

I.O.S.

OFF SHORE TIDE GAUGE DATA

by

G A ALCOCK and J M VASSIE

Irish Sea	1972, 1973, 1974
Celtic Sea	1973
Southern North Sea	1973
North Bay of Biscay	1973
Northern North Sea	1974

DATA REPORT NO. 7

1975

NATURAL ENVIRONMENT
INSTITUTE OF
OCEANOGRAPHIC
SCIENCES
RESEARCH COUNCIL

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ABSTRACT

This report describes the results from various deployments of O.S.T.G.s (Off Shore Tide Gauges) by the Bidston Laboratory of the Institute of Oceanographic Sciences in the U.K. shelf seas from 1972 to 1974. The positions of the deployment stations are shown on Fig.1.

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.

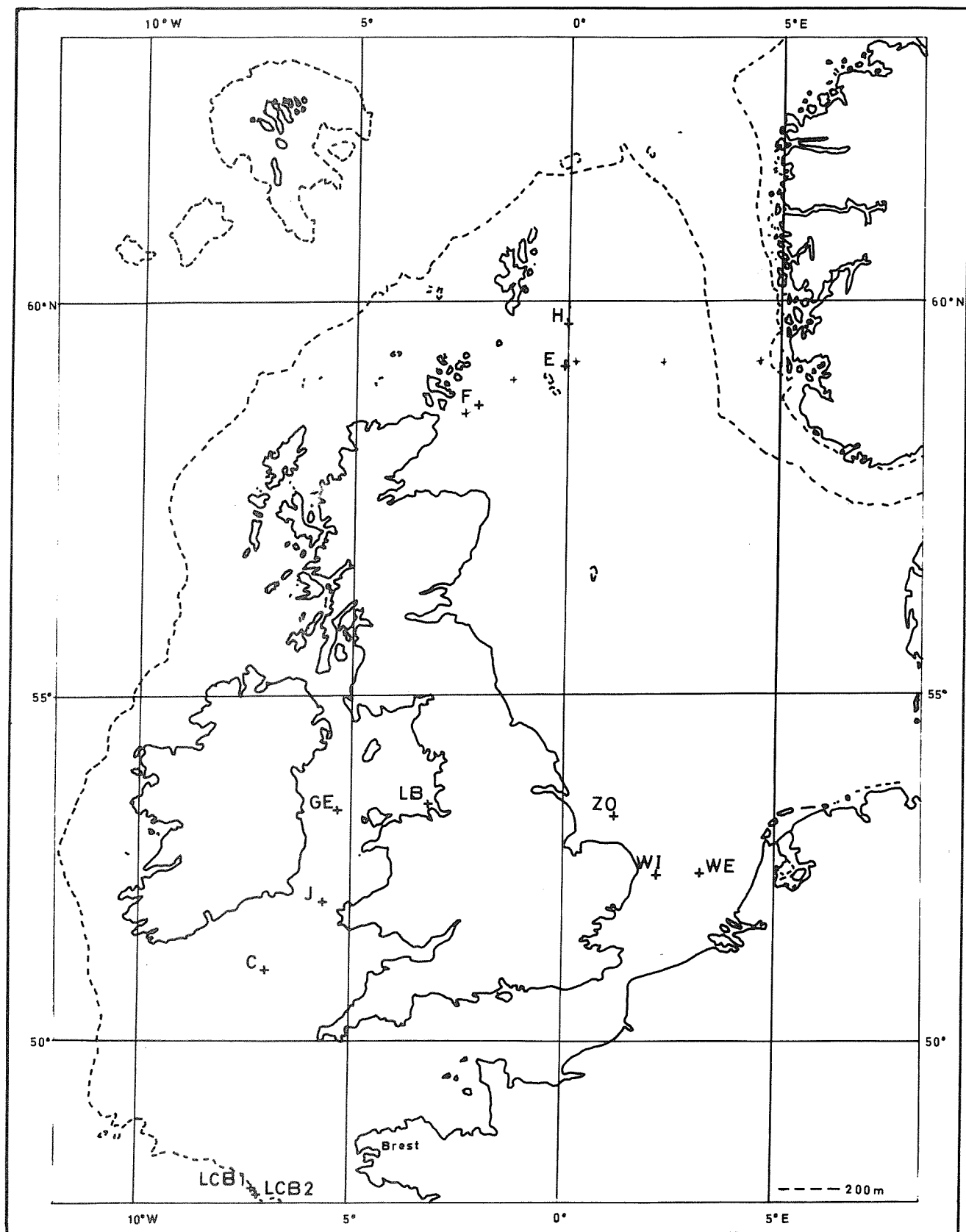


FIG 1 POSITIONS OF DEPLOYMENT STATIONS

1.

TYPE I O.S.T.G. (Designated IOSW on computer plots)

(i) Logger and transducers

This type of OSTG was developed at the I.O.S. Wormley Laboratory (formerly National Institute of Oceanography) by P. Collar and R. Spencer and has been used in a series of deployments along the northwest European continental shelf (Collar and Cartwright 1972, Cartwright 1975). It incorporates a sea-bed mounted pressure transducer interfaced to a 12 channel Normalair-Garret data logger housed in a 56 cm diameter aluminium pressure sphere. The FM (frequency modulated) transducer consists of a diaphragm which when flexed by changing hydrostatic pressure varies the gap of a parallel plate timing capacitor in a LC oscillator circuit. The pressure casing enclosing the transducer circuitry is evacuated so that absolute rather than relative pressure is measured. The frequency output is divided down to about 100 Hz and is counted over a period of 890s to average out the unwanted fluctuations due to waves: this sampling period gives approximately 50 dB (99.999%) attenuation of energy from 10s period waves, but only 0.006 dB (0.14%) attenuation of semi-diurnal tidal energy (Collar and Spencer 1970). Pressure sensitivities of the FM07 sensor were 0.97 Hz cm^{-1} for the deployment at station "GE" 1972, 0.98 Hz cm^{-1} for station "C" 1973, and 0.84 Hz cm^{-1} for station "Z0" 1973. Pressure sensitivities of the FM32 sensor were 1.27 Hz cm^{-1} for station "J" 1974 and 1.47 Hz cm^{-1} for station "H" 1974.

The data logger has twelve input channels. Two are pulse counting channels having resolutions of 1 in 10^4 and 1 in 10^3 respectively and are used to record the 4 most significant and 3 least significant digits of the pressure transducer output. Two have parallel 4 decade B.C.D. (binary coded decimal) inputs and are used for identification labels for the logger, sensor, and deployment. The other 8 accept analogue voltages in the range 0 to 100 mV. Two of the analogue channels are used to record temperatures, one from a thermistor mounted in

2.

the transducer pressure casing and in contact with the sea, and the other from a thermistor mounted inside the sphere. Two other analogue channels monitor the supply voltages to the transducer and logger circuits. A voltage sawtooth of period 2h derived from a low torque potentiometer driven by a high precision mechanical clock is applied to a fifth analogue channel; this provides a recorded time check for each scan of the twelve channels and is used to check continuity of scans in the data processing. The integration period of 890s and the subsequent 10s scanning and recording sequence are controlled by 900s pulses from a crystal clock. The reading from each channel is recorded serially in either 3 or 4 decade B.C.D. on $\frac{1}{4}$ in magnetic tape and a parity bit is added during each scan by the digital serializer, the packing density on the tape is 150 bits per inch. A synchronizing signal is recorded on a second track of the tape to assist in translating the magnetic tape to paper tape during the data processing.

(ii) Calibration

All pressure/frequency calibrations were carried out by members of the Research Technology Group of I.O.S. Bidston using the pressure chamber at Wormley. Pressure in the oil-filled chamber was controlled using a Texas Precision Gauge incorporating a quartz bourdon tube with an optical servo-system; another servo-system controlled the speed of rotation of a pump to maintain pressure in the chamber.. Temperature in the insulated chamber was kept constant to within 0.1°C by a bank of chillers. Once the temperature of the chamber had settled to the predetermined value, a calibration run was made over the available pressure range of $0.2 \times 10^6 \text{ N m}^{-2}$ to $2 \times 10^6 \text{ N m}^{-2}$ (approximately equivalent to a water depth of 20m to 200m), and this was repeated for a range of temperatures in order to provide information on the temperature dependence of the pressure/frequency relationship. FM07 had a temperature coefficient equivalent to $39.6 \text{ cm }^{\circ}\text{C}^{-1}$ for the deployment at station 'GE' 1972 (mean depth 85m),

37.9 cm $^{\circ}\text{C}^{-1}$ at station "C" 1973 (95m); and 45.7 cm $^{\circ}\text{C}^{-1}$ at station "Z0" 1973 (23m). FM32 had a temperature coefficient equivalent to 28.5 cm $^{\circ}\text{C}^{-1}$ at station "J" 1974 (94m) and 27.3 cm $^{\circ}\text{C}^{-1}$ at station "H" 1974 (137m).

The calibration of the thermistors was carried out at Bidston using a Lauda water bath, the temperature of which could be controlled to a few millidegrees, and a digital test set to display the output from the appropriate logger channel. All the data from the pressure and temperature calibrations were fitted to low order polynomials using a least squares method computer program.

(iii) Launch and recovery

The sphere containing the data logger and interfacing electronics was mounted in a tripod framework made of tubular steel with the pressure transducer mounted on the base of the framework and beneath the sphere. The tripod was supported on a disposable heavy ballast frame consisting of welded girders and the two frames were connected by three corrodible magnesium alloy links and a pyrotechnic release mechanism. Acoustic transmitting and receiving magnetostrictive scrolls were carried above the sphere and were used in recovery of the gauge.

The tide gauge was deployed by winching it down on a wire to within a few metres of the sea bed; the wire being attached by a Levitt release mechanism to lines fixed to framework. When the gauge was near the sea bed, a brass messenger was sent down the wire, triggered the release and the gauge dropped on to the sea bed.

The tide gauge was located prior to recovery using one or two pairs of hydrophones streamed from the ship to pick up signals from the pinger mounted on the framework. By selecting the signal from each hydrophone in turn, it was possible to determine whether the ship was approaching or leaving, and to port or starboard of the tide gauge position.

When the tide gauge had been located, the pyrotechnic release was fired by acoustic command and the gauge rose to the surface under the sphere's positive buoyancy. A flashing Xenon lamp helped visual sighting of the tide gauge when it was on the surface and it was hauled on board after grappling the line attached to the framework.

(iv) Data processing

The magnetic tape from the logger was translated into ASCII II code on punched paper tape using a Normalair Garrett tape translator and punch at Wormley, and this tape was processed at Bidston using the in-house IBM 1130 computer. The data on the paper tape were read into disk storage using a program, developed by M. Amin, which translates the ASCII II code into machine compatible code, checks each scan of the twelve channels for illegal characters and correct scan length and sets any incorrect scan to zero.

A second correction program checked the record for continuity using the data recorded on the mechanical clock channel, and checked the absolute values and differences between sequential values against predetermined upper and lower bounds for all channels except the pressure frequency channels. The two pressure frequency channels were checked for correct overlap and combined to form the integrated frequency count over the 890s period. All scans with errors were listed together with values of integrated frequency at 3h intervals; all corrected data were stored on disk.

A third program calculated the temperatures recorded by the thermistors mounted in the sphere and pressure transducer casing and used the latter to correct the pressure frequency, using the frequency temperature coefficient, to the reference temperature at which the pressure/frequency calibration had been carried out. The polynomial fit for this calibration was then used to calculate the values of pressure recorded by the tide gauge and these were punched on to cards.

TYPE II O.S.T.G. (Designated IOSB on computer plots)

(i) Logger and transducers

The data logger was developed by Marconi Space and Defence Systems Ltd., in conjunction with the Bidston Laboratory of I.O.S. (Skinner and Rae 1974). The logger can sample a maximum of twenty input channels at periodic intervals and record their values by means of an incremental tape recorder in a computer compatible format. Any input channel is capable of sampling either D.C. (Direct Current) or frequency modulated A.C. (Alternating Current) inputs - the FM inputs can be sampled for periods of $15/64$, $15/16$, $3\frac{3}{4}$, 15 or 60 seconds or "continuously", i.e. the integrating time is virtually equal to the sampling period of the data from the channels. The number of channels scanned can be truncated to less than twenty and the "data recycling time" can be $1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$, 15, 30 or 60 minutes. An integration time of 899.994s and sampling time of 900s for each channel were used for all deployments, and all twenty channels have been used in order, where possible, to achieve redundancy by recording on two separate channels the pressure or temperature output from each transducer. Each channel contains a voltage to FM converter which permits handling of voltage inputs in the same way as FM signals. Each channel is recorded as four six bit binary characters, each with an associated parity bit to give odd parity. The most significant character is used for control purposes and the remaining 23 bits are used for sample data. Channel 1 is used for recording elapsed time and is permanently held open to count elapsed time pulses derived from a crystal oscillator. All integration, gating, and recording periods are controlled by a second crystal oscillator. The recording format of the sampled data is 7 track NRZI, 200 characters per inch and 1280 characters per block (other possible block lengths are 10240, 5120 or 2560 characters per block). The data being recorded on the tape may be monitored on board ship while the tide gauge is on the seabed using a direct wire telemetry link to a teleprinter.

Sensor packs used with the logger incorporated both a pressure and a temperature sensor and were completely self-contained units with their own sensor electronics and power supplies. Different types of pressure sensor based on either vibrating wire, quartz crystal and strain gauge systems have been used on the tide gauge. Two types of vibrating wire sensor have been used: the Vibroton model 8140 (Lefcort 1968) and the Ocean Applied Research model WS-704. In each type, a tungsten wire is stretched between a rigid frame and a diaphragm and mounted in a magnetic field. Any movement of the diaphragm due to a change of pressure will increase or decrease the tension of the wire and hence change its natural frequency of oscillation. The wire is connected in the feedback loop of an amplifier and thus makes a variable frequency oscillator where frequency is a function of pressure. To achieve temperature compensation, the coefficient of expansion of the supporting frame is designed to balance the expansion of the wire, the transducer of the Vibroton sensor is evacuated and that of the OAR is filled with a small amount of dry nitrogen.

The quartz crystal type sensors used were Hewlett Packard Oceanographic pressure probes model D-101 and consist of a 5 MHz quartz resonator coupled by piezoelectric action to an electronic oscillator and mounted in an oil filled case adjacent to a pressure case containing the electronic circuitry. A second closely matched quartz crystal resonator is mounted in the pressure case and is therefore not exposed to hydrostatic pressure and is used for temperature compensation by heterodyning the frequency outputs of the two crystals. The sensors used had crystals with matched turning points at about 0°C, so that the temperature coefficient was a minimum at this temperature.

The strain gauge sensor used was developed using a Bell and Howell type 4-306 transducer and operates as a phase shift oscillator whose frequency is controlled by the ratio

of output to input voltage of the transducer Wheatstone bridge network. The circuit was originally developed for temperature measurement, using a platinum resistance thermometer in the bridge network, and was the basis of the temperature sensors used on the tide gauge (Butlin 1974). The thermometer is fitted into the copper heat sink in which each of the pressure sensors are mounted. The temperature resolution of the system was of the order of $1 \text{ m}^{\circ}\text{C}$.

(ii) Calibration

All the transducers were calibrated for pressure sensitivity using the facilities at Wormley; temperature calibrations were carried out at Bidston, as described in the previous section (ii).

For the La Chapelle Bank deployment in June 1973, the VIB 1/2, HP 3/2, and SG 2/1 sensors were used, with pressure sensitivities of 0.038 hz cm^{-1} , 0.128 hz cm^{-1} , and 0.070 hz cm^{-1} respectively; and temperature coefficients of $6.0 \text{ cm }^{\circ}\text{C}^{-1}$, $22.5 \text{ cm }^{\circ}\text{C}^{-1}$ and $213 \text{ cm }^{\circ}\text{C}^{-1}$ respectively.

For the Liverpool Bay deployment in June 1973, the VIB 1/1, VIB 1/3 and HP 3/1 sensors were used, with pressure sensitivities of 0.040 hz cm^{-1} , 0.038 hz cm^{-1} , and 0.126 hz cm^{-1} respectively; and temperature coefficients $2.8 \text{ cm }^{\circ}\text{C}^{-1}$, $9.9 \text{ cm }^{\circ}\text{C}^{-1}$ and $26.0 \text{ cm }^{\circ}\text{C}^{-1}$ respectively.

For the Jonsdap "WI" deployment in September 1973, the VIB 1/2 and SG 2/3 sensors were used, with pressure sensitivities of 0.039 hz cm^{-1} and 0.046 hz cm^{-1} respectively; and temperature coefficients $5.1 \text{ cm }^{\circ}\text{C}^{-1}$ and $182 \text{ cm }^{\circ}\text{C}^{-1}$ respectively. For the Jonsdap "WE" deployment in September 1973, the VIB 1/3 and SG 2/1 sensors were used, with pressure sensitivities of 0.036 hz cm^{-1} and 0.091 hz cm^{-1} respectively; and temperature coefficients $11.3 \text{ cm }^{\circ}\text{C}^{-1}$ and $176 \text{ cm }^{\circ}\text{C}^{-1}$ respectively.

For the La Chapelle Bank deployment in November 1973, the OAR 4/2, VIB 1/1, HP 3/2, and SG 2/2 sensors were used with pressure sensitivities of 0.046 hz cm^{-1} , 0.042 hz cm^{-1} ,

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0.128 hz cm⁻¹, and 0.071 hz cm⁻¹ respectively; and temperature coefficients of 3.2 cm °C⁻¹, 4.5 cm °C⁻¹, 22.5 cm °C⁻¹, and 218 cm °C⁻¹ respectively.

For the north North Sea "F" deployment in October 1974, the OAR 4/1, VIB 1/2, and SG 2/5 sensors were used, with pressure sensitivities of 0.040 hz cm⁻¹, 0.037 hz cm⁻¹, and 0.047 hz cm⁻¹ respectively, and temperature coefficients of 1.3 cm °C⁻¹, 4.9 cm °C⁻¹, and 181 cm °C⁻¹ respectively. For the north North Sea "E" deployment in November 1974, the OAR 4/2, VIB 1/3, and SG 2/3 sensors were used, with pressure sensitivities of 0.043 hz cm⁻¹, 0.040 hz cm⁻¹, and 0.041 hz cm⁻¹ respectively, and temperature coefficients of 3.4 cm °C⁻¹, 9.0 cm °C⁻¹, and 247 cm °C⁻¹ respectively.

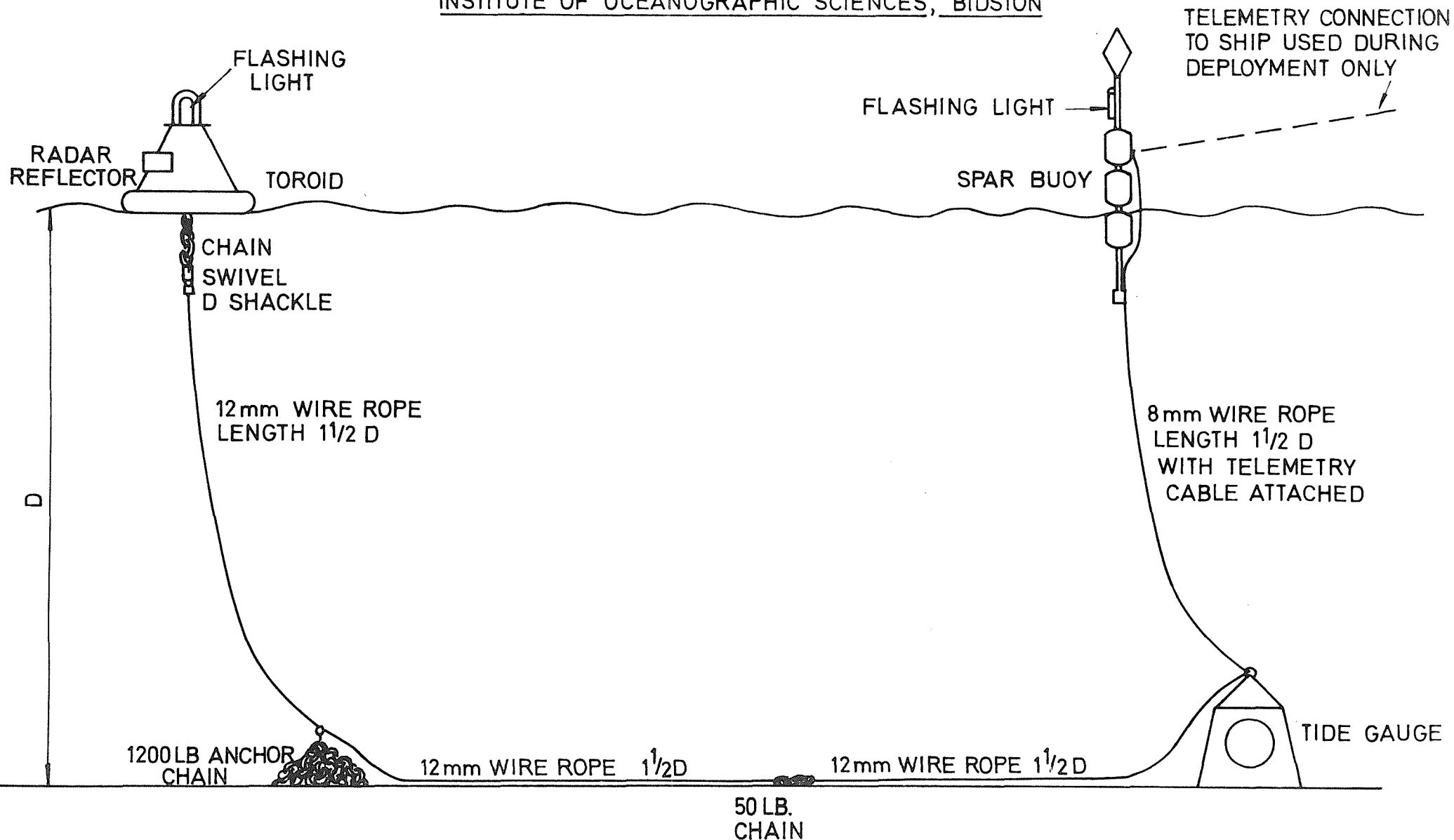
(iii) Launch and recovery

The data logger and its batteries were housed in a 56 cm diameter aluminium sphere with sufficient space left within the sphere for sensor batteries, acoustic release electronics and ancillary sensor electronics. Water tight connectors mounted on the ports of the sphere enabled sensors external to the sphere to be powered and their output signals fed into the sphere. The sphere and a number of sensor packs were mounted in an aluminium sub-frame which in turn was protected by a heavy steel outer frame.

During the launch phase, a toroidal buoy was deployed first followed by its anchor weight. The tide gauge was then lowered on to the sea bed by winch with the telemetry cable taped to its wire. The data being recorded on the tape were monitored throughout the launch and after satisfactory data had been received from the gauge on the sea bed, the telemetry link was disconnected and the spar buoy released. Fig.2 shows the deployment configuration.

Before recovery, the tide gauge's acoustic command system was switched to its transmission mode to aid location of the gauge. The spar buoy was recovered first and the gauge winched

OFF SHORE TIDE GAUGE MOORING SYSTEM
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up, followed by the anchor weight and toroidal buoy. If the spar buoy was missing then a grapple was used to drag for the wire connecting the tide gauge to the anchor weight.

(iv) Data processing

The magnetic tape from the logger was copied, with a density of 1800 bpi, on to a 9 track magnetic tape using a program written by A. Davies for the IBM 360/65 computer of the Liverpool University Physics Department. The data from all the channels were listed and each channel manually checked for sensor failure prior to recovery. Subsequently the program was re-run to punch on to cards the data from the appropriate channels. The IBM 1130 computer was 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 correct 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 to cards.

Drift Removal and Tidal Analysis

An interpolation program was used on the IBM 370/165 computer at the SRC Daresbury Laboratory, using the Bidston 1130 as a RJE (Remote Job Entry) terminal, 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 (126^0 per hour) - thus the amplitude response of the sixth diurnal band was -0.08 dB (1%). The filter response characteristic is shown in Fig.3. 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

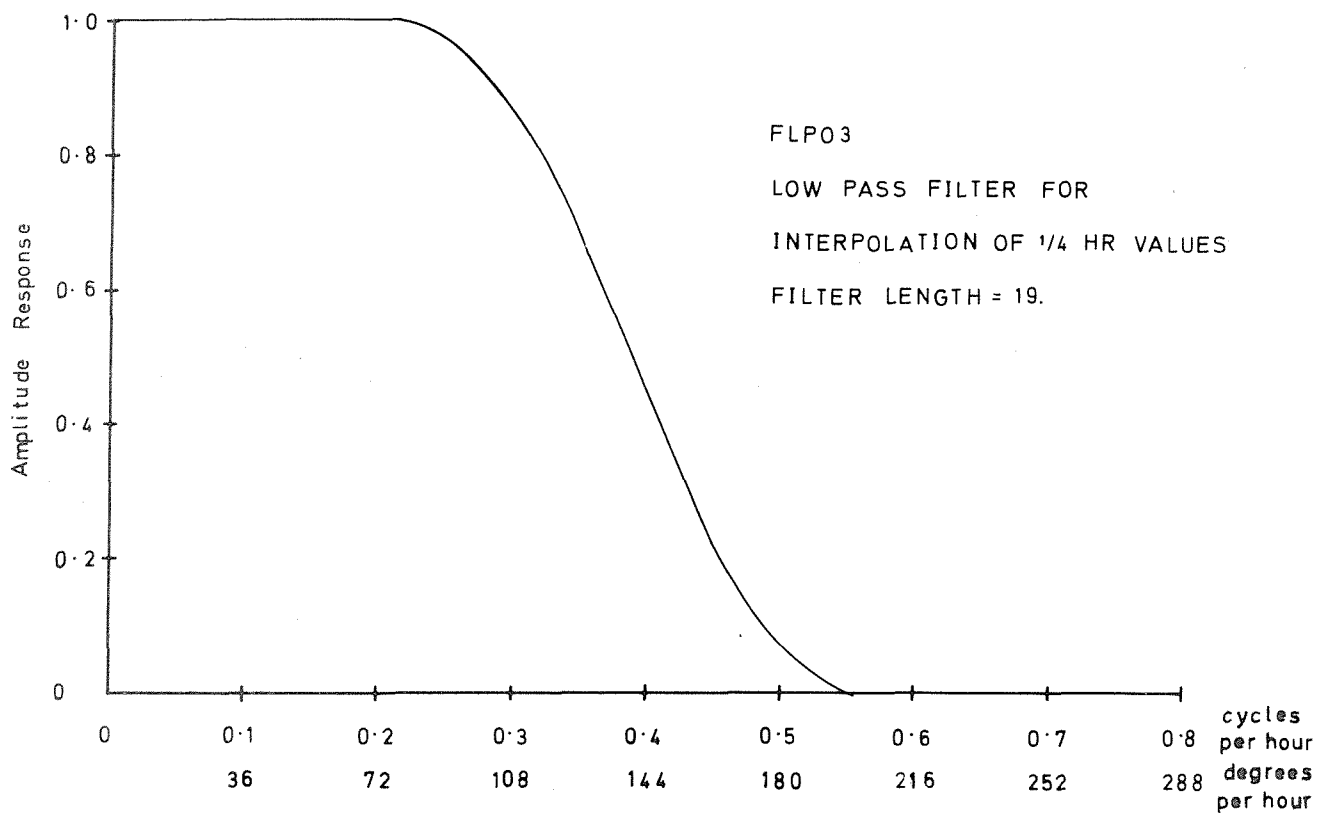
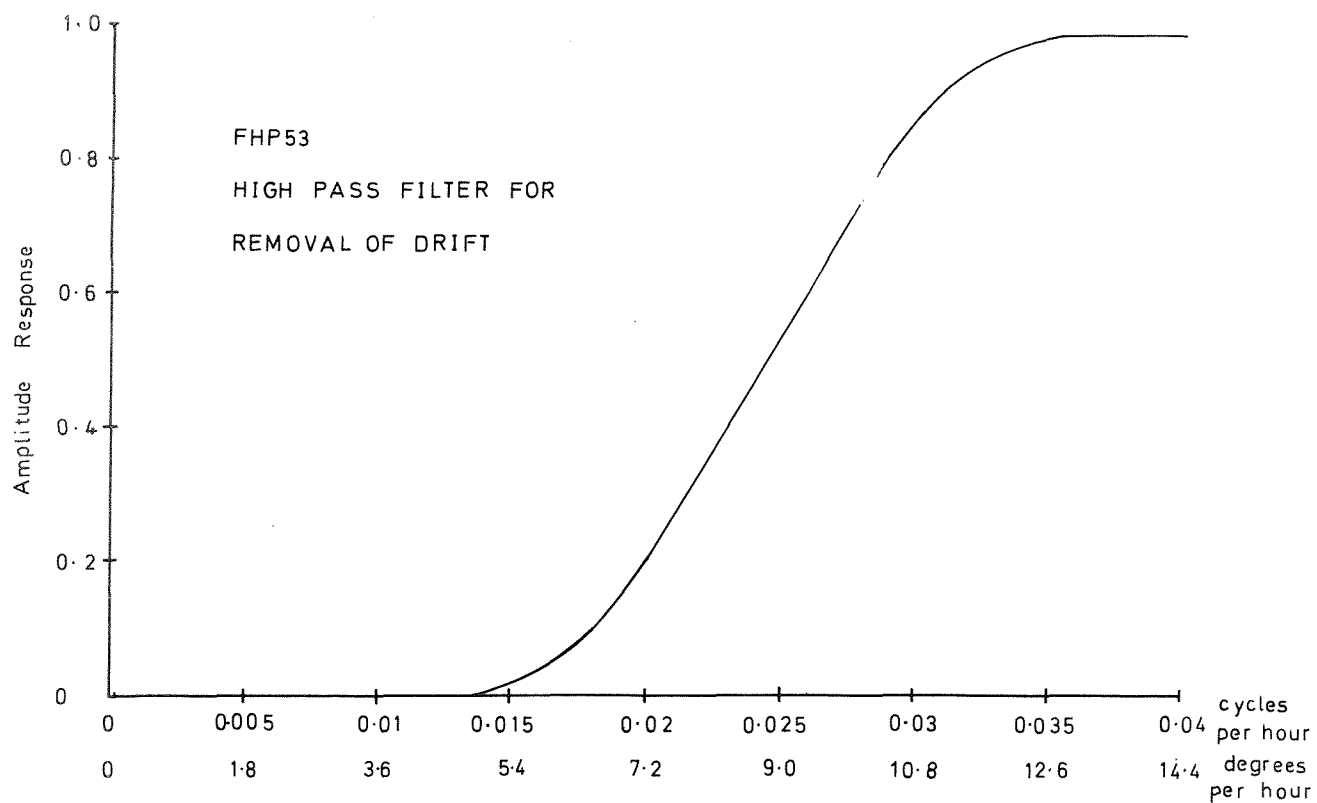


FIG 3. FILTER CHARACTERISTICS

to launch and after recovery). Root mean square errors due to the interpolation method are of the order of 0.02 mb. For those deployments of the type I tide gauge for which no temperature record was available, hourly values of the integrated frequency were computed using the interpolation program and the corresponding temperature corrections made using hourly values of temperature measured by an adjacent bottom-mounted current meter and supplied by J. Howarth.

Each hourly value obtained using the interpolation program was the total pressure measured by the tide gauge, i.e. the sum of the pressures due to the water column and air column above the sensor. The latter was subtracted using the hourly value of atmospheric pressure computed for the tide gauge position using a computer program which fitted a plane to pressures at adjacent shore stations supplied by the British, French and Irish Meteorological Services. The computed water pressures were converted to elevation using the hydrostatic equation, for which the appropriate value of density was calculated from density/depth profiles at the station obtained with the CTD (Conductivity/Temperature/Depth) Instrument during the cruise and processed by S. Loch.

The record of hourly values of the water head measured by the tide gauge contained drift signals superimposed on the tidal signal; this drift was a combination of geophysical non-tidal effects such as surges, and any transducer time-dependent drifts (in the case of the capacitance plate transducer, probably caused by mechanical instability of the diaphragm (Collar and Spencer 1970)). The non-tidal drift was removed using a program on the 370 which, by applying a tidal analysis to sequential blocks of 25 hourly values using the main tidal constituent in species 1, 2, 4 and 6, generated a drift curve composed of a series of the nearly tide-free Z_0 values. This process allowed a slight leakage of tidal energy through into the drift curve and so immediate removal of this drift curve would also have removed some of the tidal signal;

therefore a tenth order polynomial was fitted to the drift curve and the polynomial removed from the original record to leave the pure tidal record. The drift curve contained most of the energy below 0.5 cycle per day. Twelve hours of data were lost at the beginning and end of each record.

For some records this technique was not powerful enough to remove the drift, e.g. the Vibrotron 1/1 sensor deployed at station 'LCB2' had a drift which was highly non-linear with an overall drift of nearly 30m compared with a tidal range of 3.5m. Consequently, a high pass numerical filter, FHP 53, was designed with a cut off frequency (half-power point) of 0.027 cycles per hour (9.8° per hour). This filter had a half length of 72 and so three days of data were lost from the beginning and end of the record. The response of this filter is shown in fig. 3.

The two methods of removing drift were tested using a test deck formed by adding 32 tidal constants for Southend to a drift curve from the FM-type sensor in such a way that the maximum variation of the drift curve equalled the tidal range, and then removing the drift using the 25 hr analyses method and the high pass filter method. A 29 day period of the resulting drift-free record obtained using each method was analysed and the results compared with the original Southend constants. The results are displayed in Table 1 and it can be seen that both methods satisfactorily removed the drift.

Tidal analyses of a 29 day period of the drift-free record obtained from each deployment were carried out using the T.I.F.A. (Tidal Institute Flexible Analysis) program which utilises the harmonic method of analysis. For the Jonsdap "WI" and north North Sea "H" deployments, the analyses were carried out using the T.I.R.A. (Tidal Institute Recursive Analysis) program. For all deployments except "H" and Jonsdap "WI", 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 ($S = 0$). Related constituents used were π_1 , ρ_1 , γ_1 ,

and ϕ_1 all related in amplitude and phase to K_1 ; $2N_2$ and ν_2 to N_2 ; T_2 and K_2 to S_2 . For north North Sea "H", 10 major and 5 related constituents were computed, Q_1 to O_1 ; P_1 to K_1 ; N_2 and L_2 to M_2 , and K_2 to S_2 . For Jonsdap "WI", 22 major and 17 related constituents were computed, σ_1 to $2Q_1$; Q_1 and ρ_1 to O_1 ; π_1 , P_1 , S_1 , γ_1 , and ϕ_1 to K_1 ; J_1 to OO_1 ; MNS_2 and $2N_2$ to μ_2 ; N_2 , ν_2 , and L_2 to M_2 ; T_2 and K_2 to S_2 ; and MSN_2 to $2SM_2$. All relations were computed from tidal analyses of records from shore tide gauges in the deployment area, except for Jonsdap "WE" for which equilibrium tide relations were used due to the proximity of the deployment position to an amphidromic point.

CONSTITUENT	SOUTHEND HARMONIC CONSTANTS		25 HR ANALYSES METHOD		HIGH PASS FILTER METHOD	
	H (ft)	G (deg)	H (ft)	G (deg)	H (ft)	G (deg)
Zo	20.000		19.990		20.002	
Q	0.180	126.70	0.183	127.07	0.180	126.36
O ₁	0.456	188.62	0.451	188.40	0.453	188.98
M ₁ ¹	0.007	152.34	0.011	155.14	0.008	147.93
Π ₁ ¹	0.025	299.36	0.025	299.94	0.025	299.45
P ₁ ¹	0.136	344.32	0.137	344.90	0.137	344.40
K ₁ ¹	0.383	9.78	0.385	10.36	0.385	9.87
ψ ₁ ¹	0.019	71.40	0.019	71.98	0.019	71.49
φ ₁ ¹	0.016	23.46	0.016	24.04	0.016	23.55
J ₁ ¹	0.034	91.16	0.040	93.44	0.035	96.20
OO ₁ ¹	0.015	201.08	0.015	206.09	0.015	191.39
2N ₂	0.227	351.47	0.227	351.46	0.227	351.57
N ₂ ²	0.432	94.08	0.426	94.24	0.429	94.33
N ₂ ²	1.188	325.67	1.187	325.66	1.188	325.77
ν ₂ ²	0.363	317.98	0.363	317.97	0.363	318.08
M ₂ ²	6.771	352.88	6.767	352.89	6.771	352.89
L ₂ ²	0.566	29.51	0.580	30.16	0.579	30.44
T ₂ ²	0.122	35.65	0.122	35.65	0.122	35.65
S ₂ ²	1.994	48.85	1.991	48.85	1.988	48.85
K ₂ ²	0.574	47.01	0.573	47.01	0.572	47.01
2SM ₂ ²	0.130	269.62	0.135	269.00	0.133	267.73
MO ₃	0.170	120.17	0.168	120.97	0.168	120.55
M ₃ ³	0.056	96.18	0.054	94.60	0.053	96.55
MK ₃ ³	0.160	298.31	0.159	296.75	0.159	297.44
MN ₄	0.111	309.31	0.111	309.30	0.110	309.41
M ₄ ⁴	0.351	6.67	0.351	6.42	0.352	6.69
SN ₄ ⁴	0.008	100.73	0.007	98.13	0.008	84.82
MS ₄ ⁴	0.127	63.56	0.126	64.60	0.127	63.90
2MN ₆	0.086	8.86	0.091	9.21	0.090	8.54
M ₆ ⁶	0.160	35.30	0.162	35.58	0.161	35.77
MSN ₆ ⁶	0.041	62.76	0.037	60.44	0.038	62.37
2MS ₆ ⁶	0.165	82.44	0.168	82.12	0.169	82.06
2SM ₆ ⁶	0.042	132.93	0.045	132.48	0.044	131.73

TABLE 1

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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	General area, Station identification and year, Latitude and Longitude.
Water depth	Measured at launch by CTD and/or sonar, or taken from Admiralty Chart.
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.
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 record	Details of temperature record(s) available.
Atmospheric pressure	Stations used to compute atmospheric pressure record.
Drift-free data	Times of start and end of drift-free hourly water head data. Method used to produce drift free data.
Tidal analysis	Period analysed and station used for related constituents.
Comments	Comments on data reduction.

Computer plots

- (1) Plot of temperature record(s).
- (2) Plot of tidal record and drift curve of the hourly record of water head data.

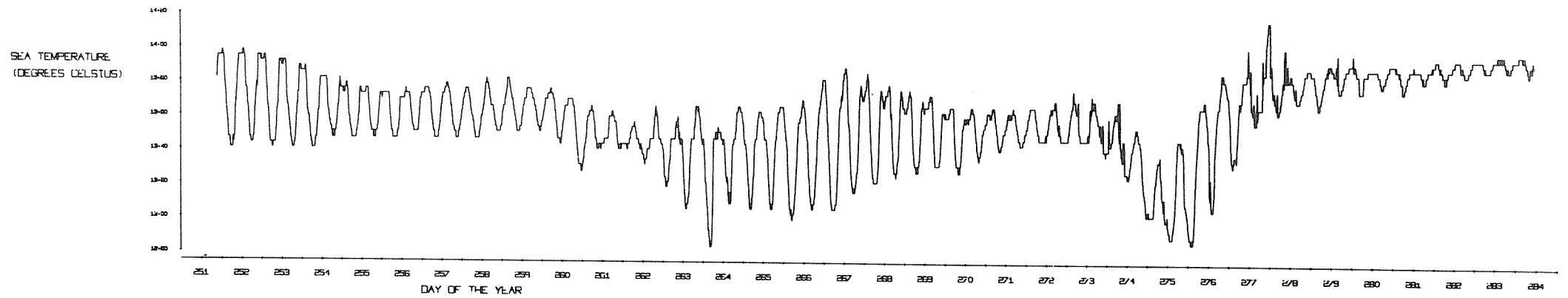
Analysis

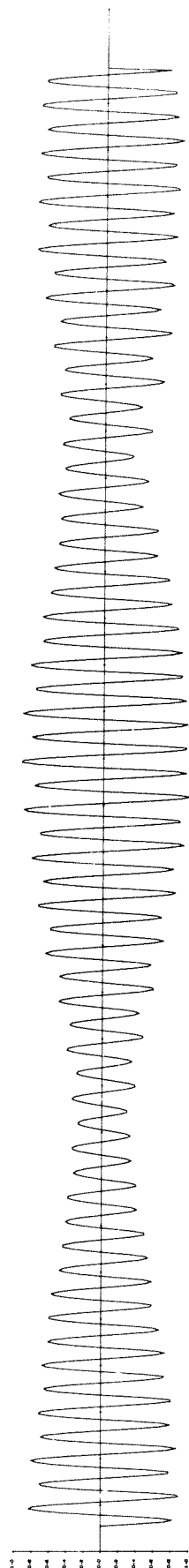
Table of amplitude and phase (G - referred to lunar transit at Greenwich and time zone $S = 0$) of 27 major and 8 related constituents of tidal record from each sensor.

OSTG position	Station 'GE', Irish Sea, 1972 Lat 53°26.5'N Long 05°22'W.
Depth of water	85m (chart 1598).
OSTG details	Type I, logger 41, sensor FM 4882/07.
Time of deployment	Launched from "John Murray" 1830 GMT day 251 (Sept.7th). On sea bed 1930 GMT.
Time of recovery	Surfaced 1130 GMT day 284 (Oct.10th) "John Murray".
CTD casts	1 cast 2000 GMT day 251. 13h period of $\frac{1}{2}$ h casts 0610 to 2003 GMT day 264 (Sept.20th). 25h period of $\frac{1}{2}$ h casts 0200 day 276 (Oct.2nd) to 0300 day 277.
Comments	During the initial deployment on day 250 (Sept.6th), the tide gauge was prematurely released before launch and one leg of the frame hit the deck. On inspection the only observable damage was a crack on the bottom framework but the deployment was postponed. A thorough internal inspection of the tide gauge revealed no damage. The recovery took more than three hours to accomplish due to difficulty in resolving the pinger signals.

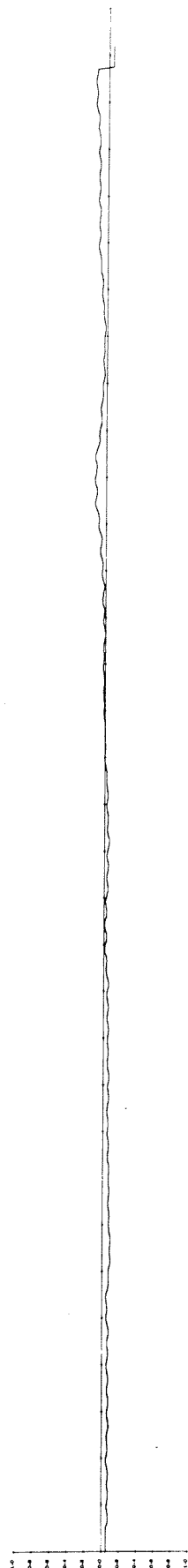
Timing	Scan 242 1930.00 GMT day 250 (Sept.6th) Scan 3486 1429.25 GMT day 284 (Oct.10th) Clock fast, gained 35s over 33d 19h.
Raw pressure data	Start 2122.34 GMT day 251 (Sept.7th) End 0952.00 GMT day 284
Temperature data	Complete records of sphere and transducer temperature.
Atmospheric pressure data	Hourly values from Dublin (Irish Met Service) 3h values from Ronaldsway and Valley (British Met Office).
Drift free data	Start 1400 GMT day 252 (Sept.8th) End 1700 GMT day 283 (Oct. 9th) 25h analyses used to produce drift curve with fitted 10th degree polynomial removed from original record.
Tidal analysis	TIFA 0000 GMT day 253 to 2300 GMT day 281 using related constituents from Holyhead (1 year analysis 1958/1959).
Comments	

OSTG FM41/07 SEP/OCT 1972
IRISH SEA 'GE' LAT 53 26.5N LONG 05 22W





DRIFT FREE RECORD
 SCALE: 1" = 0.000000 G
 ZERO VALUE: 0.000000 G



DRIFT CURVE
 SCALE: 1" = 0.000000 G
 ZERO VALUE: 0.000000 G

1972 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Station 'GE', Irish Sea, Lat 53°26.5'N Long 05°22'W
 Water head data 0000 day 253 to 2300 day 281 1972.
 *Related constituent using Holyhead (1 year analysis
 1958/1959).

Type I, Logger 41, Sensor FM07

Symbol	H (cm)	G (deg)
Q_1	3.0	0.1
O_1	10.2	42.1
M_1	0.1	298.7
* P_1	3.3	178.2
K_1	9.6	191.1
J_1	0.9	259.7
* $2N_2$	5.6	257.1
μ_2	5.0	187.9
N_2	27.4	285.0
* \mathcal{J}_2	5.2	291.8
M_2	138.3	309.2
L_2	5.7	315.7
* T_2	2.3	0.3
S_2	43.7	344.2
* K_2	13.3	336.4
$2SM_2$	2.6	259.9
M_3	1.6	243.1
MN_4	2.7	40.5
M_4	7.2	54.0
MS_4	4.6	97.3
$2MN_6$	0.6	254.8
M_6	0.6	262.6
$2MS_6$	0.6	304.6

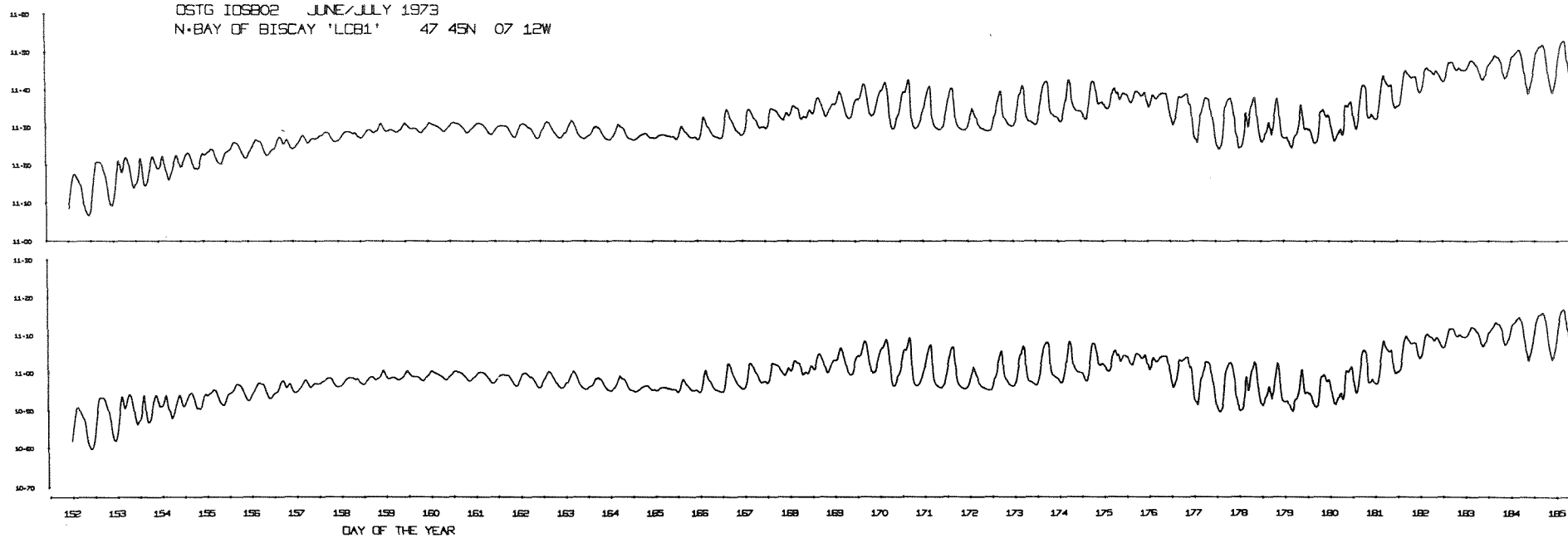
TABLE 2

OSTG position	Station 'LCB1', North Bay of Biscay 1973 Lat 47°45'N Long 07°12'W
Depth of water	174m (Admiralty chart 1104)
OSTG details	Type II, logger 02, sensors HP 3/2, SG 2/1, and Vib 1/1.
Time of deployment	Tide gauge shackled and lowered from "John Murray" 1031 GMT day 152 (June 1st). On sea bed 1042 GMT.
Time of recovery	Tide gauge on board "John Murray" 2017 GMT day 185 (July 4th).
CTD casts	3 casts at 1129 GMT, 1137 GMT, 1151 GMT day 152.
Comments	The Vibroton sensor Vib 1/1 was incorrectly connected prior to deployment and produced no data. The tide gauge was recovered after 5 hours of dragging after negative acoustic tests.

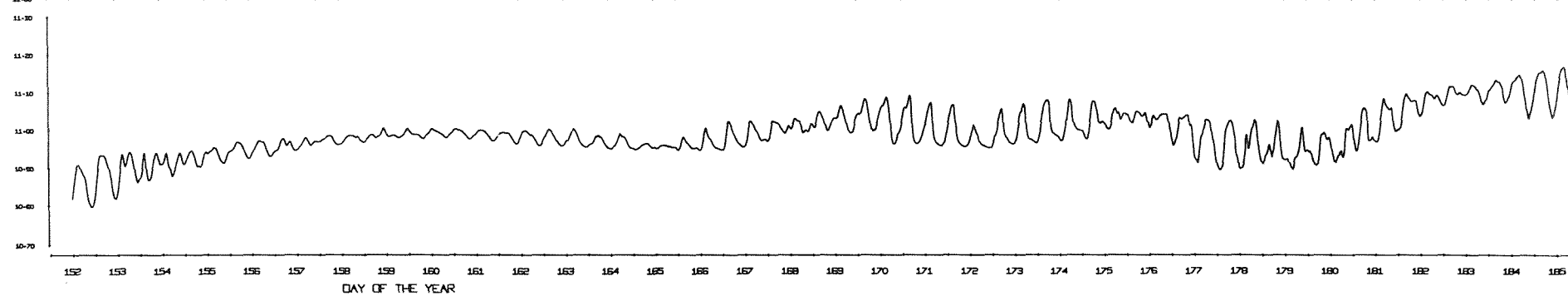
Timing	2nd scan at 1413.45 GMT day 150 (May 30th) 2nd telemetry scan on recovery at 2043.54 GMT day 185 (July 4th). Clock slow, lost 8s in 35d 6½h.
Raw pressure data	Start 1051.15 GMT day 152 End 2006.22 GMT day 185
Temperature data	Complete record of sensor temperatures from HP 3/2 and SG 2/1.
Atmospheric pressure data	3h values from St. Mary's (Scilly Isles Met Office), Brest-Guipavas (French Met Service), and Ocean Weather Ship "Kilo" (Daily Weather Reports).
Drift free data	Start 0600 GMT day 153 End 0100 GMT day 185 25h tidal analyses used to produce drift curve with fitted 10th degree polynomial removed from original record.
Tidal analysis	TIFA 0000 GMT day 155 to 2300 GMT day 183 using related constituents from Brest (1 year analysis 1973).
Comments	Some atmospheric data for OWS "Kilo" position were obtained by inspection of DWR synopsis charts when ship not on station.

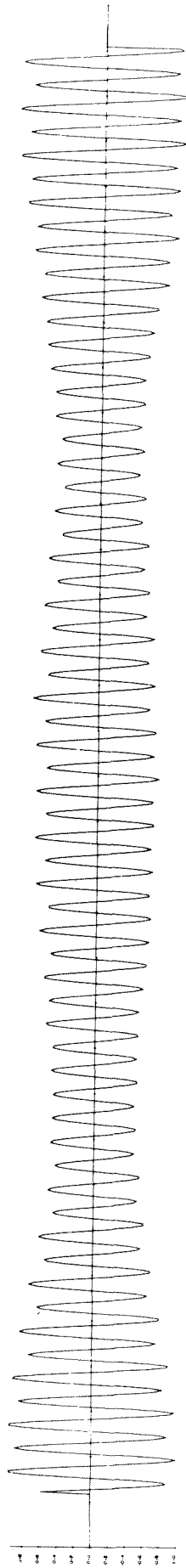
OSTG IOSB02 JUNE/JULY 1973
N-BAY OF BISCAY 'LCB1' 47 45N 07 12W

HP3/2 TEMPERATURE
(DEGREES CELSIUS)

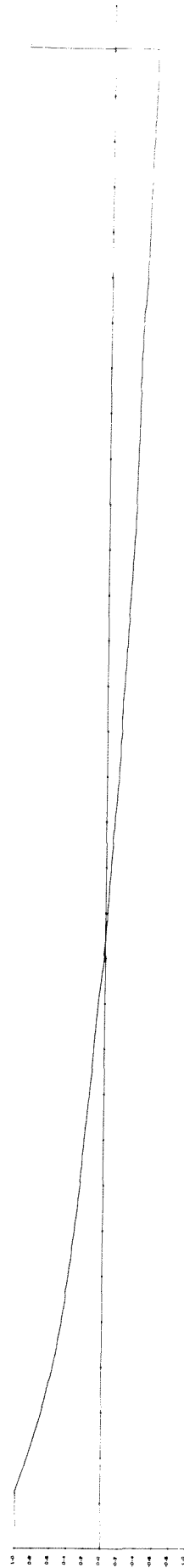


SG2/1 TEMPERATURE
(DEGREES CELSIUS)

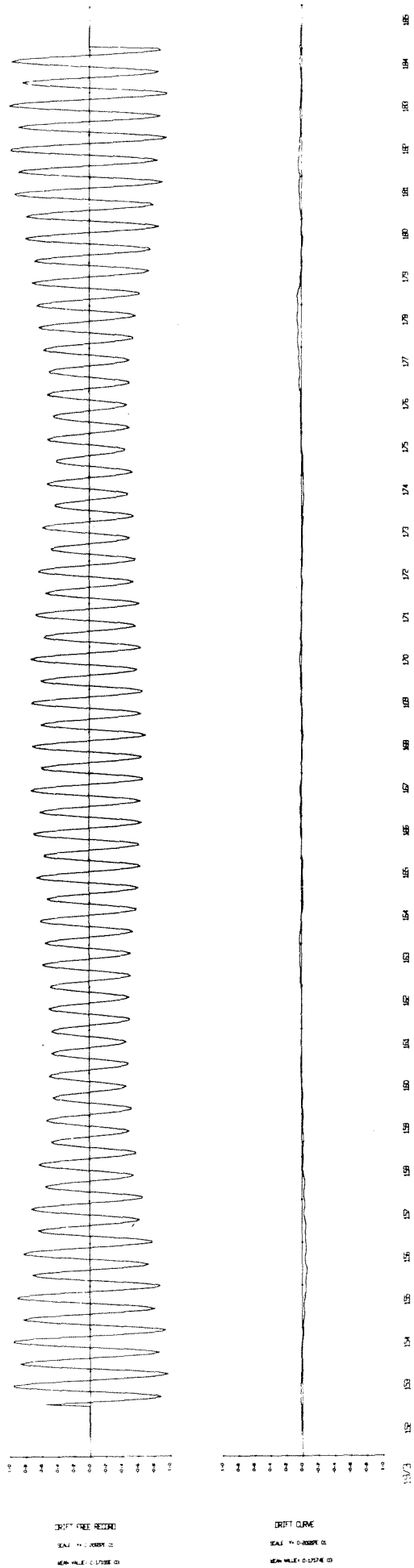




JOINT FREE RECORD
SCALE 1" = 0.125 FEET
ZERO VALUE 0.125 FEET



DRIFT CURVE
SCALE 1" = 0.125 FEET
ZERO VALUE 0.125 FEET



Station 'LCB1', N. Bay of Biscay. Lat 47°45'N Long 07°12'W

Water head data 0000 day 155 to 2300 183 1973

*Related constituent using Brest analysis (1 year 1973)

Type II, Logger 02, Sensors HP 3/2 and SG 2/1.

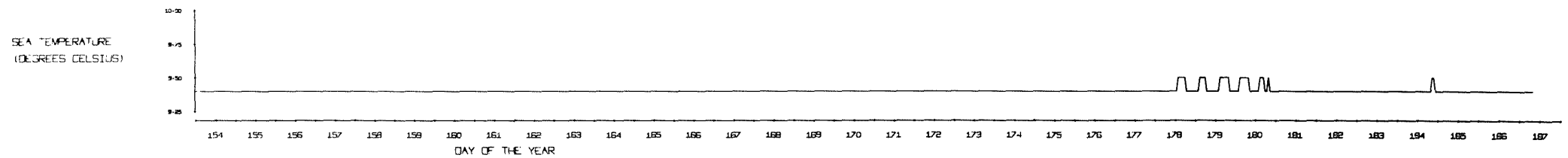
Symbol	HP 3/2		SG 2/1	
	H (cm)	G (deg)	H (cm)	G (deg)
Q ₁	2.3	280.3	2.2	280.8
O ₁	6.7	326.2	6.5	326.8
M ₁	0.6	289.4	0.6	293.0
* P ₁	2.7	64.9	2.6	65.1
K ₁	7.2	70.8	7.0	71.0
J ₁	0.6	102.5	0.6	97.0
* 2N ₂	3.9	51.2	3.7	52.0
μ ₂	4.3	73.5	4.0	69.1
N ₂	26.9	82.8	25.7	83.6
* N ₂	4.8	83.4	4.6	84.2
M ₂	128.9	102.4	123.5	102.6
L ₂	4.6	111.8	4.2	117.4
* T ₂	2.5	124.0	2.3	125.6
S ₂	45.0	137.1	41.8	138.7
* K ₂	12.6	134.7	11.7	136.3
2SM ₂	0.2	131.0	0.7	305.1
M ₃	1.0	336.4	1.0	334.2
MN ₄	0.6	292.8	0.6	273.3
M ₄	1.0	320.9	1.0	316.0
MS ₄	0.3	348.0	0.6	309.8
2MN ₆	0.1	314.3	0.1	69.7
M ₆	0.1	10.0	0.2	15.5
2MS ₆	0.0 ₃	38.7	0.2	323.7

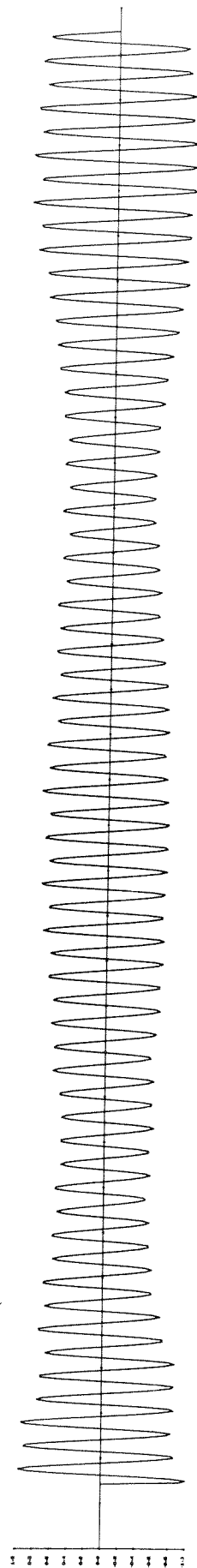
TABLE 3

OSTG position	Station 'C', Celtic Sea 1973. Lat 51°02.9'N Long 06°56.6'W.
Depth of water	95m (chart 1598)
OSTG details	Type I, logger 41, sensor FM 4882/07
Time of deployment	Launched from "John Murray" 1923 GMT day 153 (June 2nd) On sea bed 1929 GMT.
Time of recovery	Surfaced 0941 GMT day 187 (July 6th) On board "John Murray" 0945 GMT.
CTD casts	1 cast 1727 GMT day 153. 13h period of $\frac{1}{2}$ h casts from 1216 GMT day 165 (June 14th) to 0116 GMT day 166. 25h period of $\frac{1}{2}$ h casts from 0528 GMT day 172 (June 21st) to 0630 GMT day 173.
Comments	The tide gauge was initially lowered into the water for acoustic tests at 1800 GMT, recovered rigged on deck and launched at 1901 GMT but had to be recovered due to a malfunction of the Levitt release.

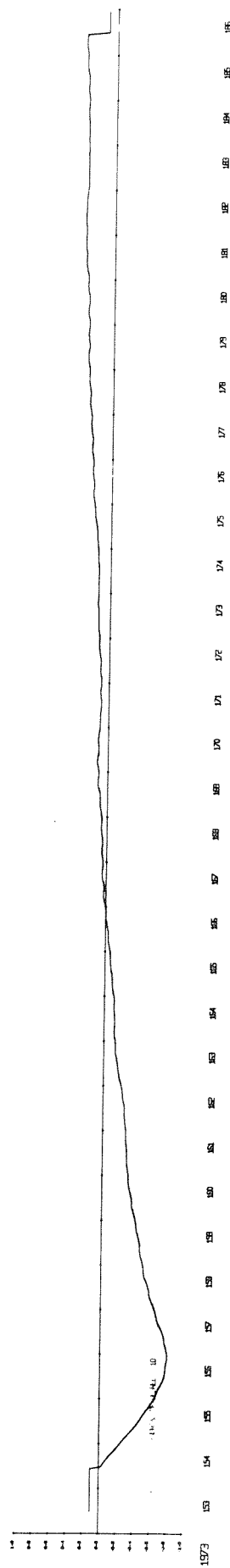
Timing	Scan 9 2100.00 GMT day 152 (June 1st) Scan 3347 1529.35 GMT day 187 (July 6th) Clock fast, gained 25s over 34d 18 $\frac{1}{2}$ h.
Raw pressure data	Start 1937.35 GMT day 153 (June 2nd) End 0837.10 GMT day 187
Temperature data	Complete record of sphere temperature but sea temperature circuit failed on deployment. Temperature record from bottom mounted current meter used for correction of frequency record.
Atmospheric pressure data	Hourly values from Roches Point and Rosslare (Irish Met. Service). 3h values from St. Marys, Scilly Isles (British Met. Office).
Drift free data	Start 1200 GMT day 154 (June 3rd) End 1100 GMT day 186 (July 5th) 25h tidal analyses used to produce drift curve with fitted 10th degree polynomial removed from original record.
Tidal analysis	TIFA 0000 GMT 157 to 2300 185 using related constituents from St. Mary's (6 year analysis 1968 to 1973).
Comments	

BOTTOM CURRENT METER JUNE/JULY 1973
CELTIC SEA 'C' 51 02.9N 06 56.6W





DRIFT FREE ROLLING
SCALE 1" = 0.5 DEGREE
10 MIN VALUE = 0.5 DEGREE



DRIFT CURVE
SCALE 1" = 0.5 DEGREE
10 MIN VALUE = 0.5 DEGREE

Station 'C', Celtic Sea, Lat $51^{\circ}02.9'N$ Long $06^{\circ}56.6'W$
 Water head data 0000 day 157 to 2300 day 185 1973
 *Related constituent using St.Mary's, Scilly Islands
 (6 years analysis 1968/1973)

Type I, Logger 41, Sensor FM07.

Symbol	H (cm)	G (deg)
Q_1	1.9	313.6
O_1	4.8	352.6
M_1	0.8	327.2
* P_1	1.3	111.9
K_1	4.1	114.2
J_1	0.4	151.5
* $2N_2$	4.3	100.9
μ_2	4.4	156.3
N_2	31.1	124.0
* ν_2	6.2	119.1
M_2	162.6	144.2
L_2	9.3	149.8
* T_2	3.3	181.7
S_2	55.0	189.5
* K_2	15.8	186.5
$2SM_2$	0.5	76.0
M_3	0.9	54.1
MN_4	2.4	188.8
M_4	4.6	221.3
MS_4	1.4	278.4
$2MN_6$	0.9	114.6
M_6	1.2	157.1
$2MS_6$	0.9	214.4

TABLE 4

OSTG position	Station 'LB', Liverpool Bay, 1973 Lat 53°30'N Long 03°13'W.
Depth of water	9.9m ODN (Mersey Docks and Harbour Company chart of Liverpool Bay 1970).
OSTG details	Type II, logger 03, sensors HP 3/1, VIB 1/1, VIB 1/3.
Time of deployment	Launched 1237 GMT day 155 (June 4th) from "John Murray". On sea bed 1241 GMT.
Time of recovery	On board "Vigilant" 0900 GMT day 204 (July 23rd).
CTD casts	None. Average density value for June/July from data recorded at Liverpool Bay Light Vessel 1935-1946.
Comments	An initial recovery attempt was made on 20th July but conditions were too rough. The vessel "Vigilant" was used for recovery by courtesy of the Mersey Docks and Harbour Company.

Timing	Scan one at 1044-40 GMT day 154 (June 3rd) Scan 5486 at 1359-43 GMT day 211 (July 30th) Clock slow, lost 3s in 57d 3h.
Raw pressure data	Start 1437-10 GMT day 155 (June 4th) End 1422-12 GMT day 198 (July 17th)
Temperature data	Complete record of temperature from each sensor.
Atmospheric pressure data	3h values from Bidston Observatory, linearly interpolated to give hourly values.
Drift free data	Start 1900 GMT day 158 (June 7th) End 1000 GMT day 195 (July 14th) FHP 53 filter used.
Tidal Analysis	TIFA days 159 to 187 using related constituents from Hilbre Island (1 year analysis 1964/1965).
Comments	Due to logger malfunction, the data were retrieved from the magnetic tape and listed by Marconi Ltd., and relevant channels subsequently manually punched on cards by personnel of the Computational Services Section at Bidston.

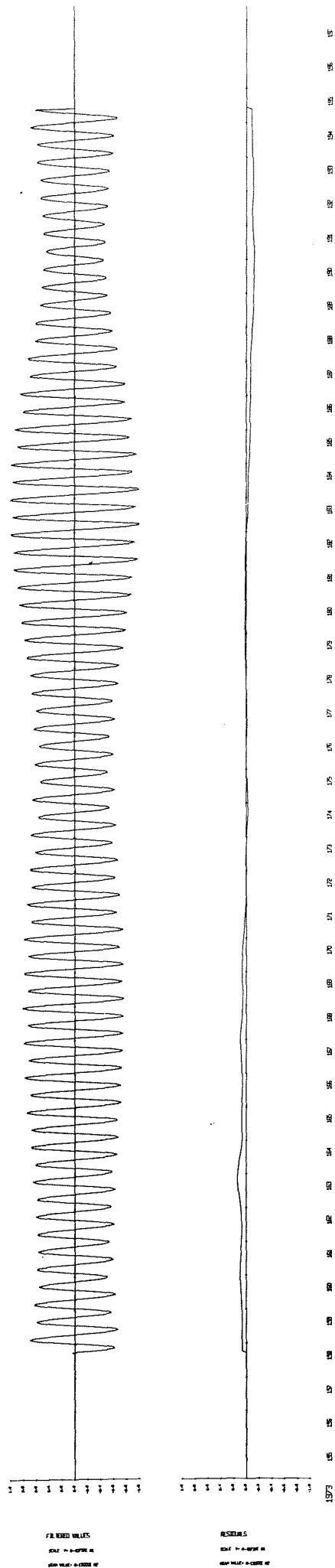
OSTG 105803 JUNE/JULY 1973
LIVERPOOL BAY 'LB' LAT 53 30N LONG 03 13W

HF3/1 TEMPERATURE
(DEGREES CELSIUS)

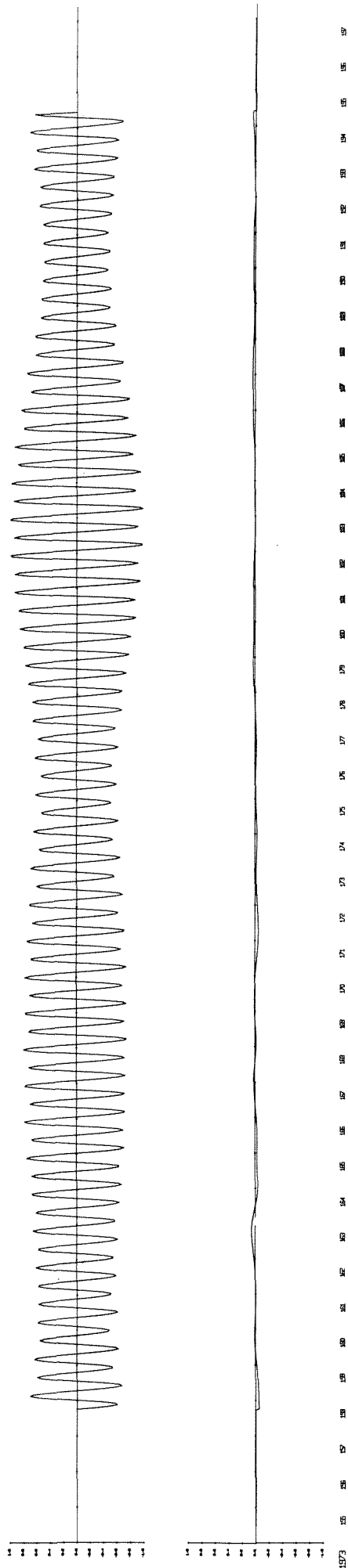
VIB1/3 TEMPERATURE
(DEGREES CELSIUS)

VIB1/1 TEMPERATURE
(DEGREES CELSIUS)

DAY OF THE YEAR



LIVERPOOL BAY 'LB' HP3/1 WATER HEAD



Station 'LB', Liverpool Bay, Lat 53°30'N Long 03°13'W

Water head data 0000 day 159 to 2300 day 187 1973

*Related constituents using Hilbre Island (1 year analysis 1964/65)

Type II, Logger 03, Sensors HP 3/1, VIB 1/1 and VIB 1/3.

Symbol	HP3/1		VIB 1/1		VIB 1/3	
	H (cm)	G (deg)	H (cm)	G (deg)	H (cm)	G (deg)
Q ₁	4.3	341.7	4.1	351.4	4.1	350.1
O ₁	10.3	32.6	10.7	34.9	10.6	34.6
M ₁	1.0	342.9	0.9	335.2	1.0	331.1
* P ₁	4.3	172.6	4.6	171.7	4.3	177.0
K ₁	11.8	179.3	12.6	178.4	12.9	177.0
J ₁	1.1	277.8	1.4	263.7	1.3	261.5
* 2N ₂	10.4	262.1	9.8	259.7	9.9	259.4
N ₂	5.4	7.8	3.1	27.9	3.4	26.7
N ₂	57.2	295.4	54.2	293.0	54.6	292.7
* N ₂	12.2	294.0	11.5	291.6	11.6	291.3
M ₂	306.4	316.8	287.7	315.3	290.4	315.6
L ₂	17.4	335.5	15.3	337.5	15.7	338.5
* T ₂	5.9	358.3	5.6	357.5	5.7	357.4
S ₂	100.7	359.5	95.4	358.7	96.4	358.6
* K ₂	29.5	357.8	28.0	357.0	28.3	356.9
2SM ₂	0.6	303.0	0.9	244.5	0.7	249.0
M ₃	2.9	297.9	3.0	306.0	3.0	304.0
MN ₄	8.2	163.6	9.0	168.3	8.7	168.3
M ₄	18.0	192.4	17.2	195.3	17.1	196.3
MS ₄	7.5	247.4	7.6	250.4	7.5	250.4
2MN ₆	2.8	25.6	2.4	336.5	2.6	342.5
M ₆	3.3	54.8	3.6	8.2	3.7	13.6
2MS ₆	2.1	82.4	2.3	55.4	2.4	59.9

TABLE 5

OSTG position	Station 'WI', Southern North Sea, 1973 Lat 52°28'N Long 02°13'E.
Depth of water	39m (PDR)
OSTG details	Type II, logger 03, sensors SG 2/3, VIB 1/2.
Time of deployment	Launched from s.s. "Profiler" and in water 1843 GMT day 249 (Sept.6th). On sea bed 1848 GMT.
Time of recovery	On board "John Murray" 1642 GMT day 292 (Oct.19th).
CTD casts	1 cast 1900 GMT day 249. $\frac{1}{2}$ h casts from 1659 GMT day 255 to 0600 GMT day 256. 1 cast day 261, day 280, day 286.
Comments	

Timing 1st telemetry read out 1915.15 GMT day 249
 Last scan 1045.17 GMT day 310.
 Clock slow, lost 2s in 60d 15 $\frac{1}{2}$ h.

Raw pressure data (1) Start 2052.45 GMT day 249 }
 End 1557.45 GMT day 257 } For SG 2/3
 (2) Start 0952.46 GMT day 270 } and VIB 1/2
 End 1622.46 GMT day 292 }

Temperature data As for raw pressure data

Atmospheric pressure data Hourly data from Valkenburg ZH and De Kooy
 (Netherlands Met. Institute), 3h data from
 Gorlestone (British Met. Office).

Drift free data (1) Start 0200 day 253
 End 0500 day 257
 (2) Start 1600 day 270
 End 1200 day 289
 FHP 53 filter used.

Tidal analysis TIRA analysis of 15 days of data from days
 271 to 285 using related constituents from
 Lowestoft (1year analysis 1964/1965).

Comments Discontinuity of ~ 225 mb at 1800 GMT day 252.
 Due to a logger malfunction, the tape drive
 stopped after 1600 GMT day 257 and re-started
 for scan at 1000 GMT day 270.

The constants were also derived using a response
 analysis because of the high noise level on the
 records, and the standard error was computed
 using the formula

$$\text{S.E.} = \left[\frac{1}{2} \times \frac{\text{Residual variance}}{\text{Recorded variance}} \times \frac{27.3}{\text{No. of days of data}} \right]^{\frac{1}{2}}$$

Standard errors for diurnal band were 19.7% in
 amplitude and 11.3 $^{\circ}$ in phase for VIB 1/2 and
 17.56% and 10.1 $^{\circ}$ for SG 2/3.

Standard errors for semidiurnal band were 25.3%
 in amplitude and 14.5 $^{\circ}$ in phase for VIB 1/2 and
 12.6% and 7.2 $^{\circ}$ for SG 2/3.

TABLE 6

Station 'WI', Southern North Sea 1973

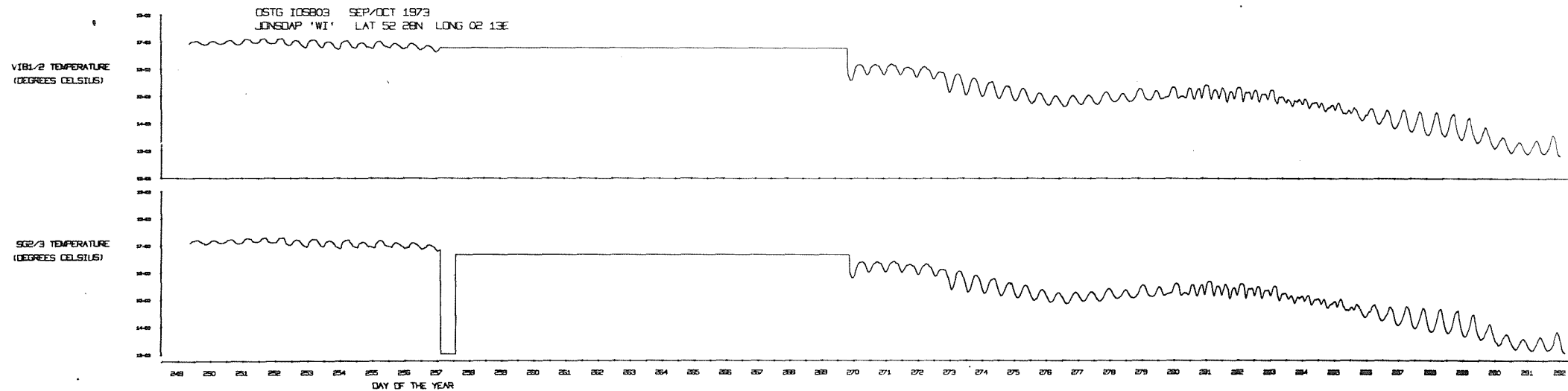
Lat 52°28'N Long 02°13'E

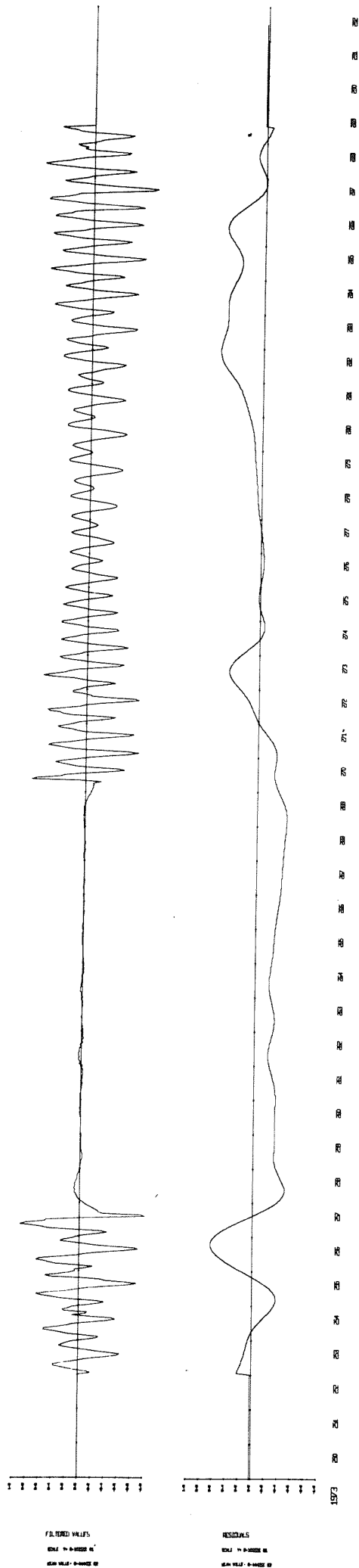
Drift free water head FHP53 filter

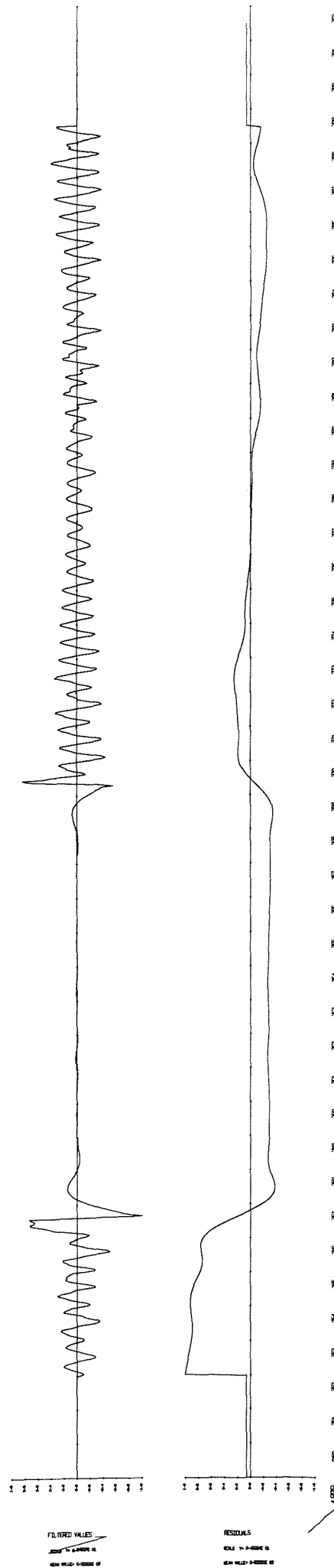
Days 271 to 285 1973

* Related constituent using Lowestoft (1 year analysis
1964/1965)

Symbol	VIB 1/2		SG2/3	
	H (cm)	G (deg)	H (cm)	G (deg)
2Q ₁	1.5	211.7	1.4	315.2
* σ_1	2.2	246.8	2.0	350.3
* Q ₁	4.2	105.2	3.8	106.1
* ϱ_1	0.9	76.0	0.8	76.9
O ₁	14.3	162.3	12.8	163.2
* π_1	0.2	152.2	0.2	151.7
* P ₁	3.8	310.7	4.1	310.2
* S ₁	0.9	264.1	1.0	263.6
K ₁	9.6	320.3	10.4	319.8
* γ_1	0.7	202.2	0.8	201.7
* ϕ_1	0.8	40.4	0.8	39.9
* J ₁	2.0	147.6	1.7	126.0
OO ₁	1.9	188.2	1.7	166.6
* MNS ₂	0.2	318.5	0.4	305.0
* 2N ₂	2.8	294.7	5.3	281.2
μ_2	2.0	149.4	3.8	135.9
* N ₂	7.4	248.0	9.3	243.0
* ν_2	2.0	263.9	2.6	258.9
M ₂	38.0	276.9	48.0	271.9
* L ₂	1.4	311.4	1.7	306.4
* T ₂	0.6	307.7	0.6	322.9
S ₂	12.1	305.6	12.8	320.8
* K ₂	3.5	308.2	3.7	323.4
* MSN ₂	0.3	296.4	2.0	68.4
2SM ₂	0.2	263.6	1.3	35.6
MO ₃	1.2	73.7	0.8	98.2
M ₃	0.7	170.1	2.2	179.7
MK ₃	1.2	185.4	2.0	184.1
MN ₄	2.0	4.1	6.3	205.9
M ₄	6.5	30.7	2.4	272.0
SN ₄	2.6	245.6	7.1	101.5
MS ₄	2.7	36.9	8.2	64.3
2MN ₆	1.5	293.7	1.8	243.3
M ₆	2.1	341.1	1.0	232.7
MSN ₆	5.6	119.3	3.0	86.6
2MS ₆	6.5	139.5	4.1	147.1
2SM ₆	1.6	187.7	1.9	237.0







OSTG position	Station 'WE', Southern North Sea, 1973 Lat 52°27.1'N Long 03°14.5'E.
Depth of water	35m (PDR)
OSTG details	Type II, logger 02, sensors SG 2/1, VIB 1/3.
Time of deployment	Launched from s.s. "Profiler" and on sea bed 1034 GMT day 251 (Sept.8th).
Time of recovery	On board "John Murray" 1527 GMT day 296 (Oct.23rd).
CTD casts	1 cast at 1235 GMT and 1255 GMT day 251 1 cast at 1759 GMT day 258 1 cast at 0644 GMT day 261 1 cast at 1851 GMT day 285
Comments	Large sandwave structure in vicinity of tide gauge position.

Timing 1st telemetry read out 1059.30 GMT day 251
 Last scan 1014.24 GMT day 310.
 Clock fast, gained 6s in 58d 23 $\frac{1}{4}$ h.

Raw pressure data Start 1207.00 GMT day 251 } VIB 1/3
 End 1206.56 GMT day 294 }
 Start 1207.00 GMT day 251 } SG 2/1
 End 0951.56 GMT day 293 }

Temperature data Complete record of temperature data for both sensors.

Atmospheric pressure data Hourly data from Valkenburg ZH and De Kooy (Netherlands Met Institute), 3h data from Gorleston (British Met Office).

Drift free data Start 1700 GMT day 254 for VIB
 0000 GMT day 255 for SG
 End 0700 GMT day 291 for VIB
 2300 GMT day 286 for SG
 FHP 53 filter used.

Tidal analysis TIFA 0000 GMT day 258 to 2300 GMT day 286 using equilibrium tide relations.

Comments Discontinuities of 120 mb at 1700 GMT day 260
 350 0200 271
 150 1000 274

The constants were also derived using a response analysis because of the high noise level on the records and the standard error computed.

Standard errors for diurnal band were 18.4% in amplitude and 10.5 $^{\circ}$ in phase for VIB 1/3 and 19.16% and 11.0 $^{\circ}$ for SG 2/1.
 Standard error for semidiurnal band was 27.3% and 15.6 $^{\circ}$ for VIB 1/3 and 28.3% and 16.2 $^{\circ}$ for SG 2/1.

TABLE 7

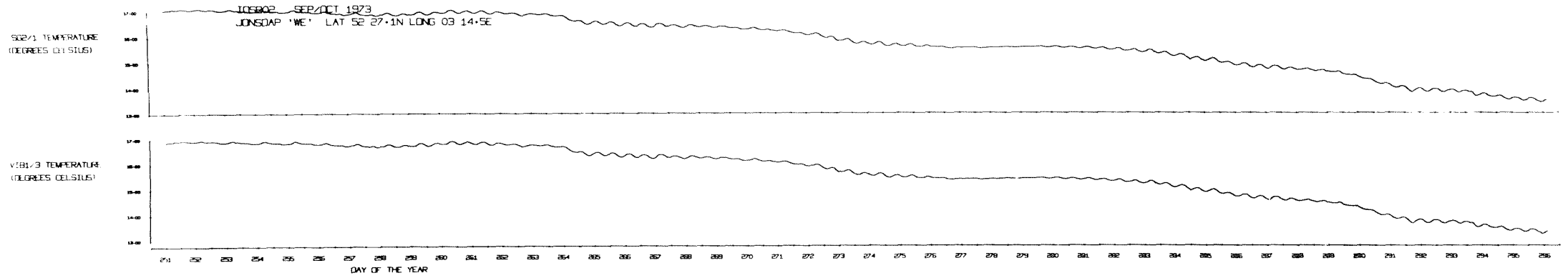
Station 'WE', Southern North Sea 1973

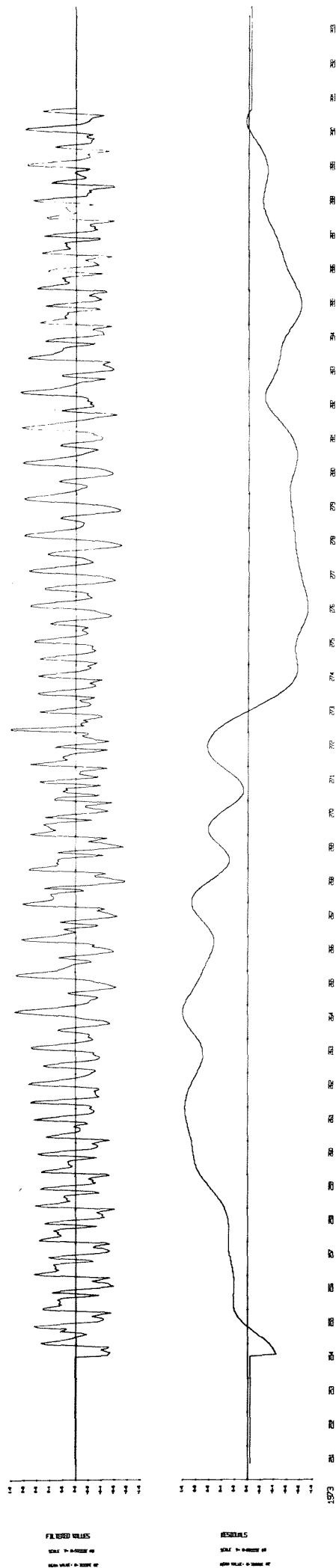
Lat 52°27.1'N Long 03°14.5'E

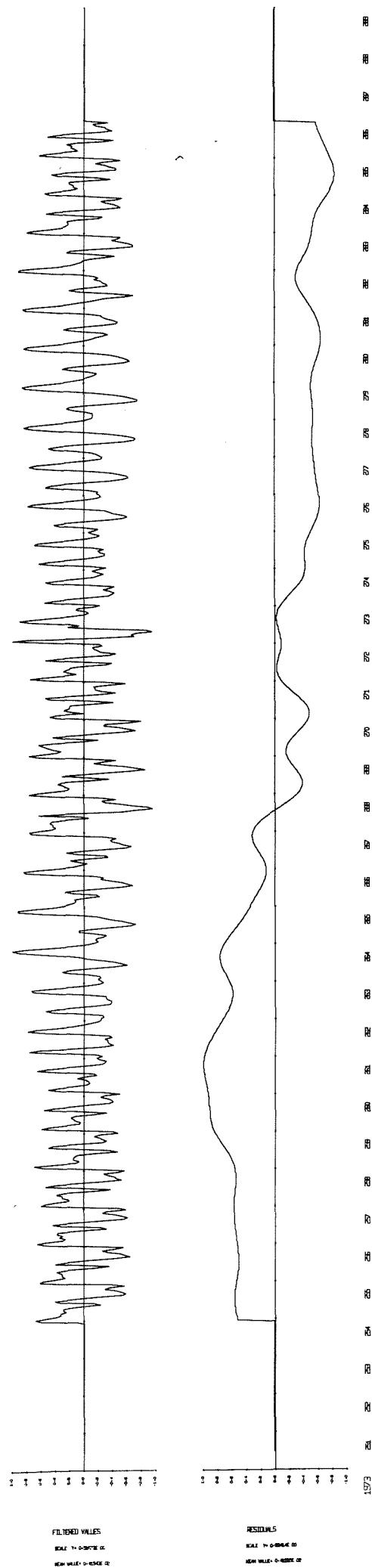
Drift free water head FHP 53 filter. Days 258 to 286
1973

*Related constituent using equilibrium tide

Symbol	VIB 1/3		SG 2/1	
	H (cm)	G (deg)	H (cm)	G (deg)
Q ₁	2.6	160.0	3.9	140.7
O ₁	11.2	176.4	12.7	178.7
M ₁	0.5	183.1	0.5	72.1
* π ₁	0.2	338.6	0.2	335.9
* P ₁	3.7	338.6	4.0	335.9
K ₁	11.2	338.6	12.1	335.9
* γ ₁	0.1	338.6	0.1	335.9
* ϕ ₁	0.2	338.6	0.2	335.9
J ₁	1.5	94.2	1.7	75.7
OO ₁	1.1	125.9	1.0	88.0
* 2N ₂	0.3	240.5	0.5	231.5
μ ₂	6.2	183.6	6.5	182.2
N ₂	2.5	240.5	3.6	231.5
* ν ₂	0.5	240.5	0.7	231.5
M ₂	15.4	53.9	16.5	44.1
L ₂	1.0	131.8	0.8	119.7
* T ₂	0.2	170.8	0.1	166.6
S ₂	2.7	170.8	2.3	166.6
* K ₂	0.7	170.8	0.6	166.6
2SM ₂	1.9	333.9	1.3	325.1
MO ₃	0.5	298.3	0.4	268.0
M ₃	0.4	282.1	0.8	291.0
MK ₃	0.6	249.0	0.3	224.7
MN ₄	1.7	55.5	1.8	57.8
M ₄	8.4	102.0	9.3	95.1
SN ₄	1.6	132.5	1.9	130.5
MS ₄	6.2	143.4	6.5	137.5
2MN ₆	0.7	143.4	0.9	43.8
M ₆	2.0	100.9	2.6	89.3
MSN ₆	1.1	107.5	1.3	90.4
2MS ₆	2.9	142.0	3.4	133.1
2SM ₆	0.6	203.4	0.7	208.9



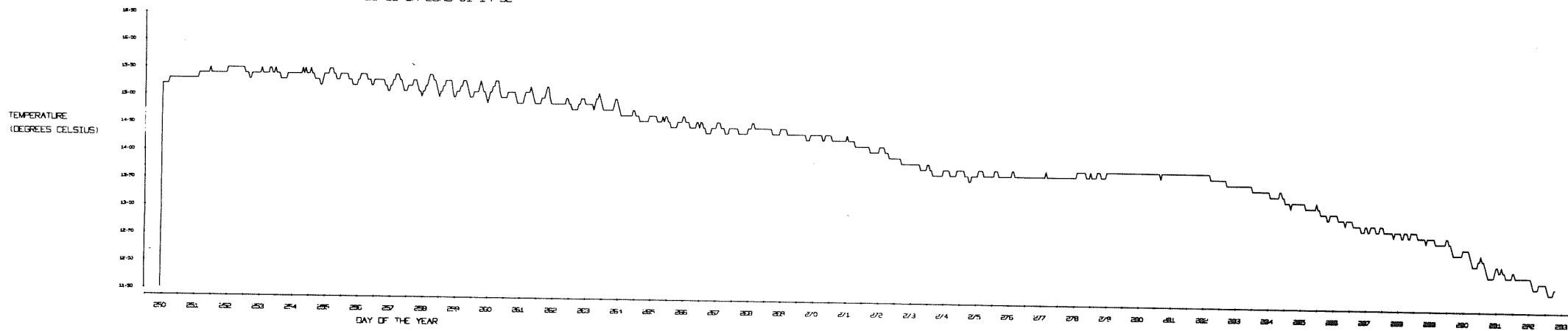


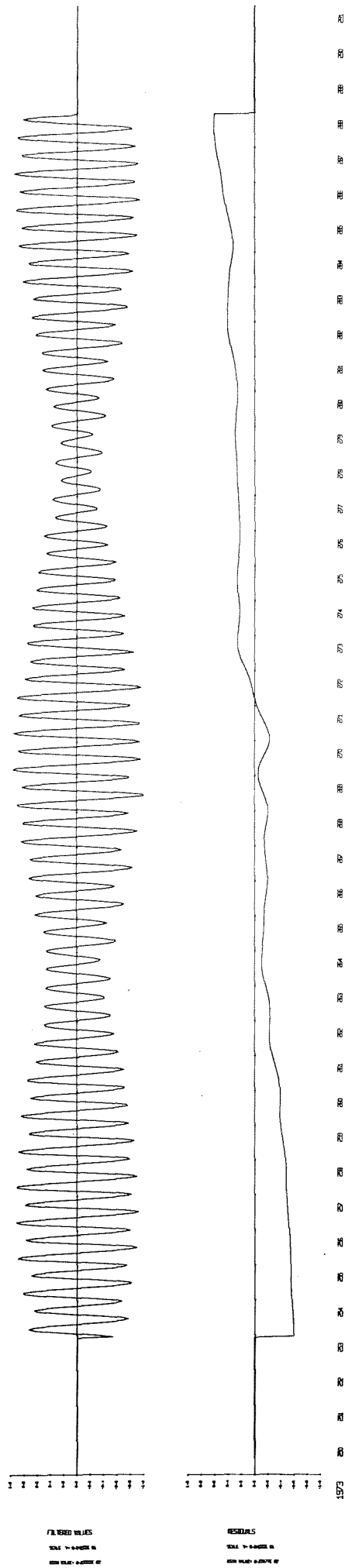


OSTG position	Station 'Z0', Southern North Sea, 1973 Lat 54°19.5'N Long 01°14.5'E.
Depth of water	23m (chart 1408)
OSTG details	Type I, logger 41, sensor FM 4882/07
Time of deployment	Tide gauge launched from s.s. 'Profiler' and in water for tests at 1258 GMT day 252 (9th September). Finally released at 1446 GMT.
Time of recovery	Tide gauge on board 'John Murray' at 1440 GMT day 297 (24th October).
CTD casts	Series of $\frac{1}{2}$ h casts from 1831 GMT day 256 to 0658 GMT day 257.
Comments	Unsuccessful attempts were made to recover the tide gauge on days 291 and 293 prior to recovery.

Timing	1st autoscan 1745.00 GMT day 248 Scan after recovery 1514.10 GMT day 297. Clock fast, gained 50s in 48d 21 $\frac{1}{2}$ h.
Raw pressure data	Start 1507.33 GMT day 250 End 0651.50 GMT day 292
Temperature data	Thermistor channels failed after 3d 15 $\frac{3}{4}$ h. Temperature data used from Current Meter deployed nearby.
Atmospheric pressure data	3h data from Kilnsea and Gorleston (British Met Office), Hourly data from De Kooy (Dutch Met Institute).
Drift free data	Start 0000 GMT day 254 End 2300 GMT day 288 FHP 53 filter used.
Tidal analysis	TIFA analysis for period 0000 GMT day 259 to 2300 GMT day 287 using related constituents from Inner Dowsing (1 year 1972/1973).
Comments	

BOTTOM CURRENT METER
JONSDAP '20' LAT 53 19.5N LONG 01 14.5E





Station 'Z0', S. North Sea, Lat $53^{\circ}19.5'N$ Long $01^{\circ}14.5'E$
 0000 day 259 to 2300 day 287 1973

Water head data

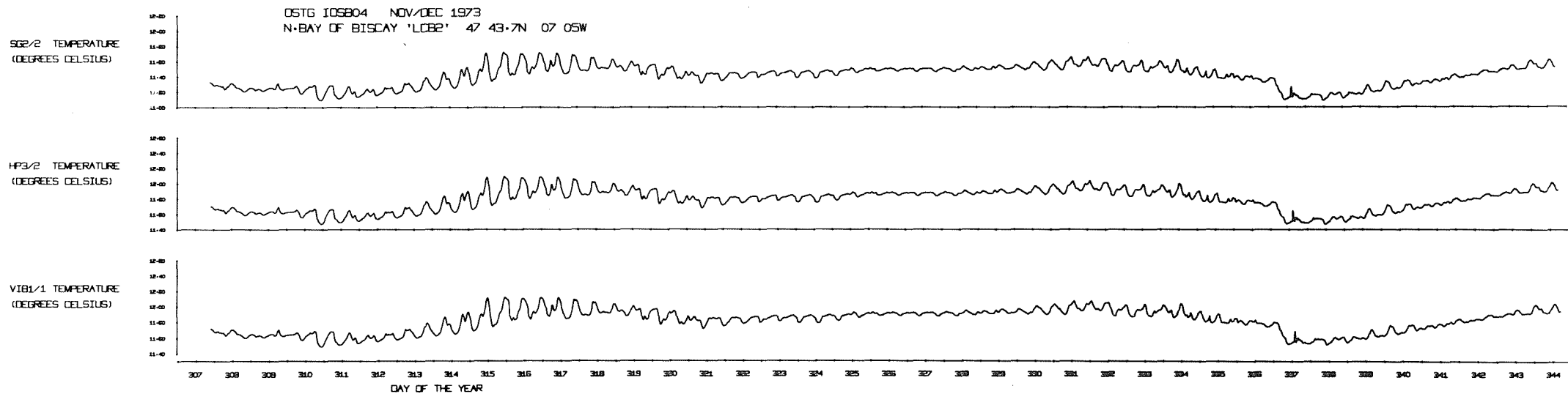
*Related constituent from 1 year analysis of Inner
 Dowsing (1972/73)

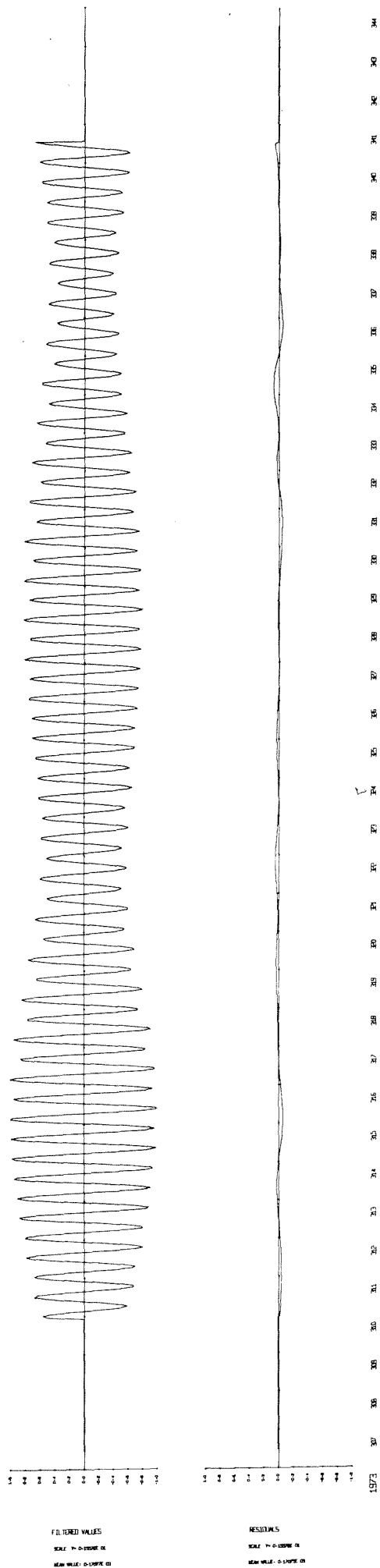
		FM 41/07	
Symbol		H (cm)	G (deg)
	Q_1	3.6	107.3
	O_1	14.9	123.6
	M_1	1.1	122.4
*	P_1	4.3	283.2
	K_1	16.0	297.9
	J_1	2.6	50.6
*	$2N_2$	4.9	109.8
	A_2	1.7	212.8
	N_2	30.6	152.9
*	\checkmark_2	7.0	147.8
	M_2	151.6	174.9
	L_2	3.6	174.1
*	T_2	2.6	205.4
	S_2	53.8	222.0
*	K_2	15.2	218.6
	$2SM_2$	1.4	38.5
	M_3	0.5	220.3
	MN_4	2.2	280.0
	M_4	5.3	259.0
	MS_4	6.2	295.6
	$2MN_6$	0.6	260.7
	M_6	1.0	270.0
	$2MS_6$	1.7	319.2

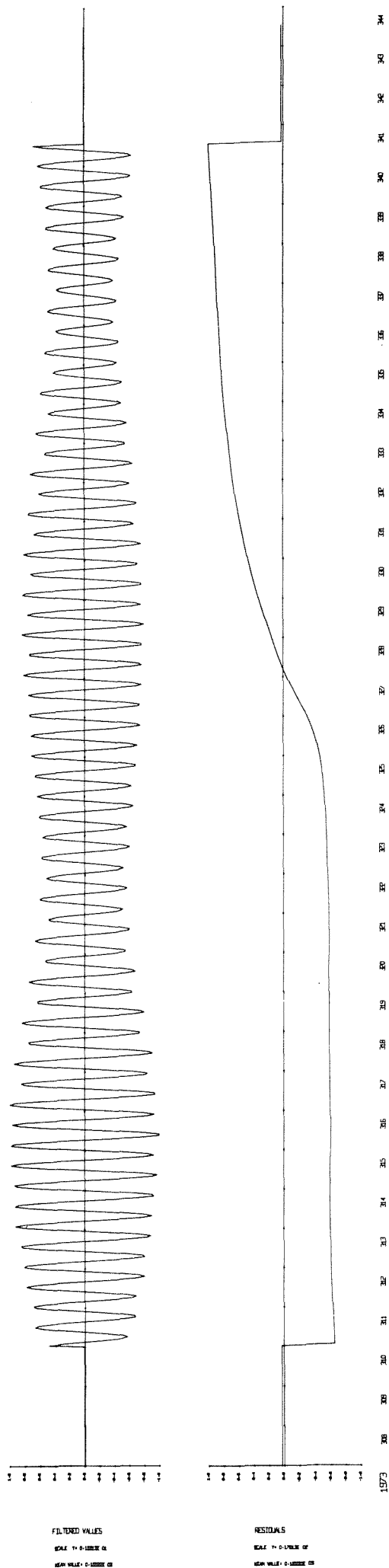
TABLE 8

OSTG position	Station 'LCB2', North Bay of Biscay, 1973 Lat 47°43.5'N Long 07°05'W.
Depth of water	165m (Ship's sonar).
OSTG details	Type II, logger 04, sensors HP 3/2, OAR 4/2, SG 2/2, SG 2/4, Vib 1/1.
Time of deployment	Launched from "Discovery" 1300 GMT day 307 (November 3rd). On sea bed 1312 GMT.
Time of recovery	On board "Discovery" 2015 GMT day 344 (December 10th).
CTD casts	None. Average density value for November/ December from 'Atlas of the hydrography of the Northern North Atlantic Ocean'.
Comments	The OAR 4/2 sensor leaked immediately on deployment, the SG 2/4 leaked between 0330 GMT and 0345 GMT day 310 (November 6th). The surface buoys were missing on recovery (one buoy was washed up at Concarneau). The tide gauge was recovered after 4h of dragging, after a negative acoustic search.

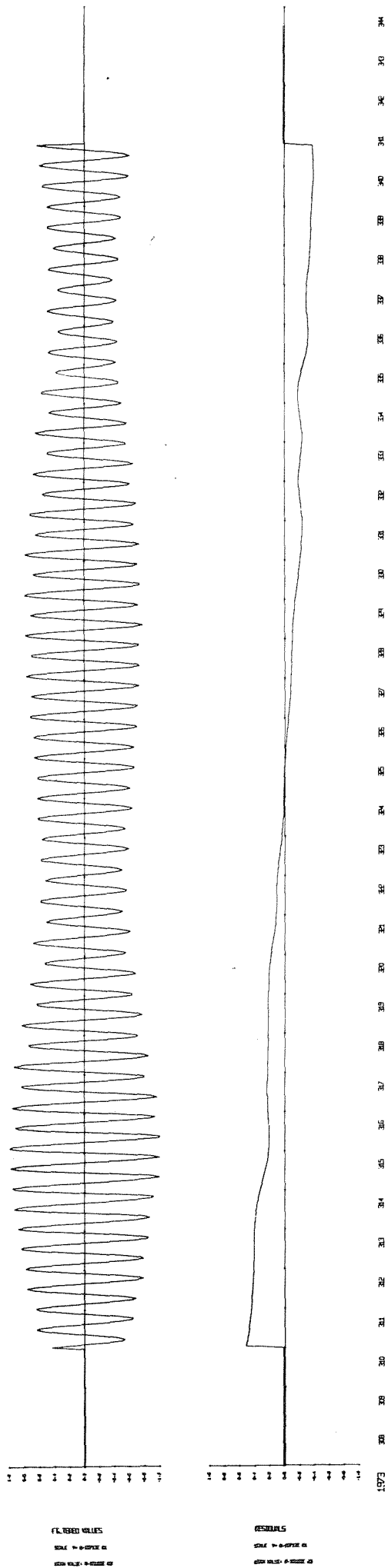
Timing	1st scan 1545.00 GMT day 285 (October 12th). Telemetry scan on recovery 2044.47 GMT day 344 (December 10th). Clock fast, gained 13s in 59d 5h.
Raw pressure data	Start 2137.25 GMT day 307 (November 3rd) End 1722.17 GMT day 344 for HP 3/2, SG 2/2 and Vib 1/1 End 0322.25 GMT day 310 (November 6th) for SG 2/4.
Temperature data	Complete record of sensor temperatures for HP 3/2, SG 2/2, and Vib 1/1.
Atmospheric pressure date	3h values from St. Mary's, Scilly Isles (British Met. Office), Brest-Guipavas (French Met. Service), Ocean Weather Ship "Kilo" (Daily Weather Reports).
Drift free data	Start 0200 GMT day 311 End 1300 GMT day 341 FHP 53 filter used.
Tidal analysis	TIFA 0000 GMT day 312 to 2300 GMT day 340 using related constituents from Brest (1 year analysis 1973).
Comments	Some atmospheric data for OWS "Kilo" position obtained from inspection of DWR synopsis charts when ship not on station. Large non-linear drift of Vib 1/1 removed by high pass filter, and HP 3/2, SG 2/2 records treated by same method. This deployment was part of the Intercalibra- tion Exercise organised by Working Group No.27 of IAPSO/SCOR/UNESCO. Their report (1975) contains tidal constants computed from our records using another harmonic method and a response method of analysis. The results differ slightly from ours, and this reflects a genuine difficulty in analysing short records from the open sea, especially where shallow water effects are not entirely negligible.







N-BAY OF BISCAY 'LCB2' VIB1/1 WATER HEAD



Station 'LCB2', N. Bay of Biscay, Lat 47°43.5'N Long 07°05'W
 Water head data 0000 312 to 2300 340 1973

*Related constituent using Brest analysis (1 year 1973)

Type II, Logger 04, Sensors HP 3/2, SG 2/2, VIB 1/1.

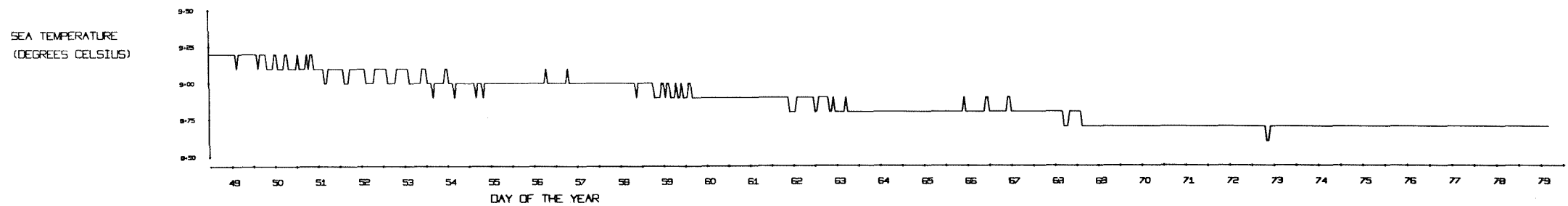
Symbol	HP 3/2		SG 2/2		VIB 1/1	
	H (cm)	G (deg)	H (cm)	G (deg)	H (cm)	G (deg)
Q ₁	2.0	294.8	1.9	295.7	2.0	301.2
O ₁	7.0	327.9	6.9	327.8	7.0	326.6
M ₁	0.3	294.6	0.3	284.1	0.2	246.0
* P ₁	2.4	74.0	2.4	75.5	2.4	74.9
K ₁	6.5	79.9	6.3	81.4	6.4	80.8
J ₁	0.6	57.9	0.6	71.7	0.3	61.3
* 2N ₂	4.0	53.7	4.1	52.7	3.8	53.8
N ₂	5.2	70.9	5.4	64.3	5.2	71.8
N ₂	27.6	85.3	28.4	84.3	26.7	85.4
* S ₂	4.9	85.9	5.1	84.9	4.8	86.0
M ₂	130.2	103.0	126.7	102.4	130.1	103.1
L ₂	3.9	104.5	3.9	117.7	4.3	104.0
* T ₂	2.5	123.6	2.5	123.0	2.5	123.2
S ₂	45.2	136.7	44.9	136.1	45.0	136.3
* K ₂	12.7	134.3	12.6	133.7	12.6	133.9
2SM ₂	0.1	118.5	1.2	196.7	0.3	104.5
M ₃	1.0	334.4	1.1	336.2	1.0	340.1
MN ₄	0.5	280.0	0.4	270.0	0.6	288.3
M ₄	0.9	300.6	1.2	274.0	1.0	292.2
MS ₄	0.3	295.3	0.4	45.9	0.6	289.1
2MN ₆	0.1	357.6	0.4	31.4	0.2	311.1
M ₆	0.1	16.6	0.5	43.6	0.2	349.2
2MS ₆	0.2	67.9	0.3	106.4	0.1	38.9

TABLE 9

OSTG position	Station 'J', Irish Sea, 1974 Lat 52 06'N Long 05 48'W
Depth of water	94m (chart 1824a)
OSTG details	Type I, logger 41, sensor FM 4882/32.
Time of deployment	Launched from "Challenger" 1540 GMT day 048 (February 17th). On sea bed 1549 GMT.
Time of recovery	Surfaced 1745 GMT day 079 (March 20th) "John Murray".
CTD casts	1 cast 1559 GMT day 048 1 cast 0943 GMT day 049
Comments	Trial launch carried out to 60m at 1500 GMT day 048.

Timing	Scan 079 1600 GMT day 038 (February 7th) Scan 4091 1059-36 GMT day 080 (March 21st) Clock fast, gained 24s in 41d 19h.
Raw pressure data	Start 1607.24 GMT day 048 (February 17th) End 1722.06 GMT day 079 (March 20th)
Temperature data	Both temperature channels failed. Temperature record from bottom mounted current meter used for correction of frequency record.
Atmospheric pressure data	Hourly values from Roches Point and Rosslare (Irish Met Service) 3h values from Aberporth (British Met Office).
Drift free data	Start 0000 GMT day 052 (February 21st) End 1300 GMT day 076 (March 17th) FHP 53 filter used.
Tidal analysis	TIRA 0000 GMT day 052 to 1300 GMT day 076 using related constituents from Fishguard (1 year analysis 1963).
Comments	The mechanical clock, which drives the potentiometer and provides a recorded time check, stopped after scan 1448 due to a loose plug connection. (The crystal clock, which controls the integration period and scanning/recording sequence, was unaffected).

BOTTOM CURRENT METER FEB/MAR 1974
IRISH SEA 'J' LAT 52 06N LONG 05 48W



Station 'J', Irish Sea, Lat 52°06'N Long 05°48'W
 Water head data 0000 day 52 to 1300 day 076 1974
 *Related constituent using Fishguard (1 year
 analysis 1963)
 Type I, Logger 41, Sensor FM32

Symbol	H (cm)	G (deg)
Q_1	2.0	312.0
O_1	6.7	25.3
M_1	1.0	10.9
* P_1	2.2	151.0
K_1	5.9	157.2
J_1	0.5	254.2
* $2N_2$	2.6	159.6
N_2	11.5	186.0
N_2	20.0	167.7
* S_2	3.2	157.1
M_2	104.0	179.7
L_2	5.8	175.4
* T_2	2.3	234.5
S_2	42.1	228.5
* K_2	12.2	227.7
$2SM_2$	1.5	0.6
M_3	0.7	183.7
MN_4	1.7	310.7
M_4	3.8	4.9
MS_4	1.8	32.7
$2MN_6$	0.1	42.5
M_6	0.3	312.4
$2MS_6$	0.9	275.4

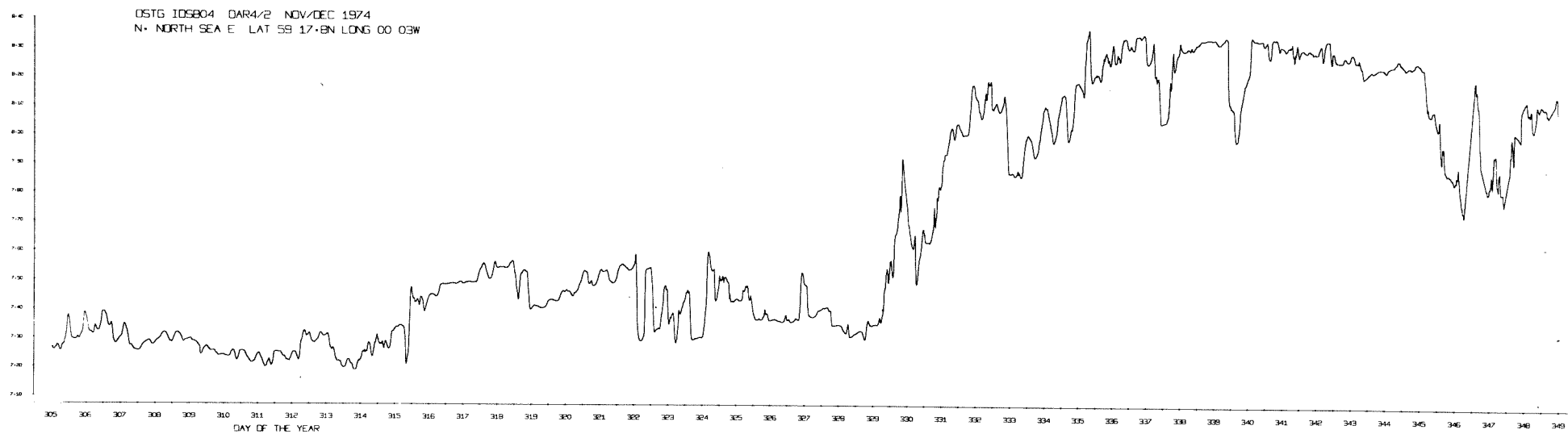
TABLE 10

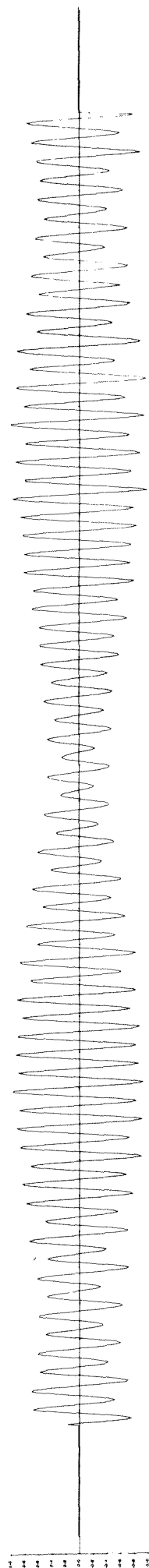
OSTG position	Station 'F', Northern North Sea, 1974 Lat 58°43'N Long 02°04.5'W
Depth of water	80.5m (PDR)
OSTG details	Type II, logger 02. Sensors OAR 4/1, SG 2/5, VIB 1/2.
Time of deployment	Tide gauge launched from "John Murray" and in water 1121 GMT day 304 (October 31st). Tide gauge on bottom 1129 GMT.
Time of recovery	On board "John Murray" at 1427 GMT day 342 (December 8th).
CTD casts	1 cast at 1640 GMT day 304.
Comments	Arrived on station at 1016 GMT but launch delayed by intercom system malfunction and wire snagged on winch drum. On deployment, the VIB 1/2 temperature and pressure sensors failed due to a leak when the main "O" ring seal failed. After recovery, it was found that the tape had not transported in the logger due to a short circuit of the main motor drive when the tide gauge was in the water. Consequently no data was recovered from any sensor.

OSTG position	Station 'E', Northern North Sea, 1974 Lat 59°17.8'N Long 00°03'W.
Depth of water	145m (PDR).
OSTG details	Type II, logger 04. Sensors OAR 4/2, SG 2/3, VIB 1/3.
Time of deployment	Tide gauge launched from "John Murray" and in water 1001 GMT day 305 (November 1st). Tide gauge on bottom 1012.52 GMT.
Time of recovery	On board "John Murray" at 1400 GMT day 349 (December 15th).
CTD casts	1 cast at 1211 GMT day 305 1 cast at 1416 GMT day 349 (December 15th).
Comments	After arriving on station at 0800 GMT, an extensive sand wave pattern was found to be present, and the ship manoeuvred to a flatter area. On recovery, some damage and corrosion was found on the Marsh Marine plug of the OAR 4/2 sensor, but this did not affect pressure or temperature records.

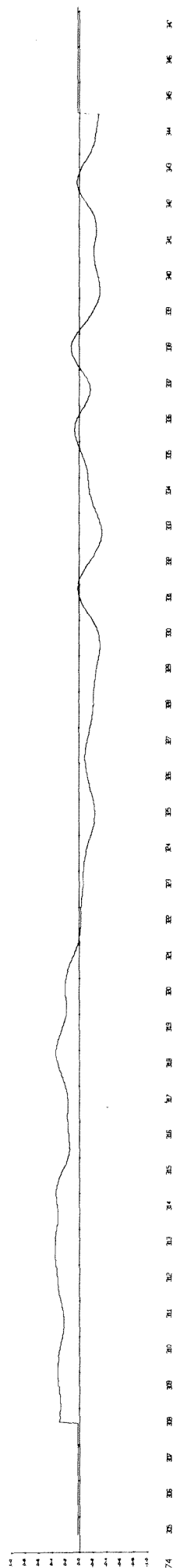
Timing	First scan 1559.43 GMT day 290 (17th Oct.1974) Last scan 1459.57 GMT day 003 (3rd Jany.1975) Clock slow, lost 14s in 77d 23h.
Raw pressure data	Start 1152.16 GMT day 305) for OAR 4/2 End 0737.23 GMT day 348) and VIB 1/3 Start 1152.16 GMT day 305) for SG 2/3 End 1137.17 GMT day 312)
Temperature data	Complete temperature data for OAR 4/2. No temperature data for VIB 1/3 and SG 2/3. OAR 4/2 temperature data used for correcting VIB 1/3 pressure data.
Atmospheric pressure data	Hourly data from Kirkwall (British Met Office, 3h data from Lerwick (British Met Office), and Sola, Stavanger (Norwegian Met Institute).
Drift free data	Start 1600 GMT day 308) for OAR 4/2 End 0300 GMT day 345) and VIB 1/3 FHP 53 filter used.
Tidal analysis	TIFA analysis of record 0000 GMT day 309 to 2300 GMT day 337 and 0000 GMT day 316 to 2300 GMT day 344 using related constituents from analysis of 5 years data from Lerwick, 1966-1971.
Comments	Both the temperature and pressure sensors of the SG 2/3 failed due to battery failure, the temperature on deployment, the pressure after 7 days. Due to the short length of data, no drift free data was obtained. The VIB 1/3 temperature failed after 7 days due to a leak in 'O' ring seal on heat sink, data before this was suspect.

TEMPERATURE
(DEGREES CELSIUS)

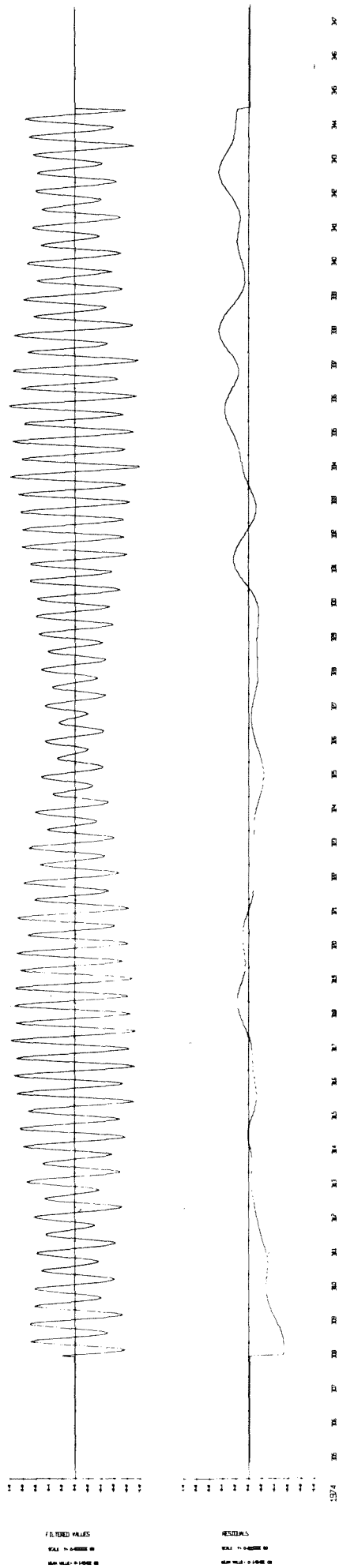




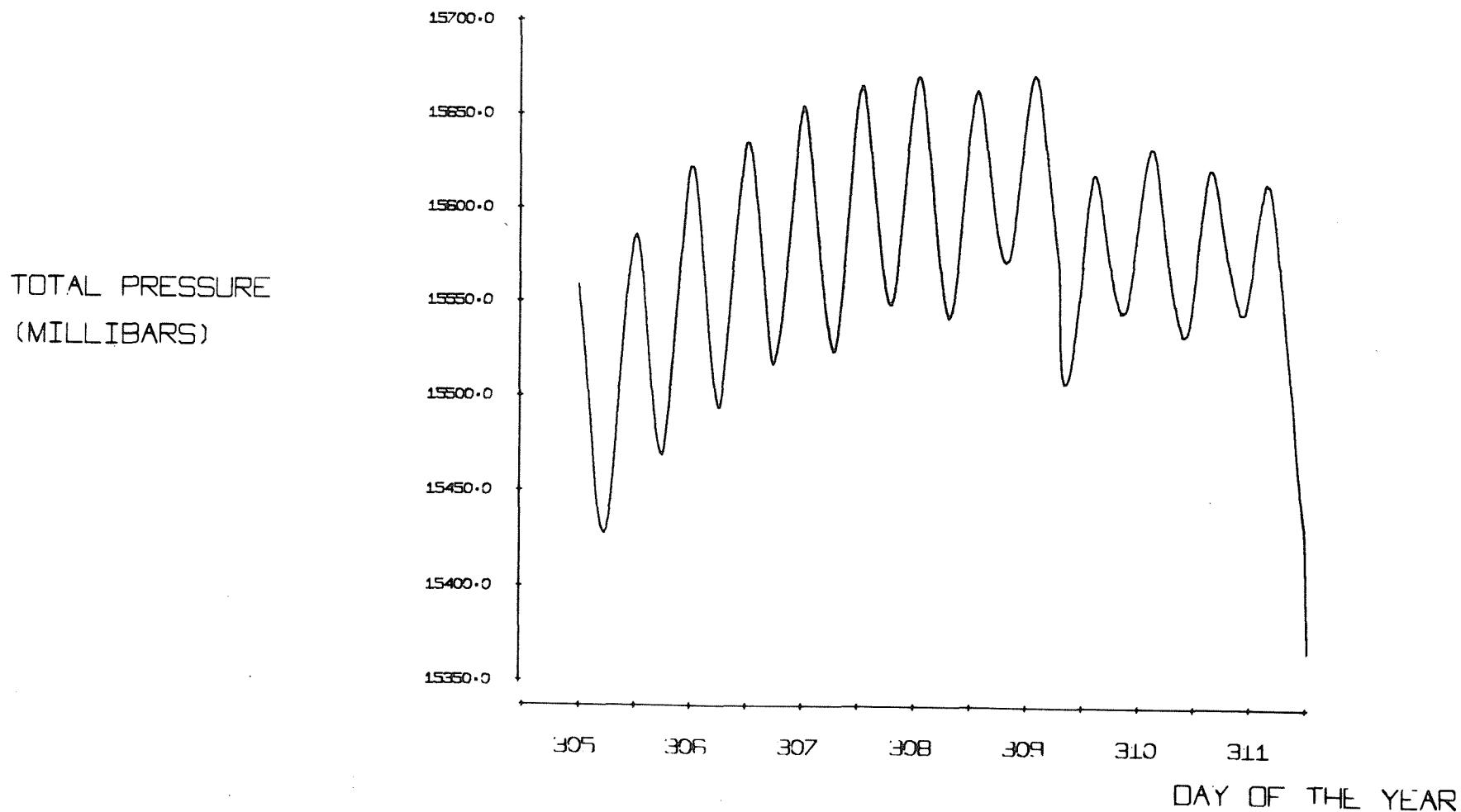
FILTERED VALUES
SCALE 10.0-UNIT 0.0
MEAN VALUE 0.0-UNIT 0.0



RESIDUALS
SCALE 10.0-UNIT 0.0
MEAN VALUE 0.0-UNIT 0.0



OSTG IOSB04 SG2/3 NOV/DEC 1974
N•NORTH SEA 'E' LAT 59 17.8N LONG 00 03W



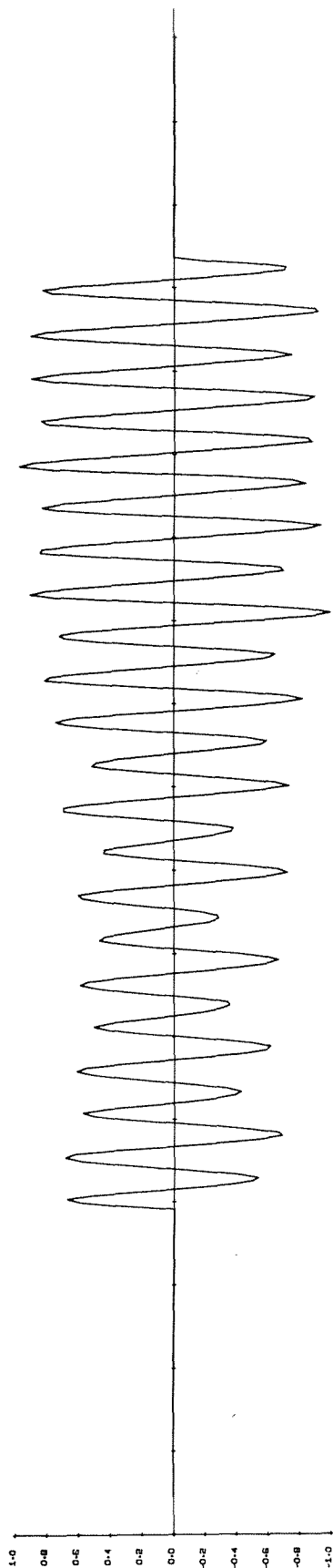
Station 'E', N. North Sea, 1974.
 Water head data FHP 53 Filter
 0000 day 309 to 2300 day 337 1974
 and 0000 day 316 to 2300 day 344 1974.
 *Related constituents using Lerwick
 1966-71 analysis.

Symbol	OAR 4/2				VIB 1/3			
	309-337		316-344		309-337		316-344	
	H (cm)	G (deg)	H (cm)	G (deg)	H (cm)	G (deg)	H (cm)	G (deg)
Q ₁	1.5	318.9	1.5	322.9	1.5	320.3	1.3	327.7
O ₁	6.4	38.4	6.7	38.2	6.3	38.3	6.7	39.6
M ₁	0.3	60.0	0.3	107.4	0.3	72.1	0.3	134.4
* P ₁	2.1	163.0	2.2	162.4	2.0	161.0	2.1	162.3
K ₁	6.7	179.1	6.9	178.5	6.5	177.1	6.9	178.4
J ₁	0.3	161.2	0.6	147.9	0.4	136.4	0.7	151.3
* 2N ₂	1.5	280.1	1.6	280.1	1.5	280.5	1.6	280.4
N ₂	1.8	290.1	1.5	293.3	1.7	293.6	1.5	299.3
N ₂	10.2	299.3	10.6	299.3	9.9	299.7	10.3	299.6
* N ₂	1.9	299.7	1.9	299.7	1.8	300.1	1.9	300.0
M ₂	52.2	319.3	52.4	319.5	51.7	319.3	51.9	319.6
L ₂	1.0	323.3	1.1	302.4	0.9	325.4	1.1	298.8
* T ₂	0.9	337.7	0.9	336.5	0.9	338.2	0.9	336.4
S ₂	19.1	352.3	19.0	351.1	19.1	352.8	19.0	351.2
* K ₂	5.3	348.8	5.3	347.6	5.3	349.3	5.3	347.7
2SM ₂	0.3	213.5	0.4	212.9	0.3	223.7	0.3	211.0
M ₃	0.6	223.2	0.7	240.1	0.7	218.6	0.7	233.6
MN ₄	0.4	239.9	0.3	249.3	0.4	229.1	0.3	243.1
M ₄	1.3	249.8	1.2	254.1	1.4	248.5	1.3	252.8
MS ₄	0.8	11.4	0.7	6.2	0.7	9.9	0.7	8.6
2MN ₆	0.4	217.2	0.5	231.8	0.4	220.9	0.5	233.2
M ₆	1.2	244.2	1.3	248.4	1.1	246.0	1.2	250.1
2MS ₆	0.8	260.4	0.8	266.8	0.8	266.2	0.8	270.7

TABLE 11

OSTG position	Station 'H', Northern North Sea, 1974 Lat 59°46.9'N Long 00°00.5'W.
Depth of water	137m (PDR).
OSTG details	Logger IOSW 41 Transducer FM 4882/32.
Time of deployment	Tide gauge initially launched from "John Murray" 1725 GMT day 305 (1st November). Finally launched 1840 GMT, on bottom 1843.30 GMT.
Time of recovery	Unknown - tide gauge trawled.
CTD casts	1 cast 1857 GMT day 305.
Comments	Prior to the final launch, there were two abortive attempts due to a rope caught on the Levitt release causing jamming. The tide gauge was trawled up sometime after 1345 GMT day 323 (19th November). It was taken by the Danish fishing vessel to Hirtshals and collected by IOS staff.

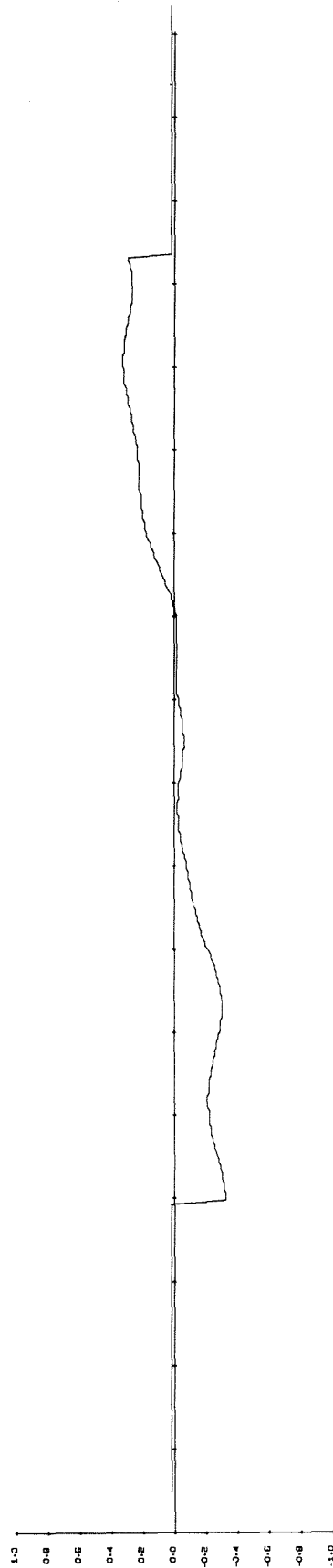
Timing	1st sea bed scan at 1915.00 GMT day 305 (November 1st). No timing corrections applied.
Raw pressure data	Start 1907.35 GMT day 305 End 1307.35 GMT day 323
Temperature data	Both thermistor channels failed after 10 days, although many values suspect before this (changes 1° between readings). No current meters were deployed at this position, therefore a constant temperature of 7.3°C was assumed.
Atmospheric pressure data	Hourly data from Kirkwall (British Met Office), 3h data from Lerwick (British Met Office), and 3h data from Sola, Stavanger (Norwegian Met Institute).
Drift free data	Start 0000 day 309 (5th November) End 0800 day 320 (16th November) FHP 53 filter used to remove drift.
Tidal analysis	TIRA analysis of record from 0000 GMT day 309 to 0800 GMT day 320 using related constituents from Lerwick (six year analysis 1966/1971).
Comments	The mechanical clock channel failed on launch, this did not affect the integration period which was controlled by a separate clock.



FILTERED VALUES

SCALE Y= 0.85600E 00

MEAN VALUE= 0.13723E 03



RESIDUALS

SCALE Y= 0.85600E 00

MEAN VALUE= 0.13723E 03

N= NORTH SEA 'H' FM41/32 WATER HEAD

Station 'H', N. North Sea, 1974
 Water head data FHP 53 filter
 0000 day 309 to 0800 day 320 1974
 *Related constituents using Lerwick
 1966-1971 analysis.

FM 41/32		
Symbol	H (cm)	g (deg)
* Q ₁	2.1	333.2
O ₁	5.7	28.0
* P ₁	1.9	152.6
K ₁	6.2	168.7
* N ₂	10.5	286.9
M ₂	50.2	309.0
* L ₂	1.1	331.1
S ₂	19.2	337.5
* K ₂	5.3	334.0
M ₃	1.0	190.3
M ₄	1.4	253.9
MS ₄	0.9	1.5
M ₆	1.4	237.0
2MS ₆	1.1	268.4
2SM ₆	0.4	312.7

TABLE 12

