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WAVE CLIMATE IN DEEP WATER WEST OF SOUTH UIST, 1980-1985

D.J.T. Carter

May 1986

Internal Document No. 258

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INTRODUCTION

This report presents a preliminary analysis of the wave measurements made by IOS at a site about 30 km west of South Uist ("the deep water site") between August 1980 and March 1985. The results have not been compared with records from other South Uist sites ('inshore' and 'offshore' sites) which are described - together with the earlier deep site records - in Fortnum et al (1979), Fortnum (1981) and Stanton (1984). Nor have wind speed measurements during these years of wave measurements been compared in this preliminary analysis with the long-term wind climate, but there is no obvious anomaly except that there was a period of easterly winds during January 1982 which gave eleven days of relatively low waves producing a significant effect upon the derived January climate statistics.

Estimates of wave power available off South Uist have been made by Gleason and Crabb (personal communication). See, also, Ewing (1980), in particular for a discussion of the non-directional spectral shape off South Uist.

WAVE DATA

Wave records were obtained using a series of Waverider buoys moored close to 57°18'N, 7°54'W (see Figure 1) in a water depth of about 90-100 m with a mean spring tidal range of $3^1/2$ m. Records were obtained at 3 hourly intervals from 15 August 1980 to March 1983 and at $1^1/2$ hourly intervals from April 1983 to March 1985.

The Waverider measures the vertical acceleration of the buoy; this acceleration is integrated twice onboard the buoy to give a continuous measure of the heave, or vertical displacement. This was telemetered continuously to South Uist using the standard Waverider am/fm system. At the shore station on South Uist the heave was recorded in digital form on a sample basis. Formerly each sample consisted of 2048 measurements of the heave made at $^1/2$-second intervals (giving a total length of 1024 sec), the start times of successive samples being separated by 3 hours. Latterly, the samples were lengthened to 4096 (total length 2048 sec) and were separated at $1^1/2$ hour intervals. An fm signal was also recorded and used if the digital data were invalid.

For each record, the spectral density, S(f), was estimated using an FFT procedure and the spectral moment, m_n, defined by

$$m_n = \int_o^\infty f^n \, S(f) \, df$$

were estimated by numerical integration from 0.0444Hz to 0.6304 Hz. Estimates of significant wave height, H_s, and mean zero-up-crossing wave period T_z were obtained using

$$H_s = 4\sqrt{m_o}$$

$$T_z = \sqrt{(m_o/m_2)}$$

The percentage of records obtained each month and the total number of records each month are given in Tables 1 and 2 respectively. Table 1 shows the poor data return obtained in some months. This was caused by a combination of telemetry failures (the distance of the buoy from the shore was some 30 km), and by recording equipment and other failures at the shore station itself.

The Waverider buoy was reported adrift on 6 January 1984; it was subsequently recovered, but it was not possible to replace the buoy on site until 21 February 1984. There were problems with the data loggers during December 1984 and January 1985.

TABLE 1

Percentage of valid records each month
(Maximum of 8 records/day till March 1983, then 16 records/day)

Month	J	F	M	A	M	J	J	A	S	O	N	D
1980	-	-	-	-	-	-	-	44	71	79	89	46
1981	66	84	95	83	95	92	94	97	97	98	75	97
1982	96	88	85	86	76	89	92	95	98	85	91	91
1983	74	28	0	24	82	29	86	78	65	49	78	36
1984	0	16	39	8	0	36	99	97	18	30	80	0
1985	0	82	73	-	-	-	-	-	-	-	-	-

TABLE 2

Total number of valid records each month

Month	J	F	M	A	M	J	J	A	S	O	N	D
1980-85	585	890	1002	558	832	745	1382	1453	1034	1042	1367	762

WAVE CLIMATE ANALYSIS

The values of significant wave height, H_s, recorded at the deepwater site are shown in Fig. 2.1-2.14. The highest value was 12.7 m on 9 January 1983, the associated mean zero-up-crossing period T_z was 12.25s. There is no record of a calm sea at any time during the five years of measurements.

Clearly from the range of values in Table 2, statistics derived from a simple compilation of all the records would not be representative of the wave climate. Therefore a 'scatterplot' giving the recorded joint distribution of H_s and T_z was calculated for each calendar month. These were then added - weighted to allow for the slight variation in days per month - to obtain the scatterplot shown in Fig. 3, representing the joint distribution of H_s and T_z throughout the year, with values expressed in parts per thousand to the nearest integer and the symbol 'o' representing <0.5 parts per thousand.

The change in sampling rate from 3-hourly to $1^1/2$ hourly during March 1983 was ignored in the derivation of Fig. 3. This change must give extra weight to the sea states prevailing after March 1983, but without investigating the correlation structure within the data it is not possible to allow for this; besides, there is no reason to expect conditions to vary about this date, so the change in sampling rate should not be expected to bias any statistical values.

A more worrying problem is the shortage of records during January, with no data for 1984 and 1985. January is clearly the roughest month of the year, so shortcomings in the data set for this month could have a significant effect upon the estimation of extreme wave heights. January 1982 - with 41% of all January records - appears to be anomalous, with very low waves, generally with H_s<2m, during the first eleven days. (A blocking anticyclone persisted, giving easterly winds off South Uist). A modified scatterplot for January was produced omitting the records from 1-11 January 1982, and incorporated into a modified yearly scatterplot. This modification clearly had a marked influence upon the distribution of wave height during January - especially upon the probability of low waves - but had rather little effect upon the annual distribution - see below for further details. An analysis of wind velocity measurements off South Uist, to determine the probability of persistent easterly winds, would indicate whether the original or modified distribution is more representative of the wave climate.

Estimates of the distributions of H_s and of T_z are given by the marginal distributions of the scatterplots. The cumulative distribution of H_s throughout the year is shown in Fig. 4. A Fisher-Tippett Type I distribution has been fitted to the data using the method of moments - see Annex A for details - and this distribution is shown in Fig. 4. Figs. 5.1-5.12 illustrate the distribution of H_s for each month. Fig. 6 shows the effect of modifying the January records - omitting the records from 1-11 January 1982. The Fisher-Tippett distribution generally appears to fit reasonably well, with the exception of the unmodified January data. Stanton (1984) found that data from the offshore site was more likely to be lost when the sea state was high, indicating that the wave height distribution given by the data are biassed towards the lower waves. No comparable check has been made on the deep water data in this preliminary analysis, although it seems reasonable to expect transmission difficulties in high sea states.

The distribution of T_z throughout the year is shown in Fig. 7. The distribution of T_z for January, April, July and October are given in Fig. 8.1-8.4 and show wave periods generally about 2 seconds lower in July than in January. There was little difference between the modified and unmodified distributions of T_z for January except that the modified distribution indicated fewer records with $T_z<6$s, and no records with $T_z<5$s. The greatest wave period recorded was 15.1 s on 23 January 1982 with a significant wave height of 6.2 m.

50-YEAR RETURN VALUE OF H_s

The cumulative distribution of H_s given in Fig. 4 is redrawn in Fig. 9.1 with the probability scale changed so that the Fisher-Tippett Type 1 distribution becomes a straight line. Assuming 3-hourly values of H_s are independent, then the 50-year return value of H_s, H_{s50} is given by

$$\text{Prob}(H<H_{s50}) = 1 - \frac{1}{50 \times 365.25 \times 8}$$

$$= 0.99999316$$

Extrapolating the FT-1 fit to this probability (the right hand edge of the figure) gives a value for H_{s50} of 16.7 m. Fig. 9.2 shows the corresponding plot using the modified yearly scatterplot to obtain the marginal distribution of H_s; the value of H_{s50} is increased to 17.0 m. (Using a scatterplot obtained by simply adding all the record values and making no adjustment for the variation in the number of records per calendar month gives an estimate for H_{s50} of 16.2 m.)

Table 3 gives the estimated values for the location and scale parameters (A and B respectively) of the FT-1 and the values of H_{s50} for the yearly distributions and for the monthly distributions.

Combining the twelve individual monthly distributions to obtain an estimate of the annual distribution and using this to determine H_{s50} gives a value which is dominated by January - 18.3 m from the poorly-fitting unmodified January data and 17.1 m from the modified. (See Figs. 9.3 and 9.4).

Fig. 10 shows the distribution of H_s plotted on "Weibull paper" together with the straight line obtained by fitting a Weibull distribution to the part of the recorded distribution $\geqslant$ 5 m. Extrapolating this Weibull distribution to the 50-year return period gives an estimate for H_{s50} of 15.0 m. Note that the data as a whole clearly is not from a two-parameter Weibull. Table 4 gives estimates of H_{s50} for a range of cut-off values, it also gives estimates using the modified distribution of H_s.

There is no theoretical justification for using either the FT-1 or the Weibull distribution for extrapolating into the tail of the wave height distribution in order to estimate H_{s50}; but the fact that the FT-1 seems a reasonable fit over the entire data distribution whilst the two-parameter Weibull only fits a fraction of the data suggests a preference for the FT-1. The data from South Uist lies slightly 'below' the line of the FT-1 in the upper tail (the uppermost 0.5% of the data) but this could be explained by random sampling or by the preferential loss of high wave records reported by Stanton (1984).

TABLE 3

Estimates of FT-1 parameters A and B and of the 50-year return value of H_s (m)

Month	A	B	H_{s50}
JAN	3.649	1.548	18.24
JAN (mod.)*	4.245	1.336	16.84
FEB	2.845	1.123	13.33
MAR	2.627	1.120	13.18
APRIL	1.695	0.799	9.20
MAY	1.324	0.739	8.29
JUNE	1.463	0.681	7.86
JULY	1.328	0.594	6.93
AUG	1.471	0.793	8.95
SEPT	2.064	0.838	9.94
OCT	2.874	1.104	13.28
NOV	2.330	1.238	13.96
DEC	2.853	1.099	13.21
YEAR	2.065	1.231	16.71
YEAR (mod.)*	2.095	1.249	16.95

*From modified scatterplot, see text.

TABLE 4

Estimates of H_{s50} (m) from fitting a Weibull distribution omitting data below the specified cut-off (% of data fitted is shown in brackets)

cut-off (m)	1980-85 data	modified data*
2.0	13.0 (61%)	13.2 (62%)
3.0	13.6 (36%)	13.7 (37%)
4.0	14.5 (19%)	14.6 (19%)
5.0	15.0 (9%)	15.1 (10%)
6.0	15.6 (4%)	15.7 (4%)
7.0	15.3 (2%)	15.3 (2%)

*see text.

TABLE 5

PREDICTED WAVE OCCURRENCES IN 1 YEAR

NUMBER OF WAVES FOR EACH HT.INTERVAL (0-1 M ETC.)

1 TO 5 M.	2109638.281	1635601.563	734577.433	329036.785	148669.969
6 TO 10 M.	68753.408	32721.071	15987.038	7996.106	4082.719
11 TO 15 M.	2119.770	1113.607	588.964	312.325	165.656
16 TO 20 M.	87.795	46.499	24.625	13.046	6.914
21 TO 25 M.	3.663	1.937	1.020	0.534	0.277
26 TO 30 M.	0.142	0.072	0.036	0.018	0.009

NUMBER OF WAVES EXCEEDING GIVEN HEIGHTS

1 TO 5 M.	2981913.000	1346311.453	611734.039	282697.227	134027.260
6 TO 10 M.	65273.853	32552.779	16565.741	8569.635	4486.916
11 TO 15 M.	2367.146	1253.540	664.576	352.251	186.595
16 TO 20 M.	98.800	52.301	27.676	14.630	7.716
21 TO 25 M.	4.053	2.116	1.095	0.561	0.284
26 TO 30 M.	0.142	0.070	0.034	0.016	0.007

DISTRIBUTION OF INDIVIDUAL WAVE HEIGHT

The probability of individual wave height H and the total number of waves in a year, N_y, may be estimated from the H_s:T_z scatterplot by the technique proposed by Battjes (1972) which assumes that the distribution of H given H_s is Rayleigh. Using the scatterplot in Fig. 3 gives the results shown in Table 5: the number of waves expected in each 1m band and the number expected to exceed specified values during a year. The total number of waves expected in a year is 5.09 10^6. (Using the modified scatterplot omitting the low waves in January 1982 gives 5.07 10^6.) If N(H) is the number of waves expected greater than H in one year, then

$$\text{Prob}\ (H>h) = N/N_y.$$

Assuming the distribution of H is a one-parameter negative exponential distribution (see Annex A), leads to

$$h = \theta\ \left[\log_e(N_y) - \log_e(N)\right]$$

or - the form more often used for wave fatigue calculations - since $1/\log_{10}e \simeq 2.3026$:

$$h \simeq 2.3026\ \theta\ \left[\log_{10}(N_y) - \log_{10}(N)\right]$$

Fig. 11 shows this line, together with the data, plotted on a negative exponential scale with a value for θ of 1.419, obtained by fitting the negative exponential distribution through the data from Table 5 at the 99.9% tile. This choice of θ ensures a reasonable fit around the value of H of importance to fatique (at South Uist close to 10 m); but, as Fig. 11 shows, it does not fit the very high waves so should not be used to estimate the 50-year return value of H - which for 5.09 10^6 waves each year corresponds to a value of $\log_{10}(N)$ of -8.4.

CONCLUSIONS

The wave climate 30 km west of South Uist, as revealed by Waverider measurements between August 1980 and March 1985, has been presented. Allowance has been made for the large variation in the number of observations recorded for each calendar month, but no investigation has been carried out into the relative severity of these years compared with the long-term average conditions.

There are many, sometimes large, gaps in the data records. In particular, the month with the severest sea conditions, January, is poorly sampled; with the additional problem that 41% of the January data comes from 1982 which had a period of eleven days of low wave height, associated with Easterly winds.

Stanton (1984) found evidence that at the nearby offshore Waverider site data gaps were more likely to occur in high sea states. Whether this also happened at the deep water site has not been investigated in this preliminary analysis.

These problems with the January data and with the distribution of missing data put more uncertainty than usual upon estimates of the 50-year year return value of significant wave height. It would seem reasonable to take the value given by fitting a Fisher-Tippett Type I distribution to the data omitting the low wave heights in January 1982, which gives 17.0 m.

ACKNOWLEDGEMENTS

My thanks to Kay Thorne and Andy Tabor of IOS Bidston for sorting out the wave data; and to all those at IOS Taunton who established, maintained and calibrated the Waverider on station over the years and processed the data. The entire programme, including the preparation of this report, was funded by the Department of Energy.

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Statistical formulae

The Fisher-Tippett Type I (FT-1) distribution is given by

$$\text{Prob}(X<x) = \exp\{-\exp[-(x-A)/B]\} \qquad \text{A.1}$$

where A and B are the location and scale parameters respectively, (B>0). For this distribution A is also the mode.

The mean and variance are $A+\gamma B$ and $\pi^2 B^2/6$ where γ is Euler's constant = 0.5772 ..... So the moments estimators given data x_i, i = 1-n, are given by

$$\tilde{A} = \bar{x} - \gamma\tilde{B} \qquad \text{A.2}$$

$$\tilde{B} = \sqrt{6}\, s/\pi$$

where

$$\bar{x} = \sum_i x_i/n$$

$$s^2 = \Sigma\,(x_i - \bar{x})^2/(n-1) \qquad \text{A.3}$$

Values of $\bar{x}$ and s^2 may be estimated from grouped data.

The distribution of the maximum of N independent values is

$$\text{Prob}(X_N < x) = [\text{Prob}(X<x)]^N$$

which, from A.1, reduces for the FT-1 to:

$$\text{Prob}\,(X_n<x) = \exp\{-\exp[-(x-(A+B\log_e N))/B]\} \qquad \text{A.4}$$

So for example, the most likely highest (modal value) of X_n, $\hat{X}_n$, is $A+B\log_e N$;

which for an "average month" of 244 observations gives

$$\hat{X}_n \simeq A + 5.50\ B \qquad \text{A.5}$$

and the expected highest value in a month is given by

$$E(X_N) \simeq A + 5.50B + \gamma B$$

i.e. $E(X_N) \simeq A + 6.07B$ A.6

The N-year return value, X_{Nyr}, is given, assuming 8 x 365.25 independent observations per year by

$$P_{Nyr} = \text{Prob}(X_{Nyr} < x) = 1 - 1/(Nx8x365.25)$$

Substituting in A.1 gives

$$X_{Nyr} = A + B(-\log_e(-\log_e P_{Nyr})) \qquad \text{A.7}$$

So, for example, if N = 50 or 100

$$X_{50yr} \simeq A + 11.89\ B$$

$$X_{100yr} \simeq A + 12.59\ B$$

For monthly values assuming Nx8x365.25/12 independent observations:

$$X_{50yr(1\ month)} \simeq A + 9.41\ B$$

$$X_{100yr(1month)} \simeq A + 10.10\ B$$

The two-parameter Weibull distribution is given by

$$\text{Prob}(X<x) = 1 - \exp\left[-(x/A)^B\right] \qquad x>0$$

$$= 0 \qquad x \leq 0 \qquad \text{A.8}$$

where A>0 and B>0 are the scale and shape parameter respectively - the location parameters is 0. So the probability distribution function is

$$p_x(x) = \frac{B}{A}\left(\frac{x}{A}\right)^{B-1} \exp\left[-(x/A)^B\right] \qquad \text{A.9}$$

Note that the distribution of $-\log_e(x)$ is FT-1 with location and scale parameters of $-\log_e A$ and $1/B$ respectively, so to fit a Weibull distribution to data, we could take -log(data) and fit an FT-1 using A.2. However, if we wish to fit only the data in the upper tail, it is easier to work with the Weibull distribution, since it is integrable in terms of the incomplete gamma function.

Defining 'partial' moments about the origin of values above some specified level x_o by:

$$\nu_r = \int_{x_o}^{\infty} x^r \, p_x(x) \, dx \qquad \text{A.10}$$

Substituting for p_x from A.9 leads, for r=1 and 2, to

$$\nu_1 = \frac{x_o}{D^C} \quad \Gamma(1+C,D)$$

$$\nu_2 = \left(\frac{x_o}{D^C}\right) \quad \Gamma(1+2C,D) \qquad \text{A.11}$$

where

$C = 1/B$ and

$D = (x_o/A)^B$

and

$$\Gamma(p,D) = \int_D^{\infty} y^{p-1} \, e^{-y} \, dy$$

Therefore given estimates of ν_1 and ν_2 from data using A.10, and a value for x_o, then estimates of C and D, and hence of A and B can be obtained by numerical solution of A.11.

The N-year return value is given by

$$X_{Nyr} = \tilde{A} \left[\log_e (Nx8x365.25)\right]^{1/\tilde{B}} \qquad \text{A.12}$$

where ~ represents an estimated value.

<u>The negative exponential distribution</u> is given by

$$\mathrm{Prob}(X<x) = 1 - \exp(-x/A) \qquad A>0$$

i.e.

$$\mathrm{Prob}(X>x) = \exp(-x/A) \qquad A>0 \qquad \text{A.13}$$

This is the one-parameter form with the location parameter assumed to be zero. The mean is A, so may be estimated, for fitting to data, by calculating the mean of the data. If the fit into the upper tail is of particular importance then A may be estimated from the p^{th} percentile of the data, x_p, by

$$\frac{p}{100} = 1 - \exp(-x_p/\tilde{A})$$

i.e.

$$\tilde{A} = x_p/\left[-\log_e(1-p/100)\right]$$

For example if p = 99.9

$$\tilde{A} = x_p/6.908$$

where x_p is estimated from the data.

Fig.1 Approximate location of the South Uist deep water site.

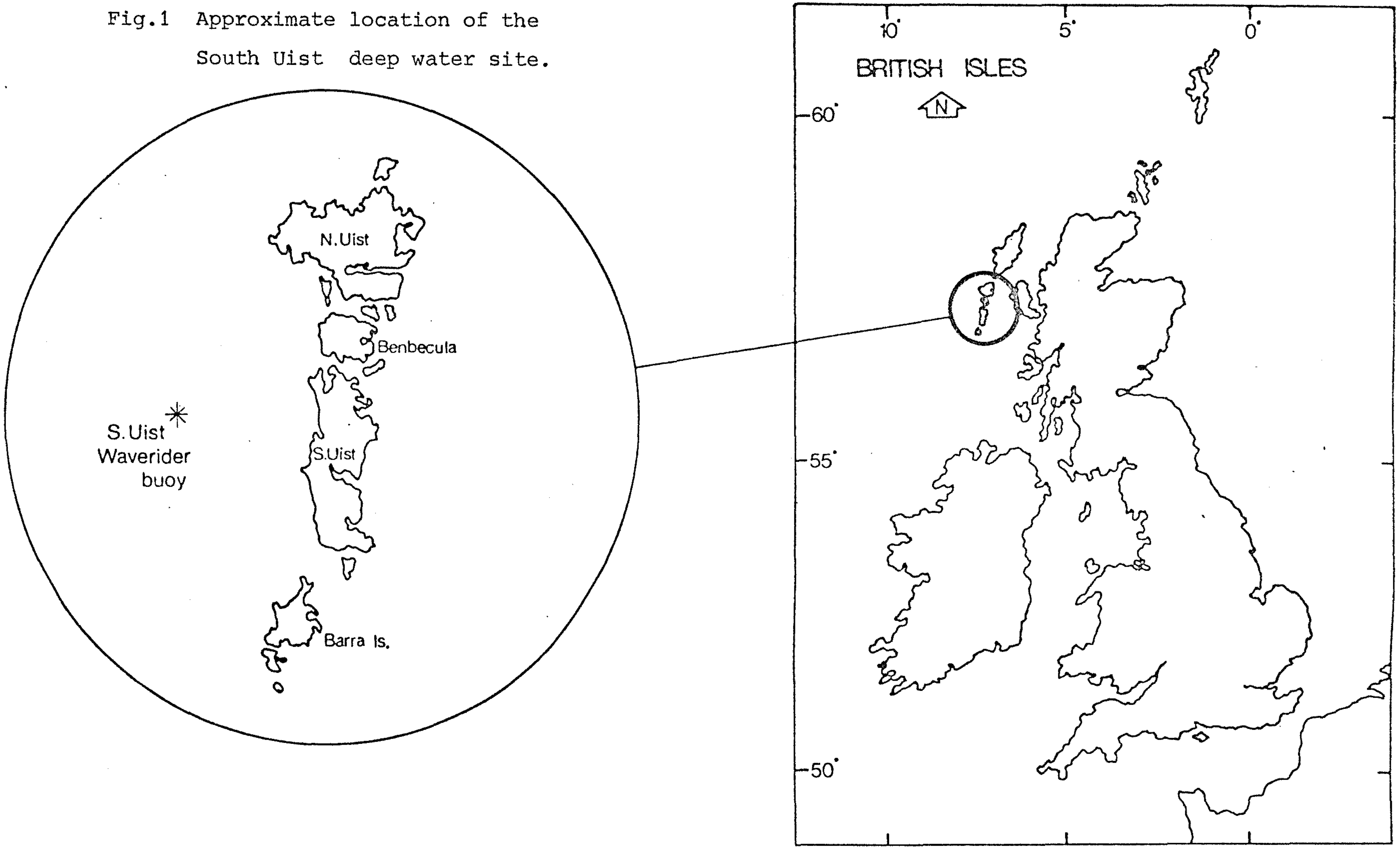
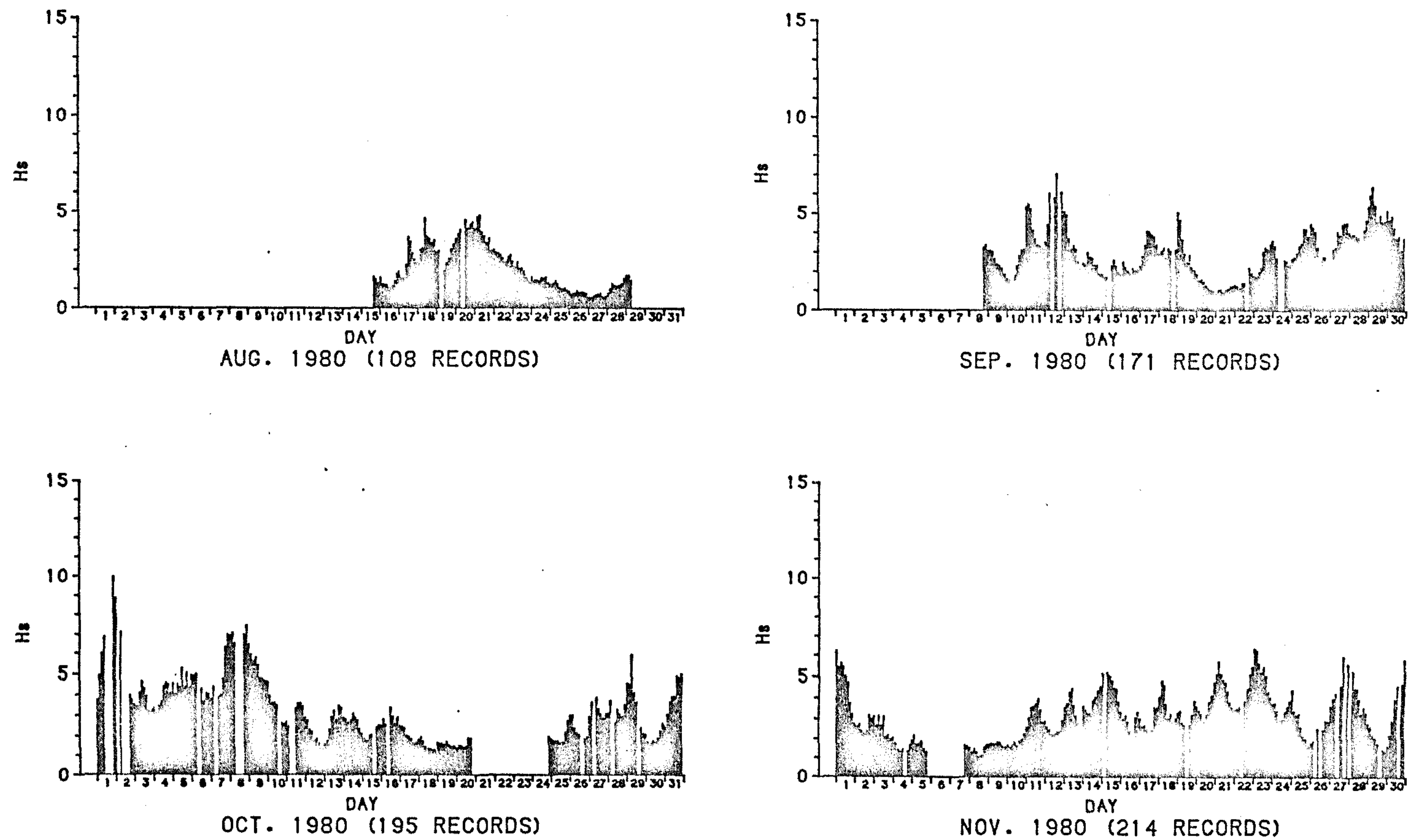


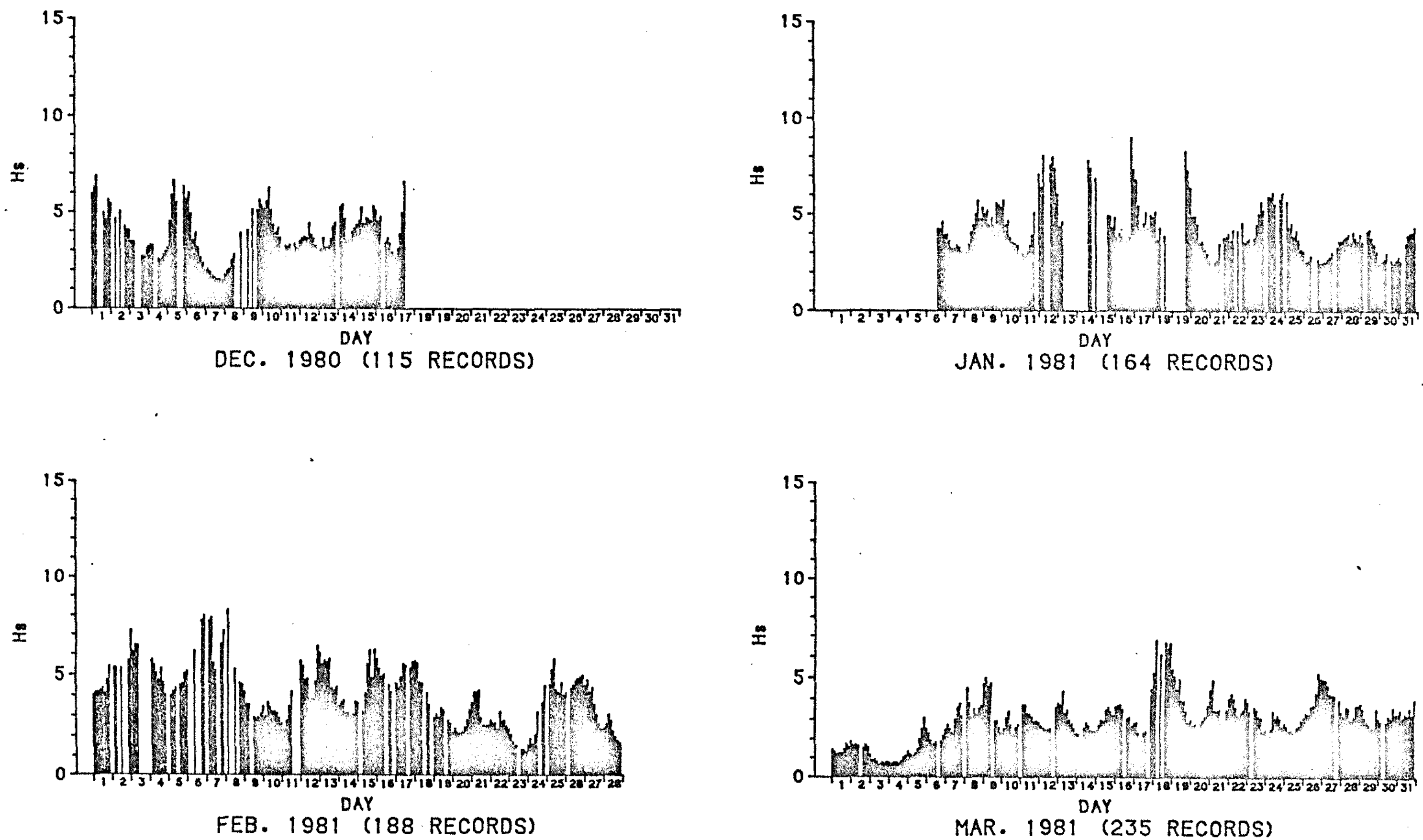
Fig.2.1



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

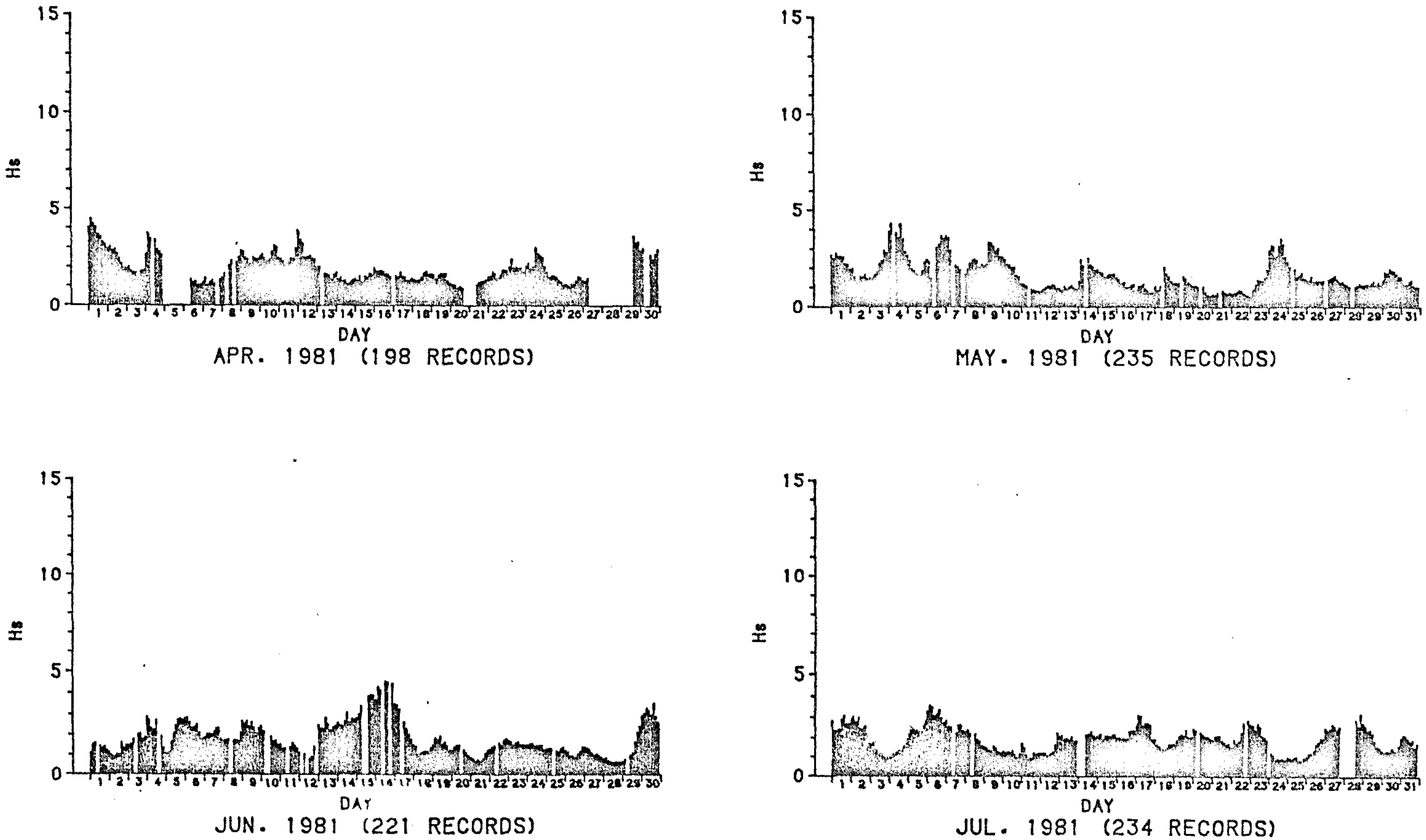
Fig.2.2



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

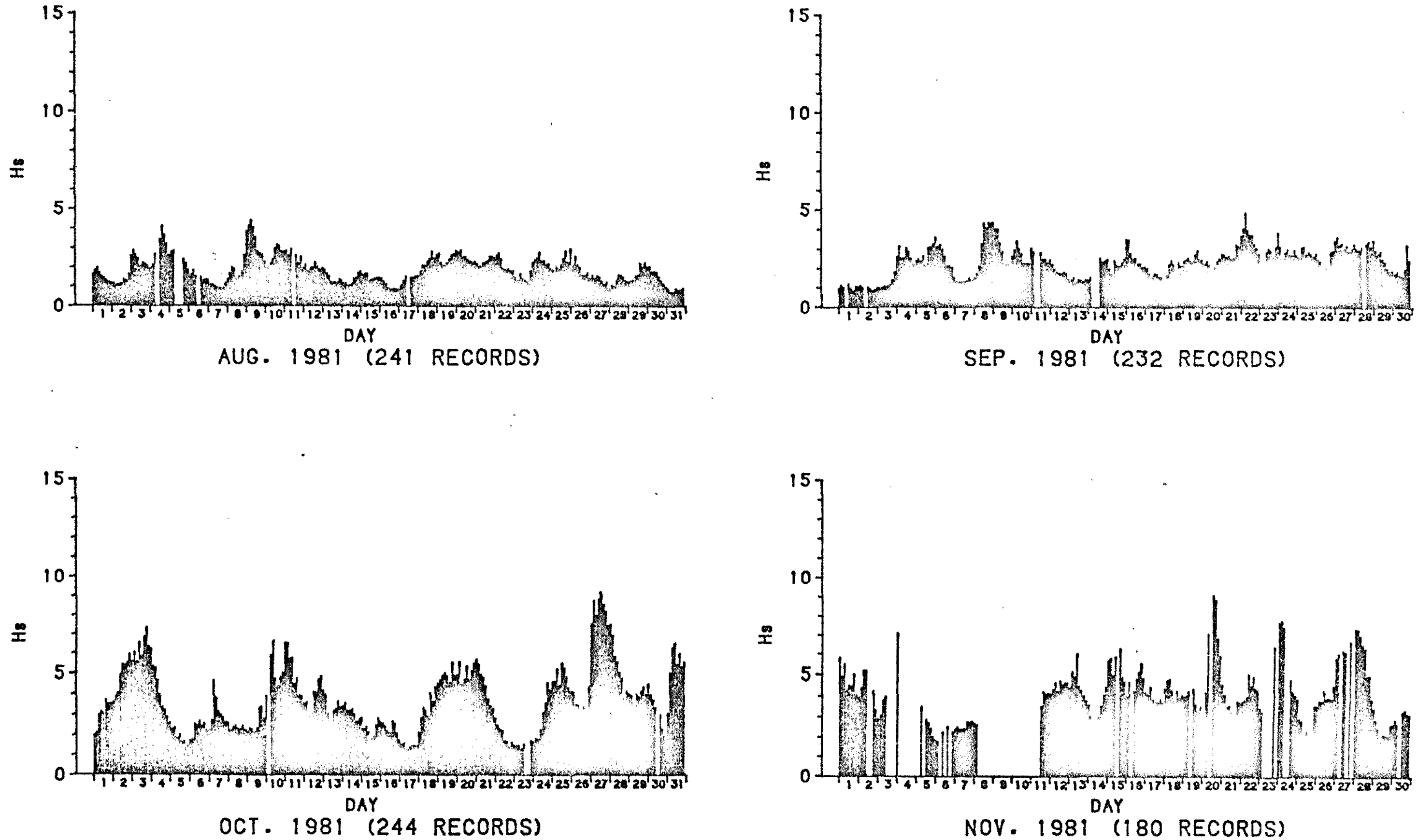
Fig.2.3



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

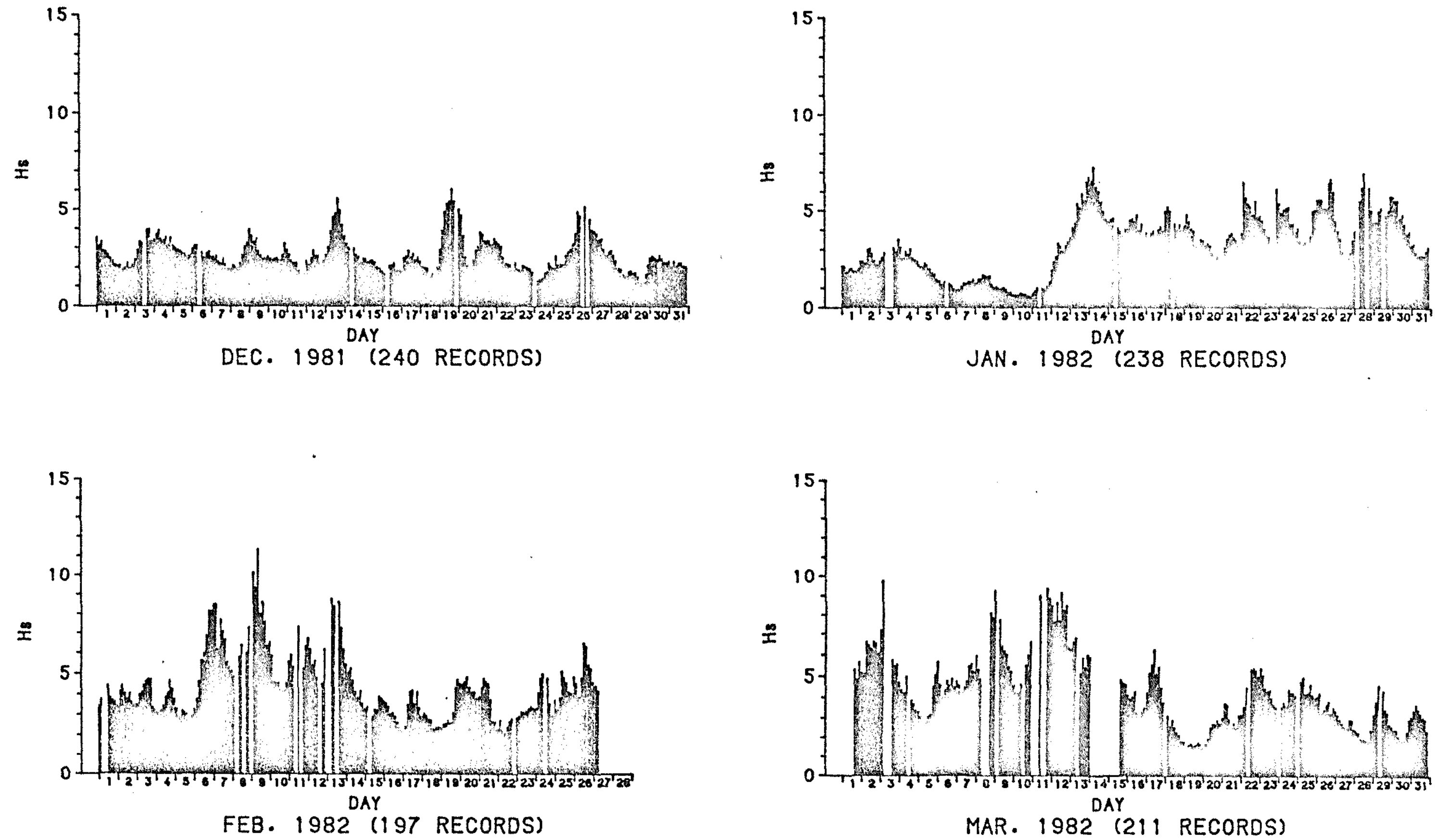
Fig.2.4



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

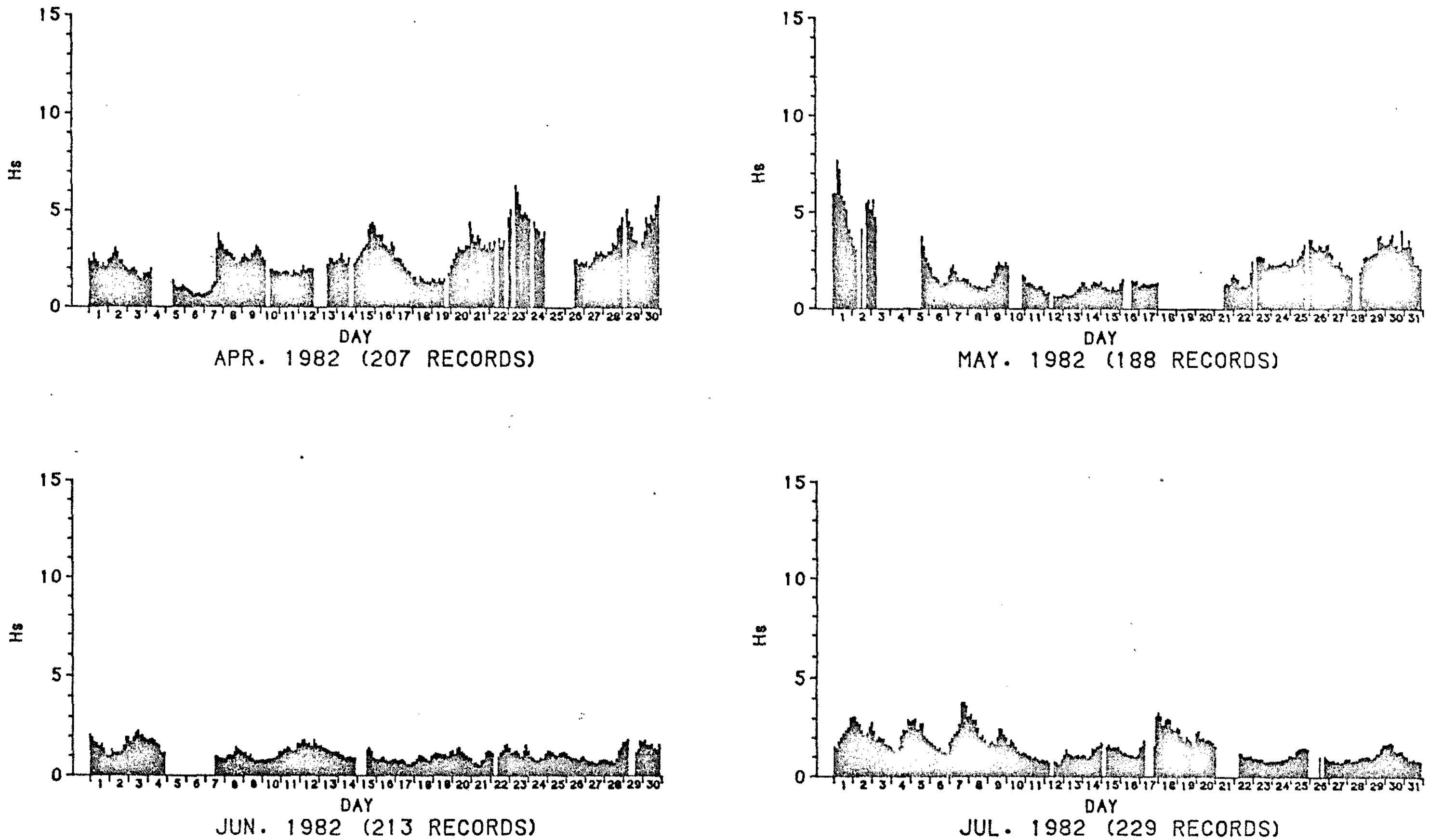
Fig.2.5



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

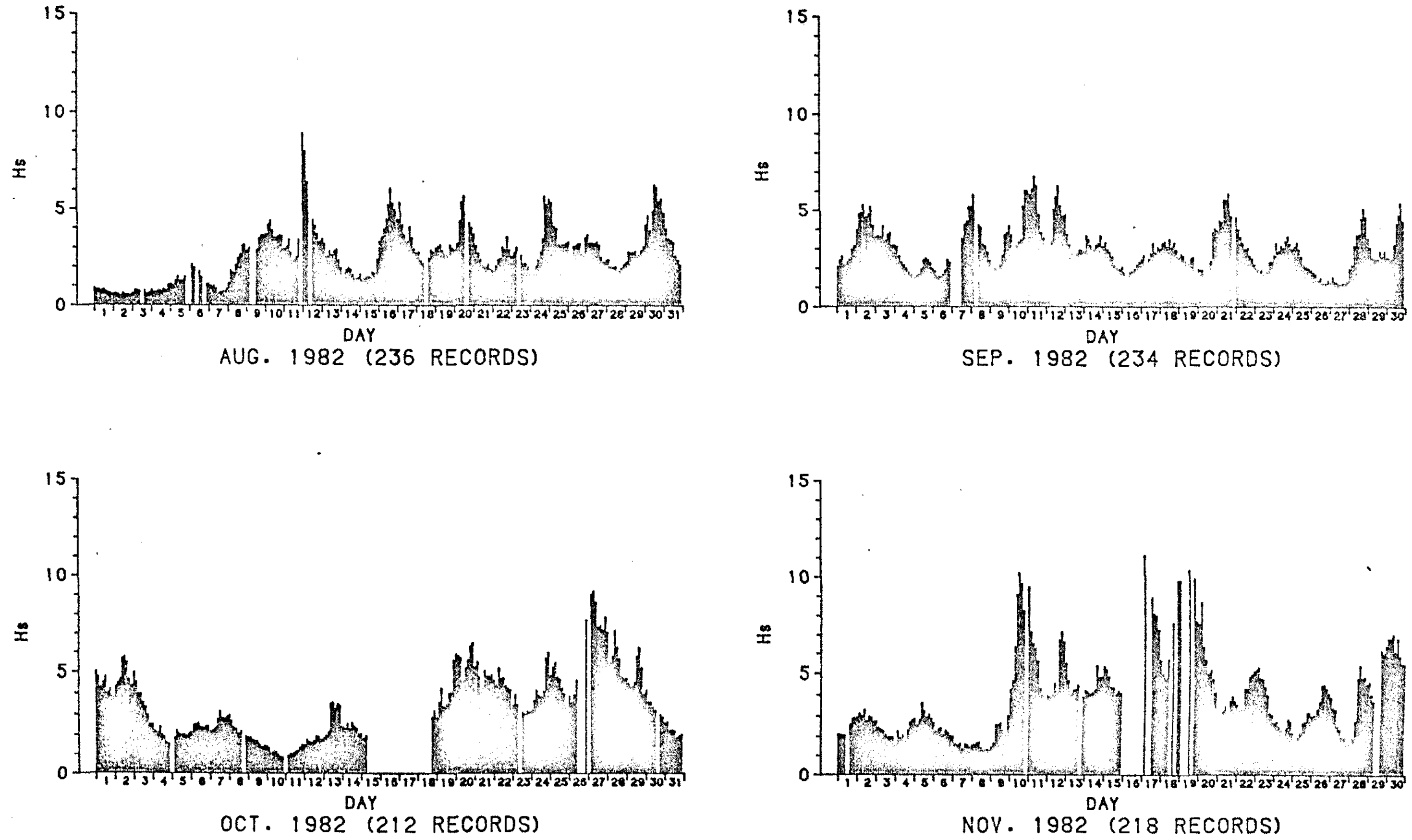
Fig.2.6



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

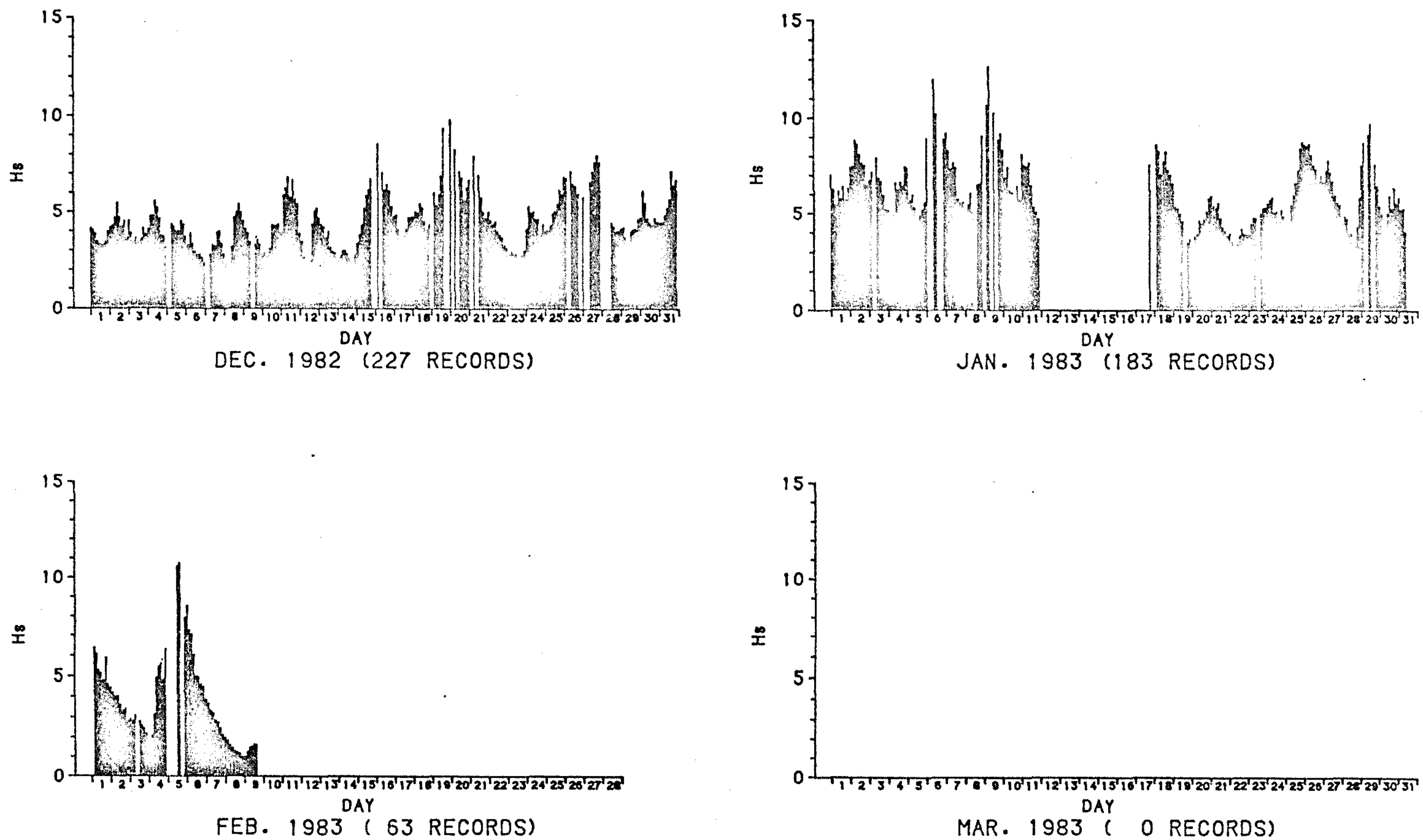
Fig.2.7



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

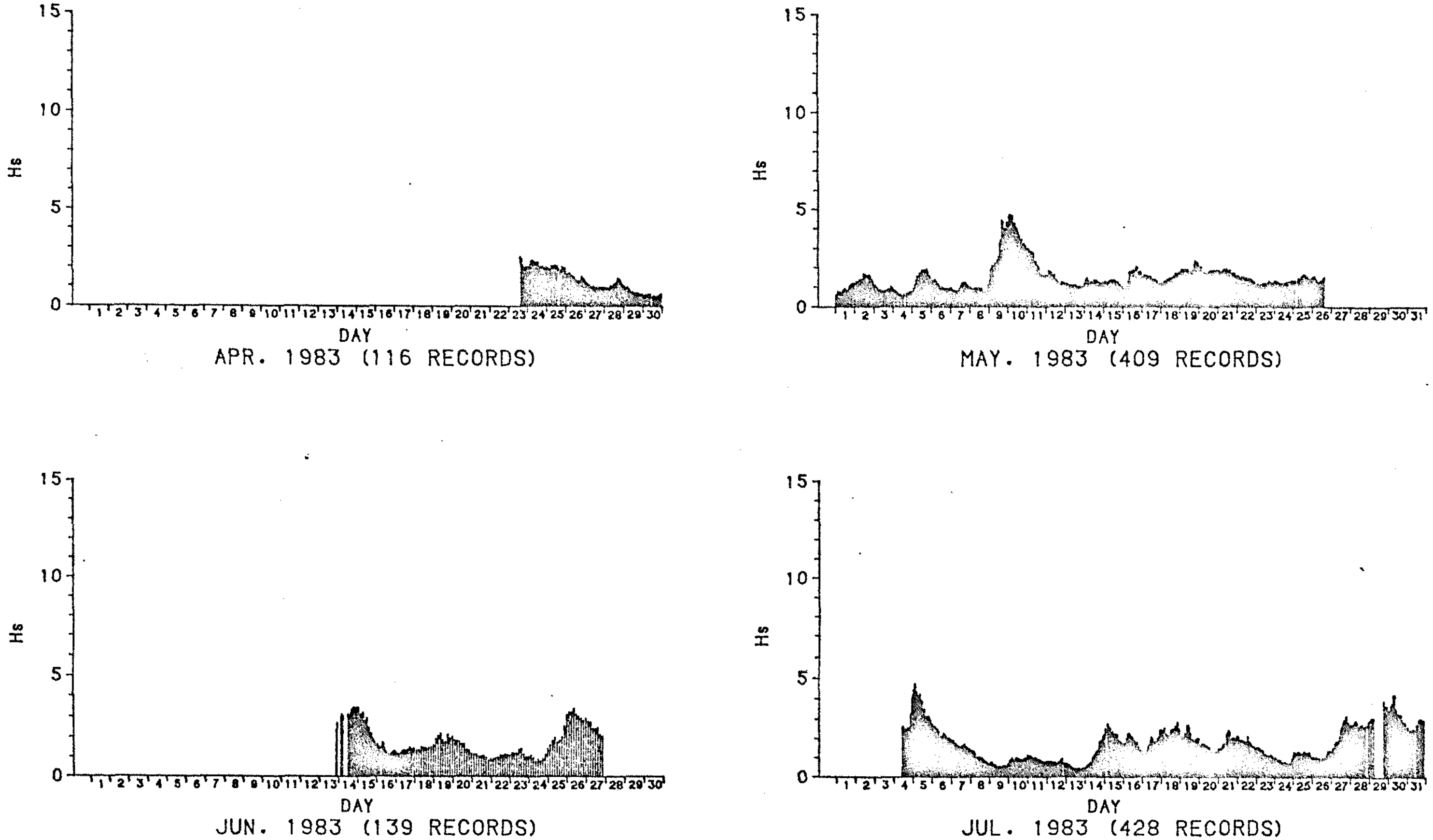
Fig.2.8



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

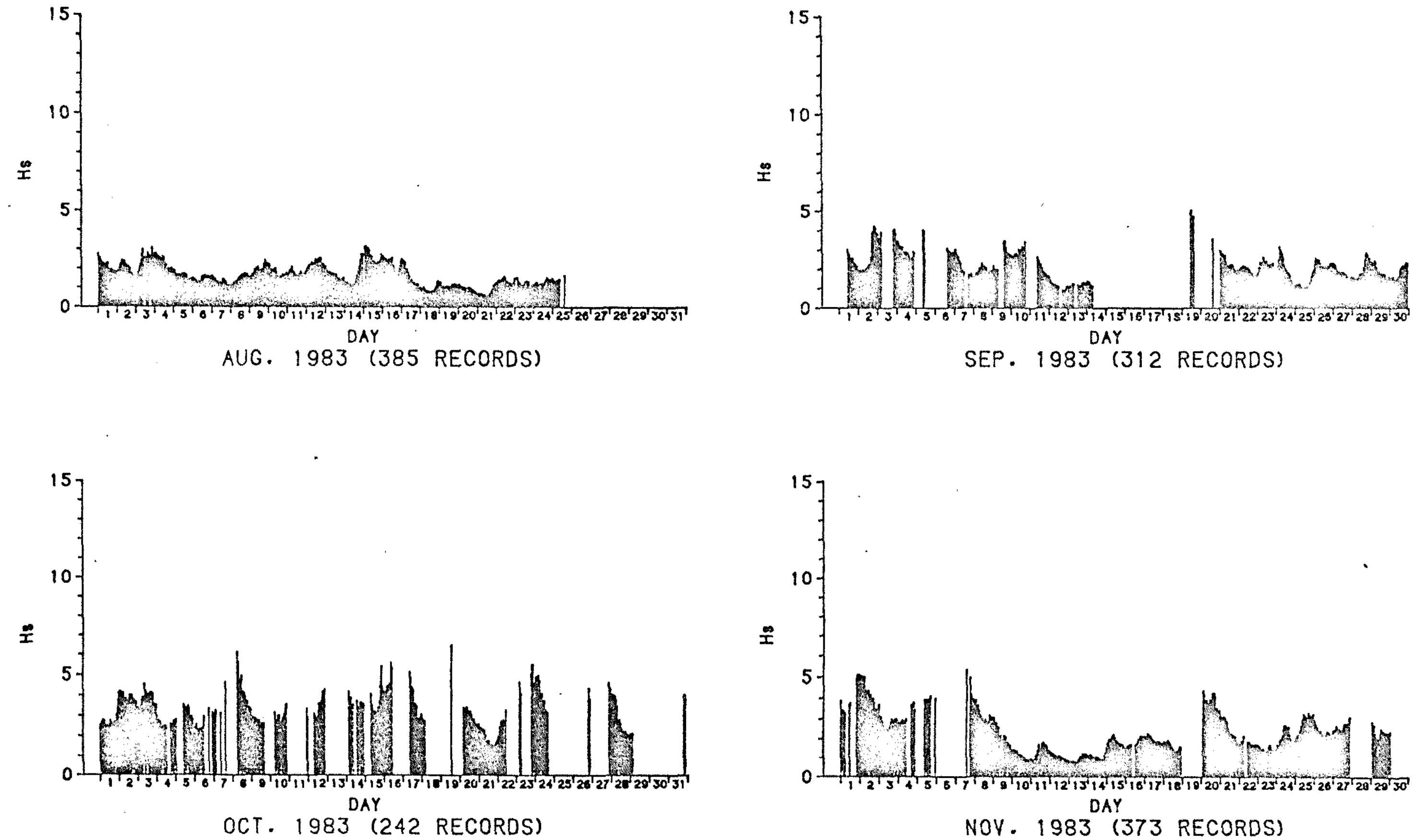
Fig.2.9



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

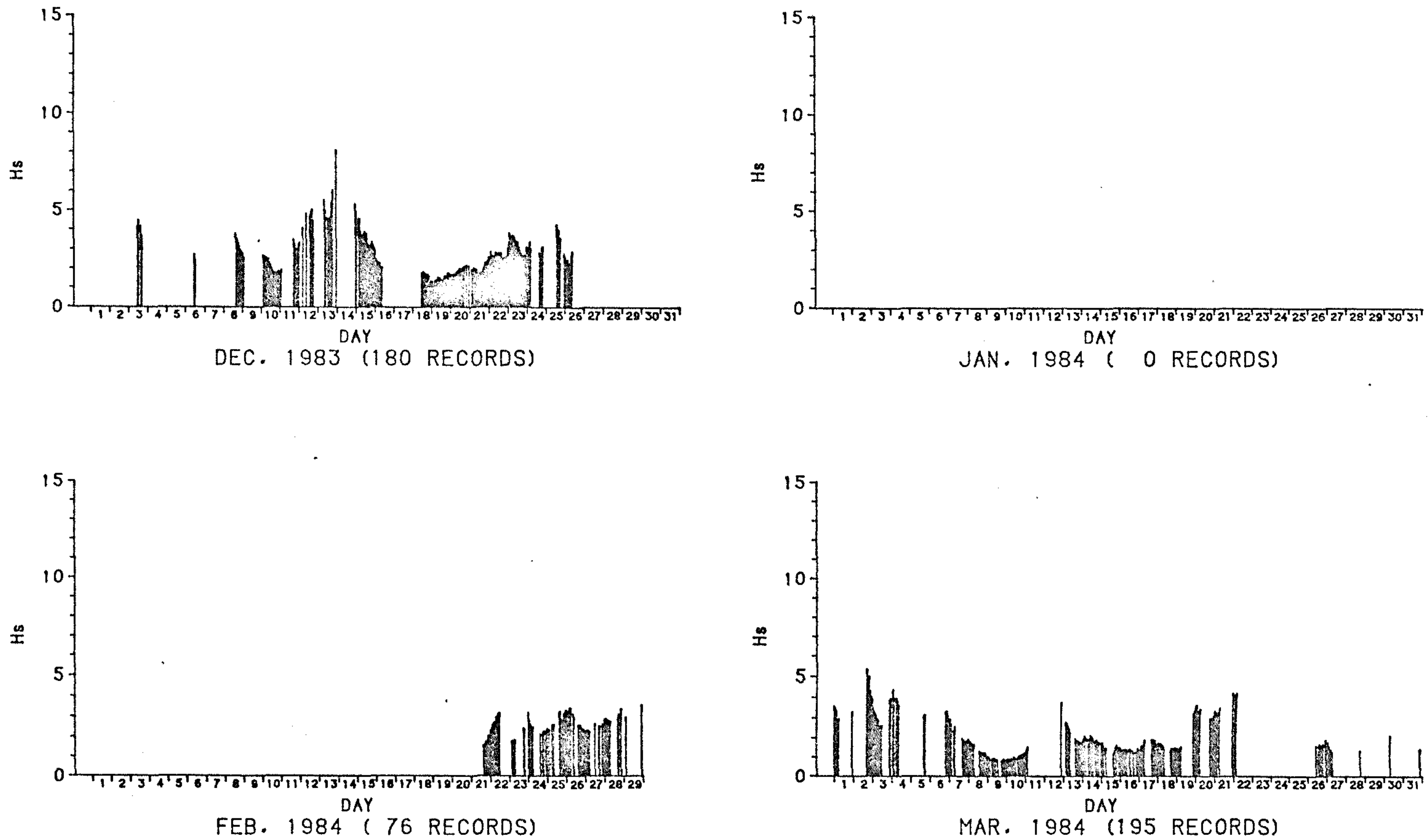
Fig.2.10



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

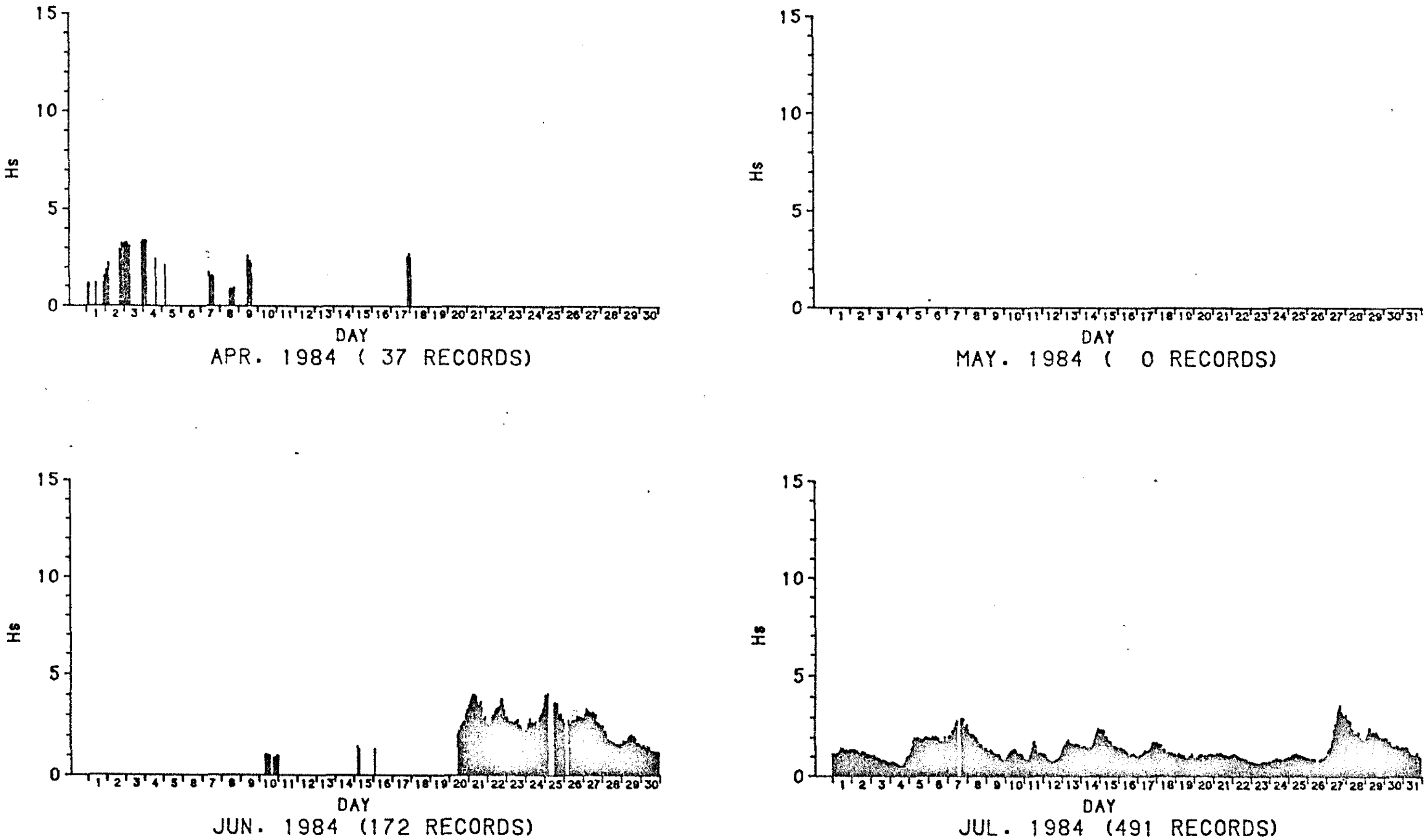
Fig.2.11



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

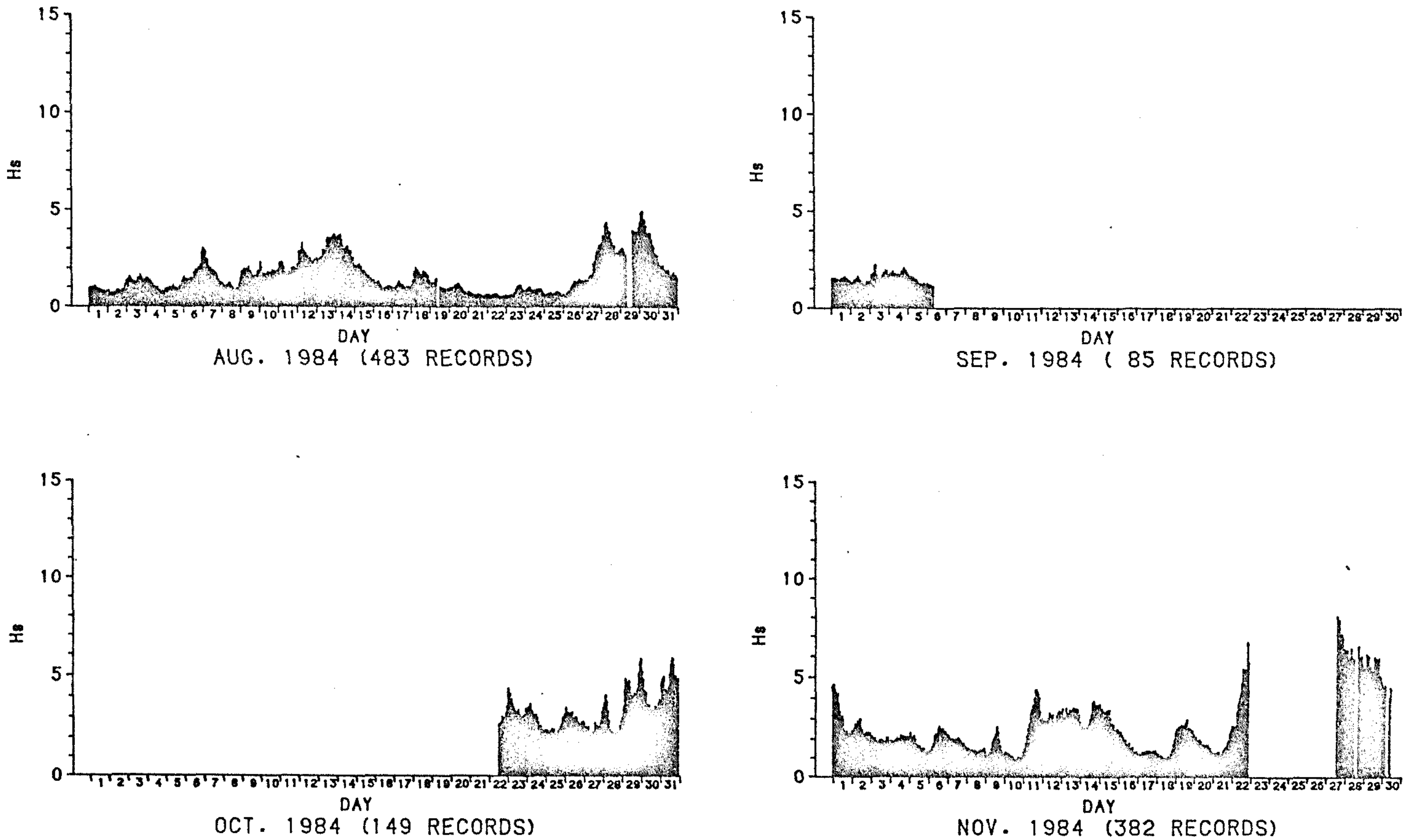
Fig.2.12



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

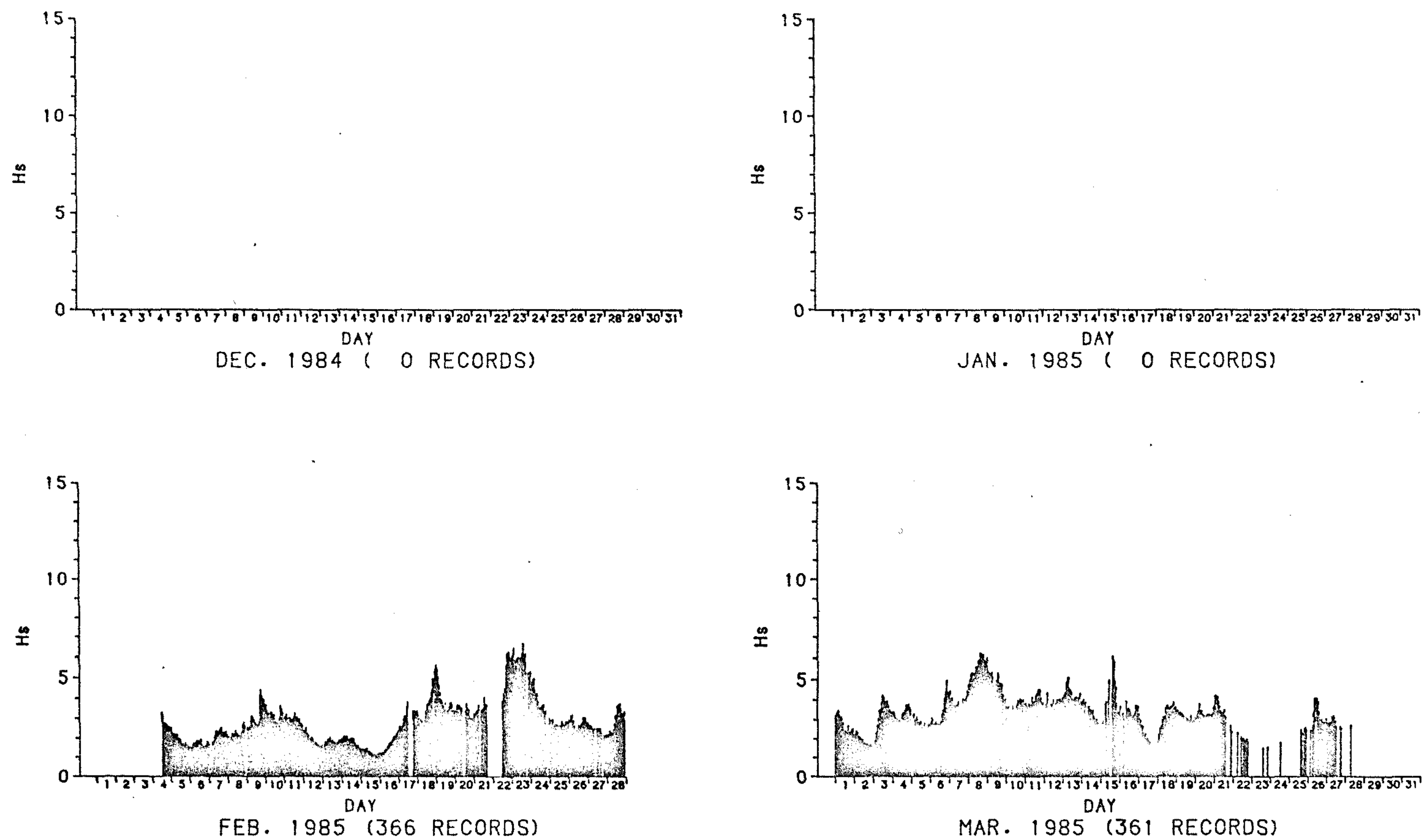
Fig.2.13



SIGN. WAVE HT, Hs(M)

SOUTH UIST DEEP WATER SITE

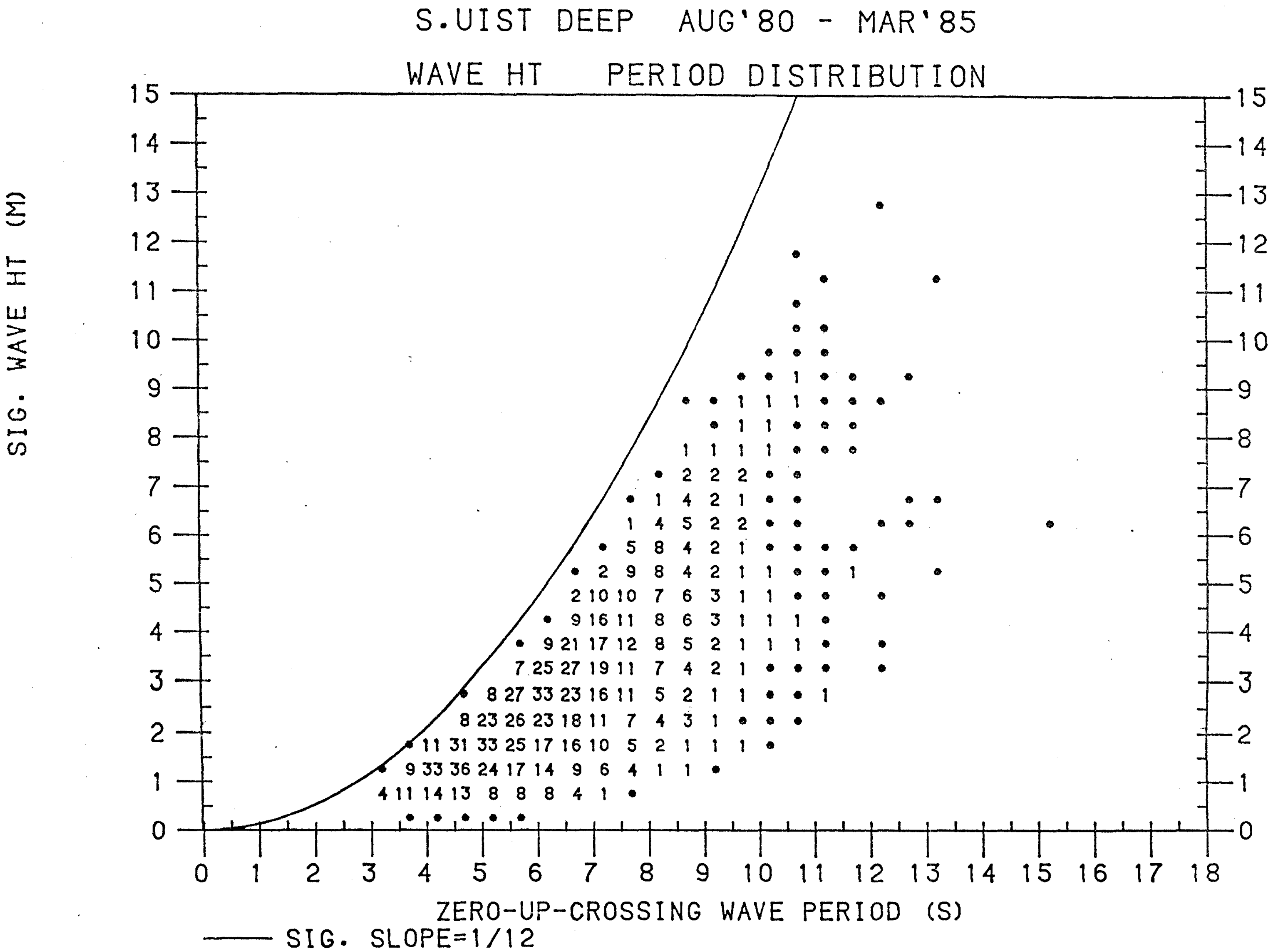
Fig.2.14



SIGN. WAVE HT, Hs(M)

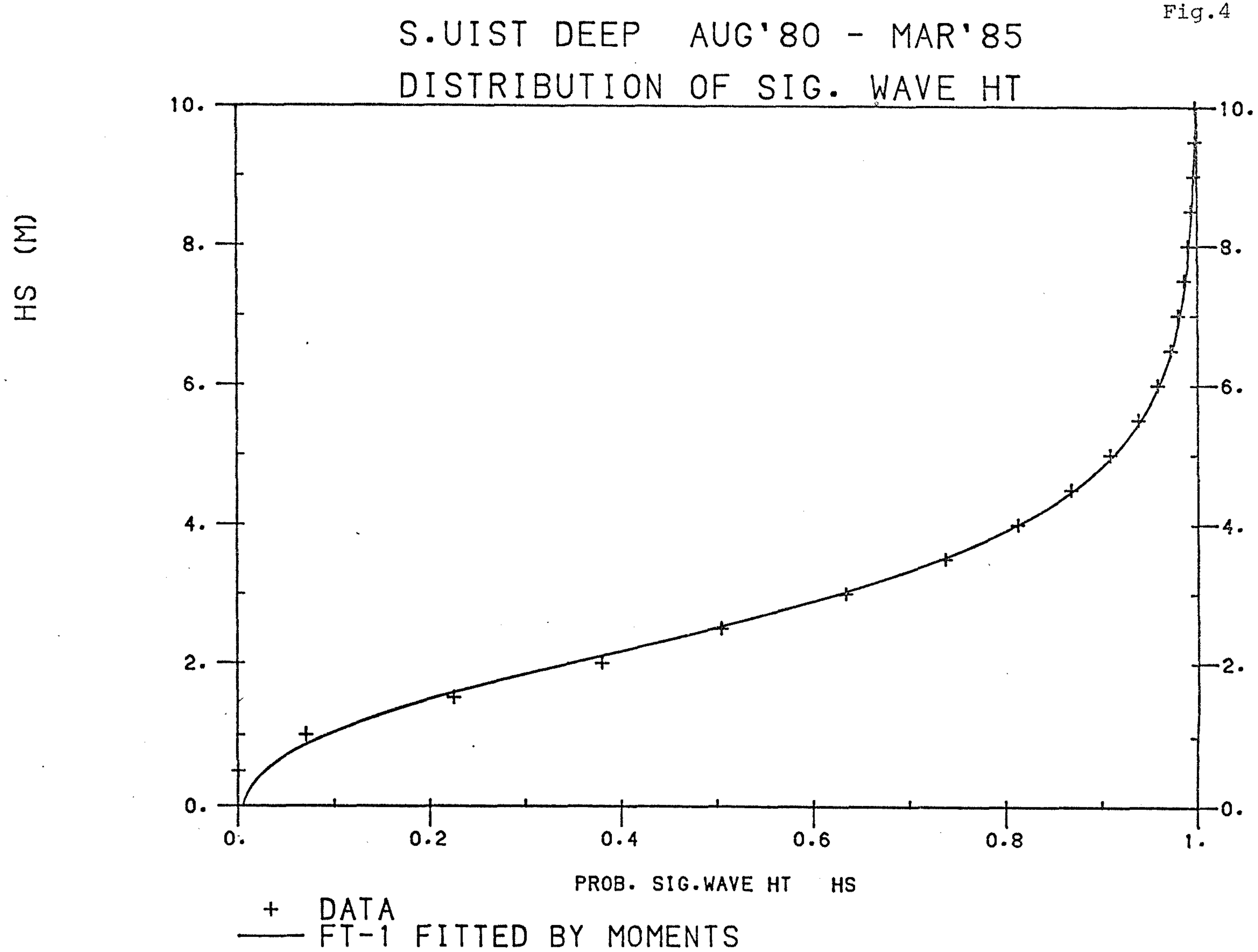
SOUTH UIST DEEP WATER SITE

Fig.3



S.UIST DEEP AUG'80 - MAR'85
WAVE HT PERIOD DISTRIBUTION
SIG. WAVE HT (M)
ZERO-UP-CROSSING WAVE PERIOD (S)
SIG. SLOPE=1/12

Fig.4



S.UIST DEEP AUG'80 - MAR'85
DISTRIBUTION OF SIG. WAVE HT
HS (M)
10.
8.
6.
4.
2.
0.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

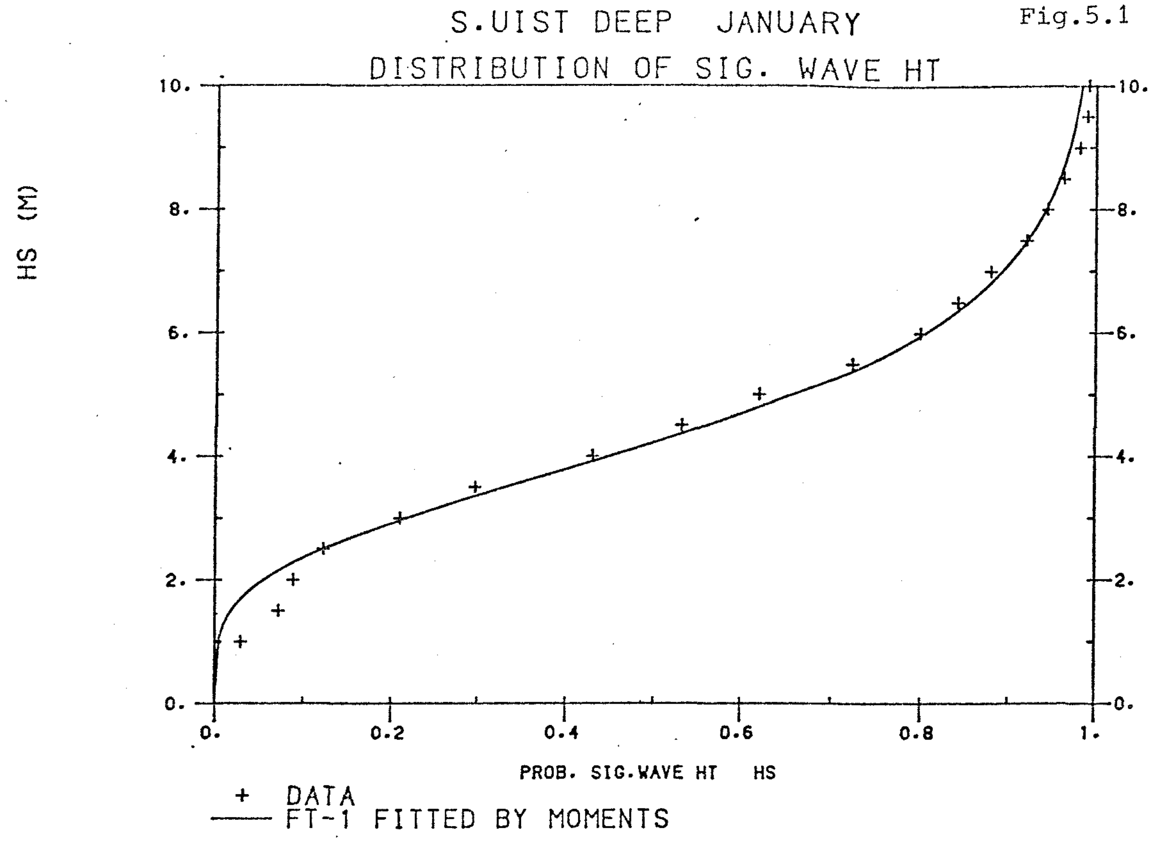

S.UIST DEEP JANUARY
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
2.
4.
6.
8.
10.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.1

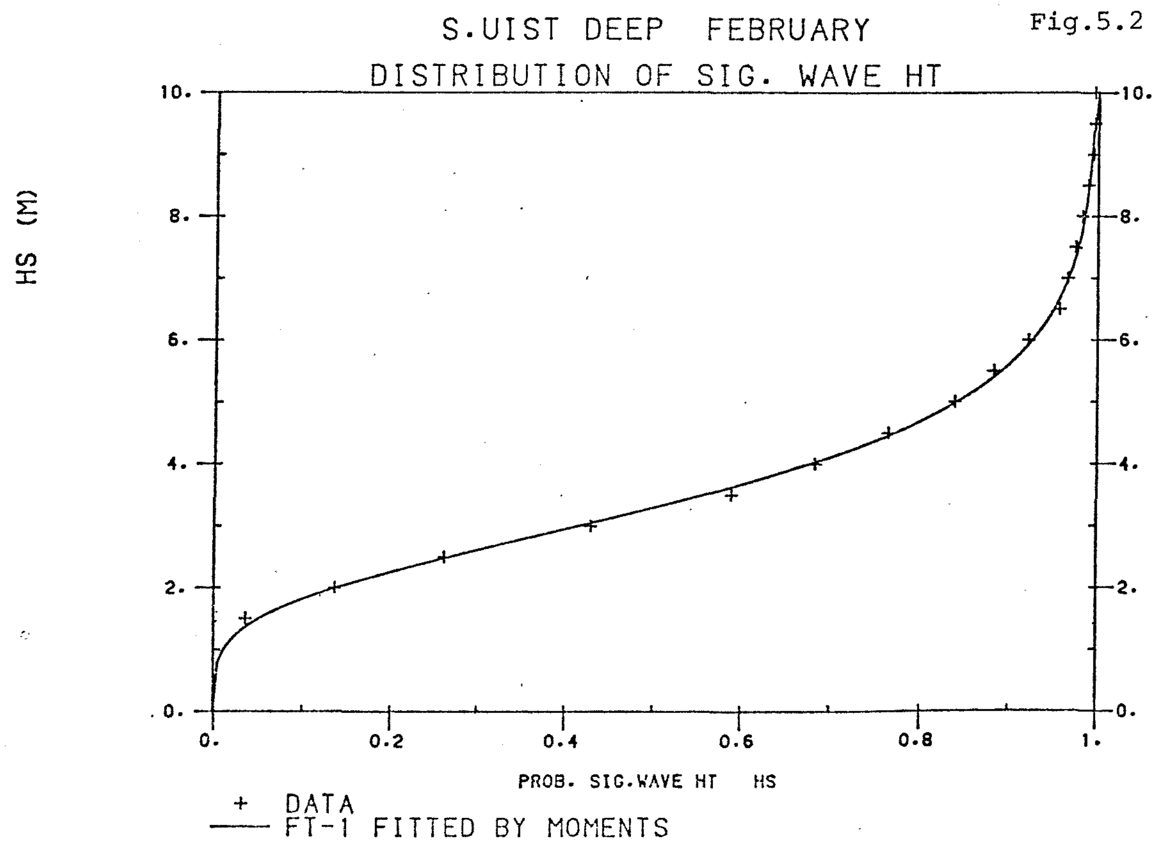

S.UIST DEEP FEBRUARY
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
2.
4.
6.
8.
10.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.2

Fig.5.3

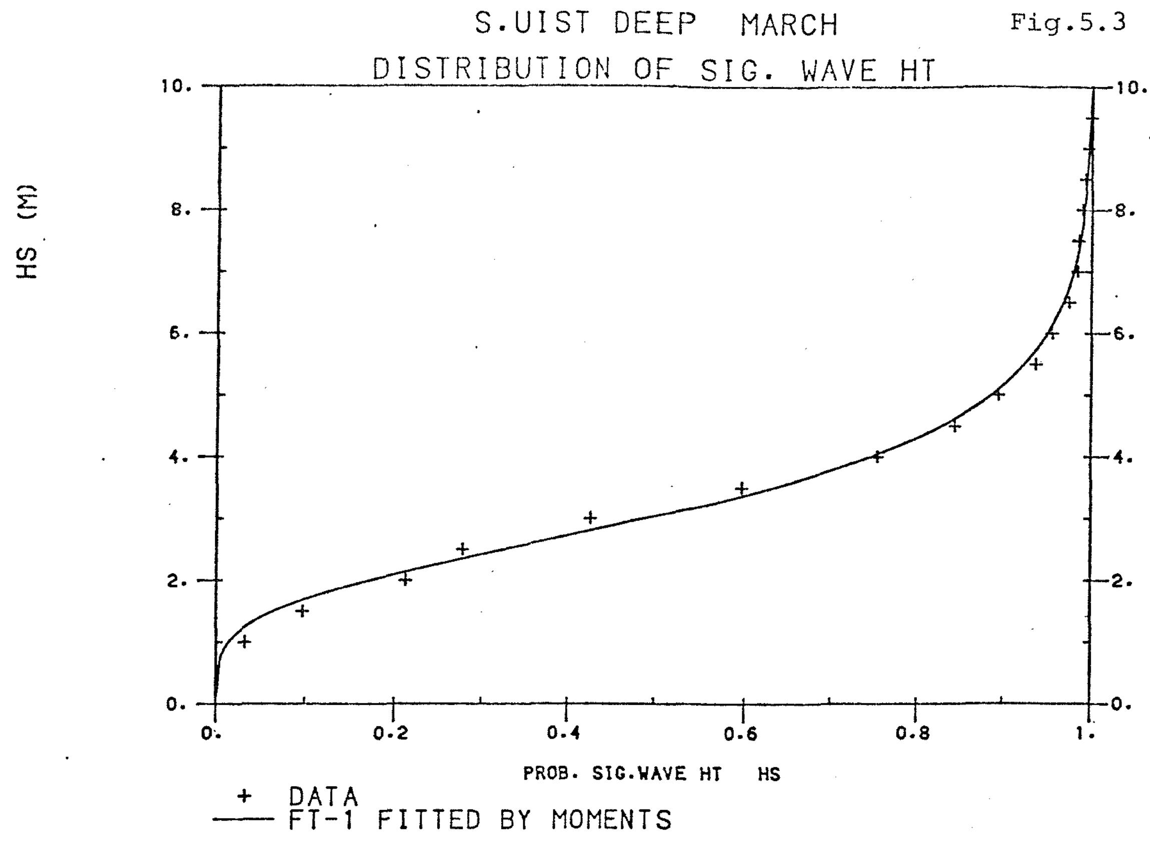
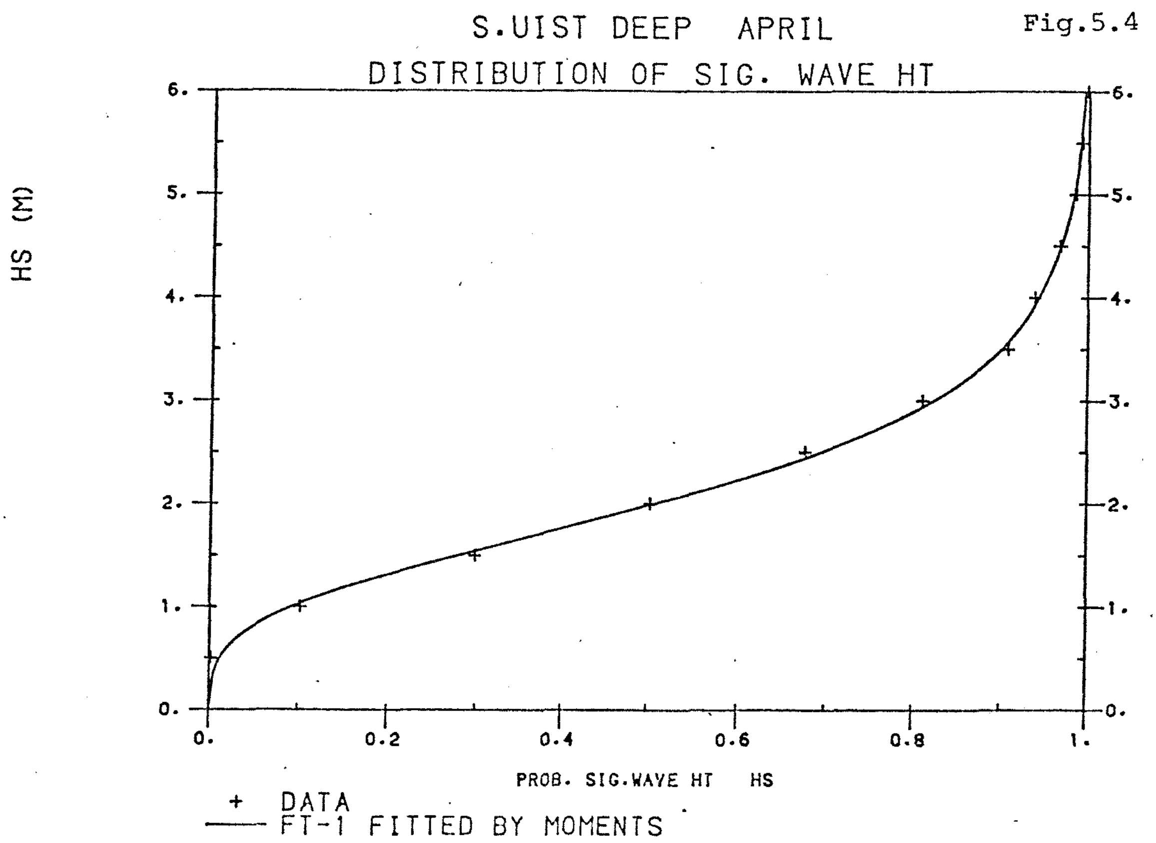

S.UIST DEEP MARCH
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
2.
4.
6.
8.
10.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.4


S.UIST DEEP APRIL
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
1.
2.
3.
4.
5.
6.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

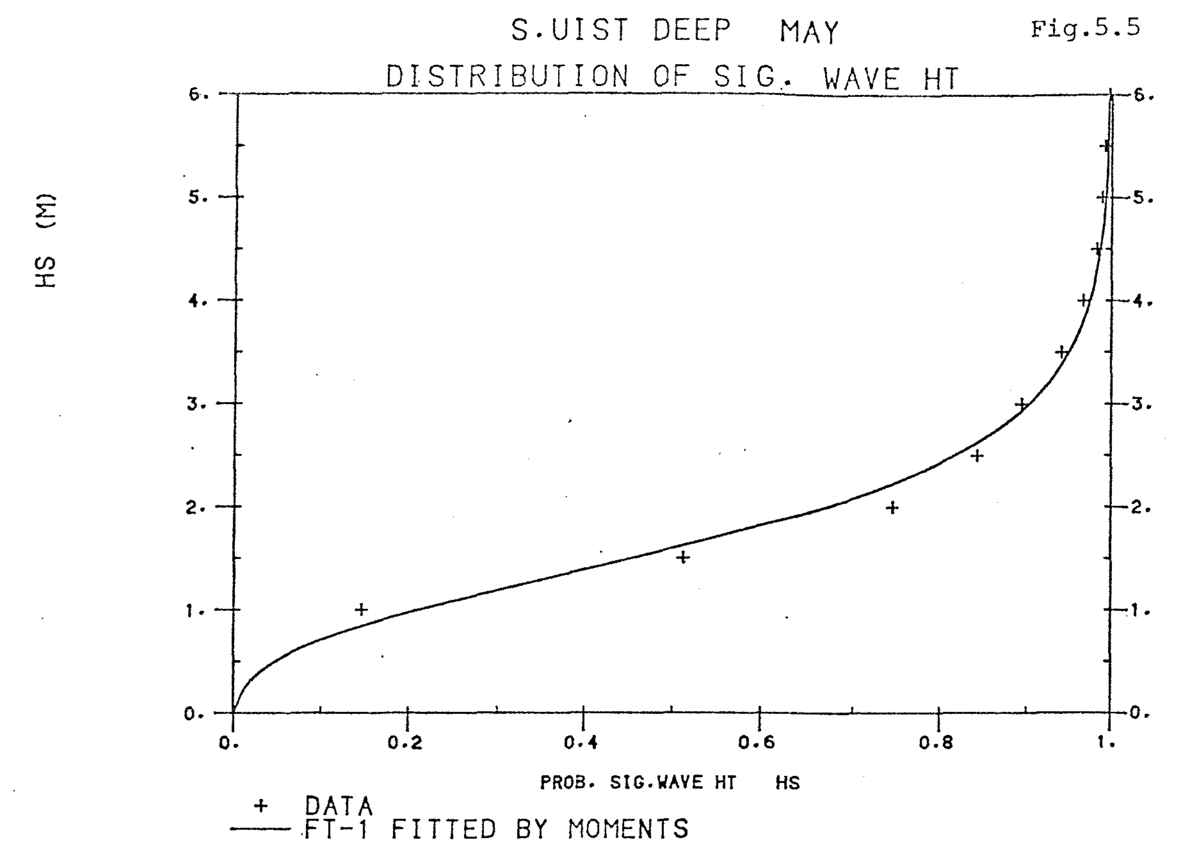

S.UIST DEEP MAY
DISTRIBUTION OF SIG. WAVE HT
HS (M)
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.5

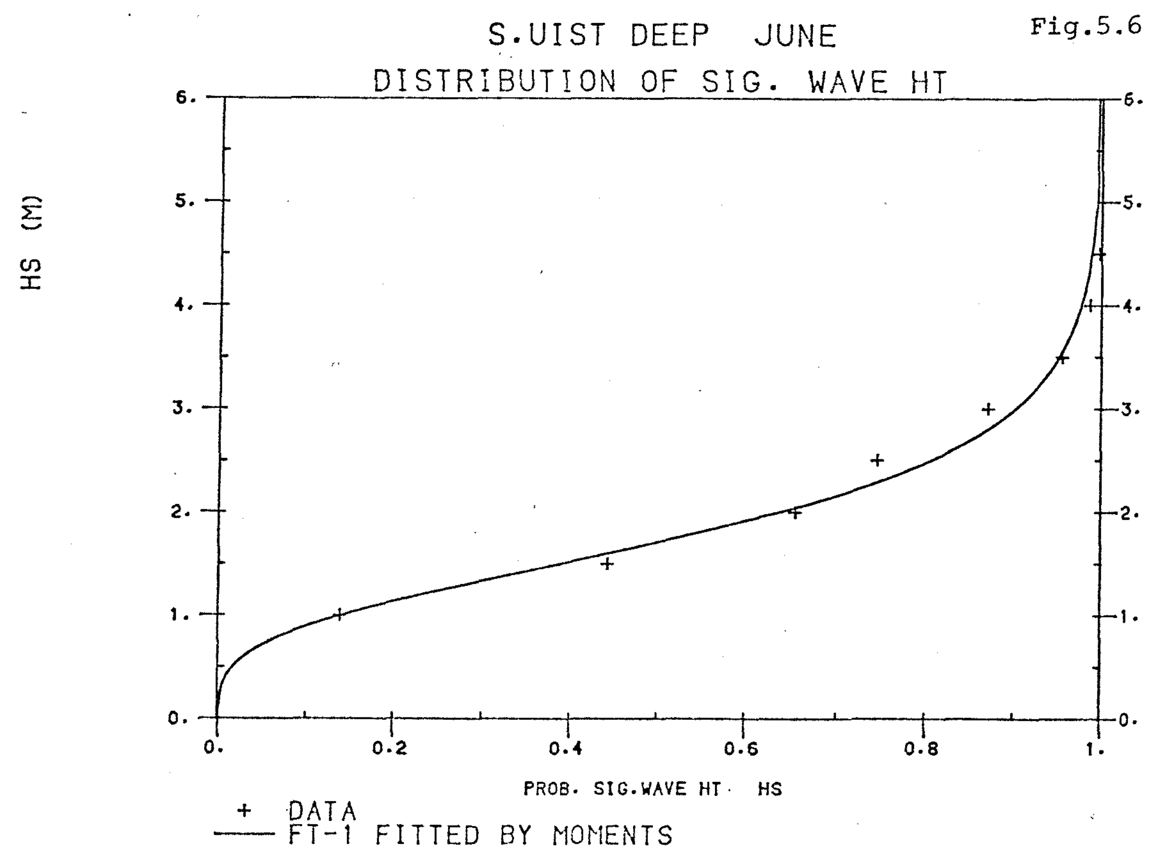

S.UIST DEEP JUNE
DISTRIBUTION OF SIG. WAVE HT
HS (M)
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.6

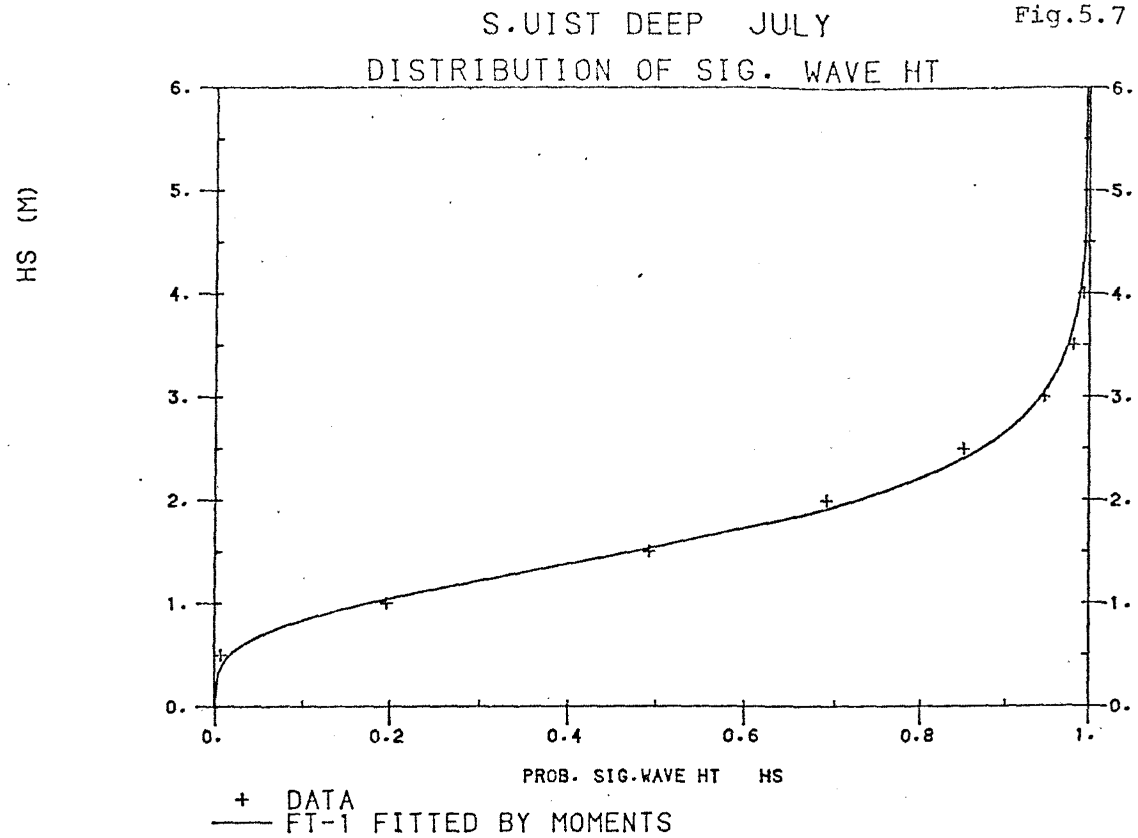

S.UIST DEEP JULY
DISTRIBUTION OF SIG. WAVE HT
HS (M)
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.7

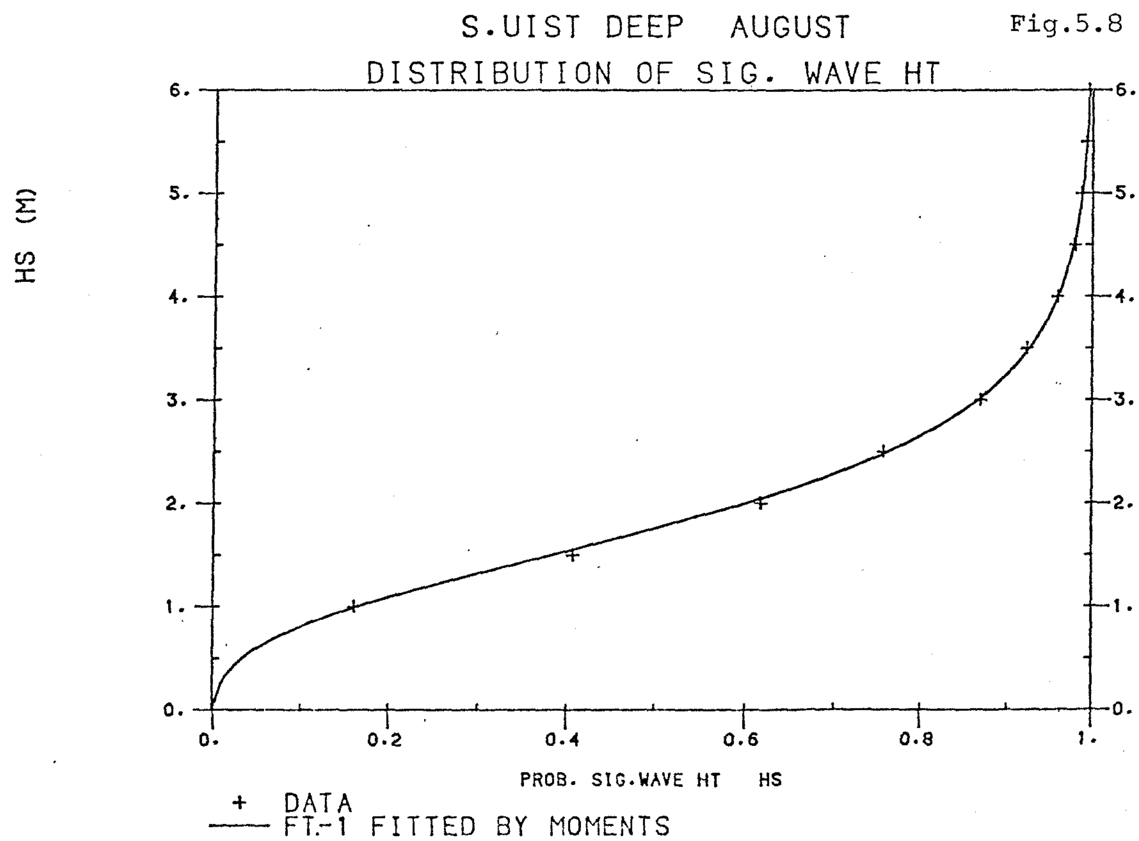
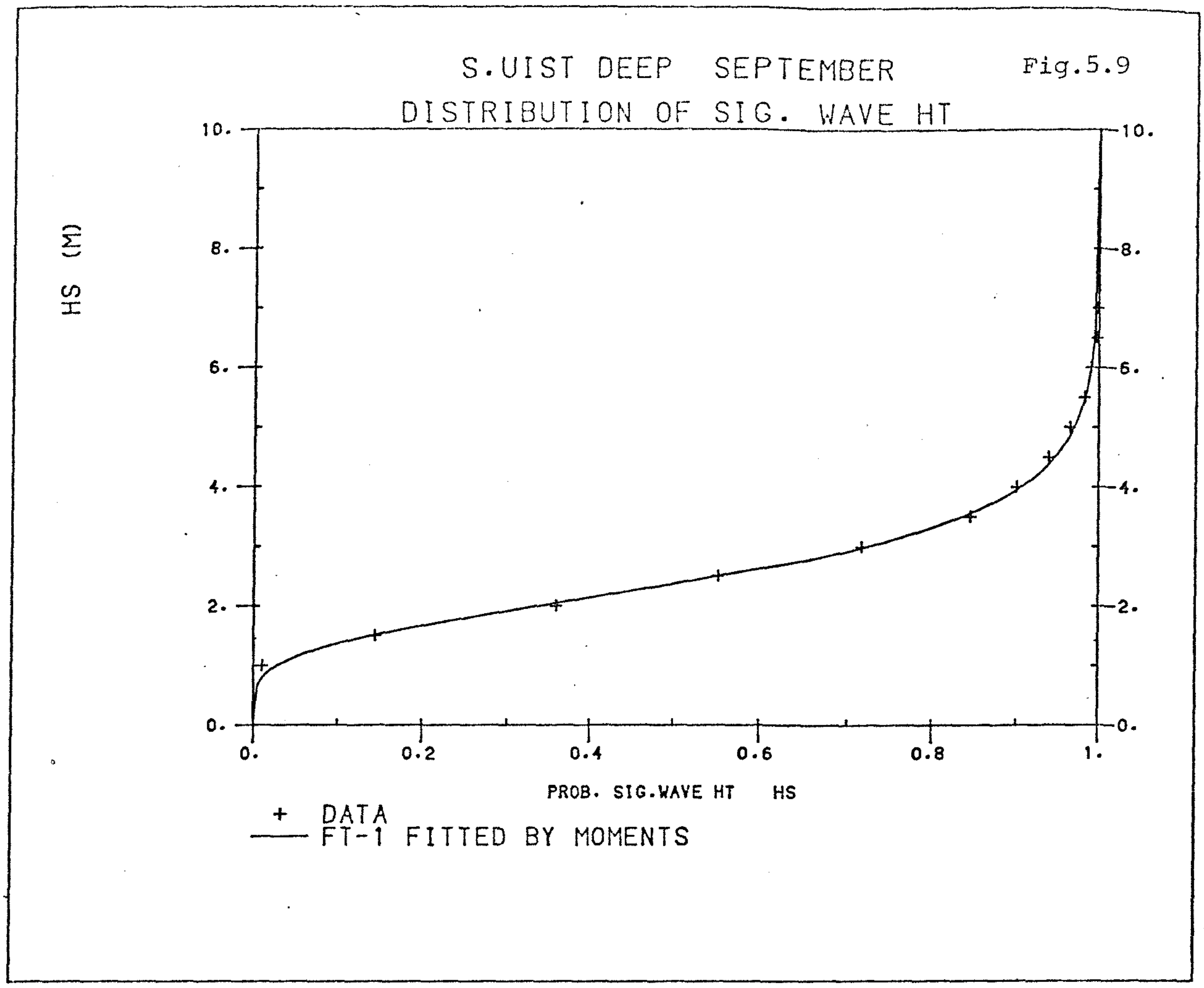

S.UIST DEEP AUGUST
DISTRIBUTION OF SIG. WAVE HT
HS (M)
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.8


S.UIST DEEP SEPTEMBER
Fig.5.9
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
2.
4.
6.
8.
10.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

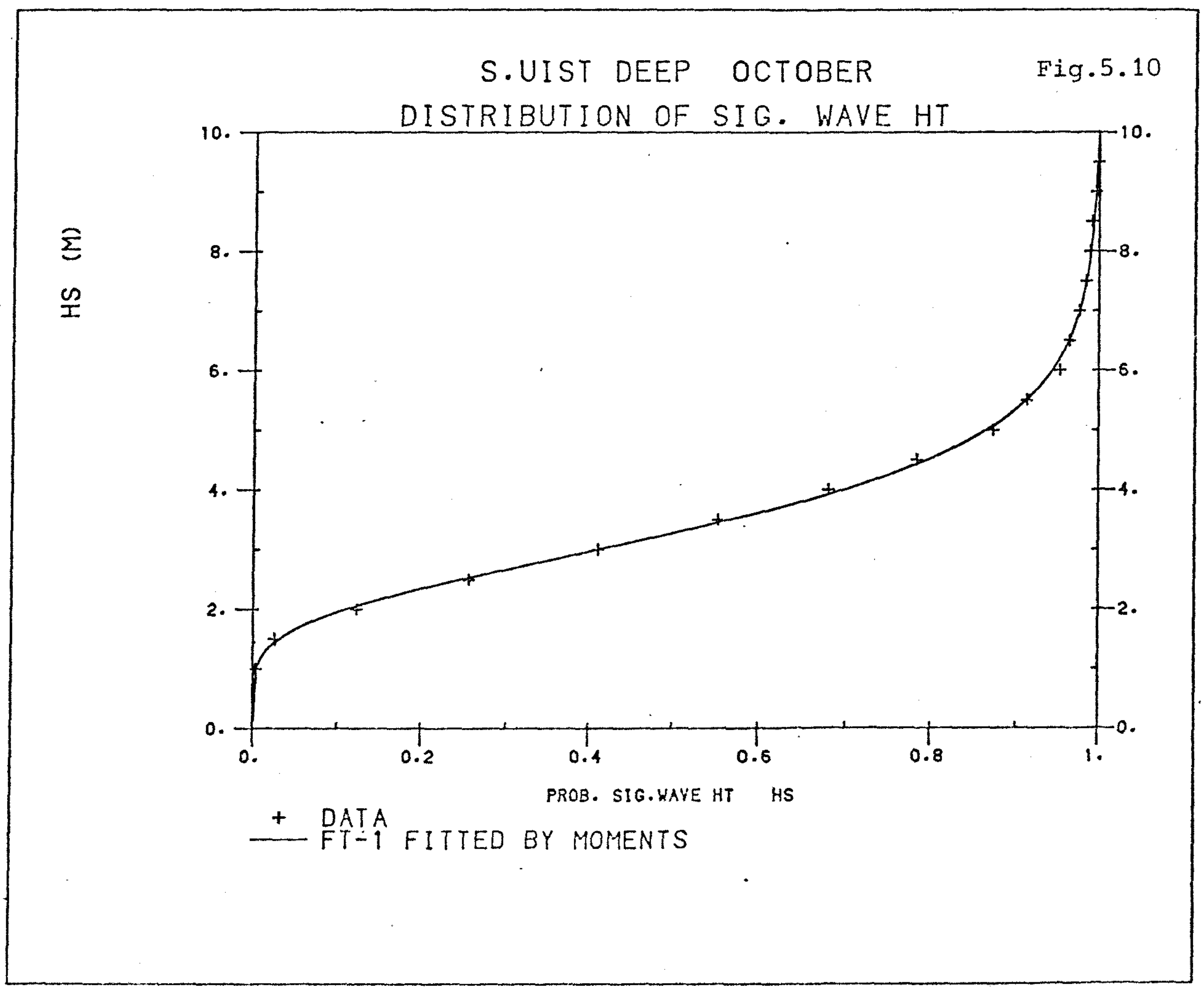

S.UIST DEEP OCTOBER
Fig.5.10
DISTRIBUTION OF SIG. WAVE HT
HS (M)
0.
2.
4.
6.
8.
10.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.5.11

S.UIST DEEP NOVEMBER
DISTRIBUTION OF SIG. WAVE HT

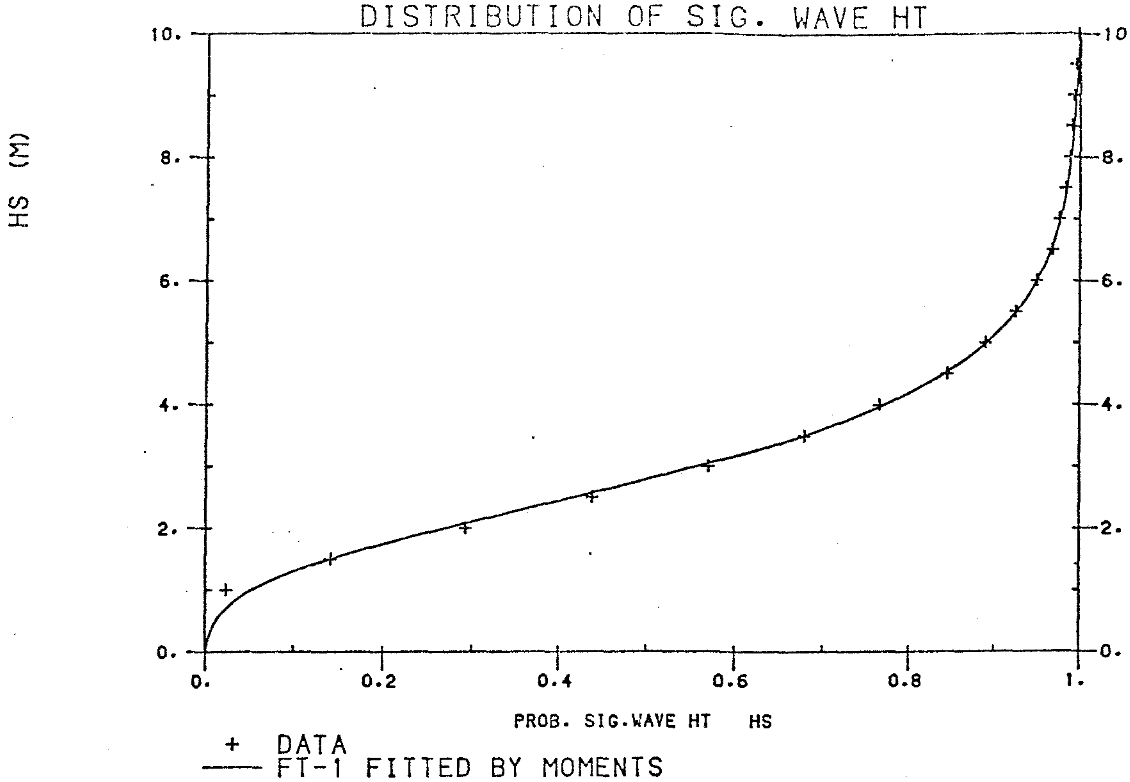
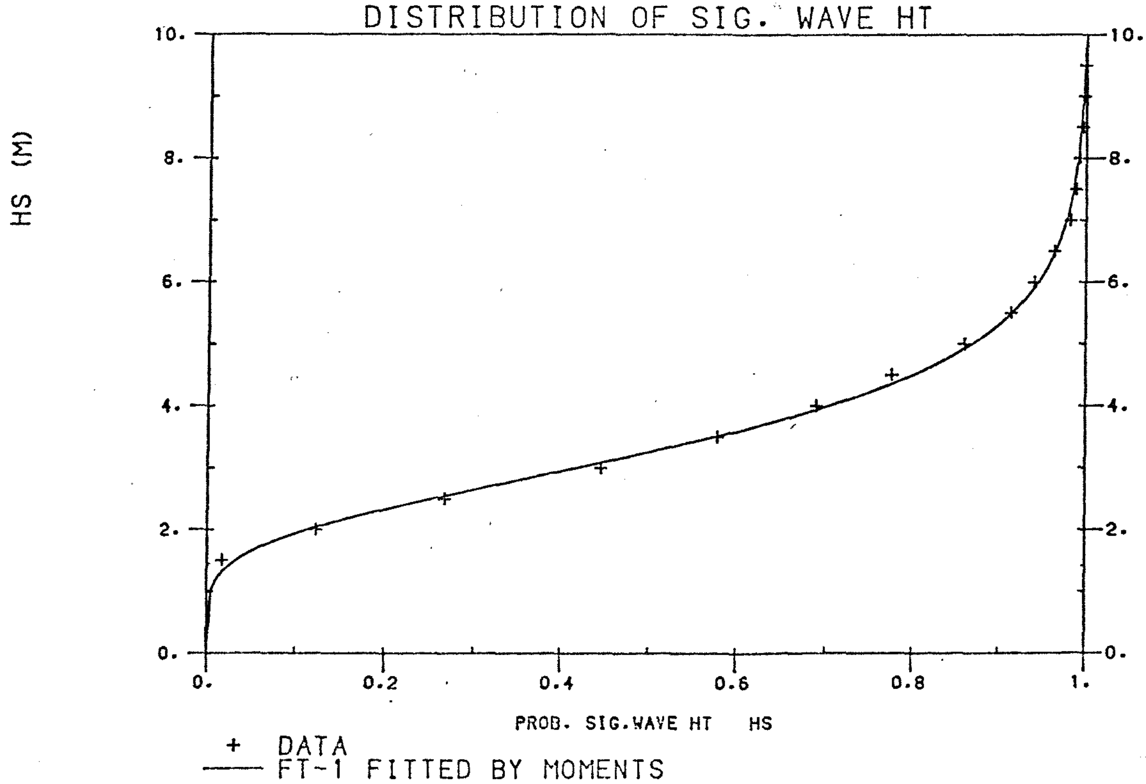
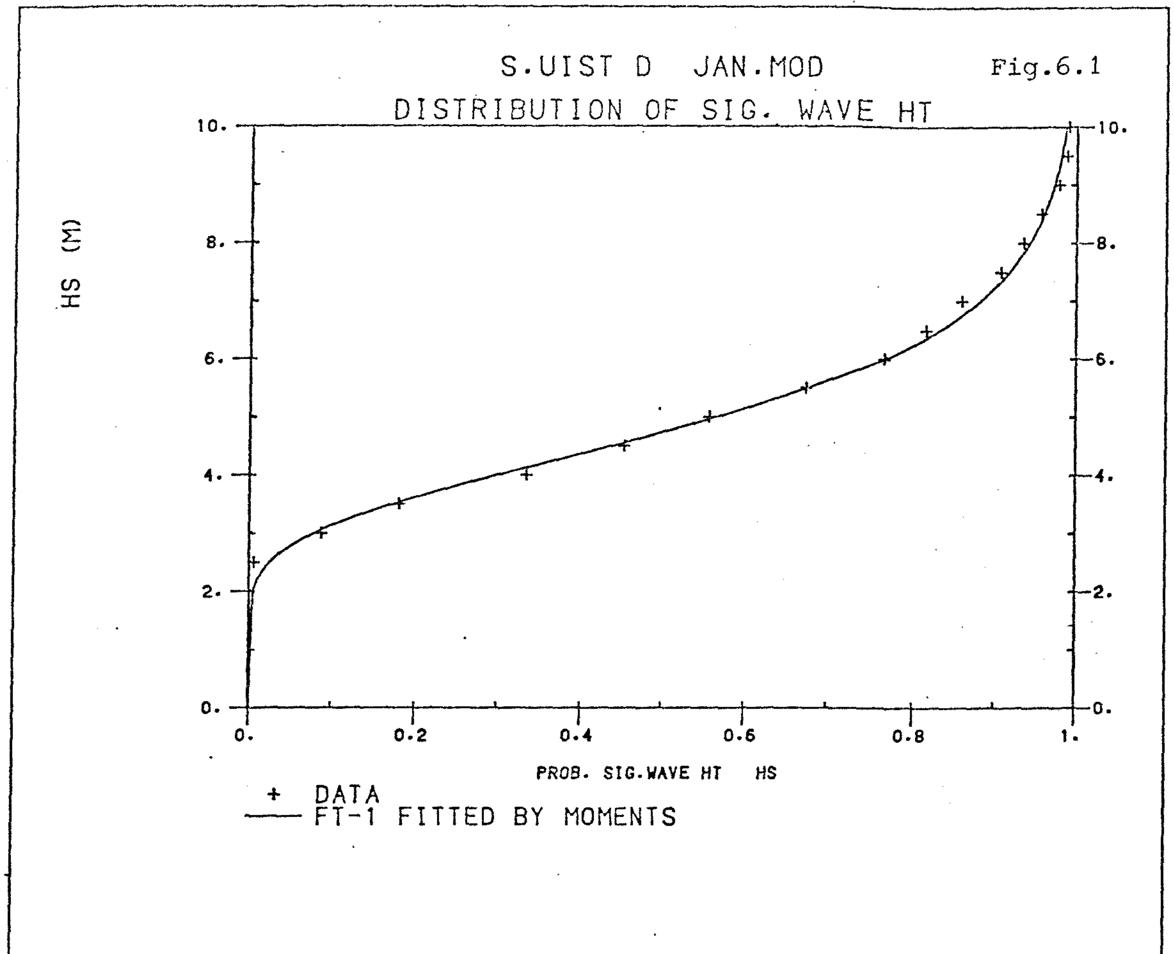


Fig.5.12

S.UIST DEEP DECEMBER
DISTRIBUTION OF SIG. WAVE HT




S.UIST D JAN.MOD
Fig.6.1
DISTRIBUTION OF SIG. WAVE HT
HS (M)
10.
8.
6.
4.
2.
0.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

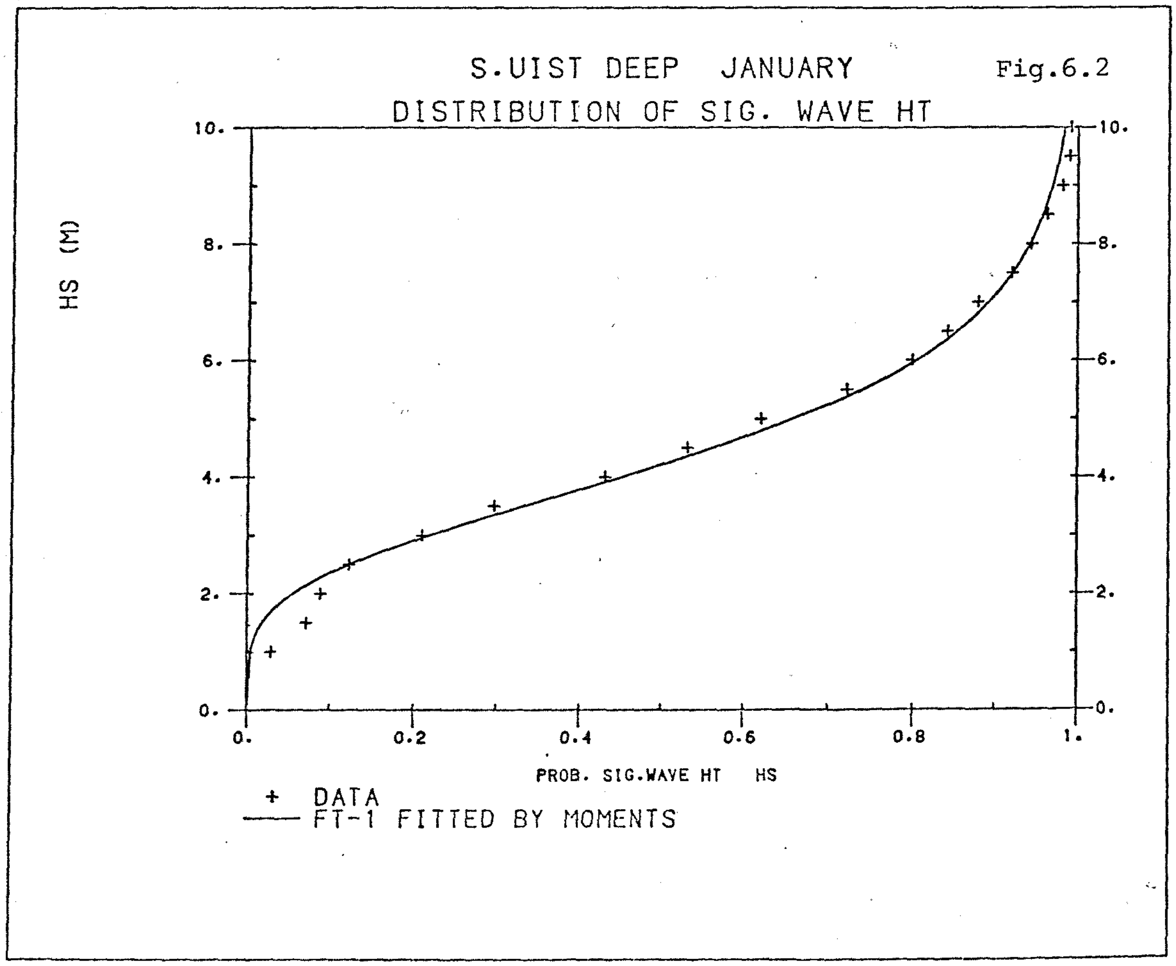

S.UIST DEEP JANUARY
Fig.6.2
DISTRIBUTION OF SIG. WAVE HT
HS (M)
10.
8.
6.
4.
2.
0.
0.
0.2
0.4
0.6
0.8
1.
PROB. SIG.WAVE HT HS
+ DATA
FT-1 FITTED BY MOMENTS

Fig.7

S.UIST DEEP AUG'80 - MAR'85
DISTRIBUTION OF WAVE PERIOD

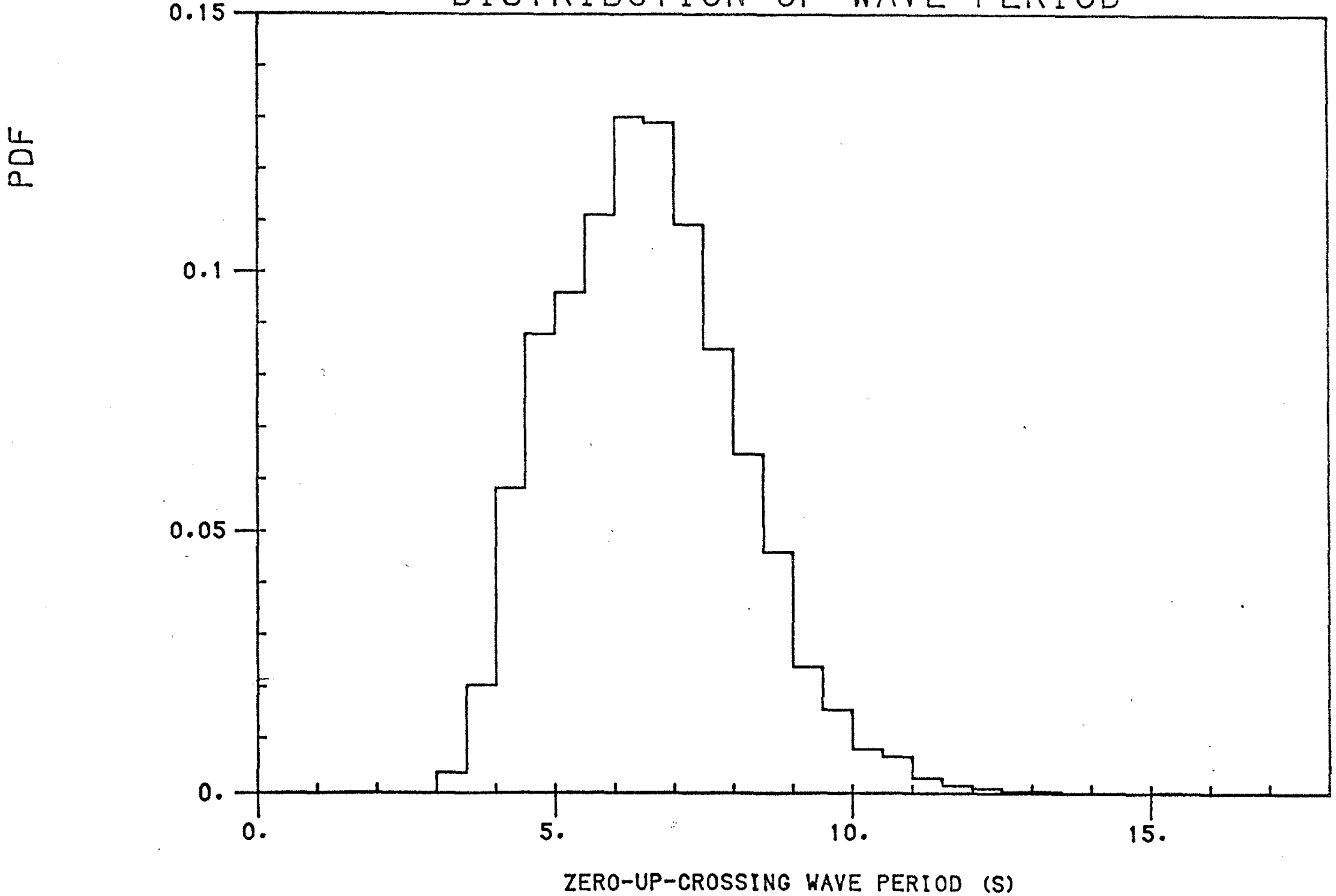


Fig.8.1

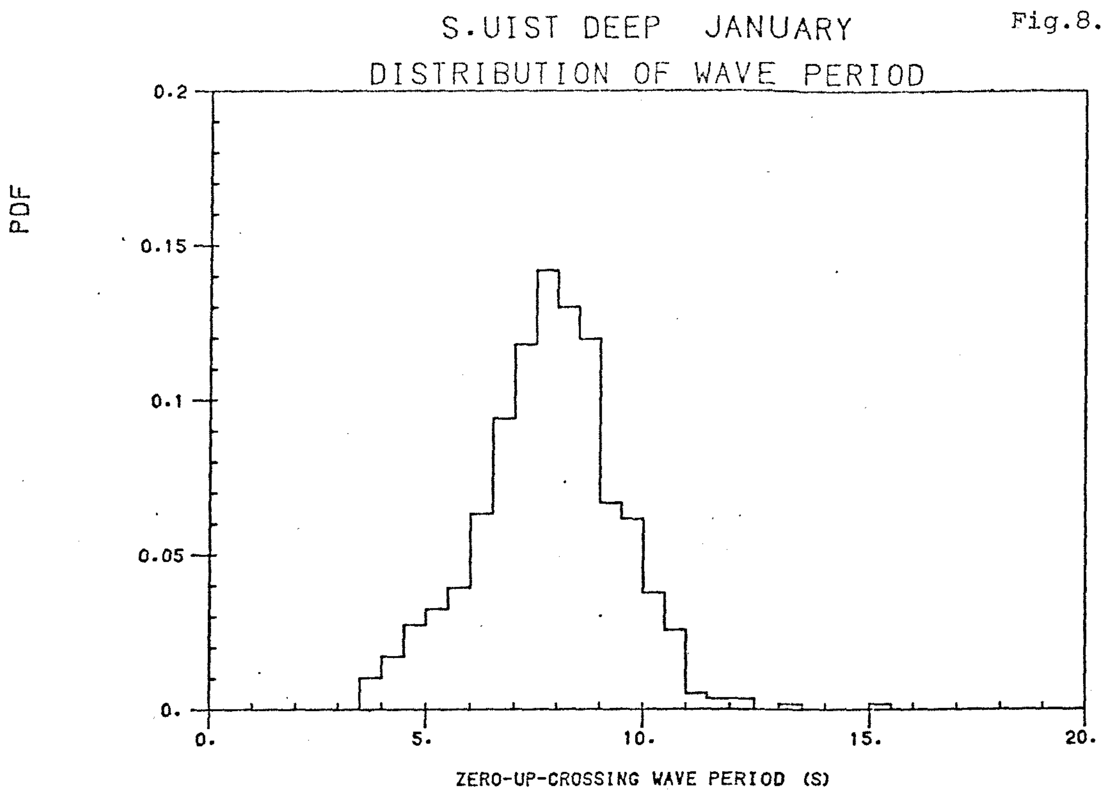

S.UIST DEEP JANUARY
DISTRIBUTION OF WAVE PERIOD
PDF
0.2
0.15
0.1
0.05
0.
0.
5.
10.
15.
20.
ZERO-UP-CROSSING WAVE PERIOD (S)

Fig.8.2

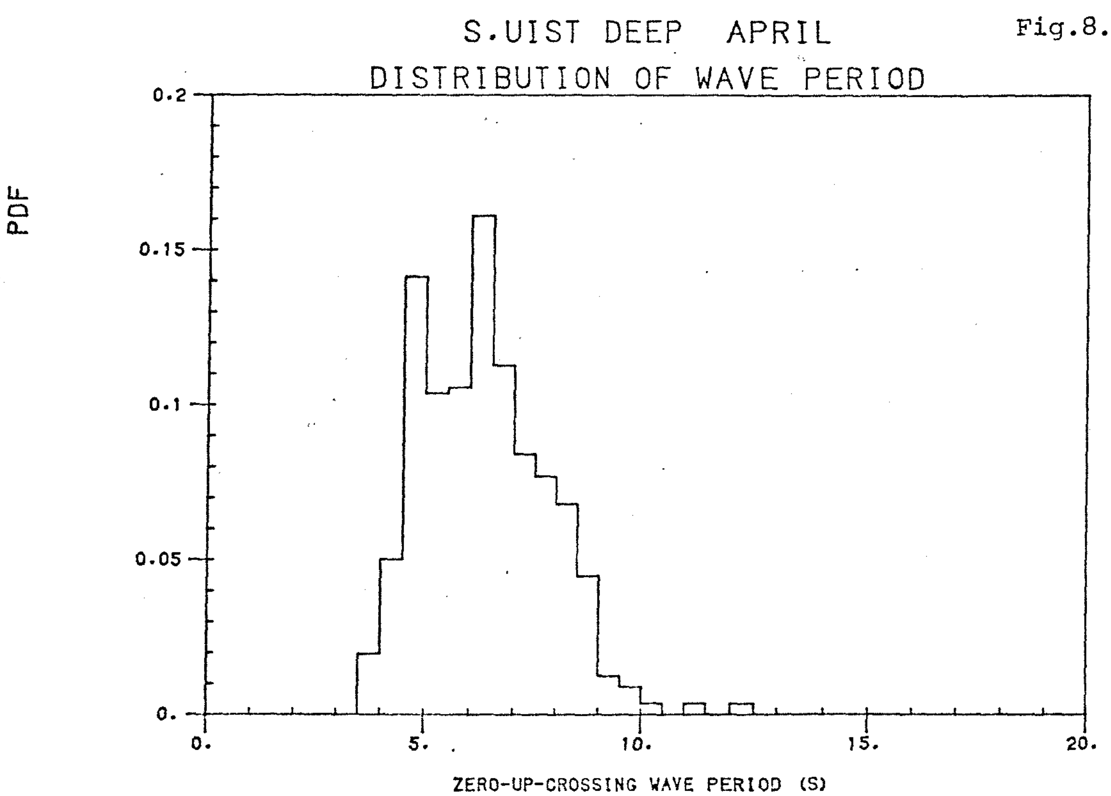

S.UIST DEEP APRIL
DISTRIBUTION OF WAVE PERIOD
PDF
0.2
0.15
0.1
0.05
0.
0.
5.
10.
15.
20.
ZERO-UP-CROSSING WAVE PERIOD (S)

Fig.8.3

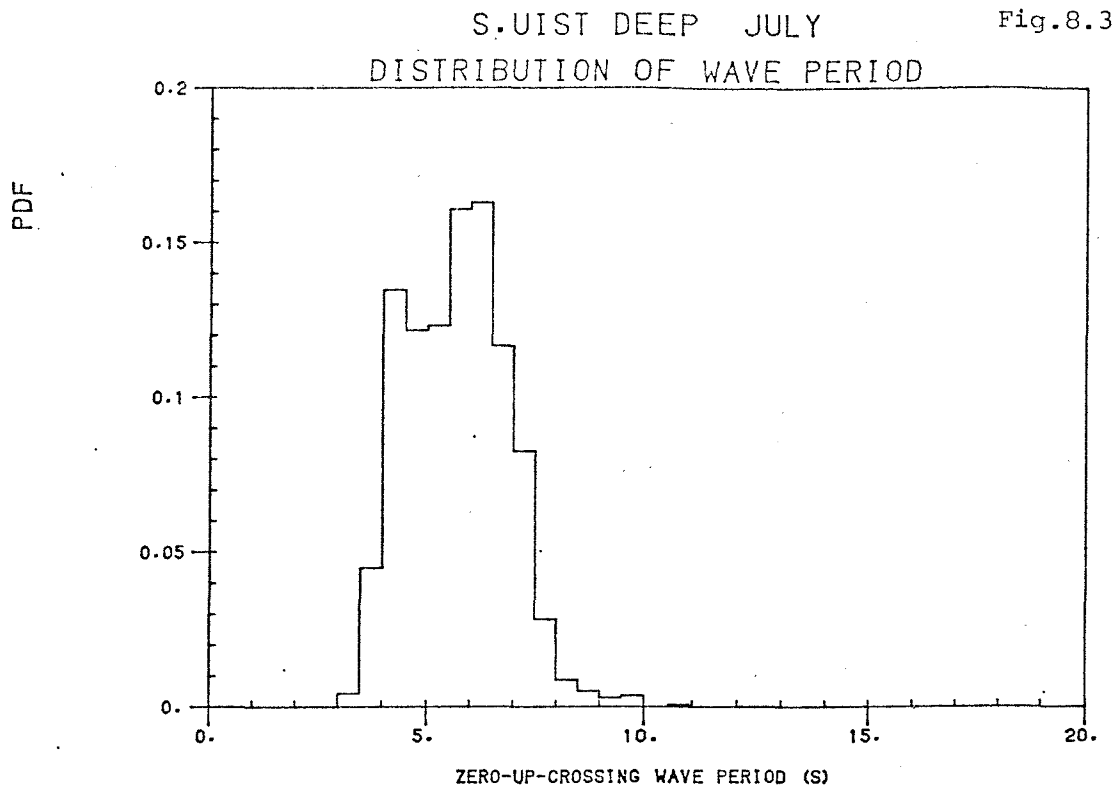

S.UIST DEEP JULY
DISTRIBUTION OF WAVE PERIOD
PDF
0.2
0.15
0.1
0.05
0.
0.
5.
10.
15.
20.
ZERO-UP-CROSSING WAVE PERIOD (S)

Fig.8.4

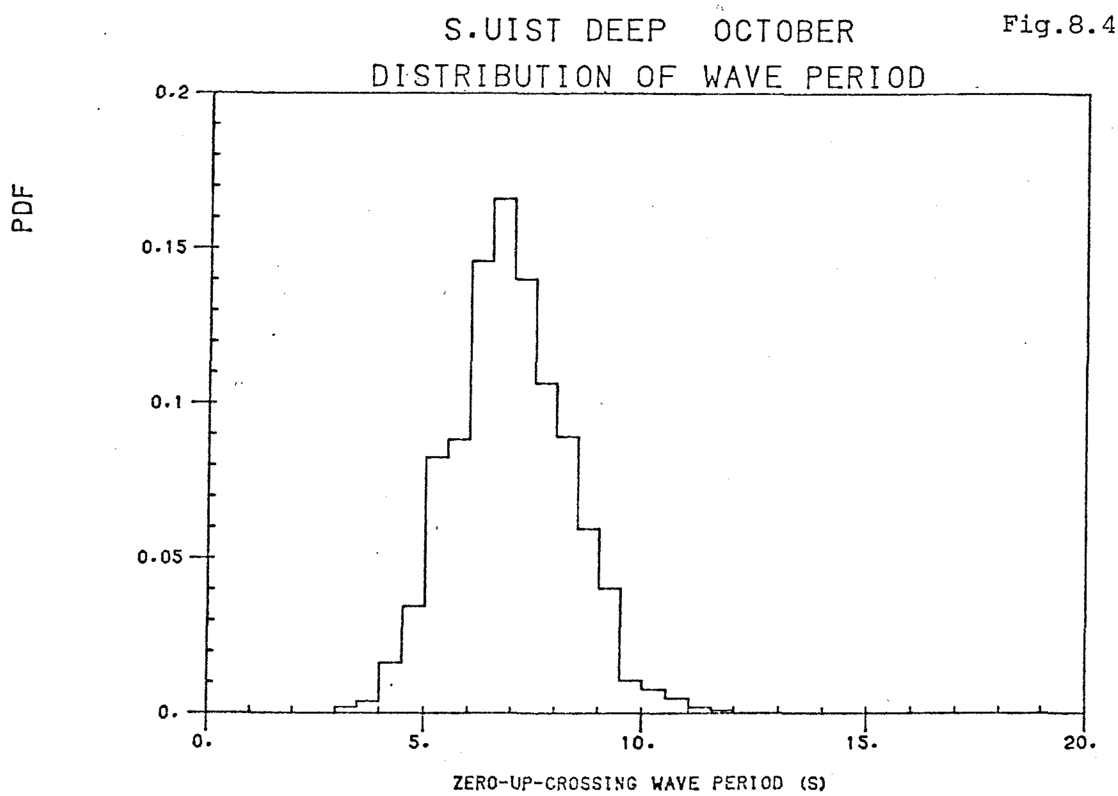

S.UIST DEEP OCTOBER
DISTRIBUTION OF WAVE PERIOD
PDF
0.2
0.15
0.1
0.05
0.
0.
5.
10.
15.
20.
ZERO-UP-CROSSING WAVE PERIOD (S)

Fig.9.1

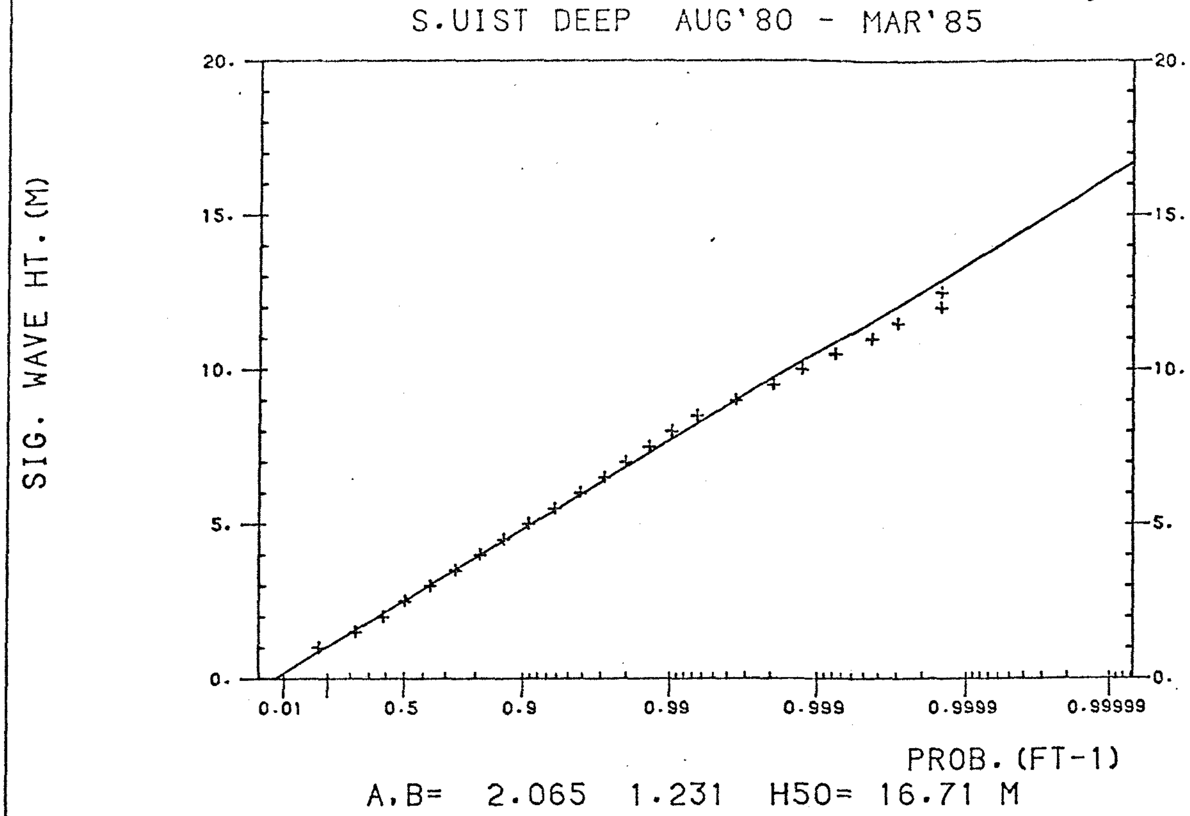

S.UIST DEEP AUG'80 - MAR'85
SIG. WAVE HT. (M)
20.
15.
10.
5.
0.
0.01
0.5
0.9
0.99
0.999
0.9999
0.99999
PROB. (FT-1)
A,B= 2.065 1.231 H50= 16.71 M

Fig.9.2

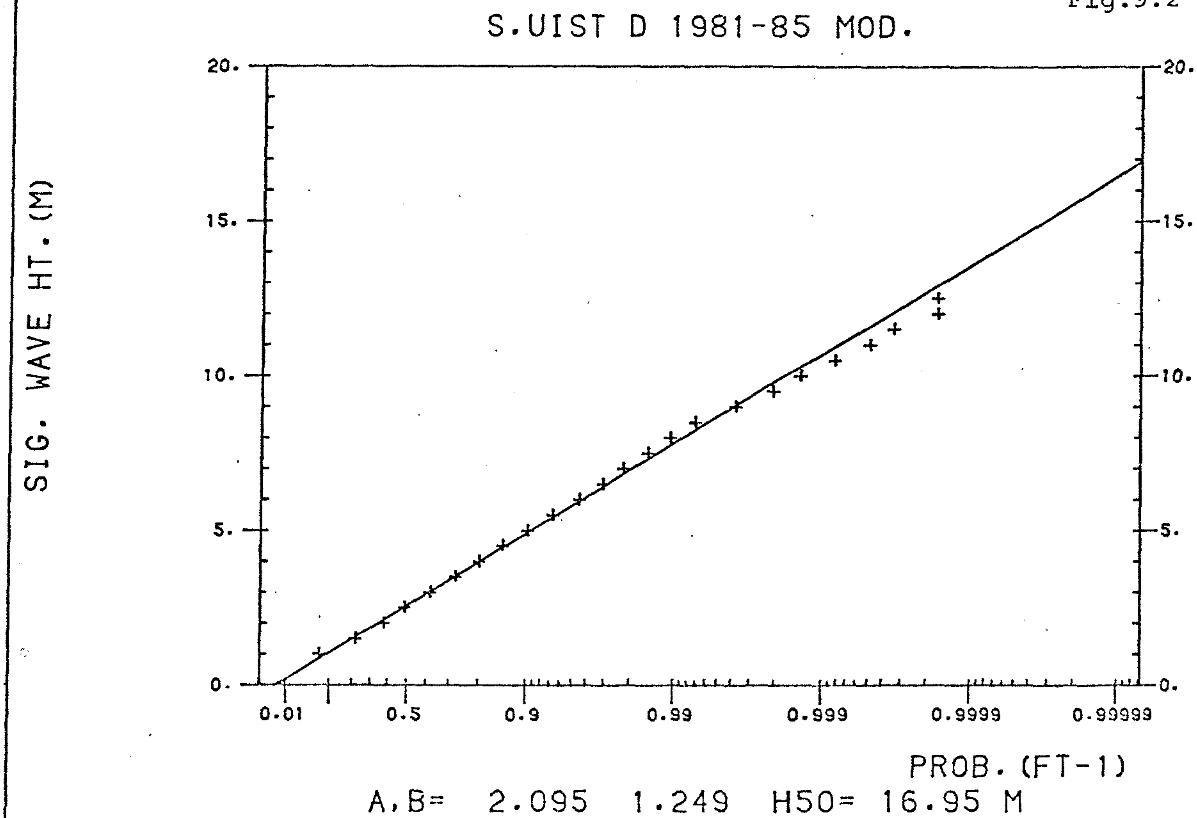

S.UIST D 1981-85 MOD.
SIG. WAVE HT. (M)
20.
15.
10.
5.
0.
0.01
0.5
0.9
0.99
0.999
0.9999
0.99999
PROB. (FT-1)
A,B= 2.095 1.249 H50= 16.95 M

Fig.9.3

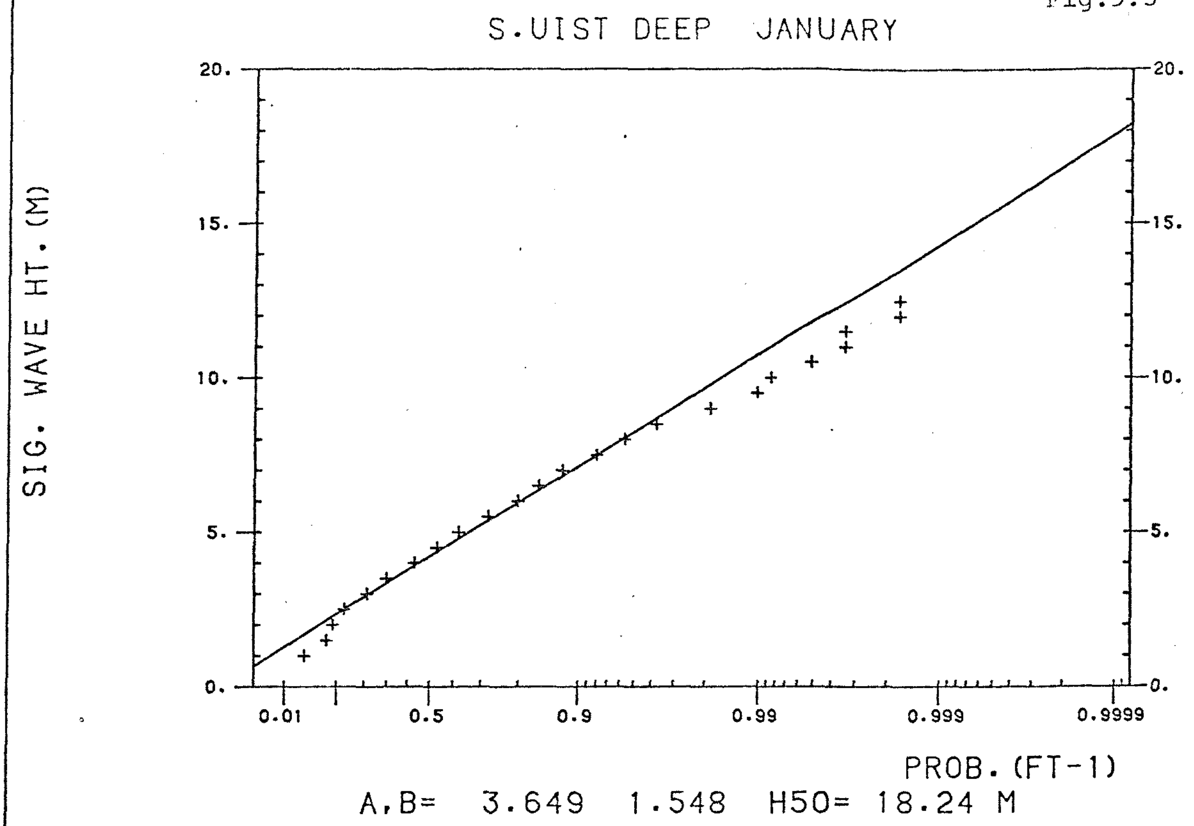

S.UIST DEEP JANUARY
SIG. WAVE HT. (M)
20.
15.
10.
5.
0.
0.01
0.5
0.9
0.99
0.999
0.9999
PROB. (FT-1)
A,B= 3.649 1.548 H50= 18.24 M

Fig.9.4

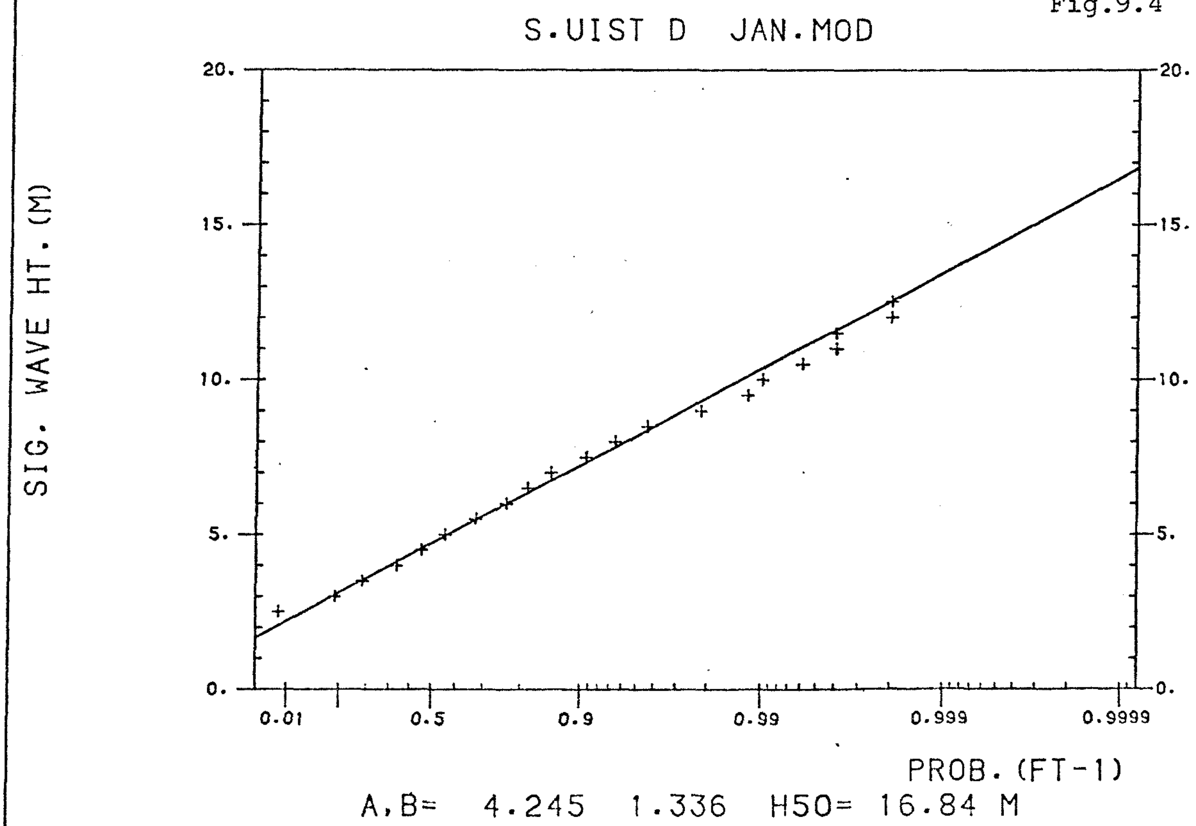
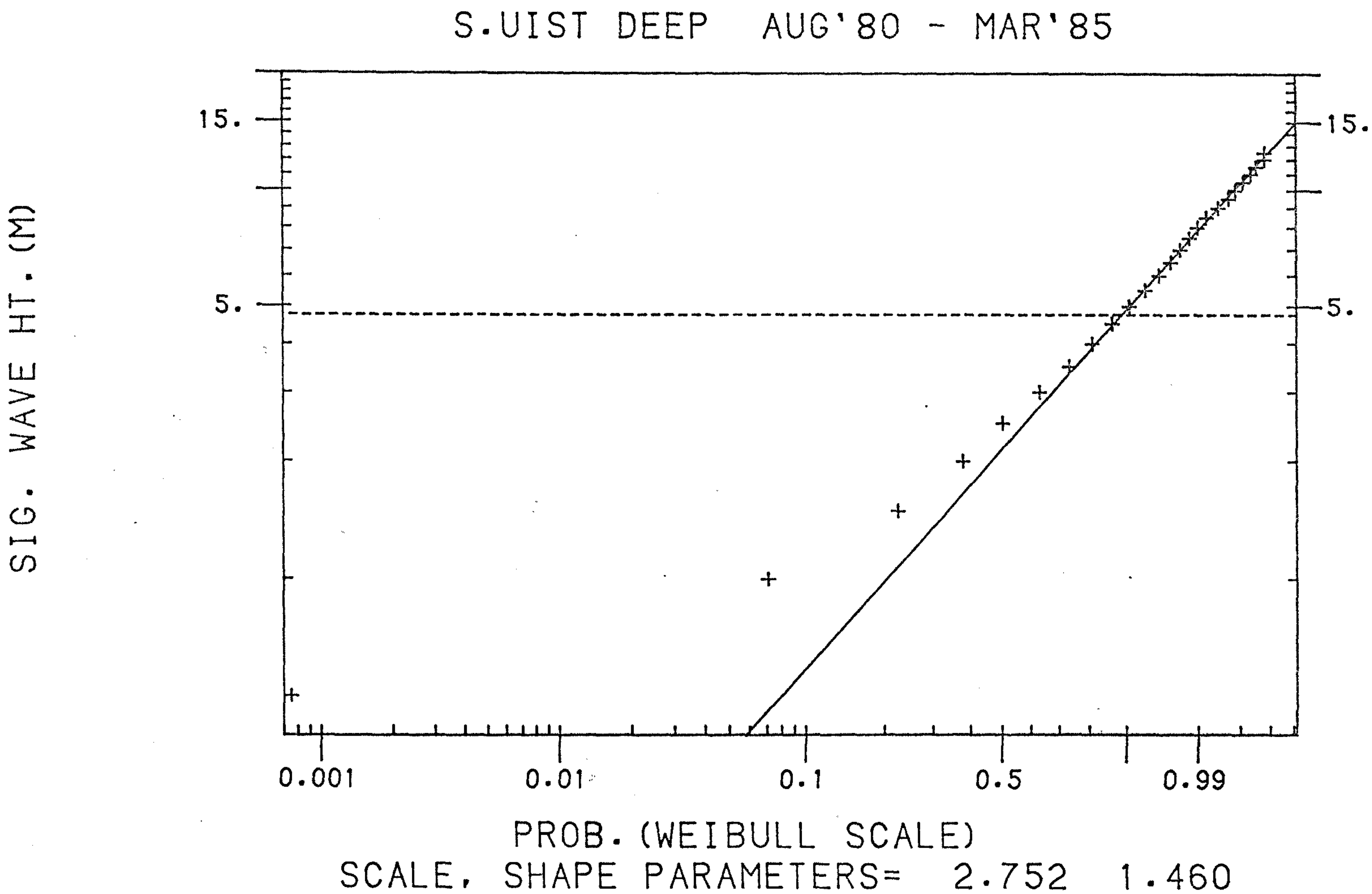
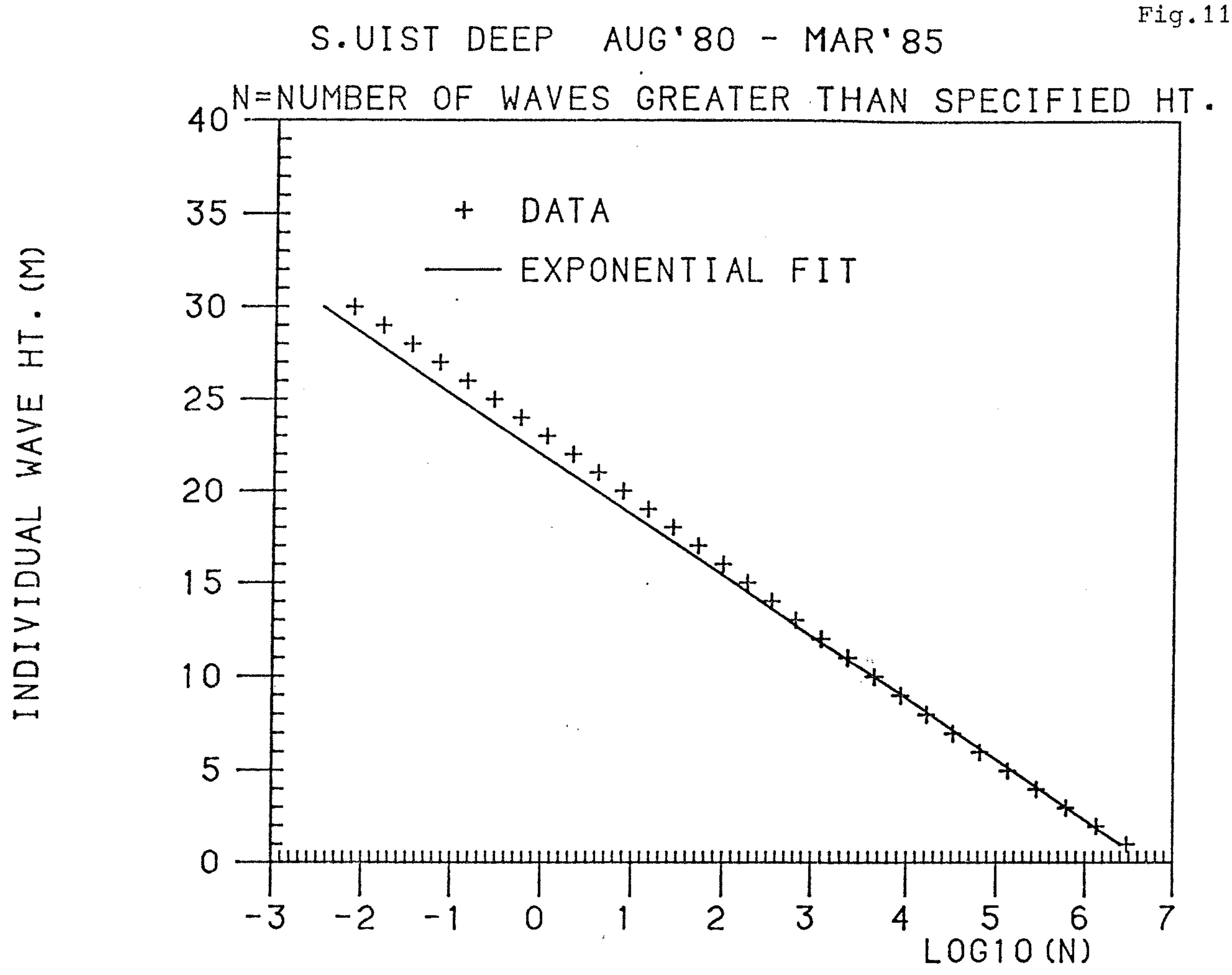

S.UIST D JAN.MOD
SIG. WAVE HT. (M)
20.
15.
10.
5.
0.
0.01
0.5
0.9
0.99
0.999
0.9999
PROB. (FT-1)
A,B= 4.245 1.336 H50= 16.84 M

Fig.10



S.UIST DEEP AUG'80 - MAR'85
SIG. WAVE HT. (M)
15.
5.
0.001
0.01
0.1
0.5
0.99
PROB. (WEIBULL SCALE)
SCALE, SHAPE PARAMETERS= 2.752 1.460

Fig.11


S.UIST DEEP AUG'80 - MAR'85
N=NUMBER OF WAVES GREATER THAN SPECIFIED HT.
+ DATA
EXPONENTIAL FIT
INDIVIDUAL WAVE HT. (M)
0
5
10
15
20
25
30
35
40
-3
-2
-1
0
1
2
3
4
5
6
7
LOG10 (N)