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I.O.S.

Hutton Field Development.
Water depth measurement and tide predict
model. Contract 13860-TS-55.
First progress report, March 1983.

G.A.Alcock

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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1. Introduction

Conoco is developing the Hutton Field located in the northern North Sea and utilising a single Tension Leg Platform (TLP) for drilling, production and personnel accommodation. Water level variations due to tide and storm surge have significant effects on the mean tension in the tension legs, therefore it is desirable for the operating personnel to have available reliable predictions of the tidal levels and variations due to storms.

The Institute of Oceanographic Sciences (IOS) is contracted to collect, analyse and interpret water level data, and to develop a tide prediction model and use it to calculate predicted tide levels for the Hutton Field for a twenty year period. Data acquisition, using two pressure gauges, is planned to take place over one year, with periodic recovery and redeployment of one gauge to examine the data quality. This report concerns data collected over the period 31st October 1982 to 14th January 1983.

2. Deployment and Recovery

Conoco provided two Aanderaa WLR-5 pressure gauges, serial numbers 444 and 445, and these were tested, modified and calibrated by IOS staff. (Modifications were made to improve the timing circuits and to eliminate possible corrosion risks by removing the acoustic transducer on each gauge). IOS staff designed and manufactured mounting clamps to enable the gauges to be attached to the existing well head template at levels of 864.0 and 412.5 mm above the bottom deck level of the sensor table for gauges 445 and 444 respectively.

J. Casson and A. Harrison of IOS travelled to Aberdeen on 3rd October with gauges and mountings and briefed Conoco and Comex personnel on the installation of the equipment. Unfortunately, the planned subsequent deployment could not take place due to accommodation problems on the "Dundee Kingsnorth" (DKN). J. Casson and D. Flatt of IOS travelled to DKN on 24th - 25th October but rough weather made an immediate installation impossible. As accommodation was not available for IOS personnel after 26th October, they briefed the Conoco Supervisor and Comex diving team on the installation of the equipment, started and checked the gauges and left DKN on 26th October. The mountings and gauges were later installed on 31st October by Comex divers under Conoco supervision.

It was planned to recover and redeploy pressure gauge 445 during the first week of January and A. Harrison travelled to DKN on 1st January, but all recovery attempts were thwarted by bad weather. He made a further visit to DKN on 13th - 14th

January, and the gauge was recovered and on board at 1742 GMT 14th January 1983. The gauge was checked and found to be in good working order. A new battery and tape were fitted, and the gauge finally redeployed at 2229 GMT, 14th January, after several unsuccessful attempts due to snagging of the winch wire.

3. Data Processing

The magnetic tape from pressure gauge 445 was copied onto a 9 track magnetic tape and the channel counts listed using the CAMAC work station at Bidston. It was evident from the block count channel that the gauge had been manually stopped and restarted whilst on board the DKN prior to deployment, but after IOS personnel had left. This left a gap of 2 days in the surface pressure record but there were no gaps or errors in the bottom pressure record.

Pressure frequencies were calculated from the channel counts and the bottom pressure calculated from the pressure/frequency calibration and stored on disk. The ½ hourly values of bottom pressure are plotted in Figure 1 and show a good signal except for occasional "spikes" at some turning points and a particularly noisy period on 9th - 10th January 1983. (This period coincided with work done by Conoco in cleaning up the cell riser area of the seabed).

An interpolation programme was used to produce an output of hourly values, on the hour (GMT), of the bottom pressure record. This programme smoothed the data using a low-pass filter, FLP 07, of half length 12 and cut-off frequency (half-power point) of 0.375 c h^{-1}; this reduced the amplitude response at the M_6 tidal frequency by 1% but had negligible effect at other tidal frequencies. The resulting series was then interpolated, using a cubic spline, to obtain the hourly values, on the hour (GMT). It was not possible to determine if the recorder clock was fast or slow, and therefore apply time corrections, because the exact time of switching on the recorder had not been noted when it had been restarted prior to deployment. Root mean square errors due to the interpolation method are of the order of 0.02 mb.

Each hourly value of bottom pressure obtained using the interpolation programme was the total pressure measured by the recorder, i.e. the sum of the pressures due to the water column and air column above the sensor. The latter was subtracted using hourly values of atmospheric pressure, extracted from a barometer chart record from DKN and supplied by Conoco for the period beginning 0800 GMT 11th November 1982. The computed water pressures were converted to elevations using the hydrostatic equation. A sea water density value of 1027.3 Kg m^{-3} was used, as determined by O.E.S. following their measurements of temperature and salinity (Ref. 2). The resulting sea level elevation record obtained was for the period 0800 GMT 8th November 1982 to 1100 GMT 14th January 1983.

4. Data Analysis and Results

Tidal analyses of two 29 day periods of the hourly sea level data were carried out using the IOS TIRA programme which utilises the harmonic method of analysis and which performs a least-squares fit to the data. The amplitude (H in mm) and phase lag (G in ^{o}), relative to Greenwich epoch, of 27 major and 8 related constituents were computed, the time zone being Greenwich Mean Time. The constituents π_1, P_1, ψ_1, ϕ_1, $2N_2$, ν_2, T_2 and K_2 are not separable with only one month of data, and so they were related to the major constituents using values derived from the analysis of six years of data from the nearby permanent coastal station at Lerwick.

Table 1 gives the tidal constituents obtained by the analysis of each period, together with their vector means. The fact that the constituents vary from month to month is well known; the mechanisms causing the variations are poorly understood but are thought to include non-linear shallow water interactions and variations in the atmospheric tide (Ref. 1).

Table 1 also gives the mean value (Z_o in mm) of the sea level elevation above the sensor level for each period. These values should only be taken as a rough guide to the mean sea level (msl) at the Hutton Field site because of the difficulties of obtaining absolute measurements of water levels with a bottom pressure gauge, and because of the seasonal and annual variations of msl. (At Lerwick over the period 1957 - 1981, variations in monthly msl were approximately $\pm$130mm about the annual mean within any particular year, and variations in annual msl were approximately $\pm$70mm about the 25y mean).

The vector mean values of Z_o, M_2 and S_2 have been used to compute the tidal parameters of Mean High Water Springs, Mean High Water Neaps, Mean Low Water Neaps and Mean Low Water Springs (MHWS, MHWN, MLWN and MLWS respectively), and these are given in Table 2.

The set of harmonic constituents obtained from this short data span is not sufficient to predict the tidal levels accurately enough to obtain Highest and Lowest Astronomical Tide (HAT and LAT). Therefore these statistics have been estimated using Flather's method (Ref. 3) based on tidal statistics at Hutton and Lerwick, but using the vector mean of the observed values of M_2 and S_2 rather than those from his Continental Shelf Model. The values of HAT and LAT given in Table 2 are only approximate as the true values depend on seasonal variations and other constituents not derivable from one month of data.

5. Conclusions

Good quality bottom pressure data has been obtained from the Hutton Field site for the period 31st October 1982 to 14th January 1983, and has been processed to yield a hourly sea level record from 0800 08 November 1982 to 1100 14 January 1983.

Tidal statistics have been computed from analyses of two 29 day periods but the results should be treated with caution because of the short span of data available.

6. References

1. On the time variation of ocean tides. T.F. Baker and G.A. Alcock. Proceedings of 9th International Symposium on Earth tides, 1981.

2. Temperature, salinity and density measurements, Hutton Field. O.E.S. ref. PROJ795/82, 1982.

3. Estimates of extreme levels for the Hutton Field. R.A. Flather. Appendix 3 of BRVO Report No. 200-00-00-M735-OR, 1981.

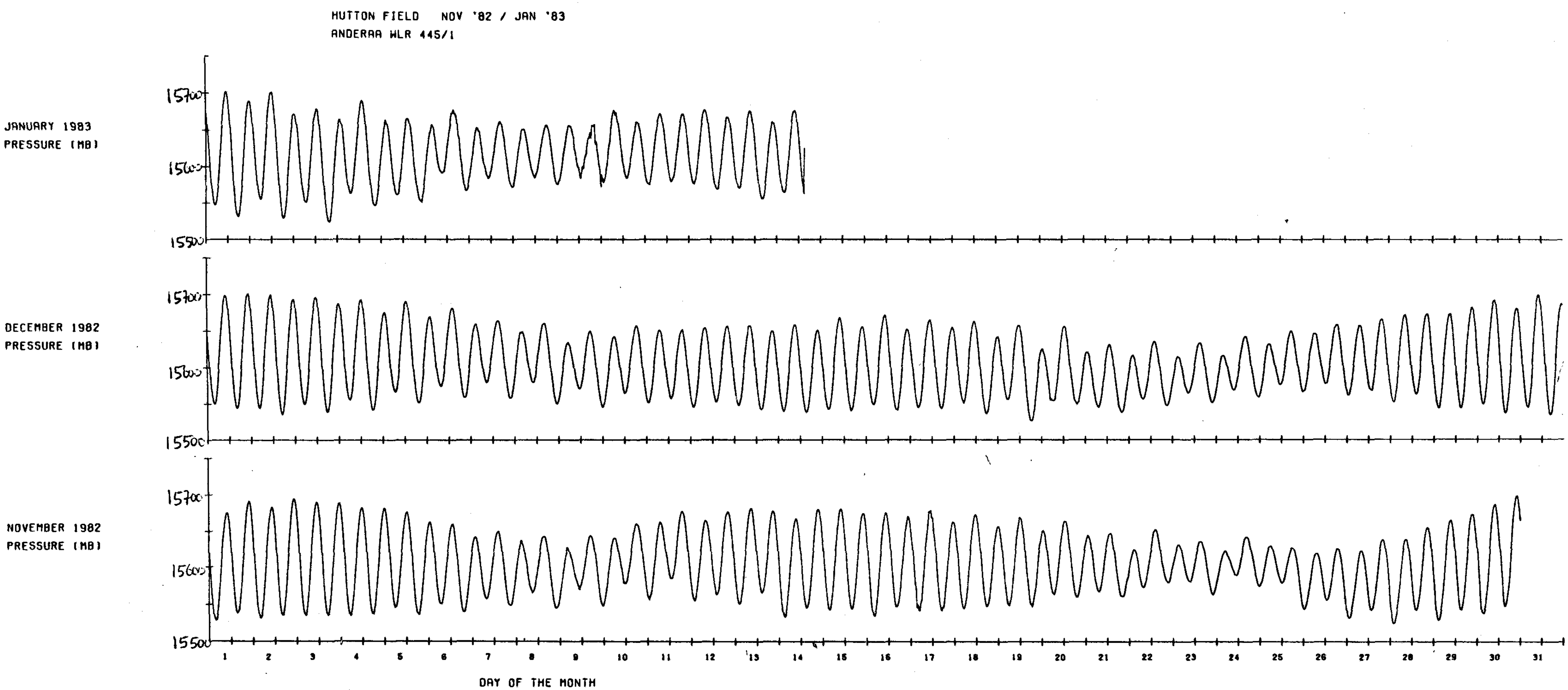
HUTTON FIELD NOV '82 / JAN '83
ANDERAA WLR 445/1
JANUARY 1983
PRESSURE (MB)
DECEMBER 1982
PRESSURE (MB)
NOVEMBER 1982
PRESSURE (MB)
15700
15600
15500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF THE MONTH

Figure I

TABLE 1. HUTTON FIELD TIDAL CONSTITUENTS

Constituent	12/11/82 to 10/12/82 H (mm)	12/11/82 to 10/12/82 G (°)	11/12/82 to 08/01/83 H (mm)	11/12/82 to 08/01/83 G (°)	Vector mean H (mm)	Vector mean G (°)
Z_o	144813		144854		144834	
Q_1	23	2.3	21	359.1	22	0.8
O_1	49	34.9	61	39.4	55	37.4
M_1	7	21.5	9	342.8	8	359.5
π_1	1	110.6	2	104.7	2	107.6
P_1	19	154.0	21	148.1	20	150.9
K_1	61	170.1	66	164.2	64	167.1
ψ_1	2	182.3	2	176.5	2	179.3
ϕ_1	1	198.6	1	192.7	1	195.5
J_1	5	306.5	9	155.5	3	181.8
OO_1	1	236.8	10	19.1	5	17.3
$2N_2$	16	248.8	16	250.2	16	249.5
μ_2	19	250.5	17	239.7	18	245.5
N_2	105	268.0	104	269.4	104	268.7
ν_2	19	268.4	19	269.8	19	269.1
M_2	505	289.2	503	288.7	504	289.0
L_2	13	288.7	20	291.3	17	290.3
T_2	9	307.8	9	308.0	9	307.9
S_2	181	322.4	180	322.6	180	322.5
K_2	50	318.9	50	319.1	50	319.0
$2SM_2$	2	165.9	1	212.5	1	173.6
MO_3	3	265.6	4	196.2	3	225.9
M_3	6	160.6	2	182.6	4	166.7
MK_3	2	285.1	3	0.0	2	332.1
MN_4	1	301.7	1	176.1	1	257.6
M_4	4	233.3	4	214.7	4	223.5
SN_4	1	107.4	2	35.8	1	67.6
MS_4	6	324.8	5	325.4	5	325.1
$2MN_6$	3	252.3	4	222.0	3	234.9
M_6	4	242.2	5	261.9	5	252.7
MSN_6	1	275.5	0.1	245.3	0.3	270.9
$2MS_6$	5	289.2	3	306.4	4	296.0
$2SM_6$	1	317.0	0.2	302.2	0.4	313.6

TABLE 2. TIDAL STATISTICS AT HUTTON FIELD

		(m)
Z_o	relative to sensor level	144.83
HAT	relative to Z_o	+ 1.01
MHWS	relative to Z_o	+ 0.68
MHWN	relative to Z_o	+ 0.32
MLWN	relative to Z_o	- 0.32
MLWS	relative to Z_o	- 0.68
LAT	relative to Z_o	- 1.08

Note : All statistics are based on analyses of two 29 day periods, 12/11/82 to 10/12/82 and 11/12/82 to 08/01/83, of water level data from sensor 445.