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WAVES RECORDED AT TWO SITES OFF HOLDERNESS 1986-1987

S. Bacon

January 1988

Internal Document No. 278

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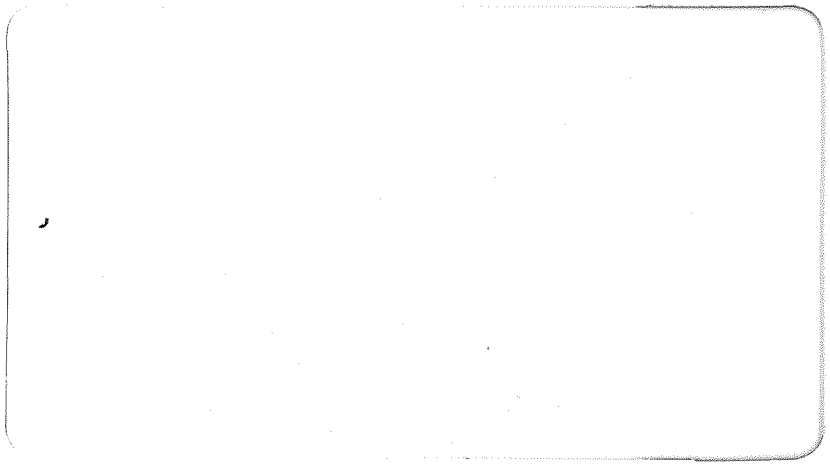

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DOCUMENT DATA SHEET

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ABSTRACT

Measurements were made routinely with two Waverider buoys off Holderness on the Humberside coast over 1986 and 1987, one nearshore on site for four months, the other offshore on site for thirteen months. This report provides information detailing the location, the instrumentation and the data return. Obtained from the wave records are estimates of significant wave height, H_S, and zero-up-crossing period, T_Z. Histograms from these values are presented indicating the probability distributions of H_S and T_Z appropriate to the operational period of each site. Each observed H_S distribution is fitted to a Fisher-Tippett Type 1 probability distribution which is then extrapolated to obtain an estimate of the fifty-year return value of H_S. Observed joint probability distributions of (H_S, T_Z) are presented. For months when data are available from both sites, comparisons between sites are presented of H_S and of T_Z.

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KEYWORDS	*INTERCOMPARISON* *SCATTER DIAGRAMS* *SIGNIFICANT WAVE HEIGHT* *WAVE DATA* *WAVERIDER BUOY* *50-YEAR RETURN VALUE* *HOLDERNESS*	*CONTRACT* *PROJECT* PH 47 *PRICE*

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1. INTRODUCTION

Wave measurements were recorded off Holderness using two Waverider buoys, one nearshore, on site from March to June 1986, and one offshore, on site from March 1986 to March 1987. This report describes the wave climate as derived from these measurements. The work was funded by the UK Ministry of Agriculture, Fisheries and Food.

2. LOCATION

The sites at which the wave measurements were taken are shown on the maps in figure 1. The table below gives the mooring site details, with bearing and distance referred to Hornsea on the Humberside coast.

	Latitude	Longitude	Bearing	Distance (n.m.)	Water Depth (Chart datum, metres)
Nearshore Buoy	53°55'05"N	00°03'32"W	E	3.7	12
Offshore Buoy	53°55'56"N	00°01'24"E	E by N	6.6	17

Tidal heights above Chart Datum reach a maximum of 5.5-6.0 m, with a mean height of the order of 3.0 m.

The receiving site for the FM buoy signals was at Hornsea Coastguard Station.

The site is open to the North Sea from N through E to SSE. The sea floor slopes gently downwards from the coast; there are no off-lying banks in the immediate vicinity.

3. MEASUREMENT AND RECORDING SYSTEMS

Wave measurements were made using standard Waverider buoys moored as described by Humphery (1982). This instrument senses the vertical acceleration of the buoy by means of a stabilized accelerometer and uses analogue double integrators to reconstitute the surface elevation. This information is transmitted ashore via a high-frequency radio link employing a frequency-modulated subcarrier to encode the wave height information.

At Hornsea, the buoy's transmissions were received and a counting arrangement (described in Thorne and Gleason, 1986) was used to decode the

wave height information. In this way a measure of surface elevation was obtained at 0.5 second intervals in the form of a digital count which was recorded on magnetic tape. The time between starts of successive records was 1.5 hours, and the length of each record was 34 minutes.

4. MAINTENANCE

The buoys were maintained on site by Hydraulic Research Ltd. and the shore station by IOS; special visits were made either when data reception stopped or when data quality fell below acceptable standards. A local coastguard was responsible for tape and/or cartridge changes, and for reporting any malfunctions.

5. WAVE DATA COVERAGE, DATA PRESENTATION AND RESULTS

The tables below give the percentage data return by month, the total data return, and the data return per season.

Monthly data return (%)

Year	1986										1987		
Month	3	4	5	6	7	8	9	10	11	12	1	2	3
Nearshore Buoy	72.2	94.0	99.6	51.7									
Offshore Buoy	83.7	95.2	99.6	84.4	97.8	14.3	23.8	61.1	91.3	76.6	28.0	97.8	82.3

Total Data Return

	Actual Total	Possible Total	Actual %
Nearshore Buoy	1551	1952	79.5
Offshore Buoy	4848	6636	73.1

Seasonal Data Return

		Actual Total	Possible Total	Actual %
Nearshore Buoy	Spring	1303	1472	88.5
Offshore Buoy	Spring	1775	1968	90.2
	Summer	961	1472	65.3
	Autumn	827	1456	56.8
	Winter	985	1440	68.4

Figures 2-5 present as time series all Nearshore and Offshore records of significant wave height (H_S) and zero-up-crossing period (T_Z) over the recording period, where each vertical bar above the time axis represents a valid record whose height is proportional to the value of H_S or T_Z for that record. Missing or invalid records are represented as short vertical bars below the time axis.

Two major breakdowns of receiving site hardware occurred, affecting the data return of the Offshore buoy. The first resulted in the gap covering most of July and August 1986; the second resulted in the gap during January 1987. No difficulties were experienced with the buoy data transmission system; data return quality was affected by problems with the shore-based reception and recording systems. Some data may have been lost in high sea states due to line of transmission interruption.

Statistics of Significant Wave Height and Wave Period

The maximum value of H_S recorded at the Nearshore site occurred on the 10th April 1986 at 0600 hours with H_S = 4.21 m and associated T_Z = 7.47 s; the maximum Offshore H_S occurred on the 7th April 1986 at 2230 hours with H_S = 4.09 m and associated T_Z = 6.48 s.

The mean and maximum values of H_S recorded during each individual month are given in the table below. Figures in parentheses indicate values for a month with less than 50% valid records.

Nearshore Buoy

Month	Mean H_S	Maximum H_S
3	0.69	2.90
4	1.06	4.21
5	0.58	1.52
6	0.74	2.49

Offshore Buoy

Month	Mean H_S	Maximum H_S
3	0.76	3.12
4	1.09	4.09
5	0.65	1.62
6	0.80	2.76
7	0.51	1.14
8	(0.72)	(1.58)
9	(0.62)	(1.35)
10	0.58	1.87
11	1.04	3.00
12	1.15	2.77
1	(1.30)	(2.59)
2	0.96	2.46
3	1.51	3.61

Estimates of the probability distributions of H_S are included in figs.6 and 7 which present histograms giving the percentage occurrence of H_S over all data for both sites and over each season for the Offshore site, with the H_S values grouped in 0.25 m bins. These histograms are the marginal H_S distributions of scatterplots which were constructed allowing for the variation in the number of records per month. Note that the scatterplots used to generate both the marginal H_S and marginal T_Z distributions are not those used to present the joint (H_S, T_Z) distributions, which are binned in 0.5 m steps. The probability values for each bin and each histogram are set out in Tables 1 and 2.

Estimates of the fifty-year return value of H_S, $H_S(50)$, were obtained by fitting a Fisher-Tippett Type I distribution to the observed distributions of H_S and extrapolating to the required probability. See the table below for a summary of the results, and see also figs.8-10, where the FT-1 distribution is represented by the solid straight line; the data were binned in 0.25 m steps, as above. Fig.10 (FT-1 fit to Offshore Spring data) is included for comparison with the Nearshore FT-1 fit.

Site	Period	$H_S(50)$ (m)	location parameter (m)	scale parameter (m)
Offshore	All data	5.70	0.64	0.43
	Spring	6.10	0.67	0.52
	Summer	3.96	0.49	0.33
	Autumn	3.93	0.57	0.32
	Winter	5.02	0.92	0.39
Nearshore	Spring	5.34	0.51	0.46

The $H_S(50)$ for all the offshore data is 0.4 m less than that for just the Spring data. The implication is that were a structure to be erected in the vicinity of the Offshore buoy site, it would experience worse conditions were it to be stationed there for fifty springs than if it were stationed for fifty full years. More work is needed to resolve this apparent difficulty, although it may stem from the inadequacy of the functional form used to fit the data, the short data series, and the extrapolation techniques.

The Nearshore data are poorly fitted by the FT-1 distribution; further investigation is required but it is likely that shallow-water effects need to be taken into account.

The maximum recorded value of zero-up-crossing period T_Z occurred at the Nearshore site on 10th April 1986 at 0900 hours with T_Z = 7.63 sec and associated H_S = 3.79 m; the Offshore maximum T_Z occurred on 29th March 1987 at 1930 hours with T_Z = 8.97 sec and associated H_S = 2.68 m.

Figure 11 shows the joint probability distribution (or scatterplot) of H_S and T_Z for the Nearshore buoy; figures 12-16 show the seasonal and total scatterplots for the Offshore buoy. When computing the scatterplots, allowance was made for the variation in the number of valid records per month throughout the year by computing scatterplot for each calendar month, then combining the resulting monthly scatterplots (suitably weighted for different numbers of days per month) into plots representing the whole year and the seasons. The seasons are defined for this purpose as below.

SPRING: MAR-MAY
SUMMER: JUN-AUG
AUTUMN: SEP-NOV
WINTER: DEC-FEB

It is interesting to note the difference between the Nearshore and Offshore Spring scatterplots; the latter includes a quantity of probability ascribed to waves of T_z > 6.5 s which is not seen on the Nearshore scatterplot. This probability derives from waves generated by storms in March 1987, after the Nearshore buoy had been removed, and is indicative of the difficulty of deriving reliable wave statistics from just one year of measurements.

Comparisons were effected between records taken simultaneously at both Nearshore and Offshore sites; figs.17 and 18 show plots of Nearshore vs. Offshore values of H_s and T_z respectively.

Also included on each plot is a 45° line representing (nearshore value) = (offshore value). From these plots, it can be seen that there is some reduction in wave height from Offshore to Nearshore as might be expected by virtue of the shallowness of the water in the region, and by the reduction in fetch for offshore winds. There seems to be no significant difference between Offshore and Nearshore T_z, which is to be expected for onshore waves, since reducing water depth affects wave height but not wave period.

6. ACKNOWLEDGEMENTS

The collection of the data and the production of this report were funded by the Ministry of Agriculture, Fisheries and Food.

7. REFERENCES

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Institute of Oceanographic Sciences, Report No.226, 69pp.

Table 1a

H_S and T_Z Histogram Percentage Occurrences: Offshore Buoy

H_S % Occurrences

Range (m)	All Data	Winter	Spring	Summer	Autumn
0.0 - 0.25	3.18	-	2.01	8.65	1.99
0.25 - 0.5	21.36	6.82	24.49	30.56	23.32
0.5 - 0.75	25.00	15.60	21.59	28.14	34.61
0.75 - 1.0	19.78	23.30	16.88	16.00	23.02
1.0 - 1.25	11.56	18.95	11.88	7.55	7.97
1.25 - 1.5	6.74	12.65	6.27	4.14	3.98
1.5 - 1.75	4.46	9.55	4.62	2.07	1.65
1.75 - 2.0	2.94	6.09	3.80	0.56	1.36
2.0 - 2.25	1.93	3.71	2.22	1.21	0.60
2.25 - 2.5	1.07	2.45	1.15	0.32	0.38
2.5 - 2.75	1.10	0.79	2.37	0.56	0.68
2.75 - 3.0	0.49	0.09	1.23	0.24	0.38
3.0 - 3.25	0.16	-	0.56	-	0.07
3.25 - 3.5	0.08	-	0.33	-	-
3.5 - 3.75	0.08	-	0.33	-	-
3.75 - 4.0	0.05	-	0.21	-	-
4.0 - 4.25	0.02	-	0.07	-	-

Table 1b

H_S and T_Z Histogram Percentage Occurrences: Offshore Buoy

T_Z % Occurrences

Range (m)	All Data	Winter	Spring	Summer	Autumn
2.0 - 2.5	2.15	-	1.60	3.62	3.36
2.5 - 3.0	15.95	3.46	15.27	23.06	21.83
3.0 - 3.5	21.58	18.15	25.42	19.31	23.41
3.5 - 4.0	19.94	20.73	21.34	20.83	16.84
4.0 - 4.5	13.49	15.15	11.73	12.13	15.02
4.5 - 5.0	10.08	14.32	9.04	8.61	8.41
5.0 - 5.5	6.29	8.92	5.54	6.32	4.40
5.5 - 6.0	4.87	8.46	4.24	3.20	3.64
6.0 - 6.5	2.72	3.72	2.97	2.16	2.04
6.5 - 7.0	1.59	3.41	1.47	0.78	0.70
7.0 - 7.5	0.89	2.69	0.69	-	0.22
7.5 - 8.0	0.29	0.64	0.41	-	0.11
8.0 - 8.5	0.13	0.29	0.25	-	-
8.5 - 9.0	0.03	0.07	0.04	-	-

Table 2a

H_S and T_Z Histogram Percentage Occurrences: Nearshore Buoy

H_S % Occurrences

Range (m)	Spring
0.0 - 0.25	5.35
0.25 - 0.5	29.94
0.5 - 0.75	26.87
0.75 - 1.0	18.11
1.0 - 1.25	7.21
1.25 - 1.5	4.28
1.5 - 1.75	2.43
1.75 - 2.0	0.82
2.0 - 2.25	0.89
2.25 - 2.5	1.01
2.5 - 2.75	0.74
2.75 - 3.0	1.03
3.0 - 3.25	0.29
3.25 - 3.5	0.36
3.5 - 3.75	0.22
3.75 - 4.0	0.22
4.0 - 4.25	0.22

Table 2b

H_S and T_Z Histogram Percentage Occurrences: Nearshore Buoy

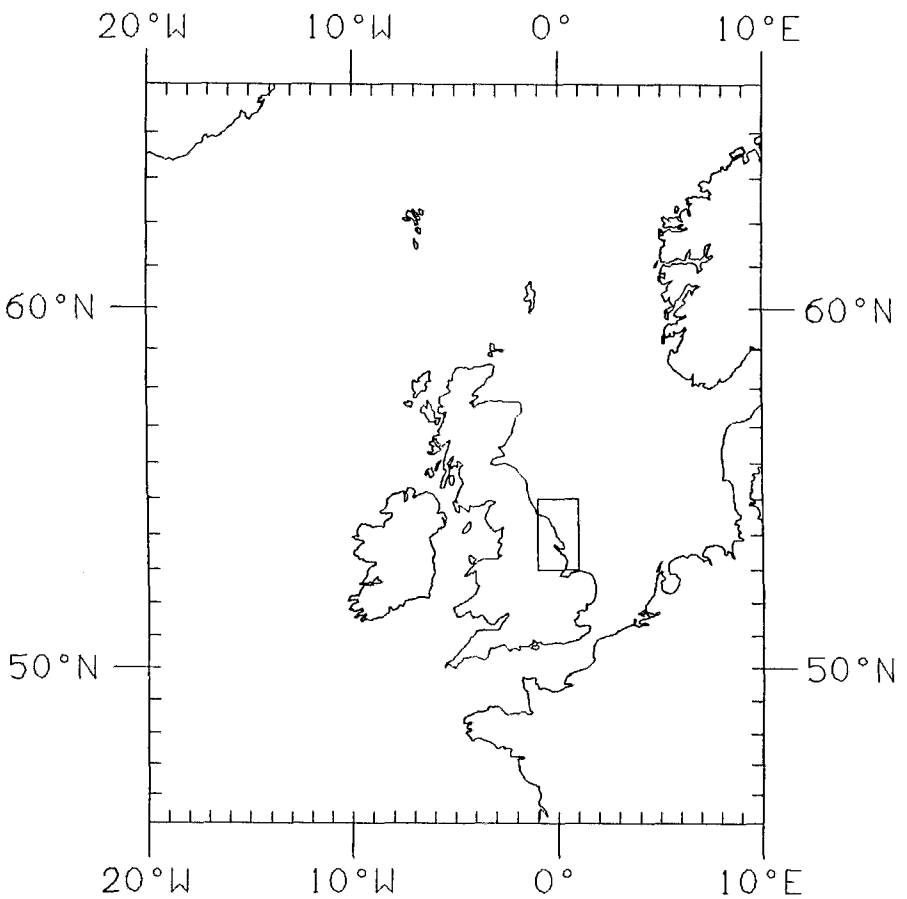
T_Z % Occurrences

Range (m)	Spring
2.0 - 2.5	3.00
2.5 - 3.0	21.16
3.0 - 3.5	30.76
3.5 - 4.0	18.61
4.0 - 4.5	10.71
4.5 - 5.0	6.48
5.0 - 5.5	3.40
5.5 - 6.0	3.48
6.0 - 6.5	1.83
6.5 - 7.0	0.75
7.0 - 7.5	0.29
7.5 - 8.0	0.07

Figure 1

HOLDERNESS OFFSHORE WAVERIDER BUOY

HOLDERNESS NEARSHORE WAVERIDER BUOY



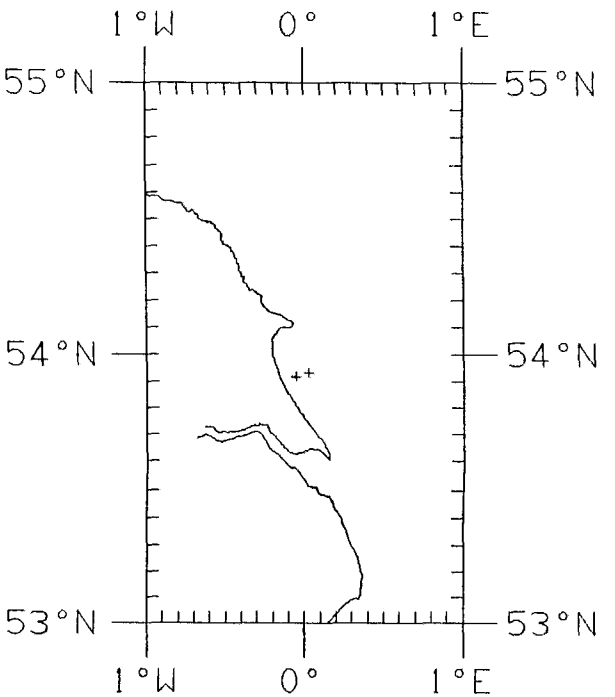


Figure 2

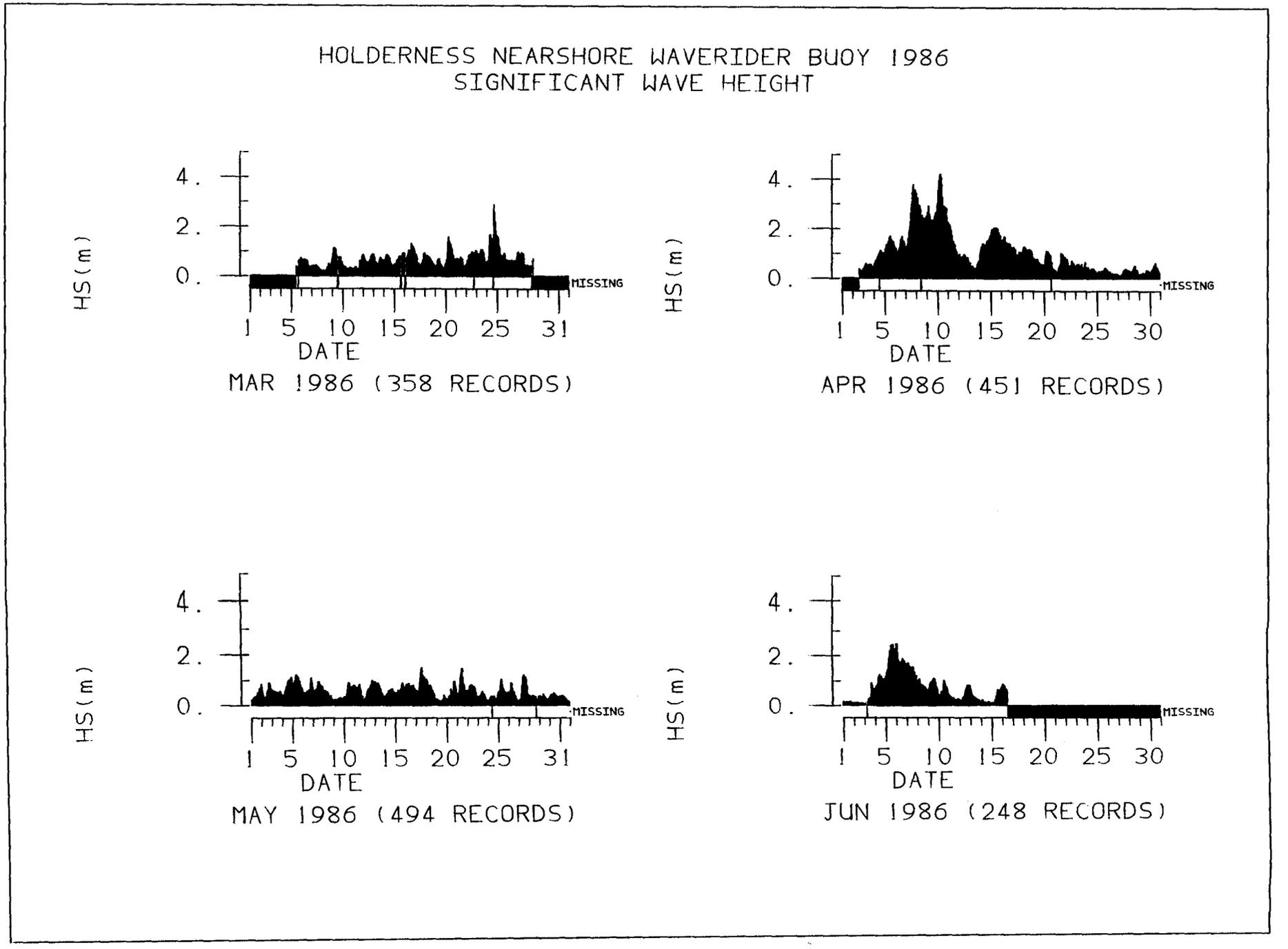
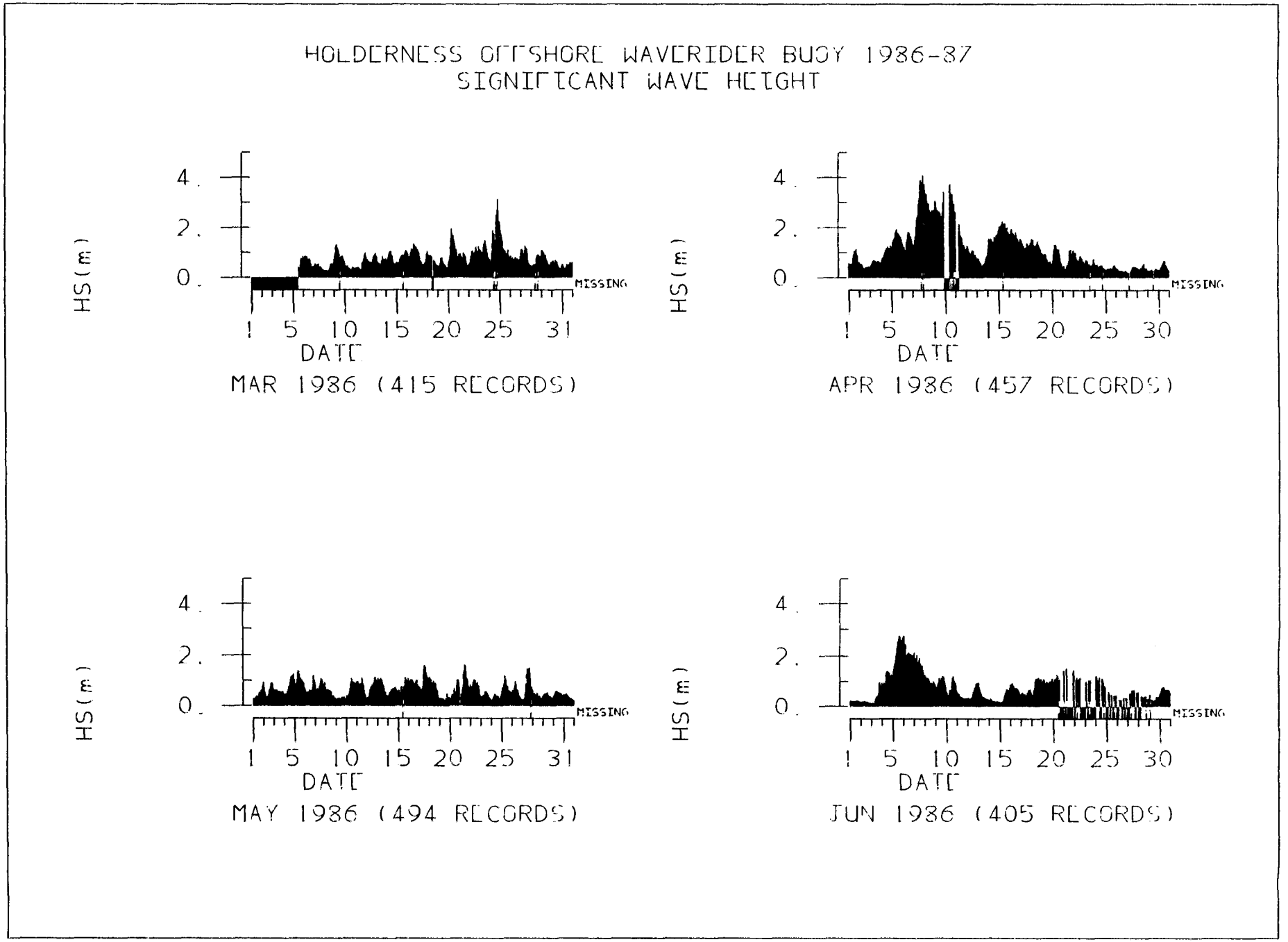

HOLDERNESS NEARSHORE WAVERIDER BUOY 1986
SIGNIFICANT WAVE HEIGHT
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAR 1986 (358 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
APR 1986 (451 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAY 1986 (494 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
JUN 1986 (248 RECORDS)

Figure 3(a)


HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
SIGNIFICANT WAVE HEIGHT
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAR 1986 (415 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
APR 1986 (457 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAY 1986 (494 RECORDS)
HS(m)
4.
2.
0.
MISSING
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DATE
JUN 1986 (405 RECORDS)

Figure 3(b)

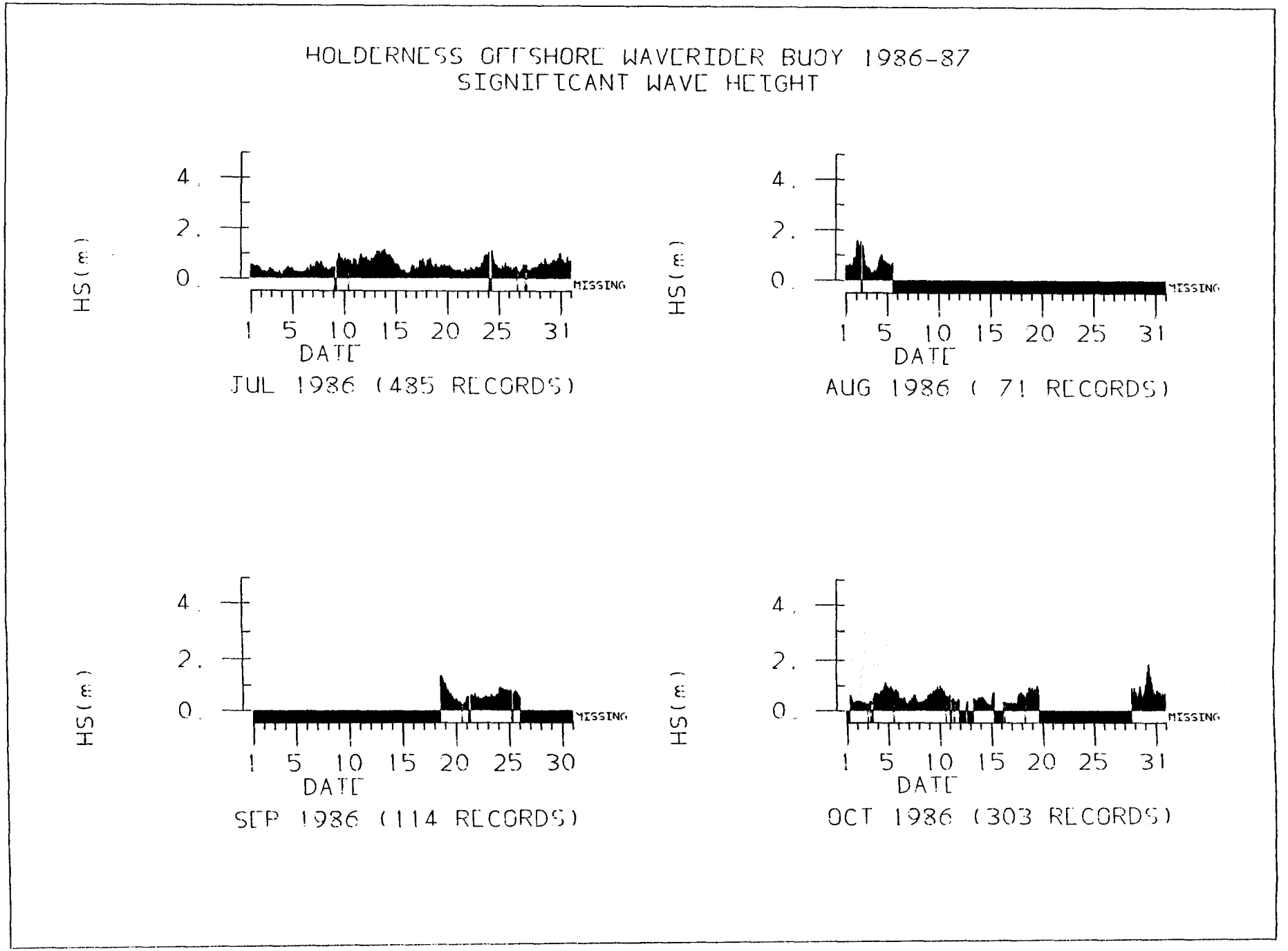
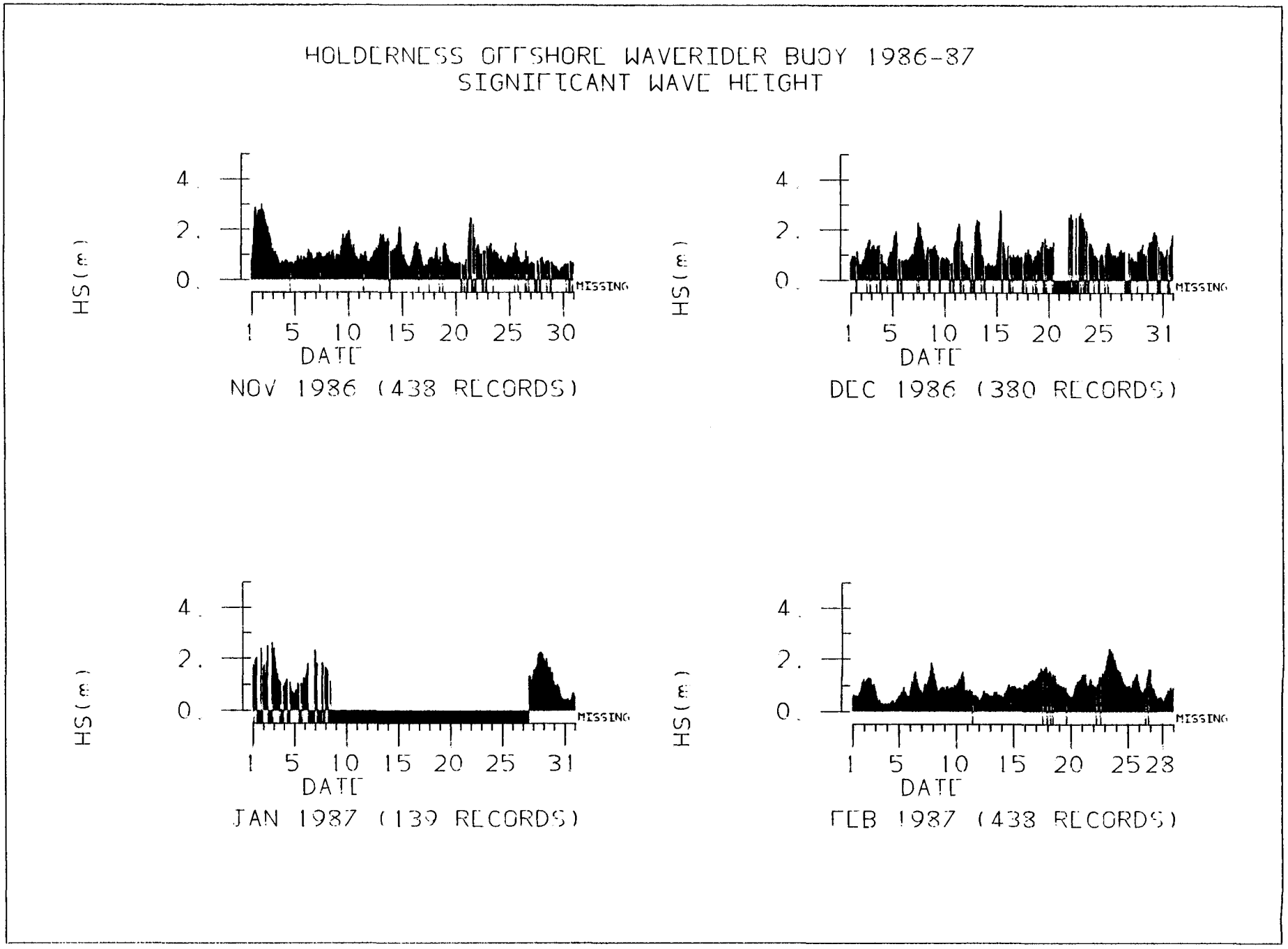

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
SIGNIFICANT WAVE HEIGHT
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
JUL 1986 (485 RECORDS)
AUG 1986 (71 RECORDS)
1 5 10 15 20 25 30
SEP 1986 (114 RECORDS)
OCT 1986 (303 RECORDS)

Figure 3(c)


HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
SIGNIFICANT WAVE HEIGHT
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
NOV 1986 (438 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
DEC 1986 (380 RECORDS)
HS(m)
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
JAN 1987 (139 RECORDS)
HS(m)
4.
2.
0.
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FEB 1987 (438 RECORDS)

Figure 3(d)

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
SIGNIFICANT WAVE HEIGHT

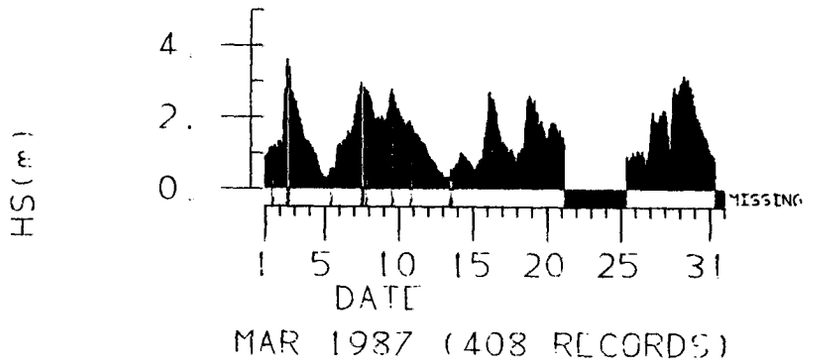
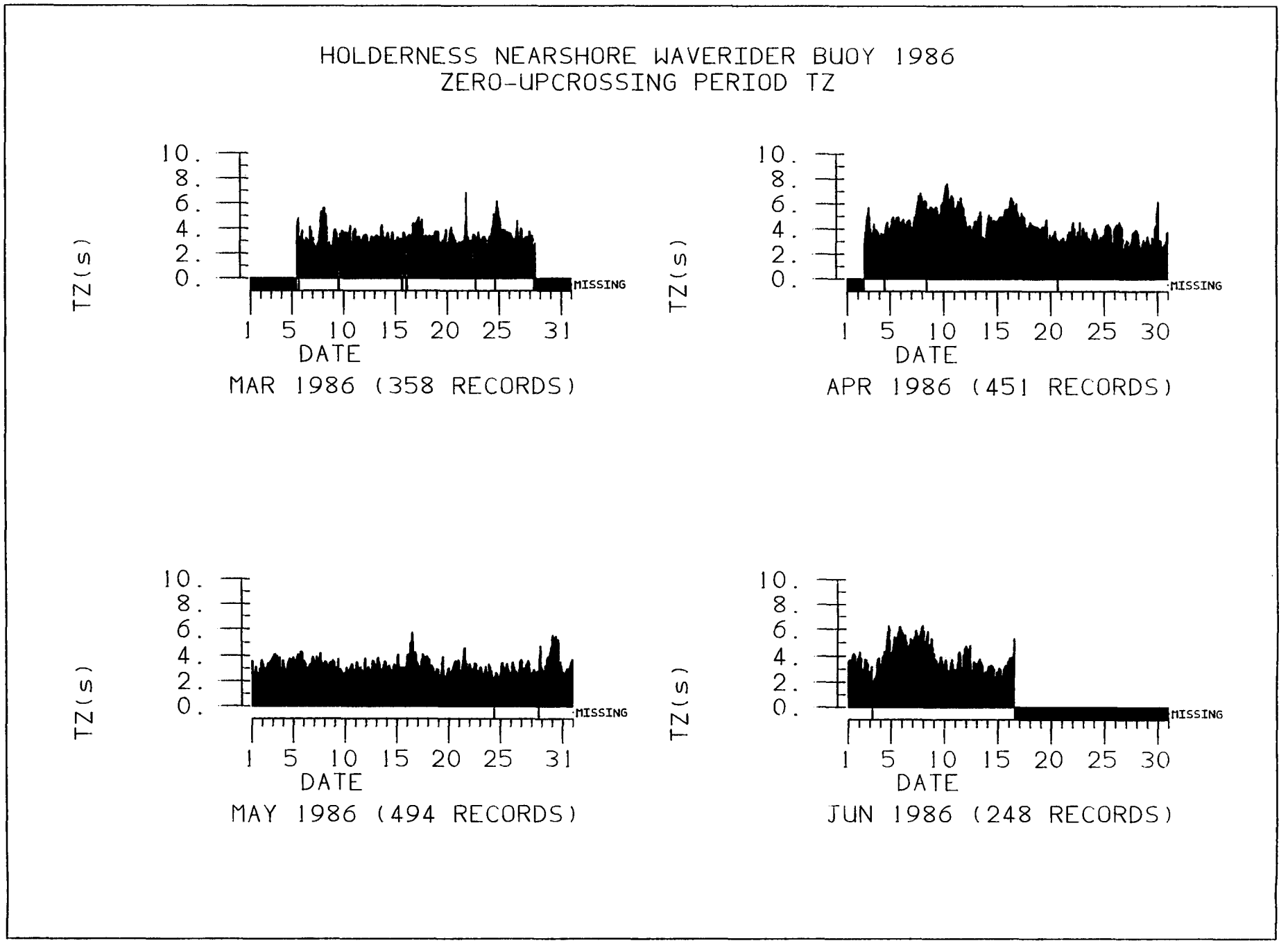


Figure 4


HOLDERNESS NEARSHORE WAVERIDER BUOY 1986
ZERO-UPCROSSING PERIOD TZ
TZ(s)
10.
8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAR 1986 (358 RECORDS)
TZ(s)
10.
8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
APR 1986 (451 RECORDS)
TZ(s)
10.
8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAY 1986 (494 RECORDS)
TZ(s)
10.
8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 30
DATE
JUN 1986 (248 RECORDS)

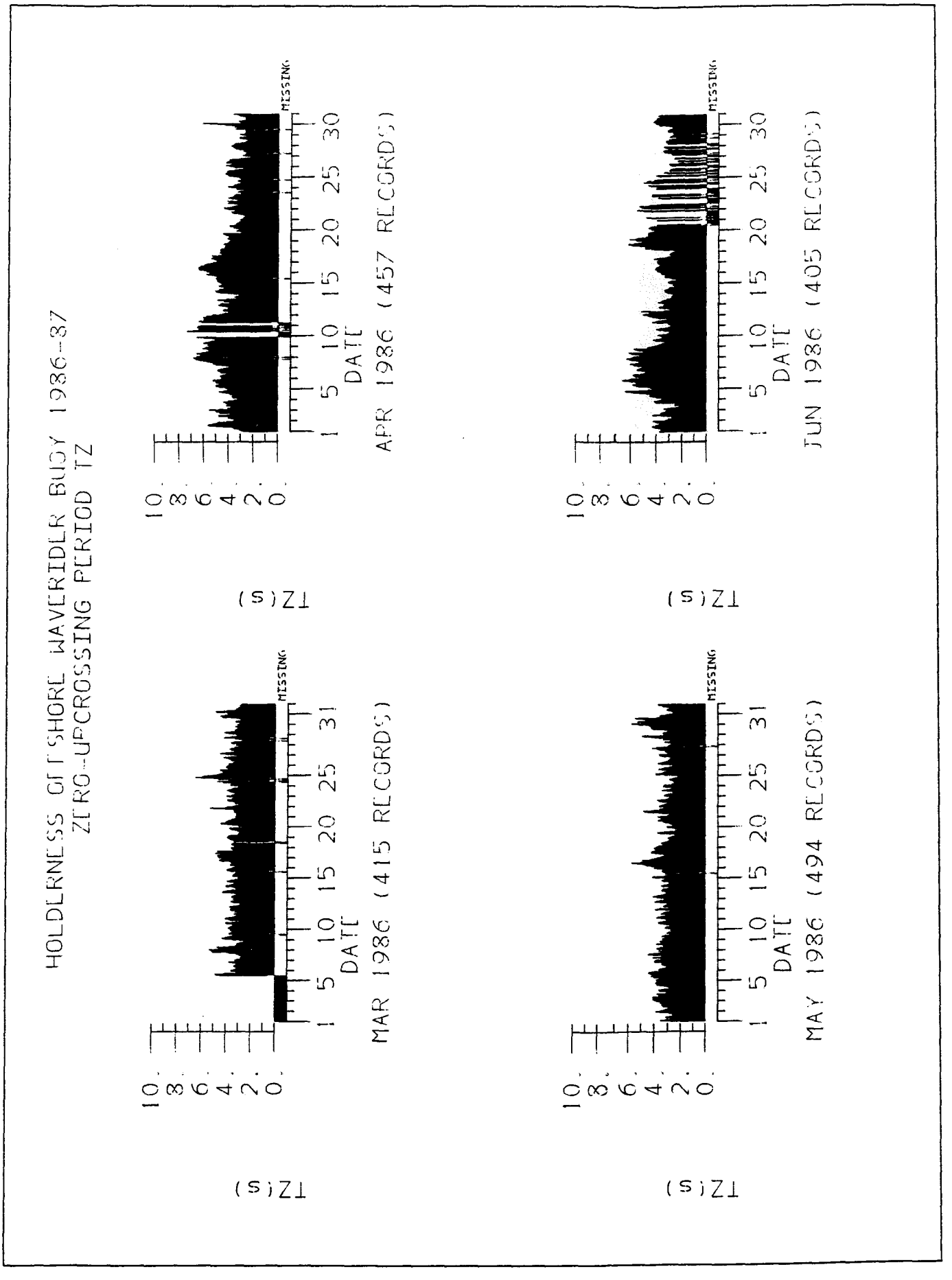
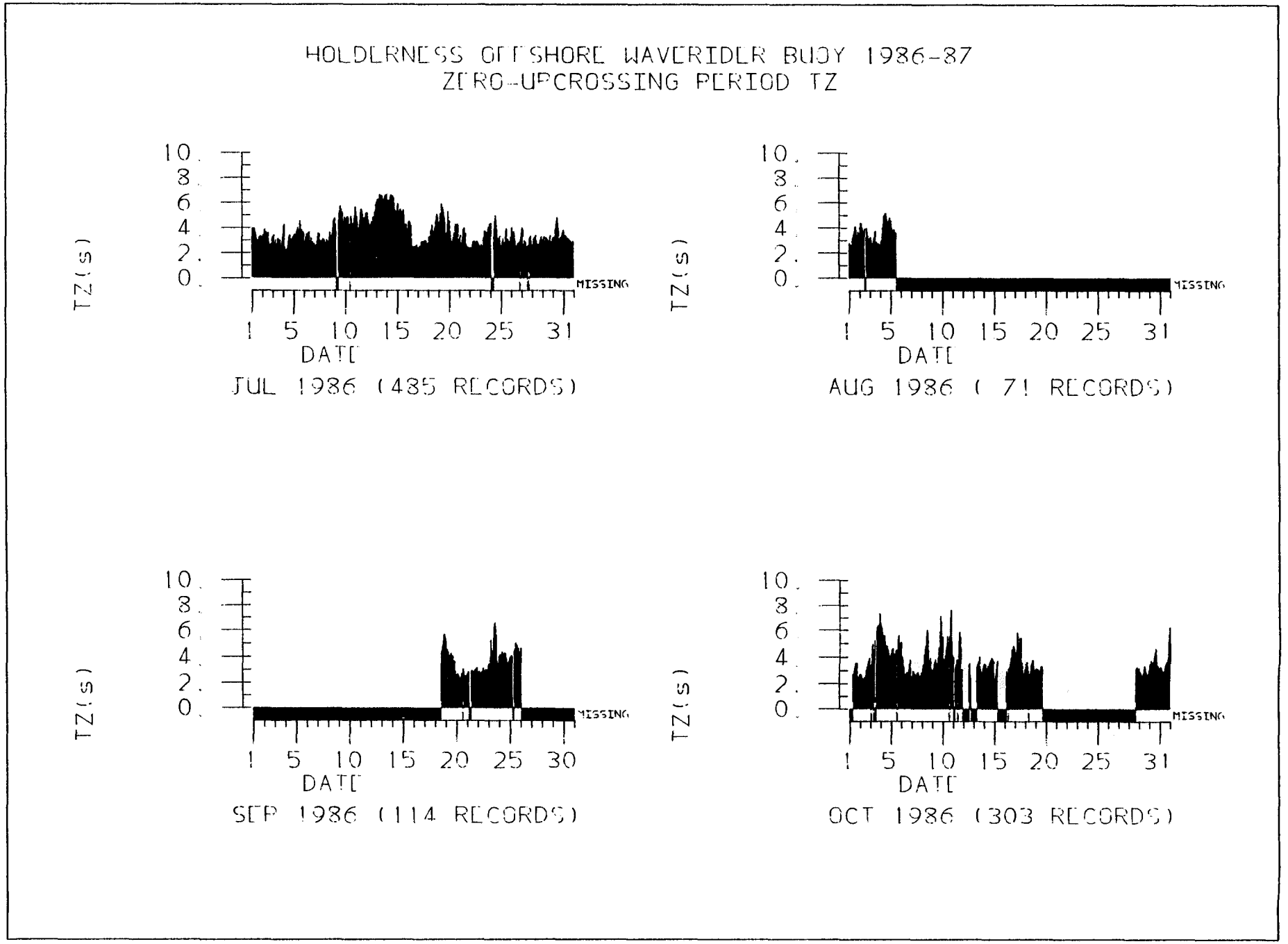

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
ZERO-UPCROSSING PERIOD TZ
TZ(S)
DATE
MISSING
APR 1986 (457 RECORDS)
MAR 1986 (415 RECORDS)
JUN 1986 (405 RECORDS)
MAY 1986 (494 RECORDS)

Figure 5(a)

Figure 5(b)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ZERO-UPCROSSING PERIOD TZ
TZ(s)
10.
8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 31
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JUL 1986 (485 RECORDS)
AUG 1986 (71 RECORDS)
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SEP 1986 (114 RECORDS)
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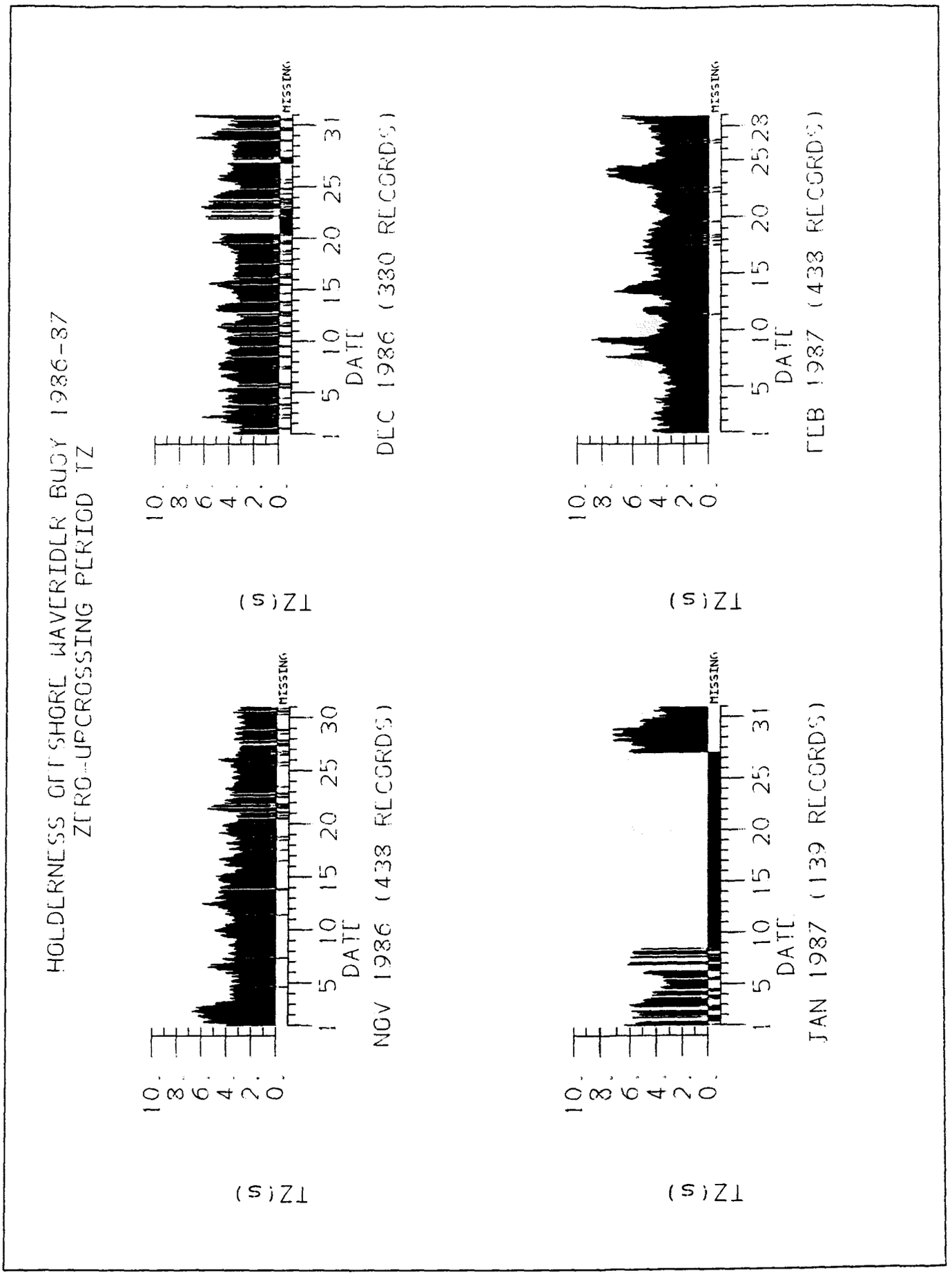
HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
ZERO-UPCROSSING PERIOD TZ
TZ(S)
DATE
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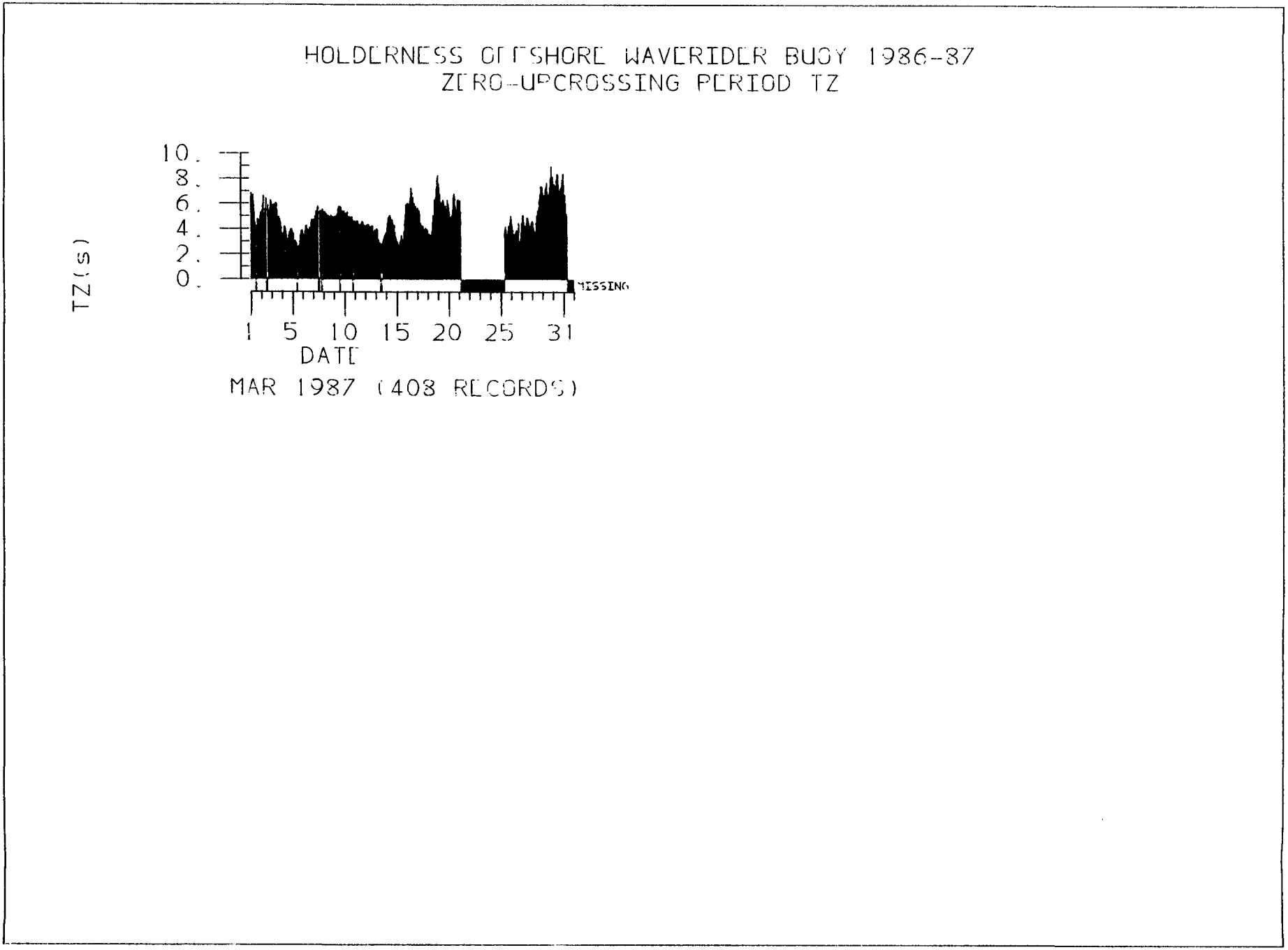
DEC 1986 (330 RECORDS)
NOV 1986 (438 RECORDS)
FEB 1987 (438 RECORDS)
JAN 1987 (139 RECORDS)

Figure 5(c)

Figure 5(d)


HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
ZERO-UPCROSSING PERIOD TZ
TZ(s)
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8.
6.
4.
2.
0.
MISSING
1 5 10 15 20 25 31
DATE
MAR 1987 (408 RECORDS)

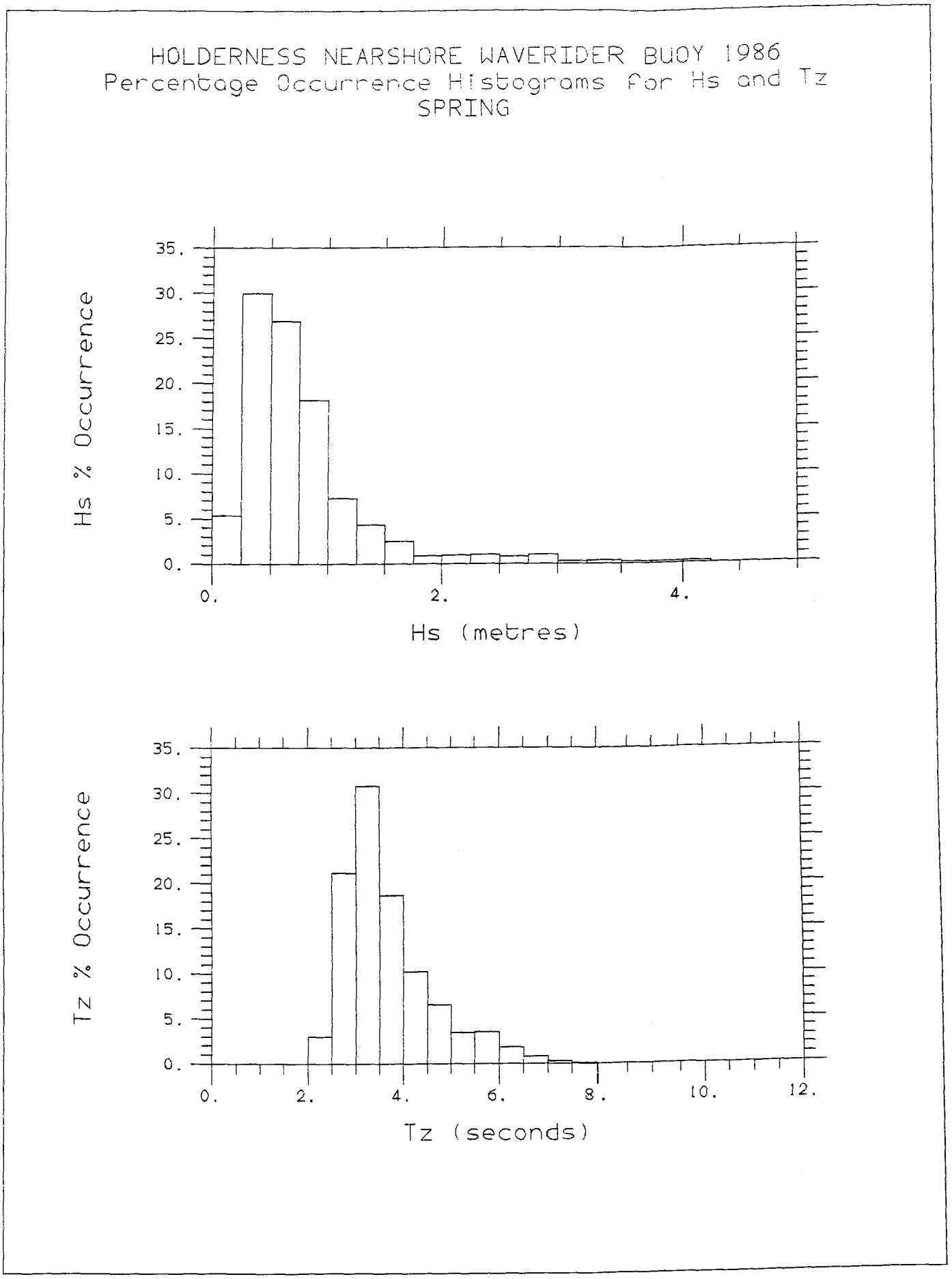

HOLDERNESS NEARSHORE WAVERIDER BUOY 1986
Percentage Occurrence Histograms for Hs and Tz
SPRING
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 6

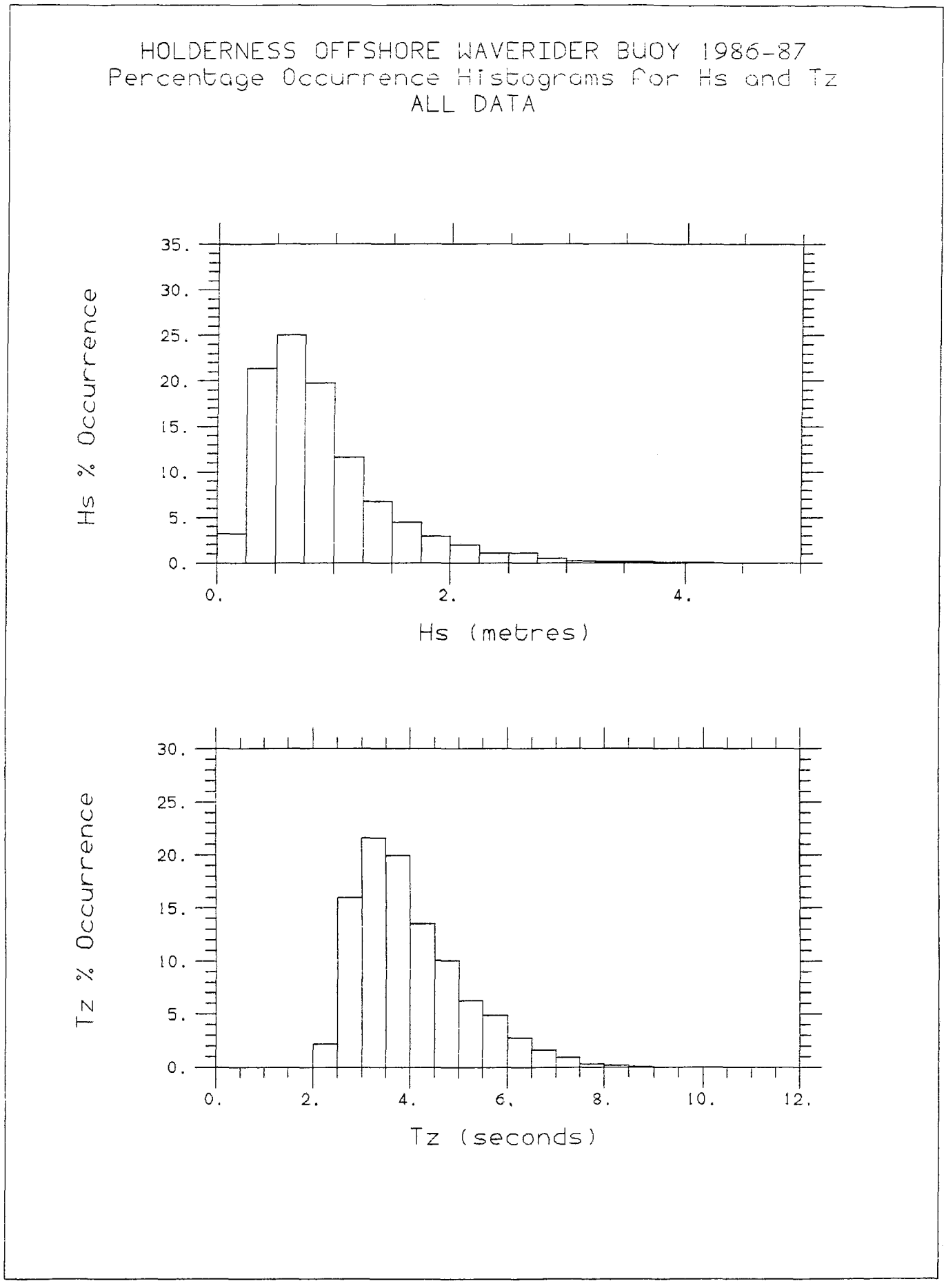

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
Percentage Occurrence Histograms for Hs and Tz
ALL DATA
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 7(a)

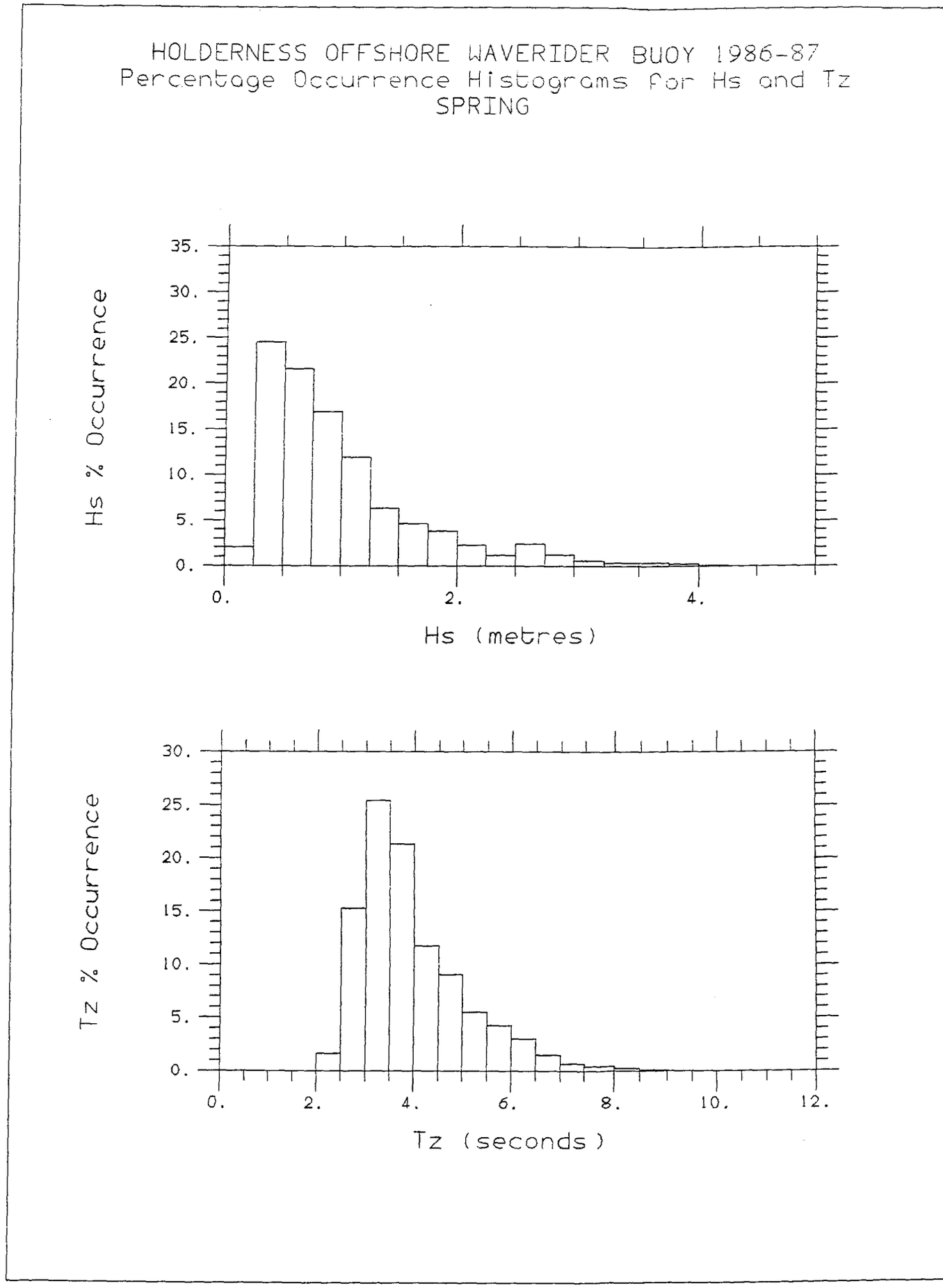

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
Percentage Occurrence Histograms for Hs and Tz
SPRING
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 7(b)

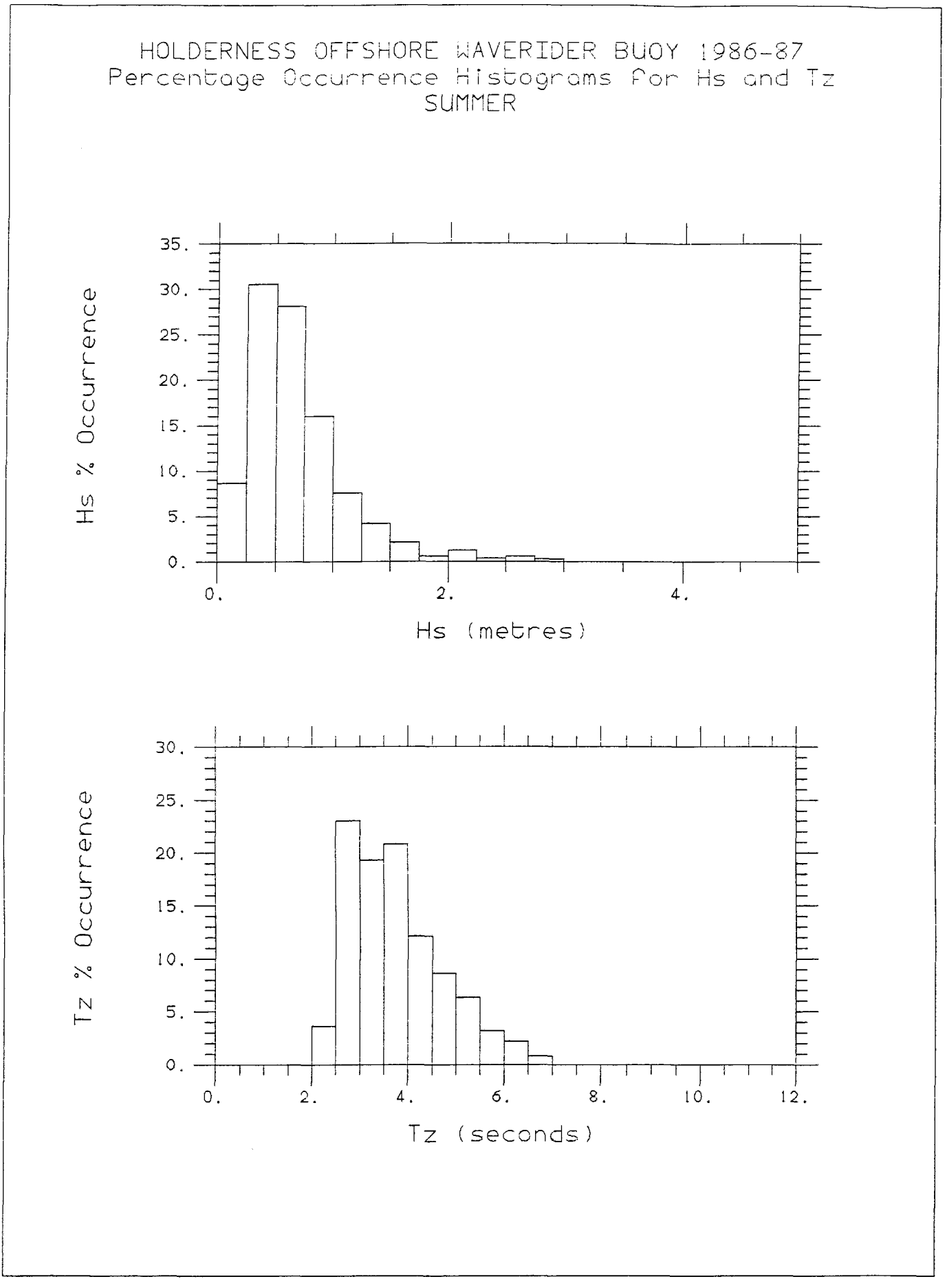

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
Percentage Occurrence Histograms For Hs and Tz
SUMMER
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 7(c)

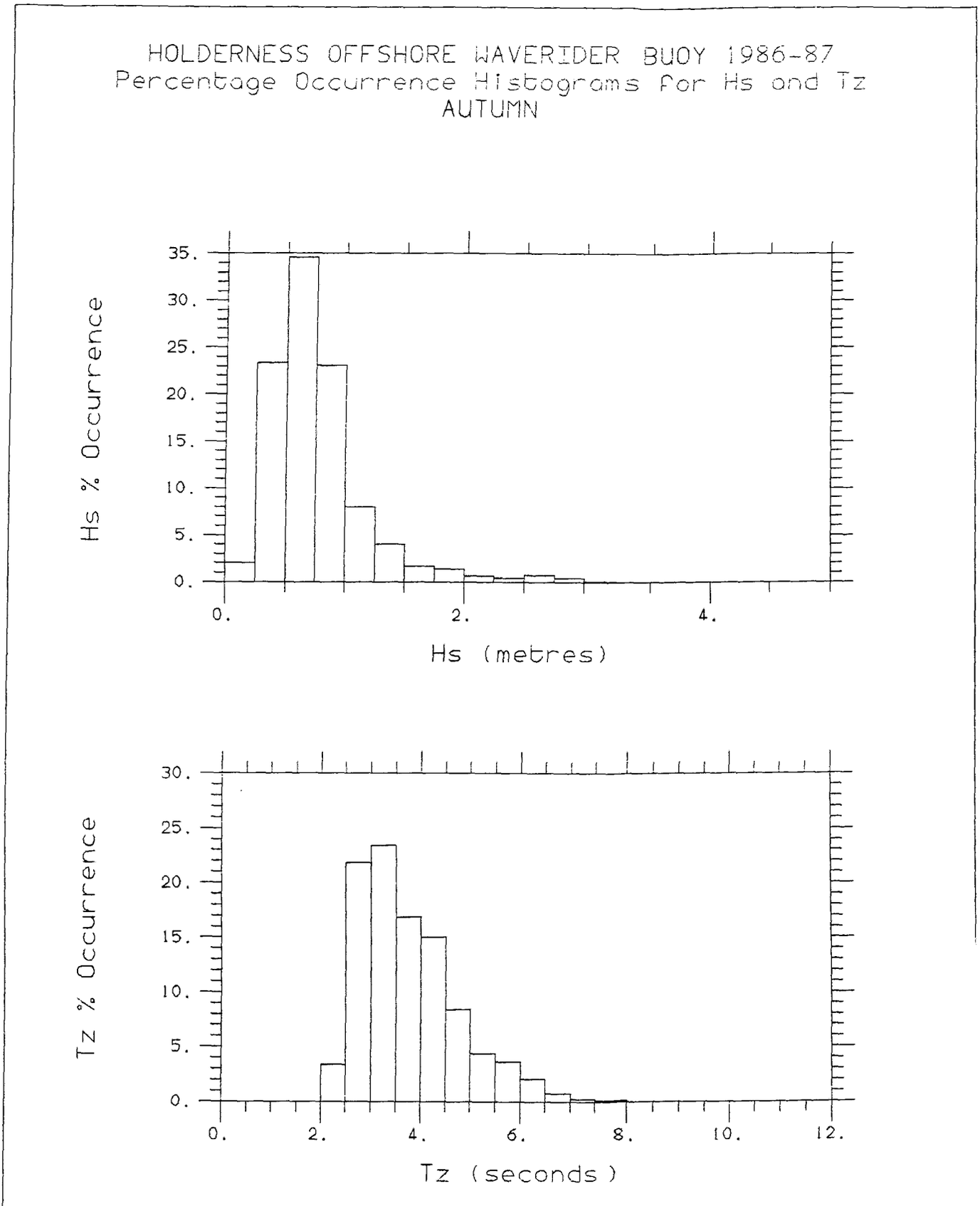

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
Percentage Occurrence Histograms for Hs and Tz
AUTUMN
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 7(d)

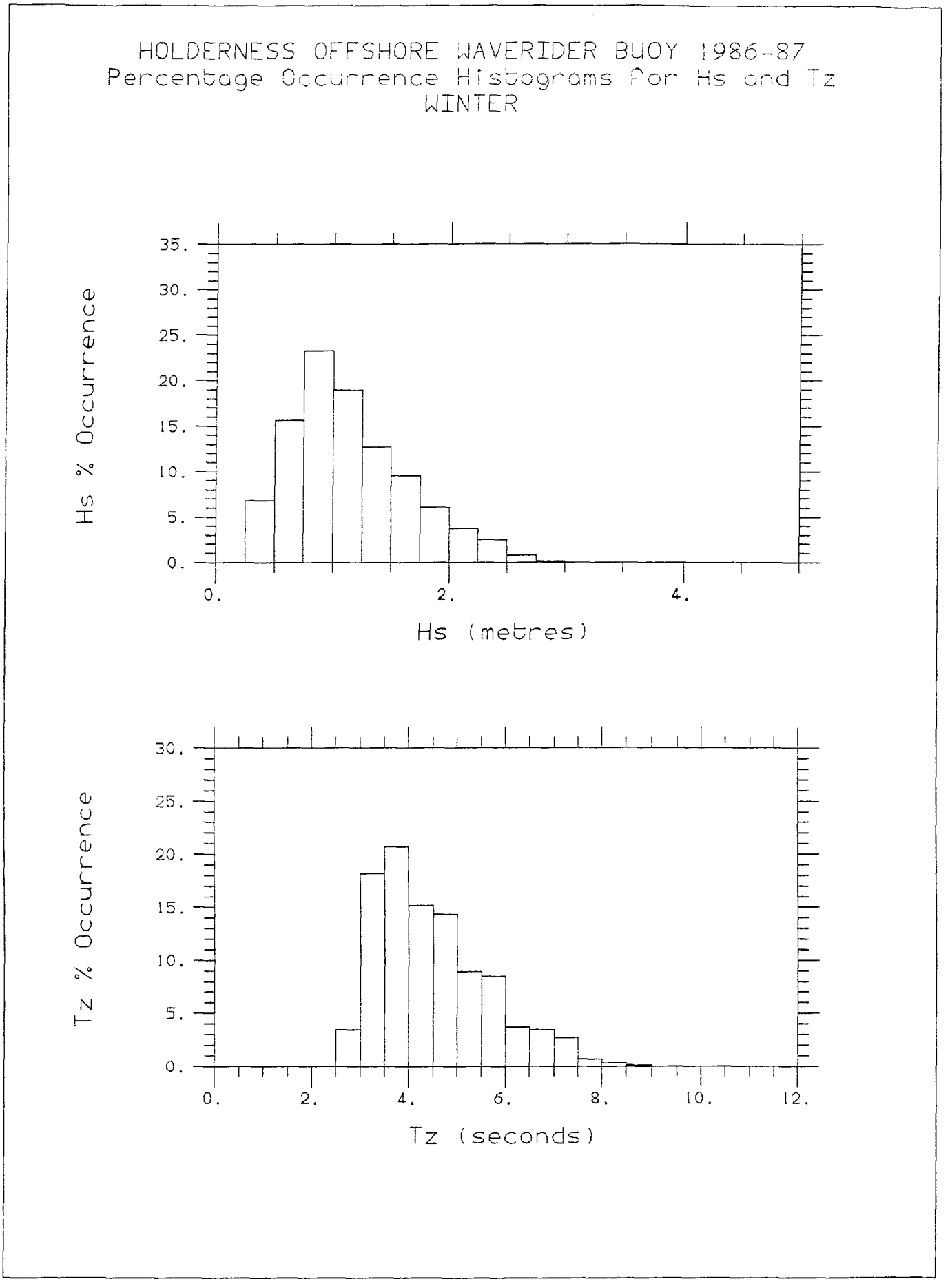
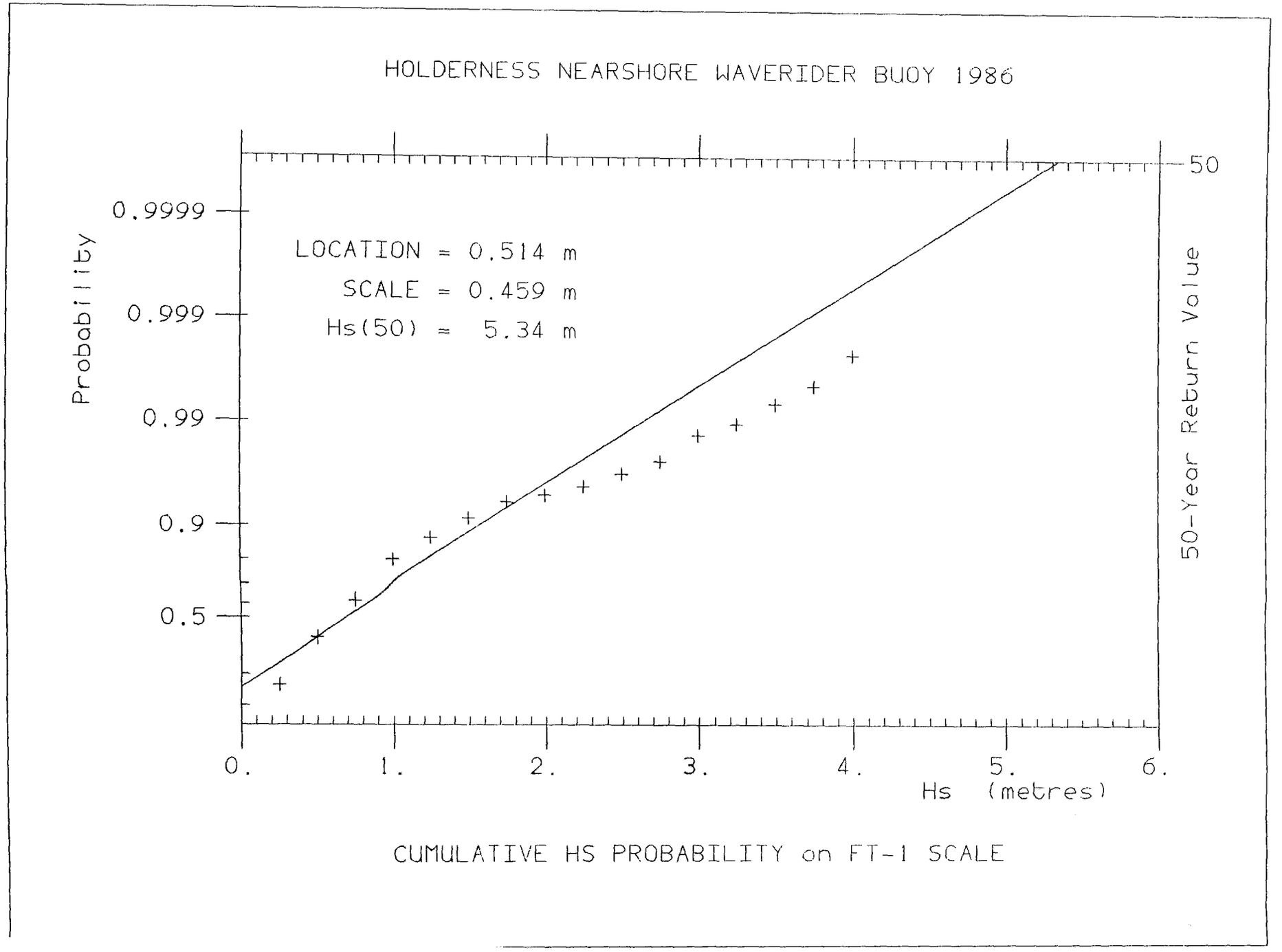

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
Percentage Occurrence Histograms for Hs and Tz
WINTER
Hs % Occurrence
35.
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
Hs (metres)
Tz % Occurrence
30.
25.
20.
15.
10.
5.
0.
0.
2.
4.
6.
8.
10.
12.
Tz (seconds)

Figure 7(e)

Figure 8


HOLDERNESS NEARSHORE WAVERIDER BUOY 1986
LOCATION = 0.514 m
SCALE = 0.459 m
Hs(50) = 5.34 m
Probability
0.9999
0.999
0.99
0.9
0.5
50
50-Year Return Value
0.
1.
2.
3.
4.
5.
6.
Hs (metres)
CUMULATIVE HS PROBABILITY on FT-1 SCALE

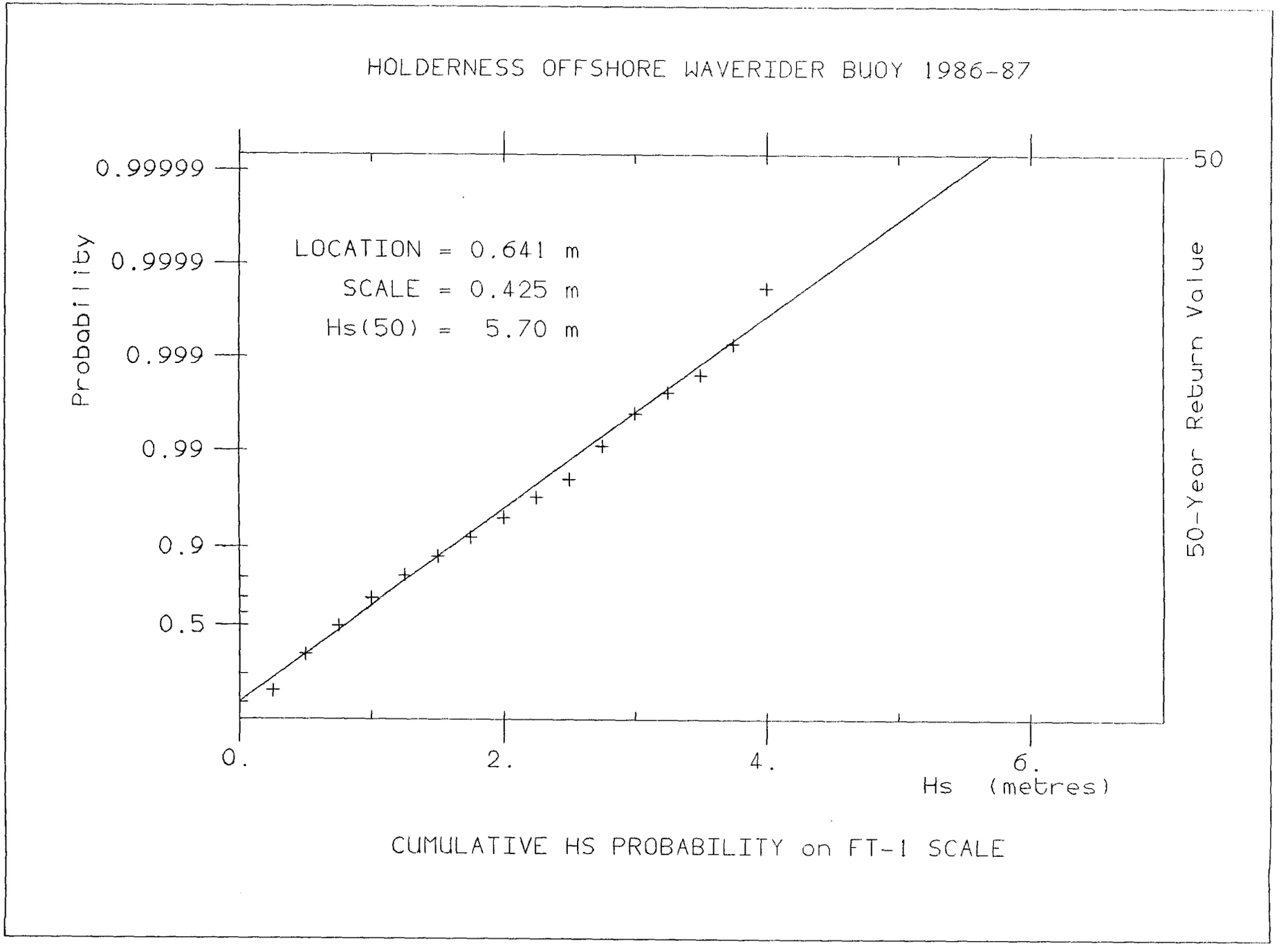


Figure 9: All data

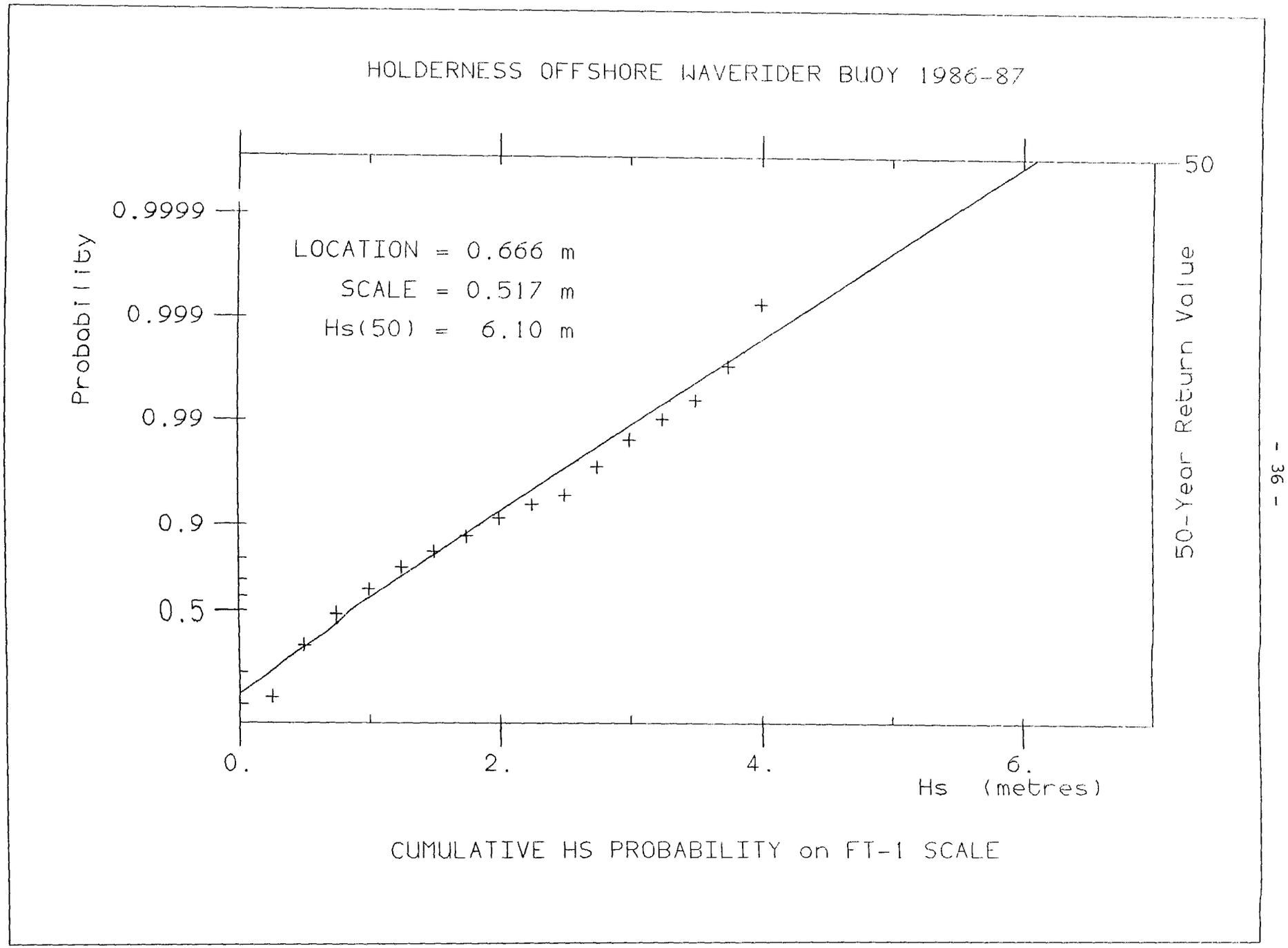


Figure 10: Spring data

Figure 11

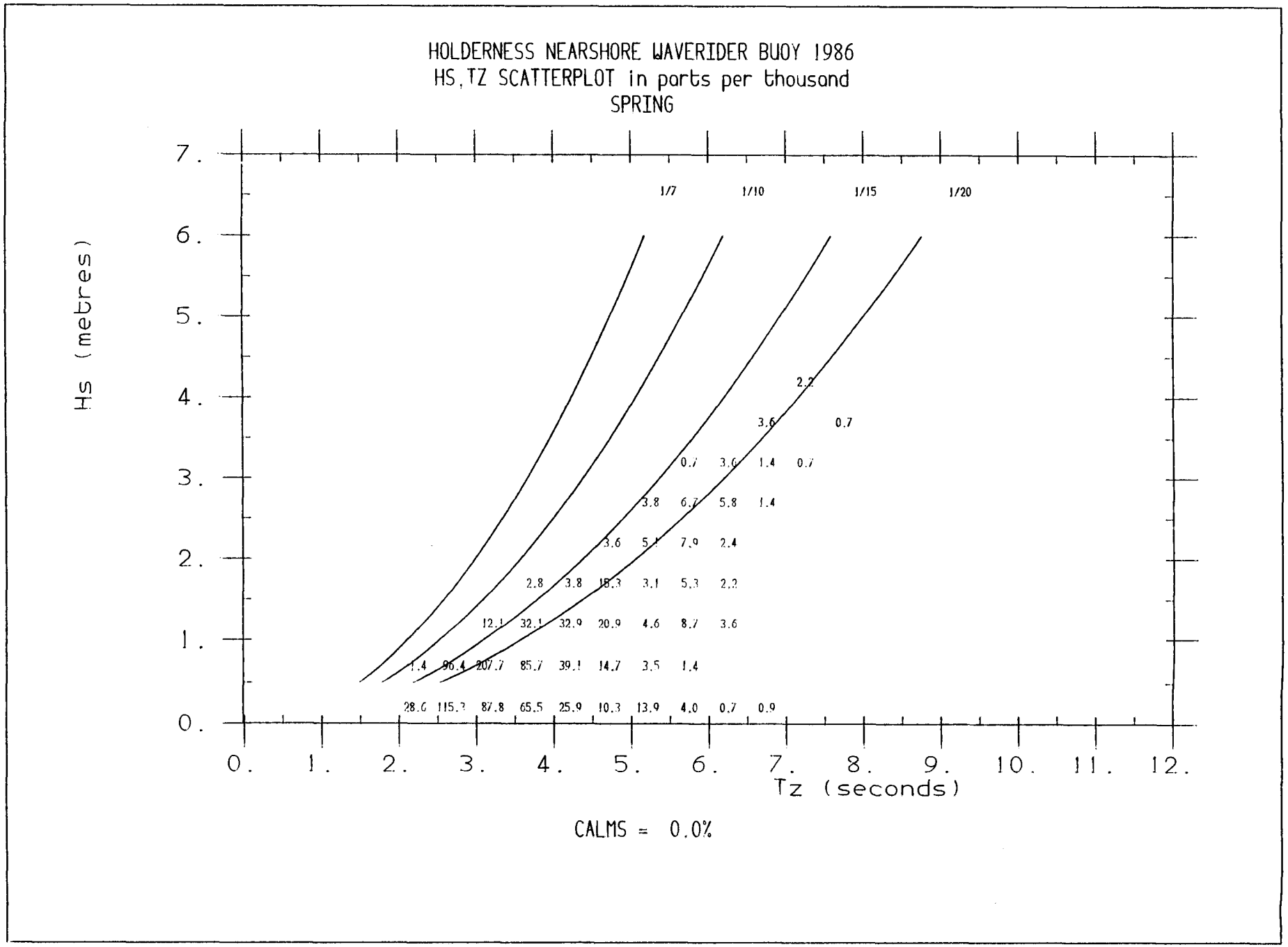

HOLDERNESS NEARSHORE WAVERIDER BUOY 1986
HS,TZ SCATTERPLOT in parts per thousand
SPRING
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0. 1. 2. 3. 4. 5. 6. 7.
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
2.2
3.6 0.7
0.7 3.6 1.4 0.7
3.8 6.7 5.8 1.4
3.6 5.1 7.9 2.4
2.8 3.8 15.3 3.1 5.3 2.2
12.1 32.1 32.9 20.9 4.6 8.7 3.6
1.4 96.4 207.7 85.7 39.1 14.7 3.5 1.4
28.6 115.3 87.8 65.5 25.9 10.3 13.9 4.0 0.7 0.9
CALMS = 0.0%

Figure 12

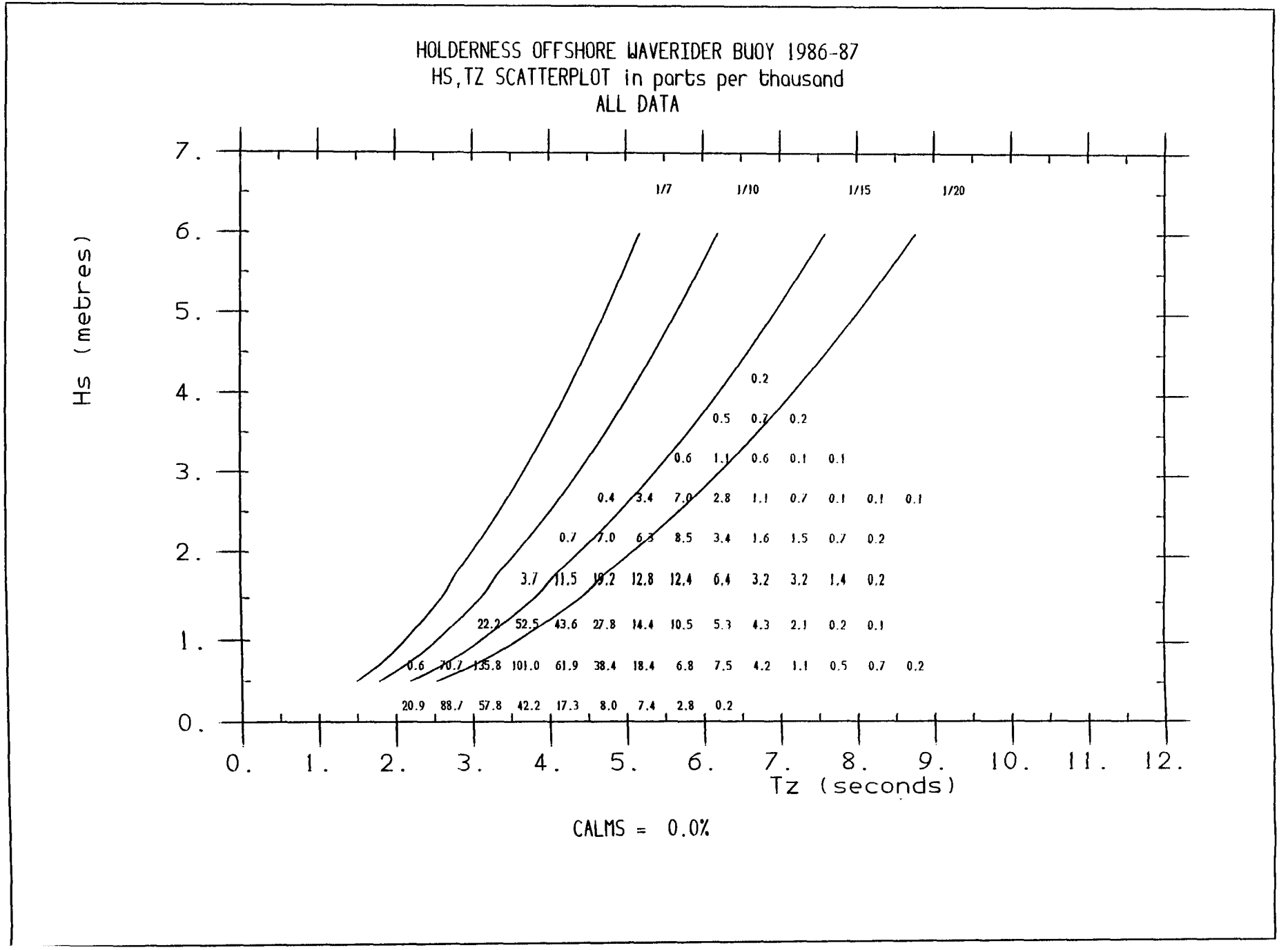

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
HS,TZ SCATTERPLOT in parts per thousand
ALL DATA
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0.2
0.5 0.2 0.2
0.6 1.1 0.6 0.1 0.1
0.4 3.4 7.0 2.8 1.1 0.7 0.1 0.1 0.1
0.7 7.0 6.3 8.5 3.4 1.6 1.5 0.7 0.2
3.7 11.5 18.2 12.8 12.4 6.4 3.2 3.2 1.4 0.2
22.2 52.5 43.6 27.8 14.4 10.5 5.3 4.3 2.1 0.2 0.1
0.6 70.7 135.8 101.0 61.9 38.4 18.4 6.8 7.5 4.2 1.1 0.5 0.7 0.2
20.9 88.7 57.8 42.2 17.3 8.0 7.4 2.8 0.2
CALMS = 0.0%

Figure 13

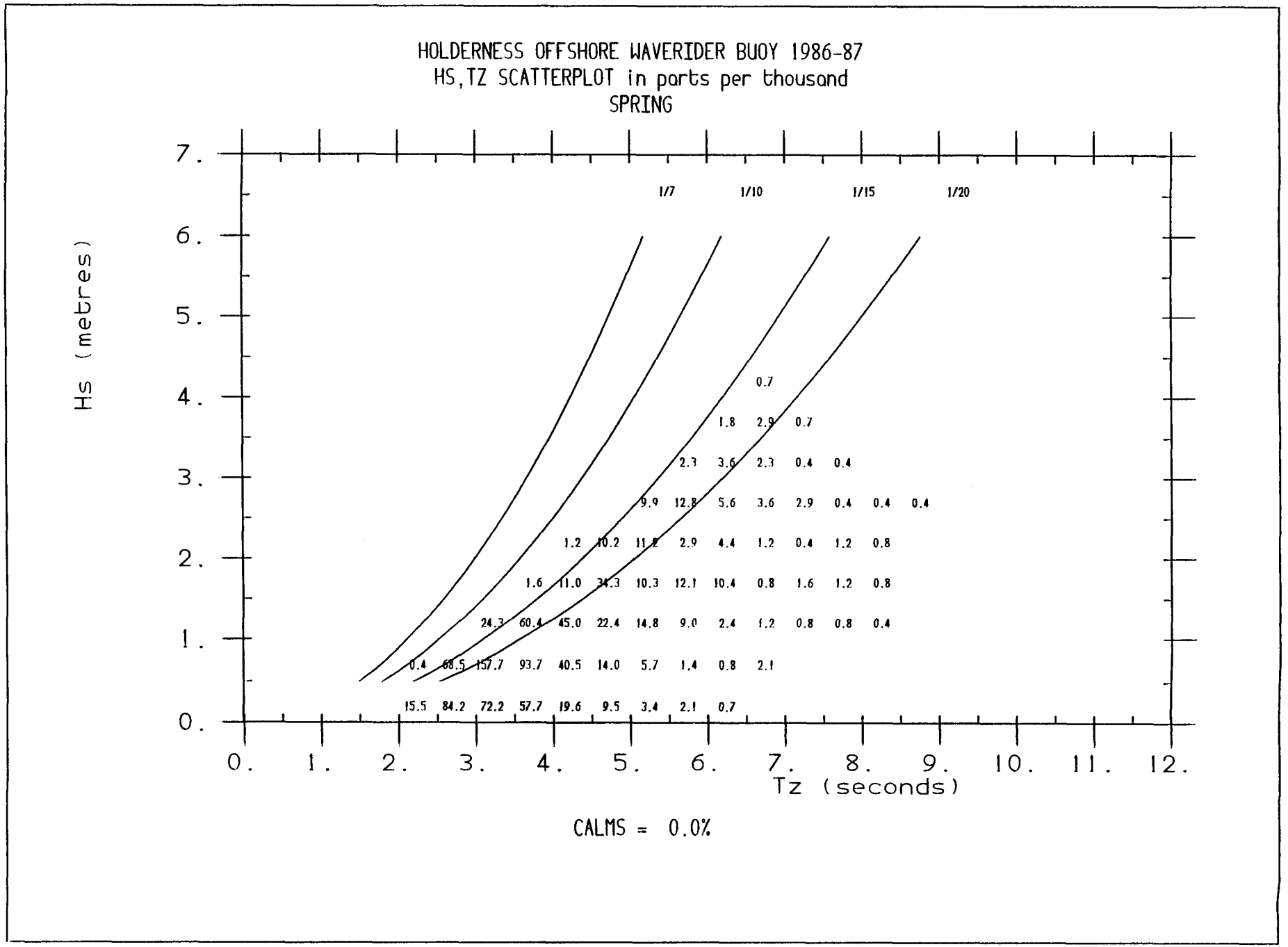

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
HS,TZ SCATTERPLOT in parts per thousand
SPRING
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0. 1. 2. 3. 4. 5. 6. 7.
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
0.7
1.8 2.9 0.7
2.3 3.6 2.3 0.4 0.4
9.9 12.8 5.6 3.6 2.9 0.4 0.4 0.4
1.2 10.2 11.2 2.9 4.4 1.2 0.4 1.2 0.8
1.6 11.0 34.3 10.3 12.1 10.4 0.8 1.6 1.2 0.8
24.3 60.4 45.0 22.4 14.8 9.0 2.4 1.2 0.8 0.8 0.4
0.4 68.5 157.7 93.7 40.5 14.0 5.7 1.4 0.8 2.1
15.5 84.2 72.2 57.7 19.6 9.5 3.4 2.1 0.7
CALMS = 0.0%

Figure 14

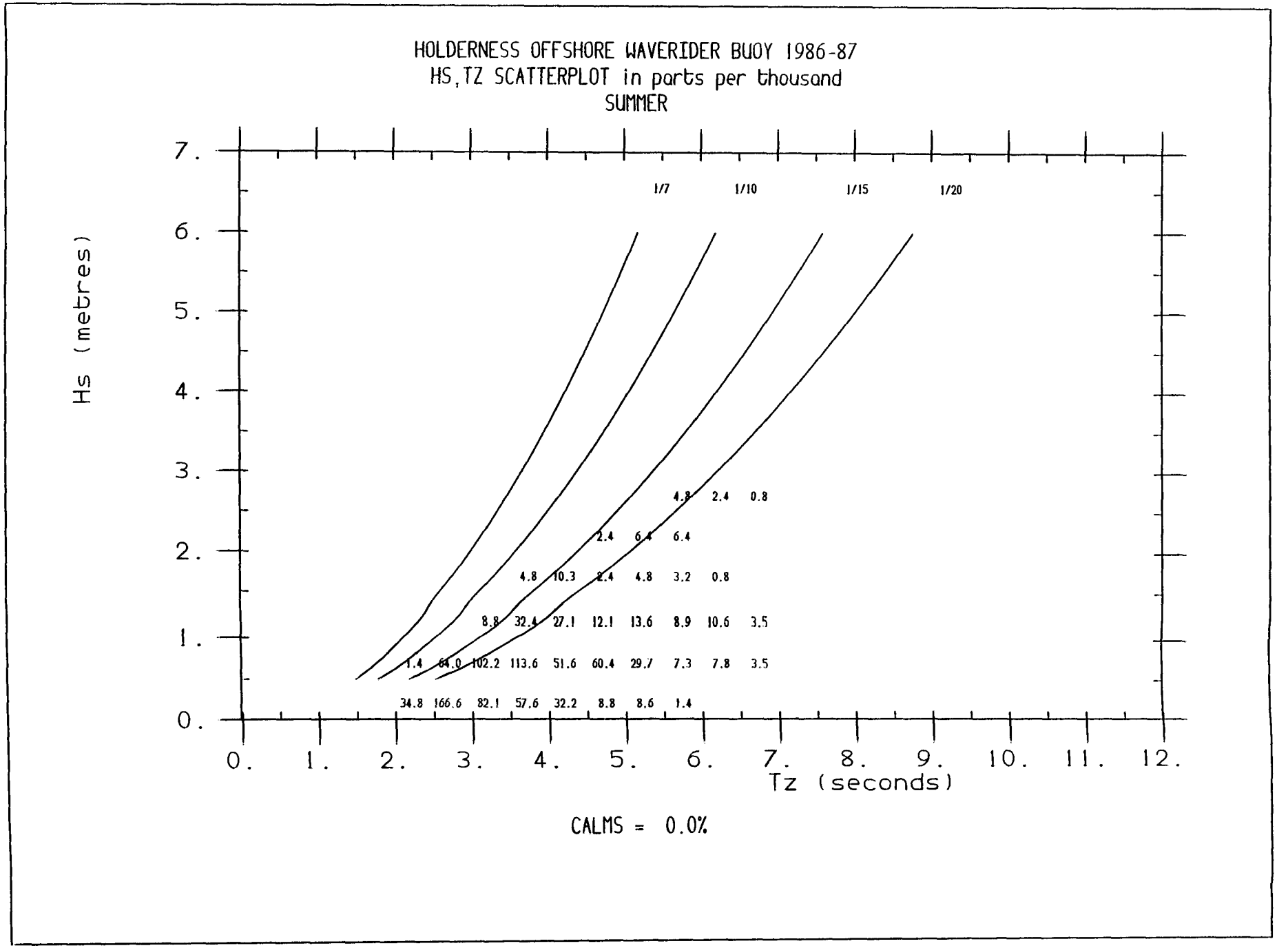

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
HS,TZ SCATTERPLOT in parts per thousand
SUMMER
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0.
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
4.8 2.4 0.8
2.4 6.4 6.4
4.8 10.3 2.4 4.8 3.2 0.8
8.8 32.4 27.1 12.1 13.6 8.9 10.6 3.5
1.4 64.0 102.2 113.6 51.6 60.4 29.7 7.3 7.8 3.5
34.8 166.6 82.1 57.6 32.2 8.8 8.6 1.4
CALMS = 0.0%

Figure 15

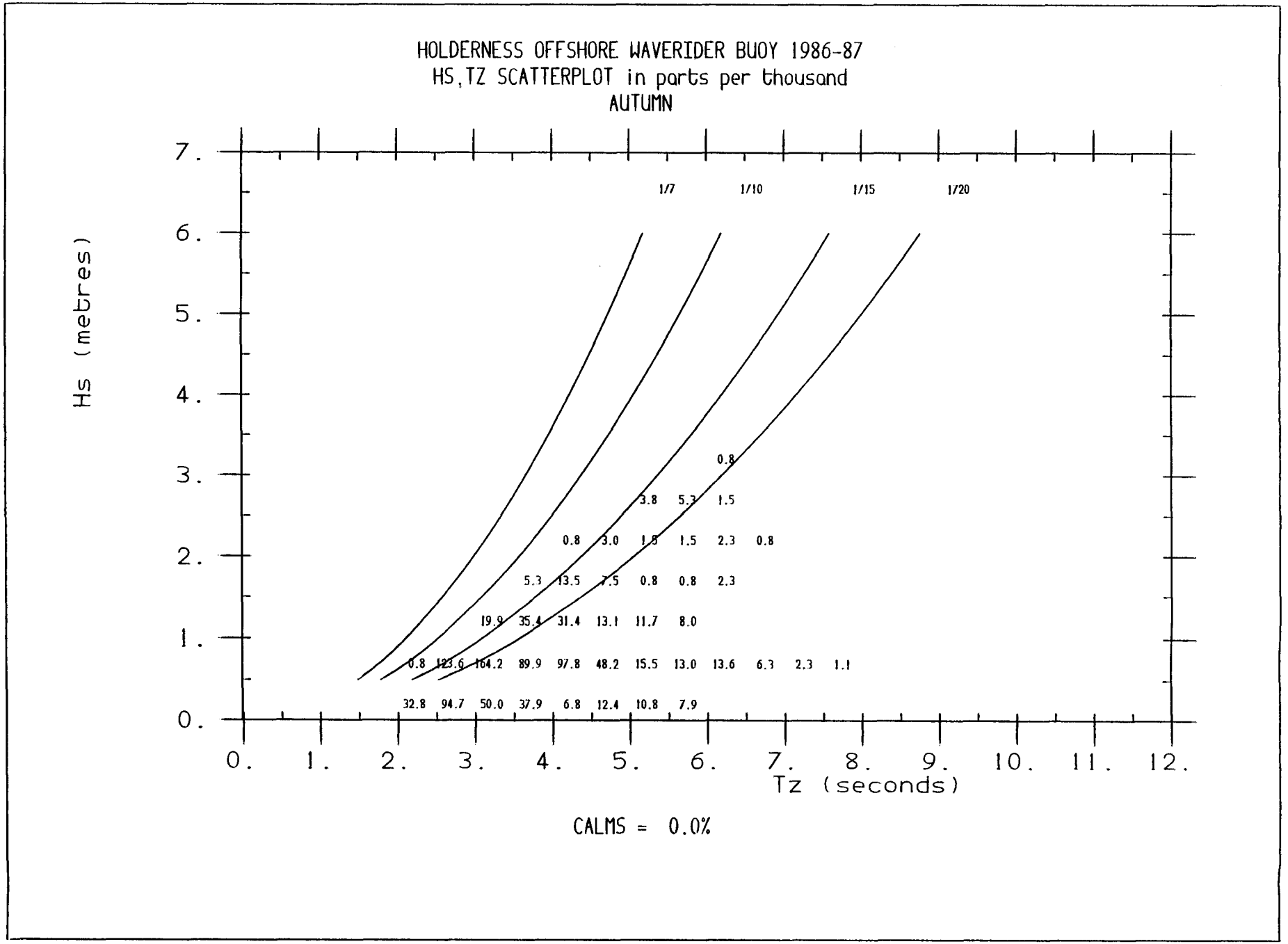
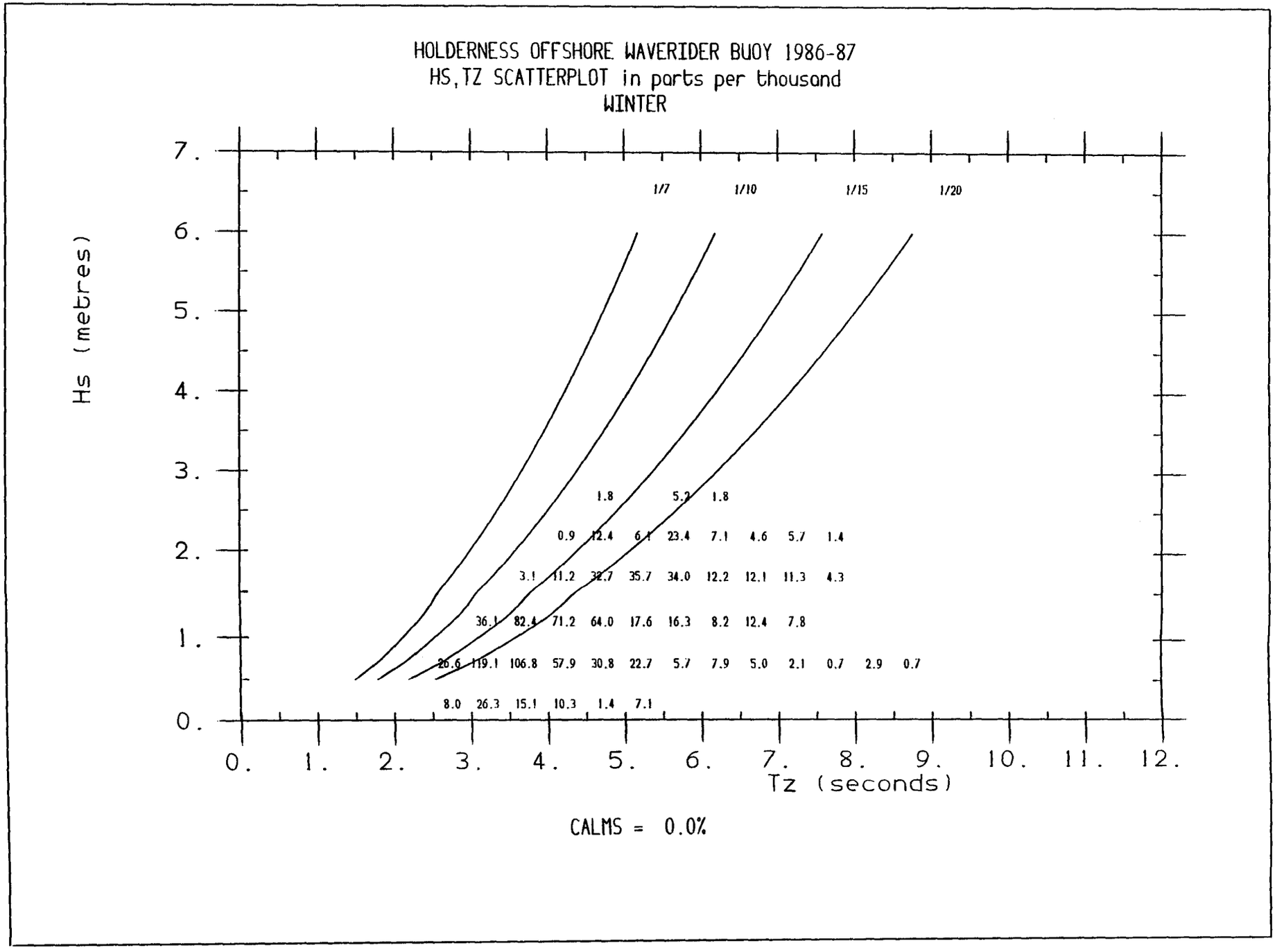

HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
HS,TZ SCATTERPLOT in parts per thousand
AUTUMN
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0.8
3.8 5.3 1.5
0.8 3.0 1.5 1.5 2.3 0.8
5.3 13.5 7.5 0.8 0.8 2.3
19.9 35.4 31.4 13.1 11.7 8.0
0.8 123.6 164.2 89.9 97.8 48.2 15.5 13.0 13.6 6.3 2.3 1.1
32.8 94.7 50.0 37.9 6.8 12.4 10.8 7.9
CALMS = 0.0%

Figure 16


HOLDERNESS OFFSHORE WAVERIDER BUOY 1986-87
HS,TZ SCATTERPLOT in parts per thousand
WINTER
Hs (metres)
Tz (seconds)
1/7
1/10
1/15
1/20
0. 1. 2. 3. 4. 5. 6. 7.
0. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
1.8 5.2 1.8
0.9 12.4 6.1 23.4 7.1 4.6 5.7 1.4
3.1 11.2 32.7 35.7 34.0 12.2 12.1 11.3 4.3
36.1 82.4 71.2 64.0 17.6 16.3 8.2 12.4 7.8
26.6 119.1 106.8 57.9 30.8 22.7 5.7 7.9 5.0 2.1 0.7 2.9 0.7
8.0 26.3 15.1 10.3 1.4 7.1
CALMS = 0.0%

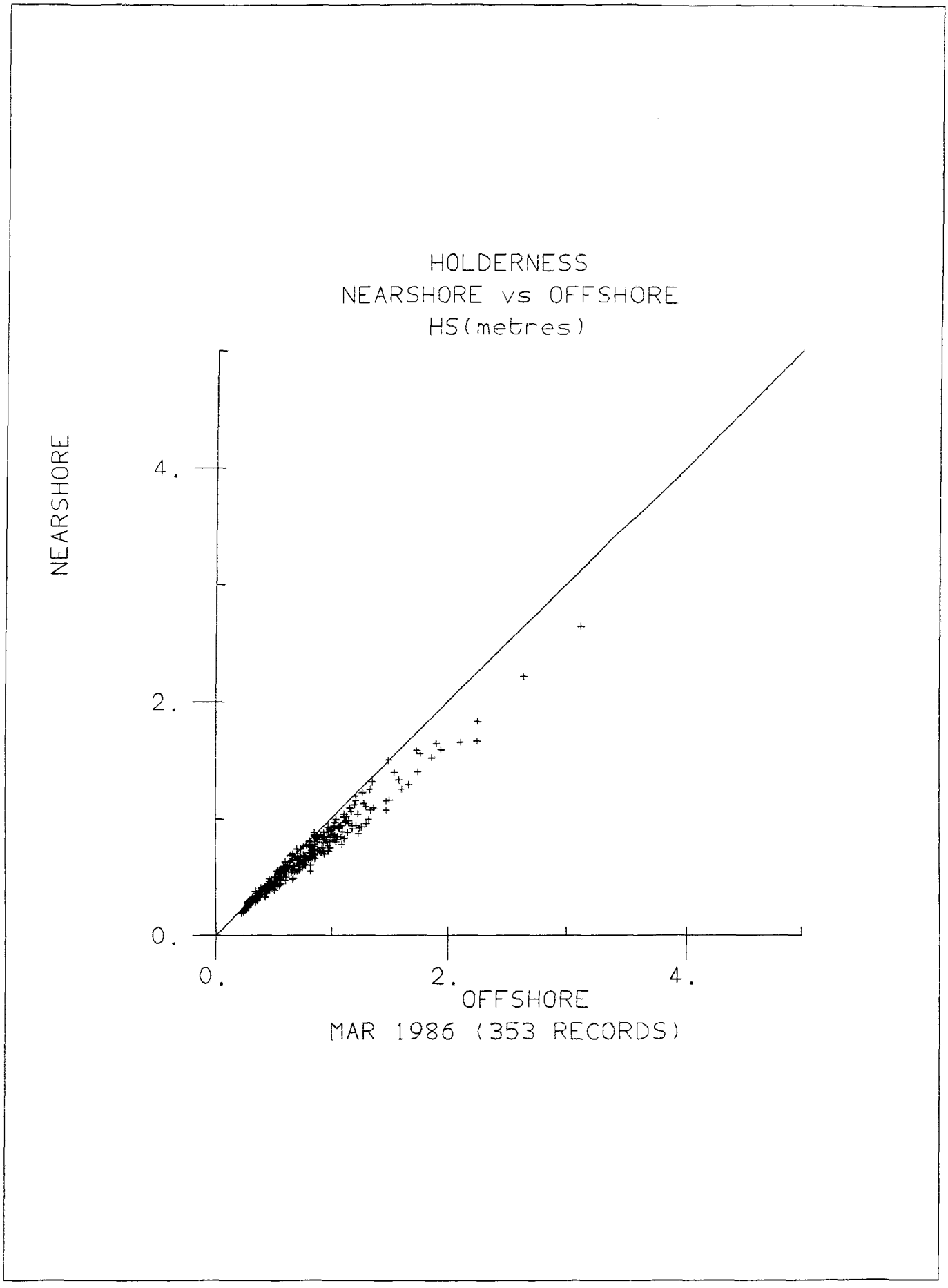

HOLDERNESS
NEARSHORE vs OFFSHORE
HS(metres)
NEARSHORE
4.
2.
0.
0.
2.
4.
OFFSHORE
MAR 1986 (353 RECORDS)

Figure 17(a)

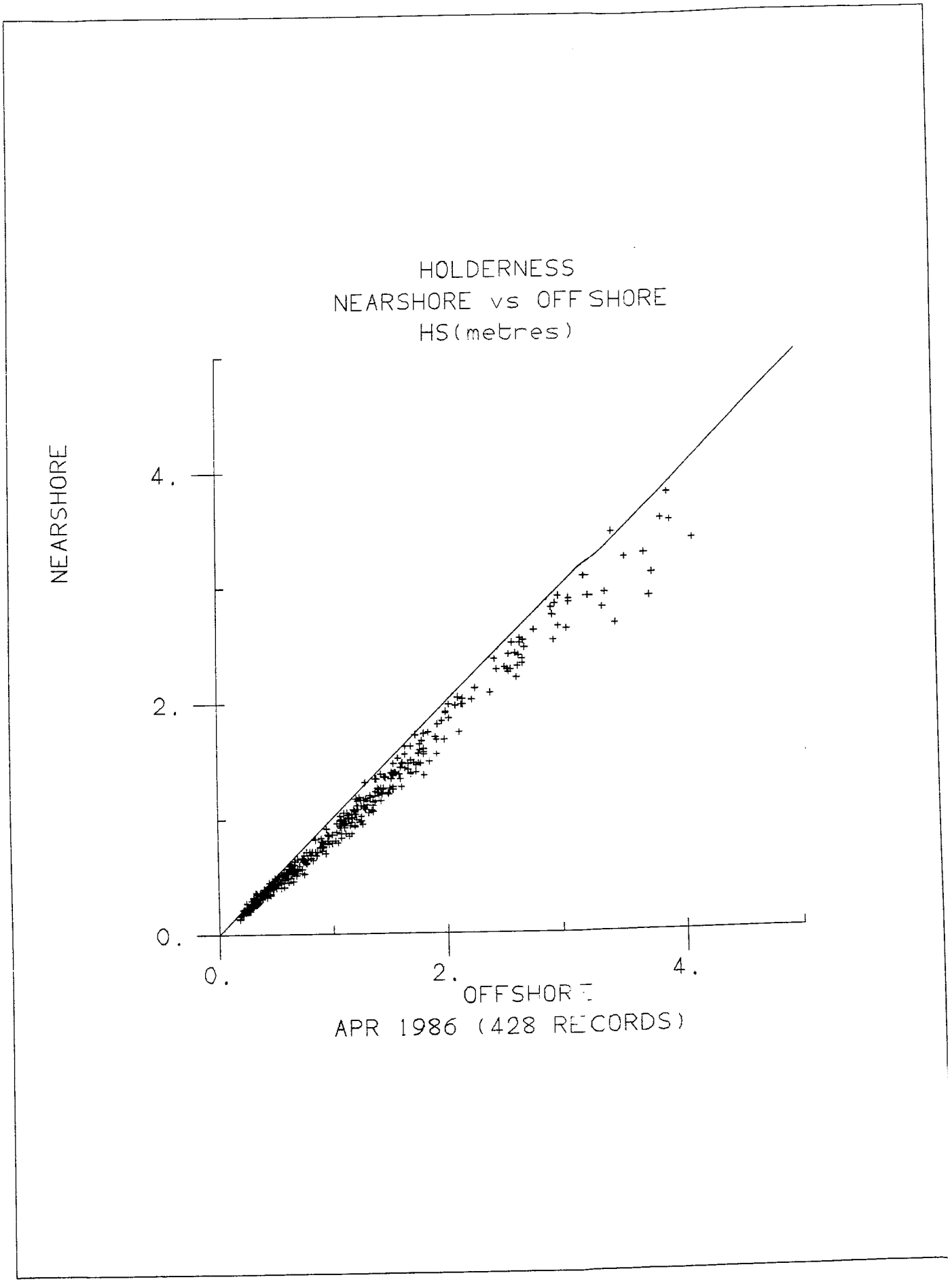

HOLDERNESS
NEARSHORE vs OFFSHORE
HS(metres)
NEARSHORE
4.
2.
0.
0.
2.
4.
OFFSHORE
APR 1986 (428 RECORDS)

Figure 17(b)

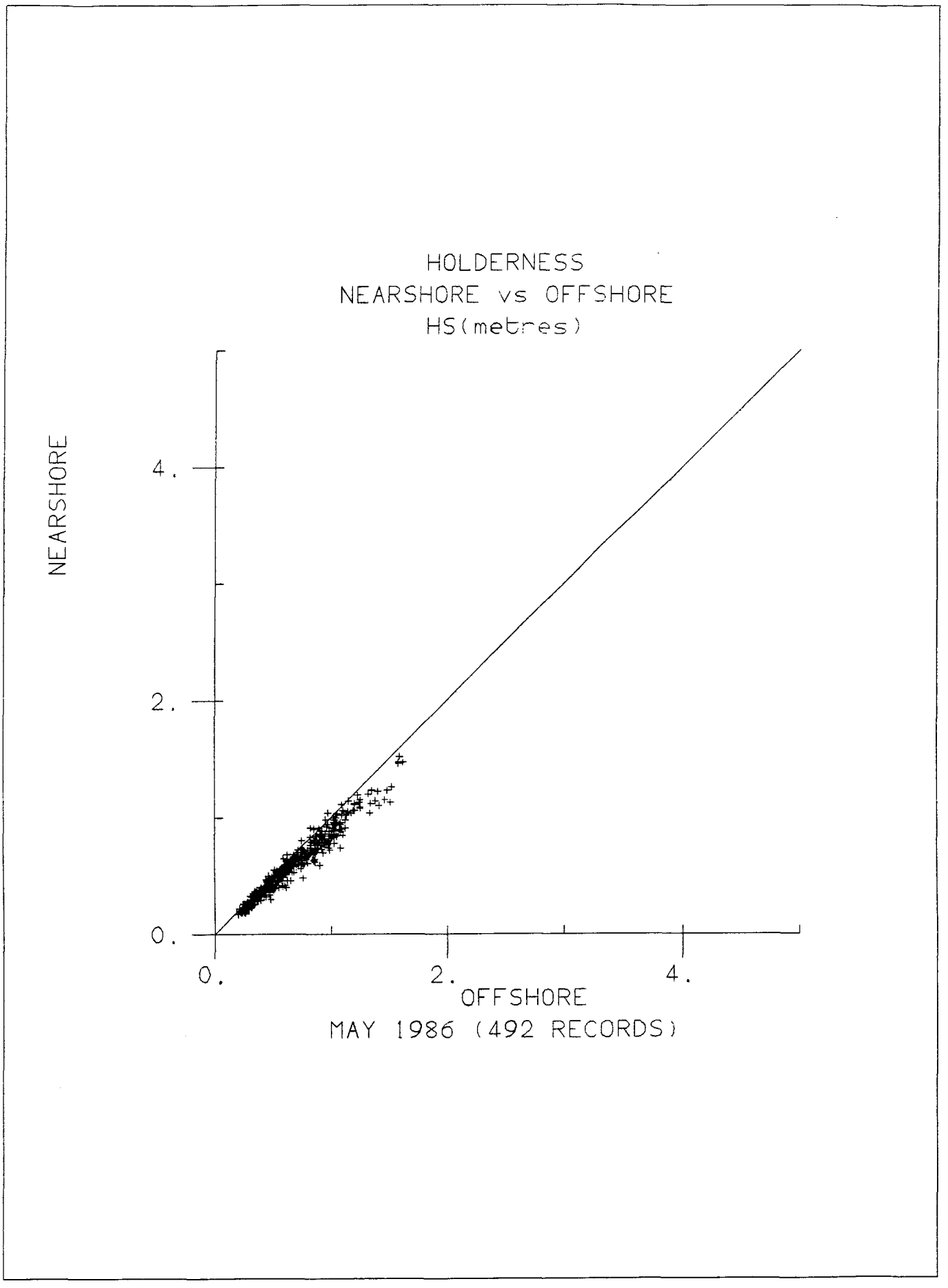

HOLDERNESS
NEARSHORE vs OFFSHORE
HS(metres)
NEARSHORE
4.
2.
0.
0.
2.
4.
OFFSHORE
MAY 1986 (492 RECORDS)

Figure 17(c)

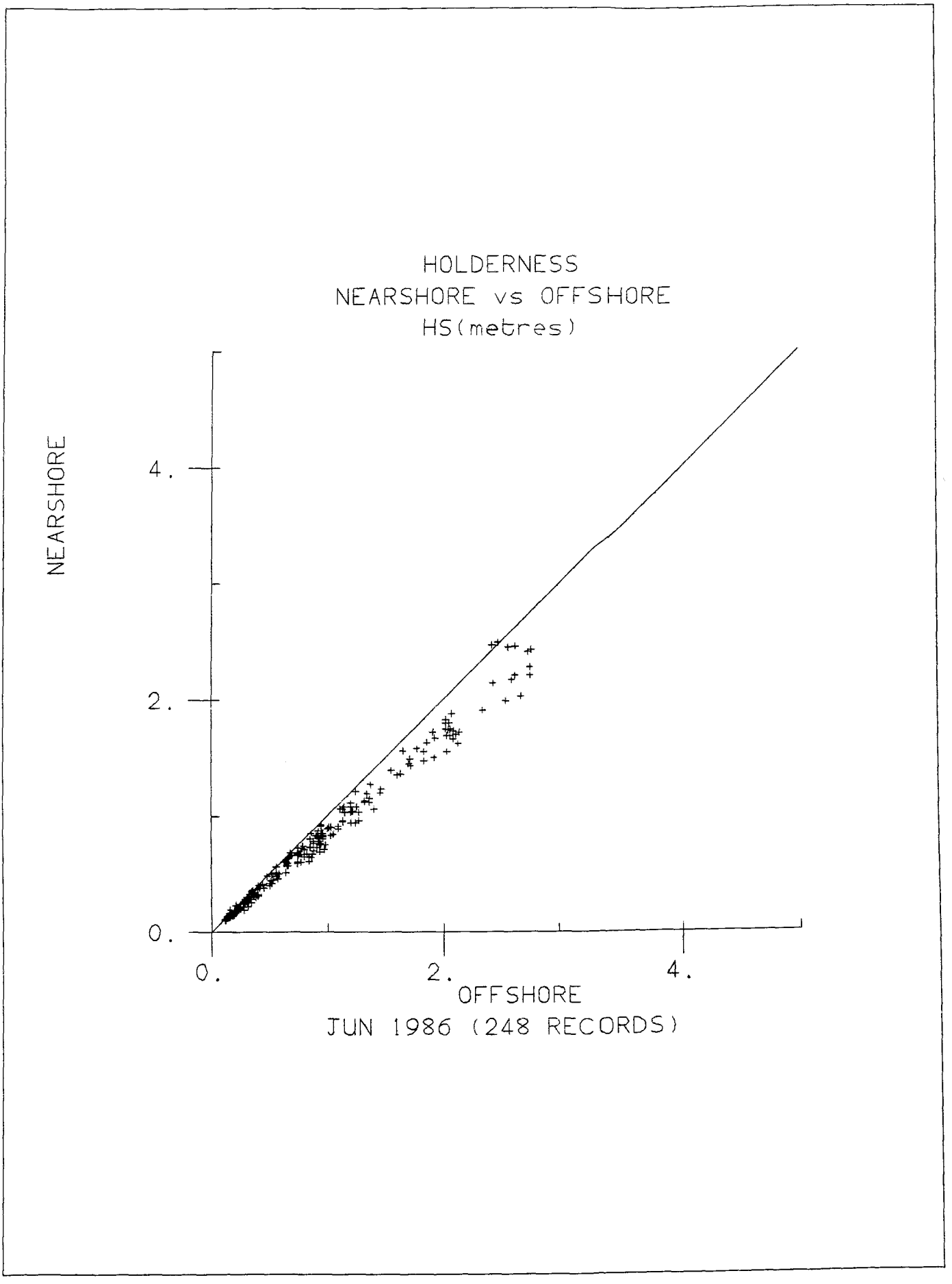

HOLDERNESS
NEARSHORE vs OFFSHORE
HS(metres)
NEARSHORE
4.
2.
0.
0.
2.
4.
OFFSHORE
JUN 1986 (248 RECORDS)

Figure 17(d)

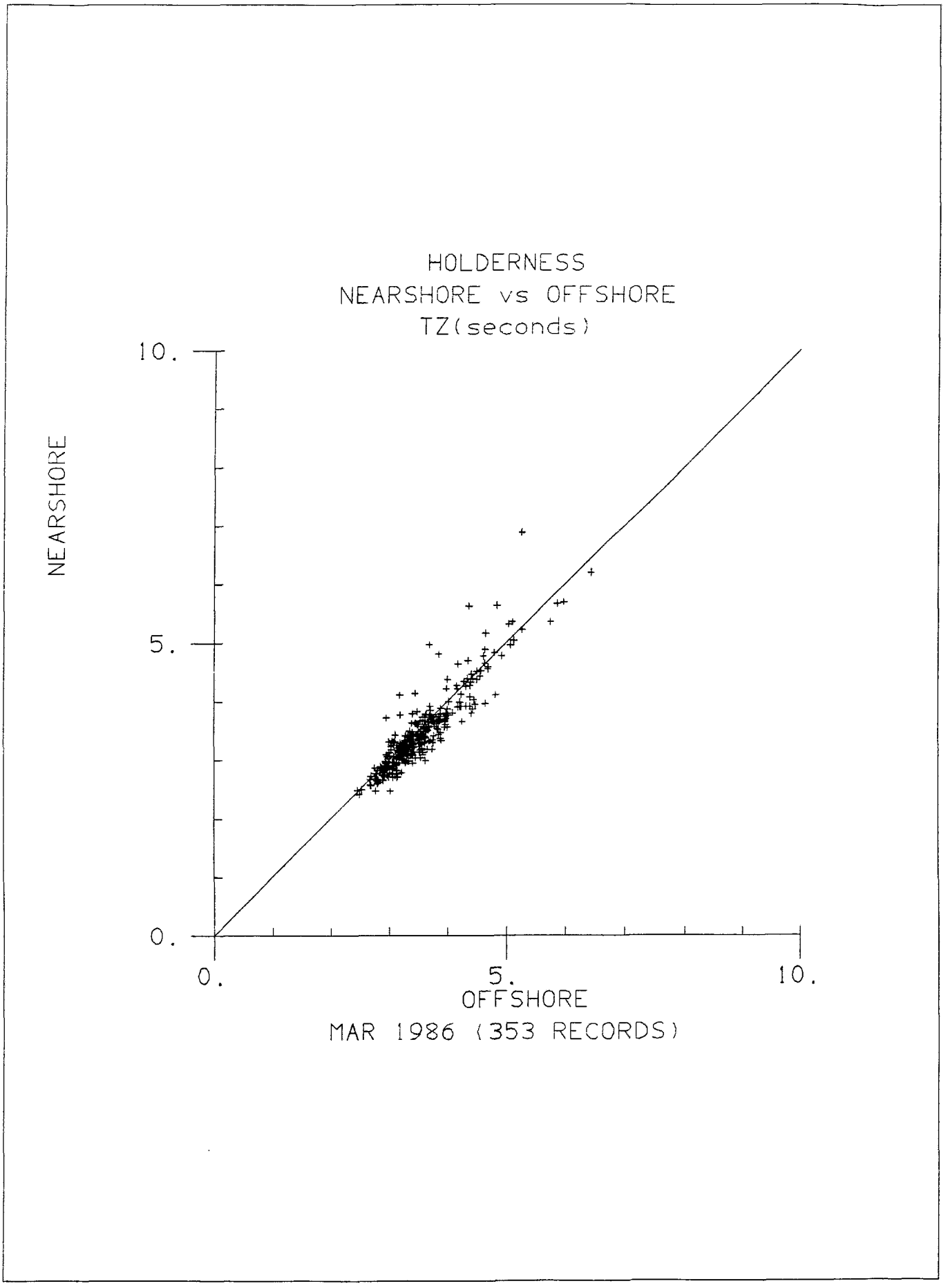

HOLDERNESS
NEARSHORE vs OFFSHORE
TZ(seconds)
NEARSHORE
10.
5.
0.
0.
5.
10.
OFFSHORE
MAR 1986 (353 RECORDS)

Figure 18(a)

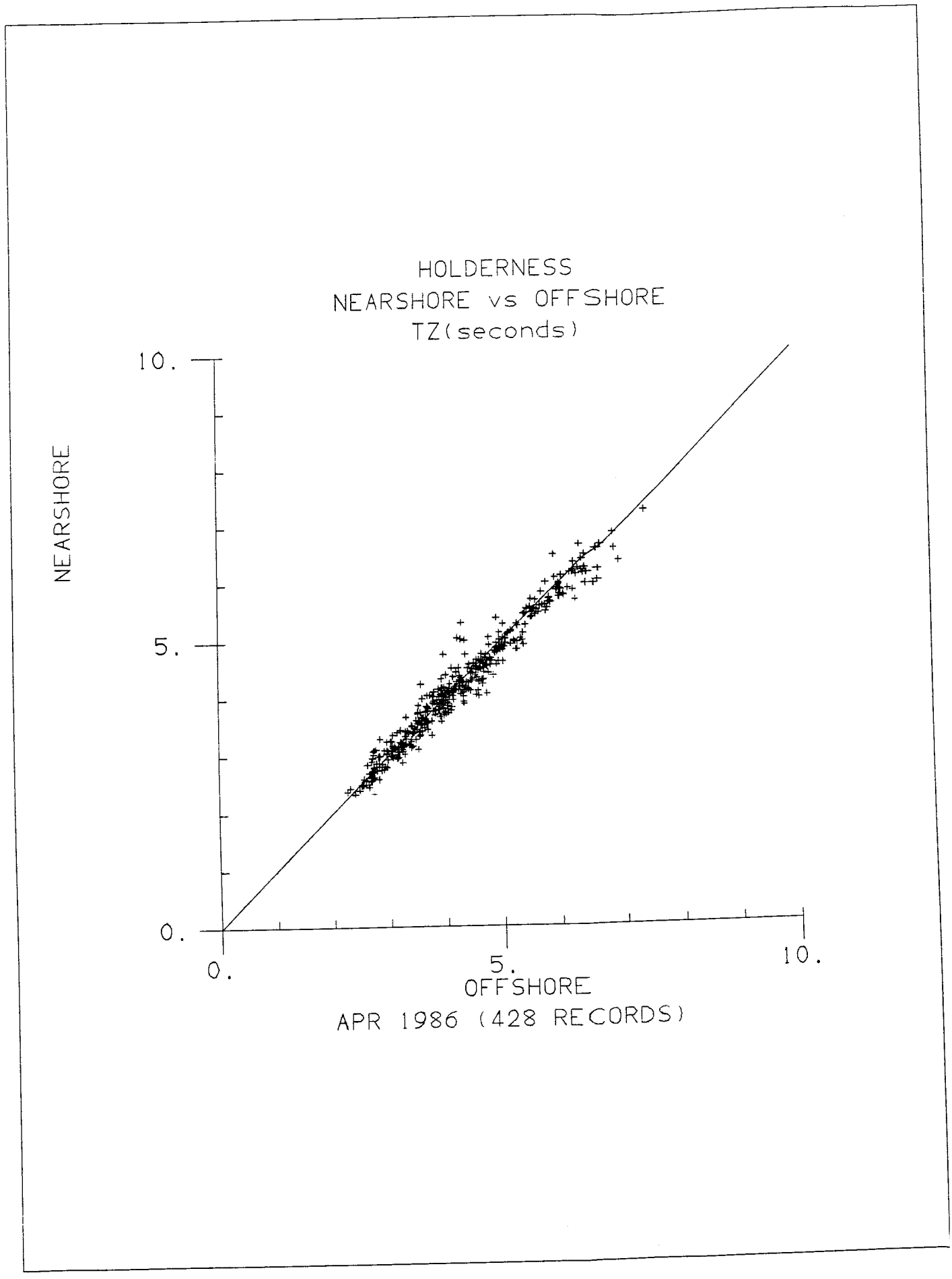

HOLDERNESS
NEARSHORE vs OFFSHORE
TZ(seconds)
NEARSHORE
10.
5.
0.
0.
5.
10.
OFFSHORE
APR 1986 (428 RECORDS)

Figure 18(b)

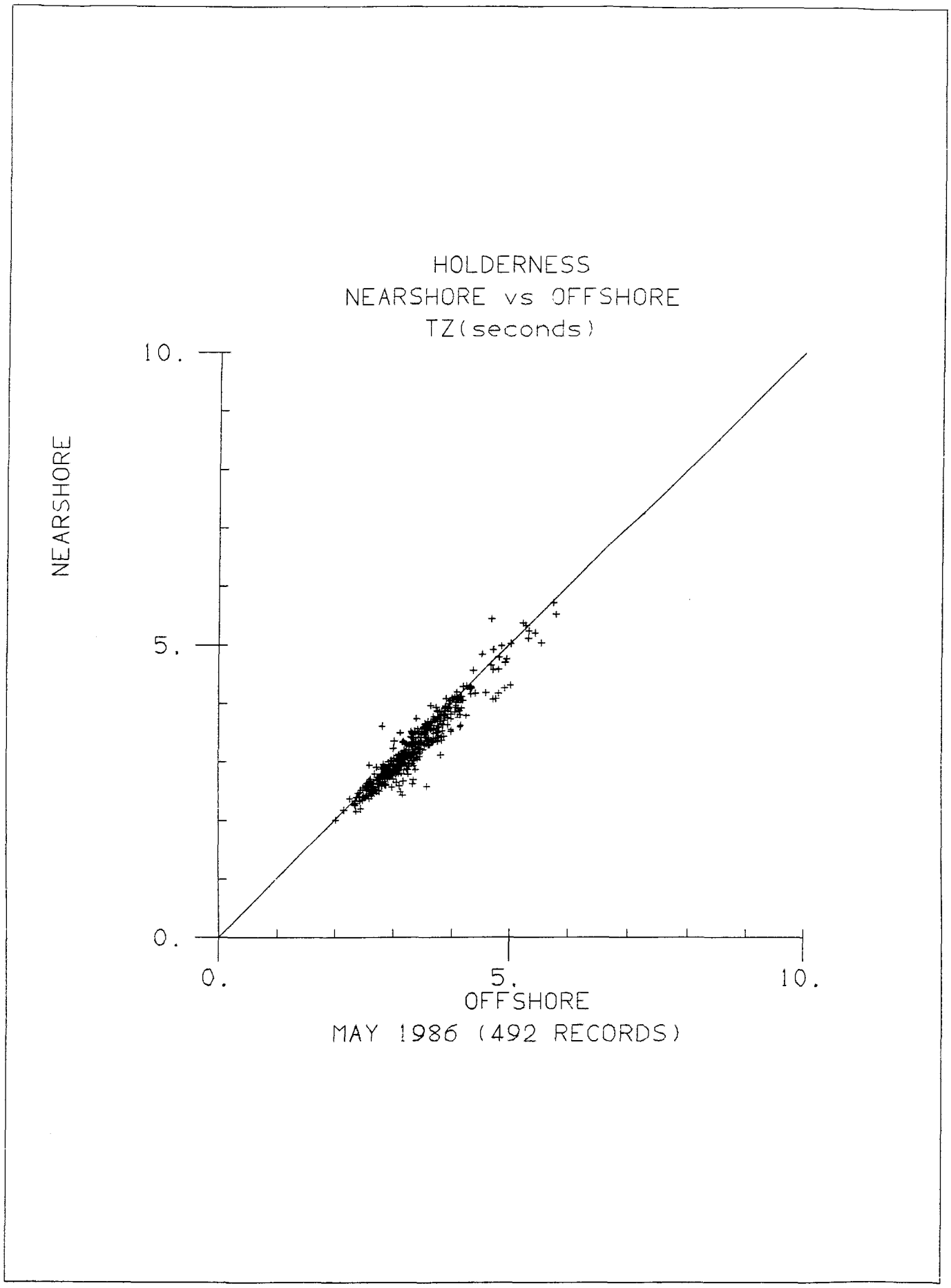

HOLDERNESS
NEARSHORE vs OFFSHORE
TZ(seconds)
NEARSHORE
10.
5.
0.
0.
5.
10.
OFFSHORE
MAY 1986 (492 RECORDS)

Figure 18(c)

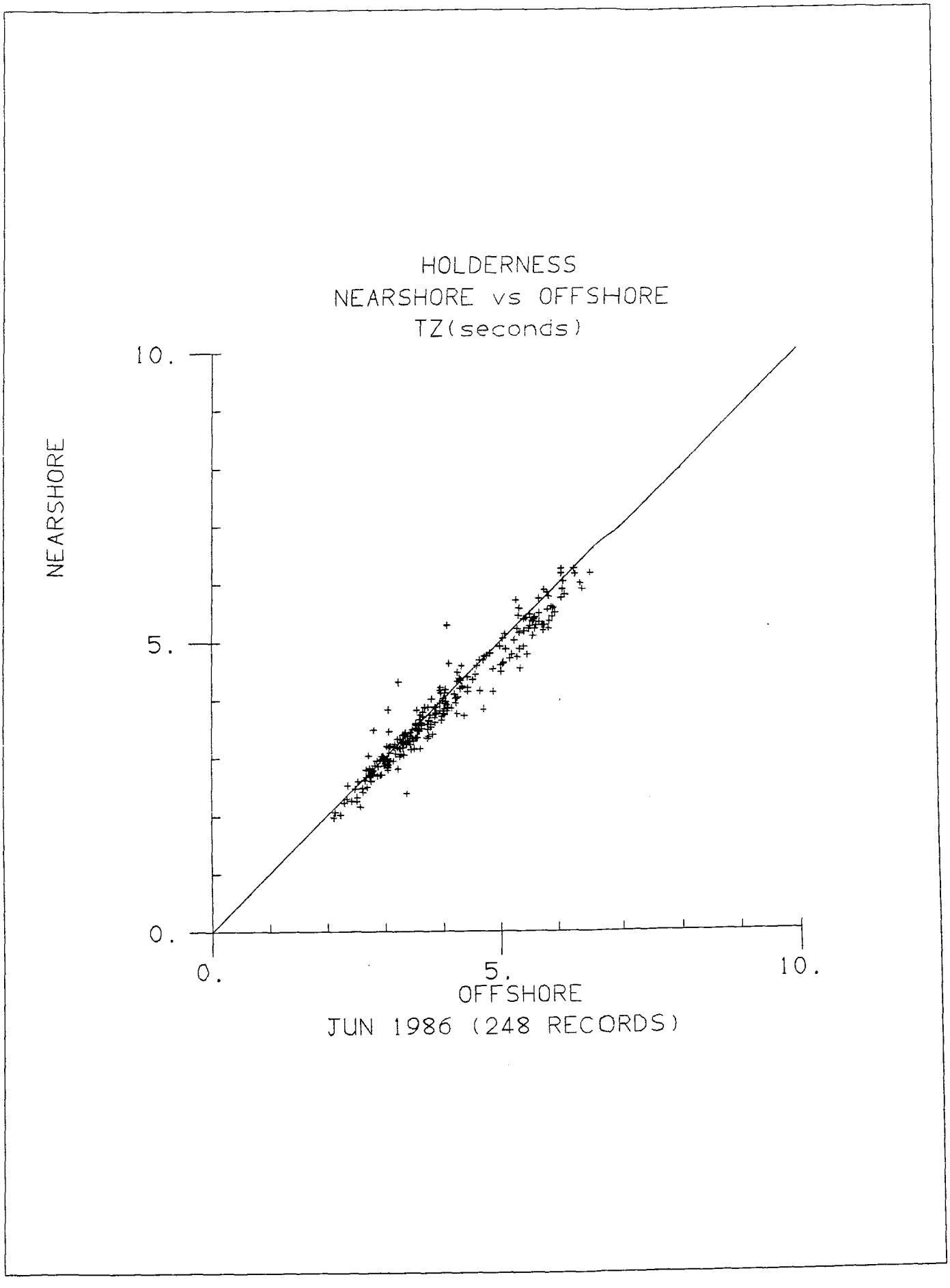

HOLDERNESS
NEARSHORE vs OFFSHORE
TZ(seconds)
NEARSHORE
10.
5.
0.
0.
5.
10.
OFFSHORE
JUN 1986 (248 RECORDS)

Figure 18(d)