

532.54(282.6Th)

**NATIONAL INSTITUTE OF OCEANOGRAPHY**

**WORMLEY, GODALMING, SURREY**

---

**Waves at Tongue Light Vessel,  
outer Thames Estuary**

by

**L. DRAPER and EILEEN G. DOBELL**

N.I.O. INTERNAL REPORT No. A. 49

---

**AUGUST 1971**

LIBRARY

Natural Environment Research Council  
**UNIT OF COASTAL SCIENTIFICATION**  
Beadon Road, Taunton, Somerset  
Telephone: 0325 82991      Telex: 46274

653

NATIONAL INSTITUTE OF OCEANOGRAPHY

Wormley, Godalming, Surrey.

---

Waves at the Tongue Light Vessel,  
outer Thames Estuary

by

L. Draper and Eileen G. Dobell

N.I.O. Internal Report No. A.49

---

August 1971

## CONTENTS

	Page
Description of the investigation	1
Discussion of results	2
Acknowledgements	3
References	4

### Figures:

	Figures
Wave Height Exceedance	
Winter	1
Spring	2
Summer	3
Autumn	4
Wave Period Occurrence	
Winter	5
Spring	6
Summer	7
Autumn	8
Spectral Width Parameter Occurrence	Whole Year
Scatter Diagram	Whole Year
Persistence Diagram	Whole Year
'Lifetime' Wave Height Prediction Graph	12

Waves have been recorded by a Shipborne Wave Recorder (Tucker, 1956) placed on the Tongue Light Vessel which is stationed in the outer Thames Estuary in 7 fathoms of water 8 miles north of Margate. The records from one year of operation, from mid December 1965 to mid December 1966 have been analysed, mainly following the method of analysis developed by Tucker (1961) from theoretical studies by Cartwright and Longuet-Higgins (1956). The method of presentation is that recommended for data for engineering purposes (Draper, 1966).

Records were taken at three-hourly intervals, and the analysis yields the following parameters:

- (a)  $H_1$  = The sum of the distances of the highest crest and the lowest trough from the mean water level.
- (b)  $H_2$  = The sum of the distances of the second highest crest and the second lowest trough from the mean water level.
- (c)  $T_z$  = The mean zero-crossing period.
- (d)  $T_c$  = The mean crest period.

From these measured parameters the following parameters have been calculated, after allowing for instrumental response:

- (e)  $H_s$  = The significant wave height (mean height of the highest one-third of the waves): this is calculated separately from both  $H_1$  and  $H_2$ , and an average taken. The relationship between the parameters is  $H_1 = f(H_s)$  where  $f$  is a factor related to the number of zero-crossings in the records (Tucker, 1963). A similar relationship is used for the calculation of  $H_s$  from  $H_2$ .
- (f)  $H_{\max}$  (3 hours) = The most probable value of the height of the highest wave which occurred in the recording interval (Draper, 1963).
- (g)  $\epsilon$  = The spectral width parameter, which is calculated from  $T_z$  and  $T_c$  (Tucker, 1961):

$$\epsilon^2 = 1 - (T_c / T_z)^2$$

The results of these measurements are expressed graphically divided into seasons thus:

Winter:	January	February	March
Spring:	April	May	June
Summer:	July	August	September
Autumn:	October	November	December

For each season a graph (Figures 1 - 4) shows the cumulative distribution of significant wave height  $H_s$ , and of the most probably value of the height of the highest wave in the recording interval.  $H_{\max}$  (3 hours).

The distribution of zero-crossing period is given for each season (Figures 5 - 8).

The distribution of the spectral width parameter is given for the whole year (Figure 9).

Figure 10 is a scatter diagram relating significant wave height to zero-crossing period, for the whole year.

Figure 11 is a persistence diagram for the whole year.

Figure 12 is a 'Lifetime' wave height prediction graph.

### Discussion of Results

Because of the extensive areas of sandbanks around this location, and because the predominant wind direction is from the land, wave conditions in this area are not as severe as at Light Vessel stations such as Varne (N.I.O. Internal Report A.34) or Smith's Knoll (N.I.O. Internal Report A.33). The highest measured wave ( $H_1$ ) of 13.5 feet with a zero-crossing period of 5.7 seconds, occurred on 14th April, although waves almost as high occurred on 21st July, and at other times during the winter. There is little seasonal variation in either the wave period or spectral width parameter. The scatter diagram of Figure 10 relates the significant wave height to zero-crossing period, with the numbers of occurrences expressed in parts per thousand; for example, the most common wave conditions were those with a significant height of between 2 and 3 feet and a zero-crossing period of between 3.5 and 4.5 seconds, which occurred for 146 thousandths, or 14.6 per cent, of the time. The rapid attenuation of the shorter waves with depth means that the pressure units, which are necessarily situated at about 4.9 feet below mean water level, do not record waves which have a period of less than about 3 seconds; this is the cause of the cut-off below that period. The figure 257 in the lower left-hand corner denotes the occurrence of calms, i.e., 25.7% of the time.

A parameter which is sometimes of interest is the wave steepness, expressed as wave height: wave length; it may also be expressed as a decimal number. It should be noted that the steepness of a wave is not the same as the maximum slope of the water surface during the passage of a wave. Lines of constant steepness of 1 : 20 and 1 : 40 are drawn on Figure 10. (In this case, steepness relates to significant wave height: wave length calculated from the zero-crossing period). An important feature of this analysis is the number of waves with high values of steepness, which would appear to result in the occurrence of individual waves steeper than that theoretically possible. The reason for this is almost certainly the presence of tidal currents, which can reach 1.7 knots, according to the Admiralty chart. As the vessel is anchored, when the current is flowing strongly in the same direction as the waves, the vessel behaves as though it were travelling through the water at a speed equal to that of the current, resulting in an encounter period shorter than the true wave period. The effect of this on the subsequent analysis is that the apparent period, and therefore the apparent wavelength, is shorter, giving increased steepness. The converse situation also applies when the tidal flow is reversed, resulting in a longer encounter period. The overall result of this effect is that there is a spread of apparent wave period introduced by the method of recording, but this is more important in its effect at shorter periods and nearly negligible at longer periods.

This effect also occurred, even more noticeably, at Varne Light Vessel in the Dover Strait, where currents up to 2.6 knots occur at spring tides (see N.I.O. Report A.34) and at Owers Light Vessel off Selsey Bill where

the currents achieve 2.8 knots. (See N.I.O. Report A.46).

From the persistence diagram, Figure 11, may be deduced the number and duration of the occasions in 1 year on which waves persisted at or above a given height. For example, if the limit for a particular operation of a vessel is a significant height of 4 feet, it would have been unable to operate for spells in excess of 10 hours on 40 occasions, or spells in excess of 20 hours on 13 occasions.

From Figure 12 may be estimated the most probable value of the height of the highest wave likely to occur in various long durations of time. For example, the graph suggests that the height of the highest wave in a fifty-year duration is likely to be about 23 feet.

Comparisons of wind conditions during the year in question with 'normal' conditions.

During the time in which wave measurements were made the wind records at Shoeburyness, the most appropriate meteorological station in the area, were rather more severe than the 11-year average. The mean wind speed was 14.1 knots, whilst the 11-year (1960-1970) average was 12.9 knots. The number of gale-hours was 81 compared with the average of 55. The figures are as follows:

Wind data Shoeburyness

Year	1960	61	62	63	64	65	66	67	68	69	70	11-year Mean
Mean Speed Knots	11.5	11.4	13.3	13.2	12.1	13.6	14.1	13.6	13.1	12.7	13.1	12.9
No. of hours of gale	10	38	113	75	65	76	81	73	35	16	25	55

From this it may be reasonable to deduce that the recorded wave heights were somewhat higher than average. If one accepts the Darbyshire coastal waters relationship where wave height is proportional to the wind speed to the power of 1.5, then the heights given in this report should be reduced by about 16% to achieve "average" conditions. Wave period is proportional to the square root of wind speed, and the data should be decreased by 5%. As the waters here are shallower than those to which this Darbyshire relationship applies, the reductions to the measured parameters should be used with caution.

Acknowledgements

The authors wish to thank the Elder Brethren of Trinity House for permission to install the equipment in the vessel, and to express their appreciation of the efforts of the Masters and Crew in taking the Records and the authors' colleague Mr. J.W. Cherriman in installing and maintaining the equipment.

The authors are indebted to Mr. H.C. Shellard of the Meteorological Office for the wind data.

REFERENCES

- CARTWRIGHT, D.E. and LONGUET-HIGGINS, M.S. 1956 The statistical distribution of the maxima of a random function. Proc. roy. Soc. A 237, 212-232.
- DRAPER, L. 1963 The derivation of a 'design-wave' from instrumental measurements of sea waves. Proc. Inst. civ. Engrs. 26, 291-304.
- DRAPER, L. 1966 The analysis and presentation of wave data - a plea for uniformity. Proc. 10 Conf. on Coastal Engineering, Tokyo, Chapters 1 and 2.
- DRAPER, L. 1968 Waves at Smith's Knoll Light Vessel, North Sea N.I.O. Internal Report A.33.
- DRAPER, L. and GRAVES, R. 1968 Waves at Varne Light Vessel Dover Strait. N.I.O. Internal Report A.34.
- TUCKER, M.J. 1956 A Shipborne Wave Recorder. Trans. Instn. nav. Archit. Lond. 98, 236-250.
- TUCKER, M.J. 1961 Simple measurement of wave records. Proc. Conf. Wave Recording for civ. Engrs. (N.I.O.) 22-3.
- TUCKER, M.J. 1963 Analysis of records of sea waves. Proc. Instn. civ. Engrs. 26, 304-316.

# PERCENTAGE EXCEEDANCE OF HS AND HMAX

WINTER - JANUARY TO MARCH

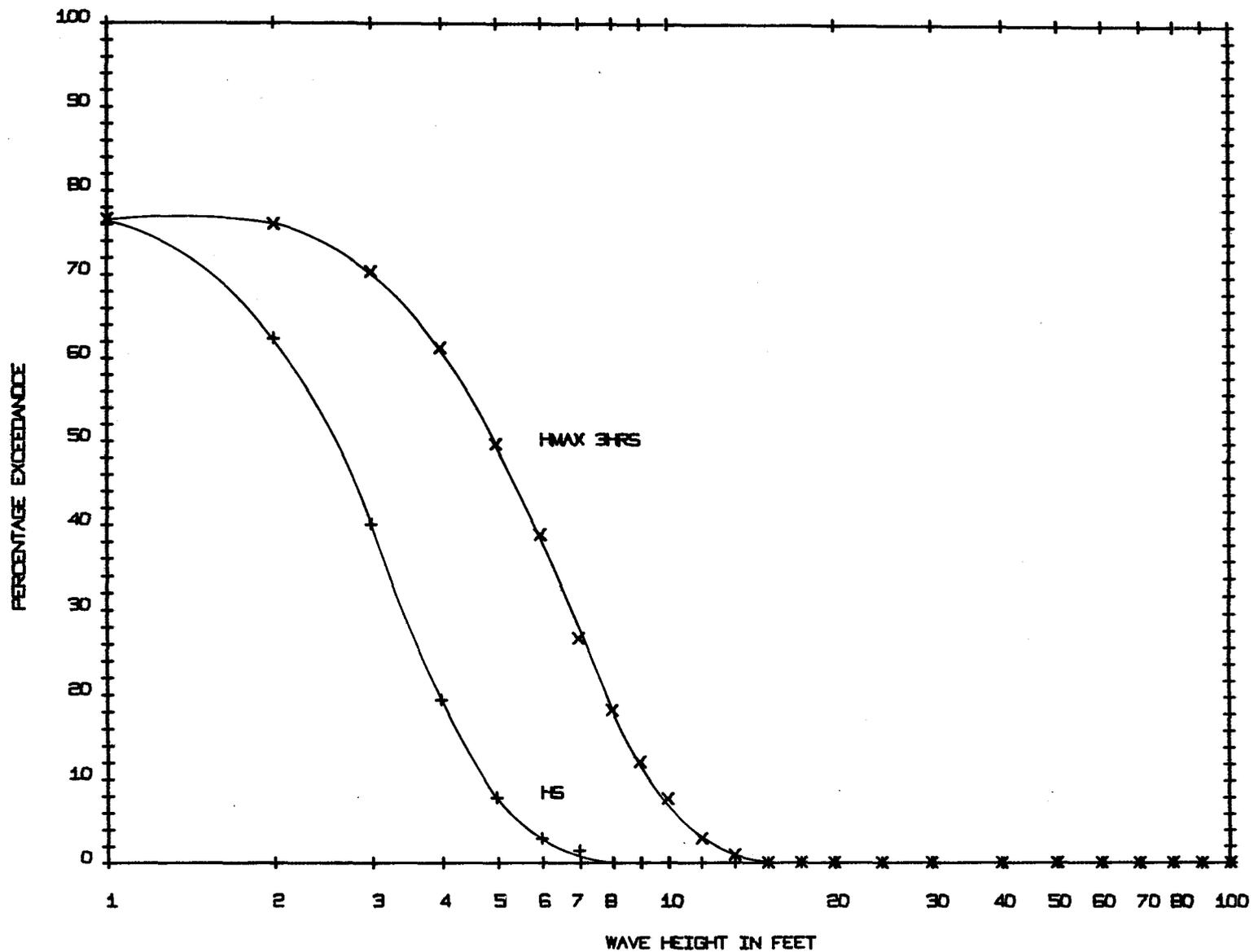


FIG.1 TNG

# PERCENTAGE EXCEEDANCE OF HS AND HMAX

SPRING - APRIL TO JUNE

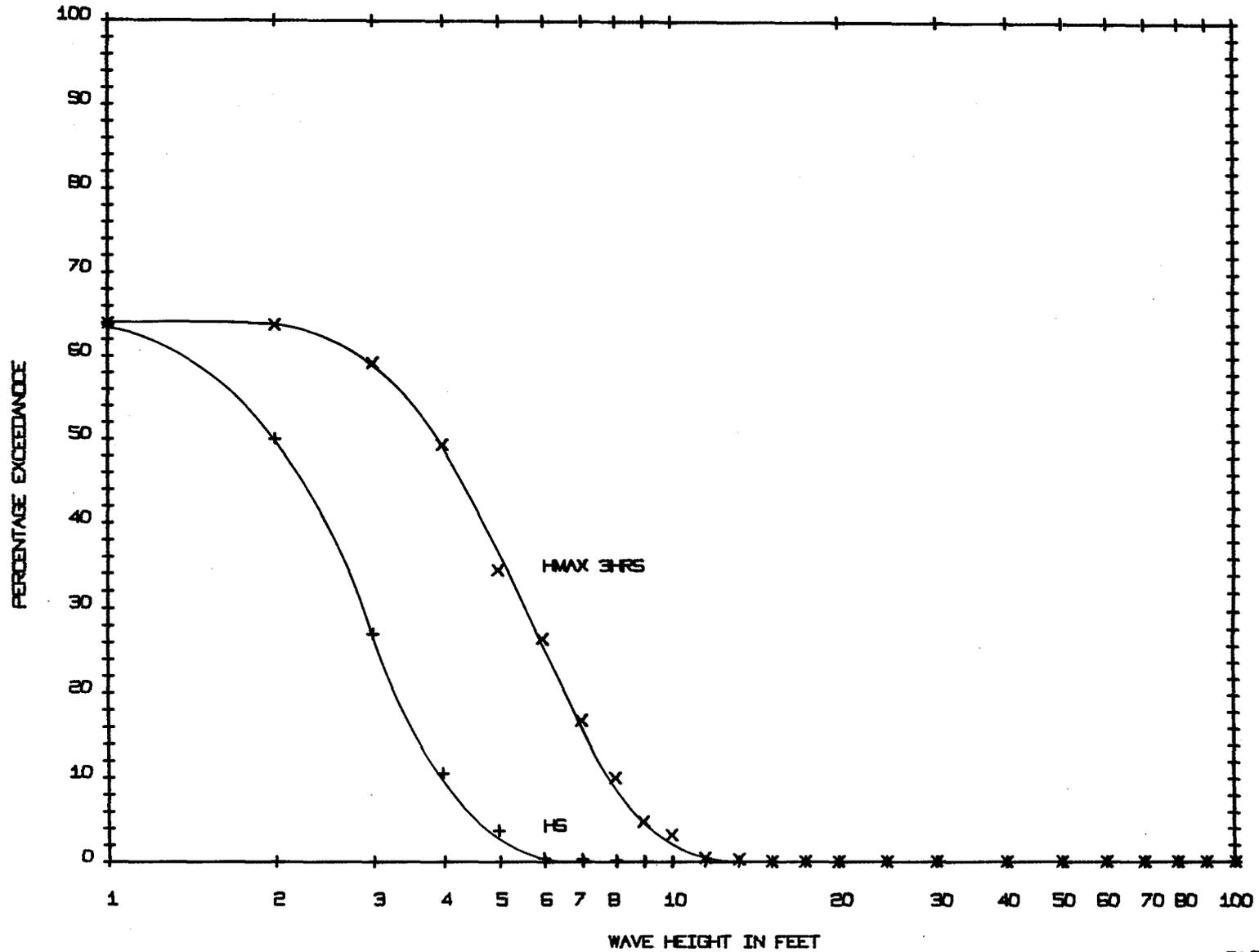


FIG. 2 TNG'

# PERCENTAGE EXCEEDANCE OF HS AND HMAX

SUMMER - JULY TO SEPTEMBER

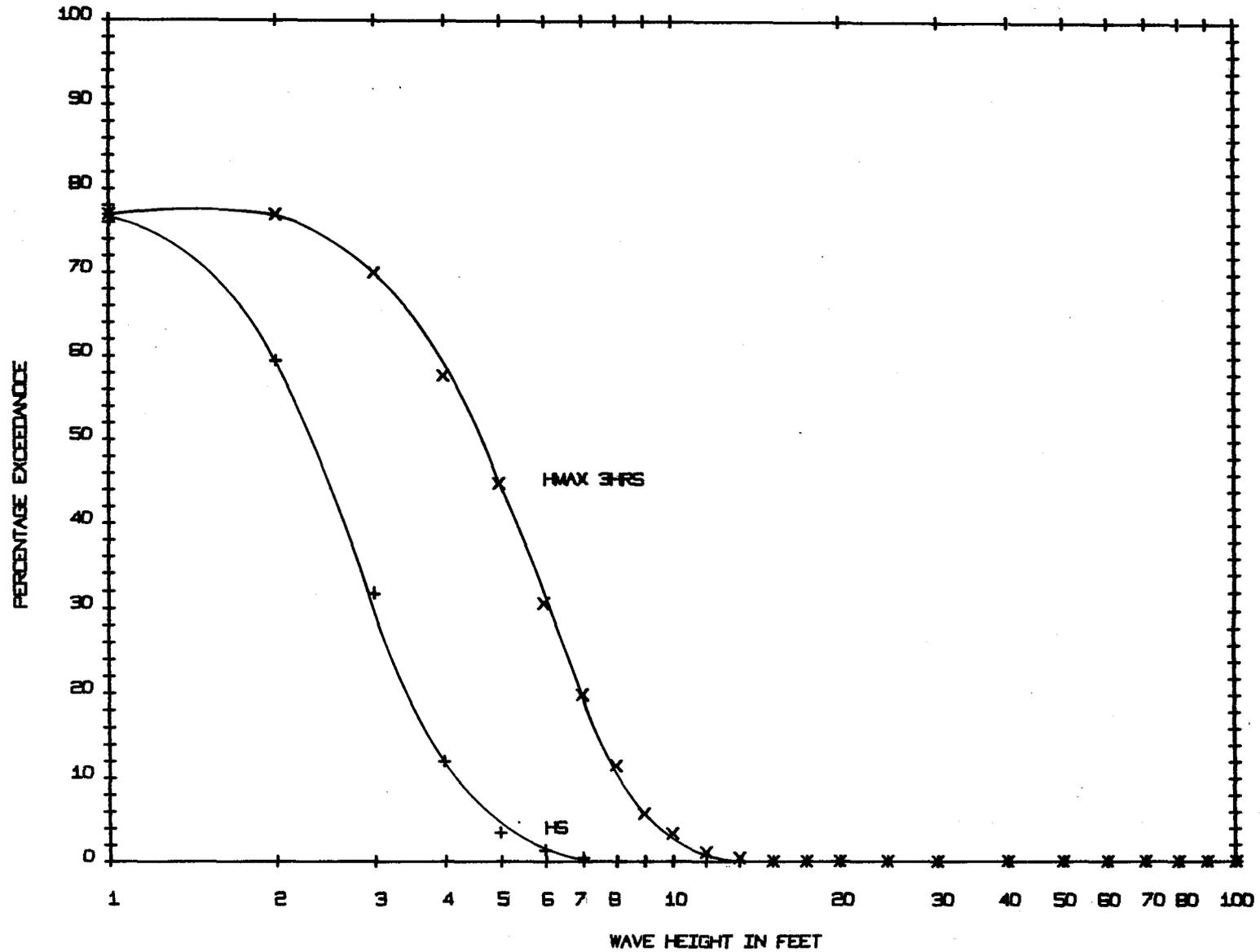


FIG. 3 TNG

# PERCENTAGE EXCEEDANCE OF HS AND HMAX

AUTUMN - OCTOBER TO DECEMBER

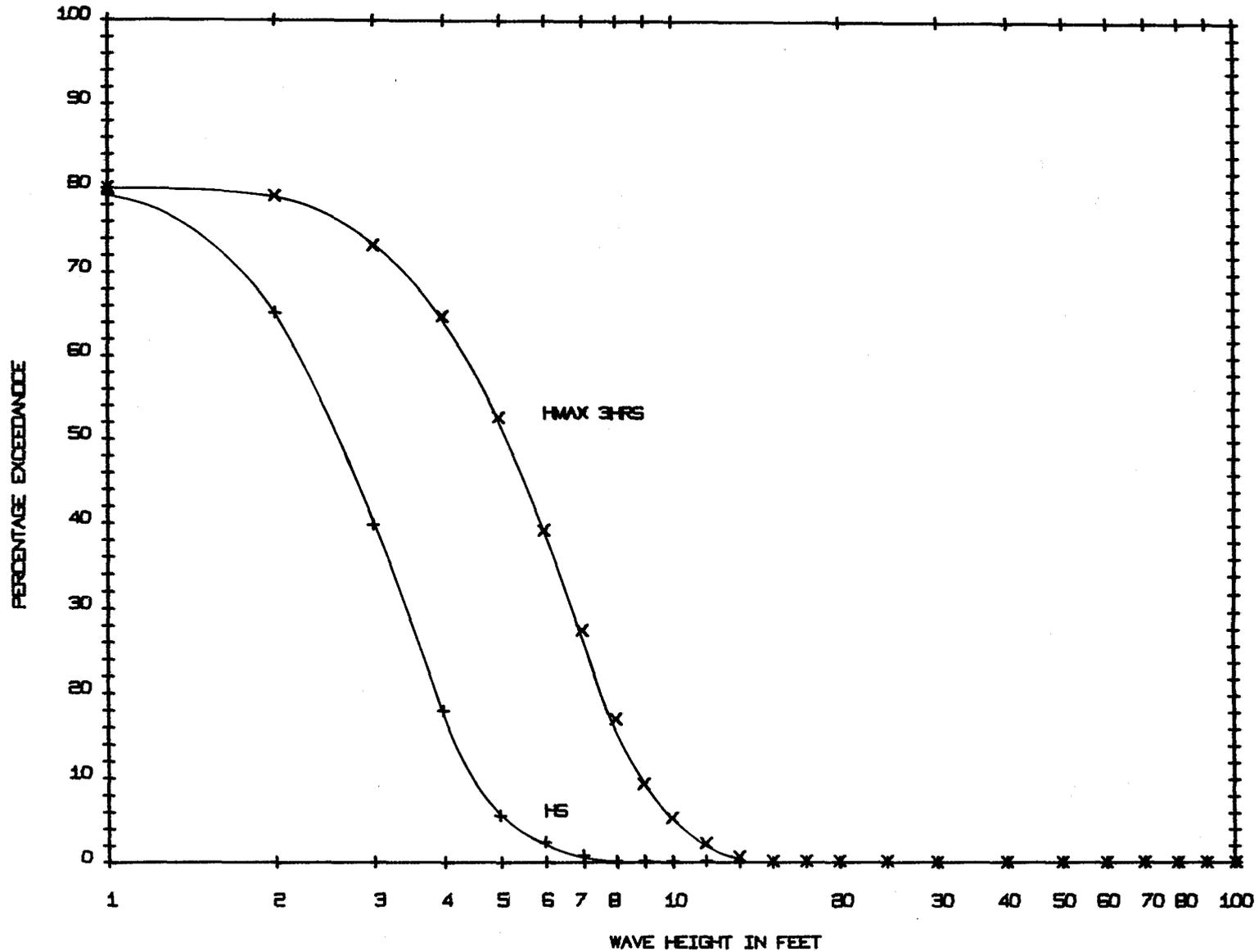
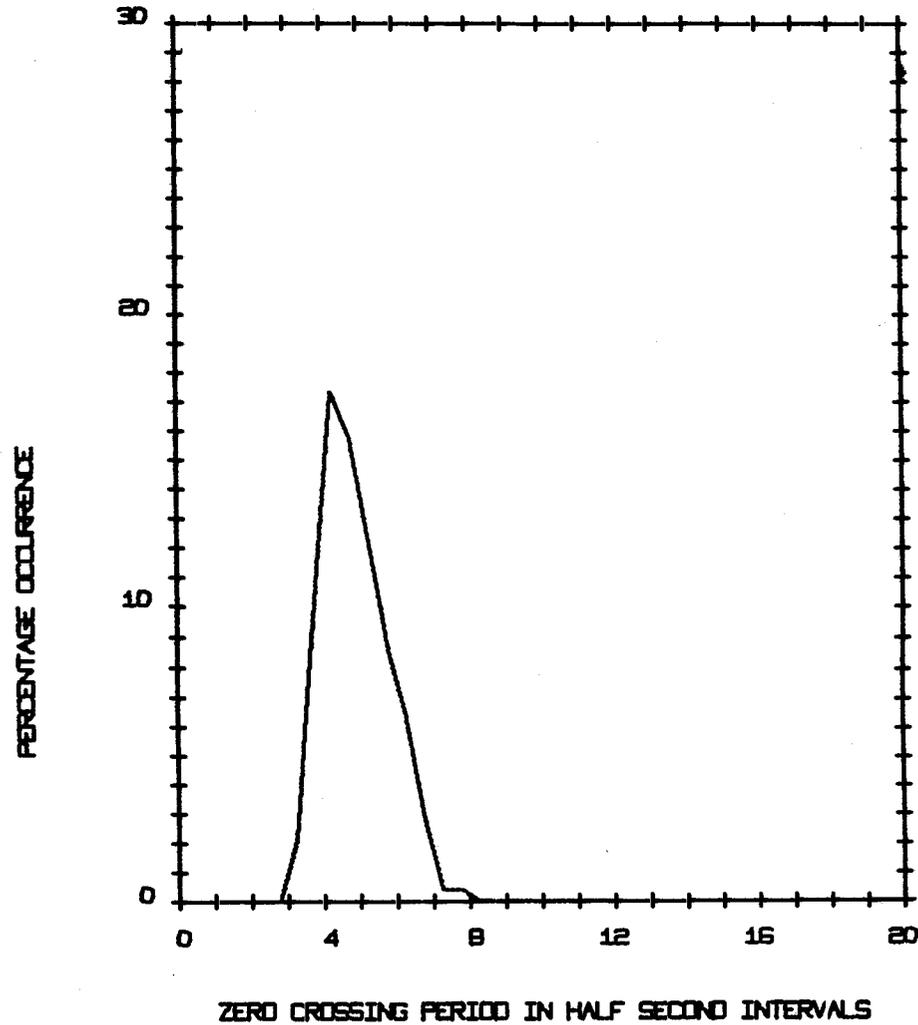


FIG.4 TNG

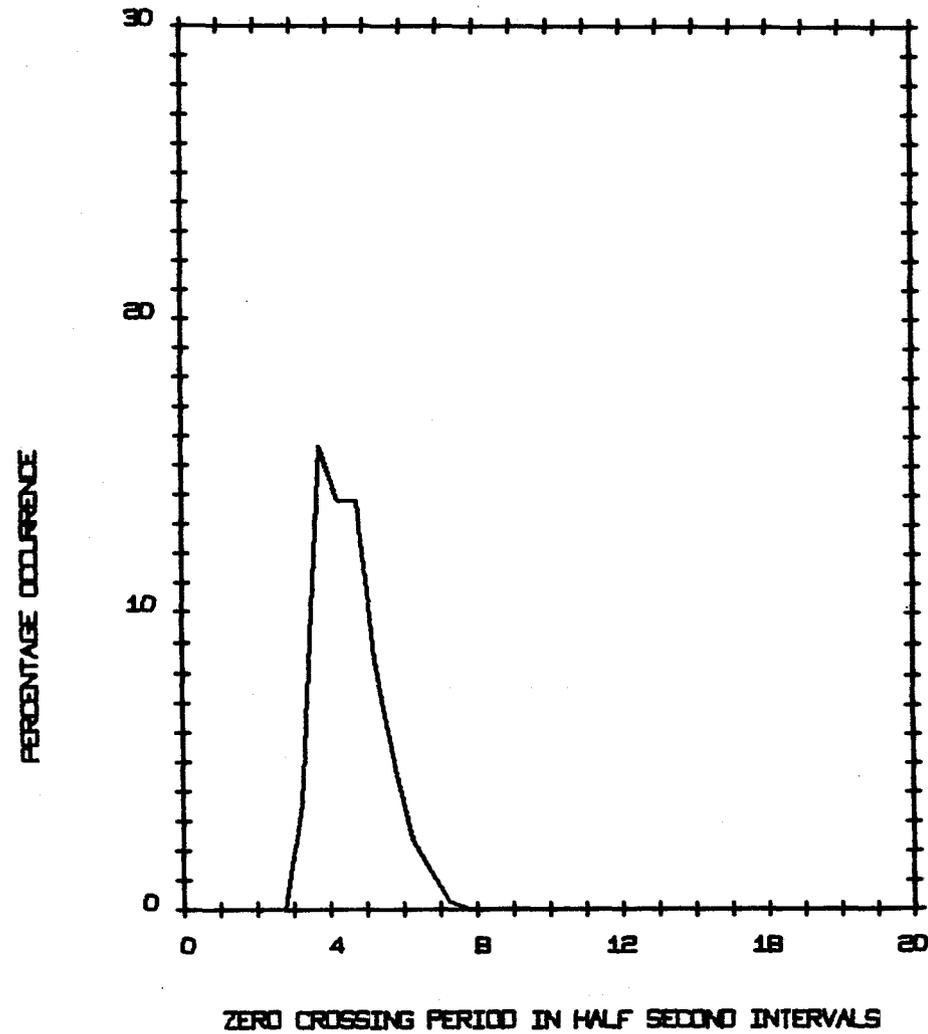
GRAPH OF PERCENTAGE OCCURRENCE OF TZ  
WITHIN HALF-SECOND INTERVALS  
WINTER - JANUARY TO MARCH



CALM = 23.47 PER CENT

FIG. 5 TNG

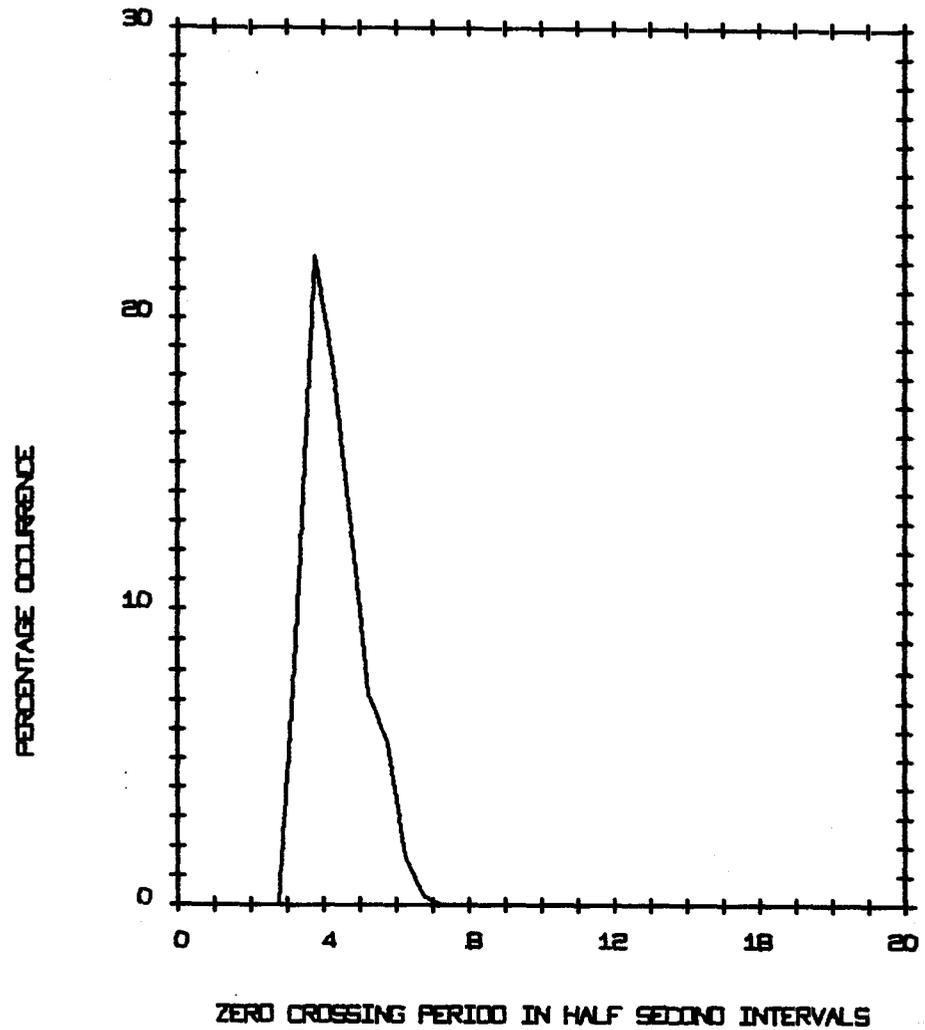
GRAPH OF PERCENTAGE OCCURRENCE OF TZ  
WITHIN HALF-SECOND INTERVALS  
SPRING - APRIL TO JUNE



CALM = 36.12 PER CENT

FIG. 6 TNG

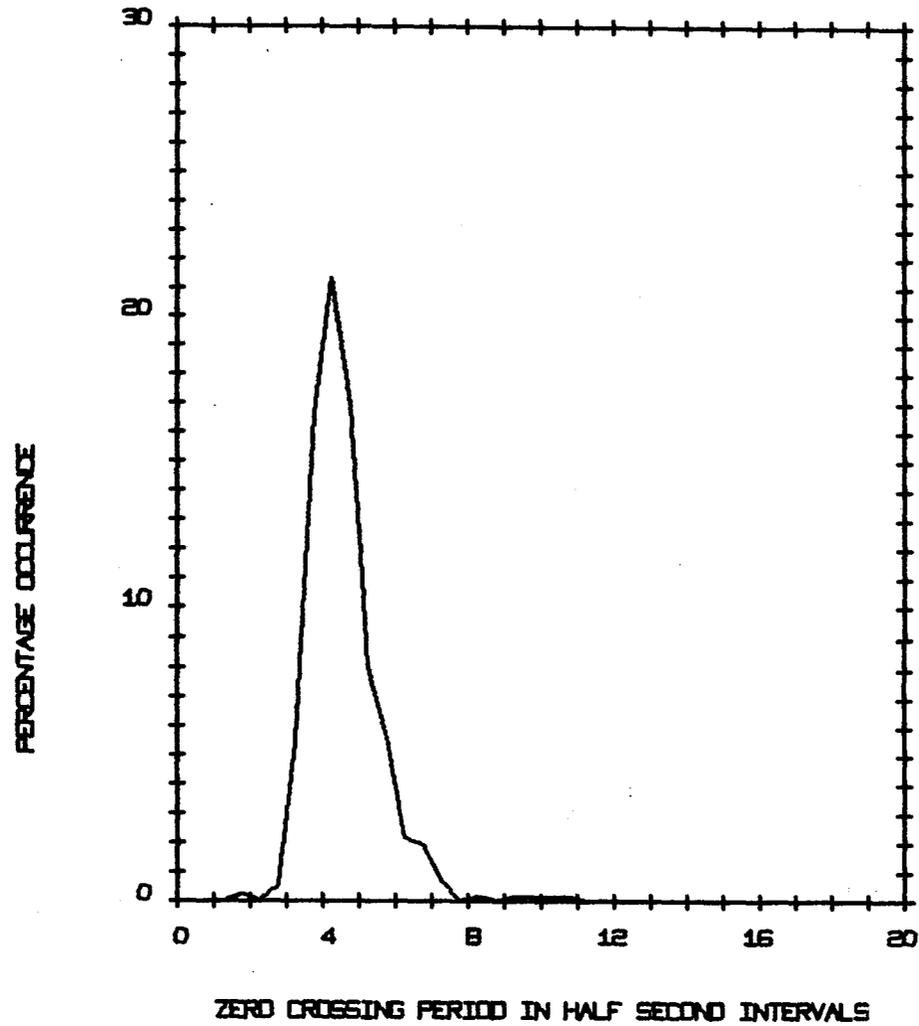
GRAPH OF PERCENTAGE OCCURRENCE OF TZ  
WITHIN HALF-SECOND INTERVALS  
SUMMER - JULY TO SEPTEMBER



CALM = 23.09 PER CENT

FIG. 7 TNG

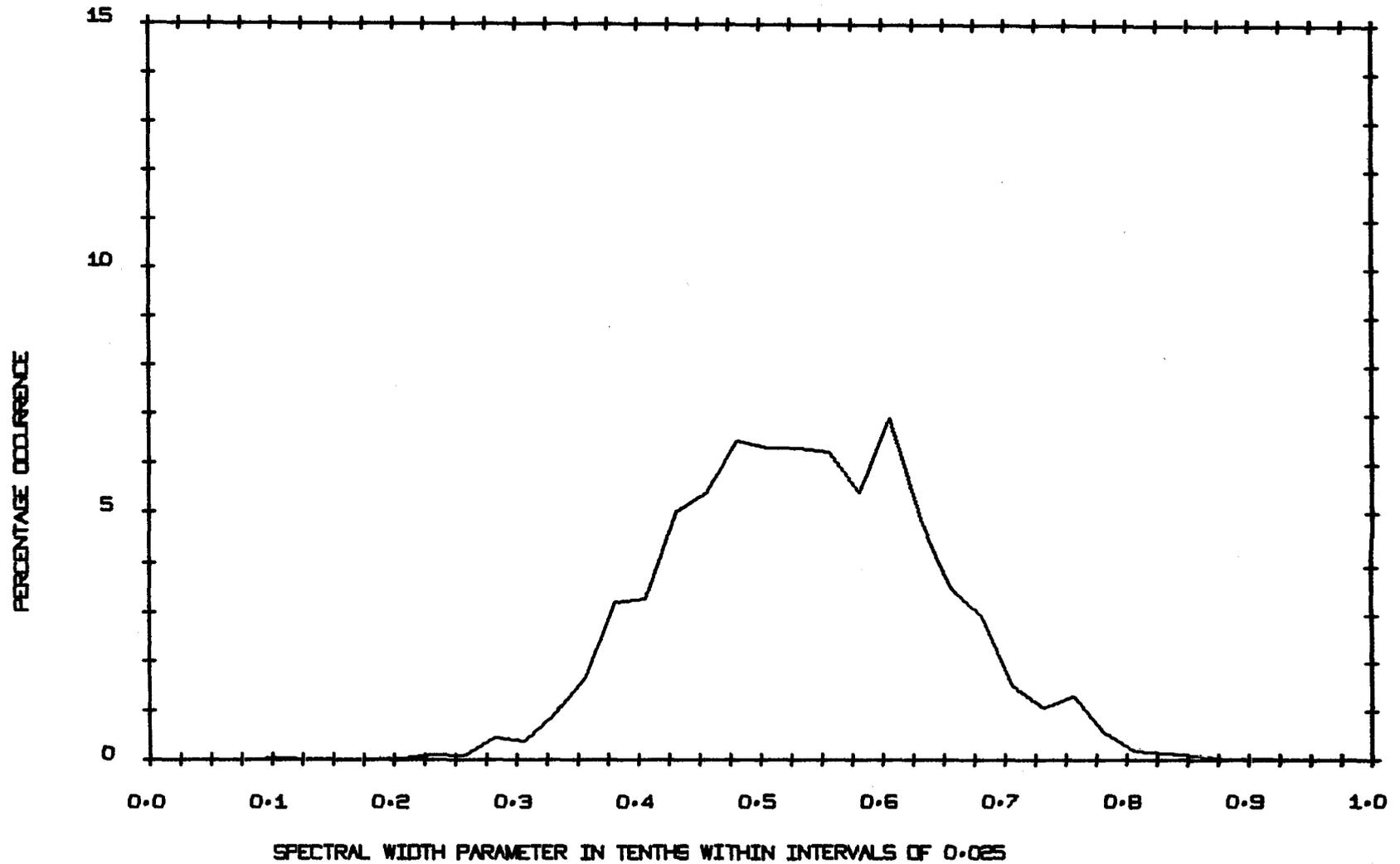
GRAPH OF PERCENTAGE OCCURRENCE OF TZ  
WITHIN HALF-SECOND INTERVALS  
AUTUMN - OCTOBER TO DECEMBER



CALM = 19.97 PER CENT

FIG. 8 TNG

GRAPH OF SPECTRAL WIDTH PARAMETER  
FOR A WHOLE YEAR



CALM = 25.65 PER CENT

FIG. 9 TNG

# SCATTER DIAGRAM FOR THE WHOLE YEAR

IN PARTS PER THOUSAND

\* = 1 OCCURRENCE, + = 2 OCCURRENCES

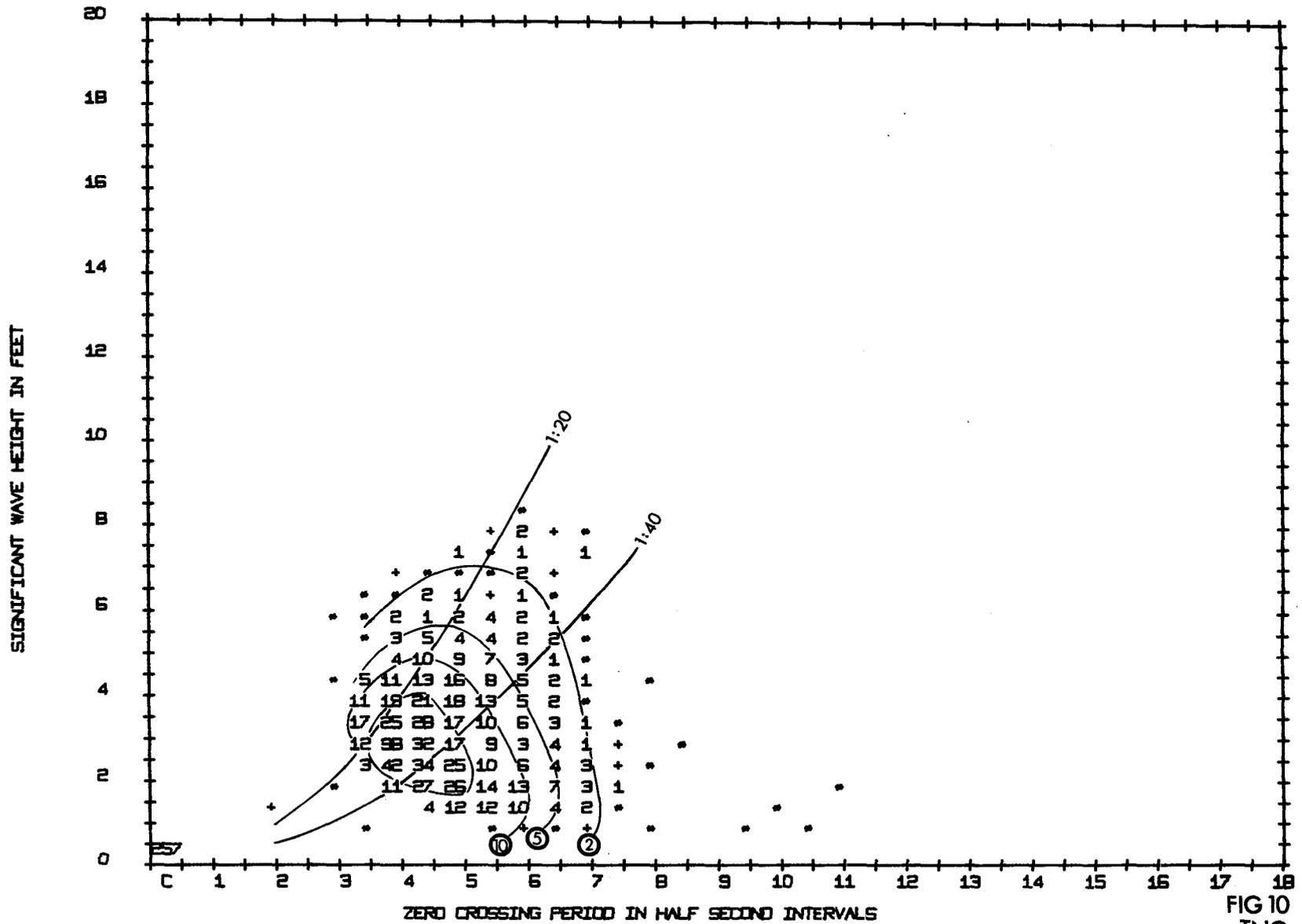


FIG 10  
TNG

# PERSISTENCE DIAGRAM FOR THE WHOLE YEAR

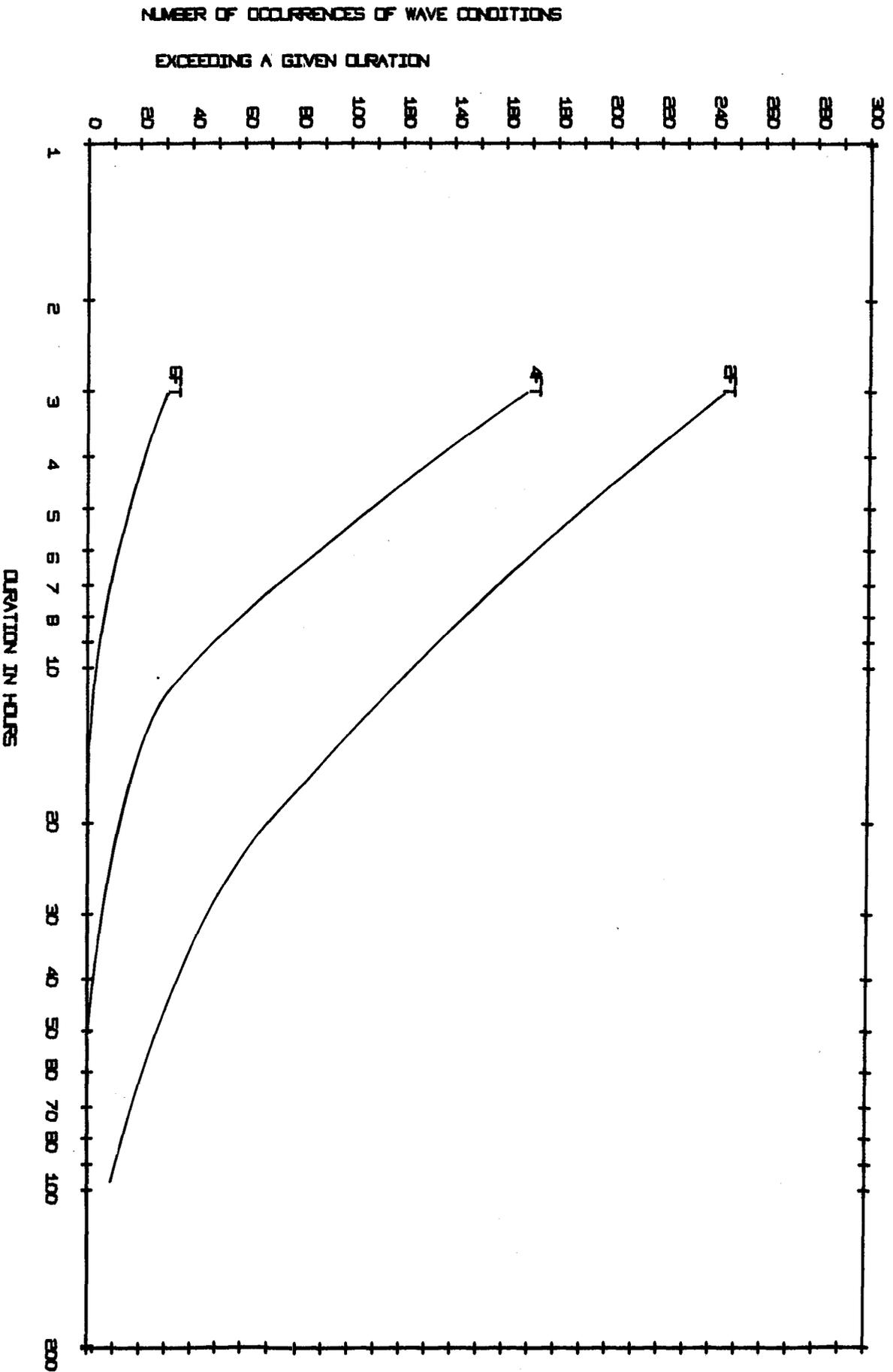


FIG. 11 TNG

# TONGUE 1966

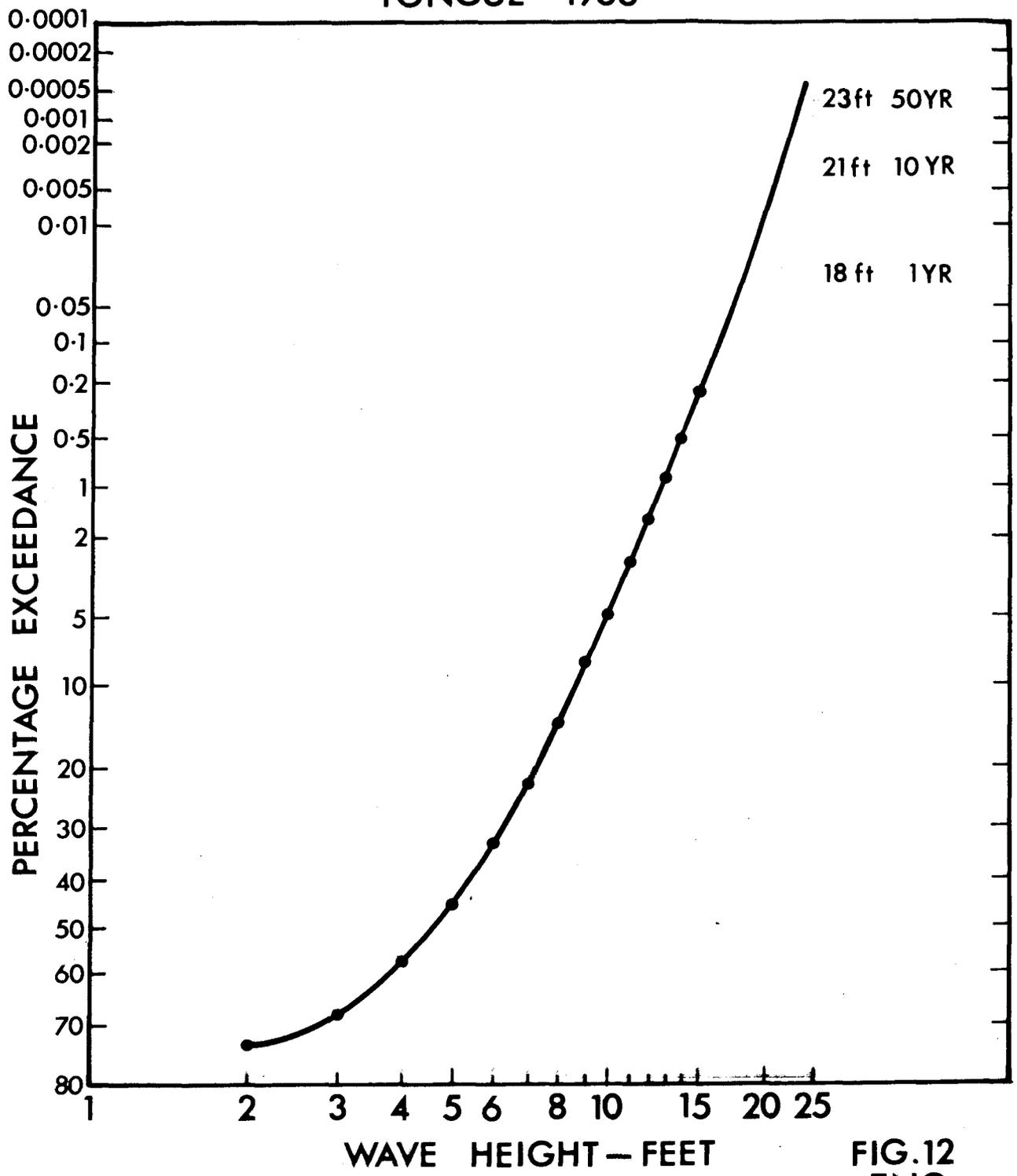


FIG.12  
TNG

