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NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY

Waves at Smith's Knoll Light Vessel North Sea

by

L. DRAPER

N.I.O. INTERNAL REPORT No. A.33

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CONTENTS

Waves have been recorded by a shipborne wave recorder (Tucker, 1956) placed on the Smith's Knoll Light Vessel (about twenty two miles ENE of Great Yarmouth). The vessel was stationed in 27 fathoms of water. The records from the first year of operation, from March 1959, were analyzed by M. Darbyshire and used by J. Darbyshire in the development of his wave forecasting technique. However, the method of abstraction of the data from the records did not follow the methods now used (Draper, 1966), which have been based on subsequently-developed theoretical studies (Tucker, 1961 and 1963) and Cartwright and Longuet-Higgins, 1956. Also, it is not easy to compare the data given in the original publication (M. Darbyshire, 1960) with more recent publications of wave data for other areas, as the presentation has also evolved appreciably in recent years. Because of these differences, the data from Mrs. Darbyshire's original sheets has been re-processed to bring it into line with current practice; for example, the values of H_{max} originally obtained have been converted to the appropriate parameter in current nomenclature, H_1, and the significant periods originally obtained have been converted to zero-crossing periods using average relationships between the two parameters.

The analysis presented here is based on the records from the first year of operation; eight of the records, mostly of 15 minutes' duration, taken each day have been analyzed.

The parameters calculated from Mollie Darbyshire's original data are:

(a) H_s The significant height (mean height of the highest one-third of the waves); this is derived from $H_1 = f(H_s)$ where f is a factor related to the number of zero-crossings in the record (Tucker, 1963). The numerical value of f for a record containing 100 waves is 1·60, and for 50 waves f = 1·49. These values of f are theoretical ones for a narrow-band spectrum (Cartwright and Longuet-Higgins, 1956), and have been shown to be substantially correct for typical wide-band spectra of sea waves (Tucker, 1963).

(b) $H_{max(3\ hours)}$

The most probable value of the height of the highest wave which occurred in the recording interval (Draper, 1963).

(c) T_z The mean zero-crossing period.

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 the most probable value of the height of the highest wave in a three-hour interval, $H_{max(3\ hours)}$. The distribution of zero-crossing period is given for each season (Figures 5 - 8).

Figure 9 is a scatter diagram relating significant wave height to zero-crossing period.

Figure 10 is a persistence diagram for the occurrence of wave conditions of specific significant heights or above, giving the number of times this occurs and the duration over which the conditions persist in the whole year.

Discussion of results

From Figures 1 - 4 may be determined the proportion of time for which H_s or $H_{max(3\ hours)}$ exceeded any given height for each season. For example, in the winter, the significant height exceeded 6 feet for 20 per cent of the time. The scatter diagram (Figure 9) relates significant height to zero-crossing period. The numbers of occurrences are expressed in parts per thousand. For example, the most common wave conditions were those with a significant height of between 2 and 3 feet with a zero-crossing period of between 5·5 and 6 seconds, which occurred for 60 thousandths, i.e. 6·0 per cent, of the time. The rapid attentuation of the shorter waves with depth means that the pressure units, which are necessarily situated 6 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 about that period. Almost all the waves appear to be of local origin, there is no record in which the zero-crossing period is as high as ten seconds, such as might be generated in the Norwegian Sea. This suggests that in travelling down the North Sea all the energy of such longer-period waves is lost by friction on the sea bed.

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 9. (In this case, steepness relates to significant wave height : wave length calculated from the zero-crossing period). A fairly well-defined limit of steepness is observed at approximately 1 : 16 (0·06). There is a theoretical limit for a progressive wave of 1 : 7 (0·14).

From the persistence diagram, Figure 10, 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 6 feet, it would have been unable to operate for spells in excess of 10 hours on 25 occasions, or spells in excess of 24 hours on 3 occasions.

The highest wave recorded during the year was 24 feet in height and of 8·4 seconds period, compared with 28 feet at Morecambe Bay. This is surprising, but, according to Mollie Darbyshire, during the winter of 1959-60 the highest wind speed recorded at Smith's Knoll was 37 knots, and this had a westerly direction and hence a very short fetch. The highest wind speed recorded from between 360° and 40° was 22 knots; between 320° and 360° and also between 40° and 80° it was 29 knots, so that the data presented here is probably slightly less extreme than than which might occur in a typical year.

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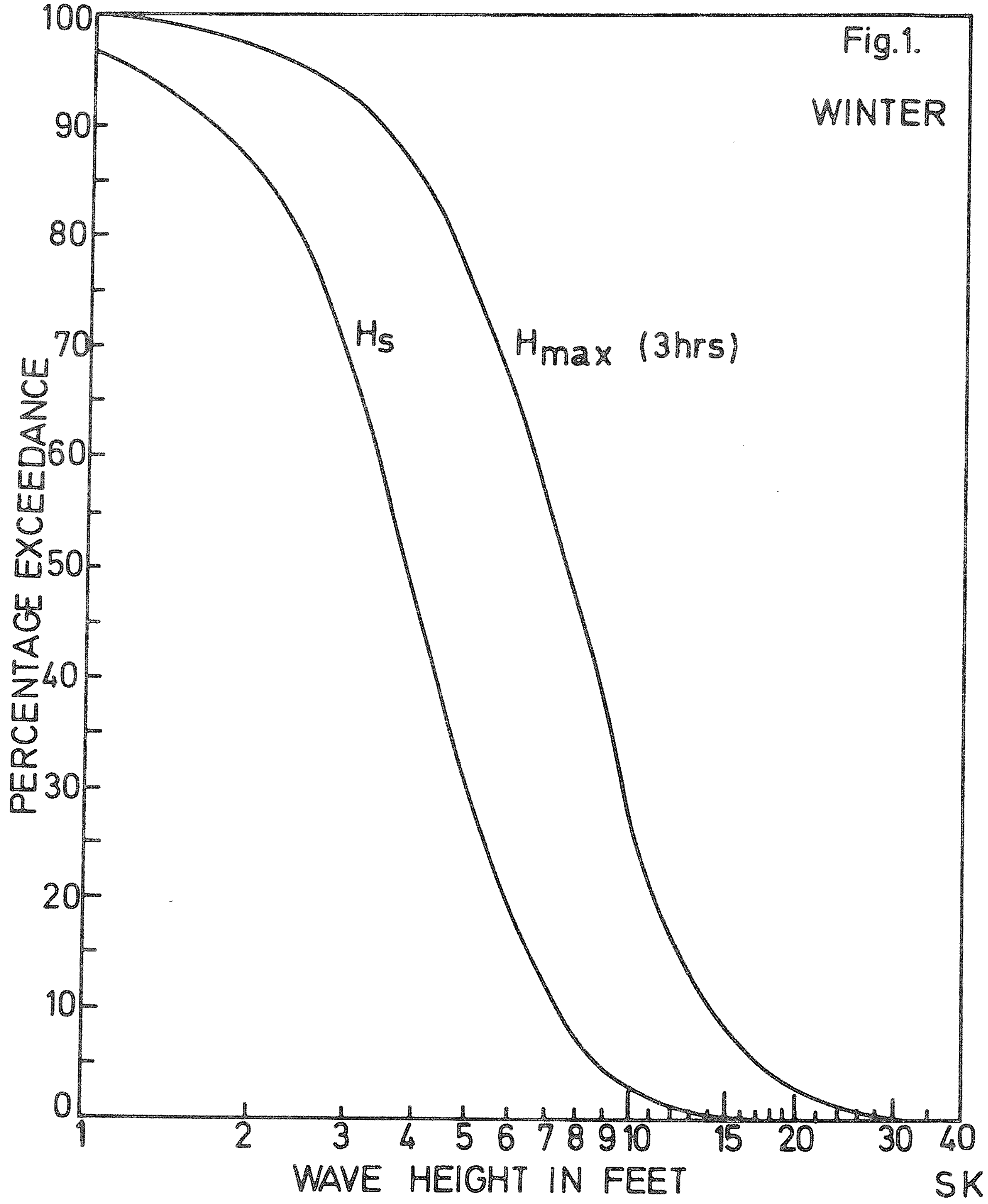


Fig.1.
WINTER
PERCENTAGE EXCEEDANCE
100
90
80
70
60
50
40
30
20
10
0
H_s
H_{max} (3hrs)
1
2
3
4
5
6
7
8
9
10
15
20
30
40
WAVE HEIGHT IN FEET
SK

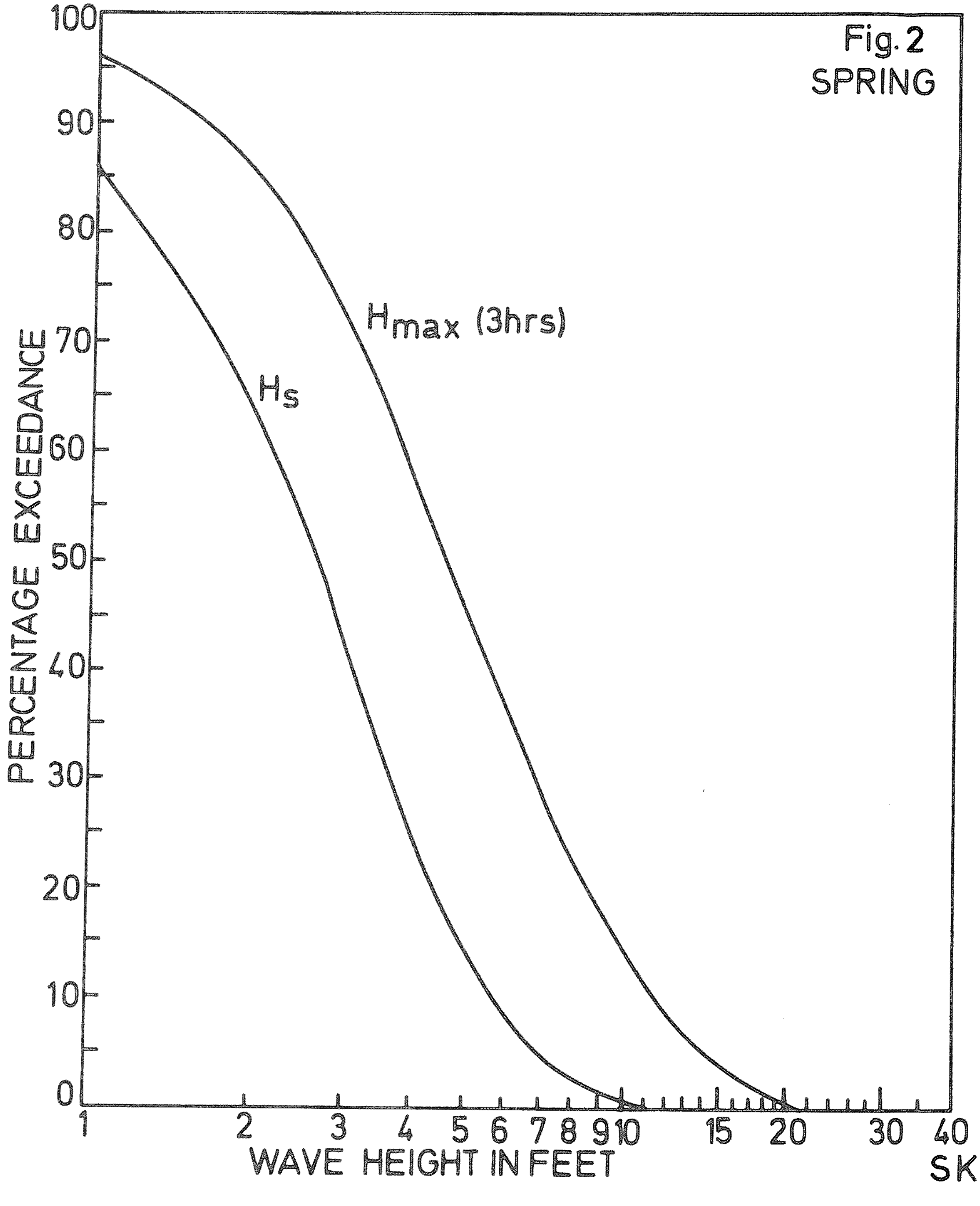


Fig. 2
SPRING
PERCENTAGE EXCEEDANCE
100
90
80
70
60
50
40
30
20
10
0
H_{max} (3hrs)
H_s
1
2
3
4
5
6
7
8
9
10
15
20
30
40
WAVE HEIGHT IN FEET
SK

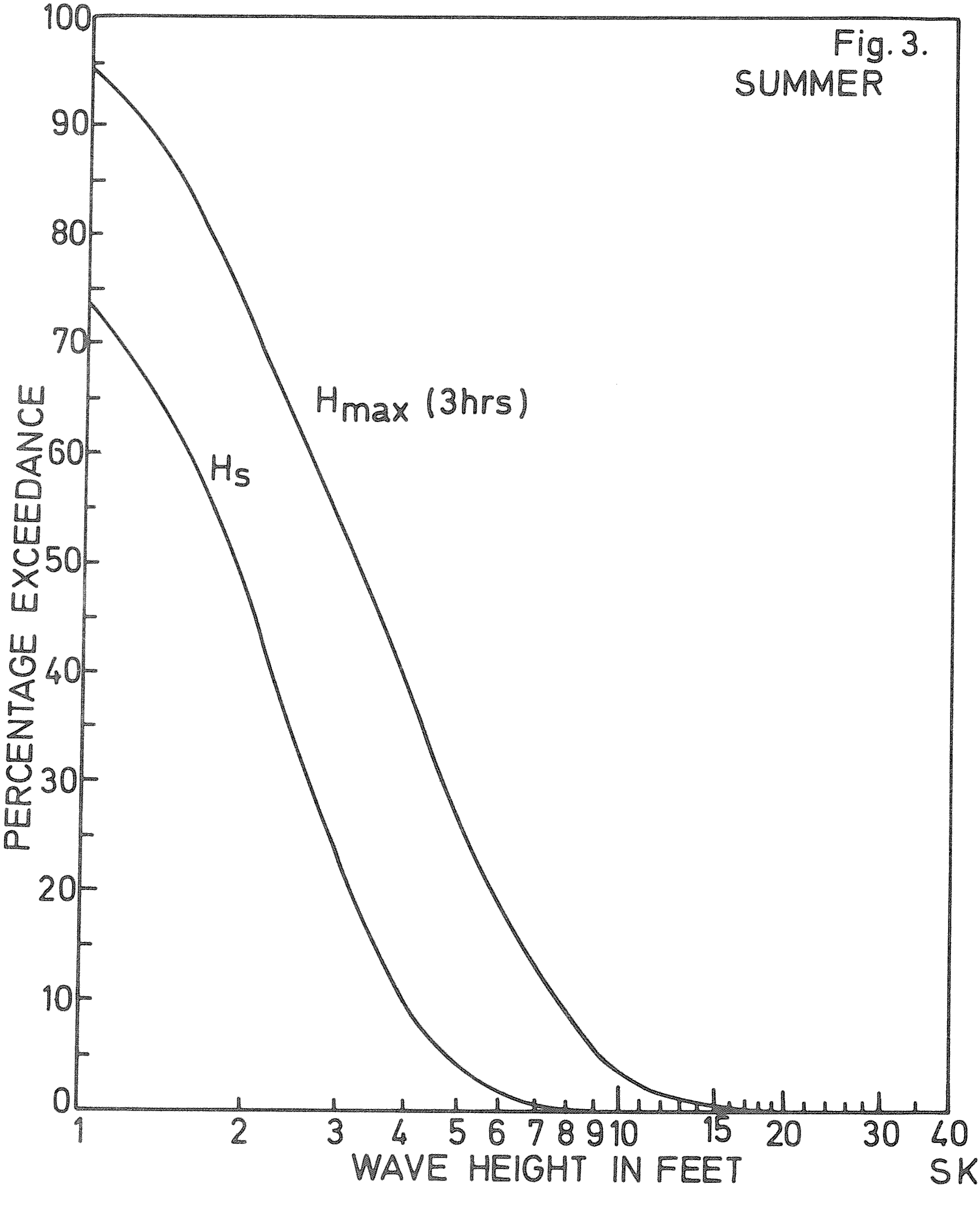


Fig. 3.
SUMMER
PERCENTAGE EXCEEDANCE
100
90
80
70
60
50
40
30
20
10
0
H_{max} (3hrs)
H_s
1
2
3
4
5
6
7
8
9
10
15
20
30
40
WAVE HEIGHT IN FEET
SK

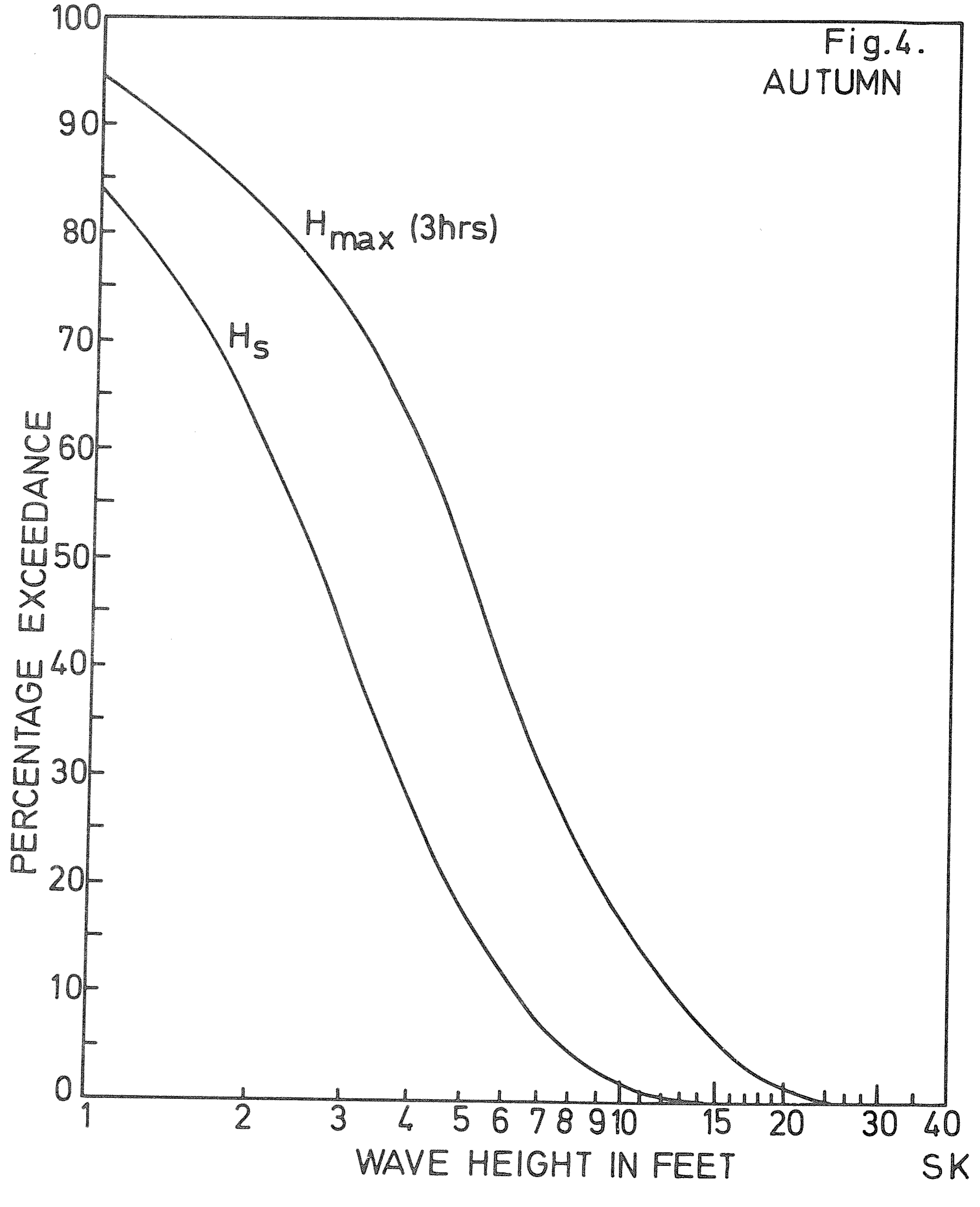


Fig. 4.
AUTUMN
100
90
80
70
60
50
40
30
20
10
0
PERCENTAGE EXCEEDANCE
H_{max} (3hrs)
H_s
1
2
3
4
5
6
7
8
9
10
15
20
30
40
WAVE HEIGHT IN FEET
SK

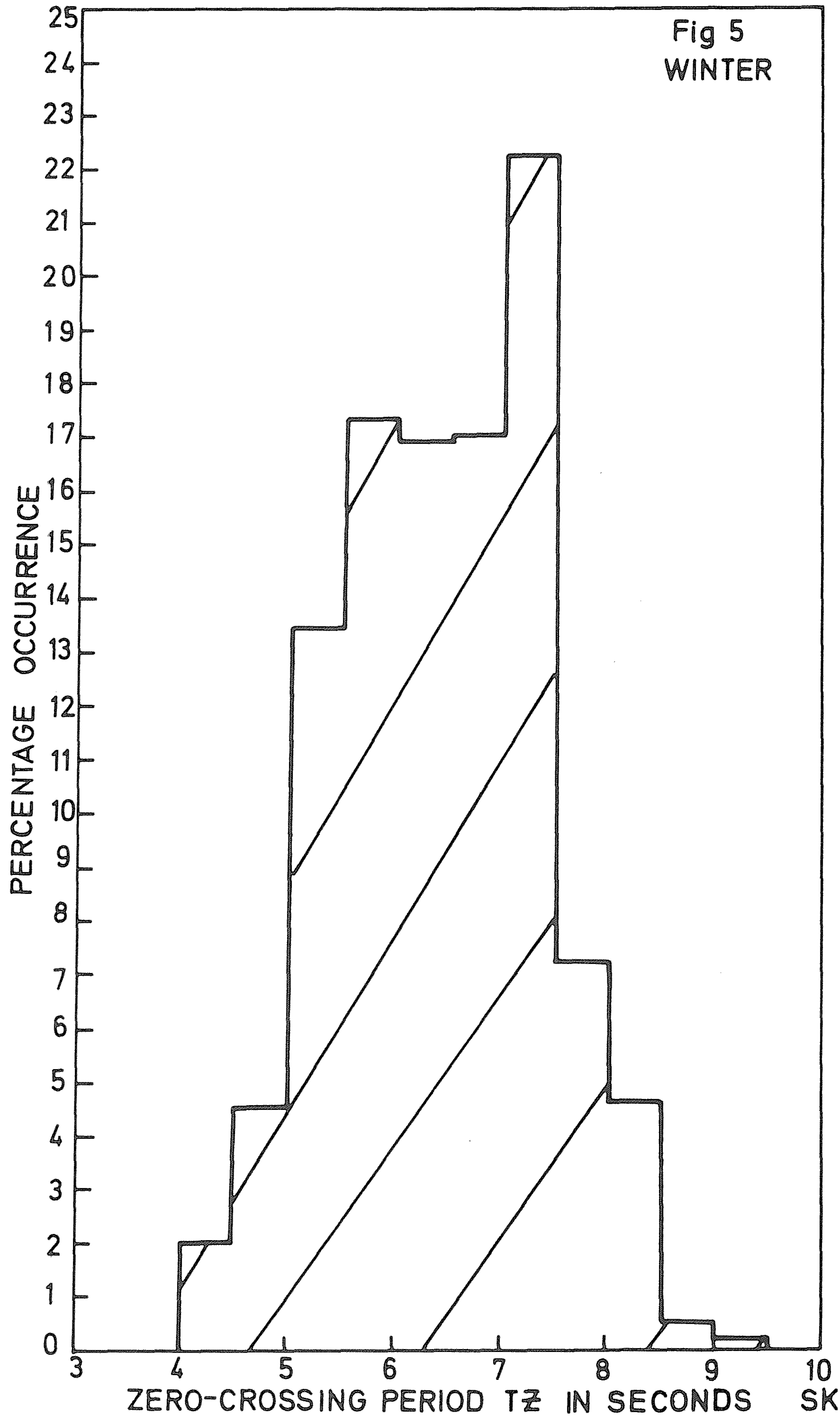


Fig 5
WINTER
PERCENTAGE OCCURRENCE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
3
4
5
6
7
8
9
10
ZERO-CROSSING PERIOD TZ IN SECONDS
SK

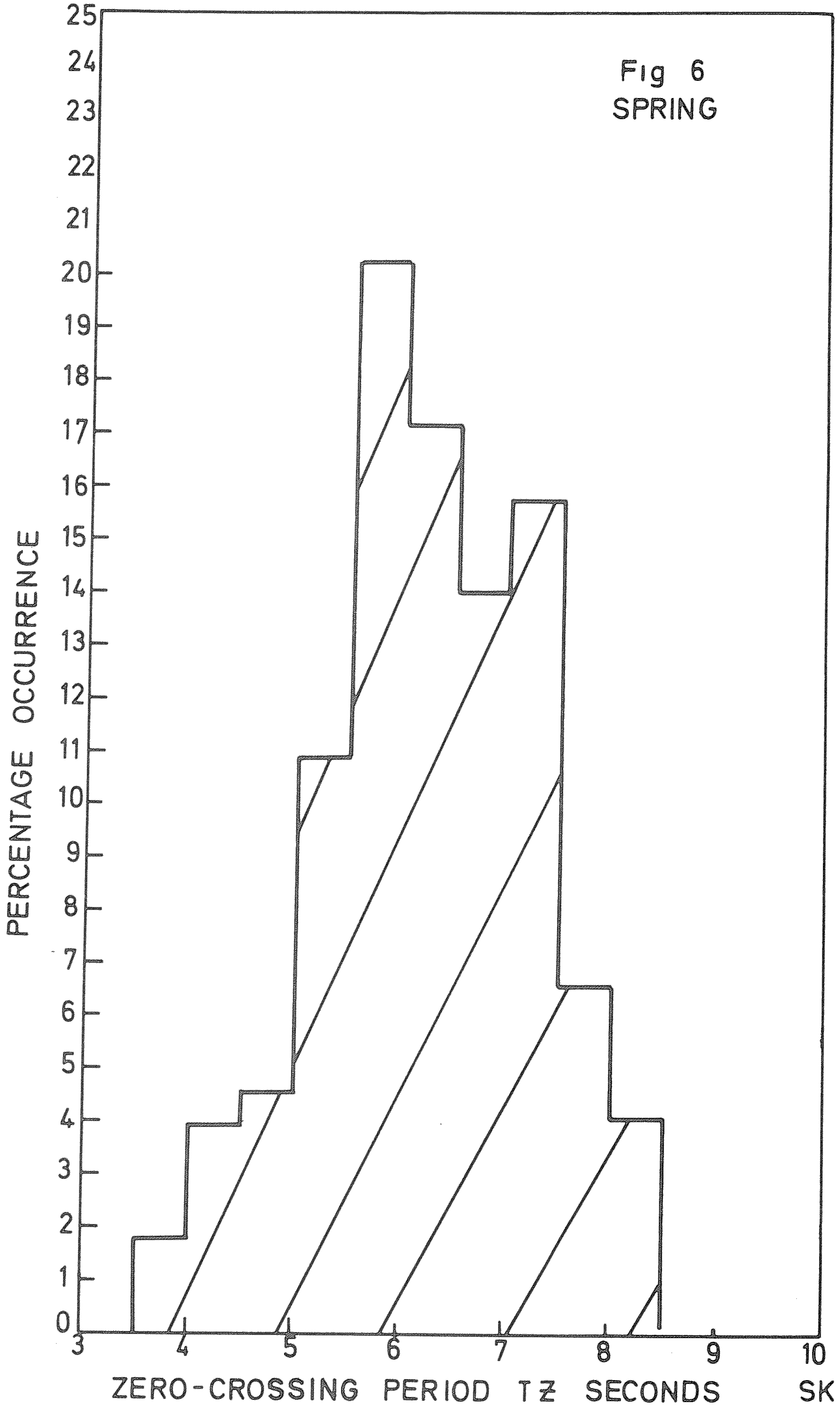


Fig 6
SPRING
PERCENTAGE OCCURRENCE
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
3
4
5
6
7
8
9
10
ZERO-CROSSING PERIOD TZ SECONDS
SK

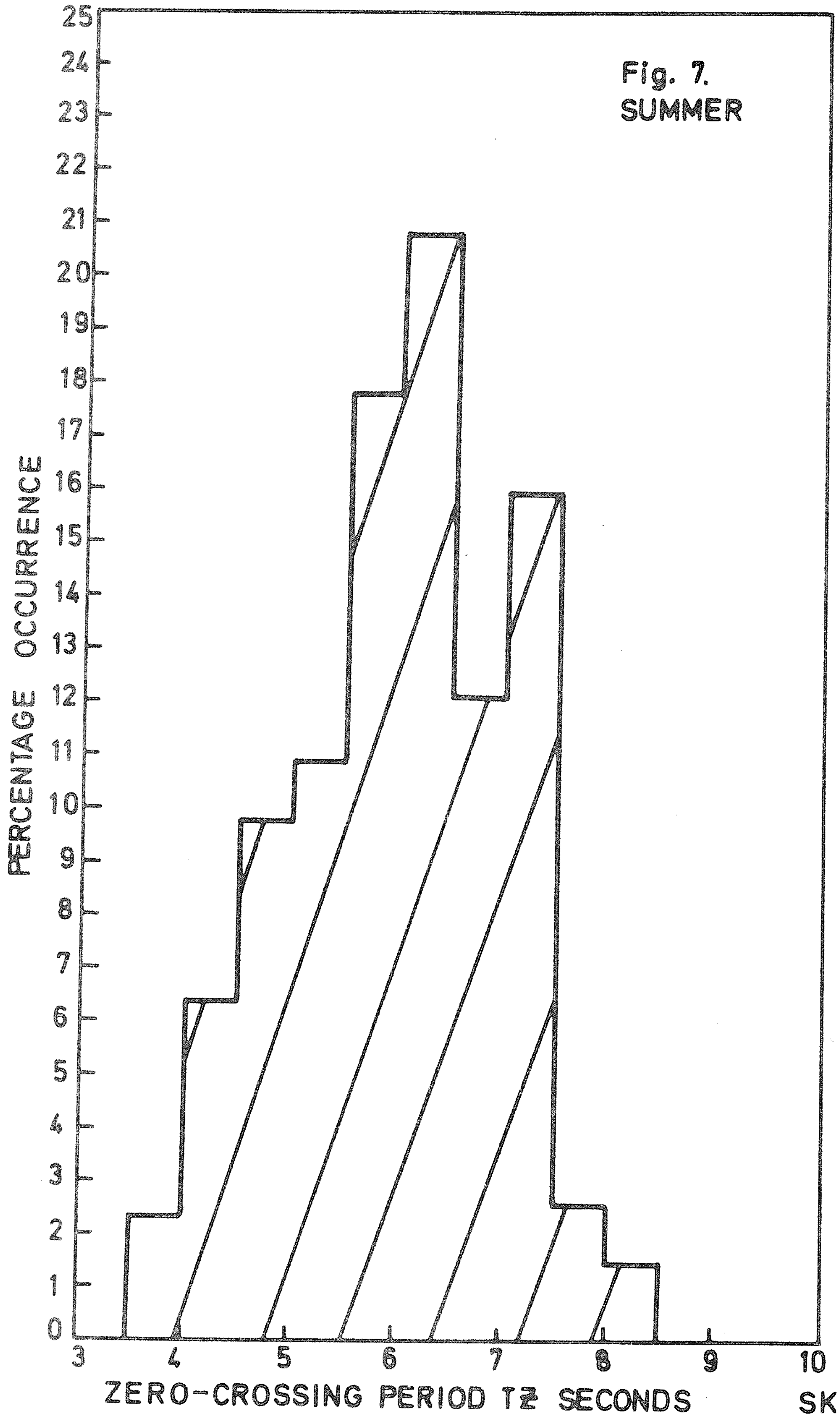


Fig. 7.
SUMMER
PERCENTAGE OCCURRENCE
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
3
4
5
6
7
8
9
10
ZERO-CROSSING PERIOD TZ SECONDS
SK

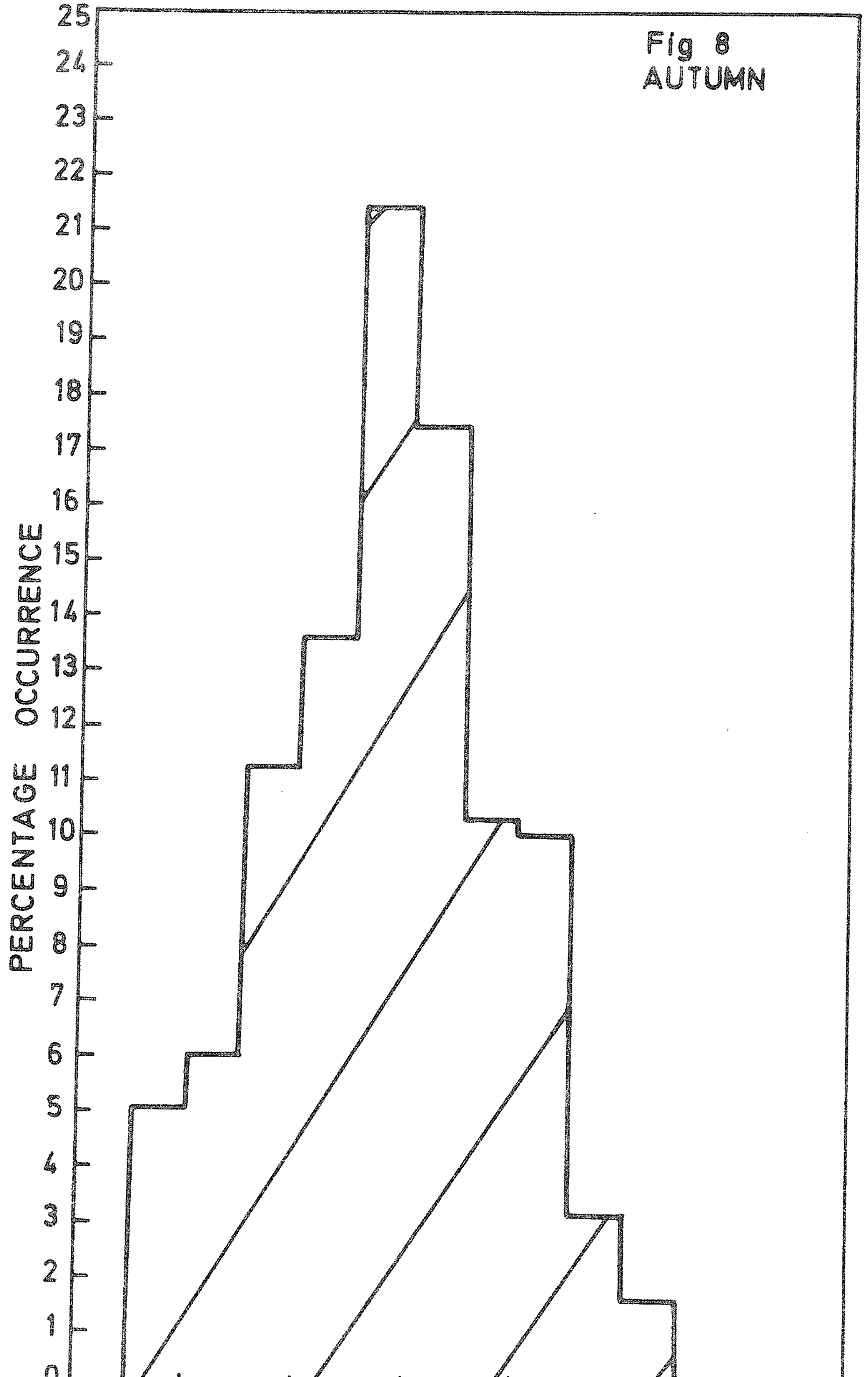
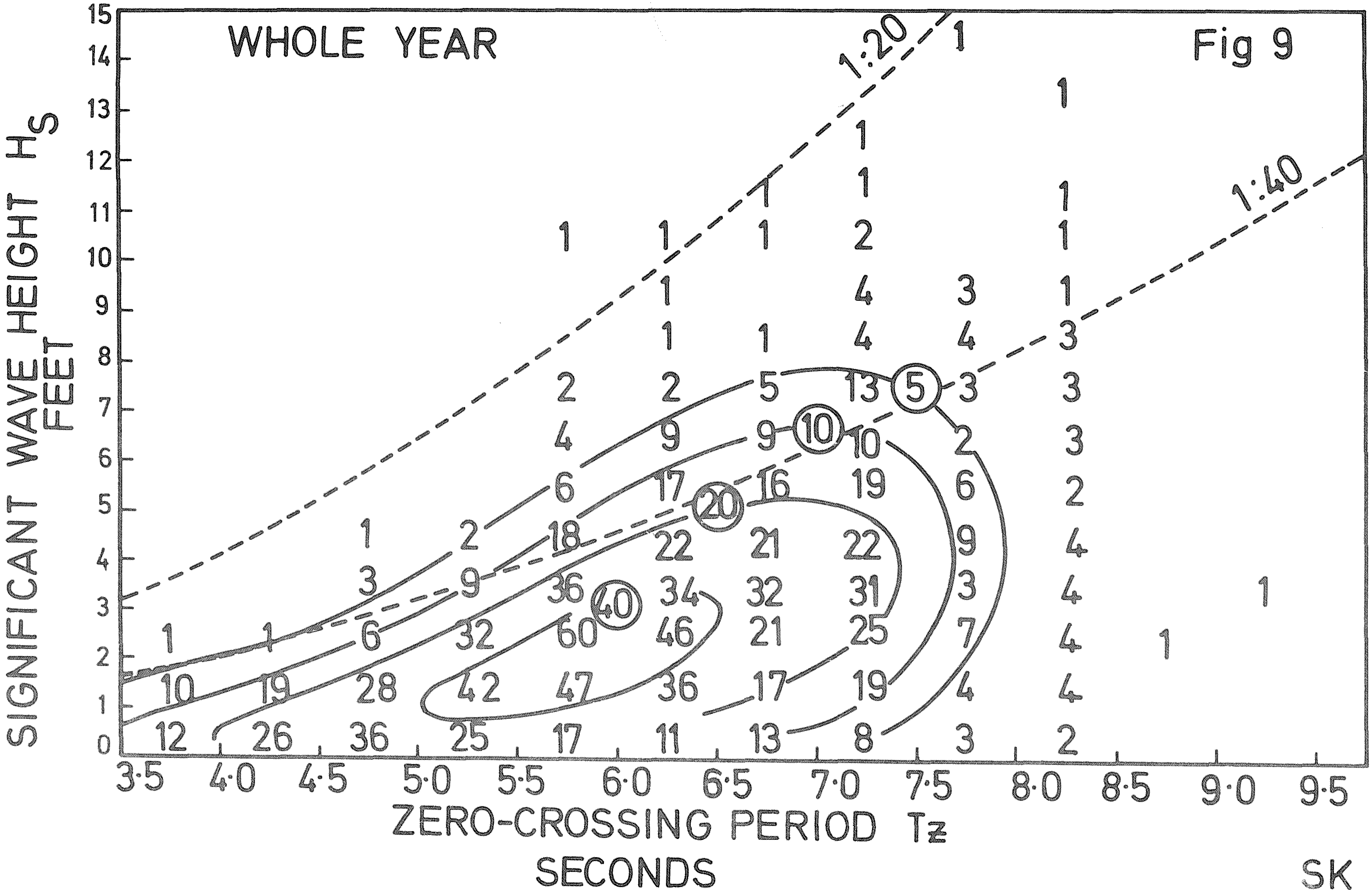

PERCENTAGE OCCURRENCE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
3
4
5
6
7
8
9
10
ZERO-CROSSING PERIOD TZ IN SECONDS SK

Fig 8
AUTUMN


WHOLE YEAR
Fig 9
1:20
1:40
SIGNIFICANT WAVE HEIGHT H_S
FEET
ZERO-CROSSING PERIOD T_Z
SECONDS
SK

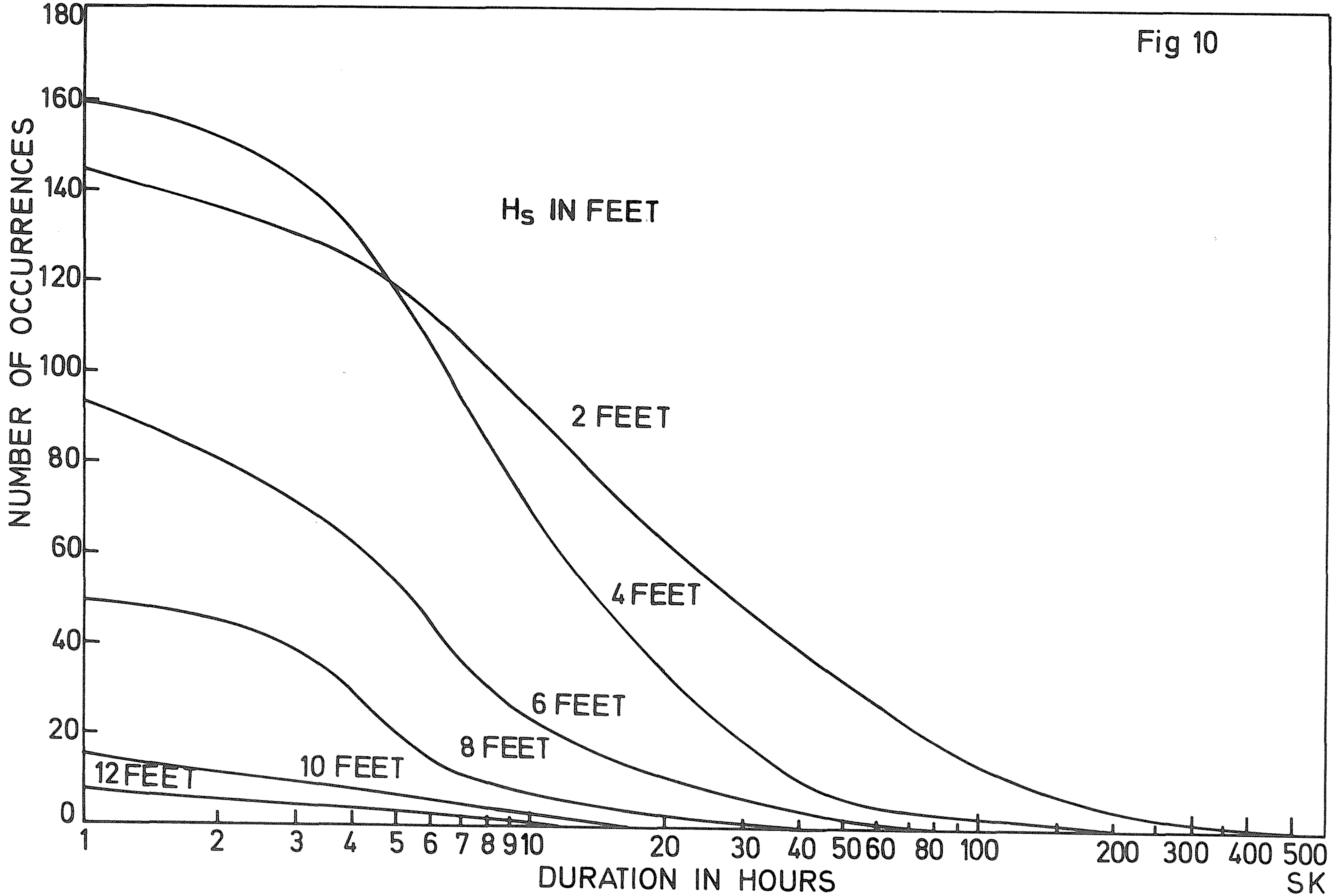


Fig 10
NUMBER OF OCCURRENCES
180
160
140
120
100
80
60
40
20
0
Hs IN FEET
2 FEET
4 FEET
6 FEET
8 FEET
10 FEET
12 FEET
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100
200
300
400
500
DURATION IN HOURS
SK