OFF SHORE TIDE GAUGE DATA

by

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ABSTRACT

This report describes the results obtained from five off Shore Tide Gauges (O.S.T.G.) deployed in the northern North Sea as part of the Joint North Sea Data Acquisition Programme (JONSDAP) during March and April 1976. The positions of the deployment stations are shown on Fig. 1 and lie on a line from Wick on the Scottish mainland, north-east as far as the $59^{o}20'$ line of latitude, and then due east to the Norwegian coast. Each station is identified by a reference code 53 to 57 inclusive.

Where necessary, a description of the loggers and sensors used on the gauges is given, followed by details of data reduction and analysis. Details of the launch and recovery phases of each deployment are included and the measurements made by each sensor are presented in graphical form and tables of harmonic constants.

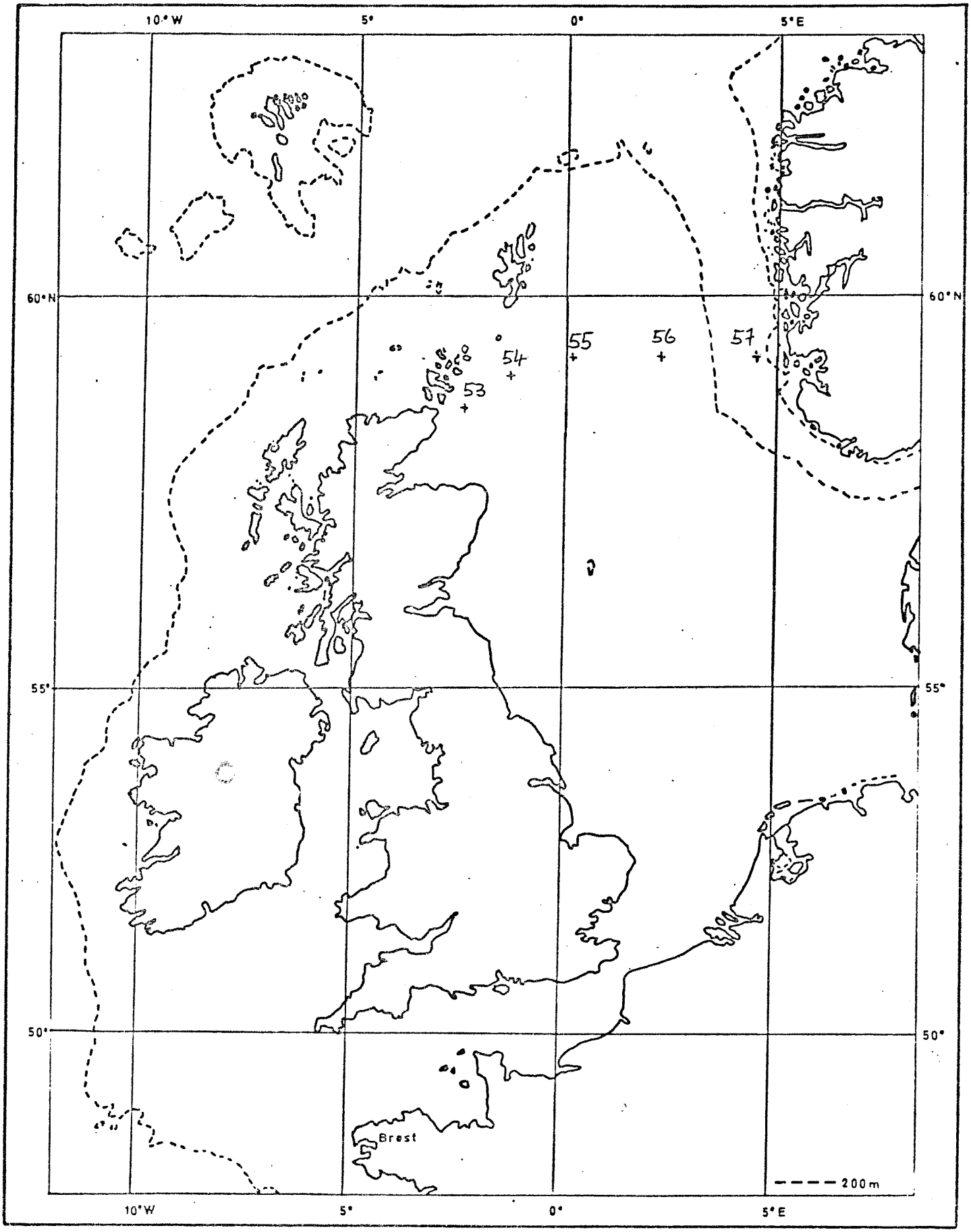


FIG 1 POSITIONS OF DEPLOYMENT STATIONS

1. INTRODUCTION

Five Off Shore Tide Gauges were deployed by staff from the Institute of Oceanographic Sciences, Bidston (IOS Bidston) as part of the JONSDAP '76 exercise which took place in the northern North Sea during March and April 1976. The location of the gauges between Wick on the Scottish mainland and Kopervik on the Norwegian coast is important to the JONSIS numerical modelling group because it is in an area which is considered to be the northern boundary of the North Sea, and in which tides and surges generated in the Atlantic enter the North Sea. The exact position of each tide gauge was determined prior to deployment using a numerical model to investigate the sensitivity of the results from the model to different deployment patterns along the Wick-Kopervik line. Ultimately the pattern shown in figure 1 was considered to be the optimum (Davies 1976).

Three types of tide gauge were used during the exercise: IOS types I and II and a design based on a modified Aanderaa logger. IOS types I and II have been discussed in IOS data report no. 7 (Alcock and Vassie 1975) and full details will not be repeated here; details of the Aanderaa gauge are given in section 2.

The data from all five tide gauges were analysed using an identical method to avoid inconsistencies. Prior to harmonic analysis, low frequency components of the signal which contained sensor drift, long period tides and a large proportion of the surge activity were removed by filtering the data. This was preferred to the normal method of drift removal, in which a polynomial is fitted to the drift component, because the surges had an amplitude which was comparable with the tidal signal.

2. LOGGERS AND SENSORS

The gauge deployed at station 53 was a bottom mounted rig which utilised a Digiquartz sensor, DIG 5/2, and an Aanderaa current meter (with the adaption of a small direction vane replacing the normal large vane), both interfaced into a modified Aanderaa current meter logger. (A.J. Harrison, personal communication). Current speed and absolute pressure count were integrated over

15 minutes and sampled by the logger every 15 minutes, together with spot readings of vane direction, temperature, elapsed time, and rig orientation. A quartz crystal clock was used for controlling the sampling interval and the data were recorded on $\frac{1}{4}$ inch magnetic tape as 10 bit binary words in serial form with the frequency count from the pressure sensor stored as most and least significant counts. The sensors were mounted approximately 0.5m above the rig base, and the rig was deployed and recovered in the same way as the Mk II OSTG (Alcock and Vassie 1975).

All loggers and sensor packs used on the Mk II OSTGs deployed at stations 54, 55 and 56 were as described in Alcock and Vassie (1975) except for strain gauge sensors SG 2/6 and SG 2/7 which incorporated improved temperature and pressure circuits to improve the stability (Banaszek and Palin 1977). A Digiquartz sensor pack, DIG 5/1, was used on the tide gauge deployed at station 54. The pressure sensor consists of a convoluted bellows linked to a 40 kHz quartz crystal resonator coupled by piezo electric action to an electronic resonator.

The Mk I tide gauge deployed at station 57 was of the "pop-up" type developed at the I.O.S. Wormley Laboratory (Collar and Spencer 1970) with strain gauge sensors 1/13 and 1/16 (Gwilliam and Collar 1974).

3. CALIBRATION

All the temperature and pressure calibrations for the sensor packs used on stations 53 to 56 inclusive were carried out by members of the Research Technology Group using equipment and facilities at Bidston. (Banaszek and Palin 1977).

For station 53, the DIG 5/2 sensor was used, with pressure sensitivity of 0.153 hz mb^{-1} and temperature coefficient of 0.4 mb $^{o}C^{-1}$.

For station 54, the VIB 1/6, DIG 5/1, and SG 2/7 sensors were used, with pressure sensitivities of 0.037 hz mb^{-1}, 0.200 hz mb^{-1}, and 0.095 hz mb^{-1} respectively; and temperature coefficients of 11.8 $mb^{o}C^{-1}$, 2.8 $mb^{o}C^{-1}$, and 7.7 $mb^{o}C^{-1}$ respectively.

For station 55, the VIB 1/4, OAR 4/1, and SG 2/2 sensors were used, with pressure sensitivities of 0.038 hz mb^{-1}, 0.045 hz mb^{-1}, and 0.069 hz mb^{-1} respectively; and temperature coefficients of 4.6 $mb^{o}C^{-1}$, 3.5 $mb^{o}C^{-1}$, and 208 $mb^{o}C^{-1}$ respectively.

For station 56, the VIB 1/1, OAR 4/2, and SG 2/6 sensors were used, with pressure sensitivities of 0.037 hz mb^{-1}, 0.041 hz mb^{-1}, and 0.087 hz mb^{-1} respectively; and temperature coefficients of 1.7 $mb^{o}C^{-1}$, 1.0 $mb^{o}C^{-1}$, and 6.2 $mb^{o}C^{-1}$ respectively.

For station 57, the strain gauge sensors 1/13 and 1/16 were used, with pressure sensitivities of 0.055 hz mb^{-1} and 0.007 mb^{-1} respectively; and temperature coefficients of 0.85 $mb^{o}C^{-1}$ and 2.8 mb $^{o}C^{-1}$ respectively.

4. DATA PROCESSING

The magnetic tape from each of the Mk II OSTGs was copied, with a density of 1800 bpi, onto a 9 track magnetic tape using the IBM 370/145 computer at the IBM data centre at Manchester; the 9 track tape was taken to the SRC Daresbury Laboratory and the data read into disk storage on the IBM 370/165 computer. As an initial check on the raw data, each temperature and pressure frequency channel was plotted. A program was then used to check the frequency data from each temperature sensor channel, calculate and plot the temperatures and store them on disk. A second program checked and calculated the frequencies from each pressure sensor channel, used the temperature value and the pressure frequency/temperature coefficient to convert each pressure frequency to the frequency at the reference temperature, and calculated the pressures using the pressure/frequency calibration. The $\frac{1}{4}$hr values of pressure were plotted, stored on disk and punched on cards.

Processing of the data from the Mk I gauge was identical to that for the Mark II gauge except that the data was translated from the logger magnetic tape onto punched paper tape before it was loaded to disk file.

The magnetic tape from the logger of the tide gauge/current meter rig at station 53 was translated into two paper tapes which contained i) elapsed time, current meter and temperature data, and ii) elapsed time and pressure data. The data on the latter

tape were read into disk storage on the IBM 1130 computer at Bidston and the data transferred into disk storage on the IBM 370/165 at Daresbury using the 1130 as a RJE (Remote Job Entry) terminal, and the same programs as for the Mk II gauge used to compute the $\frac{1}{4}$ hr values of total pressure.

An interpolation program was used to produce an output on punched cards of hourly values, on the hour (GMT), of the pressure record. This program smoothed the data using a low pass filter, FLP03, of half length 18 and a cut-off frequency (half-power point) of 0.35 cycles per hour (126^{o} per hour) - thus the amplitude response of the sixth diurnal band was -0.08 dB (1%). The resulting series was then interpolated, using a cubic spline, to obtain the hourly values, applying time corrections if the clock was fast or slow. (Exact times of scans at the beginning and end of the record were noted prior to launch and after recovery). Root mean square errors due to the interpolation method are of the order of 0.02 mb.

5. ANALYSIS OF TIDAL DATA

The series of hourly values of the sea bed pressure contained components of sensor drift and external surges as well as the desired tidal signal. Usually the sensor drift is removed by passing the data through a low power low pass filter which isolates the drift component. A low order polynomial is fitted to the drift curve and subsequently the polynomial is removed from the original series leaving the tidal signal uncontaminated. This technique was not powerful enough for records from these deployments because the surge component was comparable in amplitude to the tidal signal and had considerable energy in the low frequency spectrum normally occupied by the drift component. Therefore it was decided to filter the data with a high power high pass filter, FHP53, (Alcock and Vassie 1975) which removed jointly sensor drift, long period tides and surge activity, and isolated the tidal signal.

Tidal analyses of a 29 day period, or as close to 29 days as possible, of the drift-free record obtained from each deployment were carried out using the T.I.R.A. (Tidal Institute Recursive

Analysis) program which utilises the harmonic method of analysis. For all deployments, the amplitude and phase lag relative to Greenwich epoch of 27 major and 8 related constituents were computed, the time zone being Greenwich Mean Time (S=0). The constituents π_1, P_1, ψ_1, ϕ_1, $2N_2$, ϑ_2, T_2 and K_2 are not separable from the major harmonic constants with only one month of data, and so were related to the major constituents using values derived from the harmonic analysis of data from Lerwick for 1966 to 1971 inclusive.

The amplitude of each harmonic constant in the following tables is in units of pressure (millibars). It can be readily converted to sea surface elevation using the hydrostatic relation

$$h = P/\rho g \,, \qquad (1)$$

where h is elevation in metres, P is pressure in pascals (1Pa = 10^{-2} mb), ρ is sea water density in kilograms per cubic meter and g is acceleration due to gravity in metres per second squared. Values of ρ, derived from CTD casts, and g for each station are given in the launch and recovery details.

6. REFERENCES

ALCOCK, G.A. and VASSIE, J.M. 1975. Off shore tide gauge data. Institute of Oceanographic Sciences, Data Report, No. 7, 38 pp.

BANASZEK, A.D. and PALIN, R.I.R. 1977. IOS Report in preparation.

COLLAR, P.G. and SPENCER, R. 1970. A digitally recording off-shore tide gauge. pp. 341-352 in, Electronic Engineering in Ocean Technology, proceedings of a conference held at Swansea. London: Institution of Electronic and Radio Engineers, 556 pp. (IERE Conference Proceedings No. 19)

DAVIES, A.M. 1976. A numerical model of the North Sea and its use in choosing locations for the deployment of offshore tide gauges in the JONSDAP '76 oceanographic experiment. Deutsche Hydrographische Zeitschrift, 29, 11-24.

GWILLIAM, T.J.P. and COLLAR, P.G. 1974. A strain gauge pressure sensor for measuring tides on the continental shelf. Institute of Oceanographic Sciences, Report, No. 14, 27 pp. + figs.

7. FORMAT

The report is split into sections, one for each deployment, each section comprising a page of launch and recovery details, a page of data reduction details, and the record from each sensor displayed in two computer plots and a table of the tidal constituents obtained by analysis of the tidal record.

Launch and recovery details

OSTG position	Station identification, General area, Year, Latitude and Longitude, Value of g.
Water depth	Measured at Launch by Precision Depth Recorder.
OSTG details	Type, Logger number, Sensor type (s) and number (s).
Time of deployment	Time of launch of gauge from ship, time that gauge was on sea bed.
Time of recovery	Time that gauge surfaced or was brought on board ship.
CTD casts	Time and duration of any CTD casts on station, Value of density computed from casts.
Comments	Comments on the launch and/or recovery.

Data reduction details

Timing	Times of specific scans and timing error
Raw data	Times of start and end of raw sea-bed pressure data.
Temperature data	Details of temperature record(s) available.
Drift-free data	Times of start and end of drift-free hourly pressure record. Method used to produce drift free data.
Tidal analysis	Method used, period analysed, station used for related constituents.
Comments	Comments on data reduction.

Computer plots

(1) Plot of temperature record(s) if available

(2) Plot of tidal and non tidal components of the hourly record of sea-bed pressure data.

Analysis

Table of amplitude and phase (G - referred to lunar transit at Greenwich and time zone S = 0) of 24 major and 8 related constituents of tidal record from each sensor.

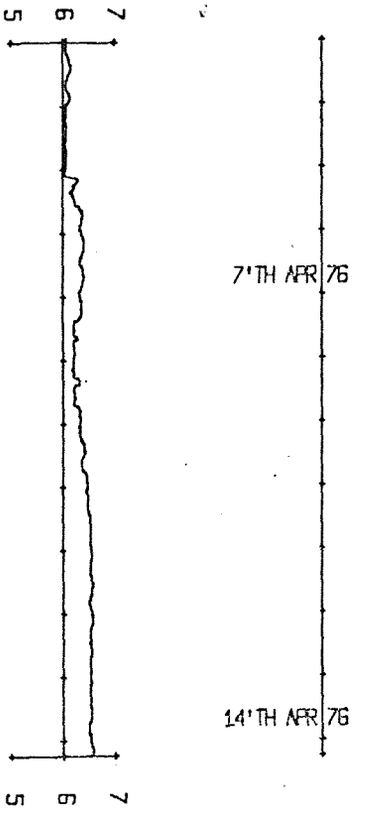
OSTG position	Station 53, North North Sea, 1976. Lat $58^{o}37.11'$N Long $02^{o}26.25'$ W. g = 9.818 ms^{-2}.
Water depth	75m.
OSTG details	Aanderaa logger no. 1747 with DIG 5/2 sensor and current meter no. 1747/4.
Time of deployment	Tide gauge in water from RRS "Challenger" at 0718 GMT day 069 (March 9th). On sea bed at 0720 GMT.
Time of recovery	Tide gauge out of water at 0620 GMT day 106 (April 15th).
CTD casts	1 cast at 0753 GMT day 069. 1 cast at 0639 GMT day 106. Density, ρ = 1027.324 kg m^{-3}.
Comments	A separate rig with current meters at 8m, 23m and 38m above sea bed was deployed nearby and recovered intact.

Timing	Scan no. 1. at 1314,42s GMT day 062. Scan no. 5579 at 1558,33s GMT day 120. Clock fast, gained 69s in 58 days and $2\frac{3}{4}$ hours.
Raw data	Start 0737,04s GMT day 069 End 0451,20s GMT day 106.
Temperature data	Record obtained from current meter no. 1747/4 and supplied by J. Howarth.
Drift-free data	Start 1200 GMT day 072 end 2000 GMT day 102 FHP filter used.
Tidal analysis	TIRA, 0000 day 073 to 2300 day 101, 29 days, using 27 major and 8 related constituents from Lerwick 1966 to 1971 analysis.
Comments	Logger error (no discontinuities) on 3 seabed scans corrected manually.

METER 1747/4

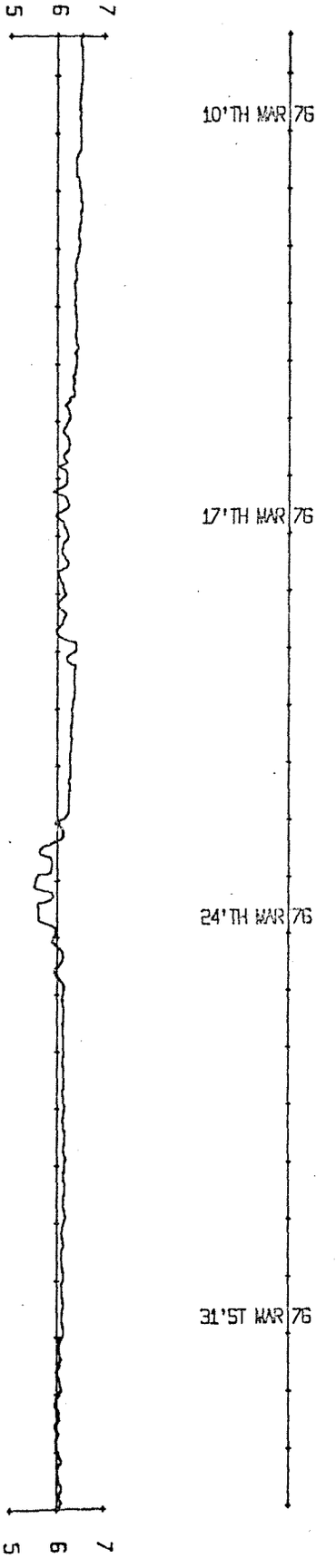
TEMPERATURE

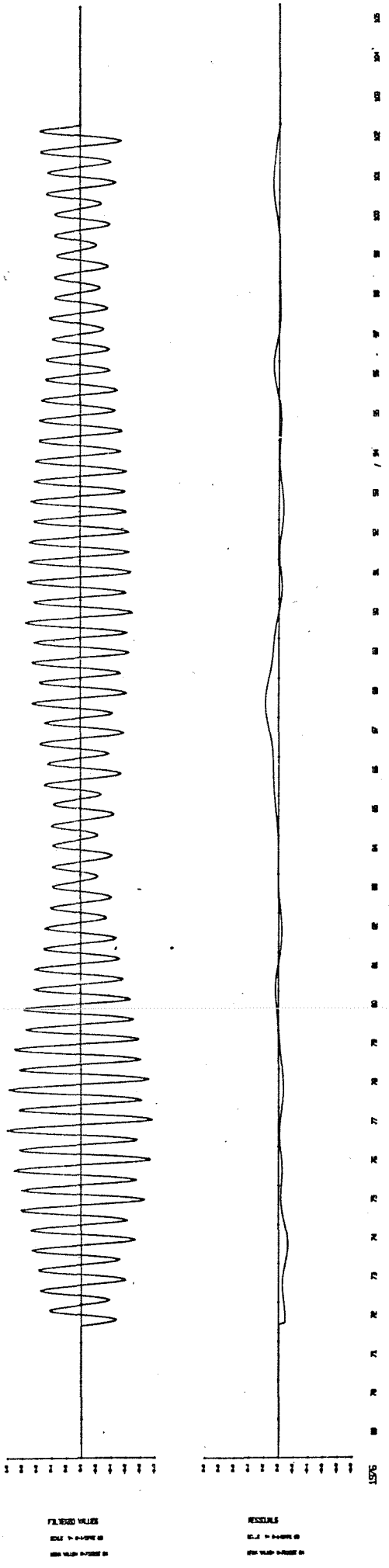
IN DEG C



TEMPERATURE

IN DEG C





N-NORTH SEA JONS3 AAND. TG TOT. PRESSURE

TABLE 1

Station 53, N. North Sea, Lat 58°37 .11'N Long 02°26 .25'W.
Aanderaa CM/TG rig, DIG 5/2 sensor.
Drift free total pressure (millibars) FHP53 filter.
0000 day 073 to 2300 day 101 1976, 29 days.
27 constituents + 8 related (*) using Lerwick 1966/71 analysis.

	Constituent	H(mb)	G(°)
	Q_1	3.9	325.6
	O_1	9.9	31.7
	M_1	0.2	94.0
*	π_1	0.2	126.5
*	P_1	2.4	169.9
	K_1	7.8	186.0
*	ψ_1	0.2	198.3
*	ϕ_1	0.2	214.5
	J_1	0.9	292.7
	OO_1	0.6	258.1
*	$2N_2$	2.3	285.1
	μ_2	2.6	295.1
	N_2	15.7	304.3
*	ν_2	2.9	304.7
	M_2	75.9	325.9
	L_2	2.3	309.4
*	T_2	1.3	349.1
	S_2	26.8	3.7
*	K_2	7.4	0.2
	$2SM_2$	0.7	64.5
	MO_3	0.2	166.7
	M_3	1.2	231.1
	MK_3	0.3	55.3
	MN_4	1.0	272.5
	M_4	1.9	308.1
	SN_4	0.6	155.1
	MS_4	1.0	47.2
	$2MN_6$	0.4	173.0
	M_6	0.7	173.0
	MSN_6	0.3	160.5
	$2MS_6$	0.8	216.0
	$2SM_6$	0.3	219.4

OSTG position	Station 54, North North Sea, 1976, Lat $58^{o}55$ .98N Long $01^{o}15'$W, g = 9.818 ms^{-2}.
Water depth	113m.
OSTG details	Mk II, logger no. 002, sensors VIB 1/6, DIG 5/1, SG 2/7.
Time of deployment	In water at 1852 GMT day 069 (March 9th) On sea bed at 1939 GMT.
Time of recovery	Gauge surfaced at 2000 GMT day 106 (April 15th).
CTD casts	1 cast at 1824 GMT day 069 1 cast at 1556 GMT day 075 1 cast at 1714 GMT day 110 Density, ρ = 1027.548 kg m^{-3}.
Comments	Immersion test at 0215 GMT day 069. Unsuccessful launch at 1420 GMT day 069. A separate rig with current meters at 8m, 48m, 78m above sea bed was deployed nearby, but not recovered.

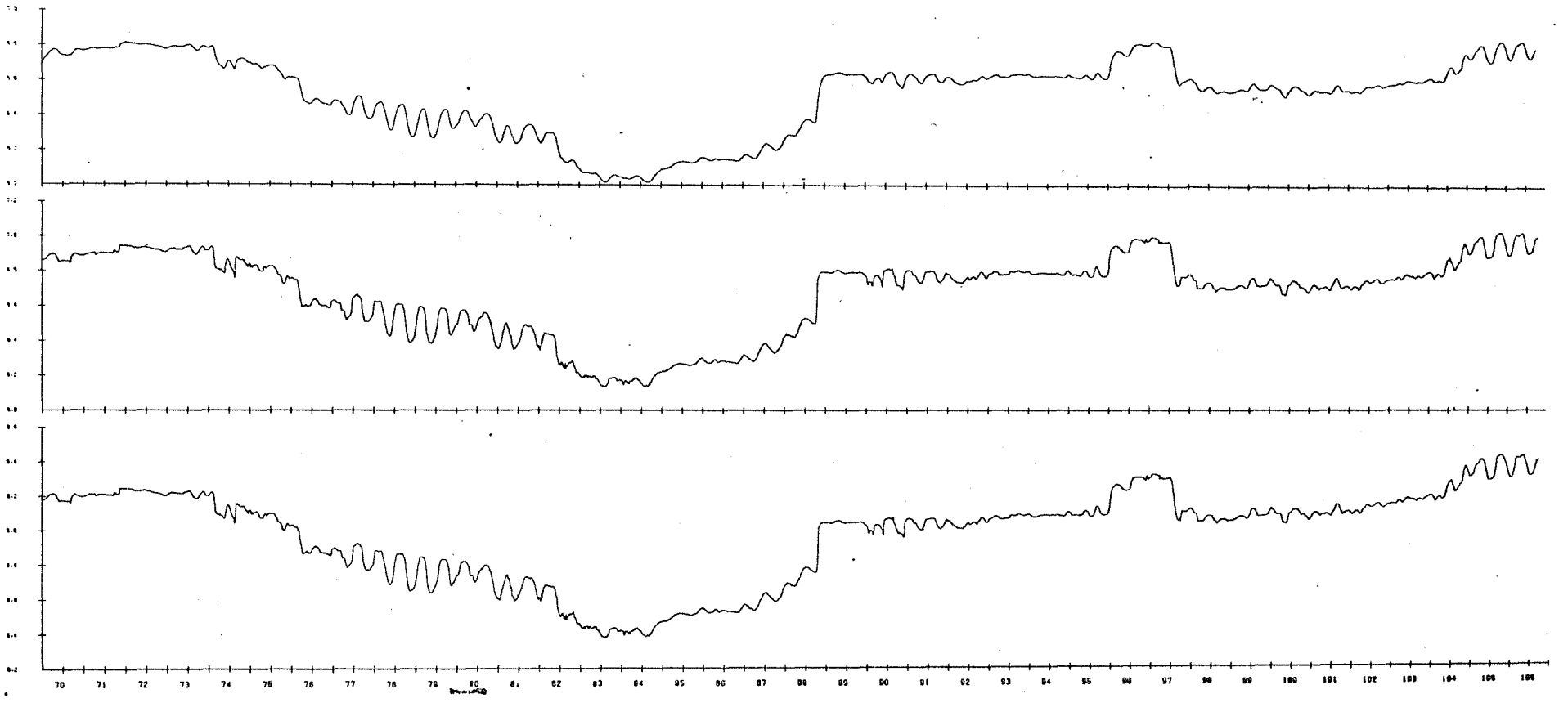
Timing	Scan no. 1 at 1200,02s GMT day 061. Test scan at 1159,50s GMT day 111. Clock fast, gained 12s in 50 days.
Raw data	Start 0152,29.5s GMT day 072 End 1852,23s GMT day 106 See Comment.
Temperature data	Complete temperature record for each sensor.
Drift-free data	Start 0600 GMT day 075 End 1400 GMT day 103 FHP53 filter used.
Tidal analysis	TIRA, 0600 day 075 to 1400 day 103, 28 days and 8 hours, using 27 major and 8 related constituents from Lerwick 1966 to 1971 analysis.
Comments	Discontinuity in record between seabed scans no. 196 and no. 198 (0045 and 0115 day 072), therefore first usable seabed scan taken after this.

OSTG MKII 02 MARCH/APRIL 1976
N.NORTH SEA JONSDAP54 58 56N 01 15W

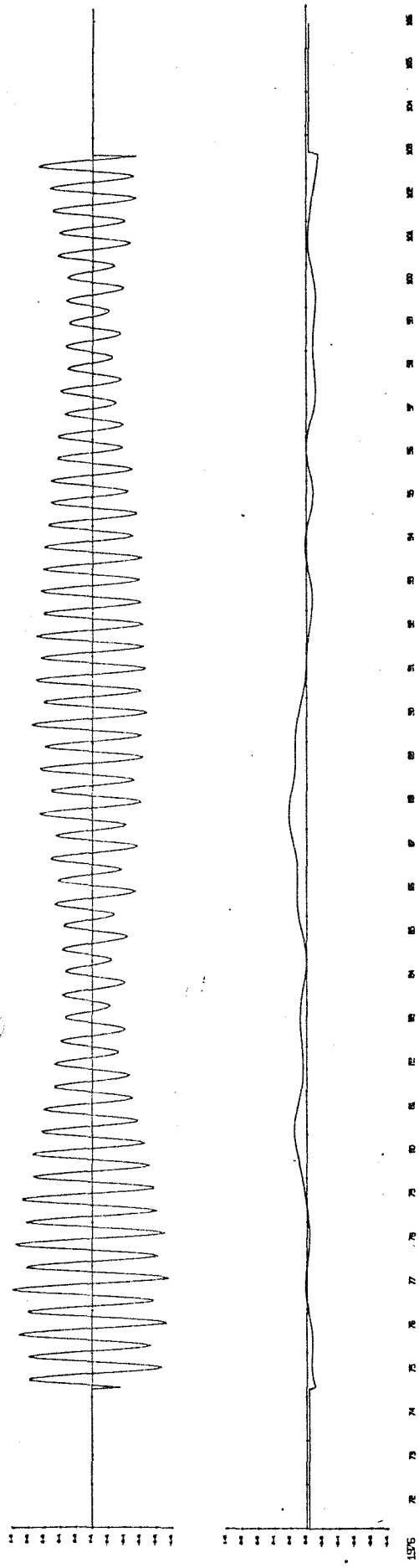
[illegible]/1 TEMPERATURE
(DEGREES CELSIUS)

SG2/7 TEMPERATURE
(DEGREES CELSIUS)

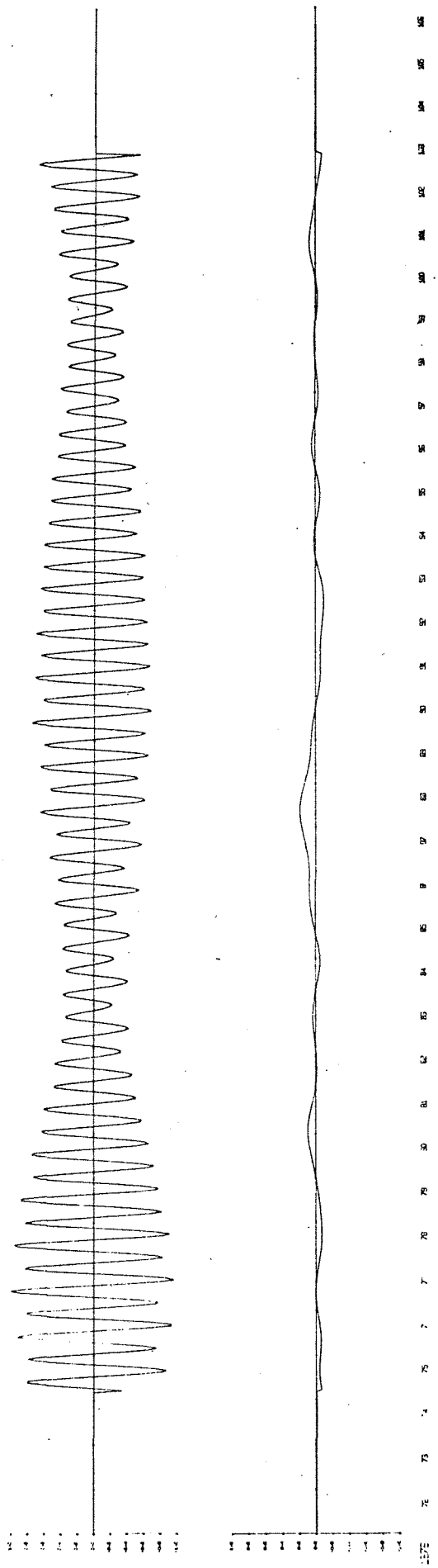
V181/6 TEMPERATURE
(DEGREES CELSIUS)

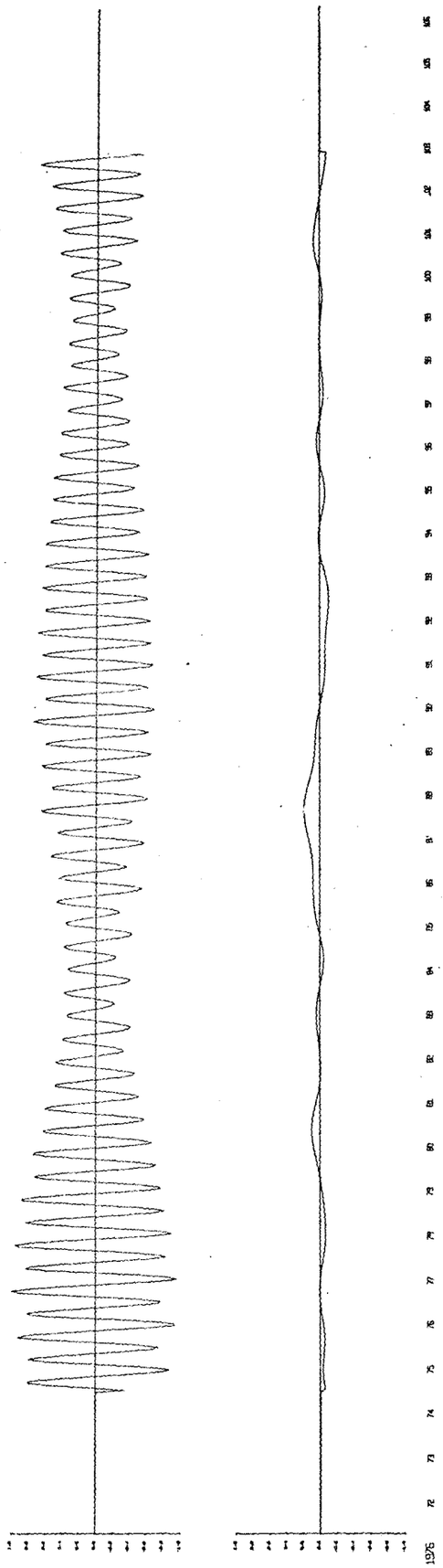


DAY OF THE YEAR



JONSDAPS4 VIB1/6 TOTAL PRESSURE





FILTERED VALUES

RESIDUALS

V-NORTH SEA JONS4 SS2#7 TOT. PRESSURE

TABLE 2

Station 54, N. North Sea, Lat 58°56'N Long 01°15'W.
Drift free total pressure record (millibars), FHP53 filter.
0600 day 075 to 1400 day 103 1976, 28 days + 8 hours.
27 constituents + 8 related (*) using Lerwick 1966/71 analysis.

Constituent	DIG 5/1 H (mb)	DIG 5/1 G (°)	VIB 1/6 H (mb)	VIB 1/6 G (°)	SG 2/7 H (mb)	SG 2/7 G (°)
Q_1	3.1	317.1	3.2	316.5	3.1	317.6
O_1	9.1	37.1	9.1	37.4	9.0	36.9
M_1	0.4	86.1	0.4	89.5	0.4	87.4
* π_1	0.2	129.8	0.2	129.7	0.2	129.8
* P_1	2.1	173.2	2.1	173.0	2.0	173.2
K_1	6.6	189.3	6.6	189.2	6.6	189.3
* ψ_1	0.2	201.5	0.2	201.4	0.2	201.6
* ϕ_1	0.1	217.8	0.1	217.6	0.1	217.8
J_1	0.9	292.9	0.8	297.3	0.9	293.6
OO_1	0.9	287.2	1.0	281.9	0.9	277.7
* $2N_2$	2.1	282.0	2.1	282.1	2.0	282.0
μ_2	2.5	275.8	2.6	275.6	2.4	276.2
N_2	13.7	301.1	13.7	301.2	13.6	301.2
* ν_2	2.5	301.5	2.5	301.6	2.5	301.6
M_2	66.8	313.2	66.6	323.3	66.5	323.2
L_2	2.1	317.5	2.0	315.9	2.1	321.1
* T_2	1.2	345.0	1.2	345.1	1.1	344.9
S_2	23.9	359.6	23.8	359.7	23.7	359.5
* K_2	6.6	356.1	6.6	356.2	6.6	356.0
$2SM_2$	0.5	51.9	0.5	56.4	0.5	50.9
MO_3	0.2	131.0	0.2	124.0	0.2	139.6
M_3	0.9	226.2	0.9	226.0	0.9	228.0
MK_3	0.2	51.0	0.2	48.1	0.2	57.0
MN_4	0.8	253.8	0.8	252.2	0.8	255.2
M_4	1.5	294.7	1.5	295.1	1.5	295.0
SN_4	0.4	131.1	0.5	131.8	0.5	129.1
MS_4	0.9	30.4	0.9	29.3	0.9	32.0
$2MN_6$	0.5	211.5	0.5	212.0	0.5	210.8
M_6	0.8	218.0	0.8	218.7	0.7	217.4
MSN_6	0.2	207.7	0.2	208.7	0.2	202.2
$2MS_6$	1.0	266.4	1.0	266.6	1.0	266.0
$2SM_6$	0.4	290.1	0.4	289.6	0.4	286.9

OSTG position	Station 55, North North Sea, 1976, Lat 59°19 .18'N 00°15 .06'E, $g = 9.819\ ms^{-2}$.
Water depth	135m.
OSTG details	Mk II, logger no.004, sensors VIB 1/4, OAR 4/1, SG 2/2.
Time of deployment	Deployment started from RRS "Challenger" at 1312 GMT day 070 (March 10th). Tide gauge on seabed at 1351 GMT.
Time of recovery	Recovery started from RRS "Challenger" at 2100 GMT day 107 (April 16th).
CTD casts	1 cast at 1249 GMT day 074 1 cast at 1638 GMT day 109 Density, ρ = 1027.717 kg m^{-3}.
Comments	Immersion test at 2215 GMT day 069.

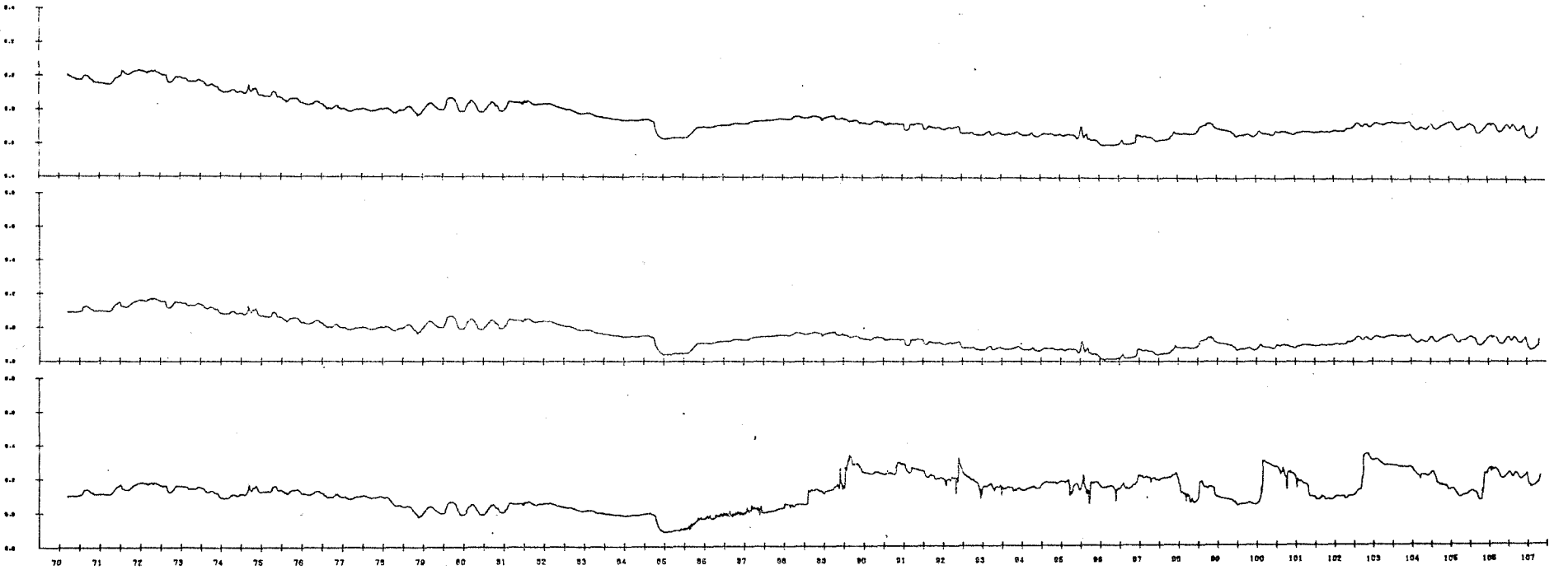
Timing	Time check at 1330,05s GMT day 070. Time check at 2200,09s GMT day 110. Clock slow, lost 4s in 40 days and 8 hours.
Raw data	Start 0122,35s GMT day 072 End 2007,39s GMT day 107 See Comments.
Temperature data	Complete records from sensors OAR 4/1 and SG 2/2, but VIB 1/4 has high frequency noise after day 085, therefore OAR 4/1 temperature record used for correction of VIB 1/4 pressure frequencies.
Drift-free data	Start 0600 GMT day 075 End 1600 GMT day 104 FHP53 filter used.
Tidal analysis	TIRA, 0600 GMT day 075 to 0600 GMT day 104, 29 days, using 27 major and 8 related constituents from Lerwick 1966 to 1971 analysis.
Comments	Discontinuity in pressure record between seabed scans no.128 andno.130 (0045 to 0115 day 072), therefore first usable seabed scan taken after this.

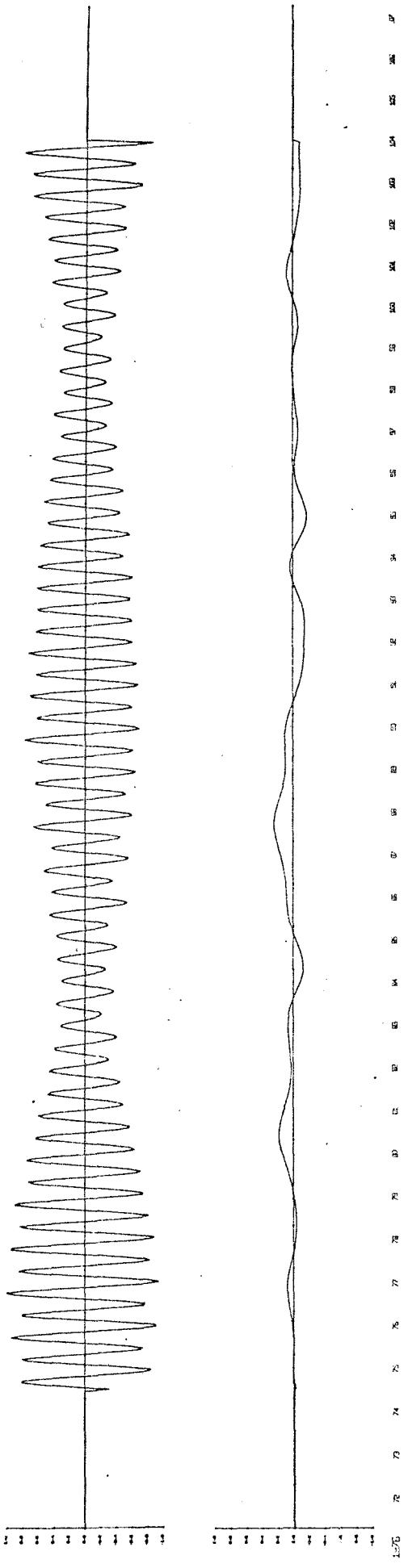
OSTG MKII 04 MARCH/APRIL 1976
N.NORTH SEA JONSCAPSS 59 19.2 00 15.1E

SG2/2 TEMPERATURE
(DEGREES CELSIUS)

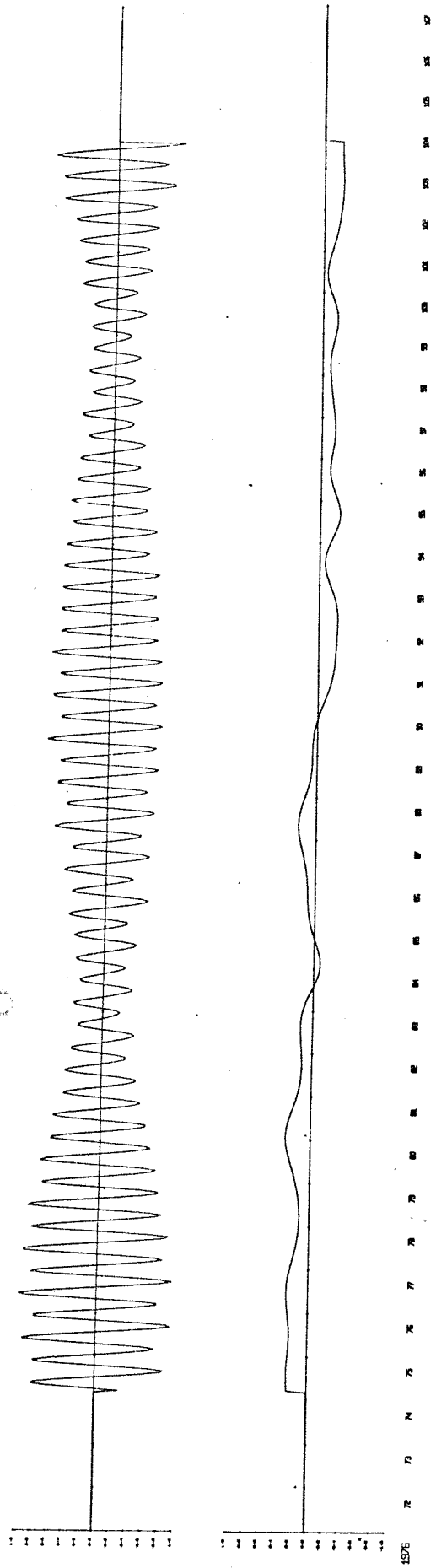
CAR4/1 TEMPERATURE
(DEGREES CELSIUS)

VIB1/4 TEMPERATURE
(DEGREES CELSIUS)





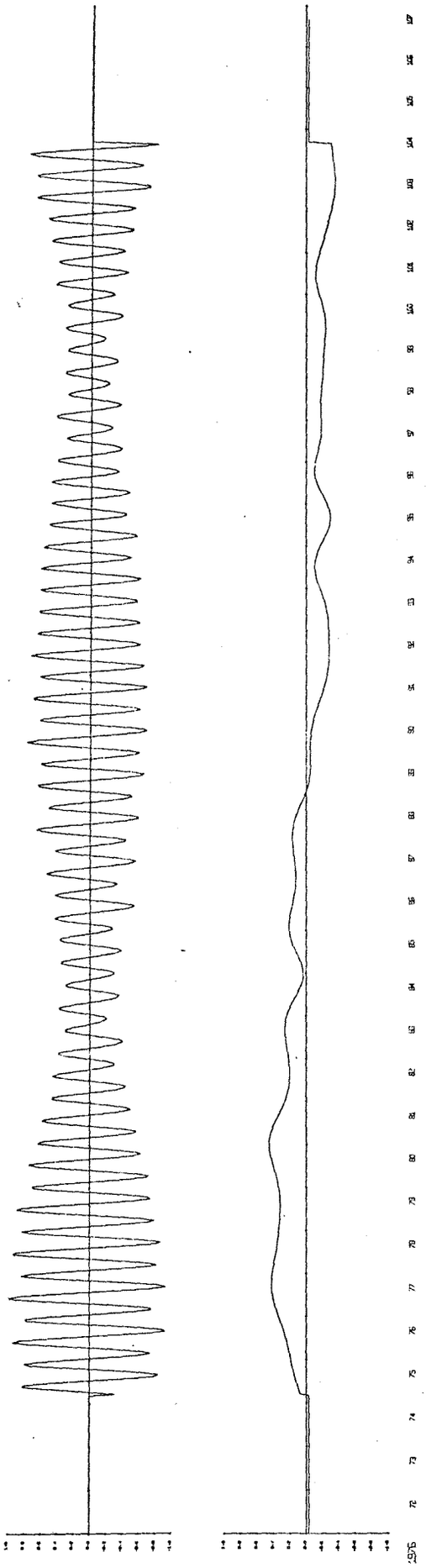
N.NORTH SEA JONES V181/4 TOT. PRESSURE



FILTERED VALUES

RESIDUALS

N-NORTH SEA JONSS DIAR4/1 TOT. PRESSURE



N-NORTH SEA JONES 5G2/2 TOT. PRESSURE

TABLE 3

Station 55, N. North Sea, Lat 59°19'N Long 00°15'E.
Drift free total pressure (millibars), FHP53 filter.
0600 day 075 to 0600 day 104 1976, 29 days.
27 constituents + 8 related (*) using Lerwick 1966/71 analysis.

Constituent	VIB 1/4 H (mb)	VIB 1/4 G (°)	OAR 4/1 H (mb)	OAR 4/1 G (°)	SG 2/2 H (mb)	SG 2/2 G (°)
Q_1	2.1	309.8	2.2	306.3	1.7	307.9
O_1	6.6	39.9	6.8	39.8	6.4	39.0
M_1	0.3	114.0	0.4	122.7	0.4	125.3
* π_1	0.1	129.6	0.1	127.9	0.1	130.5
* P_1	1.4	172.9	1.4	171.3	1.3	173.9
K_1	4.4	189.1	4.5	187.5	4.2	190.0
* ψ_1	0.1	201.3	0.1	199.7	0.1	202.2
* ϕ_1	0.1	217.5	0.1	215.9	0.1	218.5
J_1	0.7	313.3	0.5	316.4	0.8	338.1
OO_1	0.9	282.9	0.8	284.6	1.0	294.0
* $2N_2$	1.5	277.8	1.5	278.0	1.4	276.9
μ_2	2.2	271.7	2.2	271.5	1.7	276.2
N_2	10.1	296.9	10.3	297.2	9.3	296.1
* ν_2	1.8	297.3	1.9	297.6	1.7	296.5
M_2	49.1	318.4	50.2	318.1	46.8	318.6
L_2	1.5	307.1	1.6	306.0	1.4	324.0
* T_2	0.9	339.3	0.9	339.0	0.9	339.1
S_2	18.0	353.9	18.4	353.6	17.6	353.7
* K_2	5.0	350.4	5.1	350.1	4.9	350.2
$2SM_2$	0.4	37.7	0.3	40.0	0.8	54.8
MO_3	0.3	140.6	0.3	142.3	0.4	163.8
M_3	0.5	215.5	0.6	216.6	0.6	214.4
MK_3	0.2	39.8	0.1	37.9	0.1	355.1
MN_4	0.7	241.5	0.7	241.6	0.7	240.2
M_4	1.3	275.5	1.4	275.2	1.3	275.7
SN_4	0.4	90.8	0.4	95.8	0.3	104.6
MS_4	0.9	6.8	1.0	6.1	0.9	9.1
$2MN_6$	0.5	227.7	0.4	229.1	0.4	233.7
M_6	0.7	240.5	0.7	240.4	0.6	230.5
MSN_6	0.2	230.8	0.2	227.4	0.2	224.8
$2MS_6$	0.9	281.9	1.0	282.9	0.9	278.0
$2SM_6$	0.4	308.9	0.4	310.9	0.3	306.0

OSTG position	Station 56, North North Sea, 1976, Lat $59^{o}19'.51N$ Long $02^{o}46'.68E$, $g = 9.819\ ms^{-2}$.
Water depth	119m.
OSTG details	Mk II, Logger no. 001, sensors VIB 1/6, OAR 4/2, SG 2/6.
Time of deployment	Tide gauge on seabed at 0213 GMT day 074 (March 14th).
Time of recovery	Recovery started 0700 GMT day 108 (April 17th).
CTD casts	1 cast at 0027 GMT day 074 1 cast at 0606 GMT day 109 Density, ρ = 1028.623 kg m^{-3}.
Comments	Immersion test at 2110 GMT day 070.

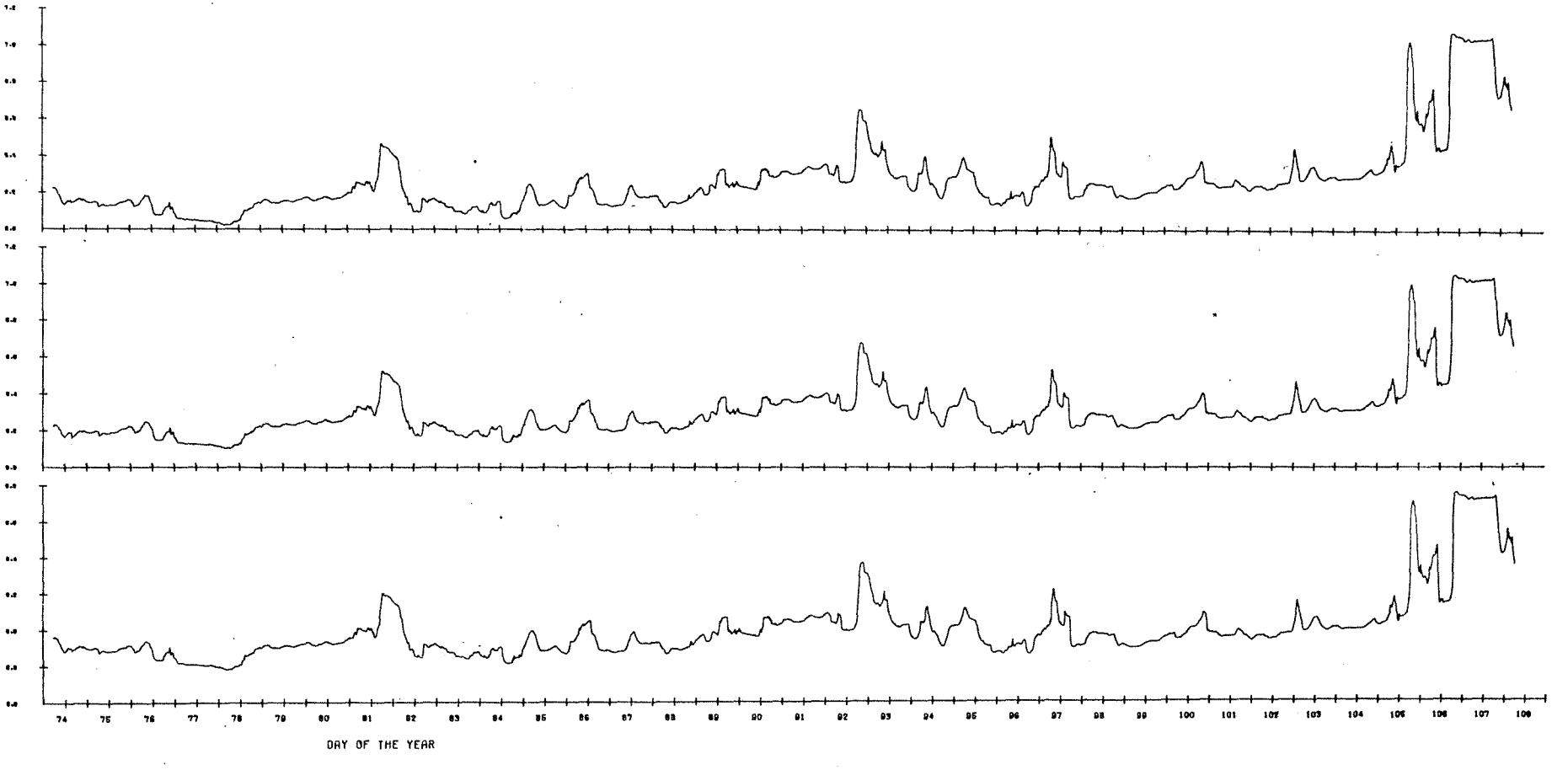
Timing	Time check at 0100,01s GMT day 074 Time check at 1659,55s GMT day 110 Clock fast, gained 6s in 36 days and 16 hours.
Raw data	Start 1552,31s GMT day 074 End 0652,25s GMT day 108 See Comments.
Temperature data	Complete temperature records from all sensors.
Drift-free data	Start 2000 GMT day 077 End 0200 GMT day 105 FHP53 filter used.
Tidal analysis	TIRA, 2000 day 077 to 0200 day 105, 28 days and 6 hours, using 27 major and 8 related constituents from Lerwick 1966 to 1971 analysis.
Comments	Discontinuity in pressure record at seabed scan no. 40 (1545 day 074), therefore first usable seabed scan taken after this.

OSTG MKII 01 MARCH/APRIL 1976
N.NORTH SEA JONSDAP56 59 19.5 02 46.7E

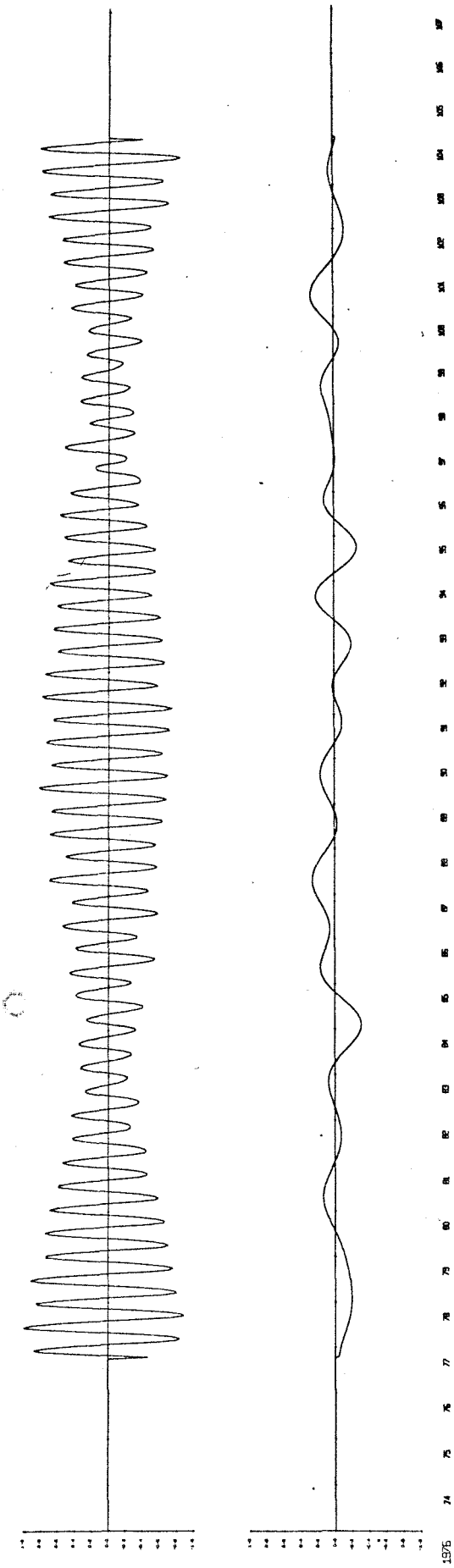
SG2/6 TEMPERATURE
(DEGREES CELSIUS)

OAR4/2 TEMPERATURE
(DEGREES CELSIUS)

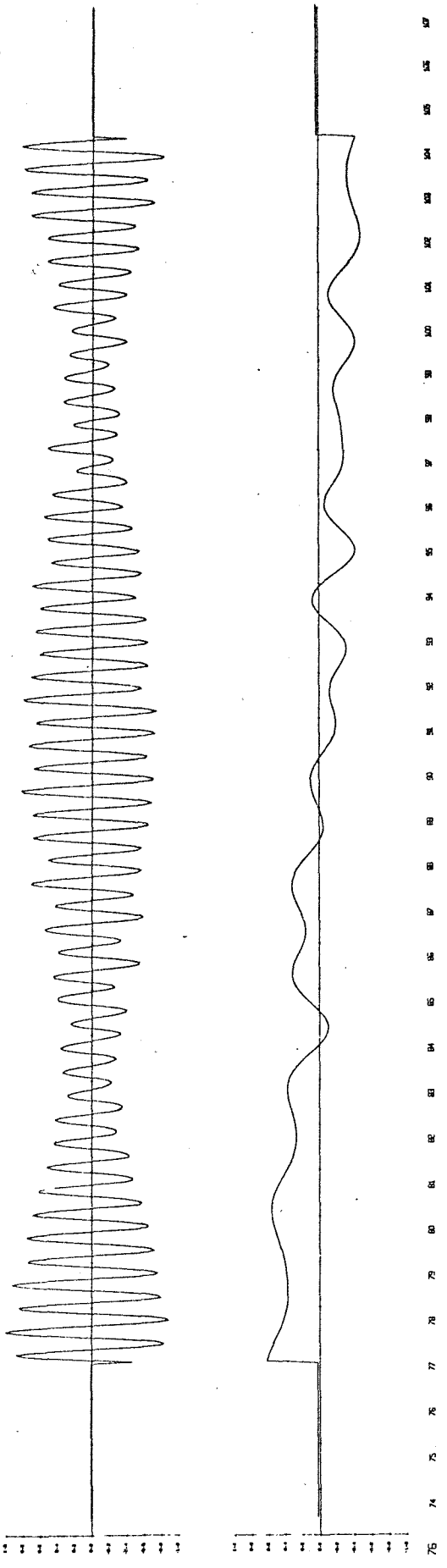
VIB1/1 TEMPERATURE
(DEGREES CELSIUS)

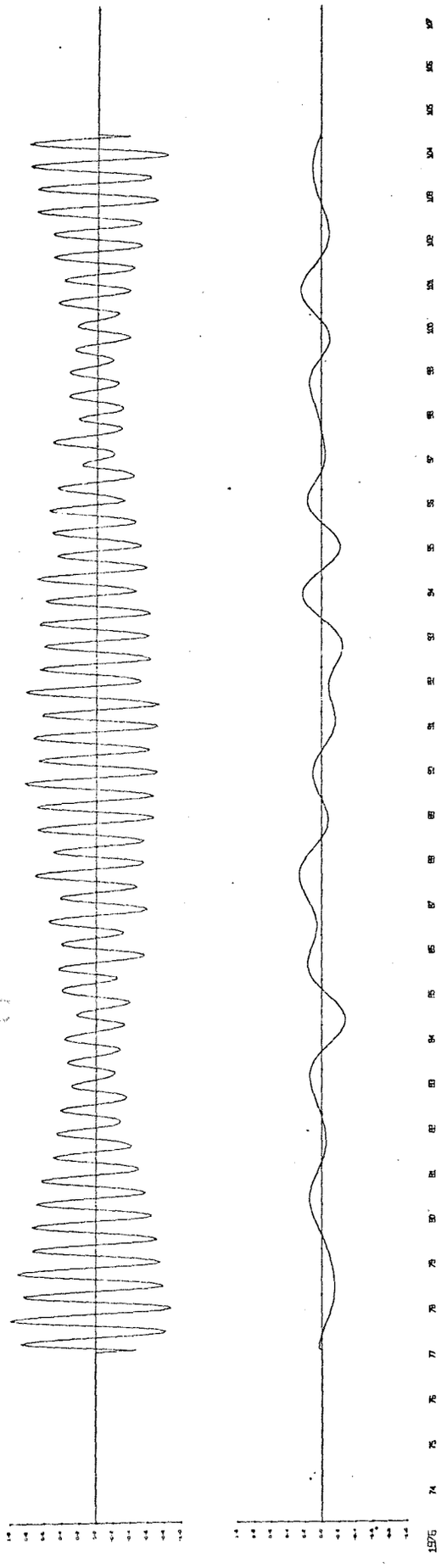


DAY OF THE YEAR



N.NORTH SEA JUN66 V1B1/1 TOT. PRESSURE


FILTERED VALUES
RESIDUALS



FILTERED VALUES

RESIDUALS

N-NORTH SEA JOINS SEP/6 TOT- PRESSURE

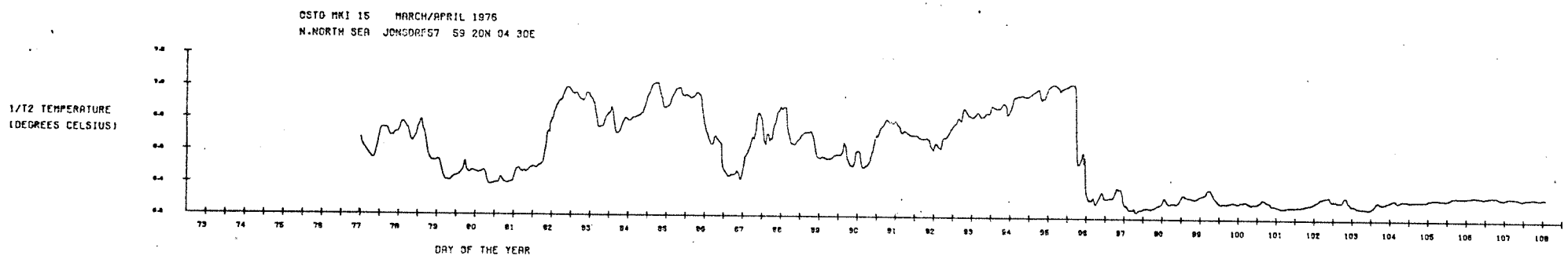
TABLE 4

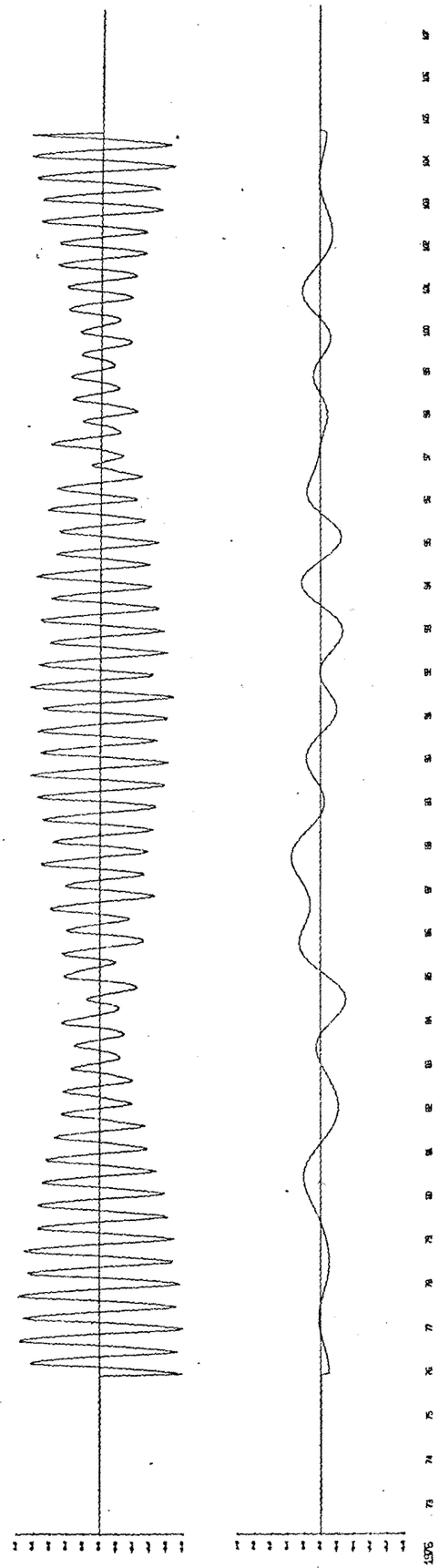
Station 56, N. North Sea, Lat 59°19 .5'N, Long 02°46 .68'E.
Drift free total pressure (millibars), FHP 53 filter.
2000 day 077 to 0200 day 105 1976, 28 days and 6 hours.
27 constituents + 8 related (*) using Lerwick 1966/71 analysis.

Constituent	VIB 1/1 H (mb)	VIB 1/1 G (°)	OAR 4/2 H (mb)	OAR 4/2 G (°)	SG 2/6 H (mb)	SG 2/6 G (°)
Q_1	1.5	280.8	1.8	272.6	2.1	256.9
O_1	3.7	56.1	3.7	51.6	3.9	48.4
M_1	0.2	204.5	0.2	196.3	0.3	196.9
* π_1	0.1	121.6	0.1	124.3	0.1	124.5
* P_1	0.8	165.0	0.8	167.7	0.8	167.9
K_1	2.6	181.1	2.6	183.8	2.5	184.0
* ψ_1	0.1	193.4	0.1	196.0	0.1	196.3
* ϕ_1	0.1	209.6	0.1	212.3	0.05	212.5
J_1	0.5	10.5	0.5	26.2	0.6	17.9
OO_1	1.4	299.0	1.0	291.2	1.1	294.9
* $2N_2$	0.9	267.7	1.0	267.1	0.9	266.2
μ_2	1.8	271.7	1.8	271.7	1.8	274.6
N_2	6.3	286.8	6.4	286.2	6.3	285.3
* ν_2	1.2	287.2	1.2	286.6	1.2	285.7
M_2	32.0	308.8	32.6	308.7	32.2	308.9
L_2	1.0	292.6	1.0	296.7	1.0	295.6
* T_2	0.6	330.6	0.6	330.4	0.6	330.6
S_2	12.5	345.2	12.7	345.0	12.5	345.2
* K_2	3.5	341.7	3.5	341.5	3.5	341.7
$2SM_2$	0.4	30.1	0.2	19.1	0.03	357.6
MO_3	0.2	145.0	0.3	142.0	0.3	138.7
O_3	0.3	220.4	0.3	193.3	0.3	180.9
MK_3	0.2	346.8	0.1	315.8	0.1	249.0
MN_4	0.4	233.7	0.5	227.8	0.4	228.0
M_4	1.2	263.6	1.2	261.4	1.2	261.8
SN_4	0.3	56.4	0.3	56.9	0.3	54.2
MS_4	0.9	4.3	0.9	1.7	1.0	0.2
$2MN_6$	0.5	21.9	0.4	27.4	0.4	27.1
M_6	0.6	43.3	0.6	46.4	0.6	48.5
MSN_6	0.1	55.1	0.1	31.5	0.1	24.2
$2MS_6$	0.6	101.3	0.7	105.1	0.7	105.3
$2SM_6$	0.1	170.6	0.2	156.0	0.2	153.9

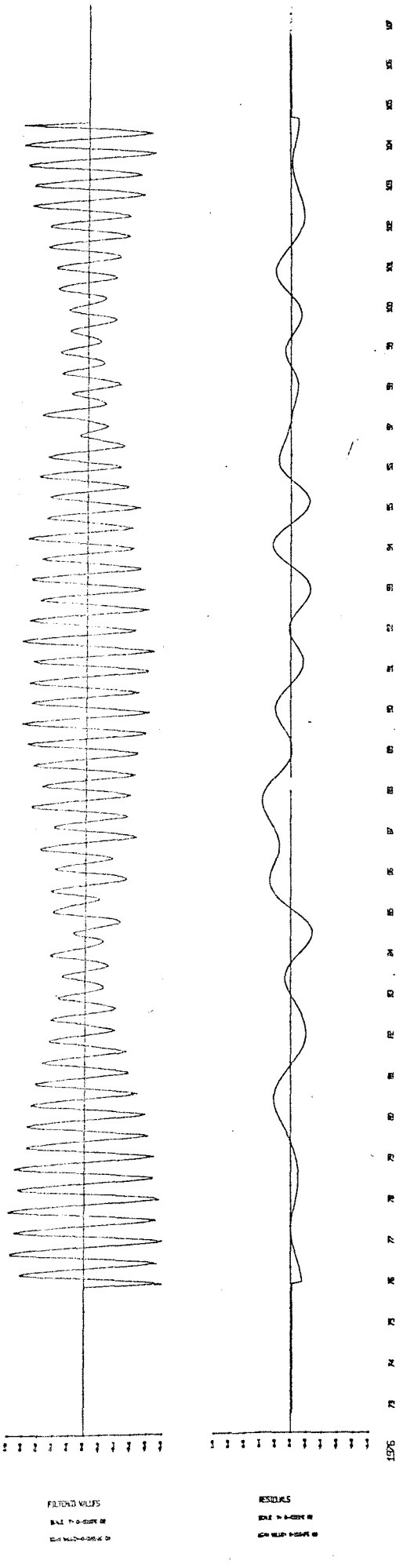
OSTG position	Station 57, North North Sea, 1976, Lat $59^{o}20'N$, Long $04^{o}31'E$, g = 9.819 ms^{-2}.
Water depth	271m.
OSTG details	Mk I, Logger no. 15, Sensors 1/13, 1/16, and 1/T2 (temperature).
Time of deployment	Tide gauge on sea bed at 1100 GMT day 073.
Time of recovery	Gauge out of water at 1400 GMT day 108.
CTD casts	1 cast at 1530 GMT day 073 1 cast at 1936 GMT day 108 Density, ϱ = 1027.384 kg m^{-3}.
Comments	Sensors 1/13 and 1/16 have no built-in temperature sensors so a separate sensor, 1/T2 was used to measure temperature.

Timing	1st scan at 1100 GMT day 069 Last scan at 1811,58s GMT day 111 Clock fast, gained 3m 2s in 1115¼h (42 days 7¼ hours).
Raw data	Start 1107, 45s GMT day 073 End 1320, 18s GMT day 108
Temperature data	Complete temperature record from sensor 1/T2.
Drift-free data	Start 1600 GMT day 076 End 0900 GMT day 105 FHP53 filter used.
Tidal analysis	TIRA, 1600 day 076 to 0900 day 105, 28 days and 17 hours, using 27 major and 8 related constituents from Lerwick 1966 to 1971 analysis.
Comments	


OSTG MKI 15 MARCH/APRIL 1976
N.NORTH SEA JONSDAF57 59 20N 04 30E
1/T2 TEMPERATURE
(DEGREES CELSIUS)
DAY OF THE YEAR



JONSWAP57 SENSOR1 TOT. PRESSURE



JONSDAP57 SENSOR2 TOT. PRESSURE

TABLE 5

Station 57, N. North Sea, Lat 59°20'N, Long 04°31'E.
Drift free total pressure (millibars), FHP 53 filter.
1600 day 076 to 0900 day 105 1976, 28 days and 17 hours.
27 constituents + 8 related (*) using Lerwick 1966/
1975 analysis

		1/13		1/16	
	Constituent	H (mb)	G (°)	H (mb)	G (°)
	Q_1	1.8	261.5	1.7	261.9
	O_1	2.3	39.6	2.3	39.7
	M_1	0.4	254.4	0.4	256.3
*	π_1	0.05	106.2	0.04	106.1
*	P_1	0.6	149.6	0.6	149.5
	K_1	2.0	165.8	2.0	165.7
*	ψ_1	0.1	178.0	0.1	177.9
*	ϕ_1	0.04	194.2	0.04	194.1
	J_1	0.1	39.4	0.1	22.4
	OO_1	1.1	296.1	1.1	294.1
*	$2N_2$	0.7	242.7	0.7	242.7
	μ_2	1.5	277.4	1.5	277.5
	N_2	4.7	261.8	4.7	261.8
*	ν_2	0.9	262.2	0.9	262.2
	M_2	24.5	286.1	24.5	286.1
	L_2	1.2	264.3	1.1	264.5
*	T_2	0.5	313.7	0.5	313.7
	S_2	9.9	328.3	9.9	328.3
*	K_2	2.8	324.8	2.8	324.8
	$2SM_2$	0.2	7.3	0.1	6.1
	MO_3	0.3	146.4	0.3	146.7
	O_3	0.2	178.5	0.2	180.2
	MK_3	0.1	345.6	0.1	351.2
	MN_4	0.3	215.0	0.3	214.9
	M_4	1.1	260.2	1.1	259.4
	SN_4	0.4	42.2	0.4	41.8
	MS_4	0.9	5.2	0.9	4.7
	$2MN_6$	0.7	45.3	0.7	45.0
	M_6	1.0	68.5	1.0	68.5
	MSN_6	0.2	61.9	0.2	65.8
	$2MS_6$	1.1	122.3	1.1	122.3
	$2SM_6$	0.3	170.0	0.3	168.2