/72. TAPE 074/4



ROTARY SPECTRUM
20M AT NH-20. 8/3/72 TO 8/30/72. TAPE 438/11




RBTARY SPECTRUM
40M AT NH-20 8/3/72 TB 8/30/72 TAPE 489/6
SPECTRAL DENSITY
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.12 -0.10 -0.08 -0.06 -0.04 -0.02 0 .02 .04 .06 .08 .10 .12
FREQUENCY, CYCLES PER HOUR


RBTARY SPECTRUM
70M AT NH-20. 8/3/72 TB 8/30/72. TAPE 455/12
SPECTRAL DENSITY
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.12 -0.10 -0.08 -0.06 -0.04 -0.02 0 .02 .04 .06 .08 .10 .12
FREQUENCY, CYCLES PER HOUR

1972 CUE Installation F

DB 7

Position: 44°51.2'N, 124°12.2'W
Depth of Water: 101 m
Set at 1723 GMT 1 August 1972 by R/V CAYUSE
Retrieved at 2200 GMT 29 August 1972 by R/V CAYUSE
Data Interval: 1759 GMT 1 August to 2154 GMT 29 August

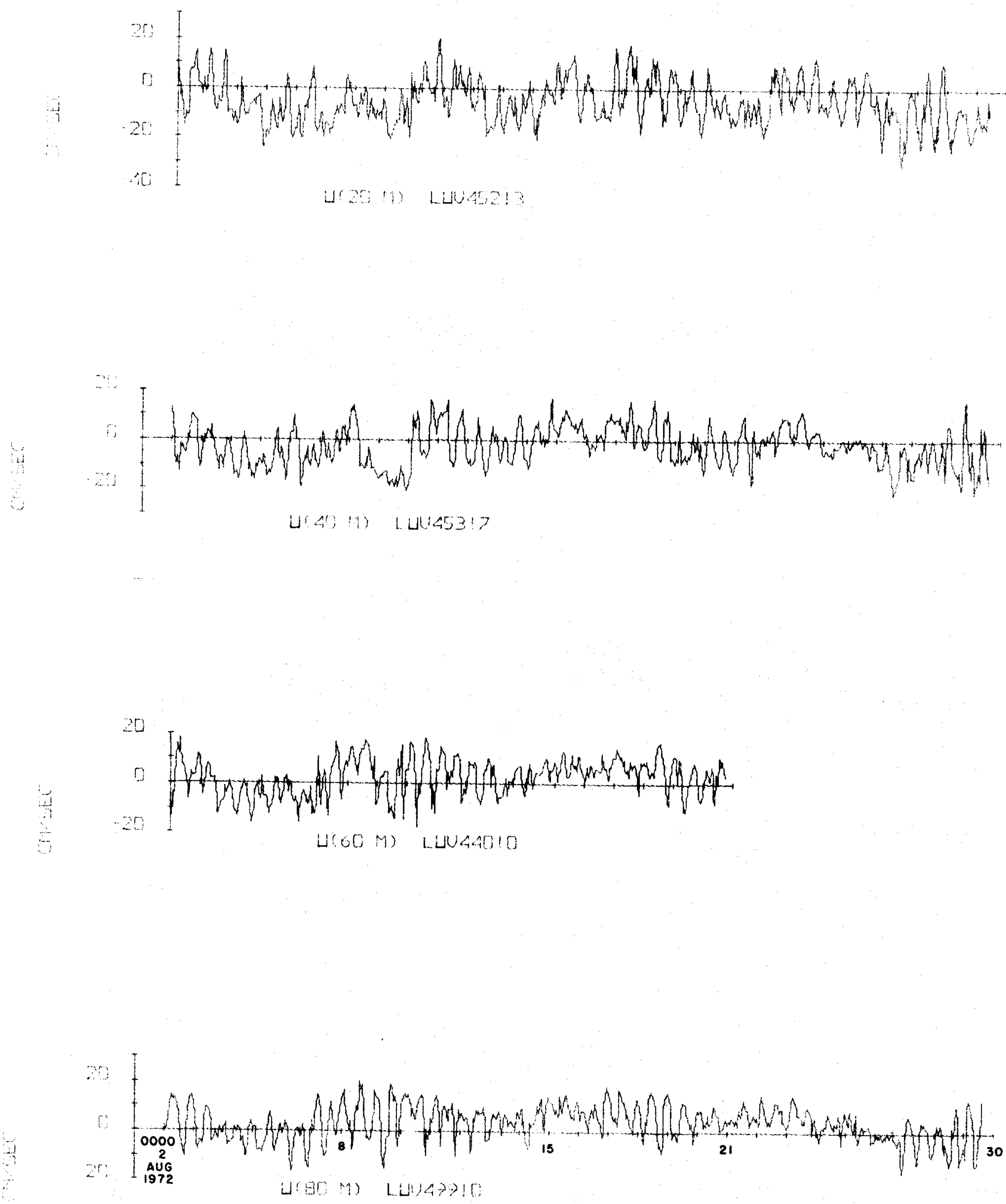
Instrumentation

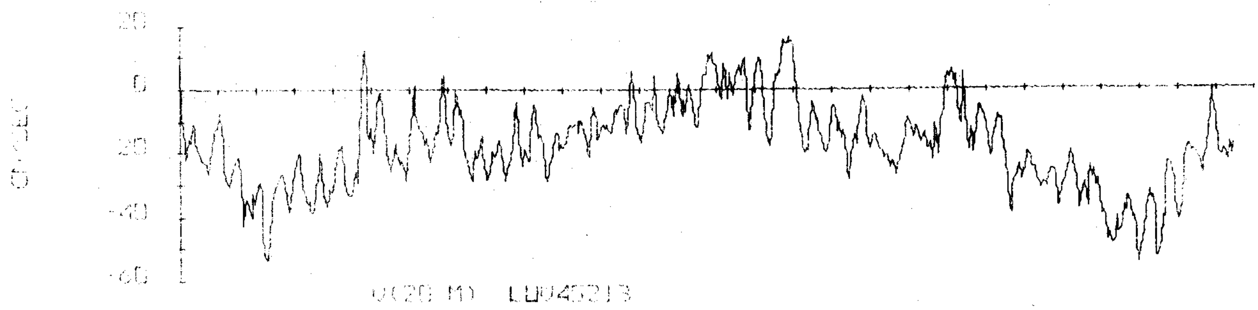
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
20 m	20 m	452/13
40 m	40 m	453/17
60 m	60 m	440/10
80 m	80 m	499/10

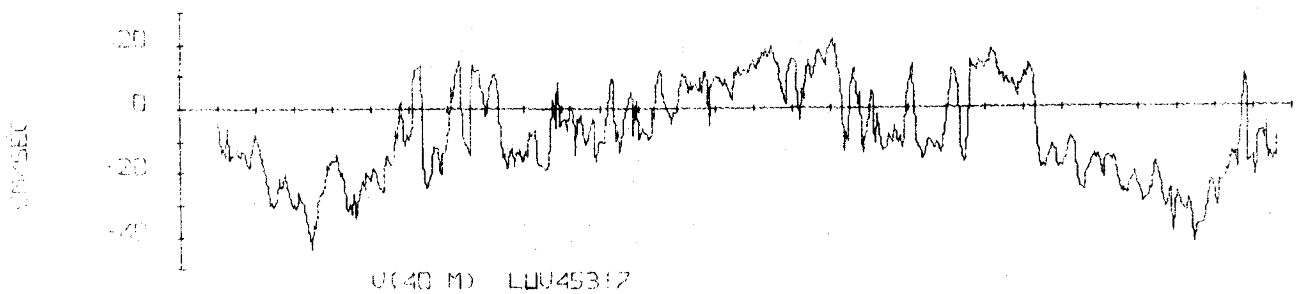
Data were recorded every 5 minutes. All instruments measured temperature, current speed,and current direction. In addition,the 80 m instrument recorded pressure. All meters operated normally except the 60 m instrument, which produced bad speeds after 23 August, bad directions after the 20th, and bad temperatures after the 25th.

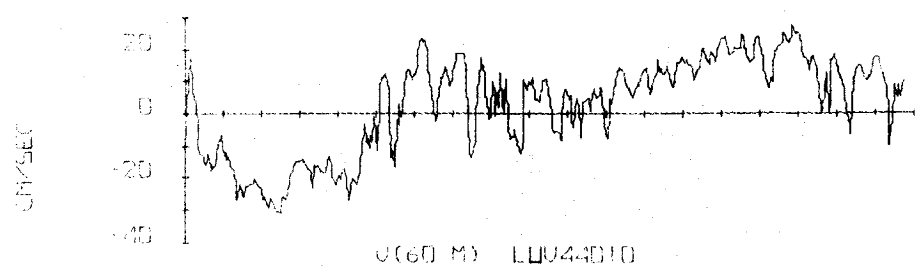
(F-DB-7)

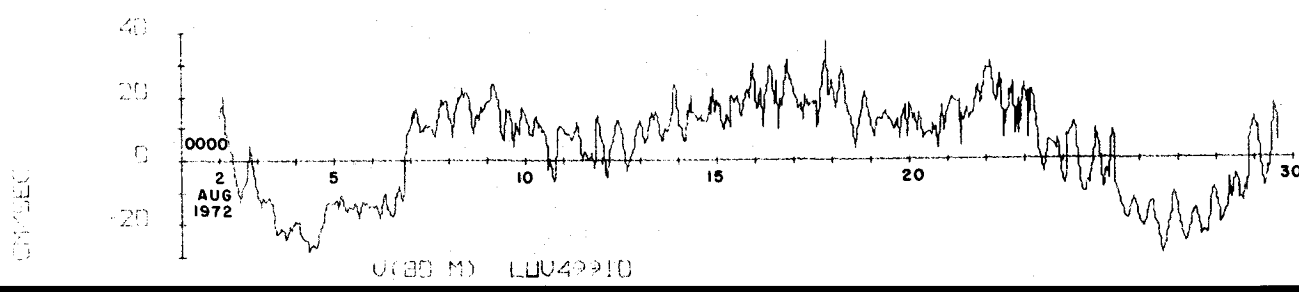
		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	22.1	10.5	0.8	3.4	55.6	1.6
.0 m	U (cm/sec)	- 5.3	8.9	0.2	2.6	20.4	-31.4
45213)	V (cm/sec)	-17.7	13.4	-0.1	3.0	16.6	-54.6
	T (C)	8.60	1.03	1.58	5.23	12.69	7.35
	S (cm/sec)	17.6	7.4	0.9	3.4	44.1	0.4
40 m	U (cm/sec)	- 2.4	8.2	-0.0	2.3	17.1	-21.6
45317)	V (cm/sec)	- 8.0	14.6	0.1	2.0	21.6	-44.1
	T (C)	8.19	0.26	0.50	3.35	9.10	7.68
	S (cm/sec)	16.0	5.7	0.4	2.8	31.2	1.3
)0 m	U (cm/sec)	2.4	7.6	-0.3	2.4	18.3	-17.5
44010)	V (cm/sec)	2.6	14.8	-0.5	2.1	27.6	-31.2
	T (C)	7.88	0.17	-0.27	2.66	8.29	7.46
	S (cm/sec)	16.1	5.9	0.4	2.9	38.3	2.7
30 m	U (cm/sec)	3.6	6.9	-0.3	2.8	20.5	-16.0
49910)	V (cm/sec)	4.0	14.8	-0.4	2.1	38.0	-29.2
	T (C)	7.64	0.13	-0.24	3.43	8.07	7.34
	P (kg/cm^2)	8.04	0.05	-0.50	3.05	8.12	7.92

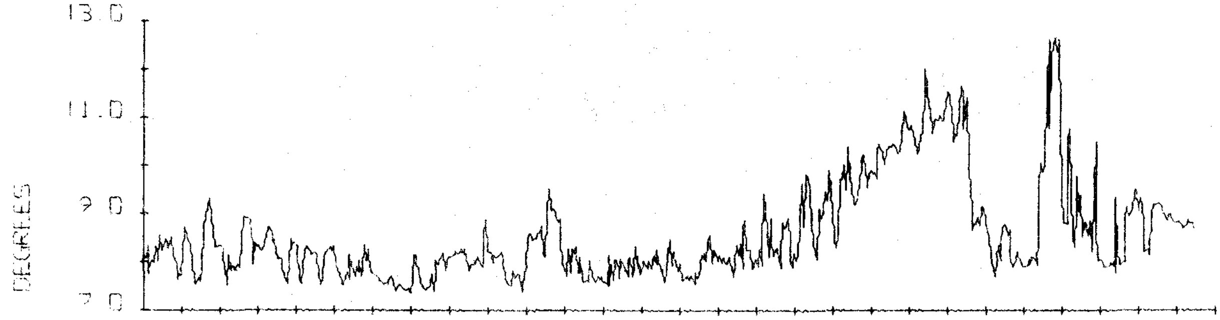

20
0
-20
-40
U(20 M) LUV45213
0
-20
U(40 M) LUV45317
20
0
-20
U(60 M) LUV44010
20
0
20
0000
2
AUG
1972
8
15
21
30
U(80 M)


20
0
-20
-40
-60
CM/SEC
U(20 M) LUU45213

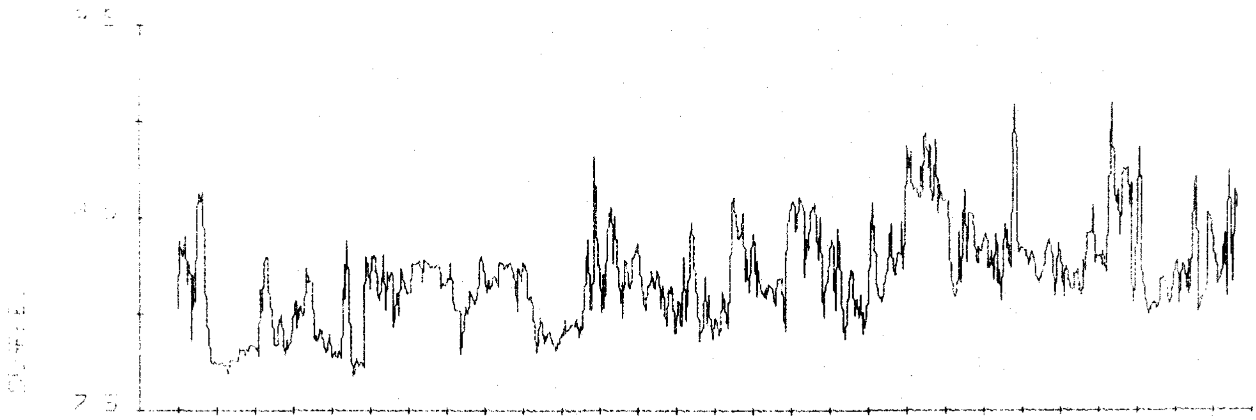

20
0
-20
-40
CM/SEC
U(40 M) LUU45317


20
0
-20
-40
CM/SEC
U(60 M) LUU44010

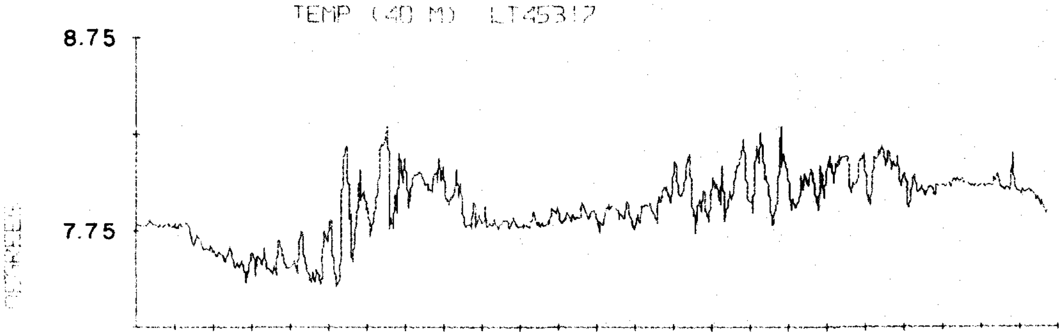

40
20
0
-20
CM/SEC
0000
2
AUG
1972
5
10
15
20
30



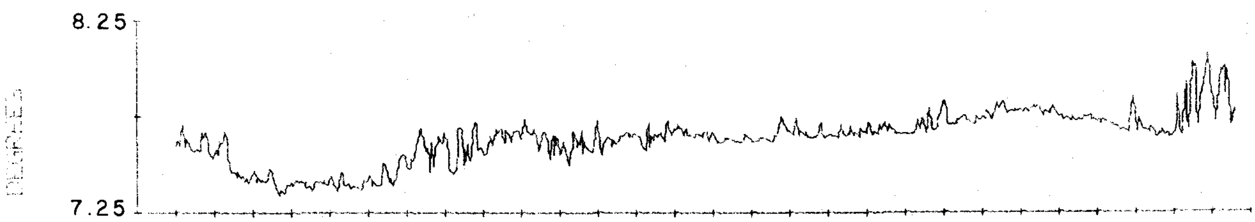
TEMP (20 M) LT45213



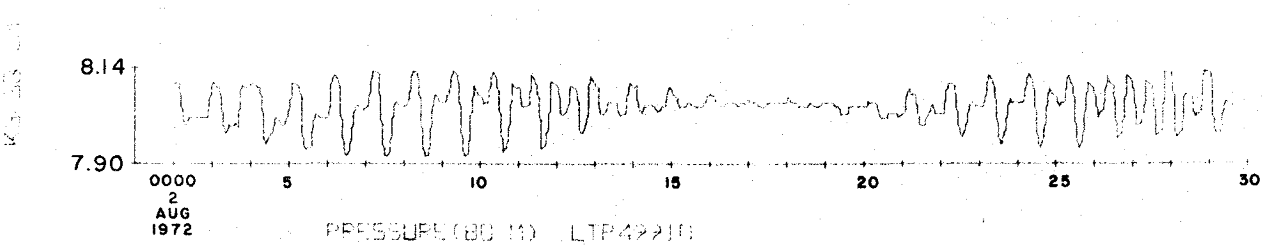
TEMP (40 M) LT45317



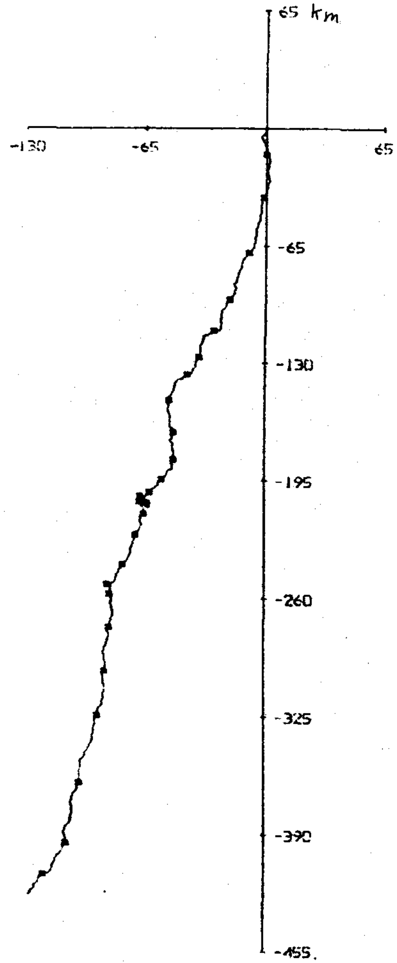
TEMP (60 M) LT44010



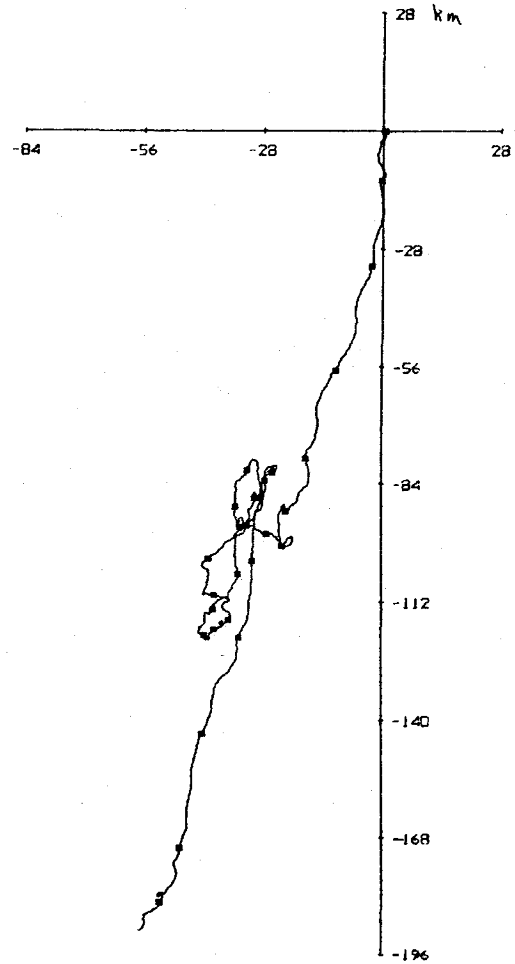
TEMP (80 M) LT49910



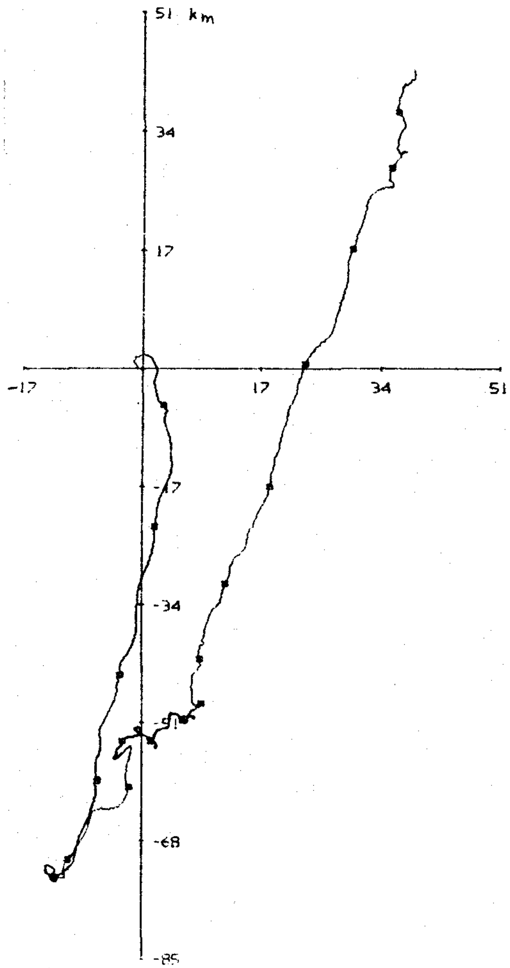
PRESSURE(80 M) LTP49910



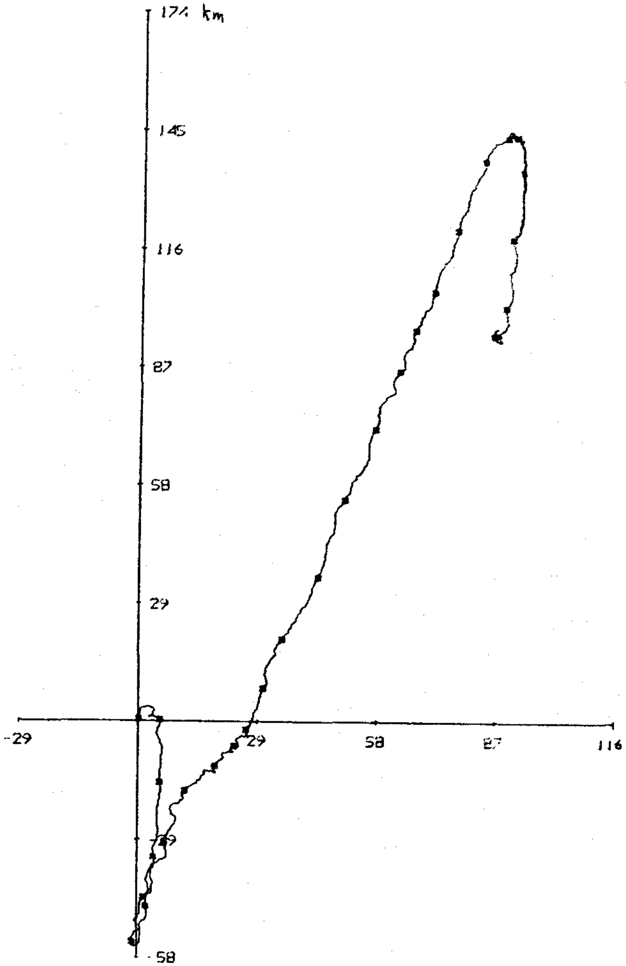
20 METERS AT DB-7. 28 DAYS STARTING 0002 8/2/72



40 METERS AT DB-7. 29 DAYS STARTING 2359 8/1/72

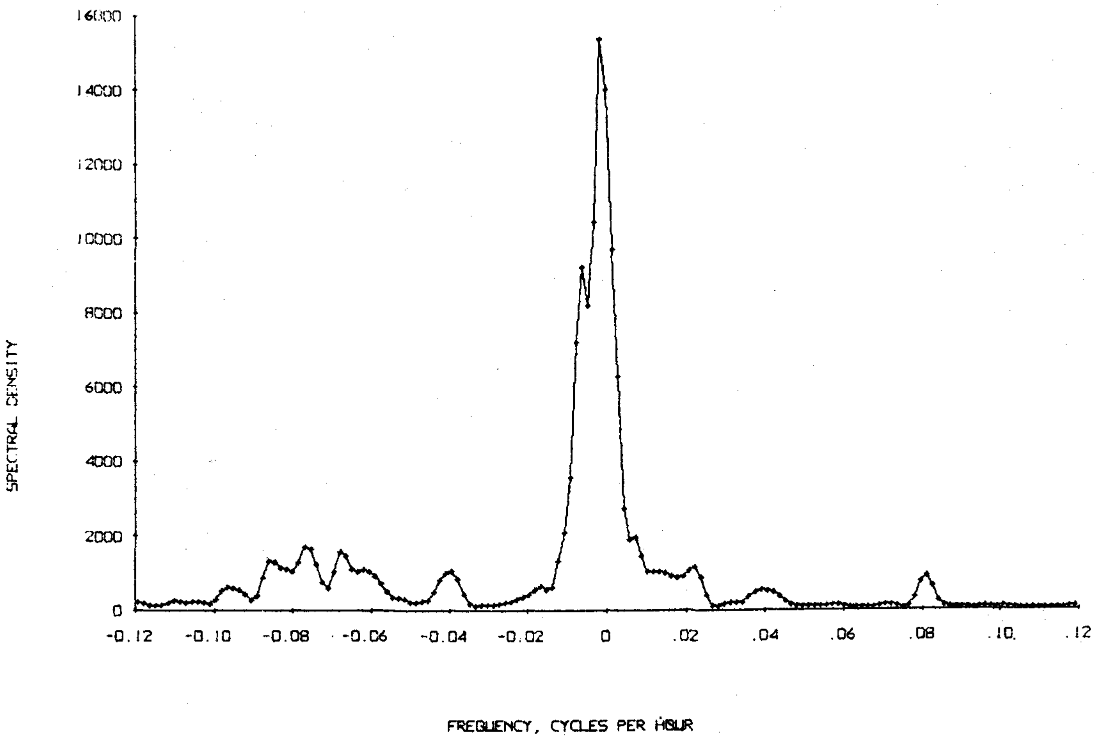


60 METERS AT DB-7   20 DAYS STARTING 0000 8/2/72

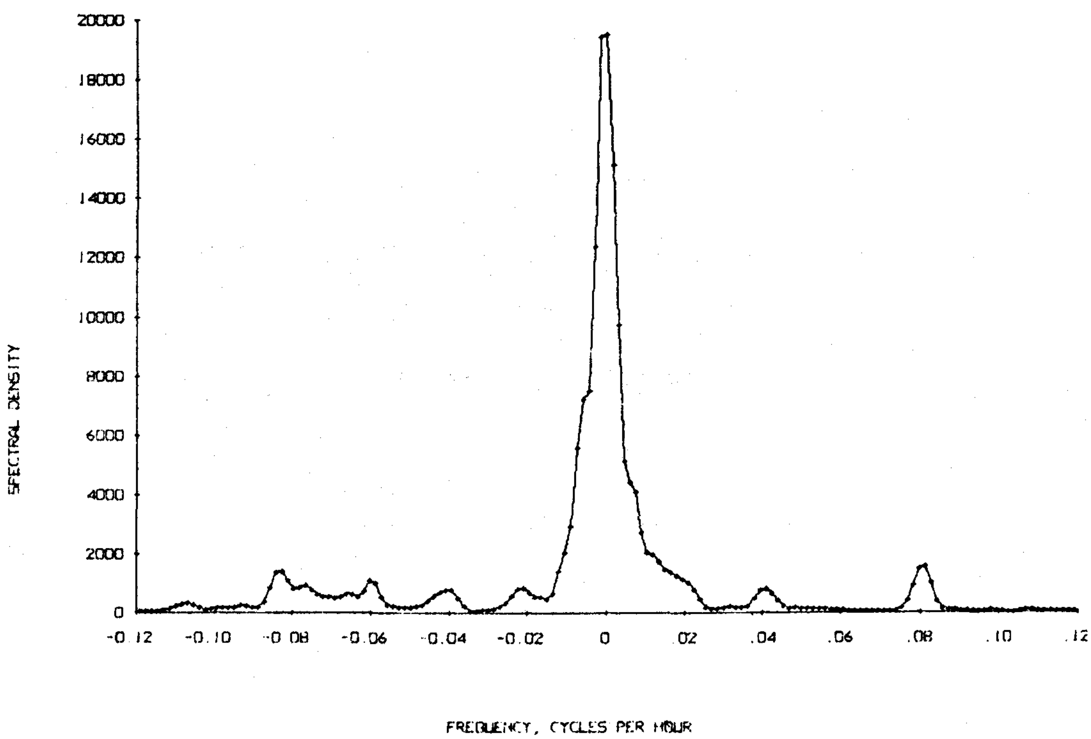


80 METERS AT DB-7.   29 DAYS STARTING 2359 8/1/72

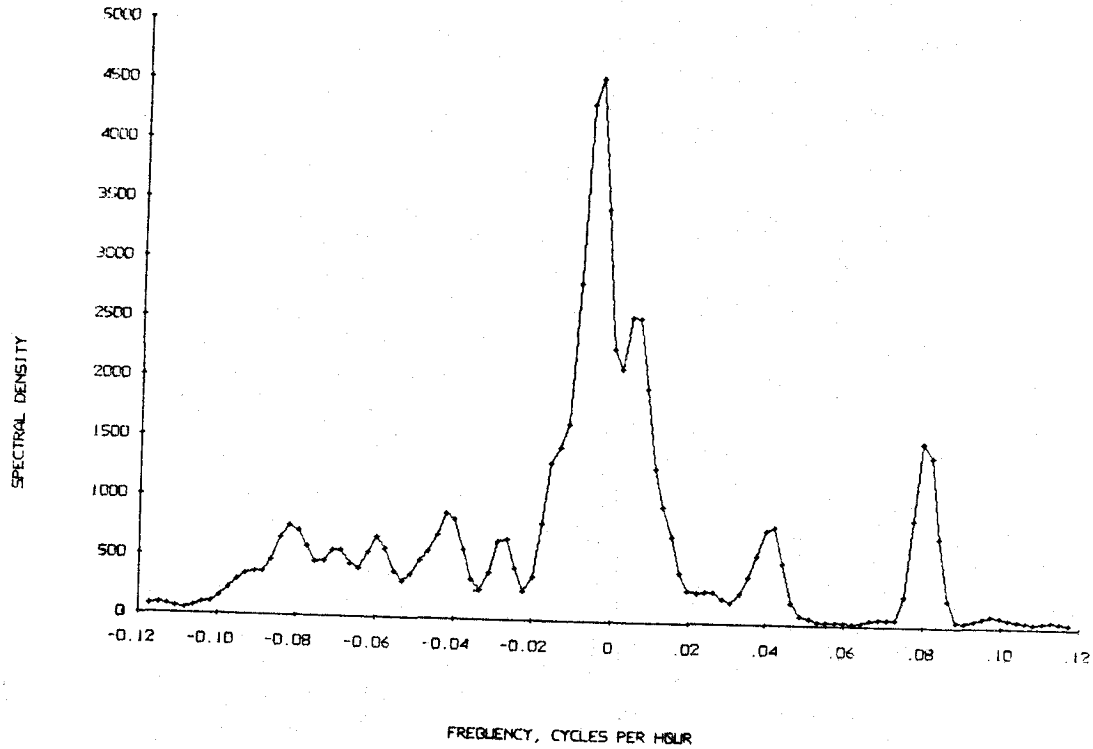
RØTARY SPECTRUM
20 METERS AT DB-7 8/1/72 TØ 8/29/72. TAPE 452/13



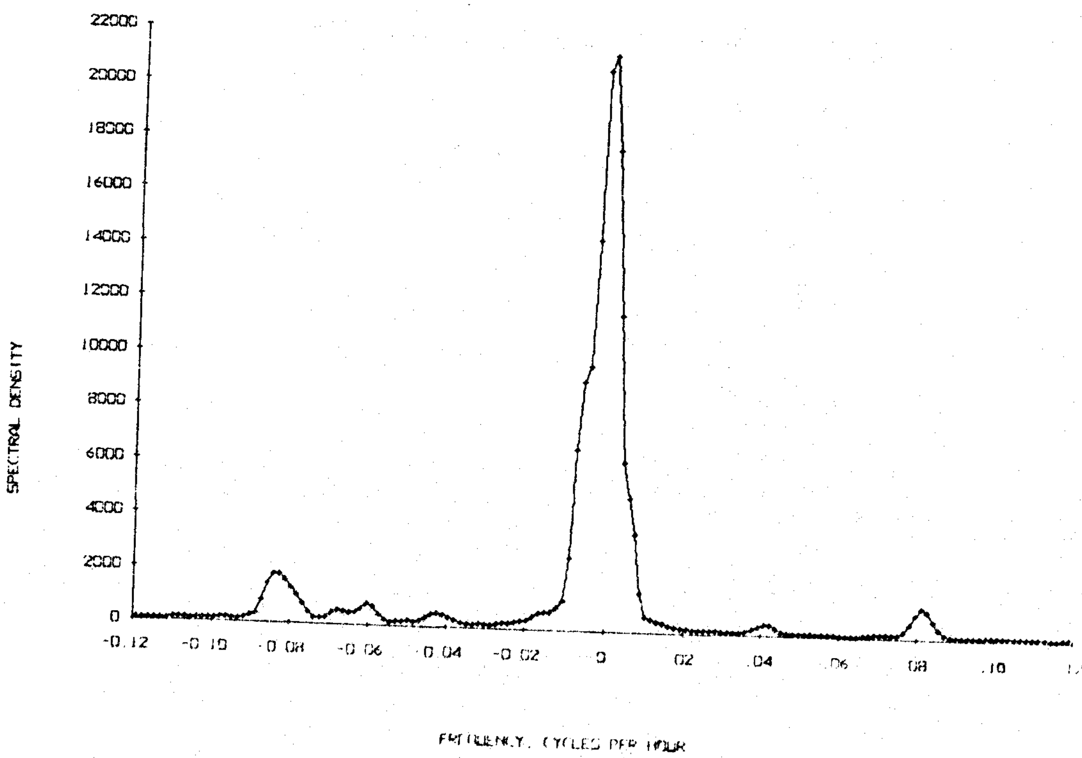
RØTARY SPECTRUM
40 METERS AT DB-7. 8/1/72 TØ 8/29/72. TAPE 453/17



ROTARY SPECTRUM
60 METERS AT DB-7. 8/1/72 TO 8/21/72. TAPE 440/10



ROTARY SPECTRUM
80 METERS AT DB-7. 8/1/72 TO 8/29/72. TAPE 499/10



1972 CUE Installation F

DB 13

Position: 44°54.0'N, 124°19.0'W
Depth of Water: 150 m
Set at 2009 GMT 9 August 1972 by R/V CAYUSE
Retrieved at 2054 GMT 29 August 1972 by R/V CAYUSE
Data Interval: 2017 GMT 9 August to 2052 GMT 29 August

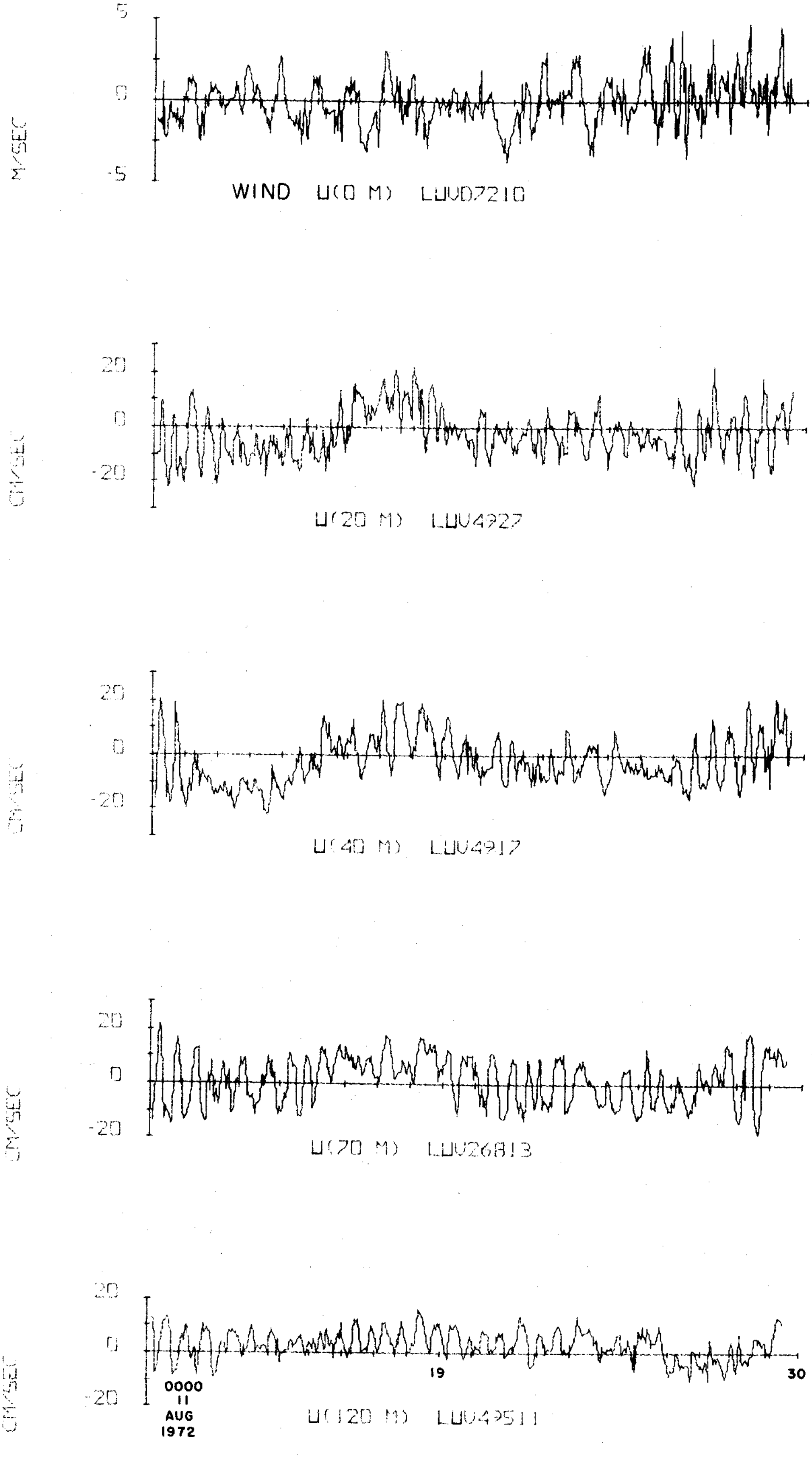
Instrumentation

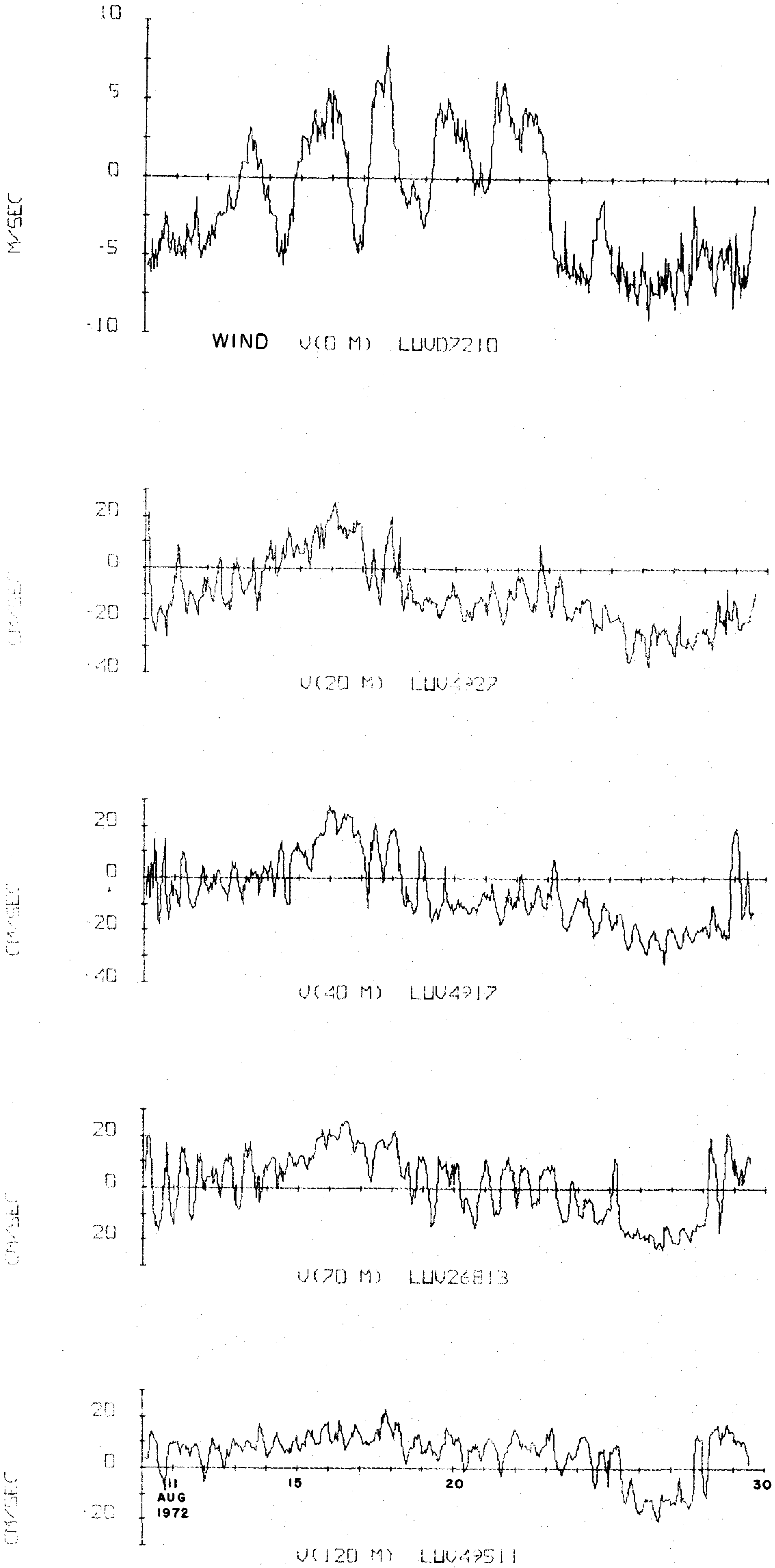
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D72/10
20 m	19 m	492/7
40 m	39 m	491/7
70 m	69 m	268/13
120 m	119 m	495/11

Data were recorded every 5 minutes. All subsurface instruments measured temperature, current speed,and current direction. The 120 m instrument also recorded pressure. The surface buoy measured wind speed and direction, air temperature,and surface water temperature.

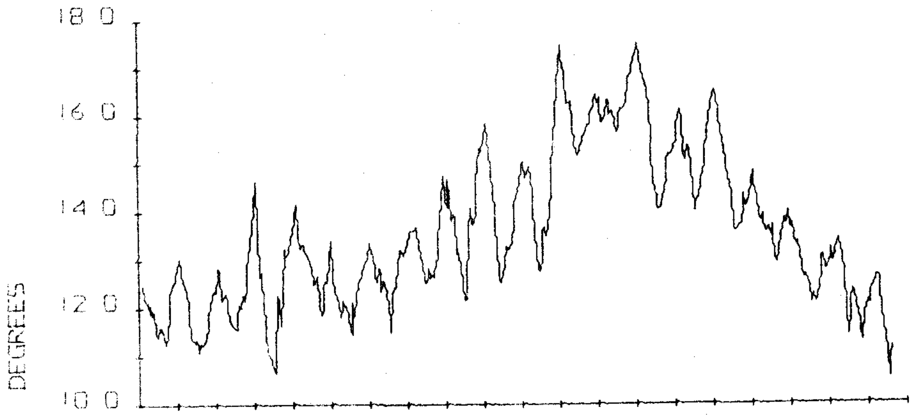
(F-DB-13)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (m/sec)	4. 2	1. 9	0. 2	2. 3	9. 0	0. 1
0 m	U (m/sec)	- 0. 0	1. 4	0. 3	3. 2	4. 8	- 3. 6
(D7210)	V (m/sec)	- 1. 6	4. 0	0. 4	1. 9	8. 5	- 9. 0
	T (C) air	13. 57	1. 57	0. 53	2. 43	17. 52	10. 51
	T (C) water	13. 02	2. 18	0. 26	1. 84	17. 20	9. 15
	S (cm/sec)	17. 5	6. 4	0. 6	3. 0	37. 6	3. 1
20 m	U (cm/sec)	- 2. 2	8. 9	0. 3	2. 7	23. 0	-22. 3
(4927)	V (cm/sec)	- 9. 7	13. 0	0. 6	2. 7	25. 7	-37. 1
	T (C)	9. 16	0. 77	0. 17	2. 46	11. 47	7. 58
	S (cm/sec)	16. 1	5. 5	0. 4	2. 7	33. 2	1. 6
40 m	U (cm/sec)	- 2. 4	9. 2	0. 5	2. 5	21. 0	-22. 2
(4917)	V (cm/sec)	- 5. 3	13. 2	0. 5	2. 5	28. 0	-33. 2
	T (C)	8. 05	0. 22	-0. 70	3. 40	8. 59	7. 46
	S (cm/sec)	14. 4	4. 7	0. 2	2. 7	27. 3	2. 6
70 m	U (cm/sec)	1. 5	8. 6	-0. 1	1. 9	21. 4	-18. 2
(26813)	V (cm/sec)	1. 8	12. 2	-0. 2	2. 0	26. 1	-23. 1
	T (C)	8. 07	0. 14	0. 54	2. 88	8. 49	7. 82
	S (cm/sec)	11. 5	3. 4	0. 5	3. 5	25. 7	1. 4
120 m	U (cm/sec)	3. 2	5. 1	-0. 1	2. 7	16. 0	-10. 1
(49511)	V (cm/sec)	6. 1	8. 4	-1. 2	3. 8	22. 9	-20. 4
	T (C)	7. 62	0. 13	0. 71	3. 45	8. 03	7. 38
	P (kg/cm^2)	11.89	0. 06	-0. 21	2. 18	12.00	11. 76

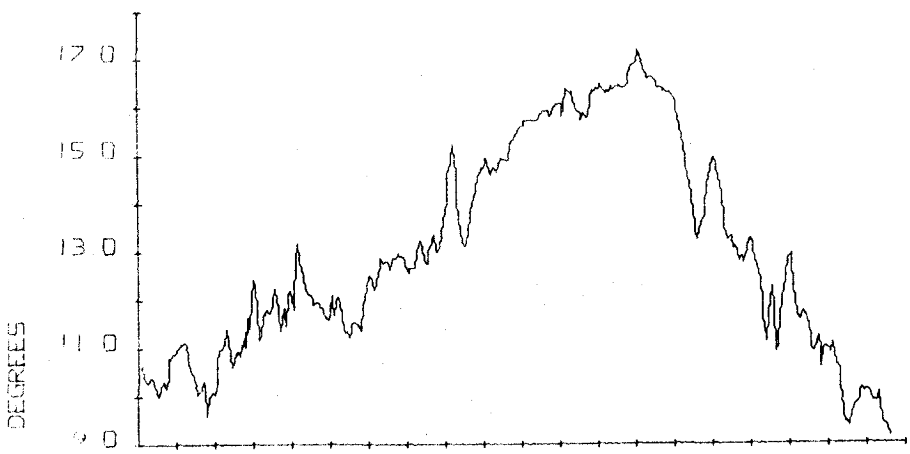

5
0
-5
M/SEC
WIND U(0 M) LUVD7210
20
0
-20
CM/SEC
U(20 M) LUV4927
20
0
-20
CM/SEC
U(40 M) LUV4917
20
0
-20
CM/SEC
U(70 M) LUV26813
20
0
-20
CM/SEC
0000
11
AUG
1972
19
30
U(120 M) LUV4951



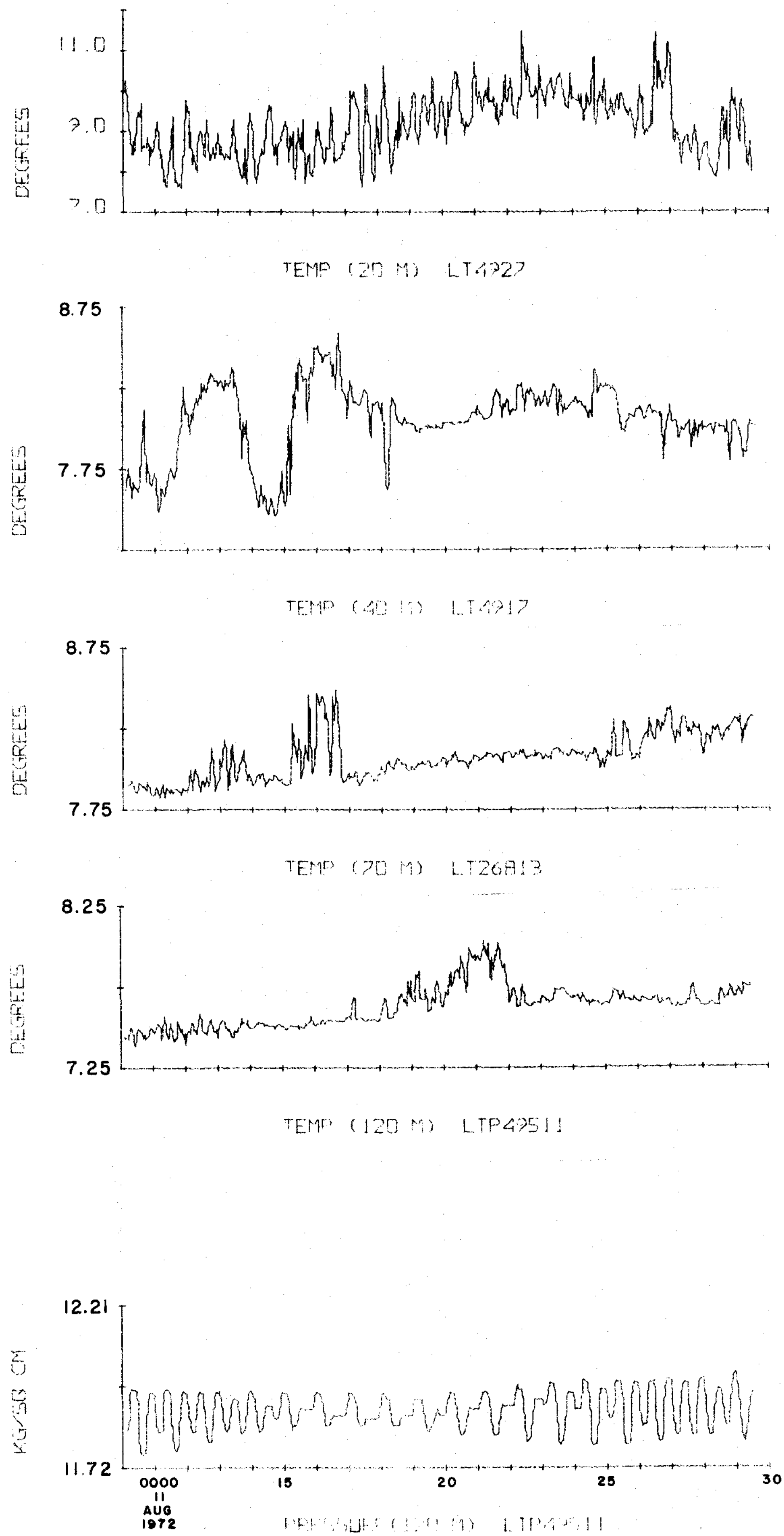
10
5
0
-5
-10
M/SEC
WIND V(0 M) LUUD7210
20
0
-20
-40
V(20 M) LUV4927
20
0
-20
-40
CM/SEC
V(40 M) LUV4917
20
0
-20
CM/SEC
V(70 M) LUV26813
20
0
-20
CM/SEC
11
AUG
1972
15
20
30
V(120 M) LUV49511



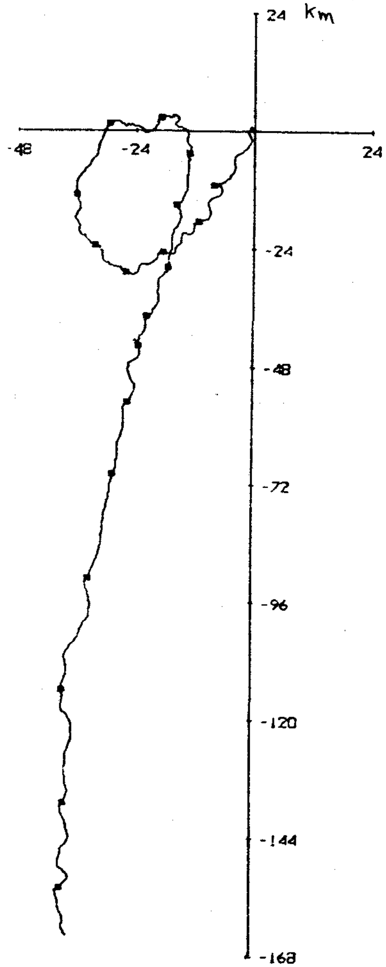
AIR TEMP(0 M) LTD7210



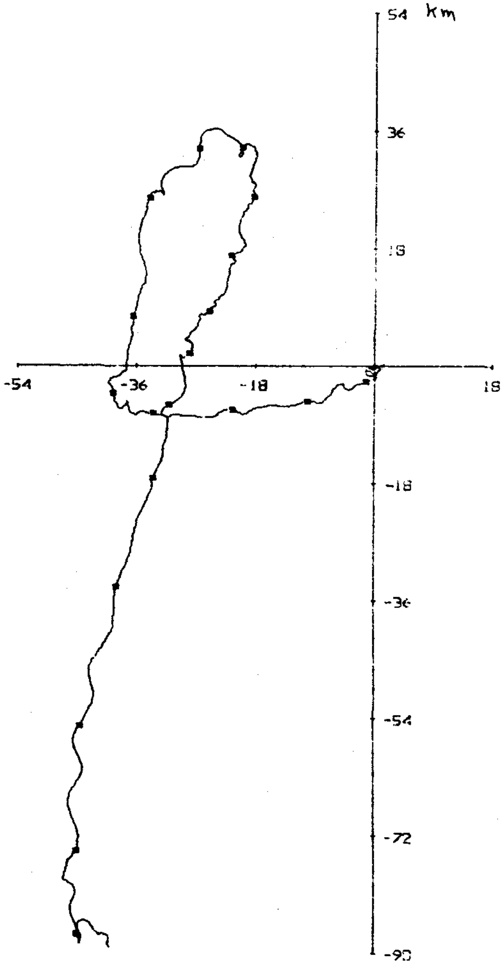
WATER TEMP(0 M) LTD7210



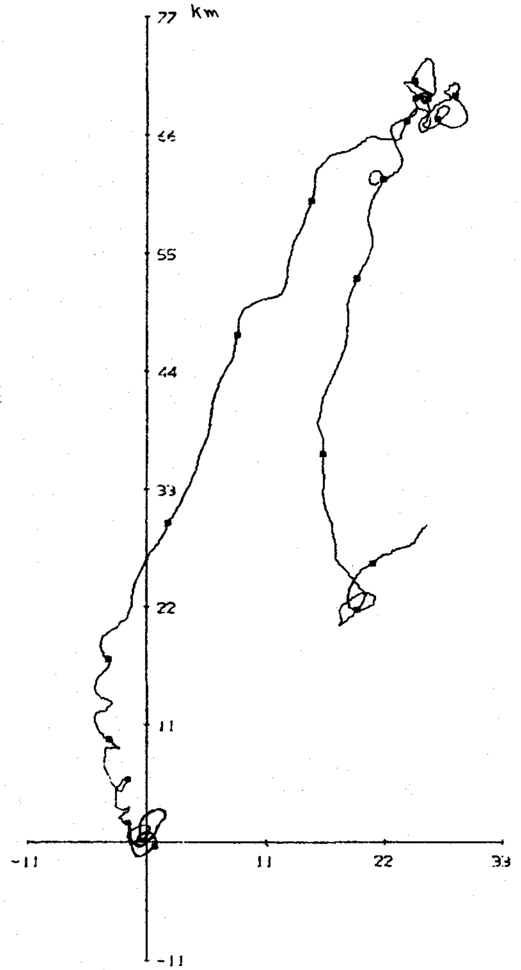
11.0
9.0
7.0
DEGREES
TEMP (20 M) LT4927
8.75
7.75
DEGREES
TEMP (40 M) LT4917
8.75
7.75
DEGREES
TEMP (70 M) LT26813
8.25
7.25
DEGREES
TEMP (120 M) LTP4951I
12.21
11.72
KG/SQ CM
0000
11
AUG
1972
15
20
25
30



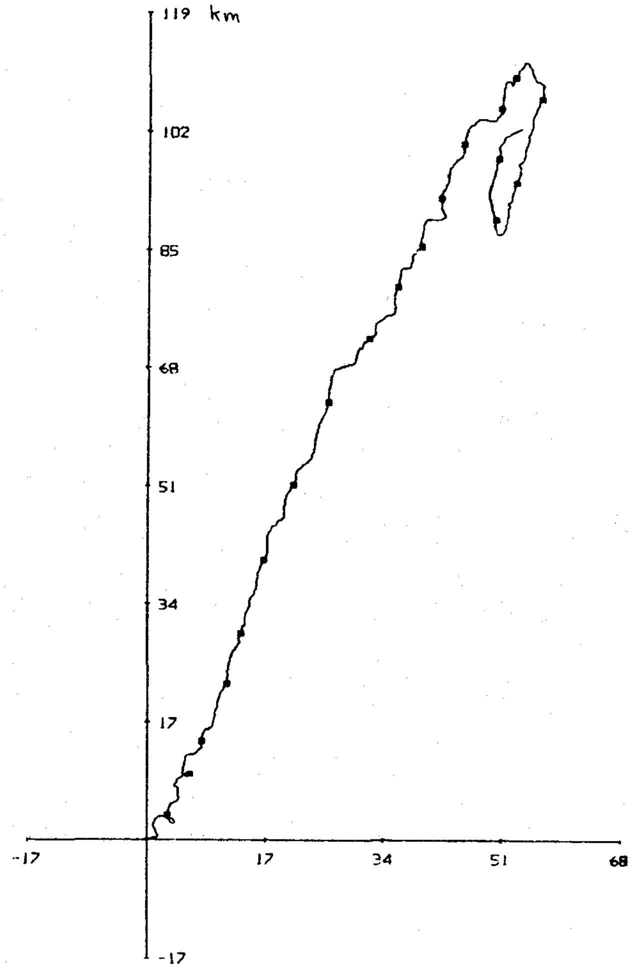
20 METERS AT DB-13. 20 DAYS STARTING 0218 8/10/72



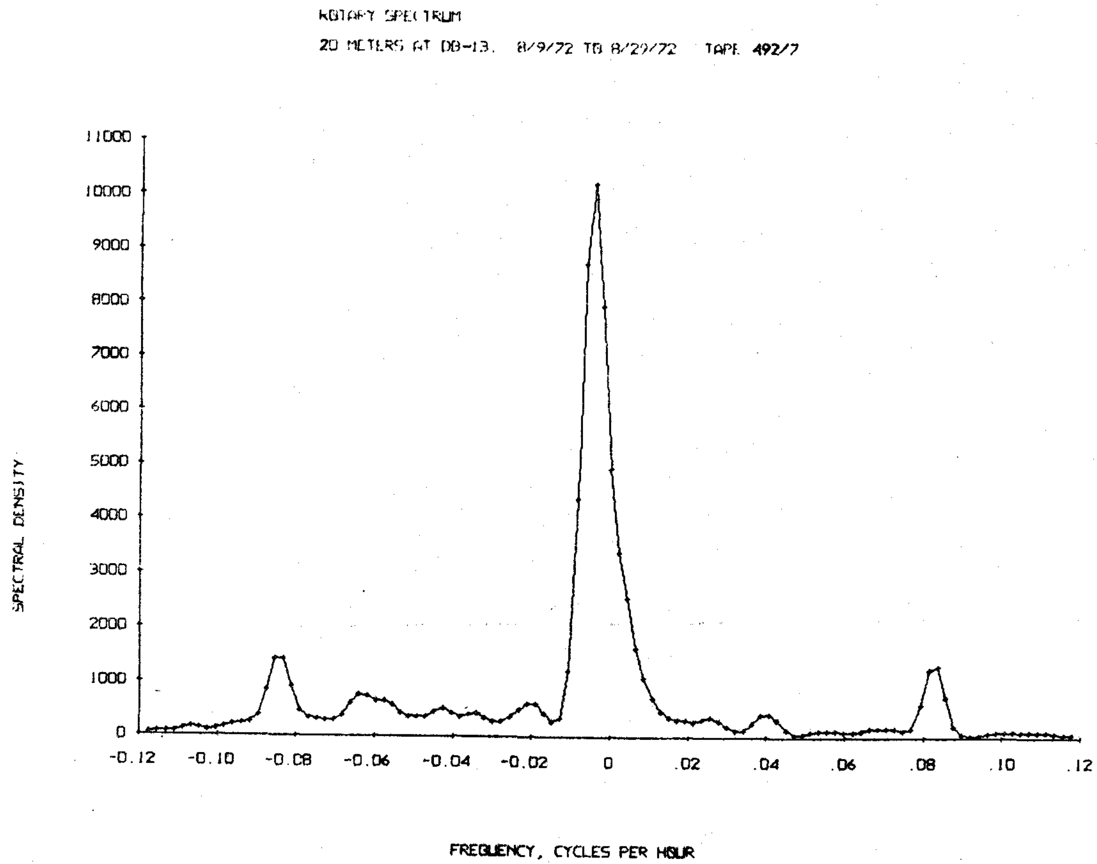
40 METERS AT DB-13. 20 DAYS STARTING 0217 8/10/72



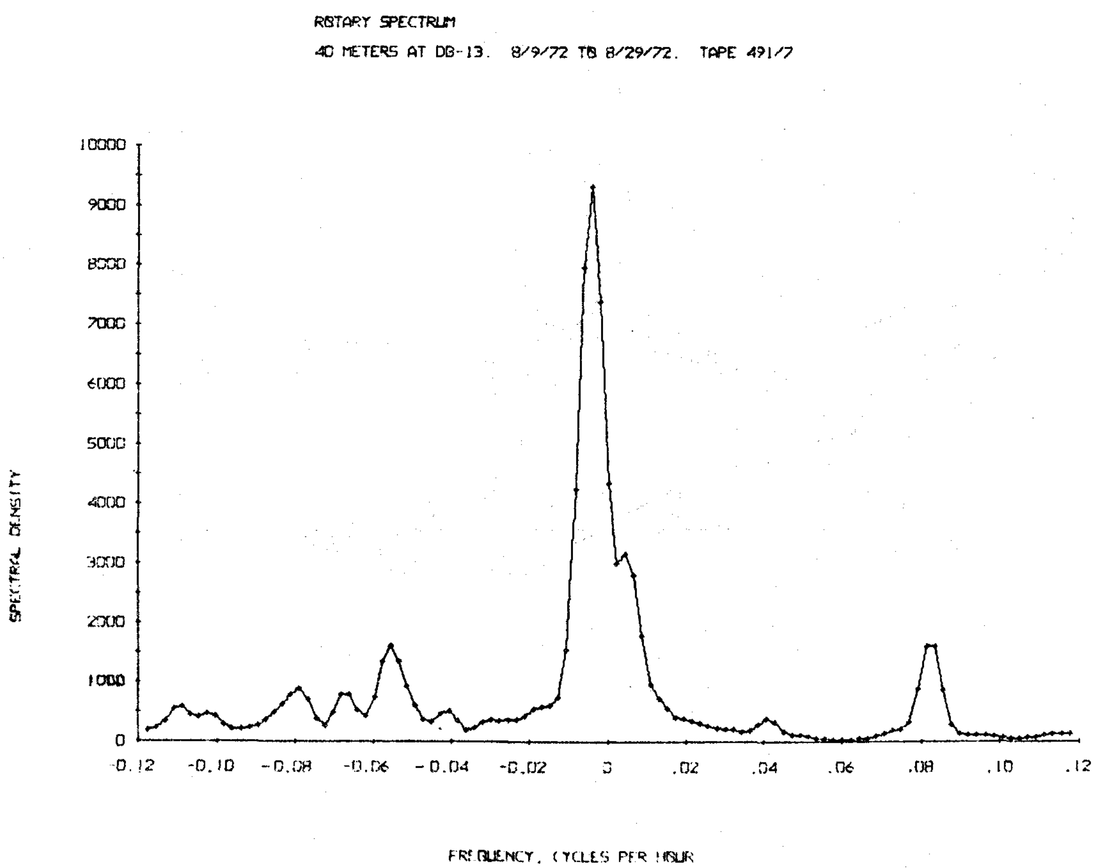
70 METERS AT DB-13. 20 DAYS STARTING 0229 8/10/72



120 METERS AT DB-13. 20 DAYS STARTING 0231 8/10/72



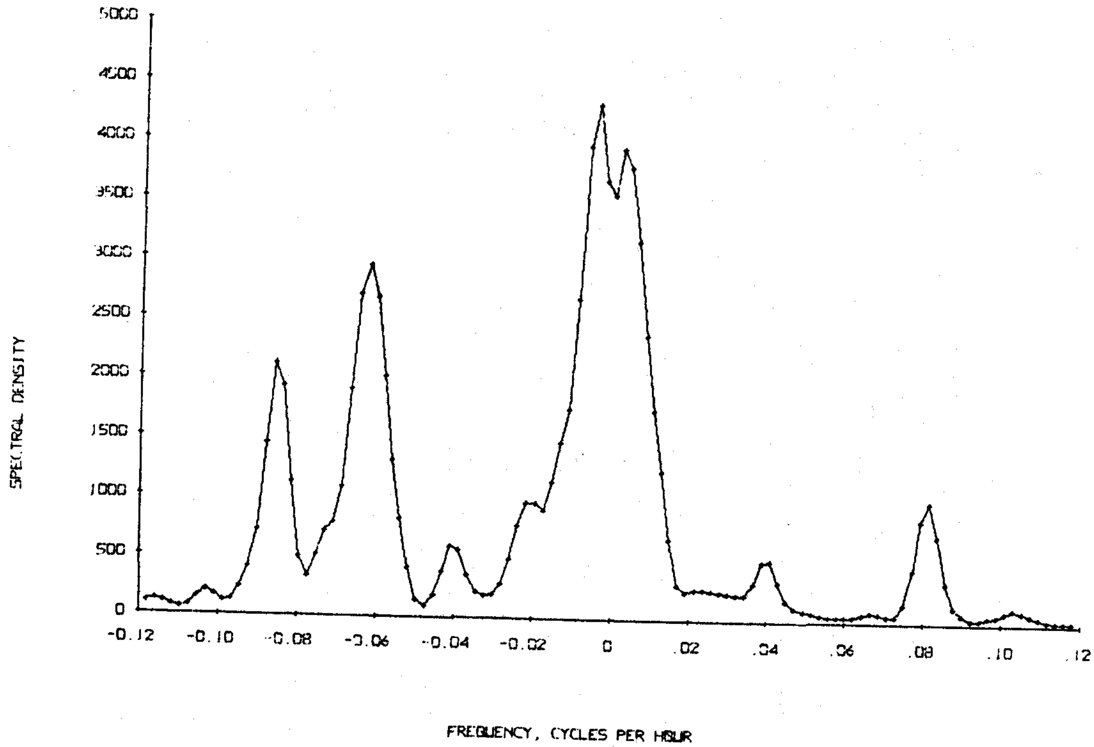
ROTARY SPECTRUM
20 METERS AT DB-13. 8/9/72 TO 8/29/72 TAPE 492/7
SPECTRAL DENSITY
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR



ROTARY SPECTRUM
40 METERS AT DB-13. 8/9/72 TO 8/29/72. TAPE 491/7
SPECTRAL DENSITY
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.12
-0.10
-0.08
-0.06
-0.04
-0.02
0
.02
.04
.06
.08
.10
.12
FREQUENCY, CYCLES PER HOUR

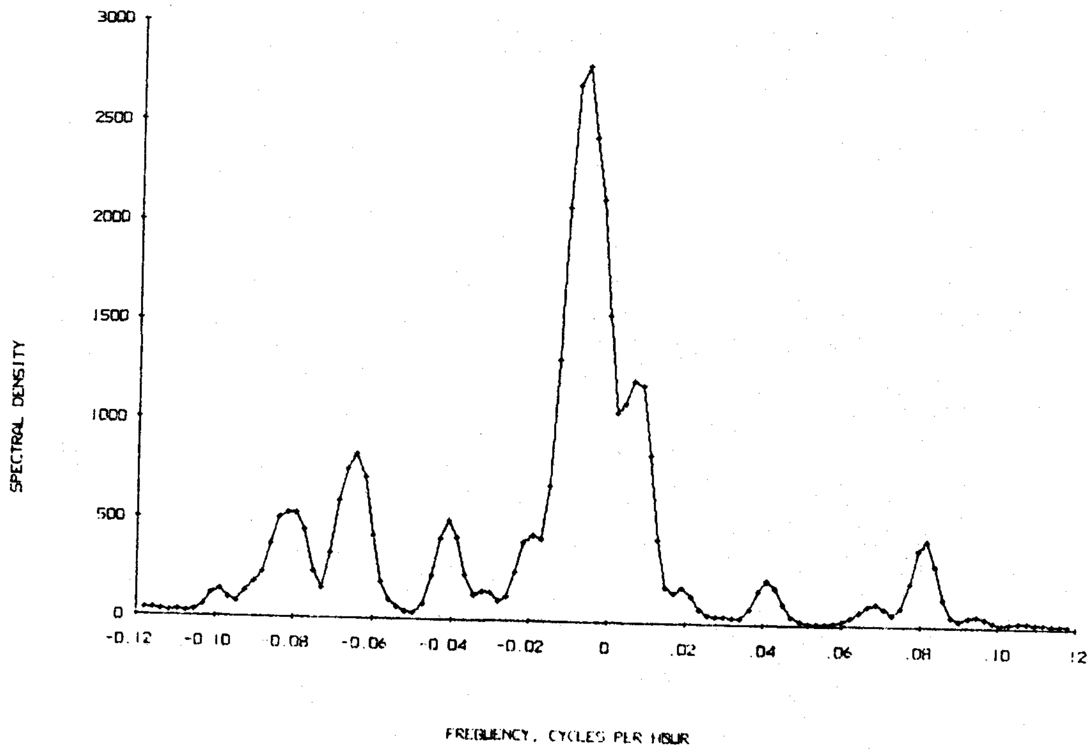
ROTARY SPECTRUM

70 METERS AT DB-13. 8/9/72 TO 8/29/72. TAPE 268/13



ROTARY SPECTRUM

120 METERS AT DB-13. 8/9/72 TO 8/29/72. TAPE 495/11



1972 CUE Installation F

POL Buoy

Position: 44°44.7'N, 124°17.1'W
Depth of Water: 102 m
Set at 1643 GMT 14 August 1972 by R/V CAYUSE
Retrieved at 1756 GMT 29 August 1972 by R/V CAYUSE
Data Interval: 1711 GMT 14 August to 1756 GMT 29 August

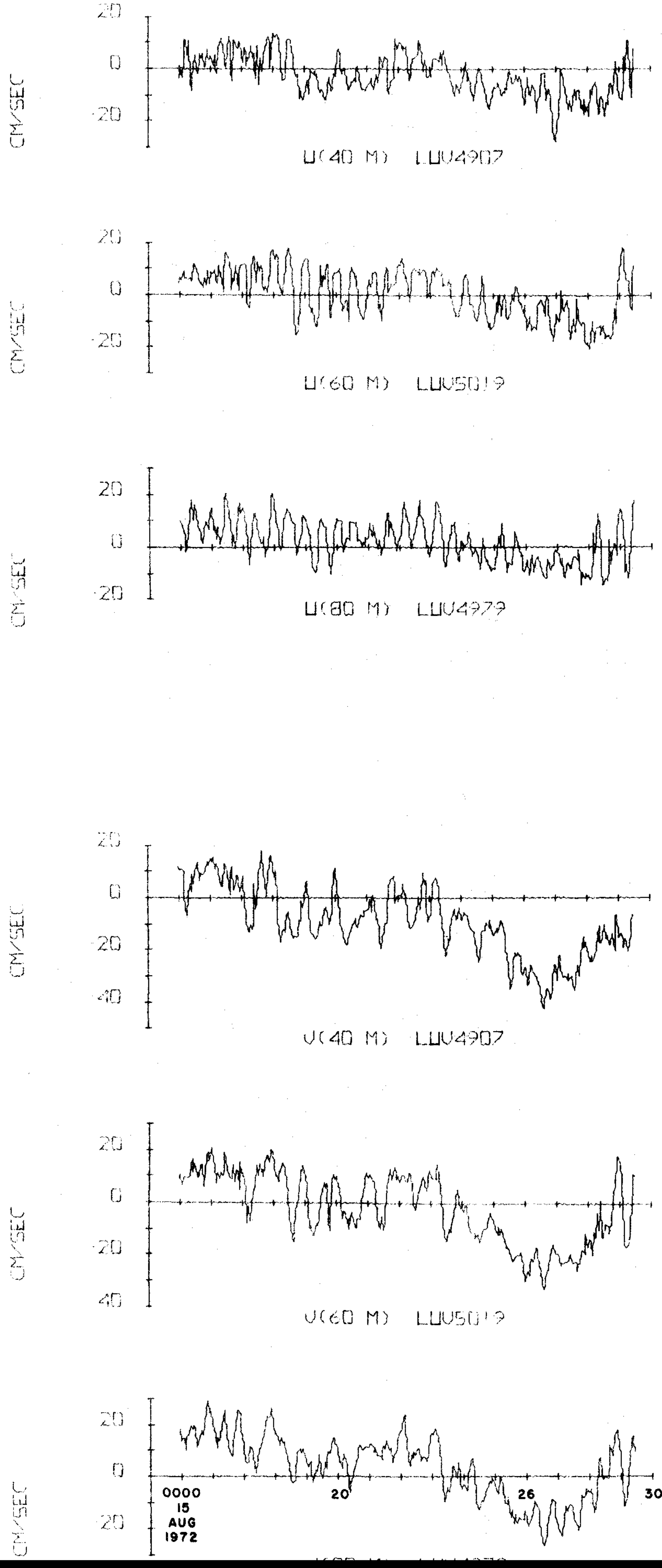
Instrumentation

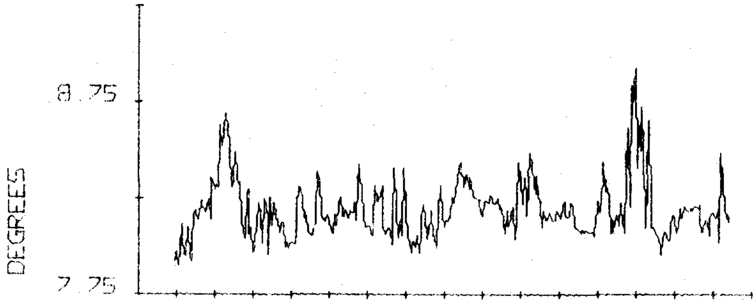
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
40 m	41 m	490/7
60 m	61 m	501/9
80 m	81 m	497/9

Data were recorded every 5 minutes. All instruments measured temperature, current speed,and current direction. In addition,the 60 m and 80 m instruments recorded pressure.

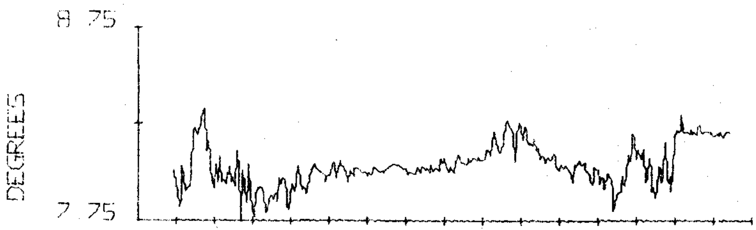
(F-POL)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	16.0	8.5	1.2	3.8	42.6	4.0
40m	U(cm/sec)	- 2.4	7.9	-0.0	2.7	13.8	-27.3
(4907)	V(cm/sec)	- 9.1	13.3	-0.1	2.4	18.0	-42.6
	T (C)	8.19	0.15	1.51	6.58	8.93	7.90
	S(cm/sec)	15.0	5.6	0.6	3.1	33.5	0.1
60m	U(cm/sec)	0.8	9.0	-0.3	2.0	18.4	-20.2
(5019)	V(cm/sec)	- 1.9	13.1	-0.3	1.9	20.8	-33.1
	T (C)	8.04	0.11	0.24	2.83	8.33	7.75
	P(kg/cm^2)	6.23	0.06	-0.00	2.43	6.36	6.10
	S(cm/sec)	14.0	5.9	0.6	3.2	31.9	0.8
80m	U(cm/sec)	2.4	7.9	-0.0	2.2	20.4	-14.5
(4979)	V(cm/sec)	3.6	12.2	-0.4	2.3	29.6	-26.3
	T (C)	7.75	0.10	0.75	3.87	8.16	7.54
	P(kg/cm^2)	8.11	0.05	-0.08	3.01	8.21	7.98

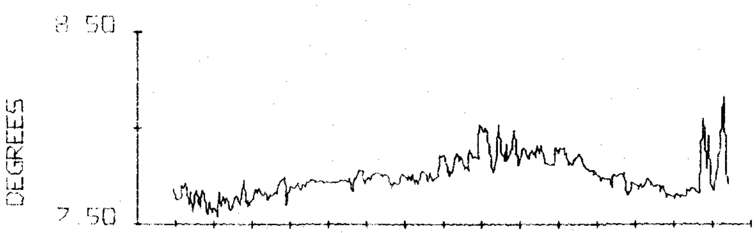

CM/SEC
20
0
-20
U(40 M) LUU4907
CM/SEC
20
0
-20
U(60 M) LUU5019
CM/SEC
20
0
-20
U(80 M) LUU4979
CM/SEC
20
0
-20
-40
V(40 M) LUU4907
CM/SEC
20
0
-20
-40
V(60 M) LUU5019
CM/SEC
20
0
-20
0000
15
AUG
1972
20
26
30



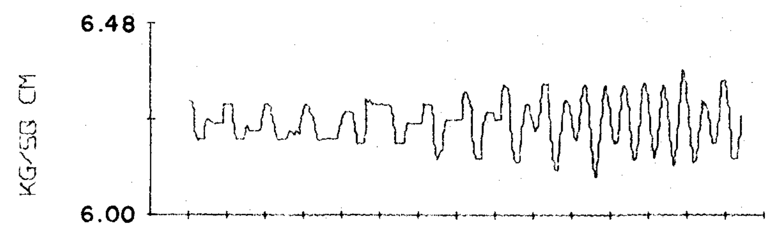
TEMP. (40 M) LT4907



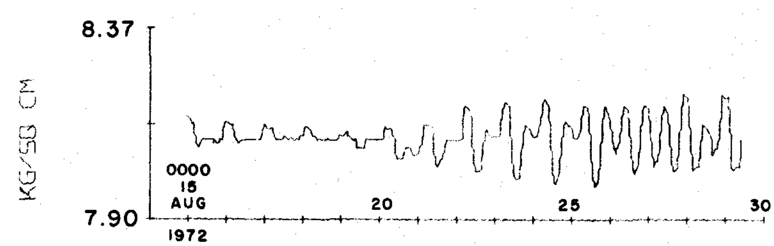
TEMP. (60 M) LTP5019



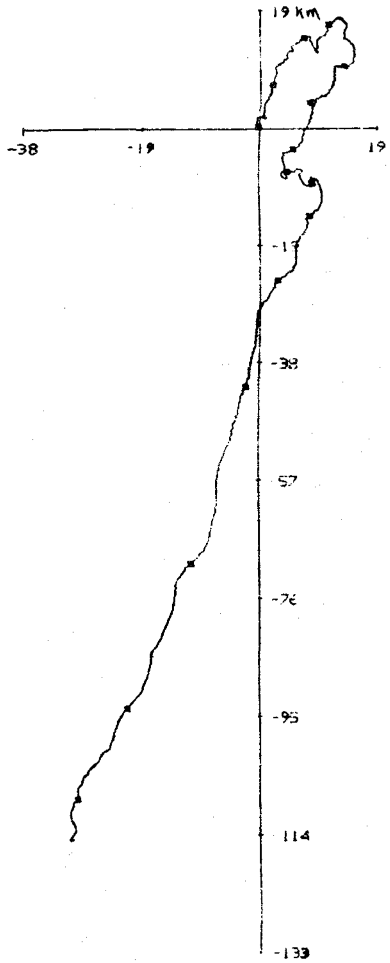
TEMP. (80 M) LTP4979



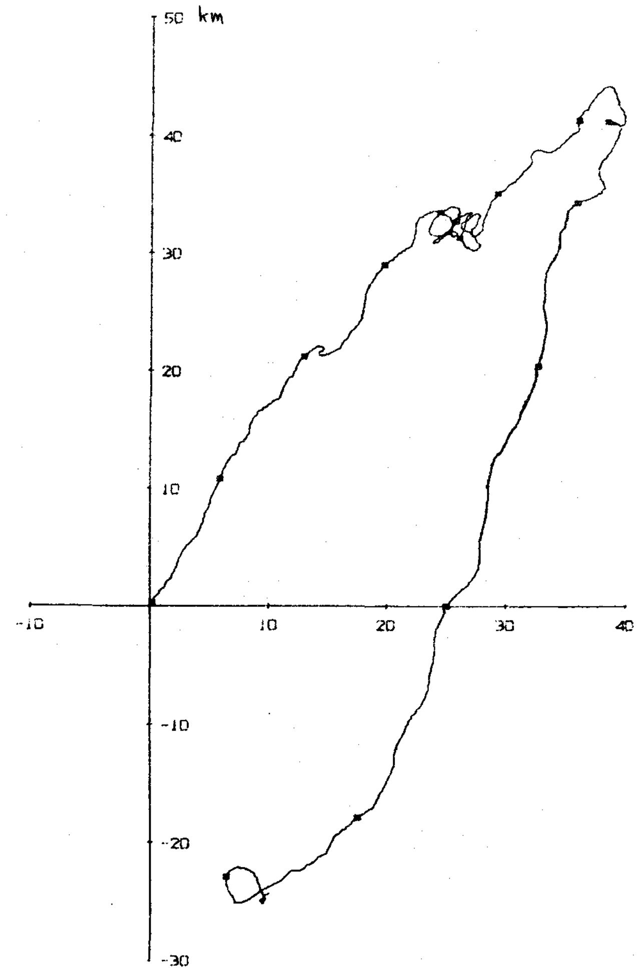
PRESSURE(60 M) LTP5019



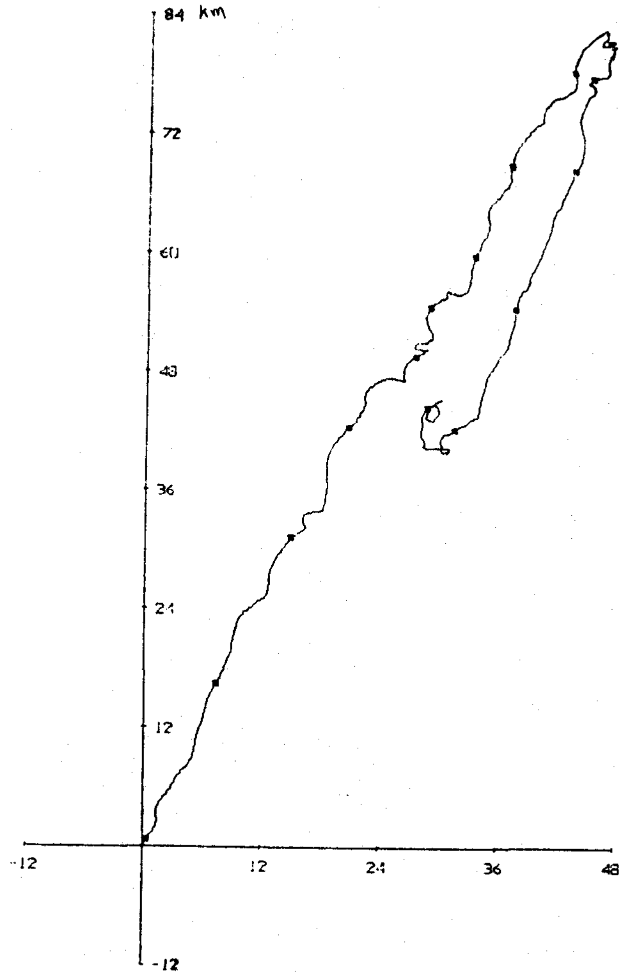
PRESSURE(80 M)M LTP4979



[illegible]0 METERS AT PBL BUSY 16 DAYS STARTING 2311 8/14/72



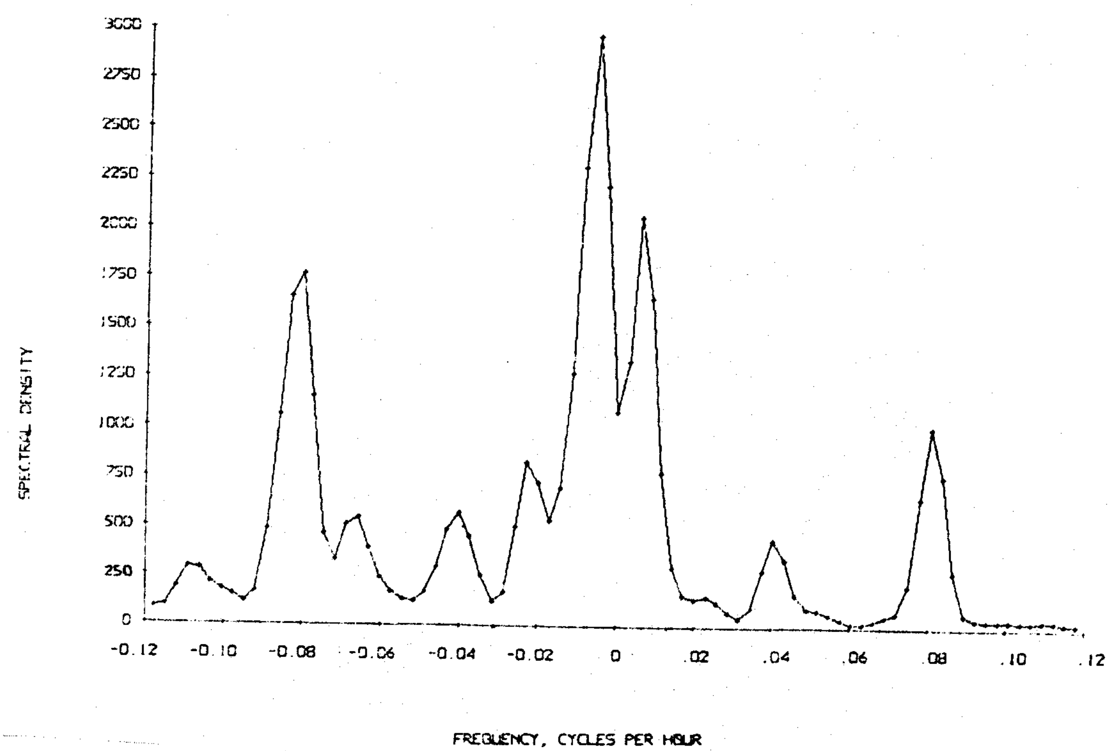
60 METERS AT PBL BUOY. 16 DAYS STARTING 2302 8/14/72



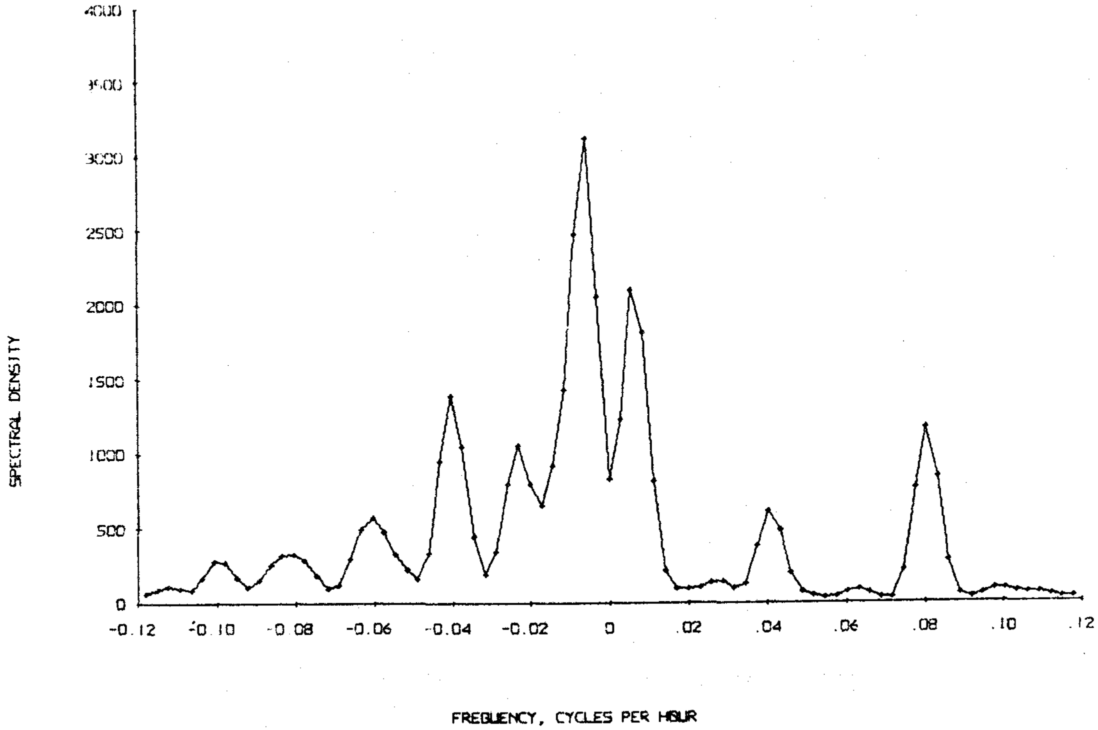
80 METERS AT PBL BUOY. 15 DAYS STARTING 2300 8/14/72

ROTARY SPECTRUM

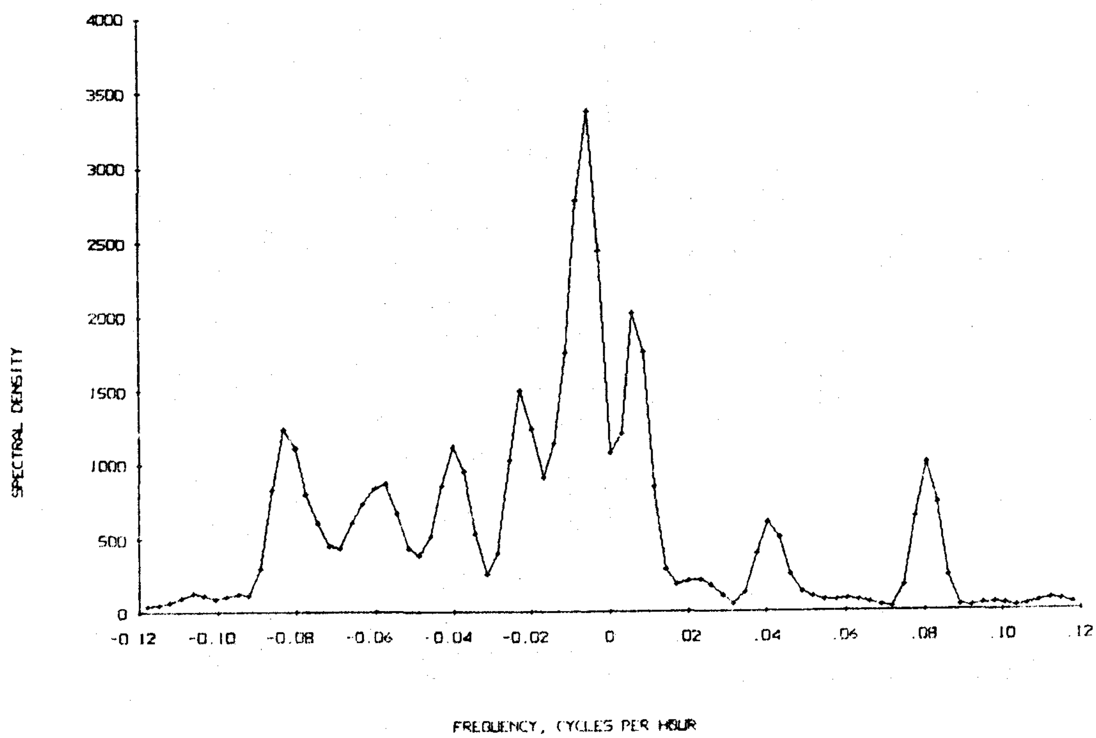
80 METERS AT PBL BUOY. 8/14/72 TO 8/29/72. TAPE 497/9



ROTARY SPECTRUM
40 METERS AT PBL BUOY. 8/14/72 TO 8/29/72 TAPE 490/7



ROTARY SPECTRUM
60 METERS AT PBL BUOY. 8/14/72 TO 8/29/72. TAPE 501/9



1972 CUE Installation G

NH 3

Position: 44°38.7'N, 124°06.9'W
Depth of Water: 42 m
Set at 2026 GMT 31 August 1972 by R/V CAYUSE
Retrieved at 1830 GMT 24 September 1972 by CHRISTIE of Newport
Data Interval: 2054 GMT 31 August to 1754 GMT 24 September

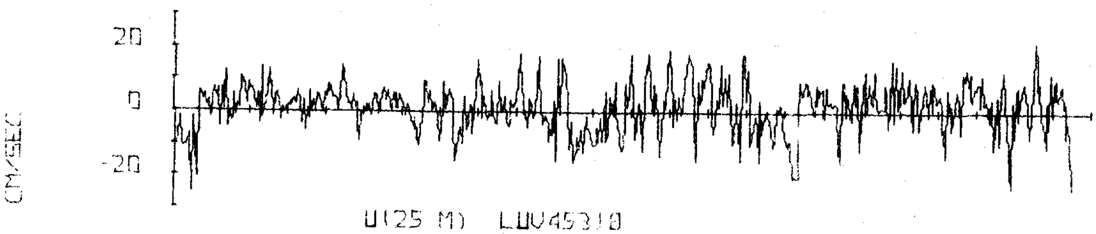
Instrumentation

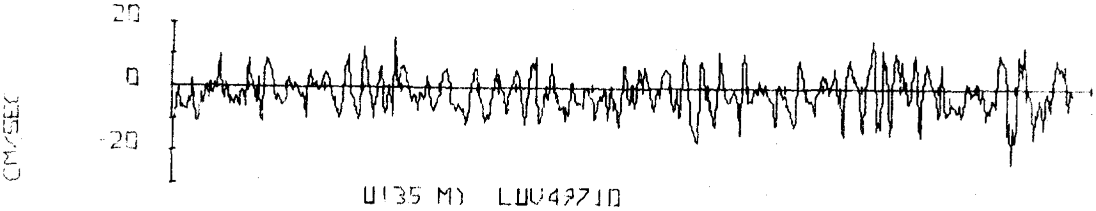
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
25 m	28 m	453/18
35 m	38 m	497/10

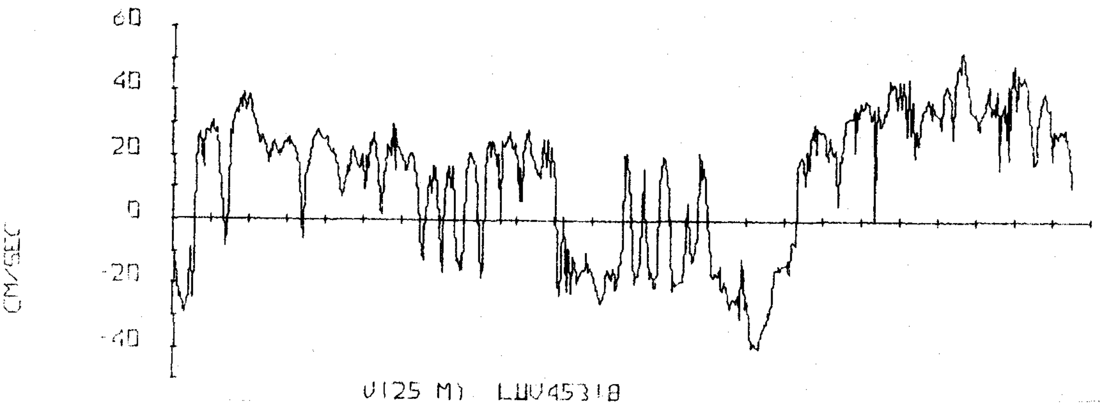
Data were recorded every 5 minutes. All instruments measured temperature, current speed, and current direction. In addition, the 35 m instrument recorded pressure.

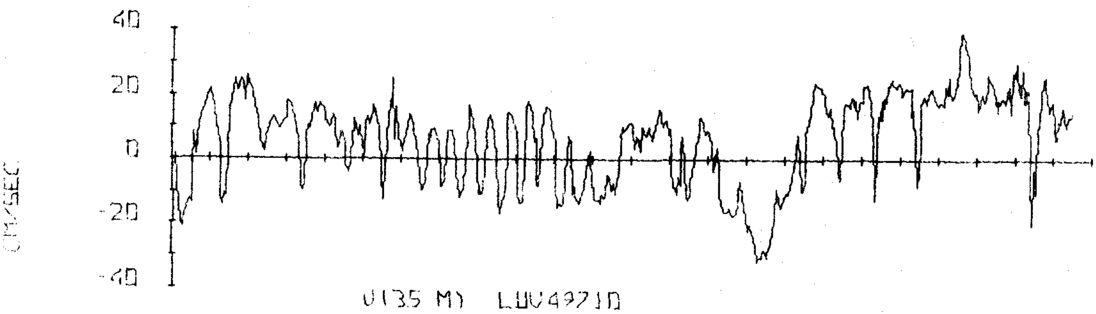
(G-NH-3)

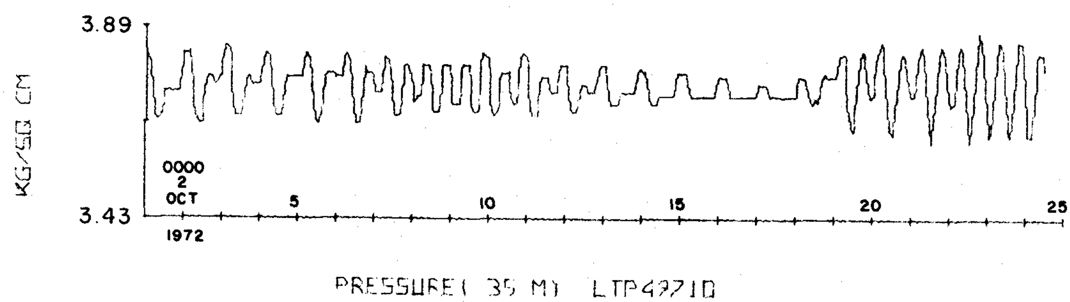
		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (cm/sec)	24.5	9.3	0.5	2.9	54.4	1.5
25 m	U (cm/sec)	1.4	7.4	-0.4	3.6	21.7	-24.9
(45318)	V (cm/sec)	12.5	21.7	-0.6	2.2	53.0	-40.4
	T (C)	9.07	0.75	0.60	2.93	11.05	7.79
	S (cm/sec)	15.0	6.3	0.8	3.7	40.2	1.4
35 m	U (cm/sec)	- 1.7	5.9	0.1	3.0	15.4	-23.3
(49710)	V (cm/sec)	6.2	13.7	-0.5	2.6	39.7	-31.8
	T (C)	8.80	0.72	1.27	4.19	10.99	7.78
	P (kgm/cm^2)	3.75	0.06	-0.04	2.58	3.87	3.61

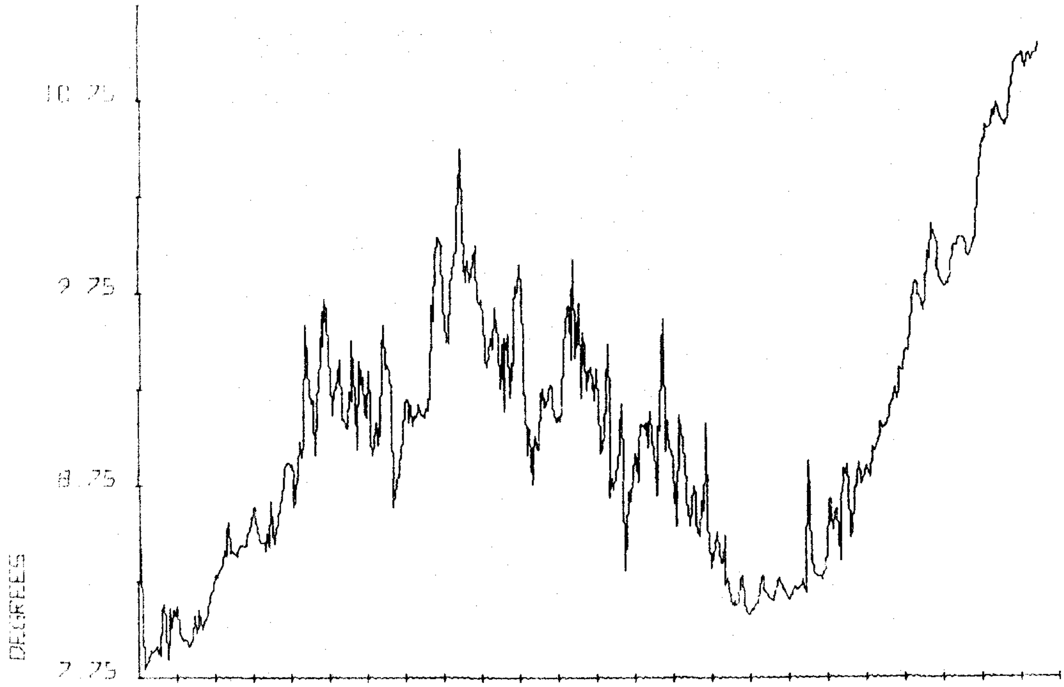

20
0
-20
CM/SEC
U(25 M) LUV45318


20
0
-20
CM/SEC
U(35 M) LUV49710

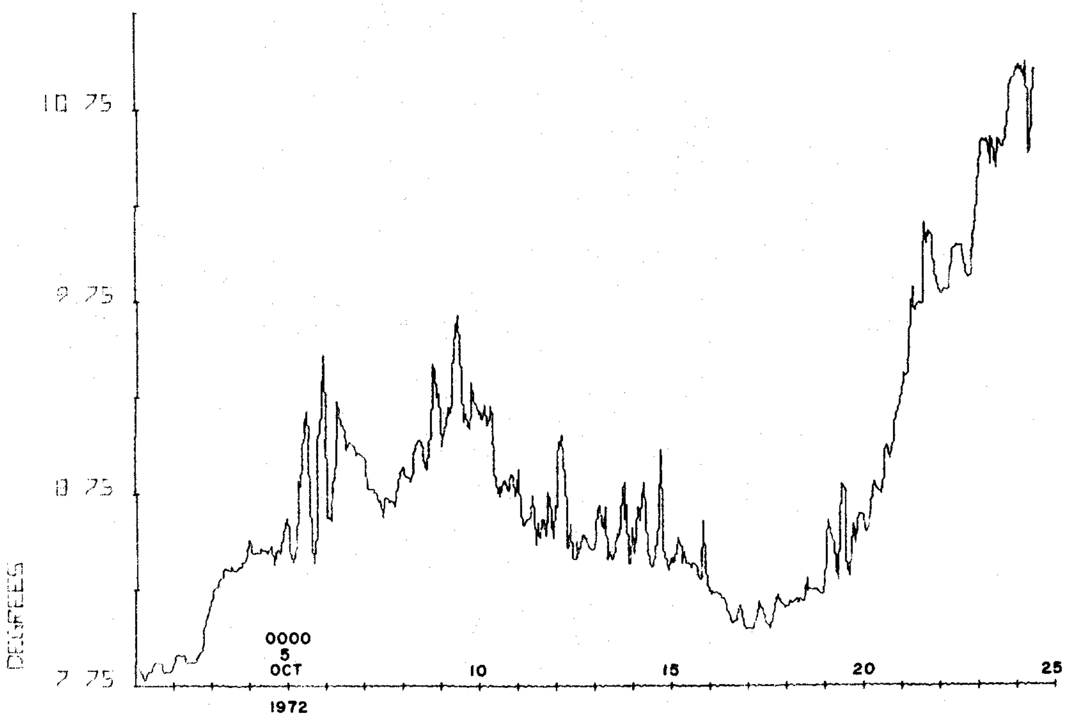

60
40
20
0
-20
-40
CM/SEC
V(25 M) LUV45318


40
20
0
-20
-40
CM/SEC
V(35 M) LUV49710

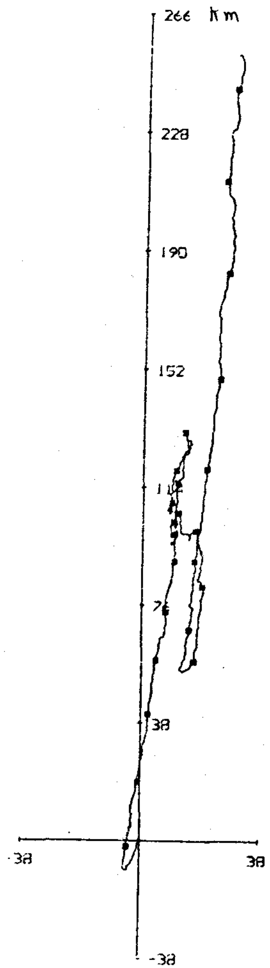

3.89
3.43
KG/SQ CM
0000
2
OCT
1972
5
10
15
20
25
PRESSURE(35 M) LTP49710



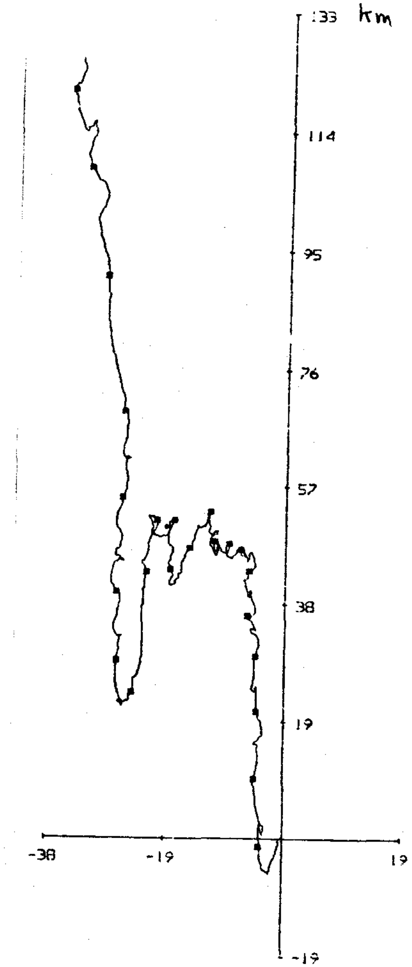
TEMP (25 M) LT45318



TEMP (35 M) LTP42210



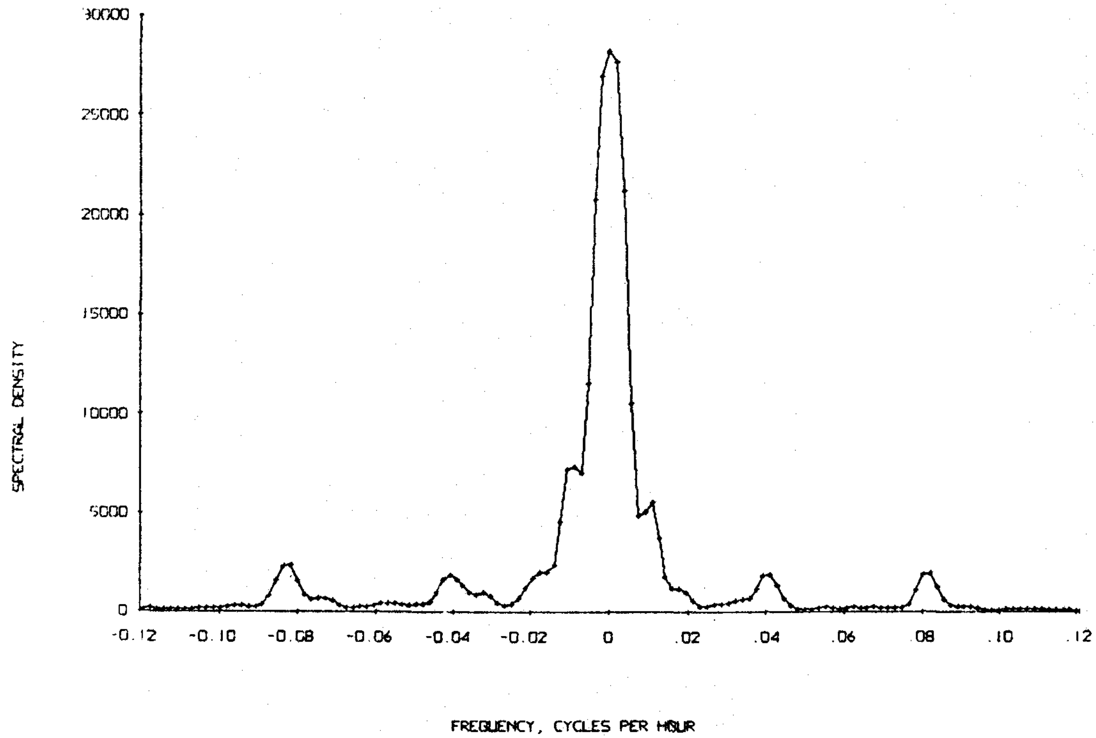
25 METERS AT NH-3. 23.4 DAYS STARTING 0254 9/1/72



35 METERS AT NH-3. 23.4 DAYS STARTING 0235 [illegible]72

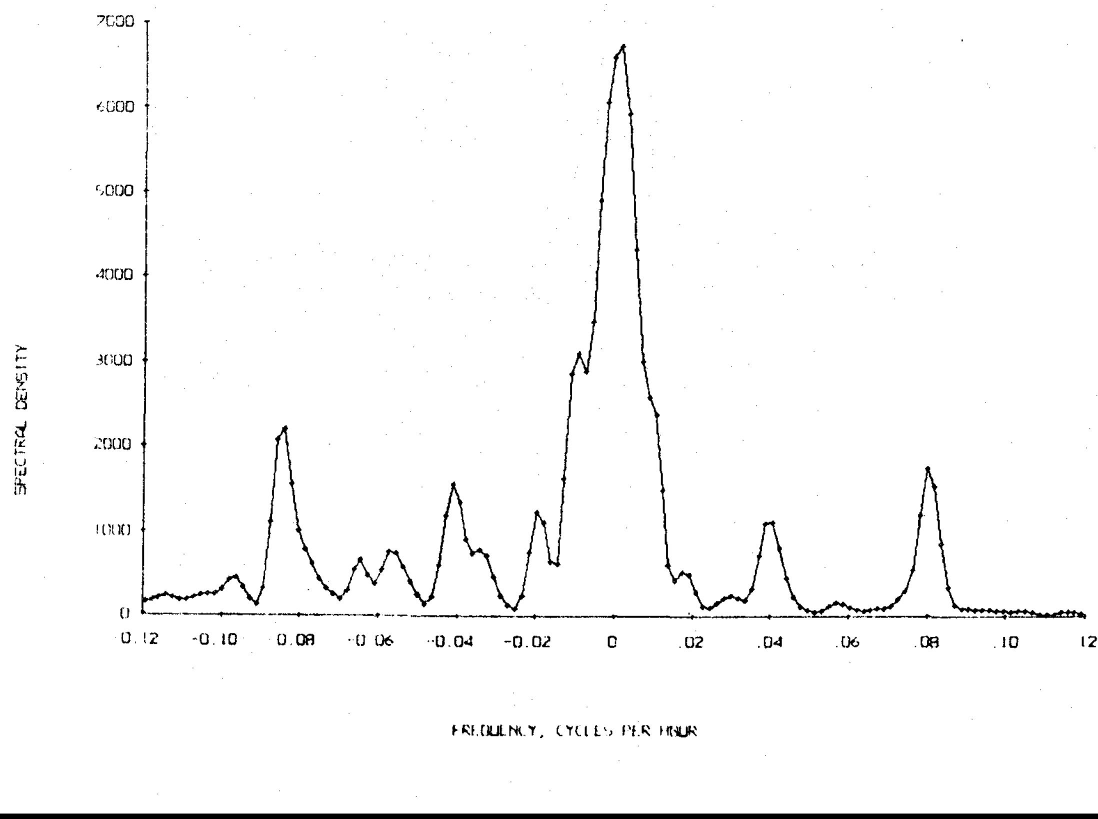
ROTARY SPECTRUM

25 METERS AT NH-3 8/31/72 TO 9/24/72 TAPE 453/18



ROTARY SPECTRUM

35 METERS AT NH-3. 8/31/72 TO 9/24/72. TAPE 497/10



1972 CUE Installation G

NH 6

Position: 44°38.8'N, 124°12.2'W
Depth of Water: 66 m
Set at 1910 GMT 31 August 1972 by R/V CAYUSE
Retrieved at 1731 GMT 29 October 1972 by R/V YAQUINA
Data Interval: 1920 GMT 31 August to 1730 GMT 29 October

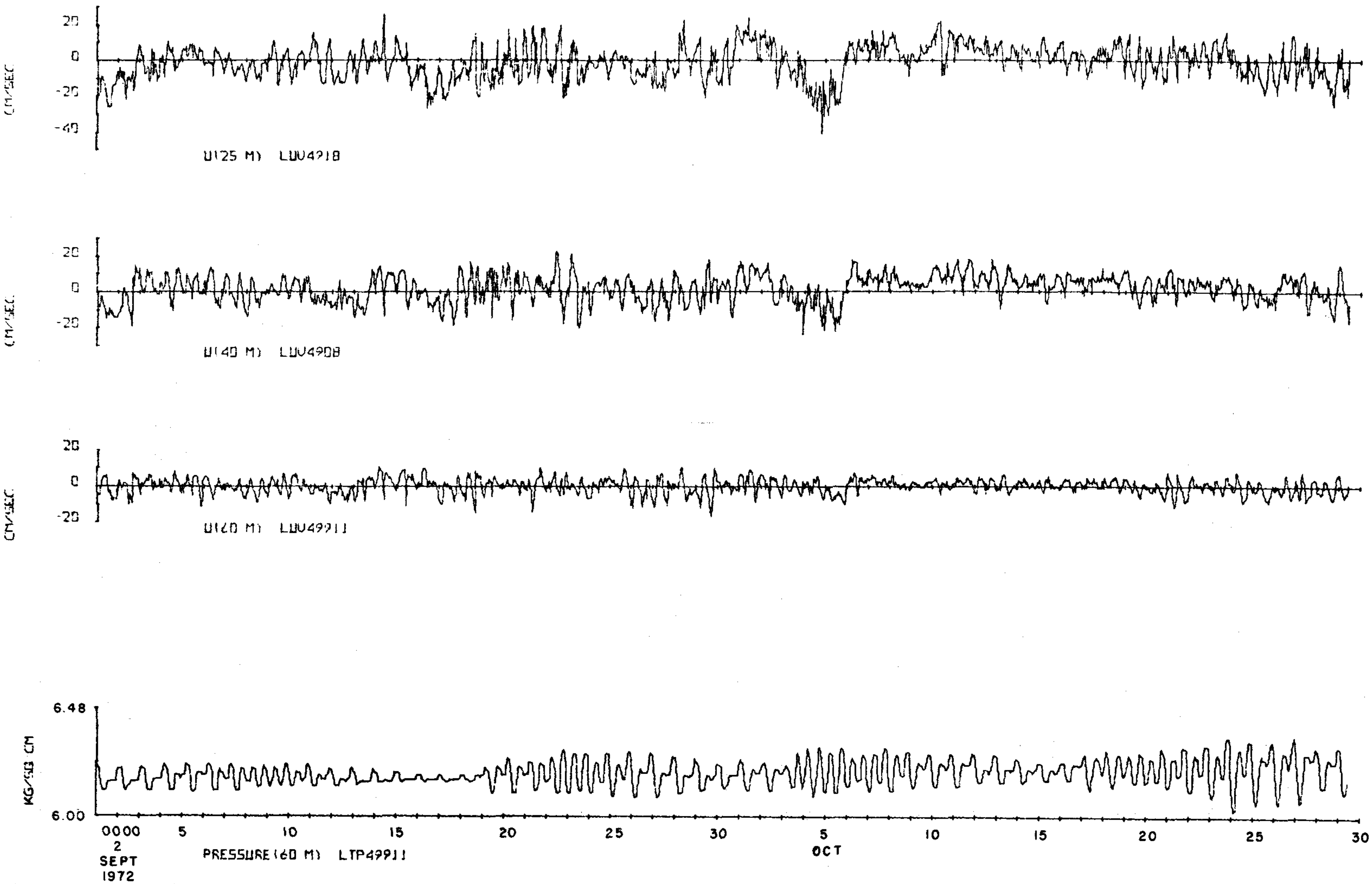
Instrumentation

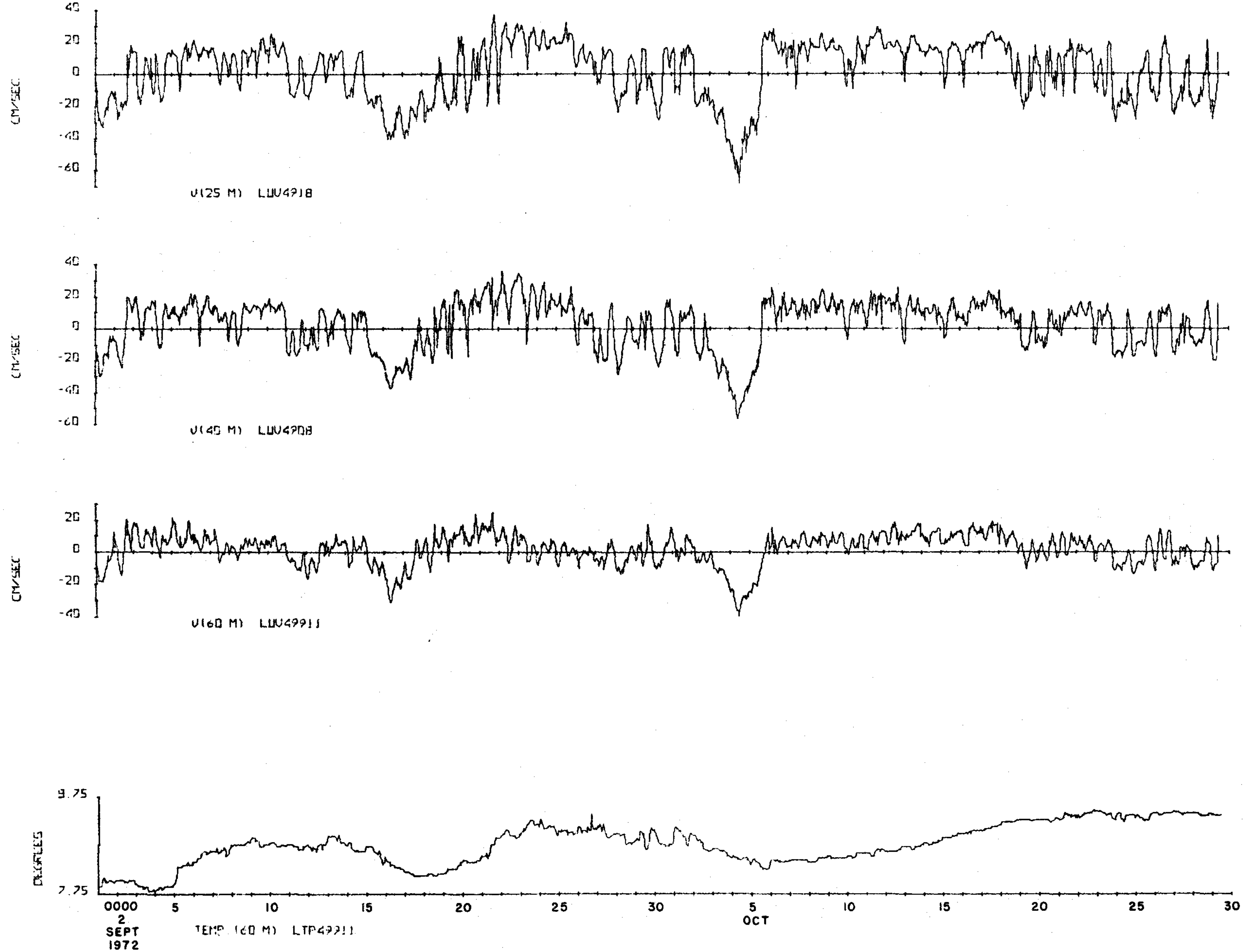
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
25 m	27 m	491/8
40 m	42 m	490/8
60 m	62 m	499/11

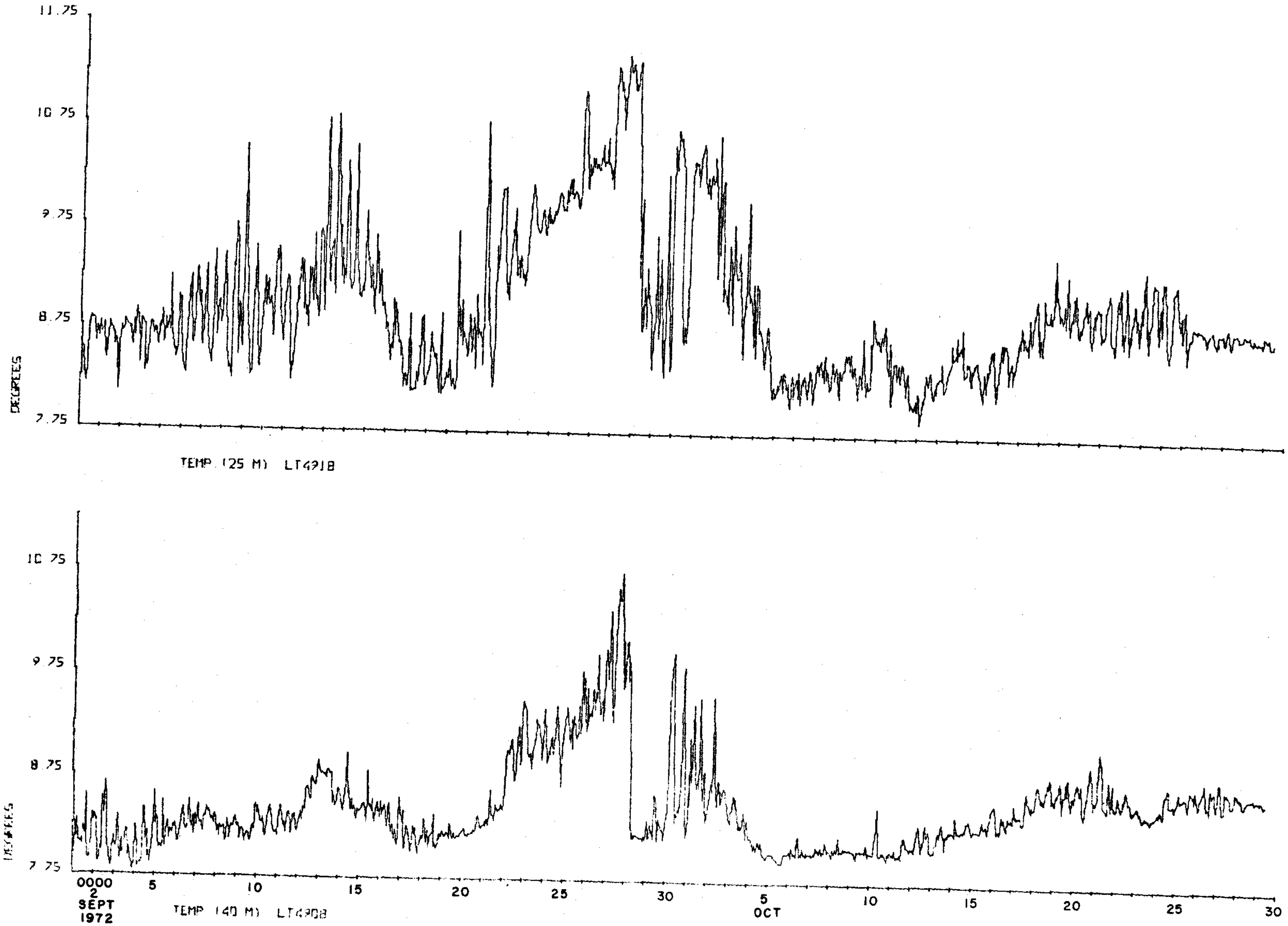
Data were recorded every 10 minutes. All instruments measured temperature, current speed,and current direction. In addition,the 60 m instrument recorded pressure.

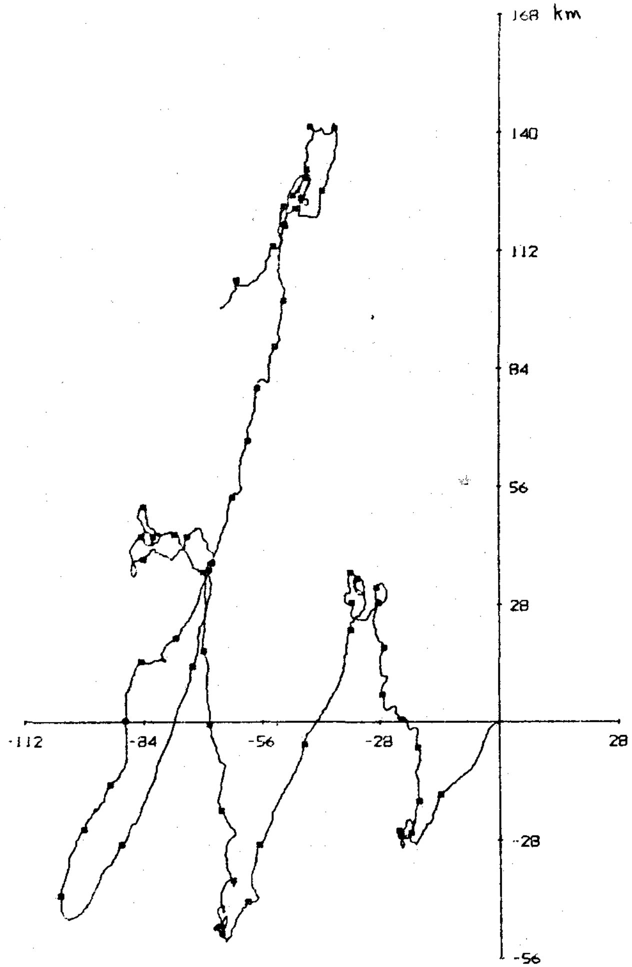
(G-NH-6)

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S(cm/sec)	18.6	8.4	1.9	9.1	69.4	0.5
25 m	U(cm/sec)	- 1.3	9.5	-0.3	2.9	26.0	-40.7
(4918)	V(cm/sec)	2.0	17.9	-0.8	2.9	37.2	-68.3
	T (C)	8.99	0.69	1.31	4.41	11.45	7.89
	S(cm/sec)	15.9	7.3	1.7	8.0	57.1	1.1
40 m	U(cm/sec)	1.9	7.7	-0.4	2.8	22.8	-23.8
(4908)	V(cm/sec)	2.6	15.4	-0.8	3.4	36.2	-56.2
	T (C)	8.47	0.43	1.72	6.93	10.76	7.80
	S(cm/sec)	9.4	5.3	1.7	7.4	39.6	0.7
60 m	U(cm/sec)	0.0	4.2	-0.5	3.3	11.0	-17.0
(49911)	V(cm/sec)	1.8	9.8	-0.9	4.2	25.4	-39.4
	T (C)	8.26	0.21	-0.23	2.33	8.62	7.78
	P(kgm/cm^2)	6.19	0.06	0.28	2.77	6.35	6.03

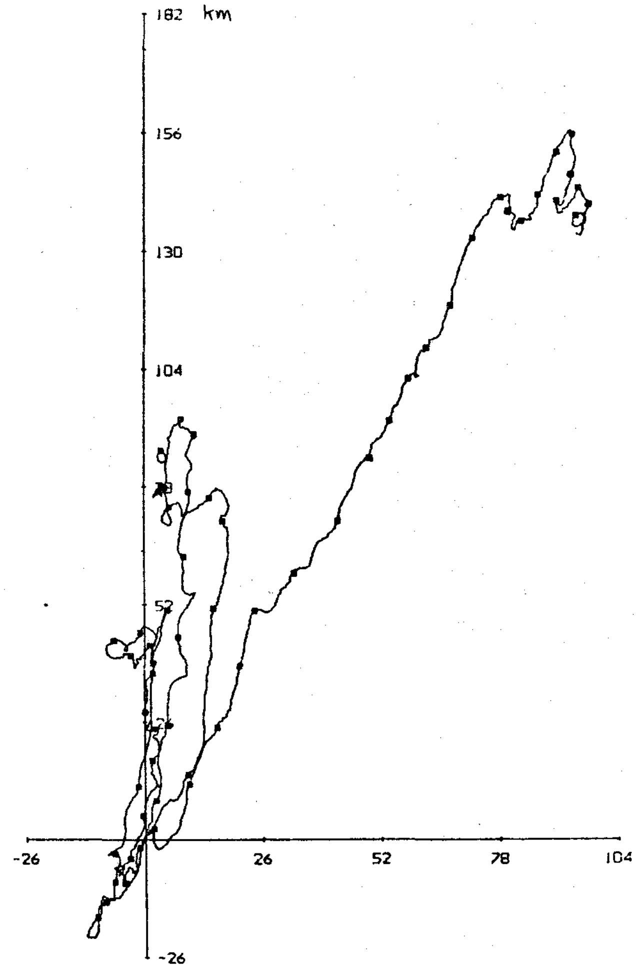

CM/SEC
20
0
-20
-40
U(25 M) LUV4218
CM/SEC
20
0
-20
U(40 M) LUV4908
CM/SEC
20
0
-20
U(60 M) LUV4911
KG/SQ CM
6.48
6.00
0000
2
SEPT
1972
5
10
15
20
25
30
5
OCT
10
15
20
25
30
PRESSURE(60 M) LTP4911


CM/SEC
40
20
0
-20
-40
-60
V(25 M) LUV4918
CM/SEC
40
20
0
-20
-40
-60
V(40 M) LUV4908
CM/SEC
20
0
-20
-40
V(60 M) LUV4911
DEGREES
9.75
7.75
0000
2
SEPT
1972
5
10
15
20
25
30
5
OCT
10
15
20
25
30
TEMP (60 M) LTP4911

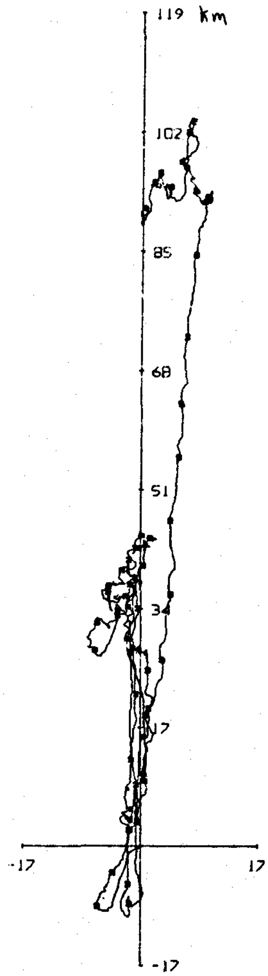

11.75
10.75
9.75
8.75
7.75
DEGREES
TEMP (25 M) LT4918
10.75
9.75
8.75
7.75
DEGREES
0000
2
SEPT
1972
5
10
15
20
25
30
5
OCT
10
15
20
25
30
TEMP (40 M) LT4908



25 METERS AT NH-6 58.4 DAYS STARTING 0122 9/1/72

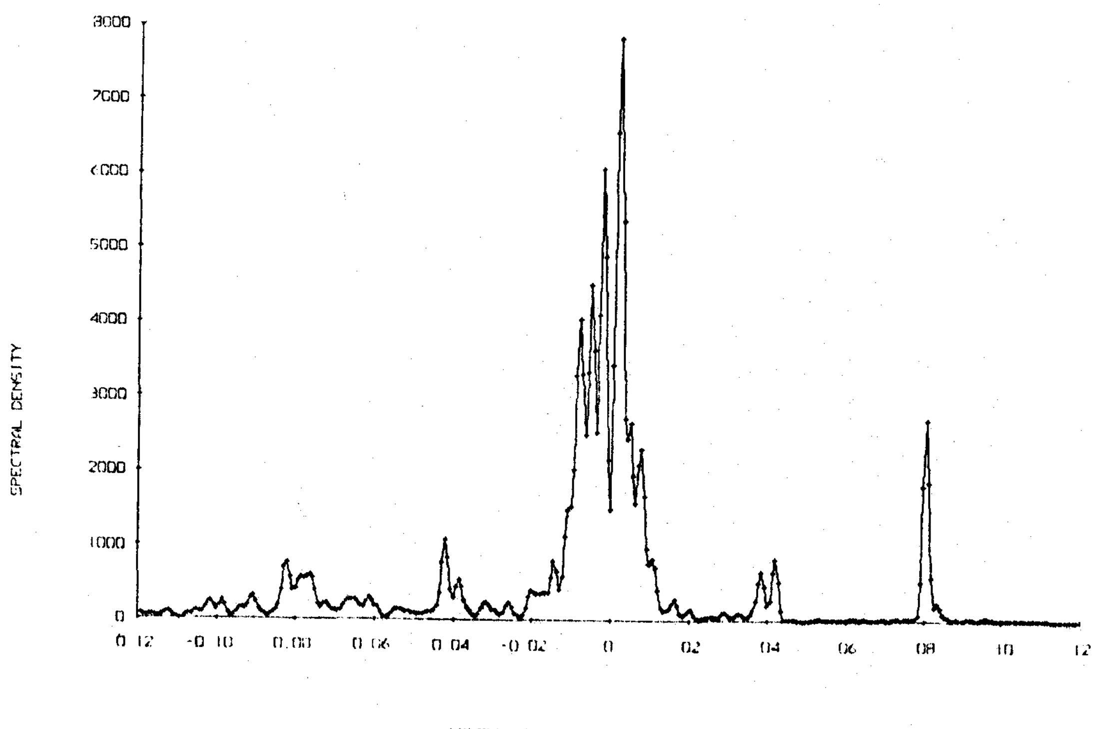


40 METERS AT NH-6 58.4 DAYS STARTING 0121 9/1/72

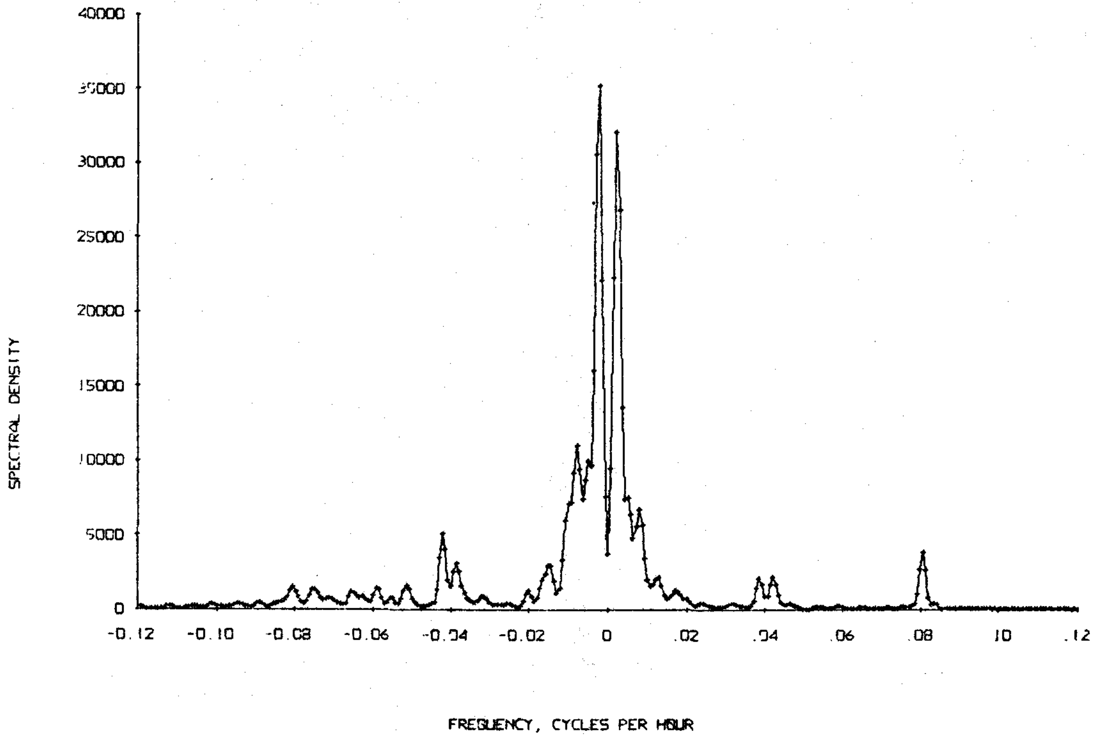


60 METERS AT NH-6. 58.4 DAYS STARTING 0120 9/1/72

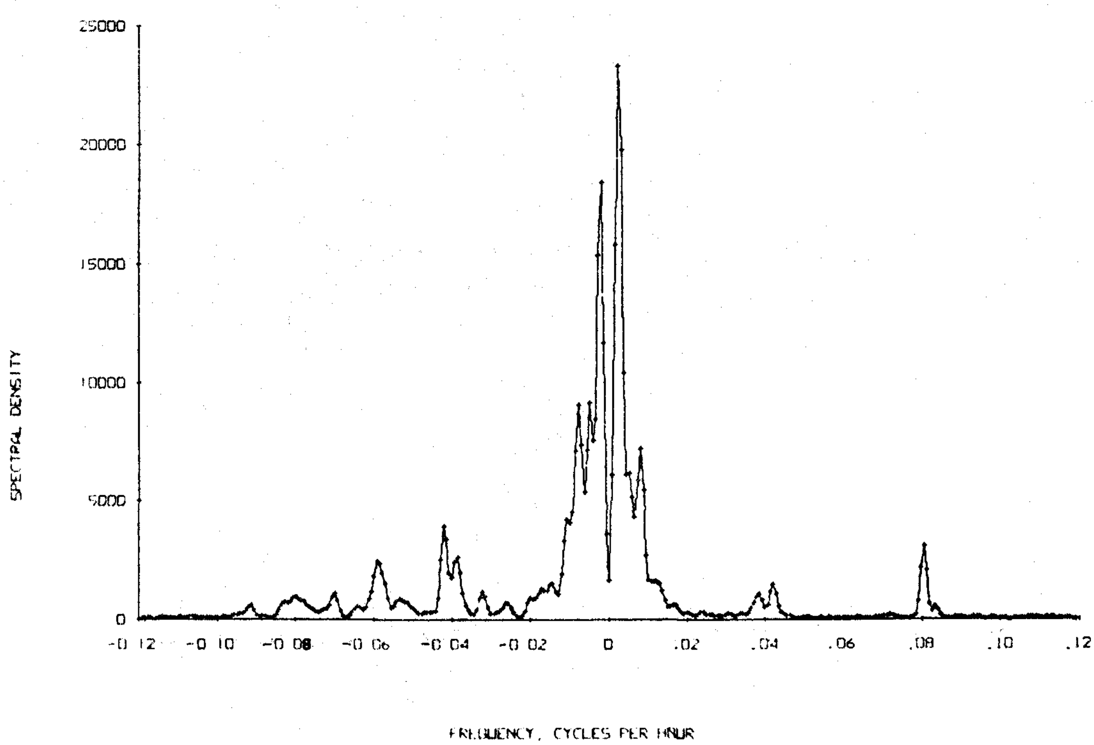
ROTARY SPECTRUM
60 METERS AT NH-6. 8/31/72 TO 10/29/72. TAPE 499/11



ROTARY SPECTRUM
25 METERS AT NH-6   8/31/72 TO 10/29/72. TAPE 491/8



ROTARY SPECTRUM
40 METERS AT NH-6. 8/31/72 TO 10/29/72. TAPE 490/8



1972 CUE Installation G

NH 10

Position: 44°39.1'N, 124°18.0'W
Depth of Water: 80 m
Set at 1536 GMT 31 August 1972 by R/V CAYUSE
Retrieved at 1943 GMT 18 September 1972 by R/V CAYUSE
Data Interval: 1555 GMT 31 August to 1940 GMT 18 September

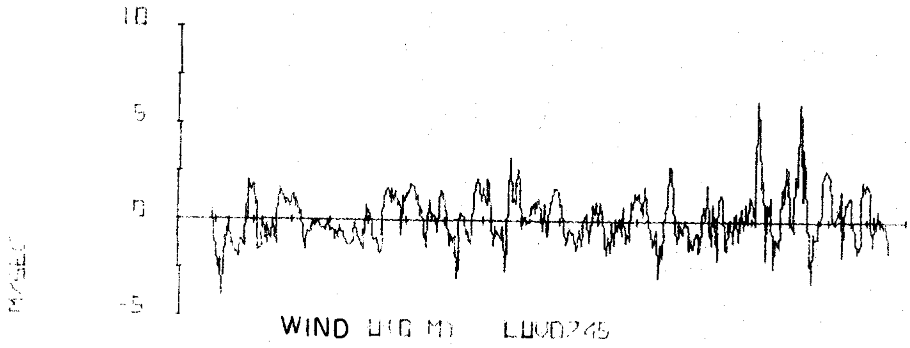
Instrumentation

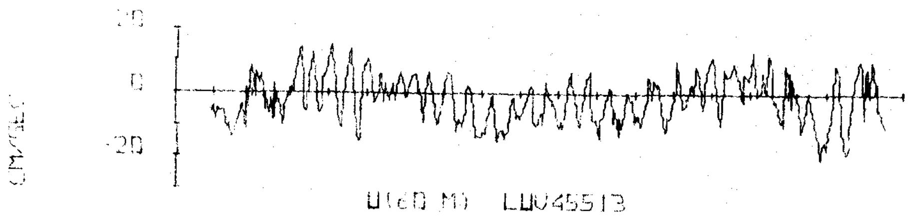
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D74/5
25 m	25 m	438/12
60 m	60 m	455/13

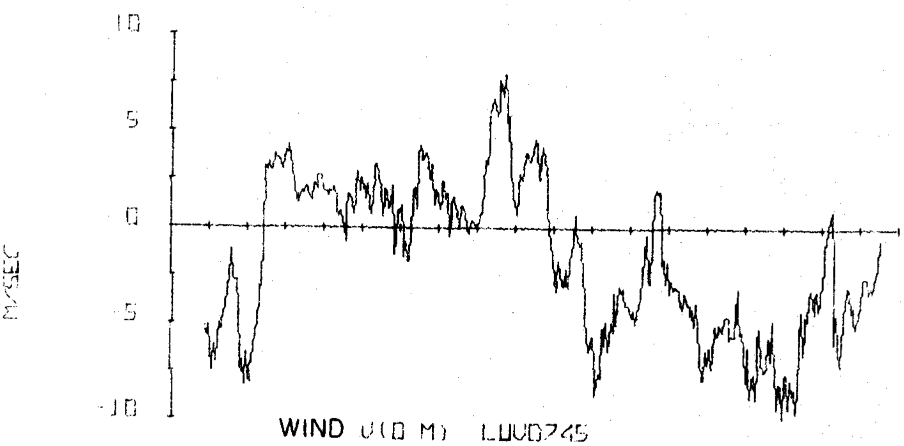
Data were recorded every 5 minutes. Both instruments measured temperature, current speed,and current direction. The 25 m instrument had a sticky rotor. The current speed for this instrument was unusable. The surface buoy recorded wind speed and direction, air temperature,and surface water temperature.

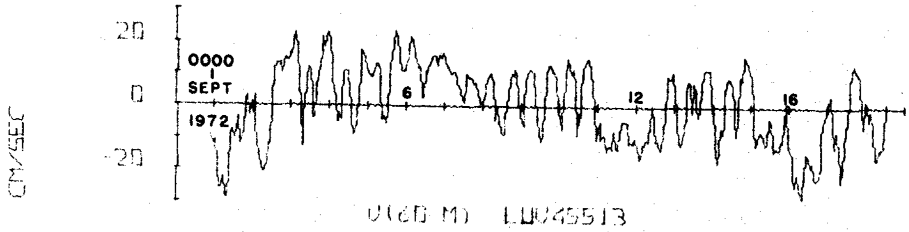
(G-NH -10)

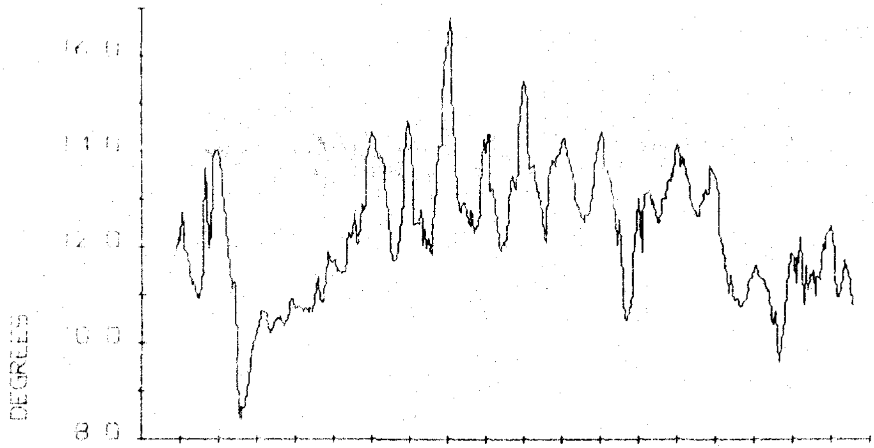
		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (m/sec)	3.9	2.2	0.7	2.8	10.8	0.1
0 m	U (m/sec)	0.1	1.3	0.7	5.0	6.3	- 3.9
(D745)	V (m/sec)	- 1.7	4.0	0.0	2.0	8.0	- 9.9
	T (C) air	12.31	1.38	0.06	3.02	16.83	8.37
	T (C) water	11.37	1.60	- 0.26	1.44	13.90	8.71
	S (cm/sec)	NONE					
25 m	U (cm/sec)	NONE					
(43812)	V (cm/sec)	NONE					
	T (C)	9.05	0.57	0.78	3.36	11.12	7.98
	S (cm/sec)	13.0	4.8	0.8	4.6	30.6	1.5
60 m	U (cm/sec)	- 1.9	7.2	0.0	2.3	14.7	-20.1
(45513)	V (cm/sec)	- 0.1	11.7	-0.2	2.2	23.5	-28.8
	T (C)	8.05	0.11	1.36	6.37	8.67	7.83
	P (kgm/cm^2)	NONE					


10
5
0
-5
M/SEC
WIND U(0 M) LUUD245

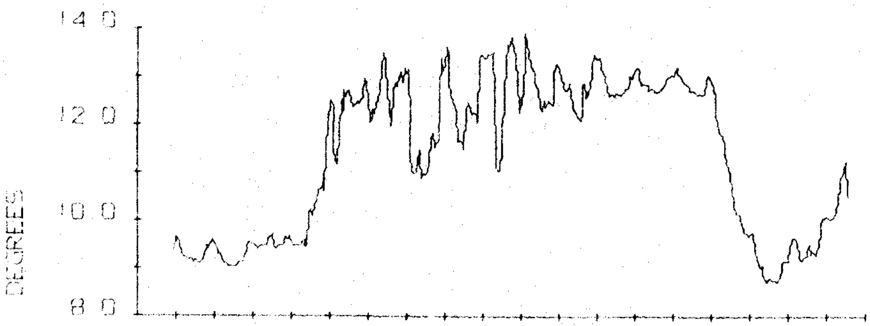

20
0
-20
CM/SEC
U(60 M) LUU45513


10
5
0
-5
-10
M/SEC
WIND V(0 M) LUUD245

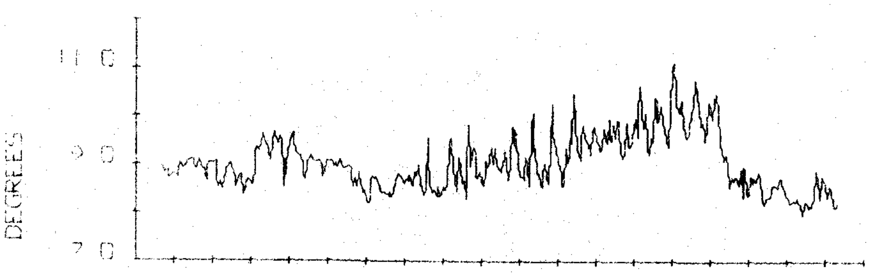

20
0
-20
CM/SEC
0000
SEPT
1972
6
12
16
V(60 M) LUU45513



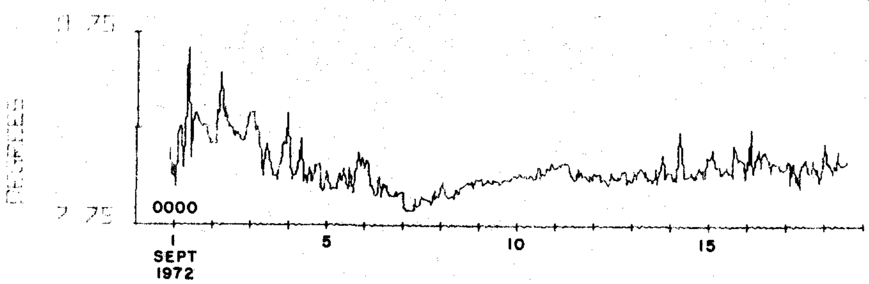
AIR TEMP(0 M) LTD745



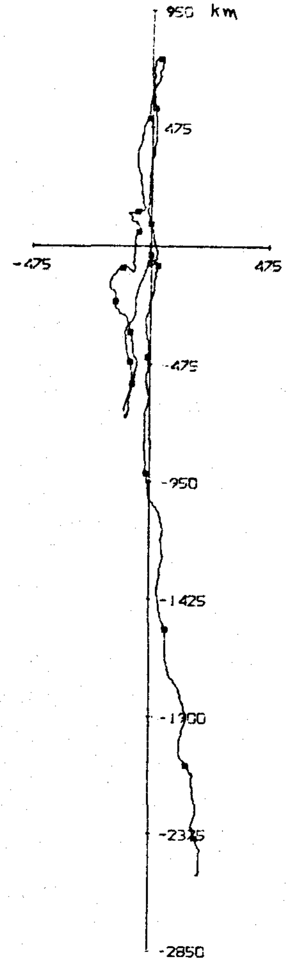
WATER TEMP(0 M) LTD745



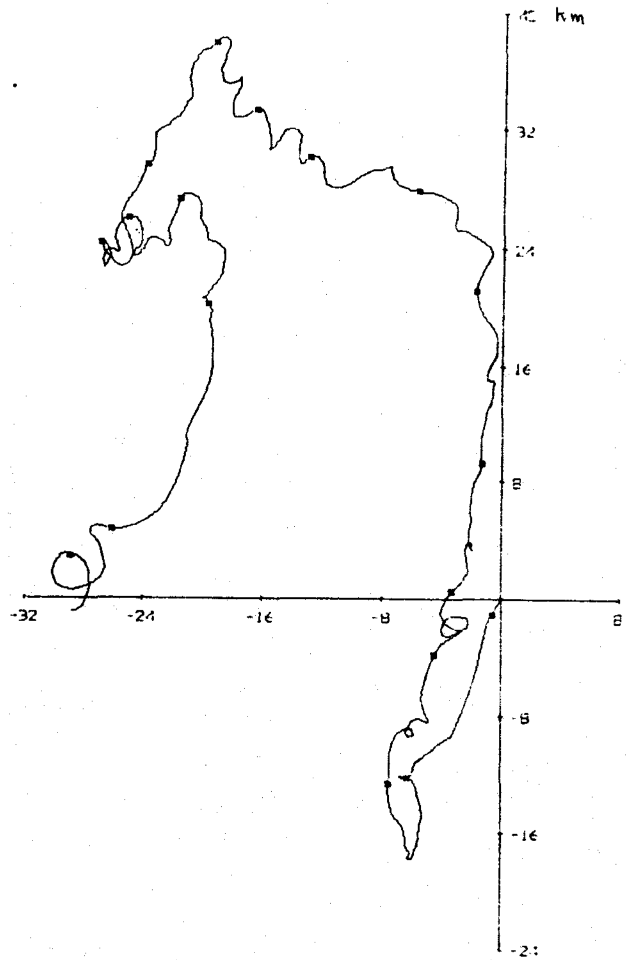
TEMP(25 M) LT43812



TEMP (60 M) LT4551[illegible]

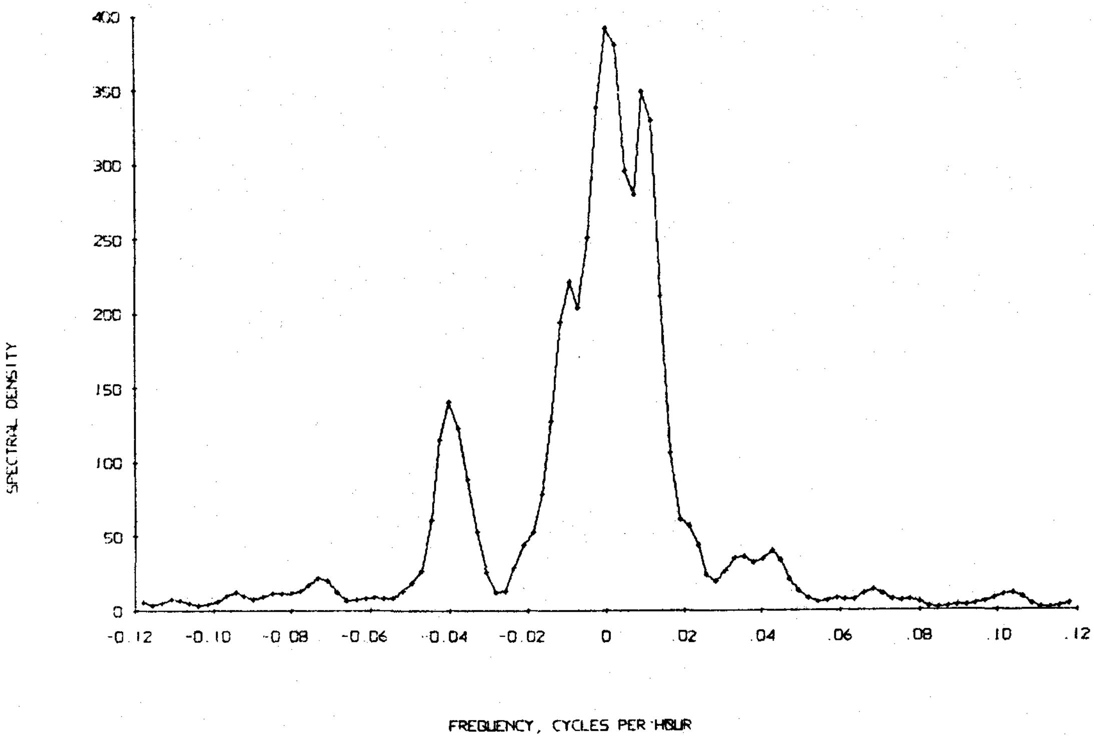


WIND AT NH-10. 17.6 DAYS STARTING 2200 8/31/72

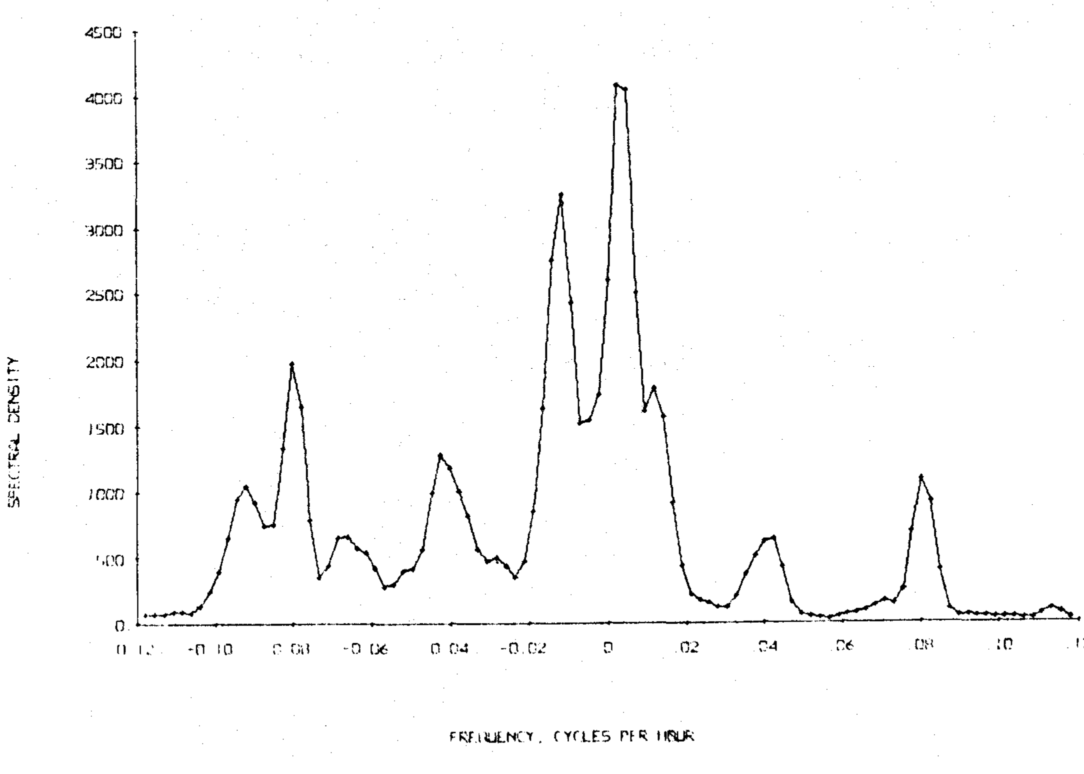


60 METERS AT NH-10. 17.7 DAYS STARTING 2155 8/31/72

ROTARY SPECTRUM
WIND AT NH-10 8/31/72 TO 9/18/72 TAPE 074/5



ROTARY SPECTRUM
60 METERS AT NH-10. 8/31/72 TO 9/18/72. TAPE 455/13



1972 CUE Installation G

NH 15

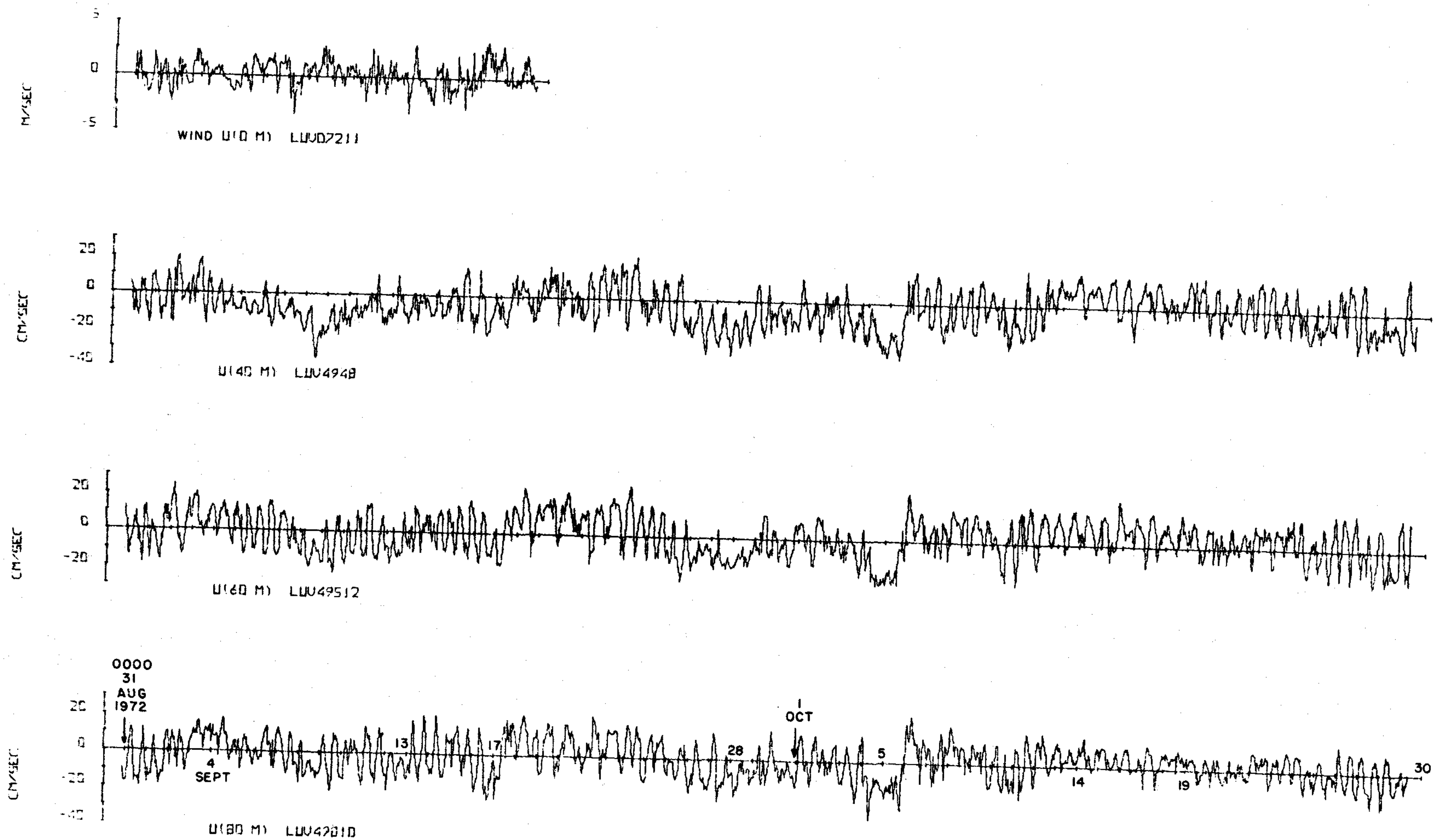
Position: 44°40.0'N, 124°25.4'W
Depth of Water: 95 m
Set at 1544 GMT 30 August 1972 by R/V CAYUSE
Retrieved at 1526 GMT 29 October 1972 by R/V YAQUINA
Data Interval: 1545 GMT 30 August to 1525 GMT 29 October

Instrumentation

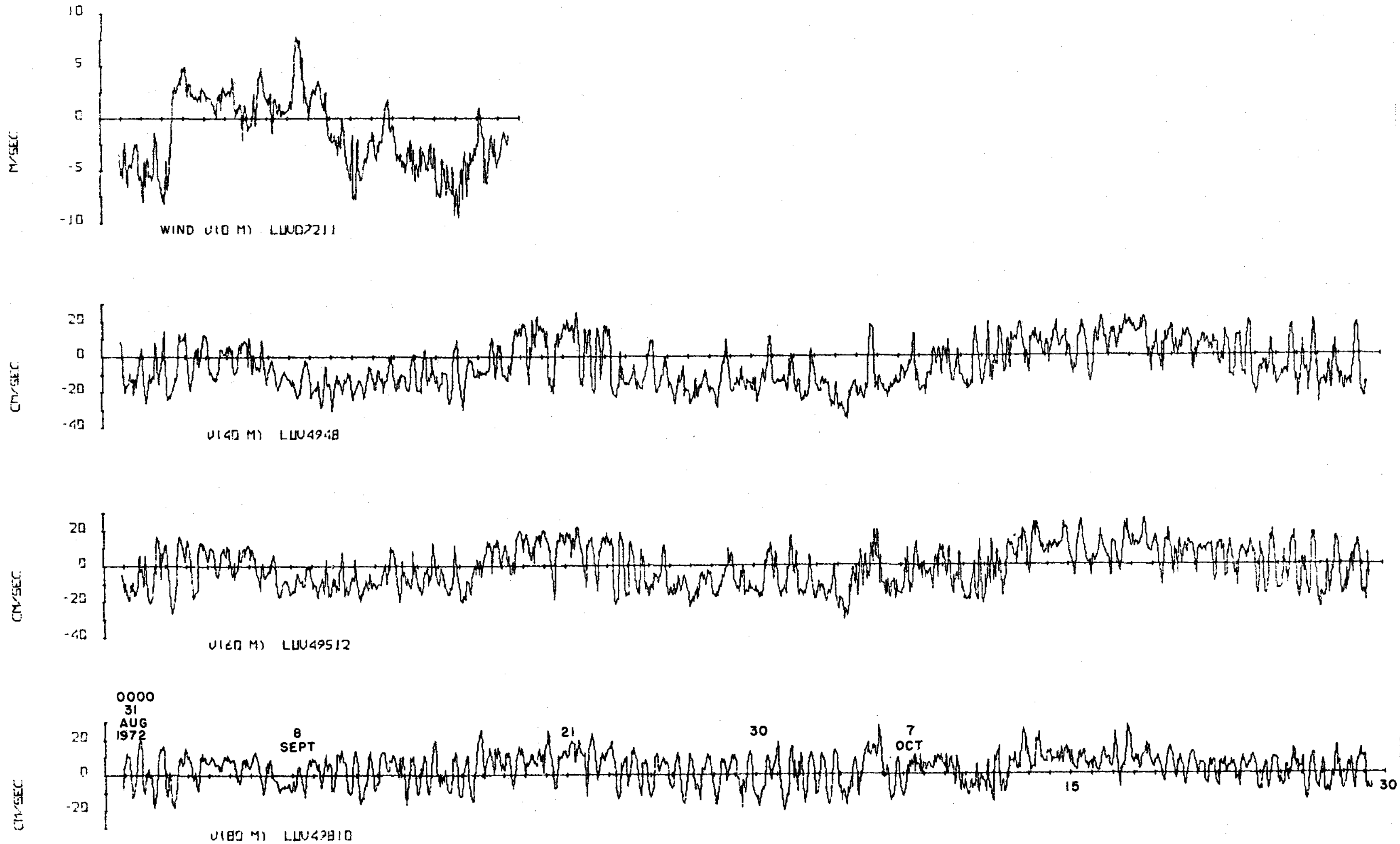
Intended Depth	Actual Depth	RCM4 Serial No./ Tape No.
0 m	0 m	D72/11
25 m	28 m	439/12
40 m	43 m	494/8
60 m	63 m	495/12
80 m	83 m	498/10

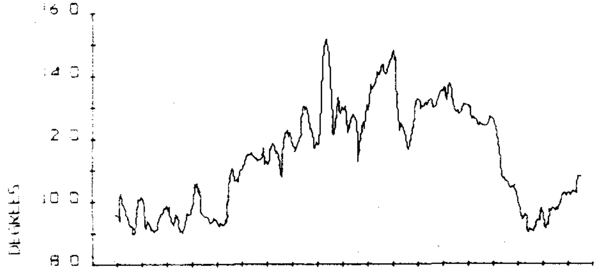
Data were recorded every 10 minutes. All subsurface instruments measured temperature, current speed,and current direction. Both the 60 m and 80 m instruments also recorded pressure. The current speed for the 25 m instrument was unusable. The surface buoy measured wind speed and direction, air temperature, and surface water temperature.

		MEAN	S. D.	SKEW	KURT	MAX	MIN
	S (m/sec)	3.6	1.9	0.7	2.8	9.9	0.5
0 m (D7211)	U (m/sec)	0.2	1.1	0.0	3.0	3.4	- 3.4
	V (m/sec)	- 1.6	3.6	0.1	2.1	7.8	- 9.5
	T (C) air	12.60	1.35	-0.22	2.90	16.09	8.41
	T (C) water	11.37	1.63	0.18	1.84	15.17	8.97
	S (cm/sec)	NONE					
25 m (43912)	U (cm/sec)	NONE					
	V (cm/sec)	NONE					
	T (C)	8.75	0.45	0.49	3.30	10.60	7.75
	S (cm/sec)	16.7	6.0	0.7	4.3	41.2	0.6
40 m (4948)	U (cm/sec)	- 3.6	10.6	0.1	2.4	23.2	-35.1
	V (cm/sec)	- 5.6	12.6	0.3	2.1	25.0	-36.0
	T (C)	8.43	0.37	0.68	3.83	10.06	7.72
	S (cm/sec)	15.1	4.7	0.2	3.5	33.6	0.4
60 m (49512)	U (cm/sec)	0.9	10.7	-0.1	2.1	27.5	-24.4
	V (cm/sec)	- 1.4	11.6	0.9	1.9	26.4	-30.4
	T (C)	8.29	0.20	-0.06	2.82	9.05	7.82
	P (kgm/cm^2)	6.32	0.07	-0.30	2.41	6.46	6.13
	S (cm/sec)	12.3	4.5	0.8	4.3	33.5	1.5
80 m (49810)	U (cm/sec)	0.1	9.3	-0.2	2.4	25.1	-31.8
	V (cm/sec)	3.1	8.7	-0.3	2.5	27.7	-20.3
	T (C)	8.18	0.13	0.42	2.16	8.51	7.90
	P (kgm/cm^2)	8.37	0.07	0.10	2.55	8.55	8.23

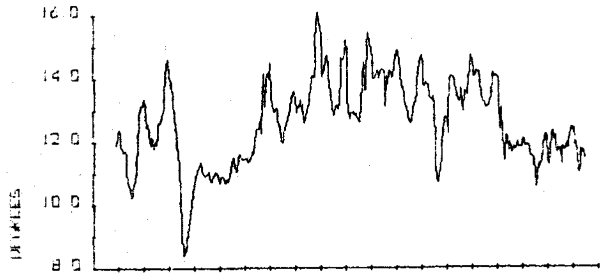


M/SEC
5
0
-5
WIND U(0 M) LUU07211
CM/SEC
20
0
-20
-40
U(40 M) LUU4948
CM/SEC
20
0
-20
U(60 M) LUU49512
0000
31
AUG
1972
1
OCT
CM/SEC
20
0
-20
-40
4
SEPT
13
17
28
5
14
19
30
U(80 M) LUU42010


10
5
0
-5
-10
M/SEC
WIND V(10 M) LUV07211
20
0
-20
-40
CM/SEC
V(40 M) LUV4948
20
0
-20
-40
CM/SEC
V(60 M) LUV49512
0000
31
AUG
1972
8
SEPT
21
30
7
OCT
15
30
20
0
-20
CM/SEC
V(80 M) LUV47810

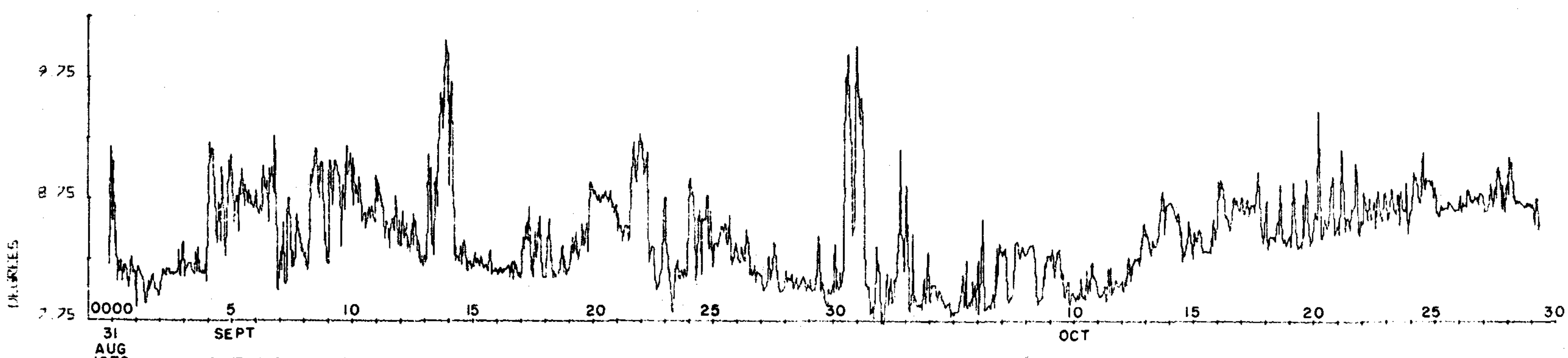


WATER TEMP(0 M) LTD7211

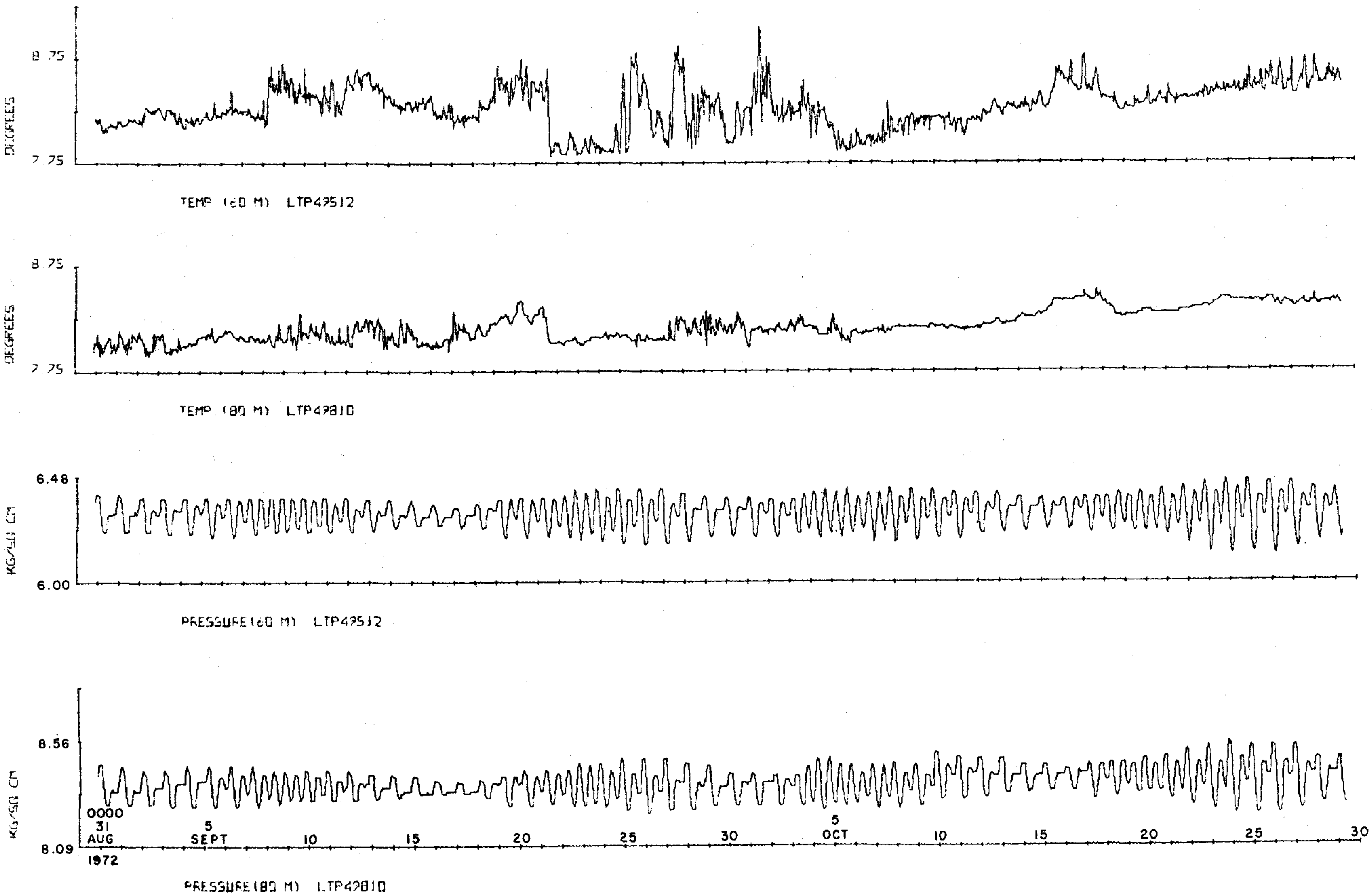


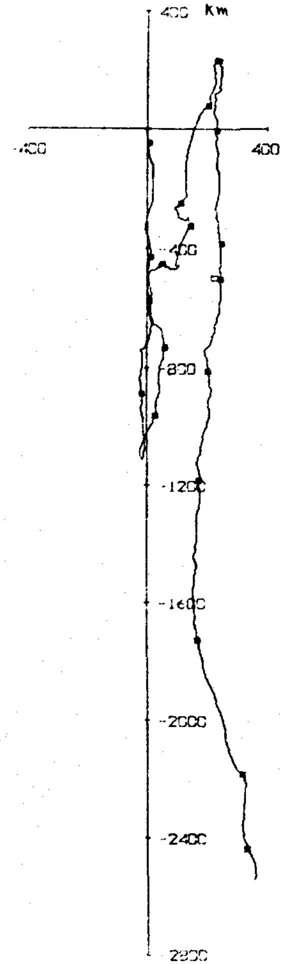
AIR TEMP (0 M) LTD7211

TEMP (25 M) LT43212

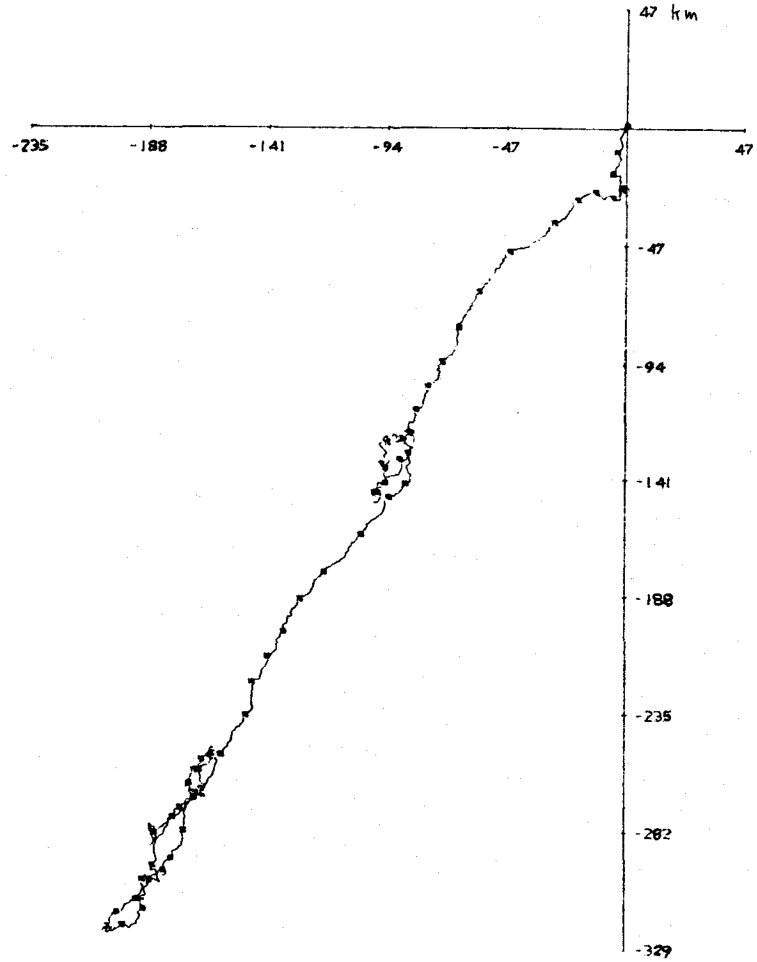


TEMP (40 M) LT4248

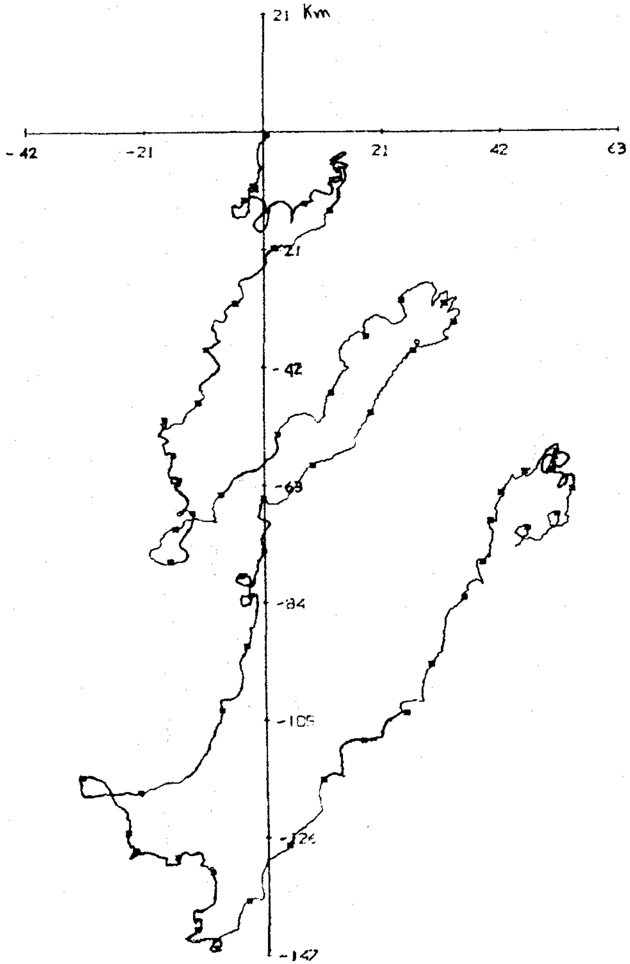

DEGREES
8.75
7.75
TEMP (60 M) LTP42512
DEGREES
8.75
7.75
TEMP (80 M) LTP42810
KG/SQ CM
6.48
6.00
PRESSURE(60 M) LTP42512
KG/SQ CM
8.56
8.09
0000
31
AUG
1972
5
SEPT
10
15
20
25
30
5
OCT
10
15
20
25
30
PRESSURE(80 M) LTP42810



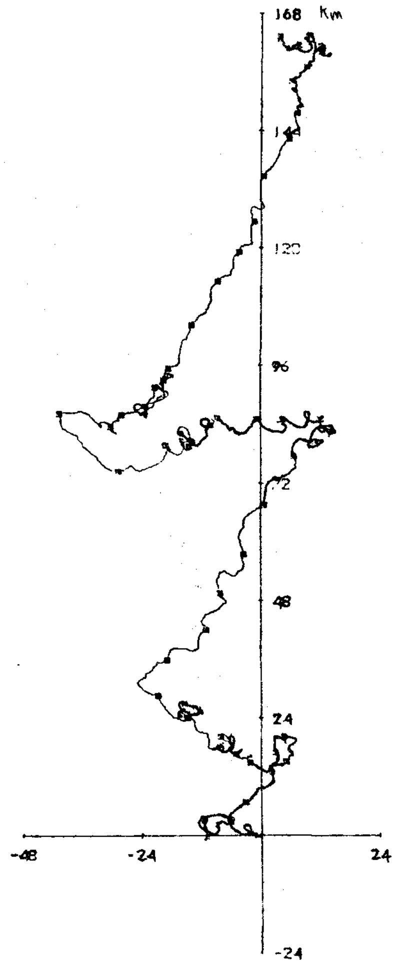
WIND AT NH-15. 19 DAYS STARTING 2153 8/30/72



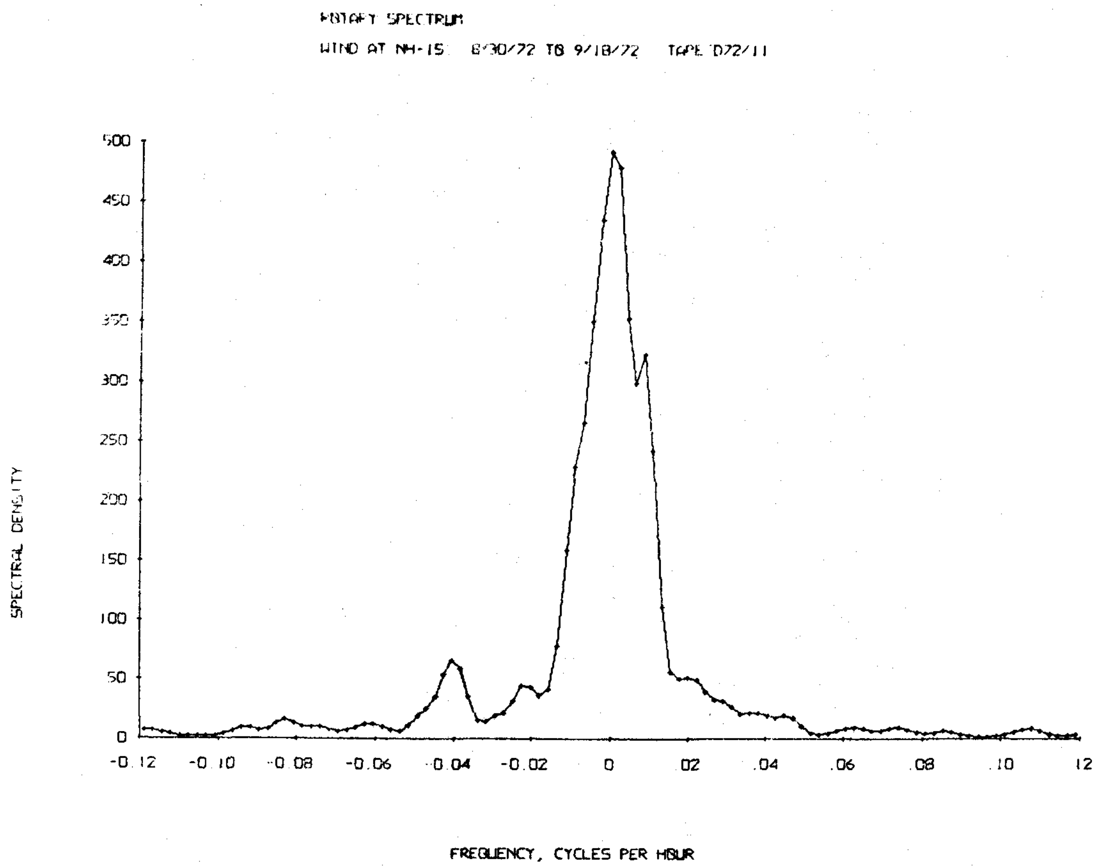
40 METERS AT NH-15. 61 DAYS STARTING 2145 8/30/72

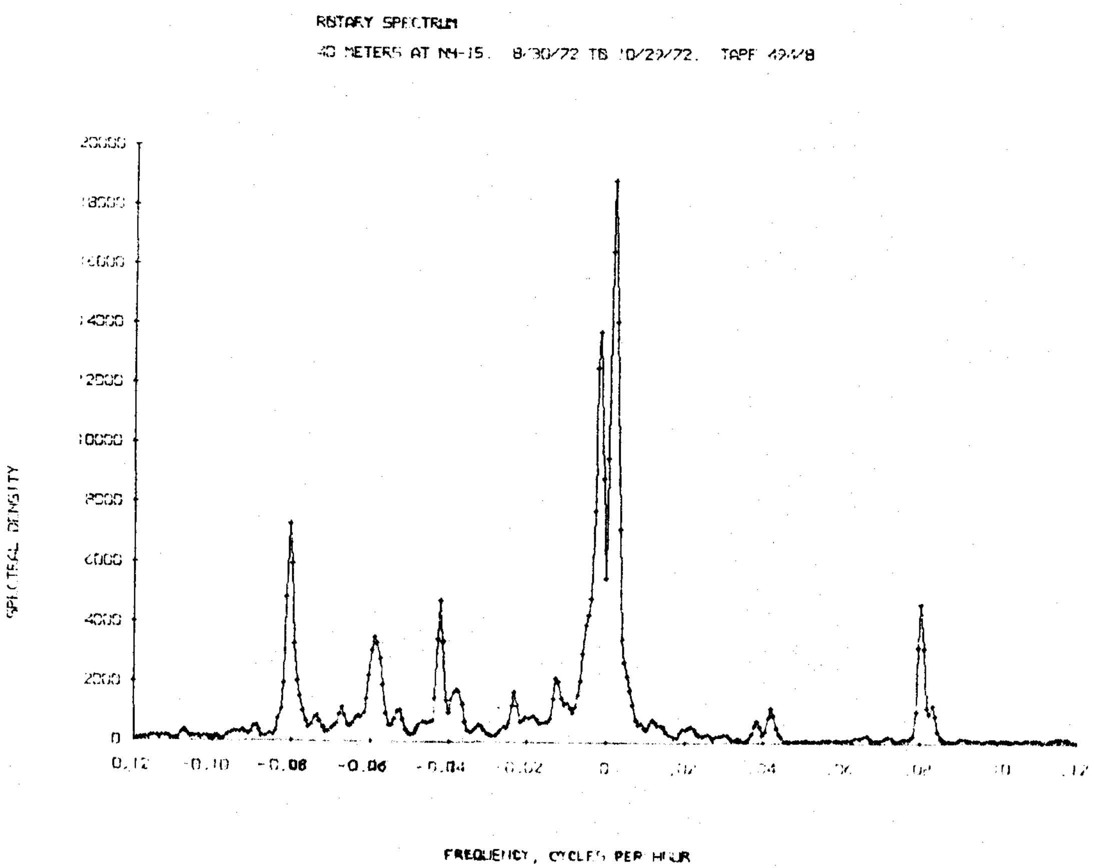


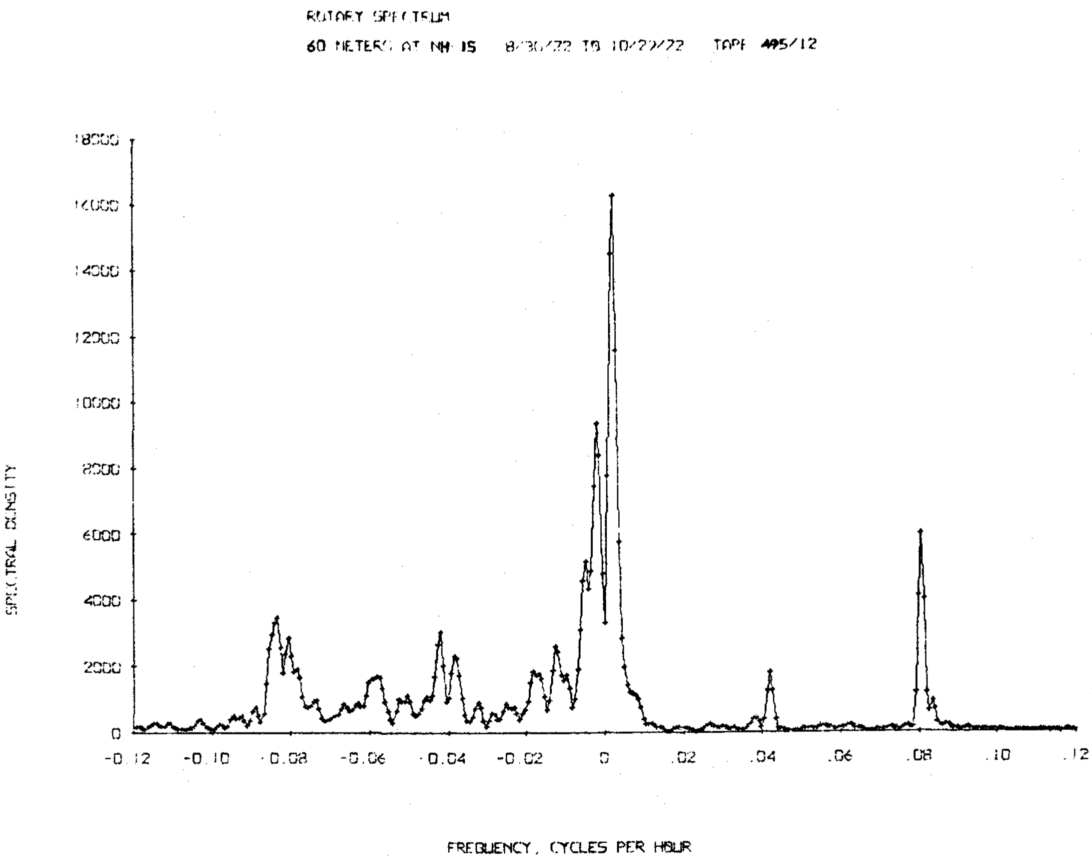
60 METERS AT NH-15. 61 DAYS STARTING 2146 8/30/72

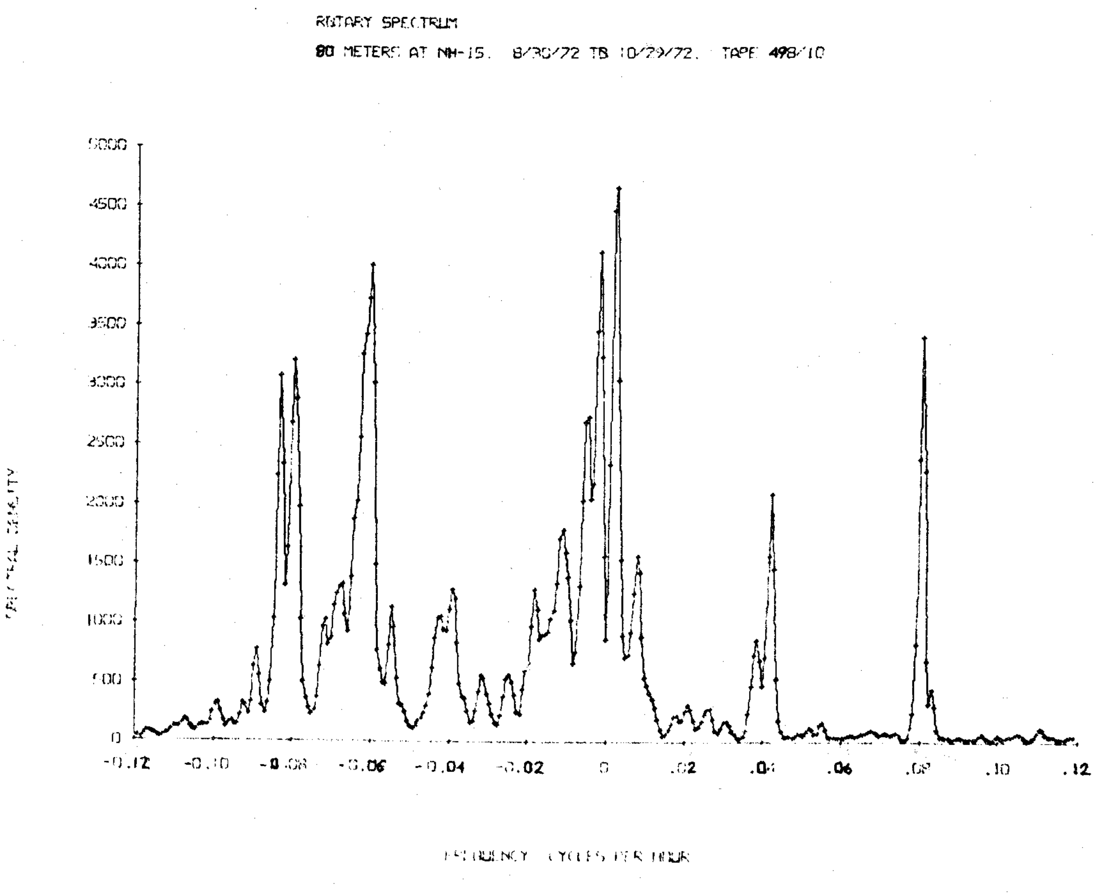


80 METERS AT NH-15. 59 DAYS STARTING 2156 8/30/72


ROTARY SPECTRUM
WIND AT NH-15 8/30/72 TO 9/18/72 TAPE D72/11
SPECTRAL DENSITY
FREQUENCY, CYCLES PER HOUR


ROTARY SPECTRUM
40 METERS AT NH-15. 8/30/72 TO 10/29/72. TAPE 49/8
SPECTRAL DENSITY
FREQUENCY, CYCLES PER HOUR


ROTARY SPECTRUM
60 METERS AT NH 15 8/30/72 TO 10/29/72 TAPE 495/12
SPECTRAL DENSITY
FREQUENCY, CYCLES PER HOUR


ROTARY SPECTRUM
80 METERS AT NH-15. 8/30/72 TO 10/29/72. TAPE 498/10
SPECTRAL DENSITY
FREQUENCY, CYCLES PER HOUR

APPENDICES

Appendix 1

A Description of the Aanderaa Current Meter used in CUE-I

A description of the Aanderaa RCM4 used in CUE-I

Reasons for choosing the RCM4

The Aanderaa Recording Current Meter Model 4 used as the primary current measuring tool in CUE-I was subjected to an extensive evaluation. The instrument was selected for several reasons:

- it was available and had a proven field history,
- it was inexpensive and relatively simple and small,
- it could record speed, direction, pressure, temperature, and conductivity, making each meter potentially a self-contained recording STD, and
- it was available as a meteorological package with only a change of sensors simplifying data processing and instrument preparation.

OSU Buoy group task for CUE-I

During CUE-I, the primary emphasis at OSU was on measuring currents with a secondary interest in meteorological measurements. With that in mind, some 30 RCM4's and five meteorological packages were ordered. We had on hand two RCM4's acquired for testing and evaluation. These two preliminary units were used to establish a procedure for evaluation for the new meters.

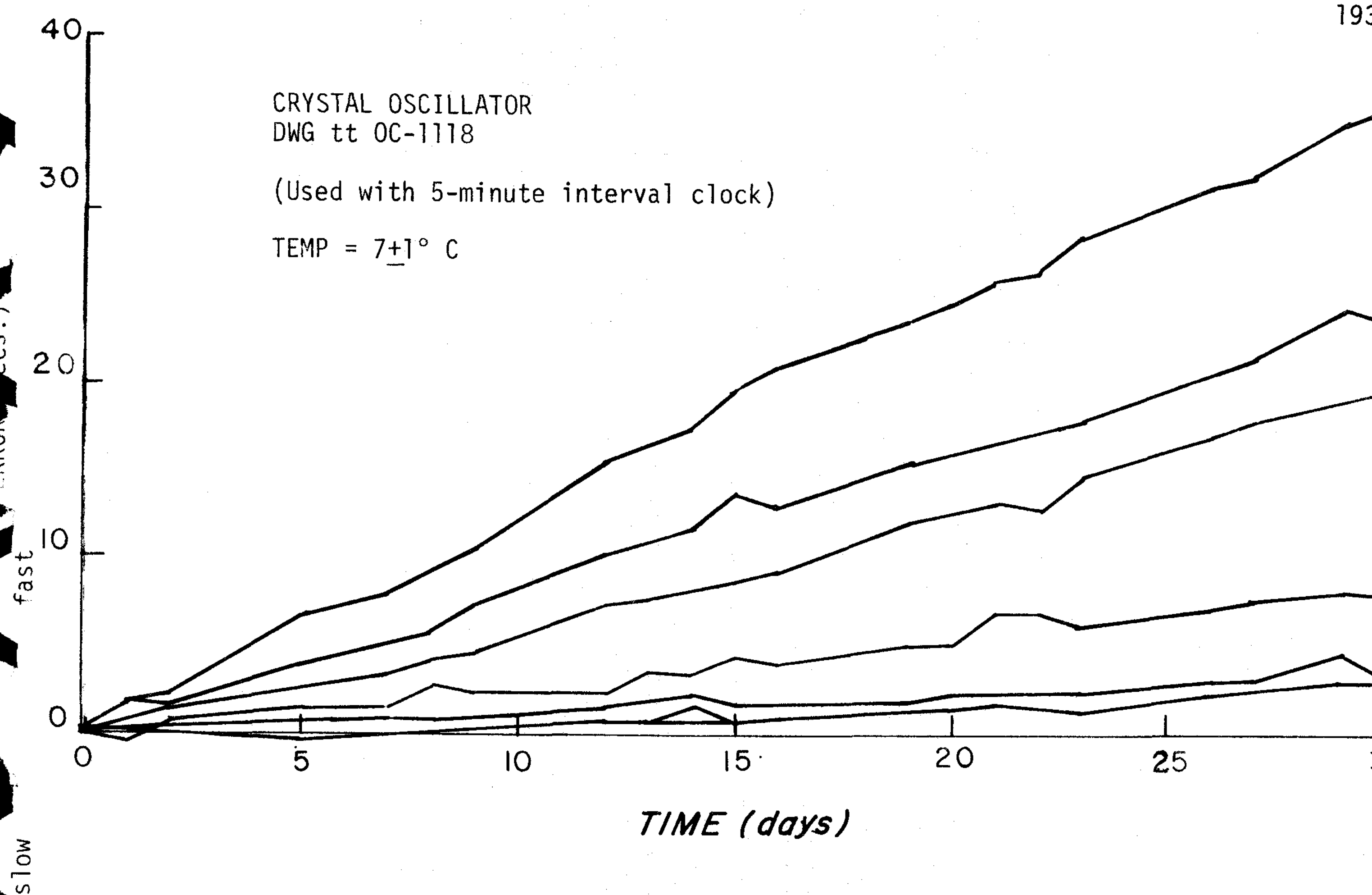
What was done following delivery of a new meter

A. Each meter was inspected for shipping damage, and all connections were tightened.

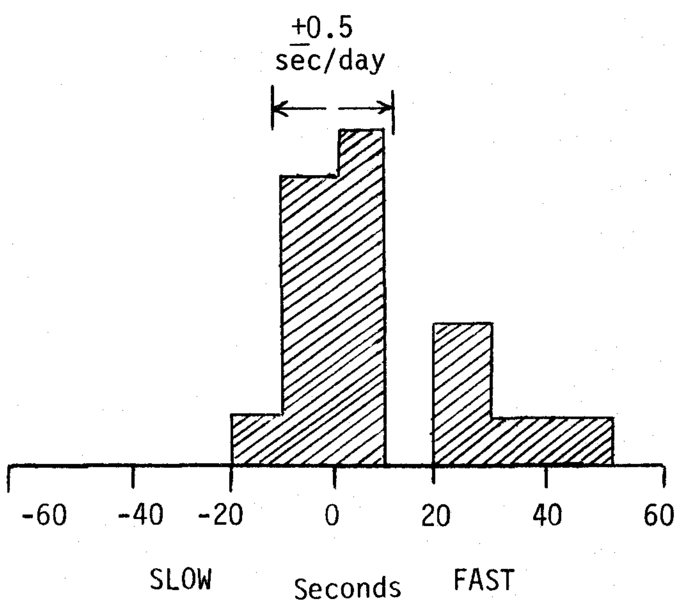
B. We had developed a quartz clock here at O.S.U. prior to knowing that Aanderaa had intended to supply one. Because of this, Aanderaa's clock was removed, and the one of our own design and manufacture was installed.

C. To check the new clock at the same time as the new meter, each meter was placed in a refrigerator cooled to about 7°C and was run on a five minute sample period for 30 days. At the start of this 30 day period the rotor was removed, and a constant speed hysteresis motor was mounted so that a magnet assembly attached to its shaft would simulate the rotor turning at a constant rate. Our intent with this test was to check for variations in sample period length and multiple sample periods. By using a constant speed motor the bit change recorded by the meter should be constant for each sample period. Battery life and tape capacity could also be checked. The starting time and duration of a sample was checked each day using WWV as a time standard. Battery voltage and the motor supply voltage were tested each day. Much of our clock testing is summarized in Figure 1-1.

D. Following the 30 day cold test each meter's temperature sensor was calibrated. Ten of our thirty meters had pressure transducers, and each of these pressure sensors was calibrated.



ACCUMULATED ERROR (6 TYPICAL UNITS)



Cumulative-Error Distribution
After 30 Days (19 Units)

Figure 1-1

Calibration of the Aanderaa RCM4 Temperature Sensor

The temperature bath used in the thermistor calibration is a 79 cm x 79 cm x 86 cm plywood box with a cylindrical fiberglass tank mounted inside. This tank has a volume of about 200 liters. Between the fiberglass tank and the outside plywood wall is 10 cm of rigid foam insulation. The tank will comfortably hold up to 10 RCM4's. In addition, water and air temperature sensors from meteorological data loggers can be attached to the bales of these current meters and plugged into dataloggers outside the bath, thus increasing the number of instruments that may be calibrated at one time. To stir the water and maintain a uniform temperature a Sargent cone-drive stirring motor is mounted in the lid of the tank. It is equipped with a stirring arm and propeller that project approximately 38 cm into the tank.

A Hewlett-Packard quartz thermometer (Model 2801A) is used in the calibration. This instrument has a temperature range of -80 to +250°C with a factory calibrated accuracy of .02°C absolute, traceable to NBS. It has a short-term stability of better than ± .0001°C and long-term stability with zero drift less than ± .01°C at constant probe temperature for 30 days. The quartz crystal probe is mounted on a current meter bale at the approximate level of the RCM4 thermistors. The read-out resolution is set at .01°C with a relatively rapid display interval.

The bath and the RCM4's are prepared for calibration in the afternoon of the day preceding the date of calibration. The RCM4's are started on a five min. sample period and are placed around the outside perimeter of the fiberglass tank with the quartz probe and the air or water temperature sensors to be calibrated fastened to the bales with electrical tape. Approximately 45 kg of ice is placed in the bath; then water is added until the instruments are completely submerged, and the thermistors and the probe are roughly 25-30 cm below the surface. The water-ice volume is about 150 liters. The bath is then left closed overnight to stabilize the temperature.

The following morning the remaining ice is removed, leaving as much water as possible. The bath's temperature is usually found to be stable between 0.00 and 1.00°C. Generally two readings per temperature level are taken. This gives 10 minutes of each temperature which insures a fair level of stabilization. It has been found that, if necessary, 5 minutes allows a sufficient degree of stabilization to take place, i.e. the difference between the first reading and the second reading is no more than .03°C.

The calibration range is from the starting temperature (0.00 - 1.00°C) to 22°C (21.48°C is the maximum for the RCM4 thermistors in our meters). After the readings are taken at some temperature, the temperature of the bath is raised with an attempt to keep the increase close to 1°C. This is done initially by adding approximately 925 cm^3 of nearly boiling water. As the volume of the water in the bath increases, an additional 925 cm^3 of hot water from the hot water faucet is added. When the volume added each time reaches the level of 925 cm^2 heated water and 2,800 cm^3 hot faucet water, then 2,900 cm^3 is removed from the bath before approximately 3,200 cm^2 is added (925 heated, the rest from hot water faucet). After the hot water is added the lid of the bath is closed and the stirring motor runs continuously for the 10 minute (or 5 minute) sampling interval.

Table 1-1 shows the resulting temperature as calculated for a bit reading of 551. The change of temperature calculated (Δt) is in the range of digitization error.

TABLE 1-1

Meter Number	Pre Calibration Temperature	Post Calibration Temperature	Difference
268	10.66	10.70	0.04
317	---	---	---
438	10.00	10.05	0.05
439	10.17	10.22	0.05
440	---	10.05	---
441	9.99	10.02	0.03
442	10.06	---	---
452	10.01	10.05	0.04
453	10.04	10.08	0.04
454	9.99	10.02	0.03
455	10.04	10.06	0.02
456	9.99	10.02	0.03
485	10.06	---	---
486	---	9.95	---
487	10.05	10.09	0.04
488	10.09	10.11	0.02
489	10.03	10.06	0.03
490	10.04	10.06	0.02
491	10.01	10.05	0.04
492	10.05	10.09	0.04
493	10.03	10.07	0.05
494	10.05	10.07	0.02
495	10.00	10.03	0.03
496	10.05	10.07	0.02
497	9.98	10.00	0.02
498	10.08	10.13	0.05
499	10.00	10.08	0.08
500	10.06	10.10	0.04
501	10.08	10.05	0.03
502	10.04	10.07	0.03
503	10.11	10.18	0.07
504	10.05	10.12	0.07
Mean	10.06	10.09	0.038

Calibration of the Aanderaa RCM4 Pressure Sensors

A pressure calibration facility for the Aanderaa RCM4 pressure sensors was constructed in early June 1972. The apparatus consists of a source of hydraulic pressure ("Porta Power" made by Blackhawk), a manifold for distribution of equal pressure to five pressure transducers, and a laboratory quality pressure gauge (made by Ashcroft). The precision of the gauge is $\pm$ 0.035 kg/cm^2.

The first calibration run was made on RCM's # 498, 499, 500 and 501. The range of the calibration was from 4.43 kg/cm^2 to 13.0 kg/cm^2. Eighteen points were taken in the range with an attempt to take a point every 0.7 kg/cm^2. A second calibration was made using RCM's # 502, 503 and 504. On this run the pressure range was from 3.55 kg/cm^2 to 12.4 kg/cm^2. Again, some eighteen points were taken in the range, spaced some 0.7 kg/cm^2 apart.

A third calibration was made on RCM's #495, 496, 497 and 317. This run was similar to the previous two in range and number of points taken. RCM # 317 was fitted with a pressure transducer whose range was from 0 - 35 kg/cm^2 while all the others calibrated were fitted with transducers whose range was from 0 - 14 kg/cm^2.

The CUE-I post calibration was done on November 30, 1972, for meters # 496, 497, 498, 500 and 501; on December 1, 1972, for meters # 499, 502, 503, and 504; and January 5, 1973, for meter # 495. The procedure used was the same as for the previous calibration.

Table 1-2 shows the pressure difference calculated using the two sets of calibration data. The pressure difference for a single bit change at this pressure is about 0.02 kg/cm^2.

TABLE 1-2

Meter Number	Precalibration Pressure @ 534 bits kg/cm^2	Post calibration Pressure @ 534 bits kg/cm^2	Difference
495	7.40	7.36	0.04
496	7.51	7.50	0.01
497	7.55	7.55	0.00
498	7.13	7.14	0.01
499	7.49	7.50	0.01
500	7.45	7.48	0.03
501	7.44	7.44	0.00
502	7.45	7.44	0.01
503	7.47	7.46	0.01
504	7.56	7.54	0.02
Mean	7.44	7.44	0.02

Calibration of the Aanderaa RCM4 Compass

The construction of a compass calibration facility at O.S.U. has been invaluable to the success of the current measuring program. After several attempts at design, a final version of the rotating portion of the compass stand is shown schematically in Figure 1-2. Four meters can be calibrated during a run. Each run has consisted of setting the meters on a 2 1/2 minute sample period, putting the meters on the compass stand, and rotating the stand 10° per sample period through 360°, generally followed by some extra samples at varying directions.

This procedure has been found very useful, both for giving good compass calibrations and for indicating bad compasses. We have had more compass failures than all other sensor failures combined. Most of the failures were due to shipping damage. We deduce this from knowledge that the compasses were operational when packed at the factory in Norway and were non-functional at delivery at O.S.U. There are several kinds of compass failure, but careful calibration indicates what kind of failure.

A good compass is one which repeats its calibration curve when recalibrated, and which gives meaningful bit values every ten degrees. By repeating its calibration curve we mean within 3°. Each compass has its individual characteristics; some of which we do not fully understand. Most of the compasses repeat within 1°, while all have repeated within 6°. Some compasses have failed during the CUE-I field program, and the post calibrations indicate clearly which these are so that repairs can be made.

Figures 1-3 and 1-4 show a typical calibration curve. Table 1-3 gives an indication of the compass to compass variation in the calibration curve.

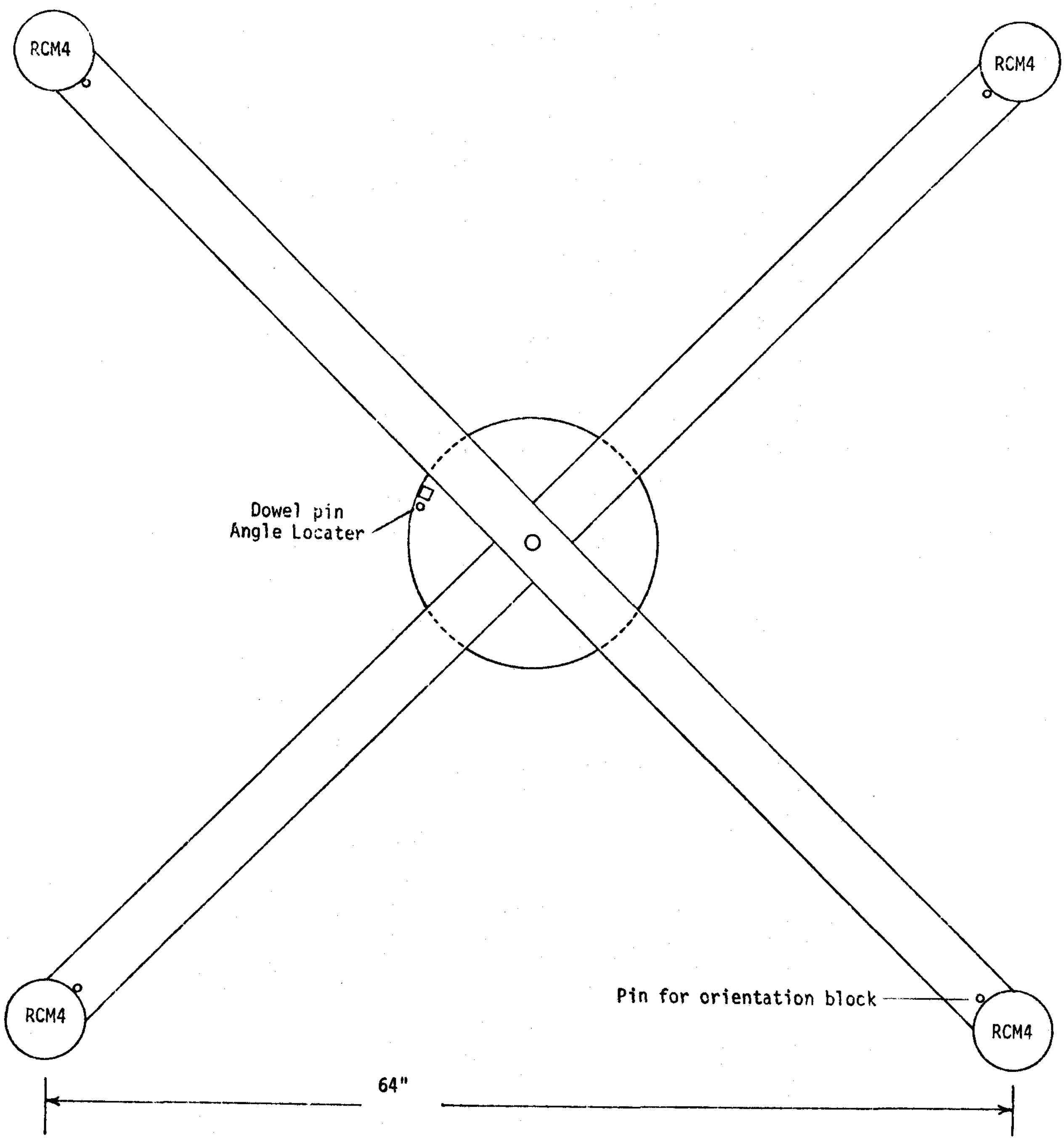

RCM4
RCM4
Dowel pin
Angle Locater
RCM4
Pin for orientation block
RCM4
64"

Figure 1-2

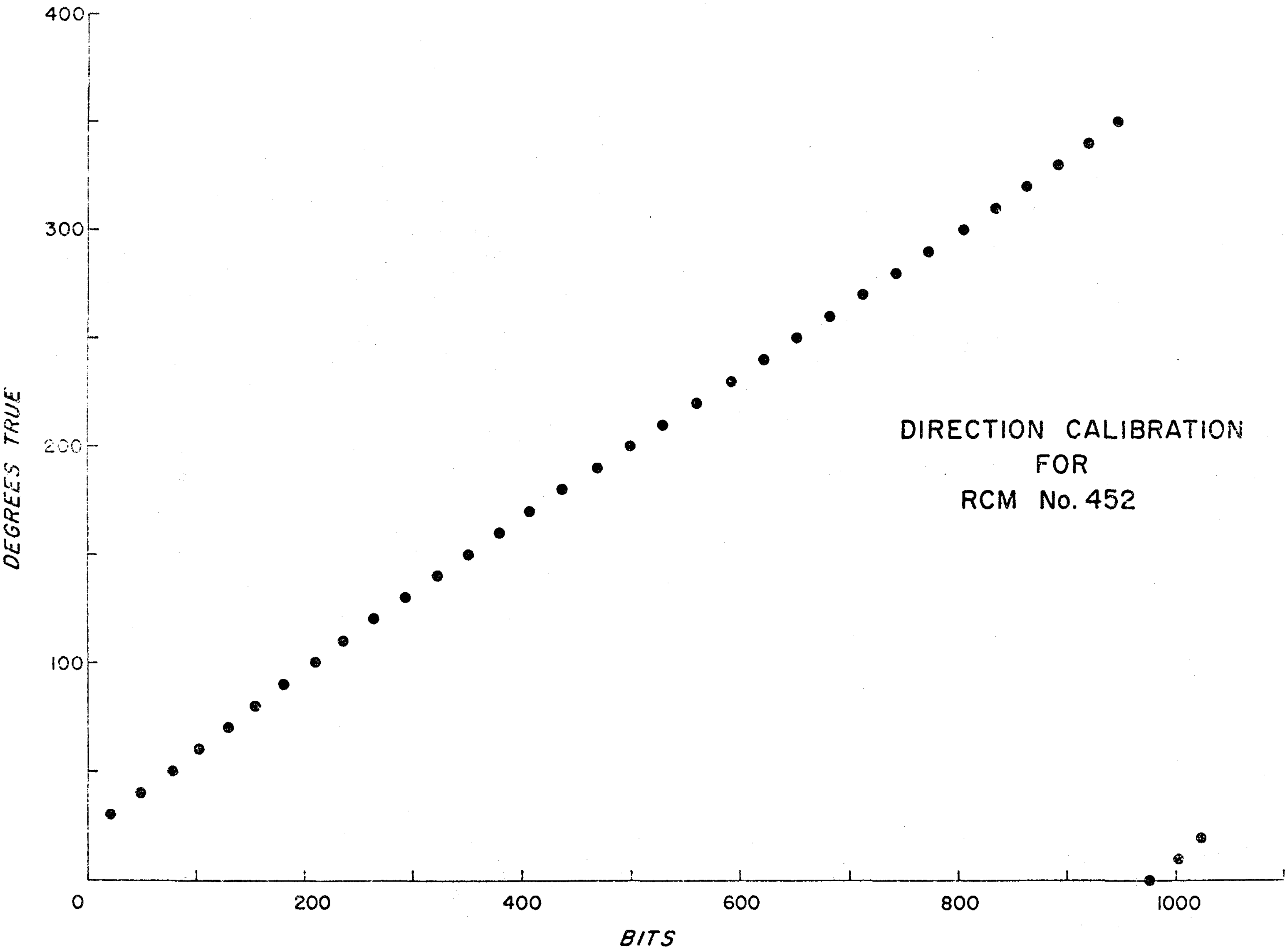

DIRECTION CALIBRATION
FOR
RCM No. 452
DEGREES TRUE
BITS
0
100
200
300
400
0
200
400
600
800
1000

Figure 1-3

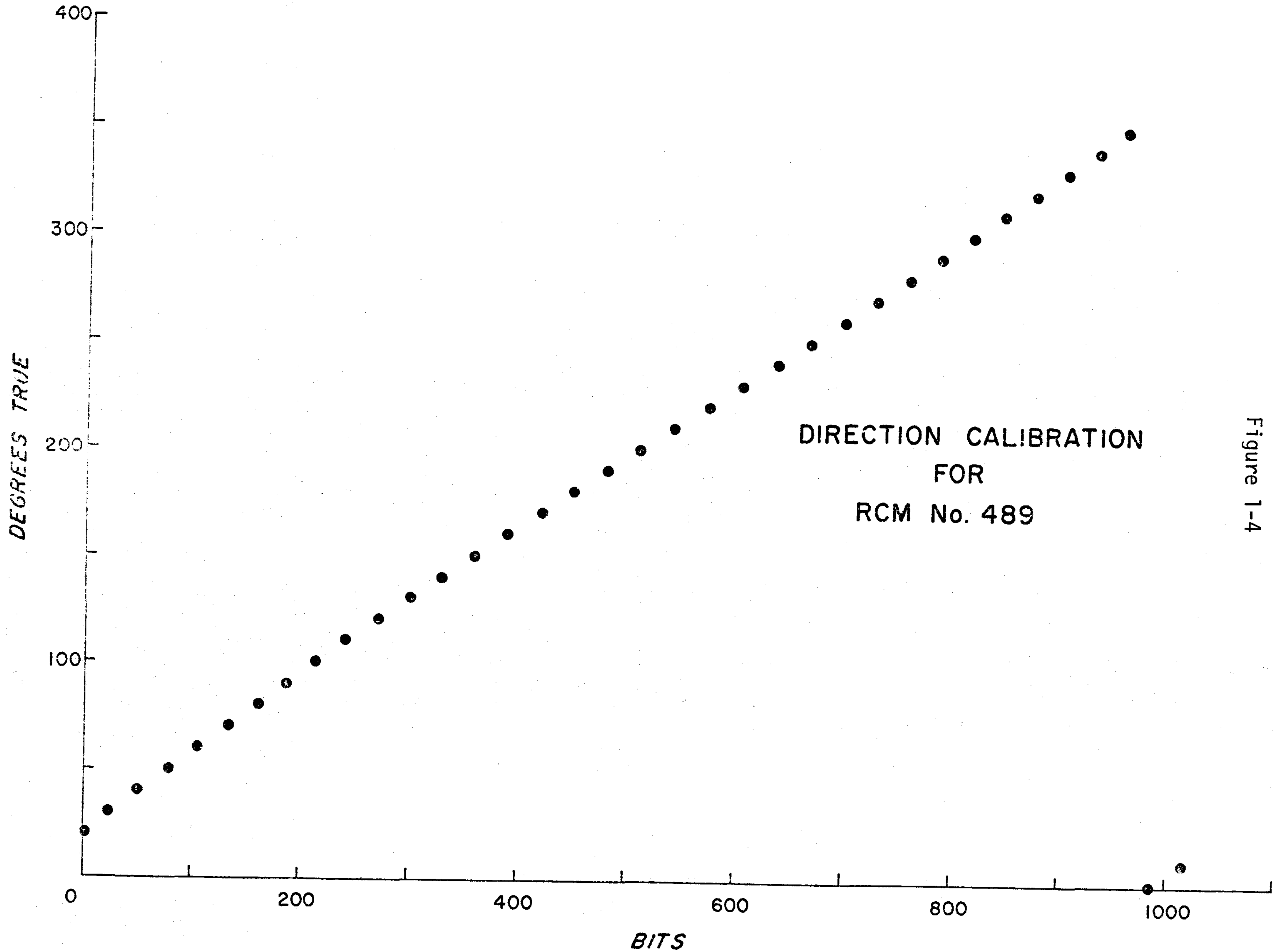

400
300
200
100
0
200
400
600
800
1000
DEGREES TRUE
BITS
DIRECTION CALIBRATION
FOR
RCM No. 489

Figure 1-4

We intend to enlarge on Table 1-3 in the future giving the statistics for every ten degree value. It is clear from Table 1-3 that it is worthwhile calibrating and treating each compass as an individual instrument.

TABLE 1-3

Meter No.	0°	90°	180°	270°
268	996	216	458	719
438	980	189	418	693
439	940	172	441	698
440	973	170	427	712
441	963	185	453	712
442	978	192	436	705
452	976	182	439	713
453	982	195	435	711
454	966	189	450	706
455	975	182	446	720
456	999	204	446	716
485	979	190	428	688
486				
487	965	185	461	720
488	947	182	462	715
489	988	188	451	729
490	965	196	479	728
491	984	204	444	710
492	952	179	455	708
493	978	189	430	695
494	982	198	445	712
495	979	201	455	722
496	955	189	459	706
497	963	187	433	695
498	968	185	418	682
499	971	200	468	726
500	982	190	424	696
501	964	204	455	694
502	974	183	422	695
503	981	188	408	688
504	952	192	438	684
Mean	972	190	443	707
St. Dev. (bits)	14	10	16	13
St. Dev. (degrees)	5	4	6	5
Max.	999	216	479	729
Min.	940	170	408	682
Range (bits)	59	46	71	47
Range (degrees)	21	16	25	16

Calibration of the Aanderaa RCM4 Speed Sensor

Our past experience with current meter rotors indicated that for speeds several cm/sec above threshold the calibration of all rotors of a given type can be considered equal. Part of our calibration work was designed to test this concept.

In March of 1972 four combinations of rotors and meters were calibrated at the Division Hydraulic Laboratory of the Corps of Engineers, U.S. Army, Bonneville, Oregon. (For a general discussion of the calibration facility at Bonneville see Johnson, 1966). Figure 1-5 shows the result of this calibration and the line in that figure is given by

$$S \text{ cm/sec} = 1.307 + 4.408 \frac{\Delta b}{\Delta t} - 0.019904 \left(\frac{\Delta b}{\Delta t} \right)^2$$

where revolutions/min = 5.80833 $\Delta b/\Delta t$ for a 6000:1 gear train in the meter.

A repeat of this calibration done in January 1973 with nine combinations of rotors and meters gives

$$S \text{ cm/sec} = 1.727 + 4.356 \frac{\Delta b}{\Delta t} - 0.01509 \left(\frac{\Delta b}{\Delta t} \right)^2$$

All of the data from both calibrations are shown and the two curves lie on top of each other. The differences calculated from the two equations range from 19% at 2 cm/sec to less than 1% at 30 cm/sec with a 4% difference at 8 cm/sec which is generally close to the lowest observed speed. One can conclude from these data that for speeds below 10 cm/sec one should calibrate each rotor with its corresponding meter. But since our mean speeds are generally between 20 and 30 cm/sec we choose not to calibrate each meter separately.

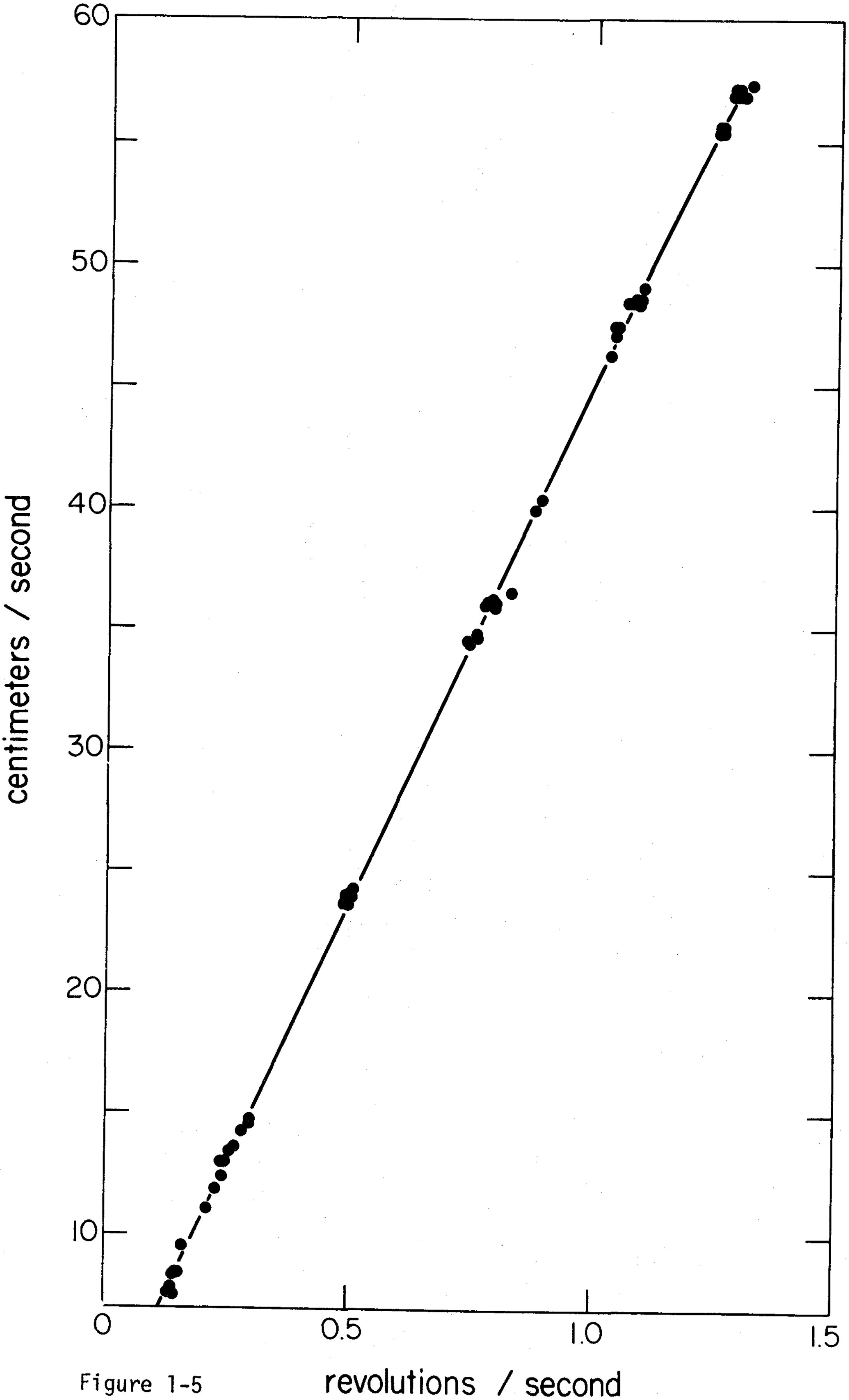

60
50
40
30
20
10
0
0.5
1.0
1.5
centimeters / second
revolutions / second

Figure 1-5

REFERENCES

Johnson, R. L. 1966. Laboratory Determination of Current Meter Performance. Technical Report No. 843-1, Division Hydraulic Laboratory, U. S. Army Engineer Division, North Pacific, Corps of Engineers, Bonneville, Oregon. 33 pp.

Appendix 2

A Description of the Processing of Data from the Aanderaa Current Meter

Introduction

During the summer of 1972 the Coastal Upwelling Group at Oregon State University undertook the measurement of currents and winds off the Oregon coast, using Aanderaa current and wind meters. The current meter selected, the RCM-4, is a six channel instrument that records water temperature, conductivity, pressure, speed, and direction (in addition to a constant reference number). Winds were measured by means of a four-sensor package connected to an Aanderaa Datalogger. The Dataloggers recorded wind speed and direction, air temperature, and surface water temperature. Most of the discussion below will be in terms of the current meters. Instances in which the wind instruments required different processing or analysis will be called out.

Aanderaa current meters and Dataloggers record on standard open-reel quarter-inch magnetic tape. The first part of the data processing operation is concerned mainly with getting the information off the tape and making it available for computer analysis. The second part is the analysis itself. In all there are four steps: (1) tape-to-tape transcription (i.e., moving the data from quarter-inch magnetic tape to computer compatible tape), (2) conversion to physical units, (3) error detection and correction, and (4) data analysis. Each of these steps will be described in detail below. The procedure has been automated and much of the work is done by the computer. During CUE-I, all computer work was done on the OSU Computer Center's CDC-3300.

The RCM-4 records 10-bit binary words. Each bit is represented by a magnetized portion of the tape extending 2 mm inward from the edge (see Figure 2-1). Redundancy is achieved by writing the same information

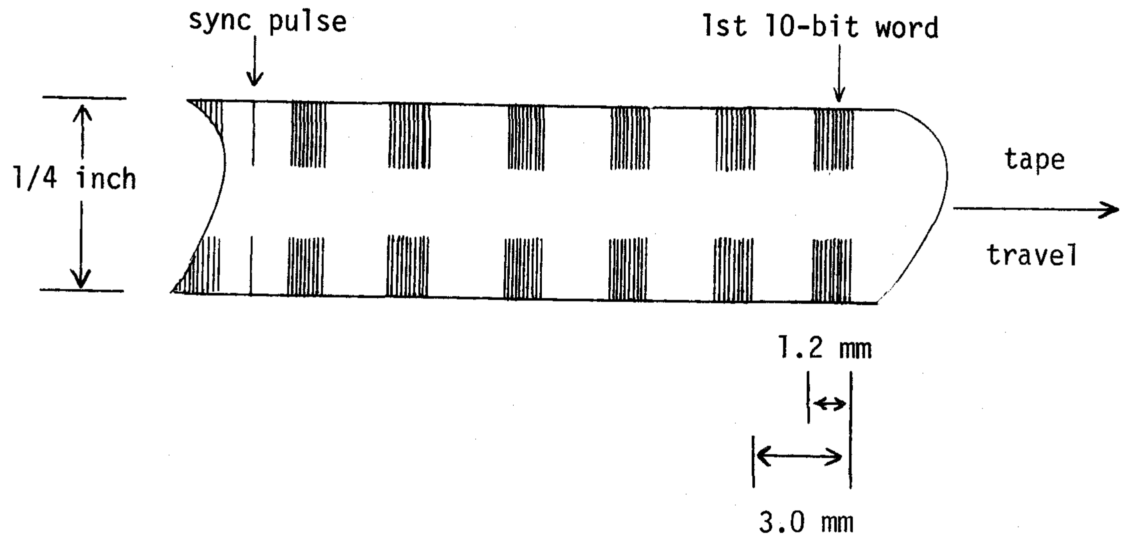


Figure 2-1. Aanderaa tape format, showing one complete 6-word cycle.

along both edges of the tape. Binary zeros are about 0.06 mm long (measured along the tape) and ones are 0.02 mm long. The spaces between bits are unmagnitized, and the entire 10-bit word is about 1.2 mm long. The first bit of each word (the righthand bit in Figure 2-1) is the most significant.

Each time the RCM-4 cycles, six binary words are written on the tape. The first word is a quasi-constant reference word that is wired into the current meter and serves to identify output from that meter. Each meter has a different reference word. The reference word seldom varies by more than one or two units; these variations are caused by the effect of temperature changes on resistors inside the meter. The second of the six words codes temperature, the third codes conductivity, the fourth pressure, the fifth direction, and the sixth speed. In most meters a sync pulse appears a short distance after the sixth word. In form it resembles a binary one, and is meant to indicate the end of a cycle. Not all RCM-4s have conductivity or pressure sensors. When the conductivity sensor is lacking the meter will record words consisting of all zeros in the conductivity channel. When the pressure sensor is lacking, all ones will be written in the pressure channel.

A ten-bit binary word is capable of representing numbers in the range [0, 1023]. Hence the meter must translate each measurement into a number in this range. It does this by means of mechanical and electrical devices that need not concern us here. The important point is that every temperature, conductivity, pressure, speed, and direction will be represented by a number in the range [0, 1023]. The calibration curves for these quantities are nearly linear, so that temperature in degrees centigrade (for example) can be found from a relation of the form

$$T = a + bx$$

where x is an integer between 0 and 1023 provided by the current meter, and a and b are calibration constants. Conductivity, pressure, and current speed and direction can be calculated from similar equations.

Speed is handled somewhat differently from the other four parameters. The speed rotor of the RCM-4 is coupled to a circular potentiometer inside the instrument via a magnetic link and a gear train that effects a 6000:1 reduction. 6000 turns of the exterior rotor cause an electrical contact to make one circuit of the potentiometer, which causes a resistance to vary from zero to a fixed maximum value. It is this resistance that is measured, translated into a number between 0 (corresponding to zero resistance) and 1023 (corresponding to maximum resistance), and written on quarter-inch tape. Thus the speed channel of RCM-4 output contains a monotone nondecreasing sequence of integers modulo 1024. Speeds are calculated from the difference between consecutive integers. The larger the current speed, the more turns the exterior rotor makes during a recording cycle and the farther the moving potentiometer contact advances. The relationship between speed in physical units (e.g., cm/sec) and bit advance (ΔX, say) is nearly linear, so that speed also can be calculated from a linear equation:

$$S = c + d\Delta x$$

Tape-to-Tape Transcription

Although the output of an Aanderaa meter is in digital form it cannot be read directly by a computer. The first step in processing, then, is to move the data from the quarter-inch Aanderaa tape to computer tape. Two Aanderaa tape translators are presently available at OSU. One has been interfaced to the School of Oceanography's PDP-15 computer. It consists of a modified Sony TC 252-D tape deck and circuitry that assembles the 10-bit words and makes them available to the PDP-15. Software transfers the data to Dectape which is then taken to the OSU Computer Center, where the information is read into disk storage by the Center's PDP-8 satellite computer. The data are then ready for further processing by the CDC-3300.

The second translator is a stand-alone unit that reads quarter-inch Aanderaa tapes and writes the data on half-inch computer-compatible 7-track magnetic tape. This machine is more convenient than the first, and was used for most of the CUE-I data. With it, tapes are read by the modified Sony TC 252-D tape deck and the data are routed to a Digidata 1307/556 RW tape recorder. The latter unit writes characters that consist of 6 data bits and a parity bit, at a rate of 556 characters per inch. Each Aanderaa word occupies two characters as shown in Figure 2-2. The Digidata produces records consisting of 400 characters followed by a 3/4 inch record gap. Each record thus contains 200 Aanderaa words. This continues until the end of the input tape, at which point the Digidata automatically writes an end-of-file mark. Several Aanderaa tapes can be transcribed at a single session. Thus a typical 7-track output tape contains several files, each terminated by an end-of-file and consisting (ordinarily) of several hundred 400 character records. This tape is taken to the OSU Computer Center and its contents are read into disk memory by means of a program (run on the CDC 3300) named AMMT2FLB.

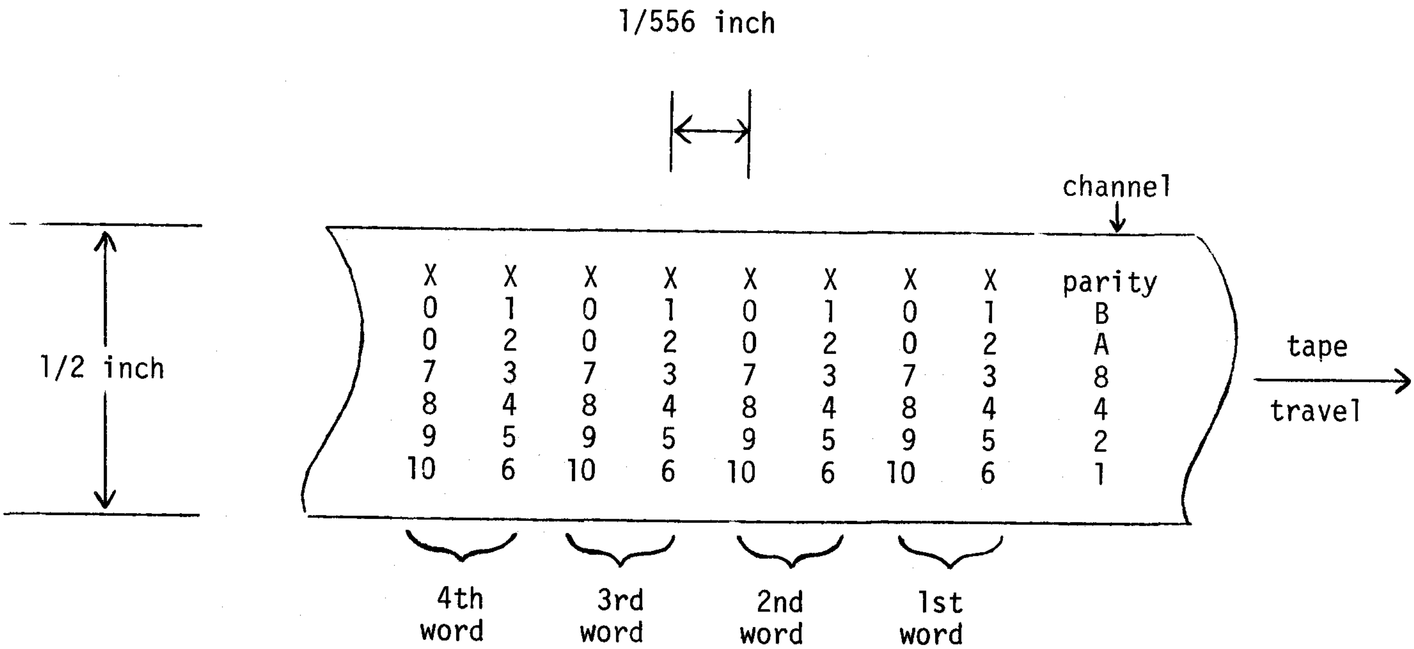


Figure 2-2. 7-track magnetic tape format. X denotes a parity bit and the integers 1 through 10 denote the bits of an Aanderaa word, 1 being the most significant bit and 10 the least significant. Zeros are always written in the B and A channels of every 2nd character, as shown.

AMMT2FLB (this is an acronym for Aanderaa Meter Magnetic Tape to File, Version B) is run as a batch job. Its inputs consist of the 7-track tape and as many data cards as there are files on the tape. The nth data card contains the name under which the nth file is to be stored on the disk. After AMMT2FLB has been run, the files are available for processing by the CDC 3300.

Conversion to Physical Units

After the data have been placed in disk memory they are converted to BCD form. In general, at all stages of the processing our practice has been to keep the data in BCD rather than binary, core image form. Although binary data are more compact and can be used in calculations more cheaply than BCD data, the latter can be listed more easily and inexpensively, and can be made accessible to other computers more readily. The program that effects the binary-BCD conversion is named AMFL2R (for Aanderaa Meter File to Raw). It reads the 200-word binary records and produces a BCD file in which each record consists of the six numbers recorded during a single current meter cycle, followed by a record count. If the meter is an RCM-4 the reference word is first, followed by temperature, conductivity, pressure, direction, and cummulative speed, in that order. Each data word is an integer in the range [0,1023] and is preceded by four blank spaces. The record count that follows the six data words is 1 for the first cycle, 2 for the second, and so on. This file is called the undated raw data.

In the case of CUE-I Datalogger output, AMFL2R produces a file consisting of records in which the reference word is first, followed by air temperature, water temperature, wind direction relative to the buoy, buoy orientation, wind speed, and the record count. For a Datalogger this order is in general variable and is determined by the way in which the sensor leads are plugged into the Datalogger; the order given above was used with all the CUE-I surface buoys. (The sequence of data words within an RCM-4 cycle is fixed, determined by hard-wired connections in the machine.) AMFL2R and all subsequent computer programs that will be mentioned here are run from the teletype, under the OSU time-sharing system.

The next step in processing is to date the raw data. Each time a current or wind meter is moored the start and stop times (i.e., the times of the first and last cycles) are recorded. From these one can calculate the number of cycles during the mooring. If this equals the number of records in the raw data file, processing can proceed; if the two numbers are not equal it is necessary to list the undated raw data and check it in detail to find the cause of the discrepancy. Assuming the raw data file has the correct length, a new file is created which differs from it in that a date and time of day have been placed at the left of each line (or record). This is the dated raw data. The new file is produced by a program called AMDATE6. A line-printer listing of this file is obtained and stored permanently; the file is also stored permanently on magnetic tape.

Recall that the raw data consist of integers in the range [0,1023]. The next and final step in this stage of the processing is to convert these analog values to physical units, i.e., temperatures in degrees centigrade, directions in degrees, etc. To do this we need calibration constants for the sensors. Although all of these sensors produce outputs that are related inputs in a nearly linear way, we elected to increase precision by using quadratic calibration curves (except with direction, which will be discussed separately). Thus temperature, pressure, and speed during CUE-I were calculated from relations of the form

$$T = a_T + b_T x_T + C_T x^2_T$$

$$P = a_P + b_P x_P + C_P x^2_P$$

$$S = a_S + b_S \Delta x_S + C_S \Delta x^2_S$$

The temperature and pressure constants were evaluated separately for each meter, since it was found that they varied significantly from meter to meter and a common value could not be used. The speed calibrations, on the other hand, were sufficiently similar from meter to meter, and the expense of calibrating every meter individually was so great, that a single a_S, b_S, and c_S were used for all the meters. The speed constants for the current meters were

$$a_S = 1.307$$

$$b_S = 0.8816$$

$$c_S = -0.0007962$$

for a cycle time of five minutes and speeds in cm/sec. A linear fit to the same points that yielded the quadratic fit shown above gave

$$a_S = 1.773$$

$$b_S = 0.8282$$

which can be compared to the manufacturer's own calibration:

$$a_S = 1.4$$

$$b_S = 0.83$$

Directions were handled in a somewhat different way. Prior to mooring, each RCM-4 was placed on a test stand and rotated through a full circle in 10° increments. At each position the meter was cycled and the analog direction (a number between 0 and 1023) was recorded. The result was a calibration curve giving the analog values corresponding to current directions of 0°, 10°, 20°, etc. Linear interpolation was used to find the direction corresponding to each analog value from 0 to 1023. The result was a table of 1024 numbers, in which the nth was the direction (in degrees relative to true north) associated with an analog value of n. Directions were then calculated by a simple table look-up.

Since none of the current meters had conductivity sensors during CUE-I, no conductivity calculations were made. Channel 3 was always zero in the raw data.

Air temperature, water temperature, and wind speed as measured by the surface buoys were handled in essentially the same way as current meter temperatures and speeds. Each temperature sensor was calibrated individually and a quadratic fit to the calibration points was obtained. Wind speeds, however, were calculated from the linear relation provided by the manufacturer:

$$S = 0.465 \frac{\Delta X_s}{\Delta t} \text{ m/sec}$$

where ΔX_s is the speed advance and Δt is the cycle time in minutes.

Wind direction as measured by an Aanderaa weather station is the sum of two numbers: wind direction relative to the buoy, and buoy orientation. These are provided by two independent sensors. During CUE-I all the buoy orientation and relative wind direction sensors were calibrated individually, and direction look-up tables were prepared in the same way as for current direction.

Raw data are converted to physical units (cm/sec, degrees centigrade, etc.) by a single pass through a computer program named AMR2P6. This program reads a dated raw data file line-by-line and produces a processed data file. Each line of the latter represents one current meter or Datalogger cycle and contains a date, time (GMT), speed, direction (toward which the current or wind was moving), u component, v component, temperature (two temperatures in the case of a surface buoy: air temperature and that of the water about two meters below the surface), possibly a pressure, and a line count. In most CUE-I moorings only the deepest current meter was equipped with a pressure sensor. Pressures are given in units of kg/cm^2 in the CUE-I data. This is a convenient unit because multiplied by ten it yields the approximate depth in meters of the sensor.

Conversion of analog temperatures, pressures, and directions to physical units by means of the calibration curves is straight-forward. A special procedure is needed with speed, however, since speed is calculated from the slope of a sawtooth function. The problem occurs where the analog speed value passes from 1023 to 0. The speed potentiometer of each Aanderaa meter has a small gap at this point, about three degrees wide, where the output is indeterminate: it can be anywhere in the range [0, 1023], though 1023 is most probable. Our practice has been to calculate speed at such points by interpolating linearly between the slopes before and after this crossover. This is done automatically by AMR2P6; no human intervention is needed.

Error Detection and Correction

The error detection procedure is straightforward but time-consuming, since it requires direct human participation and judgment. As soon as the raw quantities have been converted to physical units they are plotted as functions of time (on the Calcomp plotter). Each plot is then examined by eye and errors are noted. This is done for speed, pressure, and temperature, but not for direction. Direction ordinarily is quite noisy and we have found that plots of direction versus time are not useful in locating direction errors.

There are several possible sources of error in an Aanderaa record. One is the meter's encoder. The probability is small but finite that a given electrical resistance will be incorrectly balanced and encoded. Another more likely error source is nonuniformity in the quarter-inch magnetic tape. The tape is degaussed before installation but there is no assurance that all magnetism has been removed. In addition the tape may have variations in coating thickness and composition that affect the recording. Another error source is the tape transcriber itself, which like all digital devices occasionally drops a bit. Errors in which a bit is reversed somewhere during the encoding, recording, or transcription are easy to find if the bit in question is a high-order bit. If a low-order bit is reversed the error may be within the noise level of the instrument or the phenomenon being measured, and in that case will not (and need not) be noticed.

Another type of error, peculiar to the speed parameter, occurs when the meter's speed output, which usually increases by nearly uniform amounts from cycle to cycle over the short term, suddenly shows a very small increase followed by a large one, such that the average of the two is close to the local average increase. The opposite pattern, in which an abnormally large increase is followed by a small one, is also found. We have hypothesized that events of this kind may be caused by nonuniformities in the speed potentiometer winding. We do believe they are errors and not real happenings in the ocean.

Another, more rare, type of error is associated with clock and triggering malfunctions. Instances have been observed in which a meter has cycled several times in rapid succession, or conversely has missed one or more cycles. Since the start and stop times of the meters are always recorded, the correct number of cycles for a given record is known. If the actual number of cycles is greater or smaller we can conclude there is a cycling problem. Simple clock speed errors were not encountered during CUE-I. That is, we found no case in which the clock ran fast, for example, so that the meter consistently cycled every four minutes, say, instead of the intended five minutes. The CUE-I Aanderaa meters were equipped with quartz crystal clocks designed and fabricated at OSU. We do not know whether the clocks provided by Aanderaa are as reliable as those we used. We did note instances in which the encoder was triggered spuriously in the middle of a cycle, or failed to cycle when it should have. Events of this kind can usually be located in time by looking at the speed plot. If a file is two cycles too short, and a particular speed is three times as large as the speeds around it, the liklihood is that the speed spike coincides with the two missed cycles. Similarly, a downward speed spike may be associated with one or more extra, spurious cycles.

Errors of the kind discussed so far have been rare in the CUE-I data. On the average, a 9000-cycle speed, temperature, and pressure file (about thirty days with a measurement every five minutes) contains no more than three or four such errors. Temperature and pressure series have fewer errors than speed. We have had far more difficulty with direction than with any other parameter. Most of the direction problems were traceable to mechanical failures in the compass itself. In several cases, the clamped compass needle failed to contact the resistance ring around the periphery of the compass. This resulted in a direction record consisting wholely or partly of 1023s. In other cases directions in a certain range always registered in a different range (we do not know why), so that no directions at all were recorded in the first range. Many of these compass problems became apparent from a cursory examination of the raw data. Others were discovered later from the direction histograms.

In general, isolated errors and short runs of bad data are corrected by linear interpolation. For example, if the speed record indicates that the rotor fouled for a short period of time, new speeds are calculated by interpolating linearly between the last good speed before the fouling and the first good speed afterward. This type of correction is made by means of a computer program called LINT, which reads the uncorrected processed data file and produces a new error-free file. The program user provides LINT with the line numbers of the first and last lines of bad data, and indicates which parameters are in error; the program does the rest automatically.

A few CUE-I files contained extensive sections of bad data, too wide to interpolate across. These files were either discarded entirely, or divided into one or more shorter files consisting of good data.

Data Analysis

Every Aanderaa current meter record and anemometer record obtained by the Coastal Upwelling Group is subjected to a preliminary descriptive analysis. Several plots are made, in addition to the error-detection plots mentioned above:

1. histograms showing the distributions of speed, direction and temperature
2. a progressive vector diagram (PVD)
3. variance spectra of u, v, temperature, and pressure
4. a rotary current (or wind) spectrum

In addition, new files are made by low-pass filtering u, v, temperature, and pressure and decimating to one point per hour.

Speed histograms are produced by a computer program named AMSHST, which makes both a Calcomp plot of the histogram and a table showing absolute and relative frequencies. Class bounds in the speed histogram are selected so that each class contains the same number of "possible" speeds. Recall that speed is calculated from the difference between two successive integers in the range [0, 1023]. Since this difference is itself an integer, speed is a discrete rather than continuous function. When the cycle time is five minutes, for example, the "possible" speeds (in cm/sec) are 0.65, 2.19, 3.07, 3.94,... In most of the speed histograms, each class contains two possible speeds; a few have classes that contain three possible speeds. This choice of bounds guarantees a smooth histogram in regions where the speed distribution is itself smooth. We found that taking class bounds at arbitrary equispaced points, such as 0, 2, 4, 6,... cm/sec, produced classes containing unequal numbers of possible speeds and tended to induce an artificial unevenness in the histograms.

Temperature and direction histograms are calculated and drawn (on the Calcomp plotter) by a computer program named AMTDHST. Again, temperature as recorded by an Aanderaa meter is a discrete rather than continuous function. The separation between possible RCM-4 temperatures is only about 0.02 degrees centigrade, however, and the program sorts temperatures into classes exactly 0.1 degrees wide, so that most classes contain five possible temperatures (some contain four) and no noticeable unevenness is induced. The direction histograms have classes ten degrees wide, containing exactly ten possible directions. AMTDHST produces frequency tables for both temperature and direction along with the plots.

Variance spectra for the currents and winds are produced by a program called AMUVSPC. This is a rather large program that does several different things. First, it reads u and v from the error-free processed data file and filters both parameters, creating a new file containing low-passed hourly values of u and v and their cumulative sums. This file, like all CUE Aanderaa data files, has a date and time at the left of every line and a line count on the right. Each line represents one hour. The cumulative sums of u and v are used subsequently to make PVDs. A line printer listing of this file is made and stored permanently, and the file is also stored on magnetic tape and microfilm.

The low-pass filter used in AMUVSPC was designed to preserve as much information as a time series with a data interval of one hour can carry, without aliasing. The nyquist frequency for such a series is 1/2 cycle per hour. The half-power point of the filter in question lies at 1/2 cycle per hour, and the frequency response function has a fairly sharp roll-off with low side lobes. Thus the maximum possible amount of information is passed, without aliasing from frequencies above the nyquist frequency. We feel that the output of this filter is preferable to the simple hourly averages many investigators use. The filter weights are shown in Table 2-1, for an input data interval of ten minutes. Figure 2-3 shows the response of this filter.

Data with a five minute interval are filtered in two steps. First, consecutive pairs of values are averaged to create a series with a ten minute interval. Then the filter of Table 2-1 is applied. The response this two-step filter is very close to that shown in Figure 2-3. This procedure is used with five minute data, rather than a one-step procedure, in order to reduce computation time. The two-step algorithm is faster because in it half of the multiplications have been converted to additions, with little degradation in frequency response.

After filtering both input series and decimating the result to one point per hour, AMUVSPC computes scalar auto spectra for u and v, and a rotary spectrum. All of the spectra are computed from the hourly values, using a fast fourier transform algorithm. Two plots are made of each scalar spectrum. The first has a linear frequency scale and a logarithmic spectral density scale. The spectrum is scaled so that the area under the curve would, if the density scale were linear rather than logarithmic, equal the variance of the original time series. The second plot is of frequency times spectral density, versus frequency. The frequency scale is logarithmic and the frequency times density scale is linear. The area under this curve equals the variance of the time series, and of course the area in any frequency band equals the variance in that band. The rotary

Table 2-1. Filter weights used in AMUVSPC for a data interval of 10 minutes. The filter is symmetrical and contains 37 unique weights. The center weight is shown first.

0.17833032	-0.00753077
0.16884324	-0.00679676
0.14226211	-0.00429982
0.10376850	-0.00122497
0.06059469	0.00138740
0.02032076	0.00280708
-0.01082650	0.00300220
-0.02923579	0.00225742
-0.03443759	0.00110011
-0.02881451	0.00003495
-0.01664279	-0.00062434
-0.00278253	-0.00081015
0.00859918	-0.00064948
0.01493615	-0.00035206
0.01560687	-0.00009774
0.01170108	0.00002965
0.00536221	0.00004496
-0.00104053	0.00001542
-0.00564412	

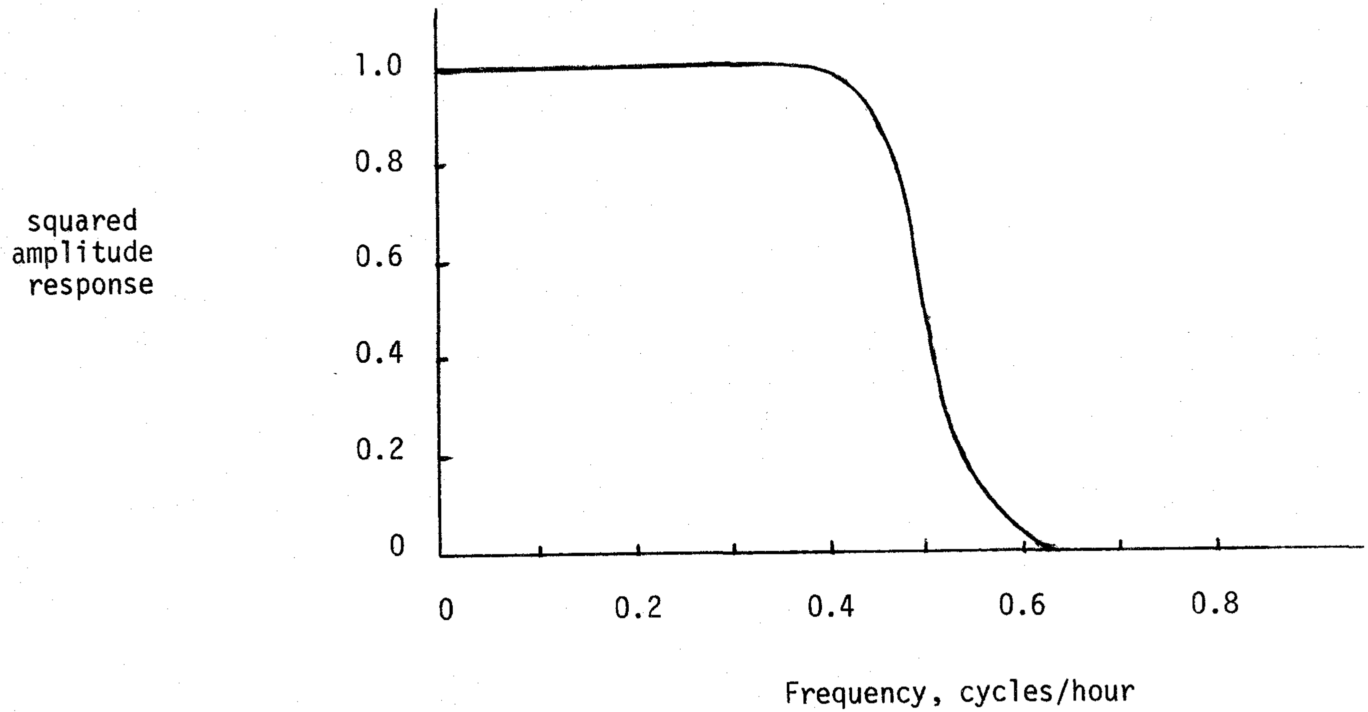


Figure 2-3. Response of the filter used in AMUVSPC, when applied to a 10-minute data interval.

autospectrum is also plotted twice, once with a linear density scale and once with a logarithmic density scale. The two-sided frequency scale is linear in both plots. Rotary spectral density is scaled such that in the linear - linear plot the area under the curve equals the sum of the u and v variances. In the scalar plots, frequency runs from 0 to 1/2 cycle/hr. The rotary spectrum runs from -0.12 to +0.12 cycles/hr.

The average kinetic energy of a unit volume of water is equal to half its mean squared velocity (i.e., half the variance about zero), and so the current spectra can be thought of as energy spectra. The energy of the mean motion is excluded, however, since both the mean and any linear trend* are removed from u and v before their fourier coefficients are computed. Thus the variances mentioned above are all variances about the linear trend, rather than about the mean or zero. It should also be mentioned that the scalar spectra are smoothed by convolving the raw spectral estimates with the binomial window 1/16, 1/4, 3/8, 1/4, 1/16. This induces about 7 degrees of freedom, since the variance-equivalent rectangular window spans about 3.5 elemental frequency bands (of width 1/T where T is the length of the input series) and we can regard each raw estimate (there is one in each band) as a chi-square random variable with 2 degrees of freedom. The rotary auto spectrum is computed from the smoothed scalar spectra and is not itself explicitly smoothed.

---

* The linear trend of a velocity series is the least-squares line of best fit, with the squared velocity deviations (as opposed to time deviations) minimized.

Variance spectra of temperature and pressure are calculated and plotted by AMTPCSPC. This program, like AMUVSPC, uses a fast fourier transform algorithm and produces two plots for each parameter. One is a plot of spectral density versus frequency (with the density scale logarithmic and the frequency scale linear) and the other is of density times frequency (linear) against frequency (logarithmic). In both plots frequency runs from 0 to 1/2 cycle/hr.

A PVD (progressive vector diagram) is a plot in which all the current or wind vectors have been drawn in succession, head to tail. The vectors are scaled in such a way that they denote distance rather than velocity; the distance from the origin of the first vector to any subsequent point on the curve, measured along the curve, is just the amount of water or wind that passed the meter after it was installed, up to the time associated with that point. CUE PVDs are drawn by a computer program called AMPVD, which takes as input the cumulative sums of filtered u and v produced by AMUVSPC. The plot is scaled to fit onto a standard 8 1/2 by 11 inch page (as are, in fact, all the histograms and spectral plots). North-south and east-west axes are drawn on the PVD with a tick and a label (the label denotes the distance from the origin to the tick, in km) every inch. The origin of the axes is at the start point of the first vector.

SCHOOL OF OCEANOGRAPHY

OSU