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Wind and wave climate in the Netherlands sector of the North Sea between 53° and 54° north latitude.

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Wind and Wave Climate in the Netherlands Sector of the North Sea between 53° and 54° North Latitude.

Abstract.

Wave data have been collected between March 1973 and February 1976 in block L (the square 53°-54°N, 4°-5°E) of the Netherlands shelf area. If one takes into account the relatively high frequencies of high wind speeds during the wave measurements as compared with wind data from 1949 until 1975 of the same area, the exceedance level of the significant wave height H_{m_0} with a probability of 0.001 percent (4.4 hours in 50 years) becomes 8.2 m. A further reduction is obtained using wave data during one storm event in particular, 3 January 1976. These data suggest that the shallow bottom of the area diminishes the probability of extreme exceedances, leading to an exceedance level H_{m_0} = 7.5 m, also with a probability of 0.001 percent. It is shown that the expected value of the maximum wave height in 30 m deep water is approximately 1.8 H_{m_0} under extreme conditions; this yields a maximum wave height with 50-year return period of about 13.5 m. Note, however, that in deeper parts of the area this may become 15 m or more.

Under extreme wave conditions, the contribution of swell entering the area from the northern North Sea is shown to be of minor importance, due to the bottom topography of the area from the Dogger Bank to the south. This implies a strong correlation between wind speed and wave height. In addition, probability distributions and the persistence of wind speed exceedance are considered. All wind data that have been used for this study originally are Beaufort estimates. It is pointed out that the conversion of these estimates to wind speeds can be sufficiently accurate, compared with measured wind data.

The shape of the wave spectrum for extreme wind waves in shallow water (30 m depth) appears to be quite similar to the JONSWAP shape for deep water conditions. It seems that the bottom depth primarily governs the probability of extreme wave heights, without causing a clear distortion of the spectral shape due to a stronger dissipation of the low-frequency part of the spectrum that has the greatest wave lengths. In addition, it has been found that H_{m_0} and the mean wave period are strongly correlated. It is concluded that the wave spectrum for extreme wind conditions in a shallow area can be inferred from the wave height only.

However, a detailed analysis of wave spectra with, say, $H_{m_0} > 4$ m is needed to evaluate the contribution of swell under various conditions.

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1. Introduction.

A number of factors has stimulated the initiation of a systematic acquisition of (measured) wind and wave data for the investigation of the wind and wave climate of the North Sea:

- the surprisingly low amount of reliable and accessible data,
- the shallowness of the area, causing problems with regard to the prediction of extreme wave heights,
- problems concerning the reduction of wind data from platforms at sea to standard height, and the interpretation of Beaufort estimates by lightships,
- the increasing amount of platforms, pipe lines etc. in the area that will be described here.

Generally speaking there are two possible ways of investigating a local wind and wave climate:

- by collecting wind and wave data at selected locations that are supposed to be sufficiently representative,
- by hindcasting wave parameters using a number of selected storms obtained from historical weather charts.

The second way is followed by the North Sea Wave Model (NORSWAM) group to construct a wave climate for the North Sea.

This report primarily follows the first way, using about 5400 wave measurements and about 80,000 wind observations which have been taken in a 3-years period, 1973 to 1976, and in a 26-years period, 1949 to 1975, respectively.

However, it turned out that reliable estimates of design waves are difficult to make without going into an analysis of the physical aspects of wind waves over a shallow bottom.

The reader who is only interested in the main results of this study is advised to read the abstract and the chapters 1, 2 and 7 only. For other readers it may be convenient to skip chapter 4 (Theory) and to consult appropriate parts of this chapter only if desired during the reading of the subsequent chapters.

1.1. Wave data.

Reliable and easy-to-handle wave instruments for use in the open sea were hardly available until the 1960's, when the waverider buoy became operational.

Most literature on wave climatology is therefore based on visually observed wave data. Examples are R. Dorrestein (1967) for the Dutch coastal region based on regular lightship data, Hogben and Lumb (1967) and U.S. Navy Marine Climatic Atlas of the World, Volume I, North Atlantic Ocean (1974) based on scattered ships observations. A review of literature has been presented by Hogben (1976).

Visually observed wave heights can be considered as quite reliable within certain limits; according to various authors the proportion $\overline{H}_{1/3}/H_v$ varies between 1.0 and 1.1, where $\overline{H}_{1/3}$ is the mean of the highest one third of the waves in a record, H_v is the visually observed wave height.

However, under high wave conditions the observations become more difficult, particularly from small vessels (like lightships). Visually observed wave periods then generally become less accurate.

All wave data for this study have been obtained with waveriders, most of them on punch tape allowing the use of a computer for data analysis; a small amount has been analysed from stripchart recordings. The data analysis of the digitally recorded wave measurements included the calculation of wave spectra; the wave parameters have been derived from the spectral moments. It will be shown in section 5.2.1 that the spectral width parameter ϵ does not yield much relevant information.

In one particular case the wave spectrum is treated explicitly; a few representative extreme wave spectra have been compared with the JONSWAP-spectrum (section 6.3., section 7).

No information on wave directions was available. Rather complicated measurement procedures are required for obtaining useful data with a sufficiently high directional resolution power; no simple method for practical use under all imaginable conditions has yet become available to our knowledge.

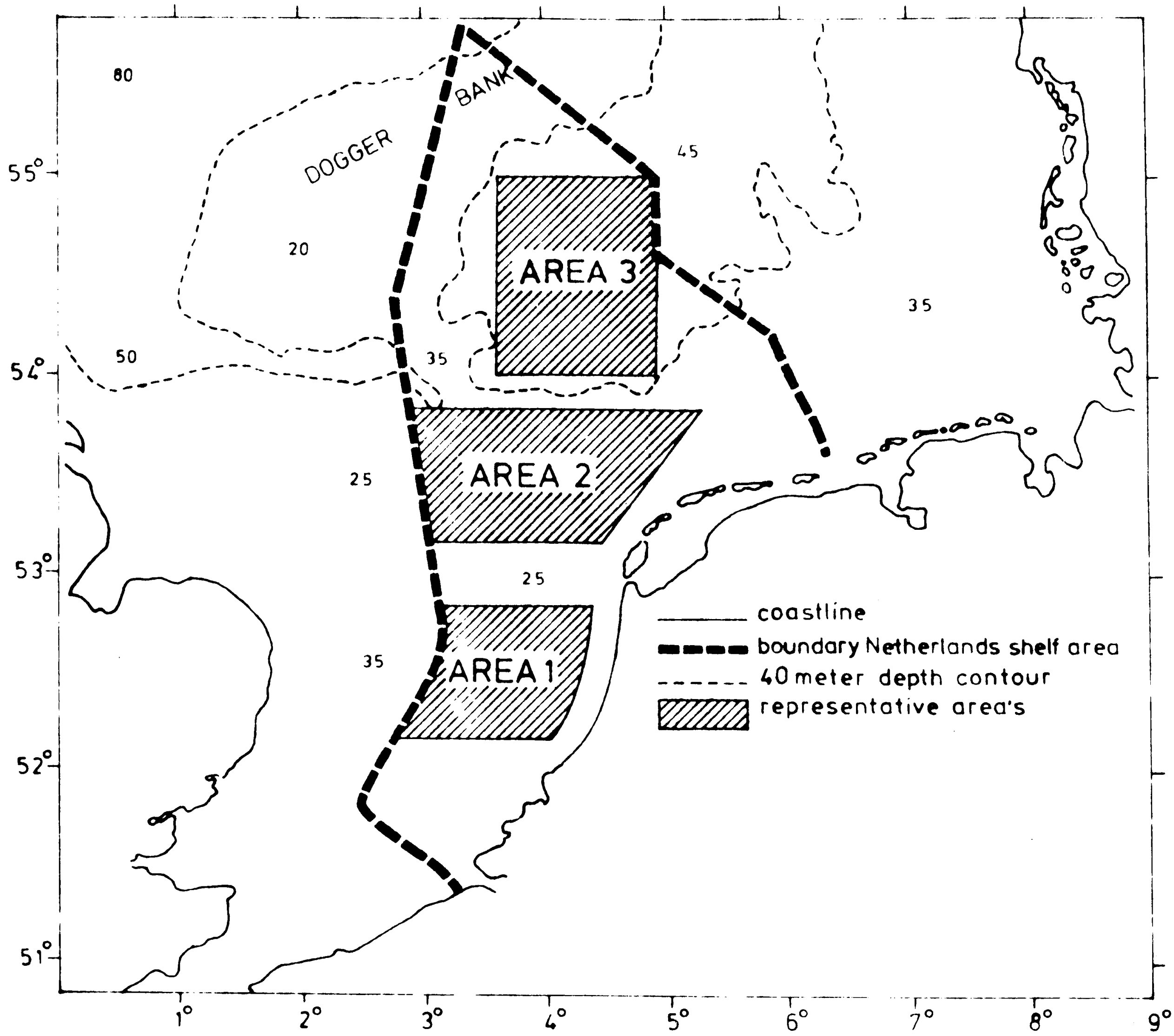


figure 1. Representative areas on the Netherlands continental shelf.

1.2. Wind data.

The original set-up of this study also included wind measurements at the various platforms where the wave measurements were located. This soon turned out to be impracticable for a number of reasons, for example:

- not all platforms have been equipped with a complete wind direction and wind speed recording system,
- calibration of existing equipment often was difficult or impossible,
- mounting of temporary wind instrumentation on attractive locations from the point of view of wind measurement requirements often could not be allowed for safety reasons, or was very difficult,
- each platforms has its individual wind disturbance characteristics.

Section 5.3.1. will go into this problem in more detail. For this study we used the synoptic hourly wind observations of lightship Texel (and for some time lightship Terschellingerbank) instead, assuming a certain homogeneity of the wind climate in the area. The lightship observations are based on estimates of wind force according to the Beaufort scale; this introduces the problem of converting Beaufort estimates into wind speed in knots or m/s. In this report we have followed a conversion table that is believed to be more reliable than the still operational WMO-Beaufort scale, in use since 1948, particularly for wind force 10 and more (section 5.3.2.).

2. Area of study.

Figure 1 shows the southern half of the North Sea; in the Dutch part of the continental shelf three areas are indicated that are expected to be sufficiently homogeneous (Kruseman, 1974). This report will be confined to area 2 (primarily block L, 53^{o}-54^{o}N, 4^{o}-5^{o}E), though the original intention was to study also the northern area 3; however, the amount of wave data from that area is still rather small. Area 1 will be subject of another study based on wave measurements 35 km west of IJmuiden and wind measurements at the port entrance of IJmuiden.

2.1. Wave stations.

The wave stations are given in table 1; see figure 2.

Nearly all wave measurements have been taken at locations near the gas platform Penrod-36 (station 29).

Table 1: waverider stations.

Station	Latitude	Longitude	Depth/m	From-until	Comments
29	53°24.5'N	4°12.0'E	26	March 1973 - Nov. 1974, February 1976	close to Penrod-36
29	53°22.9'N	4°20.8'E	30	March 1975 - Nov. 1975	5 naut.miles East of Penrod-36
3	53°2'N	4°17'E	27	January 1976 (supplem.)	near lightship Texel
4	53°29'N	4°46'E	23	December 1975 (supplem.)	near (former) lightship Terschellingerbank

Measurements at stations 3 and 4 were short series only, during high wind conditions, when the own waverider at station 29 was out of order. They have been provided by Rijkswaterstaat, Studiedienst Hoorn. Station 29 has been located near Penrod-36 during most of the time.

It was moved 5 miles eastward in 1975 to avoid collisions with ships that were involved in construction works in connection with a gas pipe line to the mainland.

2.2. Bottom topography.

Figure 1 depicts roughly the bottom topography of the southern half of the North Sea. In the north-western part of the area the Dogger Bank with water depths varying between 15 and 30 m is the main feature; in the remaining parts depths vary between 20 and 50 m, with the exception of the area north-west of the Dogger Bank, where depths are around 70 m.

Figure 2 shows bottom topography and coast lines around the wave stations in more detail. Station 29 (Penrod-36) has a minimum fetch for southeasterly winds of about 40 km. (During the short

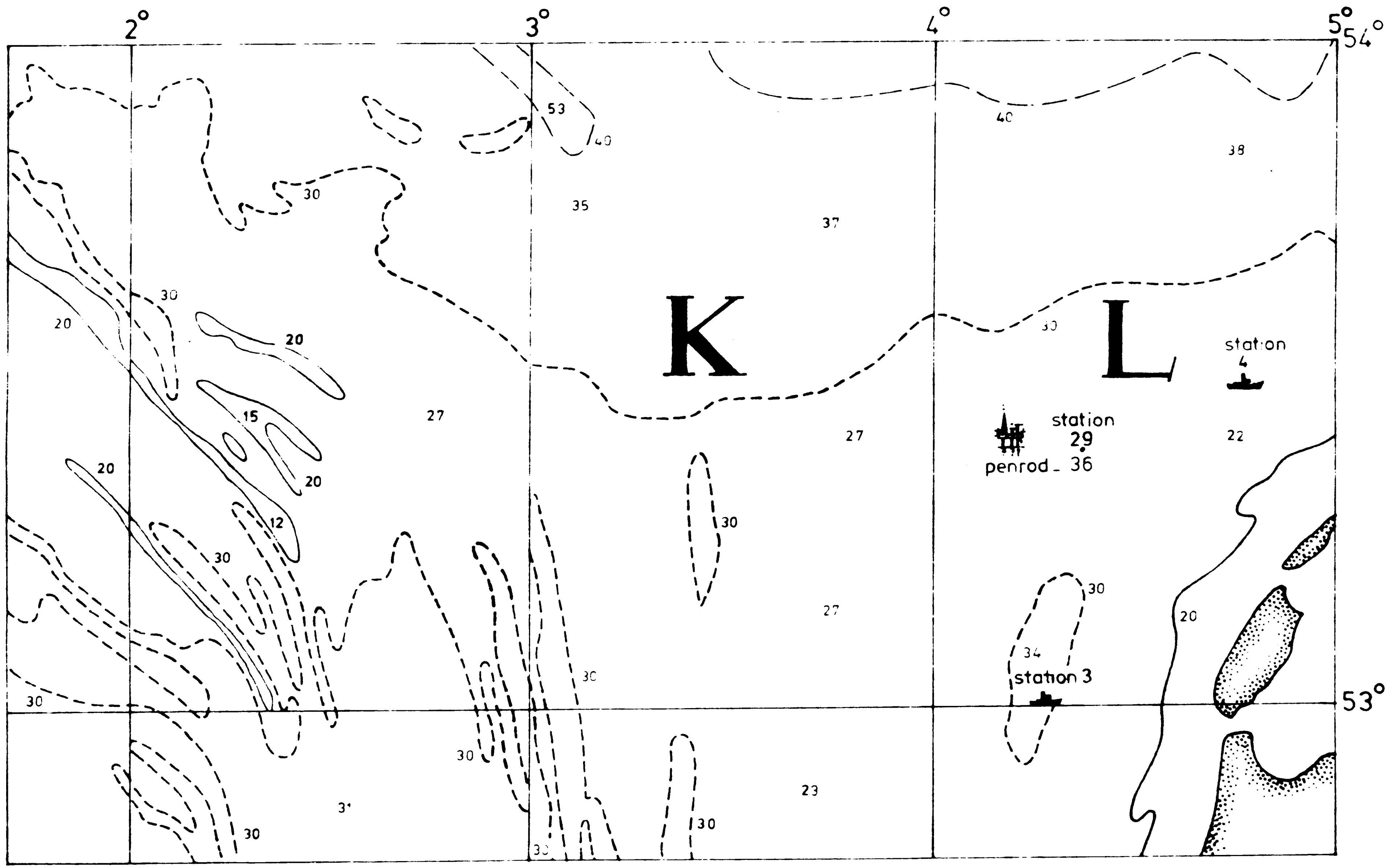


figure 2. Bottom topography and fetch around wave stations.
Depths in m.

supplementary measurements at stations 3 and 4 no offshore winds occurred). Bottom topography in relation with fetches is particularly important during extreme wind conditions like on 3 January 1976; wind directions then varied between 310° and 330°. A slight difference may exist between the waves at station 3, where the wave measurements have been taken on that occasion, and those at station 29, the representative wave station of the area.

No information is available on the occurrence of spatial variability due to refraction; it appears from extensive refraction computations by V. Goldsmith et al. (1974), that a bottom topography like in this area may cause a complicated pattern of caustics, which may lead to considerable spatial variability. However, such variability will be much less, if there is a spread of frequencies and directions of the incoming waves. In wind-wave conditions like at 3 January 1976 the variability due to caustics will probably play a minor role compared with the influence of bottom depth on wave growth. Swells that usually have a much narrower spectral spread may experience considerable variability from one location to the other.

K. Hasselmann et al. (1973), section 3.4., discussed this phenomenon, believed to be responsible for most of the scatter of their swell data that were collected in the area West of Sylt (figure 1, northeastern part) which is rather similar to area 2 as to bottom topography.

3. General aspects of wind climate.

Southwesterly to westerly winds dominate over other wind directions, in conjunction with weather patterns with relatively low air pressure over the northeast Atlantic Ocean.

Paths of active depressions associated with strong wind fields over the North Sea usually go across Scotland, turning northward to the north-west coast of Norway. Very strong and persistent northerly wind fields sometimes occur in the Norwegian Sea and the northern North Sea. Generally these wind fields do not reach the southern bight of the North Sea; however, they may cause northern swell in area 2 (blocks K and L); but this swell will be attenuated considerably on its way across the Dogger Bank (section 4.1.2.).

Depressions that are most relevant for extreme wind speeds and wave heights in block L usually go across the North Sea to Denmark or Northern Germany; the wind fields are often connected with troughs accompanying the depressions. The storm on 3 January 1976 belongs to this category, see figure 3. Winds with extreme speeds and sufficient duration for generating extreme wave heights, related with this type of weather situation, are confined to westerly and northwesterly directions (see appendices B and C, and section 6.1.5.). The shallowness in these directions will impose a limitation on the effective fetch for the area to a few hundreds of km.

4. Theory.

The first part of this section is dedicated to the physical behaviour of wind waves over a shallow bottom and of swell entering the area from northern directions. In the second part a specification is given of the statistical analysis of the data; this analysis is primarily concerned with the problem of the representativeness of the period March 1973 to February 1976 and with the occurrence of many gaps in the data series.

4.1. Physics of surface waves.

4.1.1. Wind waves.

The growth of the wind-wave spectrum in deep water is better understood since the report on the Joint North Sea Wave Project (JONSWAP), presented by Hasselmann et al. (1973). They showed that the growth rate and overshoot of individual wave components of the spectrum[1] can be explained only by considering weak nonlinear interactions between the waves; the net effect of these interactions is transfer of wave energy through the spectrum to the steep forward face. Another important conclusion of JONSWAP was the self-similarity of the shape of the wind-wave spectrum due to a feedback mechanism related with the nonlinear interactions between the sinusoidal wave components. Several conditions must be fulfilled

[1] See Notes at end of this report.

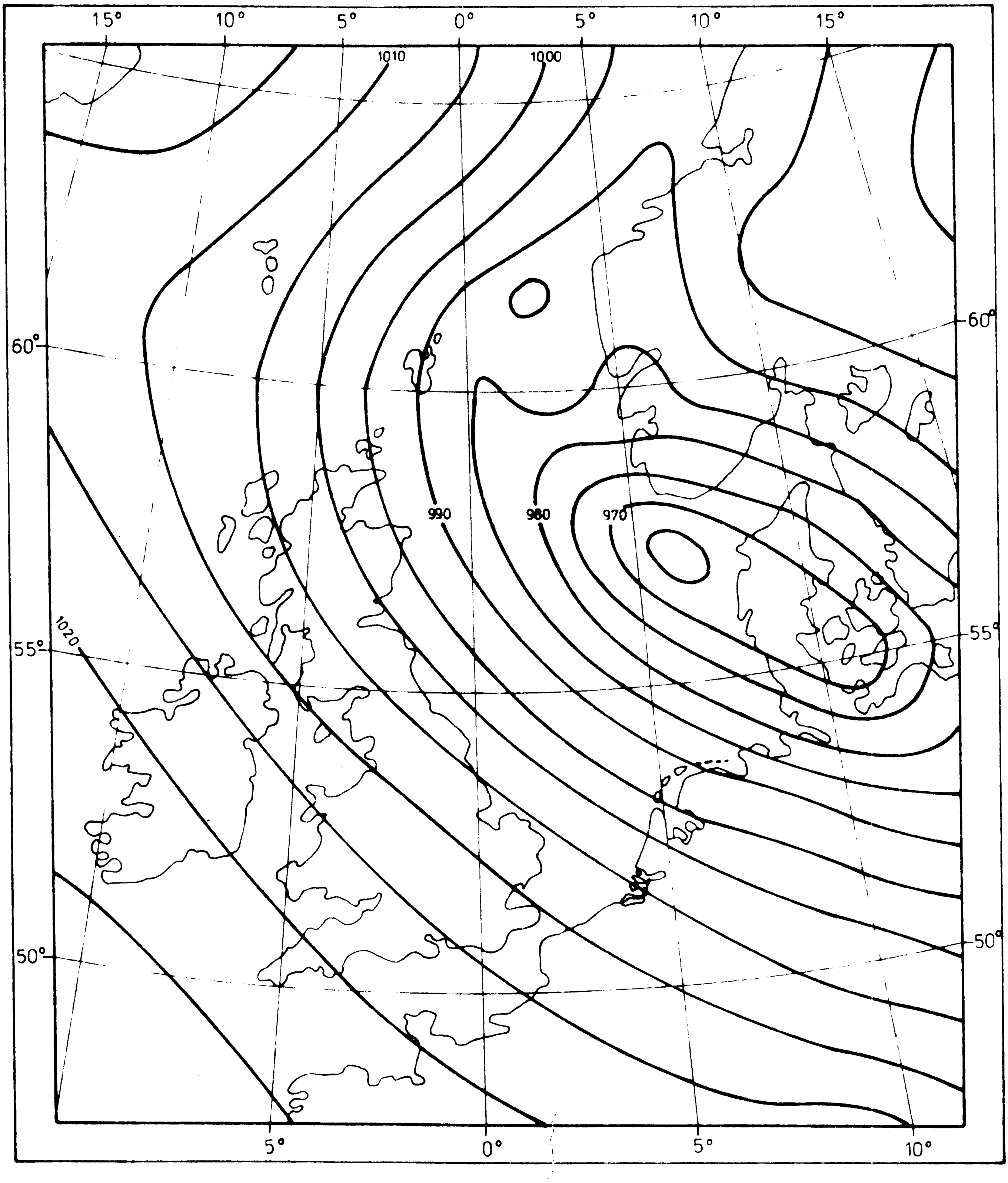


figure 3. Atmospheric surface pressure pattern of 3 January 1976, 06.00 GMT.

for these interactions to be effective: (1) the waves must be sufficiently steep, and (2) the interacting wave components must fit between themselves both in frequencies and in wave lengths (resonance conditions, depending on the dispersion relation). The wave spectrum will then assume a standard shape according to the socalled JONSWAP spectrum S_J, equation (1) (see below) and can be characterized by a number of parameters.

The behaviour of this wind-wave spectrum has only been studied for "deep" water when the dispersion relation holds:

$$\omega = \sqrt{gk},$$

where $\omega = 2\pi.f$, f is wave frequency, wave number $k = 2\pi/L$, L is the wave length, and g is the acceleration of gravity.

However, under extreme conditions the area concerned can no longer be regarded as deep water. Further, the highest of the individual waves will get a cnoidal profile, suggesting an increasing nonlinearity of the waves[2]. Nevertheless, as will be shown in chapter 6, spectra of measurements with extreme wave heights still seem to obey the deep-water spectral shape, but with a reduced net input of wind energy. This can qualitatively be explained by considering two possible factors: (a) wave attenuation through bottom friction, and (b) redistribution of wave energy due to nonlinear interactions, modified as a result of a changing dispersion relation in shallow water:

$$\omega = \sqrt{gk.\tanh kd}, \text{ and}$$

$$c = \sqrt{\frac{g}{k}.\tanh kd}, \text{ phase velocity of the waves.}$$

Taking wave height and wave frequency constant, the steepness of the waves will increase with decreasing depth d, because of a decrease of wave length $L = 2\pi/k$. Shoaling (increase of wave height caused by decreasing group velocity) is considered to have almost no influence on the wave steepness in the area when conditions are extreme; it appears that for d = 20 - 50 m the group velocity v_g is almost constant for wave frequencies around 0.08 Hz, being about 15% higher than in "deep" water (here $d > 100$ m). However, it will be shown in section 4.1.2. that advection of waves from deep water cannot be of great importance for the wave climate in the area south of 54^{o} North latitude.

If the net wind input into the waves under extreme conditions is decreased by reducing the observed wind speed, it appears that the measured spectrum is similar in shape with the JONSWAP spectrum:

$$S_J(f) = \alpha . g^2 (2\pi)^{-4} f^{-5} \exp\{-1.25\ (f_p/f)^4\} \cdot \gamma^{\exp\{-(f-f_p)^2/2\sigma_x^2 f_p^2\}} , \qquad (1)$$

where the quantities α, γ and f_p, the peak frequency of the spectrum, are empirically determined functions of fetch F and of wind speed U at standard height of observation (= 20 m, see section 5.3.2.):

$$\begin{aligned} \alpha &= 0.435.\ \tilde{x}^{-0.4},\ \text{for } 0.008 < \alpha < 0.08 \\ \alpha &= 0.008,\ \text{if } 0.435.\ \tilde{x}^{-0.4} < 0.008 \\ \alpha &= 0.08\ ,\ \text{if } 0.435.\ \tilde{x}^{-0.4} > 0.08 \end{aligned} \qquad (2)$$

$$\gamma = 2.15 - 1.15.\ \tanh \frac{\tilde{x}-10{,}000}{3500} \qquad (3)$$

$$f_p = 16.16 . U^{-0.34} .\ F^{-0.33}\ \text{Hz} \qquad (4)$$

where $\tilde{x} = gF/U^2$ denotes dimensionless fetch, U and F are given in m/s and m resp.. Relations (2) and (3) have been established by adjusting the significant wave height H_{m_0} according to S_J for various values of U and F with empirical relations of wave height to fetch and wind speed in deep water as given e.g. in the CERC Shore Protection Manual (1973).

Equation (4) is equivalent with $\tilde{f}_p = Uf_p/g = 3.50\ x^{-0.33}$, from K. Hasselmann et al. (1973). σ_x in equation (1) is the width parameter in conjunction with the enhancement factor γ :[3)]

$$\sigma_x = 0.07 \text{ for } f \leq f_p$$
$$\sigma_x = 0.09 \text{ for } f > f_p.$$

If γ gradually decreases with increasing fetch, σ_x should actually increase to get a smooth transition to the Pierson-Moskowitz spectrum; this has been neglected here.

The problem of the directional distribution of wind waves has not yet been solved satisfactorily, mainly due to the lack of good field data. Mitsuyasu et al. (1975) presented new data, using a cloverleaf buoy, a further development of the well-known NIO-pitch-roll buoy, with an improved directional resolution. Possibly multiple point array wave measurements and remote sensing techniques (stereoscopy, laser or rader altimeter profile measurements etc.) will provide in the deficiency.

4.1.2. Swell.

Extreme wave heights are likely only from directions with extreme wind speed of sufficient duration. Swell approaching from the deeper areas north of the Dogger Bank, however, may contribute to the total wave height. The question arises then, what will remain of swell that penetrates into the shallow area from the Dogger Bank onwards. To evaluate this, we use empirical data of the swell investigation of JONSWAP, presented in part 3 of Hasselmann et al. (1973).

An array of wave stations was situated in the German Bight west of Sylt. Ten distinct swell cases were investigated; a swell case was defined by its source area. Generally the total swell energy E (= variance) and the mean frequency f of a swell peak in the wave spectrum could be inferred from 678 measurements; then the energy flux $I=V_g.E$ could be evaluated (thus eliminating shoaling), where $V_g = V_g$ (f, d) is the group velocity of waves with frequency f and depth d.

For each swell case the mean rate of dissipation has been represented by

$$\Gamma = \frac{1}{I}\frac{dI}{d\xi} \qquad (m^2/s^3), \qquad (5)$$

where ξ is the normalized distance or weighted propagation distance:

$$\xi = \int_{x_o}^{x} \frac{dx}{V_g\, c^2 \cosh 2\pi d/L} \qquad (s^3/m^2); \qquad (6)$$

x is the coordinate along the path of propagation, x_o is the coordinate of the wave station at the end of the path, thus $x-x_o$ is the physical distance (m) between the starting point and the wave station.

ξ remains zero in deep water and increases in shallow areas, due to the term $\cosh^2 2\pi\, d/L$ in (6).

The mean value of the dissipation rate of all JONSWAP data was $\Gamma = 0.038\ m^2/s^3$. A typical value of ξ for a swell with wave period $T = 12$ s propagating from the central North Sea to e.g. station 29 (Penrod-36, block L-10) is 55; then according to (5) the reduction of energy flux I is by a factor 8. The JONSWAP data seem to suggest a dependency of Γ on I; the value that has been cited here has been inferred from swell cases with generally low amplitudes and I of the order of 0.05 m^3/s (swell wave height about 30 cm).

Figure 3.5.a in Hasselmann et al. (1973) suggests that Γ possibly increases to 0.1 m^2/s^3 if I becomes of the order of 10 m^3/s (swell wave height about 4 m). So if very heigh swell of say 7 m propagates from the North into the Dogger Bank area, most of it will be dissipated and the remaining wave height will be 2 - 3 m at most.

It should be noted that a satisfactory explanation of swell attenuation that is valid under a variety of conditions has not been given yet.

Various causes for attenuation can be mentioned; each of them probably contributes to the actual attenuation, but cannot be recognized individually:

- pressure fluctuations working on the bottom, percolation of water through a porous bottom or deformation of the bottom,
- turbulent bottom friction,
- movement of sediment particles,
- backscatter of swell by bottom disturbances with wave lengths of the same order of magnitude as the swell waves.

Also refraction may cause a considerable reduction - or enhancement - of swell locally.

4.1.3. Orbital motions near the sea bottom.

The horizontal orbital velocity at the sea bottom, depth d, associated with a surface displacement $\eta(x,t) = a \cos(\omega t - kx)$ is, approximated to the first order:

$$U_{hor} = \frac{\omega . \eta}{\sinh kd} \quad (m/s) \tag{7}$$

However, it appears that, even under extreme conditions, equation (7) remains close to empirical values. For example, let $a = 5$ m (individual wave height is about 10 m), $T = 12$ seconds, $d = 25$ m, then the amplitude of U_{hor} becomes 2.4 m/s. Individual waves of that size may occur in a wave field with $\bar{H}_{1/3} \geq 6$ m; then the mean of the absolute value of the orbital velocity at the bottom is ≥ 0.56 m/s.

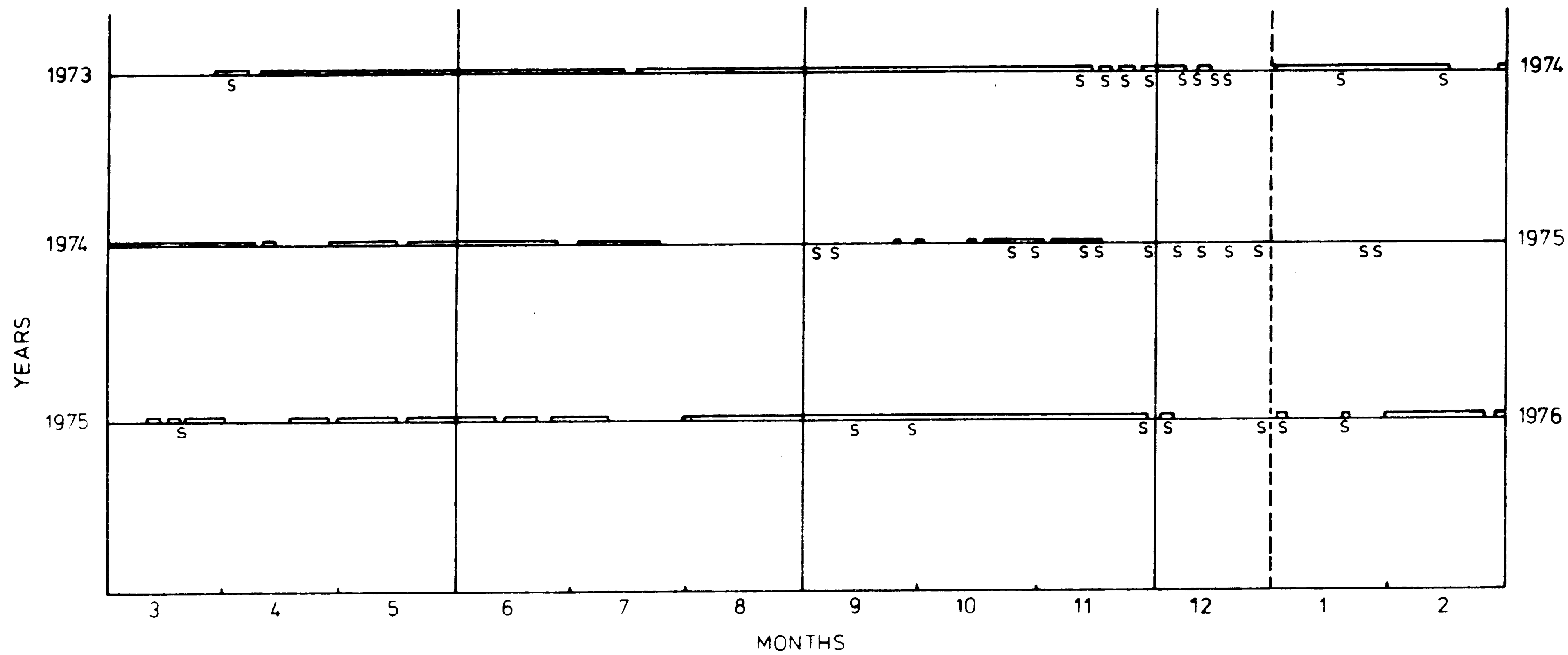


figure 4. Available wave data and gale events, March 1973 - February 1976.

: continuous wave data series,

s s : gale events, wind speed exceeding 20 m/s.

4.2. Statistical analysis of wind and wave data.

One of the major aims of this study was to determine exceedance levels with a return period of 50 years of wind speed, wave height and wave period. A problem was caused by the limited amount of wave data that has been collected during a three-year period, with a large number of gaps particularly in rough weather periods during the winter months, see figure 4.

The frequency distributions of these data can be expected to deviate from those referring to a period of 20-30 years. These could be derived by resorting to the close correlation between winds and waves and the differences, in fact, were quite clear. Extreme conditions on 3 January 1976 permitted us to adjust the 50-year exceedance values obtained from extrapolation of the empirical distribution data, the 3 January case being in itself an event that may occur once in about 20 years in the area concerned.

A problem related with extrapolations of probability distributions that usually gets much attention is the choice of the most appropriate distribution function for least-square fitting the frequency data.

For our study the Weibull function was used as such. In its cumulative form:

$$P_w(z) = 1 - \exp(-z^k), \qquad (8)$$

representing the probability that the variable considered is less than z; $z = x/v$, v is scale parameter, k is shape parameter, usually $k \approx 2$; $x = X - X_o$, where $X = (H_{m_o} | T_{m_{o2}} | U)$: wave height or wave period or wind speed, respectively; X_o is an optional offset to improve the fit; $X_o \neq 0$ only for extrapolations of $T_{m_{o2}}$ distributions. (H_{m_o} and $T_{m_{o2}}$ are defined in section 5.2.).

$P_w(z)$ has been fitted only when probability $P(z) > 0.45$, thus ignoring the low-value part of the probability distributions. In this way we eliminated the influence of spells with low wind speeds and low waves on the extrapolation necessary to obtain the element values corresponding to a "return period" of 50 years.

4.2.1. Duration of exceedances; relation between return periods and fractions of time.

For a given high wave height, H_N, the "return period", say N (years) with $N \gg 1$, is defined by the relation: probability of wave height H_N being exceeded during one year is 1/N; similarly for wave periods or wind speeds. In this report an attempt is made to estimate H_N etc. for N = 50, i.e., the "50-year return height" etc. If should be remembered that the parameter "return period" must be interpreted with caution when applied to the analysis of risks due to extreme waves: the probability of exceedance of H_N within the "return period" N (under statistically stationary conditions) is by no means small, apparently it is $1 - (1 - 1/N)^N$ or about $1 - \exp(-1) \approx 63$ percent.

Presentations of climatological data usually are based on the tacit assumption that the measured data which, in the case of wind or wave data, are mostly samples with a duration of 10 - 20 minutes per one or three hours, are on average equal to the mean values during one or three hours respectively. If it could be assumed further, that the duration of an exceedance is equal to the sampling period of e.g. three hours, then the theoretical number of observations within say 50 years is 50 x 8 x 365.25 = 146100; thus the fraction of time exceedance for the "50-year return value" would become $1/146100 = 6.84\ 10^{-6}$.

However, this approach may lead to unrealistic results, because sequential data ara not statistically independent; this means in practice that wind speed and particularly wave height usually can be predicted for the next three hours within quite narrow ranges from the former.

Battjes (1970) considering this problem pointed out that it would not be correct to define return periods at all for running mean quantities like significant wave height, because it is not possible to give exact definitions of the duration of extreme events in terms of these quantities. Battjes has presented exceedance levels for given return period of individual wave height instead, inferred from joint frequency distributions of significant wave height and mean wave period. Such an analysis is based on the assumption that the Rayleigh distribution of individual waves (see section 4.2.3.) also holds for extreme wave heights in particular. However, this is not likely in the area between 53° and 54° north latitude, considering the limited depth compared with dimensions of extreme waves.

The problem of evaluating the relation between return period and time fraction of exceedance has been tackled in this study by taking into account the physical conditions during one particular storm that has been described in section 6.3.; then wind speed and wave height remained extreme during 21 and 15 hours respectively. Generally speaking, durations of extreme conditions are of the order of 3 to 12 hours due to the dimensions of wind fields related with storm depressions that are typical for this latitude, see e.g. figure 3.

In default of a more elaborate analysis of the statistical dependency of sequential data and considering the results that are presented in section 6.3. we have chosen a standard exceedance time for extreme values of 4.4 hours (= 1/2000 or 0.05% of a year). This may be considered a conservative estimate, both for wind speed and even more so for wave height. The calculated 50-year return values, though, do not strongly depend on the mean exceedance time chosen: e.g., for 6 hours the 50-year return wave height would be only 1 to 2 decimetres lower than for 4.4 hours.

The nature of the wind data that are employed here - based on Beaufort estimates from sea state - exclude the presence of showery gusts that may reach hurricane force during a short time e.g. 10 minutes, because the sea state averages out all events of short duration; the wave field acts as a low pass filter on the wind input.

Another way of estimating return periods of exceedances for significant wave heights would be to use a distribution function for annual maximum values, Battjes (1970). This method has been applied to visually observed wave data of Netherlands lightships in section 6.2.2.

4.2.2. Interpretation of exceedance values of waves.

Wave data that are used for estimating design waves usually have been acquired during a limited period of time, for this study during three years. Depending on the characteristics of such a period with respect to long-term climatological data this may lead to overrating or underrating of the design waves.

Such errors can be eliminated by comparing the wind data that have been taken simultaneously with the wave measurements with a "normal" probability distribution based on a long series of wind speed data. From this we can infer how certain wind speed levels have been exceeded, e.g. less or more frequently than normal. The wave height probability distribution may then be corrected accordingly, by use of the narrow relationship between wind speed and wave height.

For this analysis we followed a simplified method that is easier to apply and that is believed to give reliable approximations of the "normal" exceedance values; it is particularly attractive when a large number of exceedances, defined by season and wind direction, is to be determined. We used three different distributions: (1) a standard wind speed distribution, (b) a distribution of wind speed during wave measurements, and (c) a distribution of wave heights. To each of the distributions the Weibull function (8) is fitted according to a least-square method, yielding values of v and k. Then the exceedance level x_e is obtained from:

$$x_e = v.(-\ln Q_{N_y})^{1/k} \qquad (9)$$

where Q_{N_y} is the probability of exceedance as a fraction of time corresponding with N_y years return period. Q_{N_y} is established according to section 4.2.1.:

$$Q_{N_y} = \frac{1}{2000.N_y.F_{dd}.(N_{kw}/4)} \qquad (10)$$

where F_{dd} is the fraction of occurrence within a particular wind direction sector, dd = NNE, NE, ..., NW, NNW, N; F_{dd} = 1 if all wind directions are taken together; N_{kw} is the number of seasons, e.g. N_{kw} = 1 for one season, N_{kw} = 4 for all seasons. For example, the fraction of time with a return period of N_y = 50 years becomes for all seasons and all directions:

$$Q_{50} = \frac{1}{2000\ .\ 50} = 10^{-5}, \text{ and}$$

$$x_e = v\ .\ 11.5129^{1/k};$$

the fraction of time for one season, taking wind direction "W" with F_{dd} = 0.1, say, $Q_{50} = \frac{1}{2000\ .\ 50\ .\ 0.1\ .\ (0.25)} = 4 \times 10^{-4}$; the fraction of time with respect to the limited class of directions and one season is relatively much greater.

In this way we obtained from distributions (a) of reference wind speed data, (b) of wind speed during wave measurements and (c) of wave heights [4] the exceedance values $U_e(1949/75)$, $U_{e,s}$ and H_e respectively. The reference data of wind speed are those from lightship Texel, January 1949 - December 1975, and $U_{e,s}$ and H_e are derived from data of this study. It is assumed then that the "normal" or "true" exceedance level of the wave height is approximately

$$H_{e,true} = H_e \cdot \frac{U_e(1949/75)}{U_{e,s}} . \qquad (11)$$

Equation (11) is based on the assumption that the amount of fetch under extreme conditions for a particular station and wind direction is always of the same order of magnitude. For offshore winds this is obvious, but it also seems to hold for onshore winds because for extreme wave heights the bottom depth becomes important, limiting the effective fetch to about 250 km, see for example wind wave prediction curves over a shallow bottom, section 6.3, figure 23, from Bretschneider (1954).

If we assume that

$$\frac{gH}{U^2} \propto \sqrt{\frac{gF}{U^2}} ,$$

where g is the acceleration of gravity, U is wind speed and F is fetch (approximately correct for $\frac{gF}{U^2} < 5000$), and F constant, we get the proportionality:

$$H \propto U.$$

This relation is only valid to some extent, in shallow water, extreme wind speed and limited fetch. However, it is only used to adjust H_e, so that errors originating from this crude assumption are only effective on the adjustment itself which is no more than 10 - 20% of H_e.

Estimates of the "true" exceedance levels of the mean wave period T_e have been obtained in a similar way:

$$T_{e,true} = T_e \cdot \left(\frac{U_e(1949/75)}{U_{e,s}}\right)^{1/3}, \qquad (11a)$$

based on the assumption $\frac{gT}{U} \propto \left(\frac{gF}{U^2}\right)^{1/3}$, and F constant, so that: $T \propto U^{1/3}$.

4.2.3. The maximum wave height and the 50-year return wave height.

The "50-year return individual wave height", denoted by $H_{max,e}$ is defined here as the expected height of the highest wave during the 4.4 hours period that H_{m_0} exceeds its 50-year return period level. So if we have H_e (and T_e)[5], H_{max} can be obtained from the Rayleigh distribution of individual wave heights:

$$P(H) = 1 - \exp\left(-H^2/H^2_{RMS}\right), \qquad (12)$$

where H_{RMS} denotes the root-mean-square wave height of a record of N waves ($N = \frac{4.4 \times 3600}{T_e}$ is the number of waves during 4.4 hours when the average wave period is equal to T_e), and

$$H_{RMS} = \frac{\overline{H}_{1/3}}{1.42}, \text{ approximately}, \qquad (13)$$

where $\overline{H}_{1/3}$ denotes the mean height of the highest one third of the waves of a record.[6]
The probability distribution of the maximum height of N waves can be given by

$$P'(H) = [P(H)]^N \qquad (14)$$

where P'(H) is the probability that the maximum wave height is less than H. The 50-percentile value of P'(H) will be considered as an estimate of H_{max}. Then from (14) with $P'(H_{max}) = 0.5$ and (12):

$$-H^2_{max}/H^2_{RMS} = \ln\left[1 - 2^{-\frac{1}{N}}\right], \text{ so that}$$

$$H_{max} = H_{RMS}\sqrt{\ln\left[1/(1 - 2^{-\frac{1}{N}})\right]} \qquad (15)$$

If N > 10, equation (15) is well approximated by

$$H_{max} = H_{RMS} \sqrt{\ln (1.45\ N)}.$$

Using $H_{m_o} = 1.05\ \overline{H}_{1/3} = 1.49\ H_{RMS}$ according to (13)[7] (see section 5.2) we finally obtain

$$H_{max} = 0.67\ H_{m_o} \sqrt{\ln (1.45\ N)}. \qquad (16)$$

The number of waves during 4.4 hours under 50-year exceedance conditions is approximately N = 1800; then (16) gives

$$H_{max} = 1.88\ H_{m_o} \qquad (17)$$

Relation (17) implies the assumption that the Rayleigh distribution (12) also holds for high waves over a shallow bottom. Earle (1975) cited several authors confirming this assumption, e.g. Borgman who investigated hurricane waves with H_{max} = 11.3 m and a water depth d = 31 m. However, Ibragimov (1973) presented an expression of a modified Rayleigh distribution based on empirical data; combining it with (16) we get

$$H_{max} = 0.67\ H_{m_o} \left[\ln (1.45\ N)\right]^{1/A}, \text{ where}$$

$$A = \frac{2}{1 - \exp\left[-4.6\ d/T^2\right]/\sqrt{\pi}};$$

this would lead to a reduction of H_{max} of approx. 10% for depths of about 30 m and mean wave periods about 9.5 s.
Taking a stand between both points of view and applying it to exceedance values H_e of H_{m_o}, the 50-year return individual wave heights are given by

$$H_{max,e} = 1.8\ H_e. \qquad (18)$$

Equation (18) has been used in section 6.2.2..

5. Data analysis.

5.1. Wave measurements.

Digital recordings of waves can readily be processed numerically to get wave variance density spectra, due to the statistical properties of the waves. These spectra contain all relevant information of the wave field. The spectra can be obtained in two ways that are approximately equivalent: (a) by fourier transformation of the autocovariance function of the wave signal, or (b) by fourier transformation of the wave signal using FFT followed by a reduction to get a variance spectrum

$$S(f_i) = A(f_i).\ A^*(f_i),$$

where $A(f_i)$ is the complex fourier amplitude with frequency f_i and $A^*(f_i)$ is its complex conjugate.

Wave data have been derived from measurements with waveriders. The accuracy of this instrument is good, with calibration differences of only a few percent. No explicit calibration of instruments has been done apart from the initial calibration by the manufacturer. The 80% confidence range of the total variance of the wave signal is of the order of ± 10%, due to the limited duration of the measurements. The 80% confidence range of wave heights is then of the order of ± 5%. The width of the confidence range depends on the equivalent number of degrees of freedom that is about 150 for very high waves, increasing to 750 for low short period waves.

This only applies for the measurements individually, for example in the presentations of some extreme wave heights in section 6.

The wave measurements have often been interrupted, mostly by failures of the mooring line, sometimes by failures of the automatic datalogger equipment. It seems that in most cases the (relatively small) buoys broke adrift as a result of collisions with fishery equipment or ships related with supply and construction works at gas rigs in the area. Replacement was often not immediately possible due to bad weather or to lacking availability of ships suitable for deploying a waverider.

An automatic receiver-datalogger was operated until the winter 1974/75 on "Penrod-36". Due to a number of reasons it became impossible to continue the measurements on that rig. After it has been found that good reception of the waverider signal was possible from the lighthouse in Eierland (Texel), the equipment was moved to this location.

From March 1975 onwards measurements have been resumed after an intermission of more than three months.

Figure 4 depicts how the wave data are distributed over a large number of seperate series, divided by gaps of various lengths. Due to this the persistence of wave height conditions could only partly be determined. However,frequency distributions of wave heights do not seem to have suffered so much since the frequencies of the wind speed data during wave measurements do not differ so much from those of all wind speed data between March 1973 and February 1976 (see section 5.3.2.).

5.2. Wave data analysis.

Waves have been recorded digitally on punch tape, and additionally on strip charts. Strip chart records were used for deriving the highest wave of a record (during the first year of the measurements). Strip charts were used, too,to determine the significant wave height when punch tapes were missing, by Tucker's method, described by Draper (1966).

Paper tape records have been processed using FFT to obtain wave spectra; the wave data were derived from the moments of the spectrum defined by:

$$m_n = \int_a^b f^n . S(f)\, df \quad , n = 0,1, \ldots, 4 \qquad (19)$$

where S(f) is the wave (variance density) spectrum, in m^2/Hz, f is the frequency of wave components in Hz, $f = T^{-1}$, a and b are lower and upper limit resp. of the integration interval in (19). In principle a = 0 and b = ∞ , but spectral noise is eliminated by taking a = 0.045 Hz and b = 0.505 Hz, see section 5.2.1 ; m_o is the variance of the wave signal. Then:

Significant wave height $H_{m_0} = 4.00\sqrt{m_0}$,

Wave period ("mean zero-upcrossing") $T_{m_{02}} = \sqrt{m_0/m_2}$,

"Spectral width" $\varepsilon = \sqrt{1 - \frac{m_2^2}{m_0 m_4}}$.

H_{m_0}, $T_{m_{02}}$ and are related with similar quantities of individual wave statistics: $\overline{H}_{1/3}$, the mean of highest one third of the waves in a record, $\overline{T}_z$, the mean (zero-upcrossing) wave period, and $\varepsilon = \sqrt{1 - (T_c/T_z)^2}$, the spectral width parameter, where T_c wave crest period.

5.2.1. Elimination of low- and high-frequency components of the spectrum, and consequences.

The waverider response to a wave field is quite linear. However, sometimes due to malfunctioning of the accelerator system large long-period signals (periode e.g. 40 seconds) occur; also a resonance peak is found at frequencies around 0.7 Hz; besides, the signal-to-noise ratio for frequencies below 0.05 Hz and those over 0.5 Hz usually is low. In consideration of this, the integration limits for the moments m_n of the wave spectrum in equation (19), have been chosen to be a = 0.045 Hz and b = 0.505 Hz, ignoring all other frequencies (Nyquist frequency, the half of the smapling frequency is 1 Hz). This way of truncating leaves the wave height H_{m_0} unchanged in most cases.

However, $T_{m_{02}}$ and particularly ε appear to be quite dependent of the choice of b for wind waves. This will be demonstrated for the JONSWAP wind-wave spectrum, equation (1).

Figure 5.(a) depicts the relation between $f_{5\%}$ and H_{m_0} for wind waves obeying the JONSWAP spectrum at various wind speeds; $f_{5\%}$ is defined by

$$\int_{f_{5\%}}^{\infty} S(f)\,df = 0.05 \int_{0}^{\infty} S(f)\,df;$$

taking $f_{5\%}$ as the upper frequency limit of the integration 95% of the wave energy is retained.

Figure 5.(b) shows that for low values of $b/f_{5\%}$ $T_{m_{02}}$ approaches to 2 seconds due to b = 0.505 Hz; the true wave period is then much shorter.

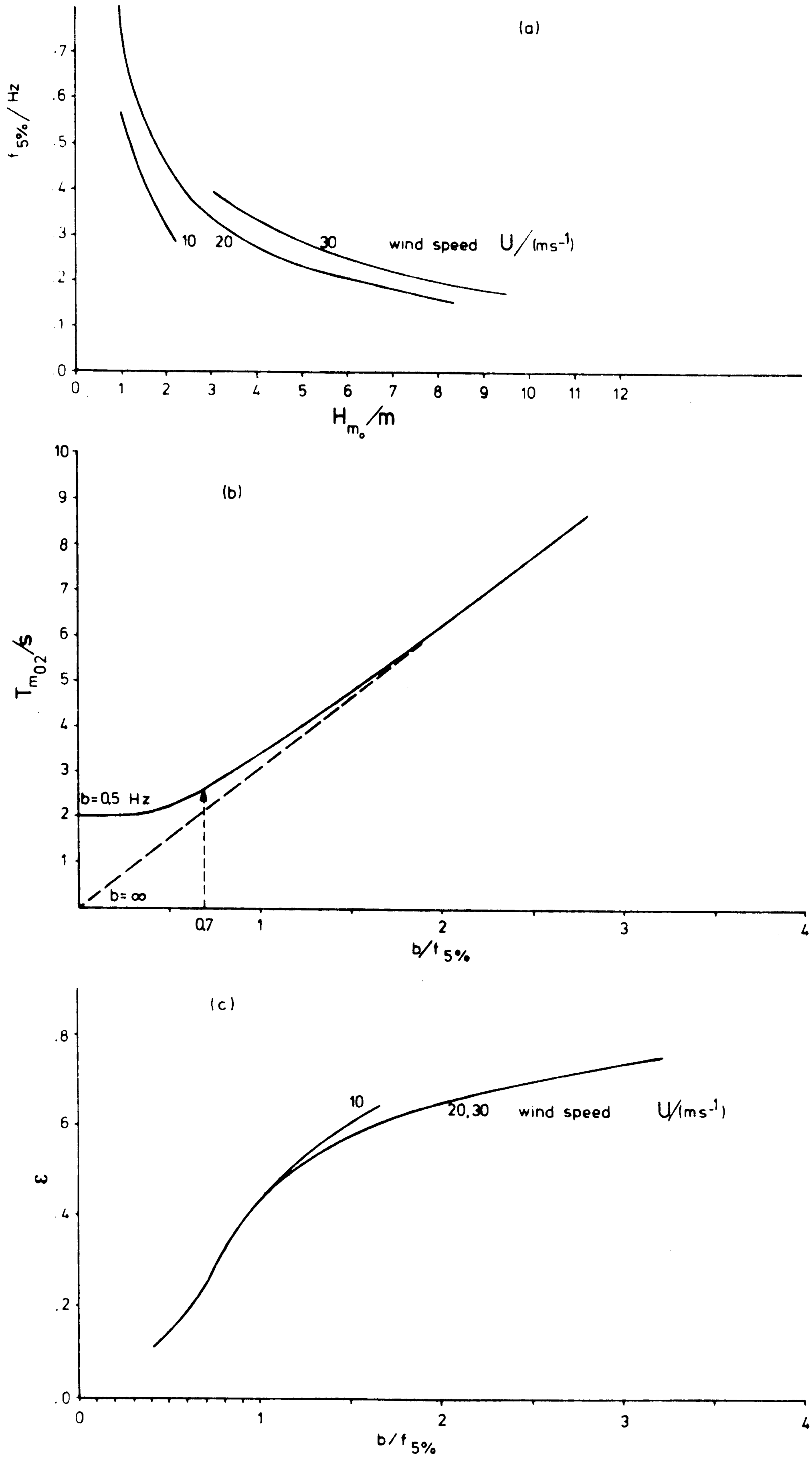


figure 5. Relations between wave parameters for JONSWAP wind-wave spectrum. For explanation see section 5.2.1.

For field measurements, however, $f_{5\%}$ mostly remains below 0.7 Hz; the absence of measured values of $T_{m02} < 3$ s indicates that $b/f_{5\%} > 0.7$, see figure 5 (b).

The most serious effect related to the fixed value of b = 0.505 Hz is experienced by the spectral width parameter ε, as is shown in figure 5.(c) for JONSWAP spectra in various stages of wave growth: a gradual but slight increase of ε for a wind-wave spectrum with increasing fetch is almost completely masked by the working of the spectral "filter" (removal of spectral components beyond 0.505 Hz); ε should actually remain between about 0.6 for wind-wave spectra at short fetches when the JONSWAP spectrum applies, and 0.75 for spectra of fully developed wind waves. This would be in accordance with the similarity of the shape of wind-wave spectra that is attributed to nonlinear interactions between the waves.

Sometimes ε is related to the length of wave trains, or to the probability of a sequence of two or more extreme waves. It should be kept in mind that ε has been derived here without discerning between various details within the spectrum, e.g. directions of the waves. Particularly swell waves often occur in relatively long groups suggesting very low values of the spectral width; but this usually will be masked due to the presence of other wave frequencies, then leading to high values of ε.

The following conclusions may be drawn:

- the elimination of spectral energy with $f > 0.505$ Hz can be accounted for values of ε below 0.6 in appendix A;
- high values of ε (e.g. 0.8) have been found to be related with the presence of swell;
- the use of ε, derived from wave data without removal of non-relevant spectral components, for estimating the length of wave trains will lead to erroneous results.

5.3. Wind data.

5.3.1. Measurements on "Penrod-36".

In 1973 wind measurements (wind speed only) on stripcharts have been collected from June until December. Because wind direction could not be recorded, these data have not been used for the climatology. Another drawback of these data was that the relation of the measured wind speed to standard height could not be specified directly; the location of the anemometer was rather unfavourable. It appeared from comparison with neighbouring wind observations that wind data like most recorded wind from other platforms at sea must be reduced with approx. 15-20%; this reduction is more or less independent of the observation height.

At lower heights the wind is accelerated by the disturbance of the structure, whereas on greater heights the wind becomes mainly dependent of height z according to a logarithmic profile:

$$U(z) = U(20 \text{ m}) \frac{\ln z/z_o}{\ln 20/z_o} , \qquad (20)$$

where z_o is the aerodynamic roughness length of the water surface. Usually z_o is taken to be about 0.0002 m, so that:

$$U(z) = U(20 \text{ m}) \frac{\ln z + 8.52}{11.51} .$$

For z = 100 m we get U(100 m) = 1.14 U(20 m), and for z = 40 m U(40 m) = 1.06 U(20 m); but it appears from comparisons with wind measurements from shore stations after correction for exposure that actual data are on average more than 10% higher for z = 40 m than predicted because of wind flow disturbances around the structure.

Stripchart recordings of wind velocity on "Penrod-36" from June until November 1973 have been used to estimate the mean gustiness $\overline{G} = \overline{U_{max}/U}$ of the wind during this period, where U_{max} is the maximum wind speed within one hour and U the average wind speed during the last 10 minutes of the hour.
Table 2 shows some results.

Table 2: Mean gustiness on Penrod-36, June - November 1973.

$\overline{U}$/(m/s)	$\overline{G}$ (June - Aug.)	$\overline{G}$ (Sep. - Nov.)
10	1.22	1.27
15	1.22	1.25
20	1.16	1.25
25	-	1.24

Note that gust durations or gust lengths are not specified here. Taking a gust length U.t = 100 m where t is the gust duration, then, following Wieringa (1973), we find for 20 m height within one hour G = 1.29; G tends to be smaller at greater heights.

5.3.2. Wind data of lightvessels.

Synoptic wind data of lightvessels have been used to obtain information of the wind climate; such data are based on Beaufort scale estimates of wind force. This may seem rather unreliable. However, errors in interpretation of wind speed data at sea due to effects of obstacles usually are of the same order. Further, this kind of data has the advantage of being directly comparable with long historical series.

For this study only wind data from 1949 until 1975 of lightvessel Texel have been used as reference; but observations go back until the 19^{th} century in principle, wind forces being expressed in Beaufort scale units.

Some problems arise when interpreting these data in terms of wind speed. According to Dury (1970) about 25 sets of mean equivalent wind speeds to the Beaufort scale have become known. It is worthwhile to realize that the Beaufort scale has been originated from the need for objective assessments of operations of sailing ships in battle; then the wind force on sails and rigging is essential. For example, anemometer readings may yield relatively low average wind speeds, despite the occurrence of strong gusts in showers; such conditions sometimes occur in autumn and winter. Then speed equivalents of Beaufort estimates generally will become higher than the measured wind speed.

The official WMO-scale that is in use since 1948 has been strongly critisized, particularly by Verploegh (1956); he proposed a quite different scale of equivalent wind speeds, partly based on a large number of comparisons between anemometer readings and routine Beaufort estimates on board lightships Texel and Terschellingerbank. Later, Dury (1970) proposed an equivalent scale (here referred to as the CMM-scale) for international use, which differs only slightly from that by Verploegh. However, the old 1946 WMO-scale still is in use, and will remain so in the foreseeable future.

In this report wind speed ff in knots from the lightships has been converted back to Beaufort estimates first according to the official WMO-scale; then the CMM-scale was used to determine U in m/s. Figure 6 depicts the relation between ff and U.

The equivalent speeds of the CMM-scale apply for 20 m height above a water surface. Our preliminary impression, based on some comparisons with a wind station in West Terschelling[8)] for wind speeds up to 20 m/s, is that 10 m height may correspond better; wind speed on that height according to equation (20) is 6% less than on reference height (20 m). However, a detailed comparison of wind force estimates of lightship Texel with averages of three coastal wind stations during the gale on 3 January 1976 (11 Beaufort during 21 hours) showed a better correspondence for 20 m than for 10 m height.

Hourly wind data (direction and speed) of lightship Texel have been employed most of the time. During the period December 1973 - April 1974 wind data of lightship Terschellingerbank have been used.

Locations of the lightships are summarized in table 1, section 2, they correspond with wave stations 3 and 4, see also figure 2. (Lightship Terschellingerbank seemed more favourably situated in the area at that time; however, its service was suspended since May 1974).

For future studies measurements of wind stations on land like in West-Terschelling will be needed because of the gradual termination of the use of manned lightships. Such data can be corrected for exposure differences easily, applying a method described by Wieringa (1976), so that a good approximation of conditions at sea is possible. However, probability distributions based on Beaufort estimates like they have been used for this study may differ somewhat from distributions of measured wind speed data, due to the difference in nature between both kinds of data.

For example, Beaufort estimates also include the effect of gusts in showers which may reach hurricane force, followed by quiet intervals; then the Beaufort estimate of wind force may become two points higher than the equivalent wind speed.

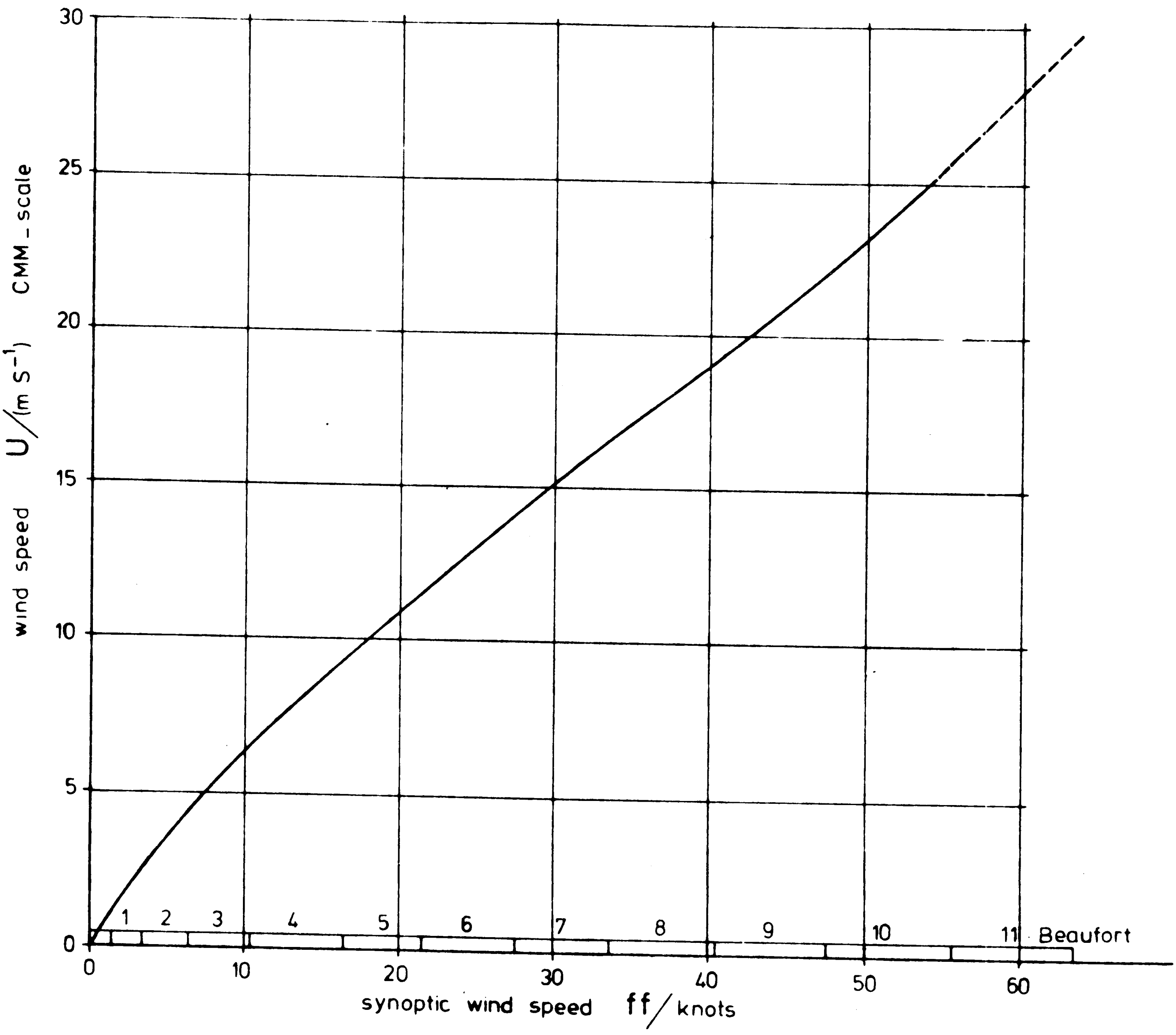


figure 6. Relation between synoptic wind speed, Beaufort scale and CMM equivalent scale of wind speeds.

6. Results.

6.1. Presentation of data.

During the measurements three-monthly summaries have been compiled of the available wave and wind data. These summaries contained a list of all available raw data, followed by a number of tables of frequency distributions of wind and wave parameters, and joint frequency distributions of several pairs of parameters. Appendix A contains five compilations of these quarterly data:

- December - February 1973/1976,
- March - May 1973/ 1975,
- June - August 1973/1975,
- September - November 1973/1975,
- all data from March 1973 until February 1976.

Raw wind speed data denoted by ff in the original summary lists have been given in knots; conversion according to the CMM-scale (see section 5.3.2) has been carried out afterwards for this presentation including appendices A and B; U (m/s) denotes converted wind speed.

Table 3 summarizes mean values of

- wind speed U (m/s) of lightship Texel from 1949 until 1975, of lightships during the data collection, March 1973 until February 1976, and idem but selected on the occurrence of simultaneous wave data;
- wave height H_{m_0} (m);
- wave period T_{m_0} (s);

finally the number of wave data that has been available.

Table 3: Mean values of wind and wave data.

(w): wind data during simultaneous wave measurements

	winter	spring	summer	autumn	all seasons
U/(m/s) (1949/75)	8.70	6.89	6.34	7.80	7.43
(1973/76)	9.76	7.12	6.13	8.73	7.93
(1973/76(w))	9.95	7.15	6.08	8.73	7.67
H_{m_0}/m	1.90	1.35	1.00	1.75	1.44
$T_{m_{02}}$/s	4.96	4.75	4.33	4.95	4.72
number of wave data	659	1529	1559	1670	5417

Comparing the 1949/75 wind data with those of 1973/76 we see that the winds during the data collection period have been stronger than usual, particularly during autumn and winter. The summer average was lower, however. Differences between the second and third line of table 3 are due to missing wave data. As the maximum number of wave data for one season is about $3 \times 8 \times 90 \approx 2200$, the percentages of coverage during winter, spring, summer and autumn were 30%, 70%, 71% and 77%; in spite of this, only averages of wind speed during winter for continuous data and data during wave measurements are somewhat different. The coverage of wind observations has been complete for most of the time.

6.1.1. Probabilities of wave heights.

Figure 7 depicts cumulative probabilities of H_{m_0} based directly on the available wave data of the seasons and of all data taken together. No corrections have been made in fig. 7 for the deviations of wind speed probabilities with regard to 1949/75 data. Data points have been fitted by straight lines only for $P(z) > 0.45$ (see section 4.2.).

In figures 7 (a), (b) and (c) the 50-year exceedance level (2% probability per year) corresponds with the probability of

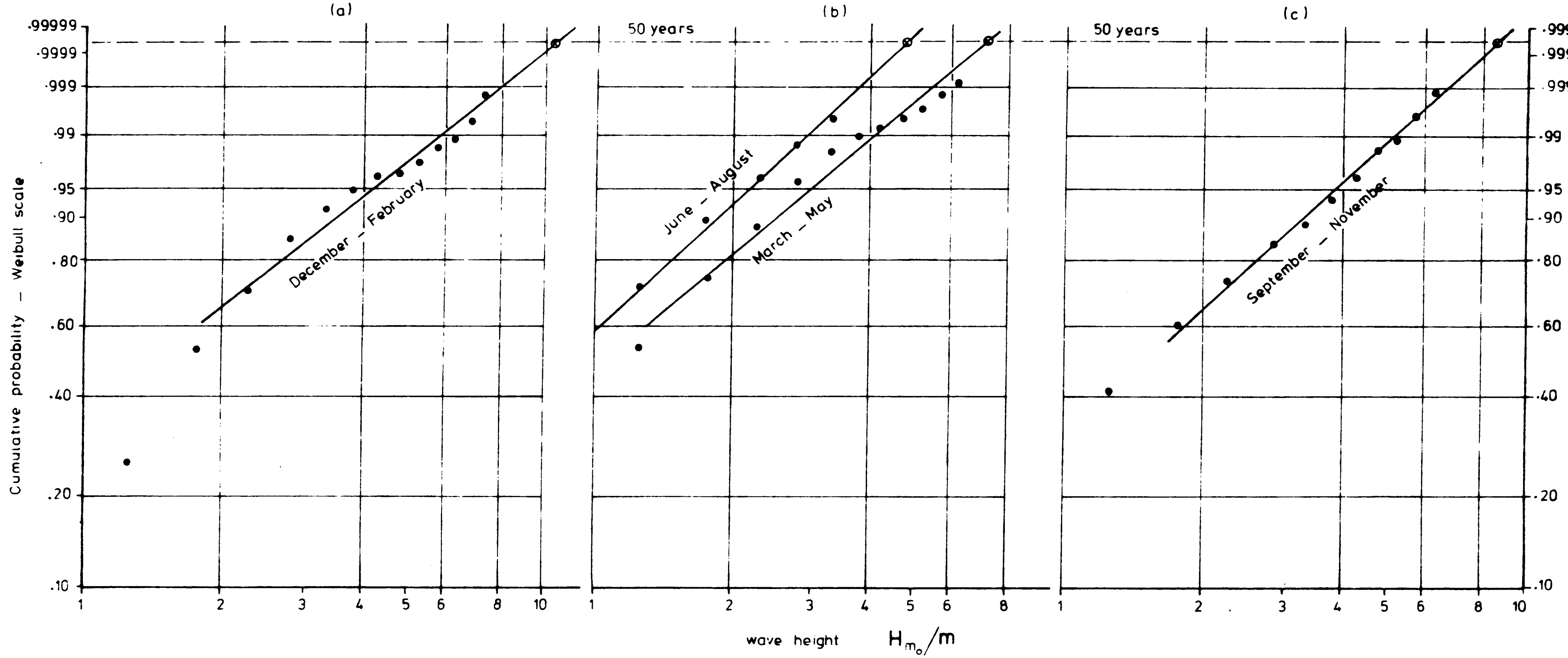


figure 7. Fits of the Weibull function to cumulative distributions of wave heights during (a) winter, (b) spring and summer, (c) autumn, and (d) all seasons. Note that the 50-year return levels of seasonal or annual distributions have different probabilities.

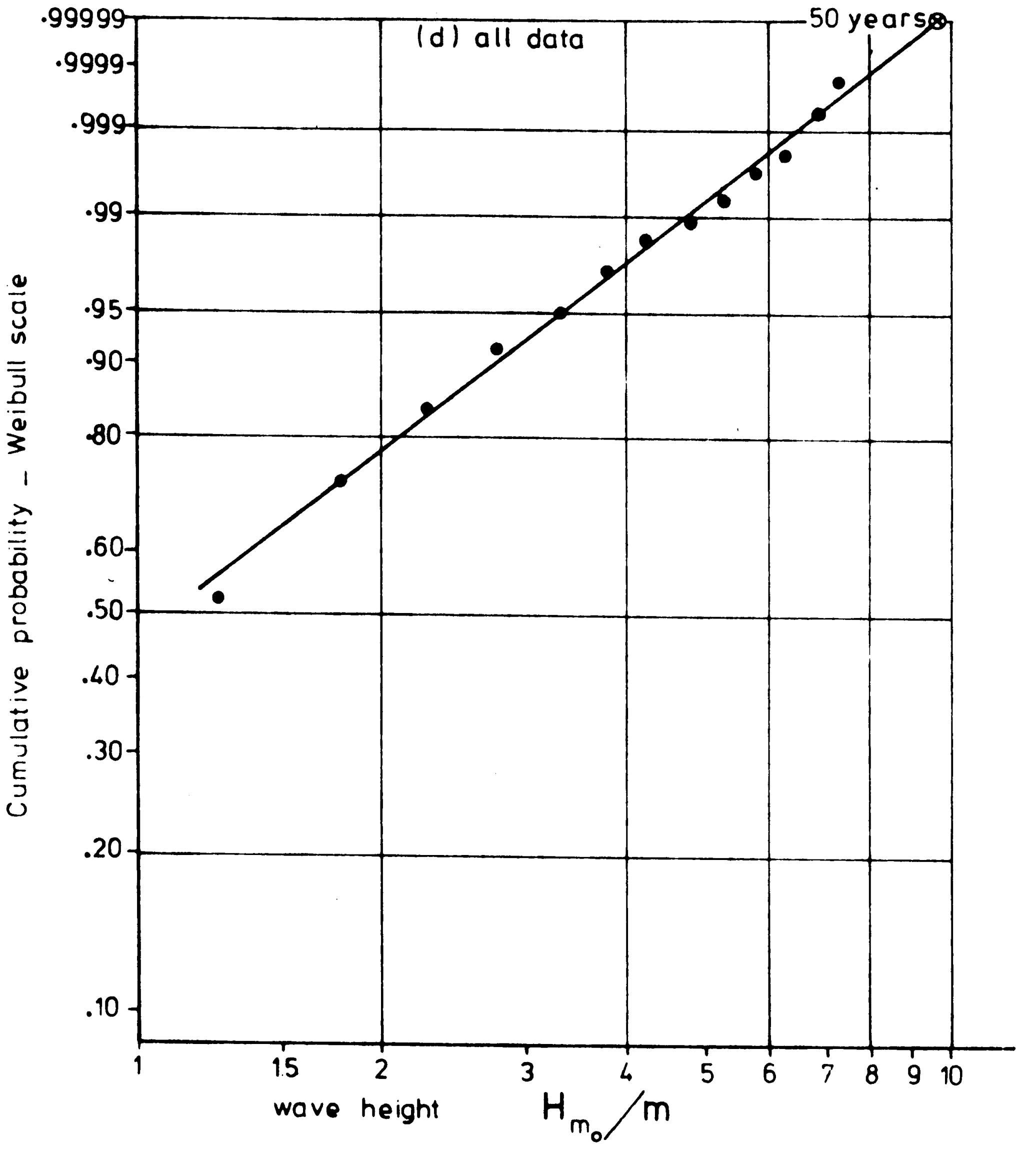


figure 7 (cont'd.)

exceedance during one season, lasting 4.4 hours, 0.004% = 1 - 0.99996; in figure 7 (d) the corresponding probability of exceedance during all seasons, lasting 4.4 hours, is 0.001% = 1 - 0.99999 (see also section 4.2.1). Remember that the 50-year exceedance levels shown in figure 7 are biassed due to differences between wind speed during the wave measurements and the standard 1949/75 data. Corrected results are shown in section 6.2.

In figure 7, particularly the winter and spring distributions show deviations from the Weibull fits. However, it was found qualitatively that these deviations tend to be reduced by correcting the probability distributions according to the distributions of simultaneous wind data.

6.1.2. Persistence of wave height.

Due to a number of technical and logistic problems (see section 5.1) the wave data series consists of 63 seperate continuous segments of different length. Table 4 gives an impression how the data are distributed over the segments.

Table 4. Intermittency of wave data, expressed as a fraction of data contained in segments ⩽ 4 days, and segments ⩽ 10 days.

season	winter	spring	summer	autumn	all data
number of days with wave data (≈ number of wave data divided by 8)	82	191	195	209	677
fraction in segments ⩽ 4 days	9%	4%	3%	8%	6%
" " " ⩽10 days	18%	26%	17%	12%	18%

If the persistence of a certain threshold value predominantly is of the order of a few days, the deterioration by the intermitterncy of the data remains acceptable. However, long persistences will become completely mutilated (see for instance persistence tables in Appendix A).

Figures 8 (a) - (f) show graphical presentations of the most relevant cases; persistences which are either long, and therefore spoiled by intermittency, or very short are omitted. Durations of extreme wave heights ($H_{m_0} > 4$ m) can be found in appendix A; see also table 5 in section 6.1.3.

The graphical presentations are in the form of cumulative distributions. Solid lines denote the total amount of durations > n days, including durations which were (partly) defined by begin or by end of a data segment (both columns taken together in persistence tables in Appendix A); dashed lines denote only durations which were defined by real exceedances of threshold levels (left columns in persistence tables).

The difference between solid and dashed lines is a measure of the reliability of the distributions; if it remains small, the deterioration by intermittency is not significant.

It should be stressed that the persistence of wave height conditions has been inferred using the three-hourly wave data, this implies that variability of H_{m_0} may lead to large numbers of short durations with wave height exceeding certain values. However, some operations at sea may require information on persistence of the 24 hours maximum of H_{m_0} (or just the highest wave during 24 hours); persistences of that kind may be much longer than exceedance related with individual gales succeeded by short spells with decreasing wind speed.

6.1.3. Selection of extreme wave conditions.

Nine extreme cases are presented in table 5 and figure 9. Table 5 illustrates quite clearly the relation between wind directions and extreme wave height. For instance $H_{m_0} > 6.5$ m appears to occur only when the wind direction is between west and north-west. Also we can see in figure 9 that for a fixed wave period $T_{m_{02}}$ the wave height increases with wind speed, in accordance with the assumed relationships $H \alpha U$ and $T \alpha U^{1/3}$ in section 4.2.2 which are employed for correcting exceedance levels.

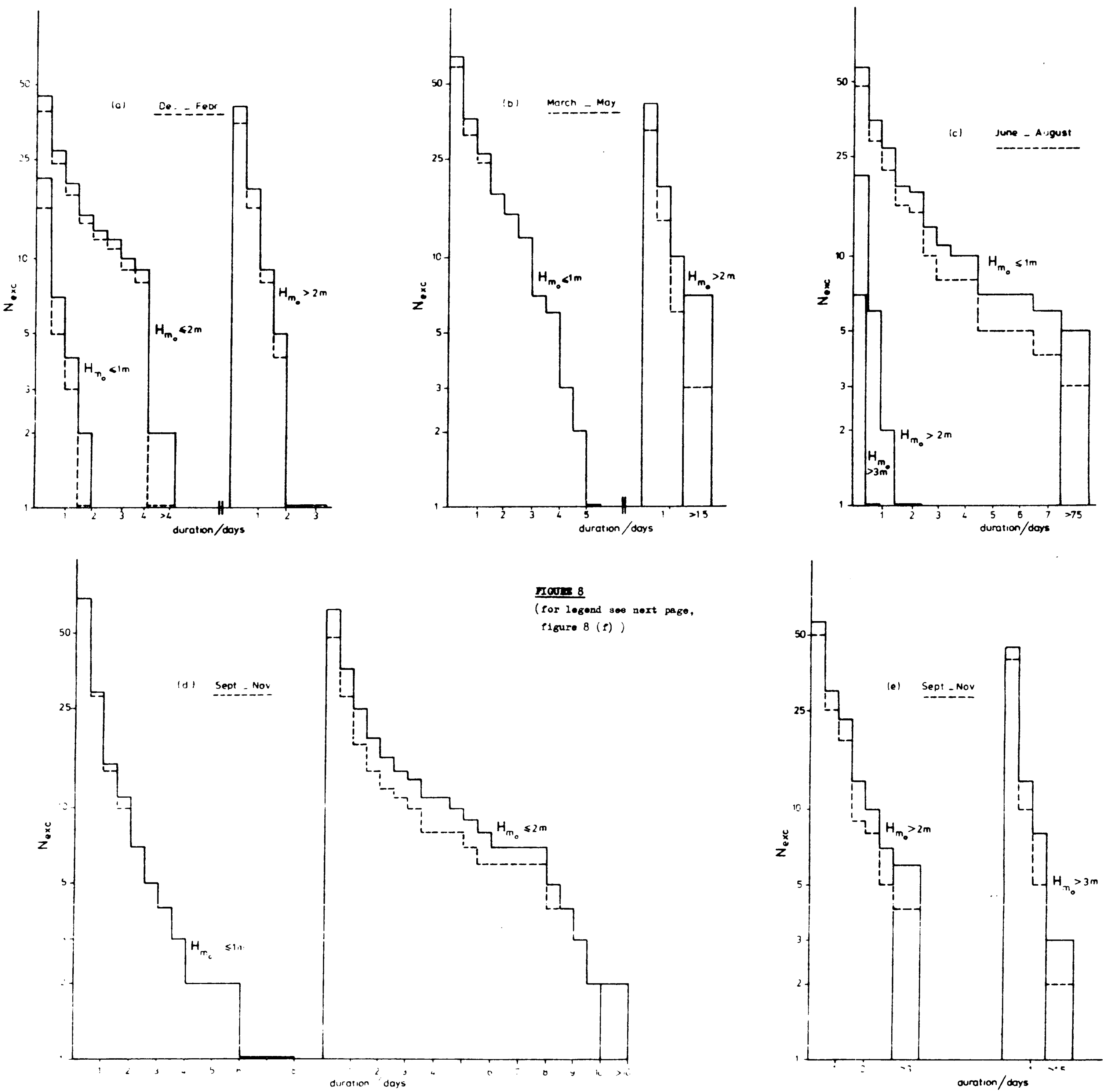


FIGURE 8
(for legend see next page, figure 8 (f))

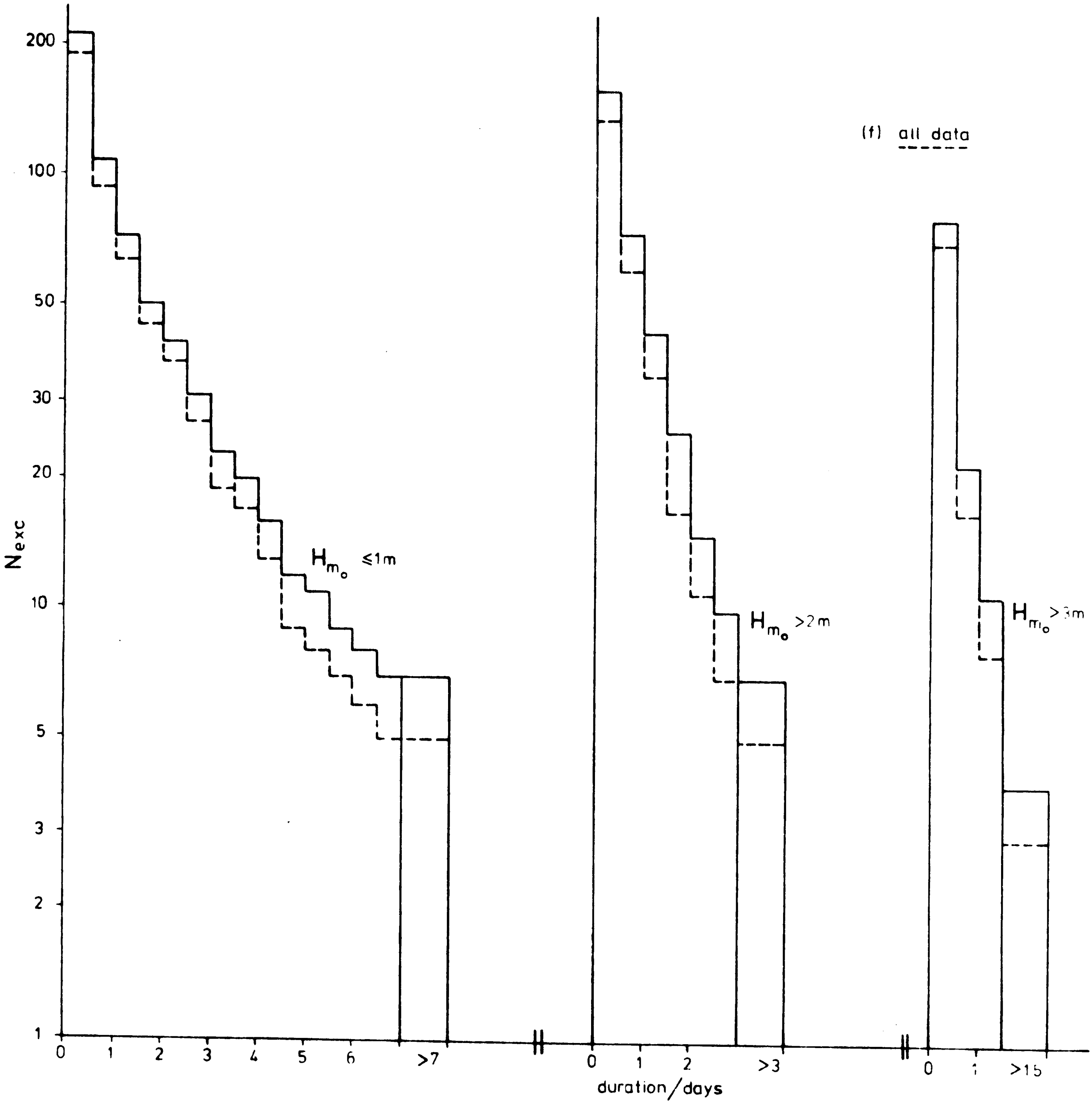


figure 8. (cont'd.)

Number of periods exceeding indicated durations of wave height conditions N_{exc} for (a) winter, (b) spring, (c) summer, (d) and (e) autumn, and (f) all seasons, plotted in a logarithmic scale. For explanations of solid and dashed lines see section 6.1.2.

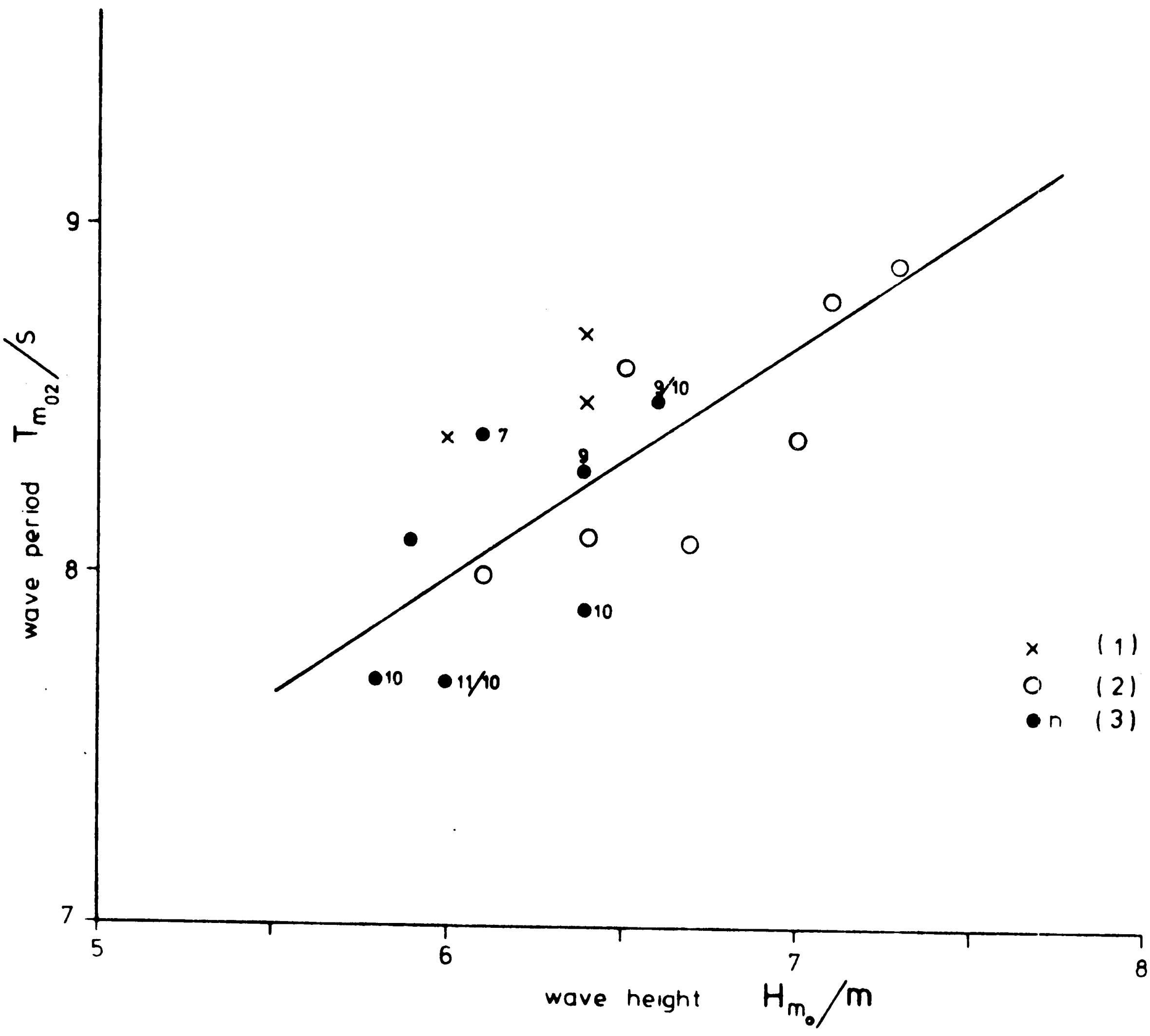


figure 9. All available wave data with H_{m_0} exceeding 5.75 m. The straight line is a least-squares fit to the data points:

$$T_{m02}/s = 0.68\ H_{m0}/m + 3.94.$$

(1) 19 November 1973, wind 9 Beaufort,

(2) 3 January 1976, wind 11 Beaufort,

(3) other data, wind n Beaufort.

Table 5: Selection of extreme wave conditions during measurements: $H_{m_0} > 5.75$ m; dd denotes wind direction (tens degrees), U wind speed in m/s, dd U (-n hr.) wind n hours before wave measurement.

		waves		wind					
date	GMT	H_{m_0}/m	T_{m02}/s	dd	U(-2 hr.)	dd	U(-1 hr.)	dd	U(0 hr.)
2 Apr.'73	21.00	6.0	7.7	32	27	32	27	33	22
3 Apr.'73	6.00	6.4	8.3	33	20	32	21	32	20
13 Nov.'73	15.00	6.4	8.5	28	18	28	18	31	19
	18.00	6.4	8.7	29	19	29	19	30	21
	21.00	6.0	8.4	29	21	31	22	31	17
6 Dec.'73	18.00	6.6	8.5	30	22	29	21	31	25
17 Jan.'74	6.00	6.4	7.9	31	22	31	23	31	24
28 Oct.'74	6.00	5.9	8.1	30	23	31	23	31	24
28 Sep.'75	3.00	5.8	7.7	25	24	25	23	25	24
20 Nov.'75	18.00	6.1	8.4	35	15	35	15	35	17
3 Jan.'76	3.00	6.1	8.0	27	28	28	30	29	30
	6.00	6.7	8.1	29	30	29	30	30	28
	9.00	7.0	8.4	30	27	31	27	32	29
	12.00	7.3	8.9	31	27	31	28	31	28
	15.00	7.1	8.8	32	29	31	29	34	27
	18.00	6.5	8.6	34	27	33	26	32	27
	21.00	6.4	8.1	32	24	33	25	32	23

6.1.4. Wind distributions.

Two different kinds of cumulative distributions of wind speed U are shown in figures 10 (a) - (e):

- solid lines and circles, based on wind data from lightship Texel from 1949 until 1975 (see also Appendix B),
- dashed lines and open circles, based on wind data from March 1973 until February 1976 (see section 5.3.2).

U(m/s) denotes wind speed obtained from Beaufort estimates, according to the CMM-scale (see sections 5.3.2 and 6.1).

Figures 10 (a-d) present the distributions of each season seperately, figure 10 (e) presents the distributions for all seasons taken together. Due to the rather large amount of missing wave data, the distributions which are presented here differ slightly from those of wind data selected on the occurrence of simultaneous wave measurements, particularly the one in figure 10 (a) (winter), see section 6.1.

The straight lines in figures 10 (a) - (e), like in figures 7 (a) - (e) represent least-square fits of the Weibull distribution function to the data points with $P > 0.45$. Note that the gale on 3 January 1976 has not been included in the 1949/75 data.

It appears that the 1949/75 data follow the Weibull function (solid lines) very well for $P > 0.5$; the distributions of the 1973/76 data do not fit so closely to the dashed lines due to the occurrence of particular events, see for example fig. 10 (b) (spring).

In table 6 exceedance levels with 50-year return period of wind speed divided over 16 wind directions are presented. It is evident from these data that the data collection period has been characterized by a frequent occurrence of westerly gales during autumn and north-westerly gales during winter.

Figure 11 shows a comparison between period (1949/75) and period (1973/76) of distributions of wind directions with two levels of exceedance of wind force. Note that there are two types of directional classes; eastern, southern, western and northern classes contain three subclasses of ten degrees each, the other classes only contain two subclasses. This has been taken into account in figure 11 by making the area of the rectangles in the histogram proportional to the frequency of occurrence.

For both exceedances we find an overrepresentation of westerly directions during period (1973/76). Particularly storms from the north-west which are most significant for the occurrence of extreme wave height have occurred more frequently than normal. This also led to relatively high estimates of the 50-year exceedance levels for these wind directions, see table 6.

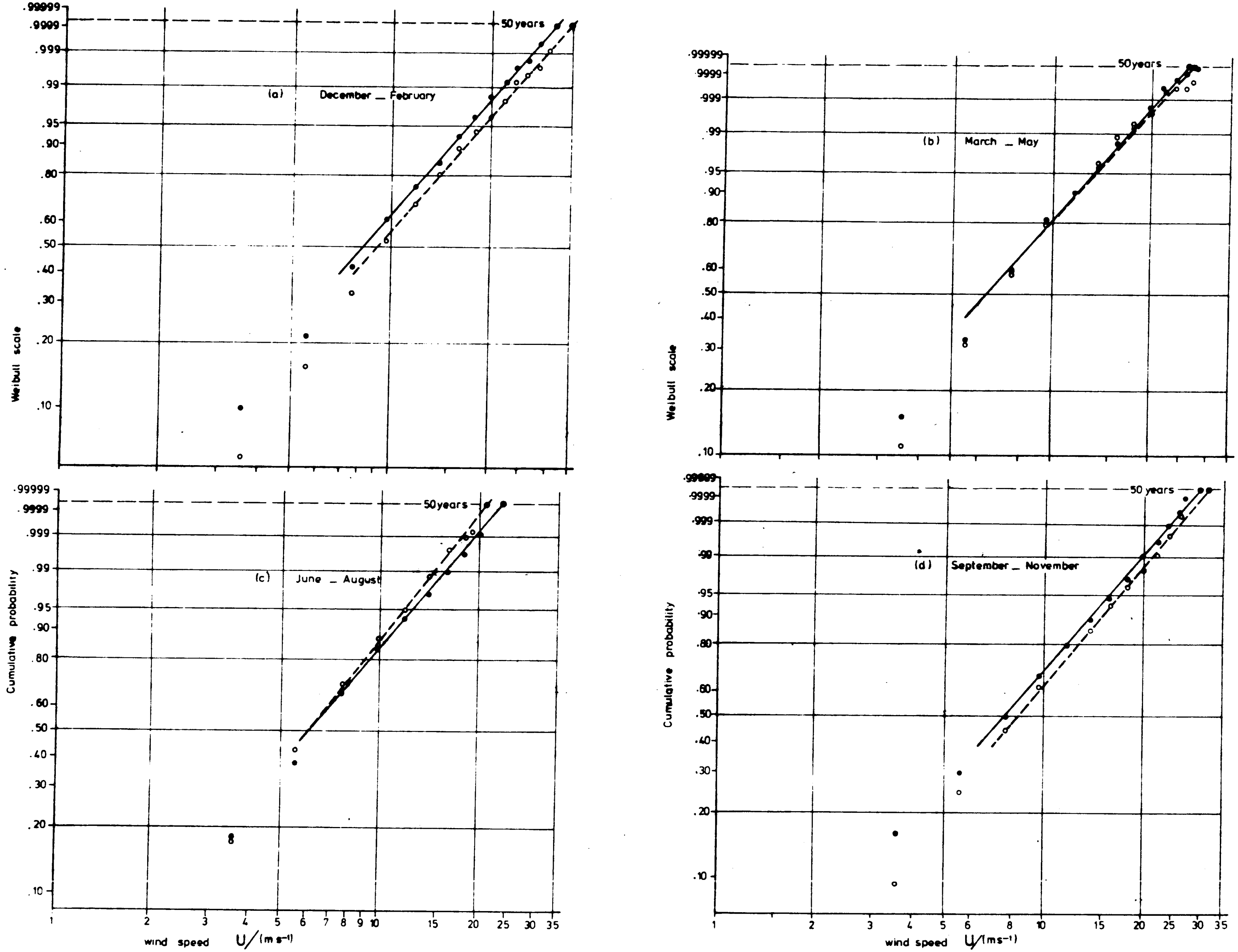


FIGURE 10
(for legend see next page, figure 10 (e))

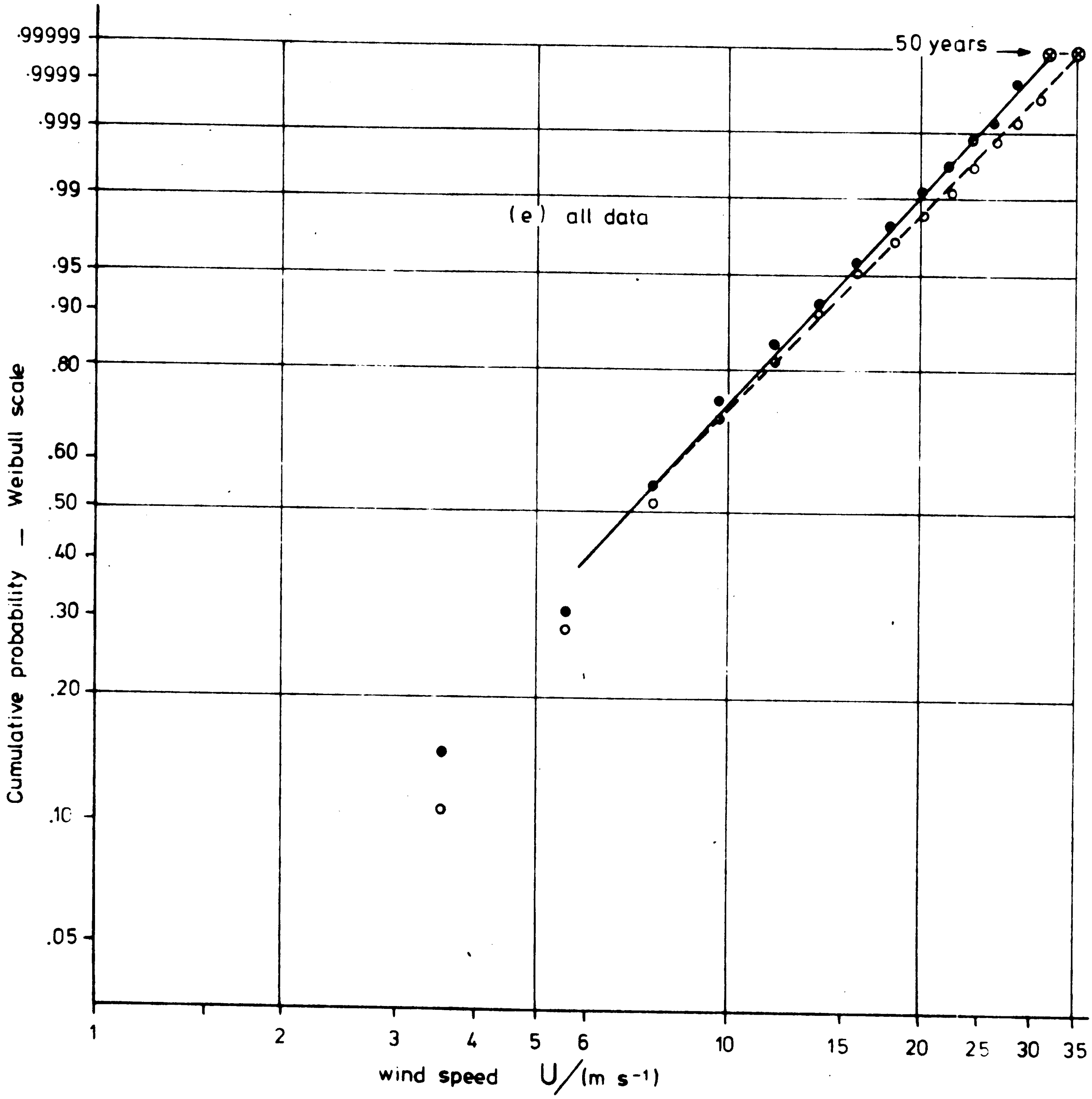


figure 10. Fits of the Weibull function to cumulative distributions of wind speeds during (a) winter, (b) spring, (c) summer, (d) autumn, and (e) all seasons.

● ———— : wind data 1949 - 1975,

o - - - - - : wind data during study, 1973/76.

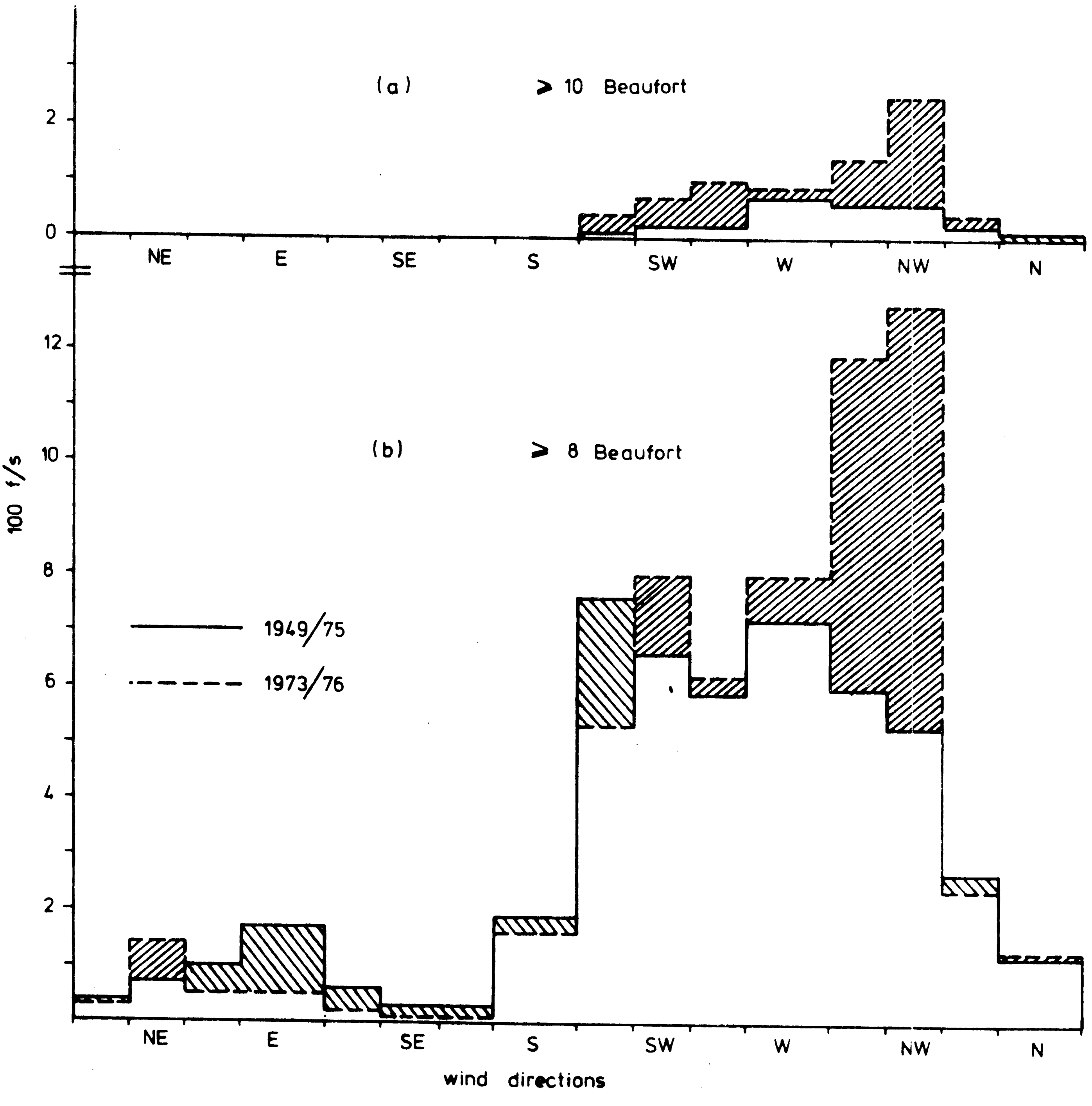


figure 11. Distributions of wind directions with wind speed exceeding (a) 22.5 m/s (≥ 10 Beaufort), (b) 16.5 m/s (≥ 8 Beaufort). Wind data (1949/75) - solid lines - compared with wind data (1973/76) - dashed lines - .
Frequency of occurrence represented by 100 f s^{-1}, where f is the fraction of the total number of data, and s is the directional fraction; east, south, west and north with sector of 30° have s^{-1}= 12, the other directions with sector of 20° have s^{-1}= 18.

Table 6: 50-year exceedance levels of wind speed U/(m/s), duration of exceedance 4.4 hours:
1. wind data 1949/75, 2. idem 1973/76.

Directions	DEC.-FEBR.		MARCH-MAY		JUNE-AUG.		SEP.-NOV.		ALL DATA	
	1	2	1	2	1	2	1	2	1	2
NNE	21.5	25.2	17.7	15.6	14.1	12.7	18.1	19.3	21.1	20.8
NE	21.0	20.1	19.8	24.2	14.2	14.0	21.7	15.7	21.6	23.4
ENE	21.5	16.6	19.8	20.3	14.2	14.2	23.8	17.7	22.7	20.2
E	22.4	23.9	21.8	18.5	14.0	11.9	20.8	16.5	23.1	21.5
ESE	19.9	19.9	23.6	18.6	12.0	12.0	18.4	16.5	22.4	20.0
SE	18.3	18.1	18.1	15.0	12.7	10.7	18.8	14.9	19.6	17.5
SSE	17.9	16.8	14.4	14.7	13.0	9.3	20.3	14.6	20.0	17.0
S	23.6	25.2	18.1	14.9	16.4	17.2	22.7	22.3	24.0	25.7
SSW	24.4	27.6	20.0	20.0	20.4	18.4	24.8	26.0	25.5	27.7
SW	25.2	27.0	21.0	21.3	20.8	20.7	25.6	26.4	26.1	27.6
WSW	24.7	24.9	21.3	16.4	20.2	18.6	25.4	29.6	26.1	28.8
W	30.1	30.1	25.1	19.6	21.7	17.0	27.2	30.0	30.0	31.0
WNW	30.4	32.7	21.6	21.3	20.8	17.9	27.3	29.5	30.2	33.6
NW	29.9	36.6	23.1	28.3	21.2	15.5	26.8	26.4	29.8	35.9
NNW	24.1	32.7	22.8	21.0	19.2	16.8	25.2	24.5	25.9	30.3
N	22.6	22.4	19.4	17.9	16.0	14.2	25.6	23.6	24.8	23.2
all	30.8	34.7	25.8	26.5	22.5	20.2	29.4	30.8	31.0	34.6

6.1.5. Persistence of wind force.

Data on the persistence of extreme wind forces, particularly within certain sectors of wind direction, are valuable additional information for estimating the probability of extreme wave heights, because of the dominant role of wind waves with respect to swell in the area concerned.

Tables in Appendix C show the amount of occurrence of exceedance durations of wind force according to the Beaufort scale. These have been derived from the same wind data of lightship Texel - based on Beaufort estimates - that have been used in the previous section to characterize wind conditions during the data acquisition period. Results are shown for all wind directions and twelve overlapping wind diraction sectors of 60 degrees; for each exceedance level - 7, 8, ..., 12 Beaufort - two tables are presented, one for all months, the other for the period November - January.

Durations of periods with wind force in excess of 9 or 10 Beaufort (in Appendix C indicated as "10 Beaufort or more" or "11 Beaufort or more" respectively) are of particular interest in connection with extreme waves. Assuming that a gale persistence must be of the order of 10 hours, when a typical fetch length of 200 km will become the limiting factor, and neglecting possible advection of wave energy from outside, it becomes evident from Appendix C that only wind directions between 255° and 315° are to be considered for extreme waves (see also section 6.2.2, table 10 and figure 12). This implies for the area that is considered here a dominant role of the bottom depth as a limiting factor for the wave height, the depth being about 30-40 m on average in the relevant upwind directions.

In table 7 exceedance durations of wind force numbers with a probability of 2% per year are shown, determined by extrapolating an approximated Gumbel distribution of annual extreme values. The duration of the storm on 3 January 1976 - 21 hours continuously 11 Beaufort ("violent storm") - can be considered from table 7 to be extreme. Detailed information on that case is given in section 6.3 and in table 5.

Table 7: Estimates of maximum durations of exceedance of wind force with 2% annual probability P_m.

Wind force	≥8 Bft	≥9 Bft	≥10 Bft	≥11 Bft
P_m/hrs.	74	49	34	21

6.2. Interpretation of wave data.

6.2.1. Quality of data.

Table 9 in the next session gives 50-year return values of wind speed, wave height and wave period. These values were obtained by fitting the Weibull function (equation (8) in section 4.2.) to the measured distributions. Sometimes, the quality of these fits is rather low as in shown in table 8 where estimates are given of the standard deviation in percentages of the exceedance values, obtained from the standard error of estimate of the least-square fit; see also figures 7 and 10.

Table 8: Standard deviations in percentages of the 50-year exceedance values; W-W: wind speeds during simultaneous wave measurements.

	wind speeds			wave	wave
	1949/75	1973/76	W-W	heights	periods
winter	1%	2%	7%	9%	7%
spring	3%	6%	7%	8%	3%
summer	3%	3%	2%	3%	4%
autumn	2%	3%	2%	3%	3%
all seasons	2%	2%	5%	4%	2%

The poor fits of the winter wave data are mainly due to the small amount and scattered nature of these data. The complete winter wind data (column wind speeds 1973/76), however, fit very well to the Weibull function.

In extrapolating the wave data to very low exceedance probabilities we have take into account a factor of physical nature: the nonlinear behaviour of high waves in shallow water. If the significant wave height H_{m_0} exceeds 5 m, then the bottom influence will gradually increase, leading to a not yet fully specified constraint on the probability of exceedance of wave heights $H_{m_0} > 6$ m. In section 6.3 some prelimanery conclusions are drawn about this constraint, based on the January 3, 1976 case.

6.2.2. 50-year exceedance levels, estimates of maximum wave heights.

In table 9 we present raw and transformed 50-year return values of wind speed, wave height and wave period, assuming that exceedances have a duration of 4.4 hours (=0.001% of 50 years).

Table 9: 50-year exceedance levels of wind speed, wave height and wave period (duration of exceedance 4.4 hours = 0.05% of one year).
(r) raw data
(t) transformed data according to probability distribution based on 1949/75 wind speed data.

	winter	spring	summer	autumn	all seasons
U/(m/s) (1949/75)	30.8	25.8	22.5	29.4	31.0
(1973/76)	34.7	26.5	20.2	30.8	34.6
H_{m_0}/m (r)	10.5	7.3	4.7	8.7	9.5
(t)	8.1	7.3	5.5	8.2	8.2
H_{max}/m (=1.8 H_{m_0}/m (t))	14.6	13.1	9.9	14.8	14.8
T_{m02}/s (r)	10.4	9.6	8.0	10.1	10.5
(t)	9.3	9.6	8.4	9.9	10.0

Dorrestein (1967) presents in his table F1 maximum values of visually observed wave heights H_v of lightships near the Dutch coast. When wave heights remain below say 3 m, then $H_v \approx \overline{H}_{1/3}$. However, it may be assumed that visually observed wave heights of lighstships $H_v \approx \overline{H}_{1/10}$ under extreme conditions, see for example wave height exceedance data in Bakker (1962). We take $H_v \approx 1.2\ H_{m_o}$, using $\overline{H}_{1/10} = 1.27\ \overline{H}_{1/3}$ and $H_{m_o} = 1.05\ \overline{H}_{1/3}$. Estimating a 50-year return wave height from table F1 in Dorrestein (1967) by fitting a Gumbel probability function of annual maximum H_v values we find 9.5 m. Reducing this according to the assumed relation we find a 50-year exceedance value of H_{m_o} of 7.5 - 8 m, which is not in contradiction with results of this study.

Estimates of 50-year return values of H_{max} have been determined by use of the relation

$$H_{max,e} = 1.8\ H_e\ . \qquad (18)$$

In section 4.2.3 this relation has been inferred, considering various sources.

During the first half of the measurement period maximum wave heights have been observed from strip chart records in order to find an empirical relationship between H_{m_o} obtained from digitized wave records and H_{max}. In Appendix A frequency distributions are presented, followed by least-square estimates of the relationship between H_{m_o} and H_{max}. For all available data combined we found:

$$H_{max} = 1.43\ H_{m_o} + 0.05\ .$$

This should hold for records of 15 minutes duration; using the mean value of wave periods 4.7 seconds we assume that on average the number of waves is N = 190. Using formula (16) in section 4.2.3 we would expect on average:

$$H_{max} = 1.59\ H_{m_o}.$$

No clear explanation could be found for the difference between this theoretical relation and the measured results. Probably it is due to a wrong use of definitions of wave heights in the data extraction from stripchart records. Nearly all H_{max} observations have been obtained under conditions where a possible modification of the distribution of wave heights due to bottom influence may well be excluded. We have found later that for most of our data the Rayleigh distribution function - equation (12) - accurately describes the distribution of wave heights during a measurement provided that conditions are stationary.

Table 10 contains exceedance levels of H_{m_0} with an annual probability of 2% (50-year return), for 16 wind directions, divided over four seasons. Figure 12 shows distributions of 50-year (solid line) and 5-year (dashed line) exceedance levels for 16 wind directions. These data have also been corrected for deviations of frequency distributions of simultaneous wind speed from distributions based on the wind data of lightship Texel 1949/75.

Table 10: 50-year exceedance levels of H_{m_0}/m, corrected according to wind speed probabilities (durations of exceedance approx. 4.4 hours). (Values between parentheses are less reliable, some values are absent due to lack of data)

Direction	winter	spring	summer	autumn	year
NNE		3.8	2.9	3.9	5.5
NE		4.5	2.4		6.0
ENE		4.7	2.1	5.4	5.5
E	3.7	4.1	2.1	4.6	4.2
ESE	3.1	4.9		2.3	4.0
SE	2.7	3.7		3.2	3.7
SSE	3.1	2.5		3.3	3.3
S	4.8	3.0	(3.1)	4.2	5.2
SSW	5.2	5.8	4.8	5.9	5.8
SW	5.2	5.1	4.1	5.4	5.6
WSW	5.7	3.2	3.2	5.6	5.6
W	7.1	5.5	4.6	6.4	7.0
WNW	7.9	4.7	4.2	7.6	8.1
NW	7.6	5.8	5.1	7.8	8.1
NNW		6.9	(6.4)	8.7	7.2
N		5.9	3.7	6.7	6.7
all	8.1	7.3	5.5	8.2	8.2

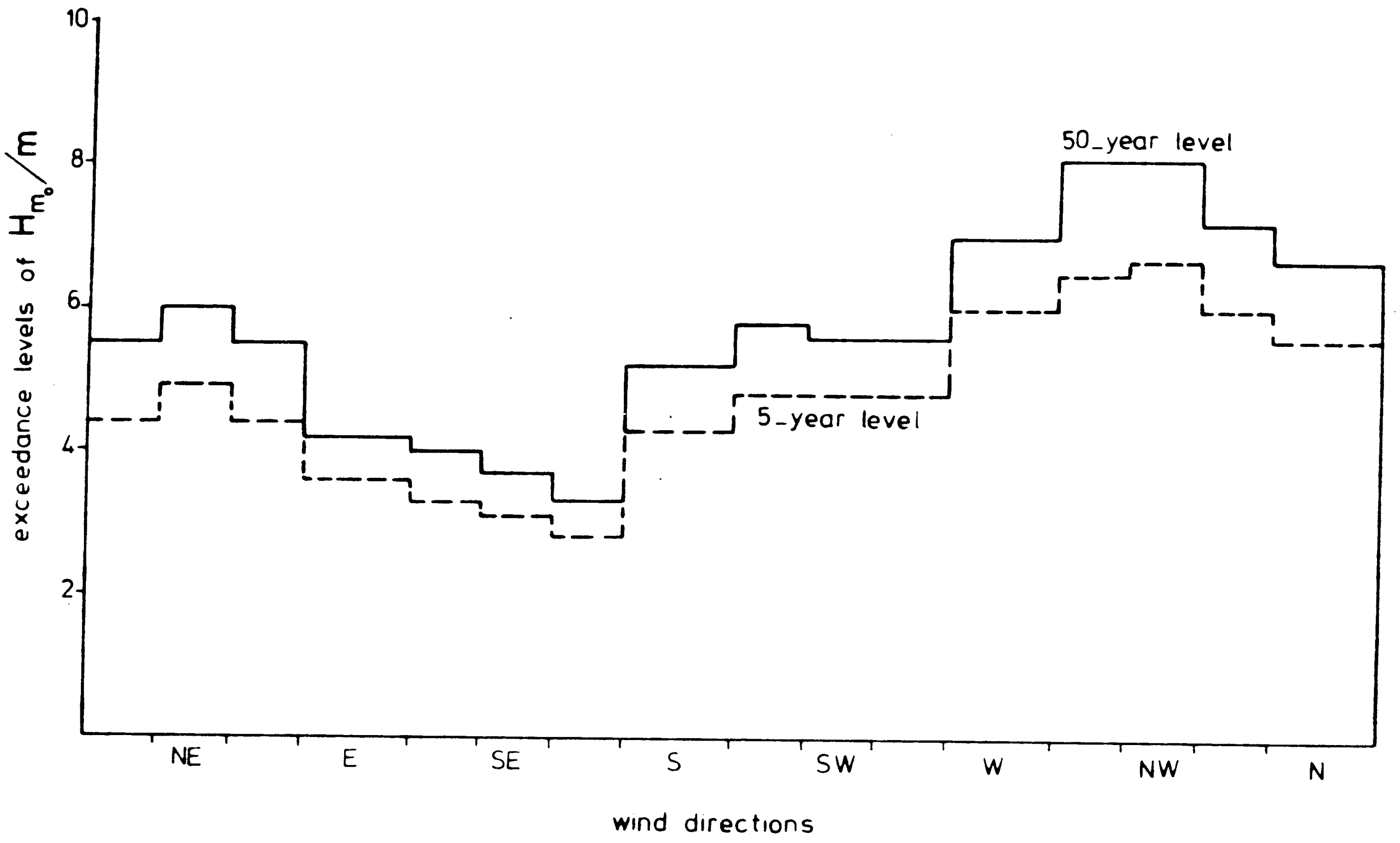


figure 12. Wave height exceedance levels depending on wind direction.
Corrections have been applied, see section 6.2.2.

Note that the value in table 10 are subject to scatter, due to a sometimes marginal amount of data; they are only intended to give some idea of the probability of extreme heights in connection with season and wind direction.

6.2.3. Estimates of orbital motions near the bottom.

In section 4.1.3. the relation has been given between the water surface displacement and orbital motions near the sea bottom. We now relate this to the wave climate that has been inferred. If $H_{m_0} = 4$ m, the maximum amplitude of the orbital velocity at 30 m depth becomes about 1 m/s.

In Appendix A least-square estimates are given of the joint frequency distributions of H_{m_0} and U, and of H_{m_0} and T_{m02}. Using all available data we get:

$$H_{m_0}/m = 0.30\ U/(m\ s^{-1})\ -0.85 \pm S_{H,U}/m\ ,$$

$$T_{m02}/s = 0.83\ H_{m_0}/m + 3.51 \pm S_{T,H}/s\ ,$$

with standard deviations $S_{H,U} = 0.70$ m and $S_{T,H} = 0.62$ s. According to these relations $H_{m_0} = 4$ m will occur when U is between 14 and 19 m/s, 7 and 8 Beaufort. The mean of the absolute values of the orbital velocity will then be of the order of 0.2 m/s. Usually the orbital velocities will be superposed on tidal currents and wind-induced currents that are of the order of 1 m/s in gale conditions.

6.3. Extreme wind and wave conditions on 3 January 1976.

No waverider was operating at the ordinary location near Penrod-36 (see figure 2), when on January 3, 1976 the area was struck by an extraordinary severe storm, Beaufort 11, for most of the day.

Fortunately, however, Rijkswaterstaat Studiedienst Hoorn collected hourly measurements using a waverider near lightship Texel. This station is considered to be fairly representative for the area.

Wave data of that day are particularly interesting because of the stationarity of both wind and waves. A deep depression moved south-eastward to Denmark (see figure 3), causing an intense north-westerly wind field, so that wave growth was not duration-limited for most of the time. The waves, therefore, were mainly determined by fetch and water depth (causing certain reduction of effective fetch).

6.3.1. Wind data.

Figure 13 depicts the wind history from the observations on lightship Texel. Both wind directions and wind speeds remain within narrow boundaries from 7.00 until 21.00 GMT; the mean wind direction was 319^{o} with standard deviation 11^{o}, and the mean wind speed (after conversion) was 28.2 m/s with standard deviation 1 m/s.

The lightship wind have been compared with measured data of coastal stations IJmuiden, Den Helder and Terschelling which were reduced to 20 m height over a water surface (roughness length $z_o = 2.10^{-4}$m), using an exposure correction method developed by Wieringa (1976). The measured data revealed that during the first six hours of the gale (until 3.00 GMT) when the wind was veering to northwest the wind speed was on average 2 m/s higher than estimated by the lightship crew; during the period 7.00 - 21.00 GMT wind speed on average was 3 m/s lower than the equivalents of Beaufort estimates. It should be noted, however, that estimates of wind force are not necessarily equivalent to mean wind speed; other factors like the occurrence of powerful gusts (very likely for north-westerly wind in that season) and the increasing wave heights are also significant for estimates of wind force. After all, Beaufort designed his scale primarily to determine the optimal amount of sail for sailing ships in battle (Kinsman, 1968). It even seems likely that Beaufort estimates correspond more closely with wave growth than average wind speeds, because of the inclusion of the effect of gusts. Finally, of we want to estimate the probability of this case by comparing it with long series of observations, we have to use data of similar nature; this requirement is particularly difficult for land stations with their variable exposure.

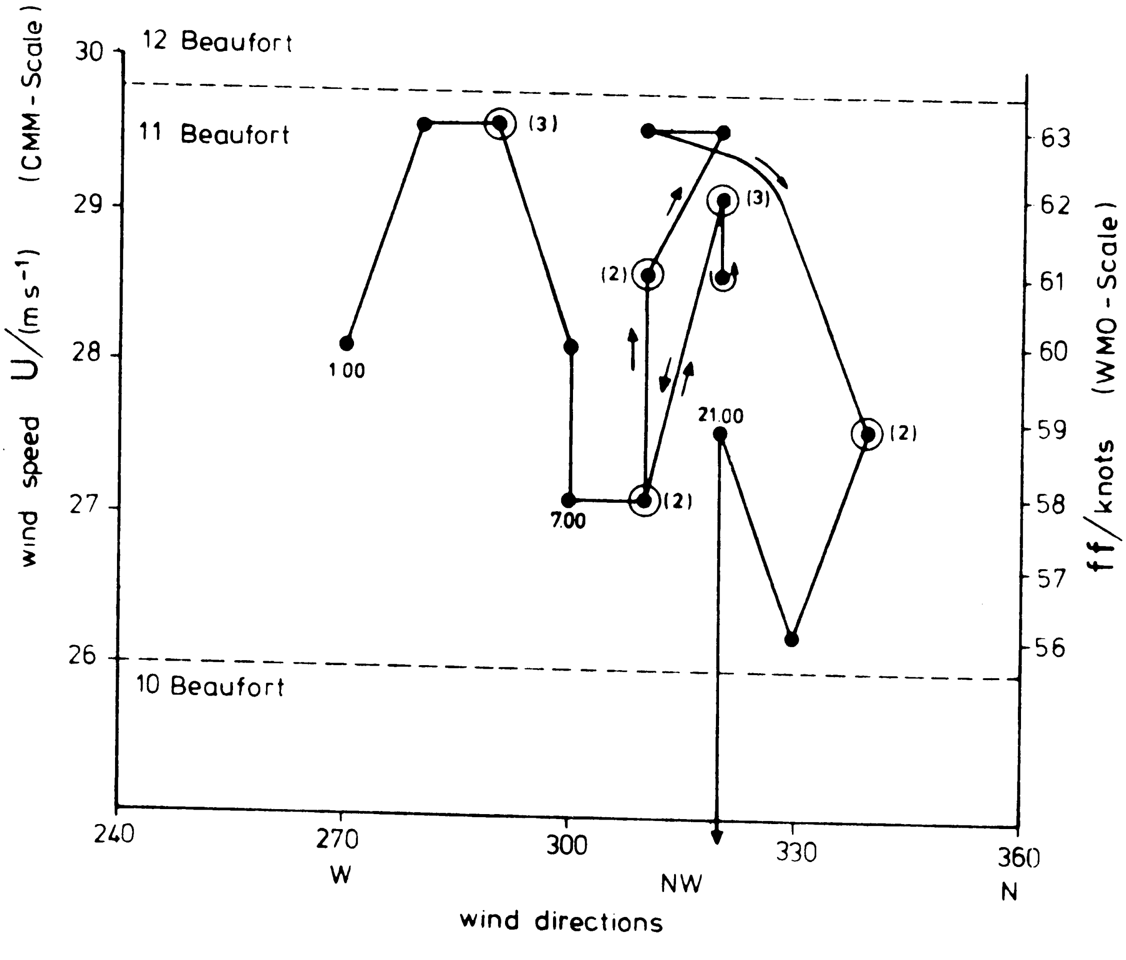


figure 13. Wind history of 3 January 1976. (n) : n observations of same wind direction and speed. (see also table 5.)

We now compare the wind speed data in fig. 13 with the probability distribution determined from the 1949/75 wind data set of lightship Texel, which is well fitted by the Weibull function (see section 4.2.2.):

$$P_w(z) = 1 - \exp(-z^k), \tag{8}$$

where $z = x/v$, v is scale parameter and k is shape parameter; a least-square fit yielded $v = 8.32$ m/s and $k = 1.86$. The exceedance value x_e is obtained from equation (8):

$$x_e = v\,(-\ln(1-P))^{1/k},$$

where P $P(z) = \int_0^{x_e/v} f(z)dz$, and $f(z)$ is the distributive probability of the wind speed. In table 11 we show a comparison between the exceedance levels during the storm on January 3, 1976 and the estimated values of x_e for indicated durations with a probability of 4% per year (25-year return period).

Table 11. Comparison of wind speed exceedance levels of the storm in 3 Jan. 1976 with predicted values using $v = 8.32$ m/s and $k = 1.86$; x_e = wind speed/ ($m\,s^{-1}$).

Number of hours	3	6	9	12
x_e (observed 3 Jan.'76)	29.6	29.2	29.0	28.4
x_e (25-year return, estimated from 1949/75 data)	30.5	29.5	28.9	28.4

It should be noted that the estimated values are based on wind data until December 1975 with $U \leqslant 28$ m/s, not including the storm concerned [9]. The probability of exceedance of such wind speeds lasting 6 to 12 hours apparently is about once in 15 - 25 years.

It also appears that the estimated values of x_e for shorter durations become greater than 30 m/s (12 Beaufort). Hurricane wind force has never been reported by lightship Texel since 1949. However, lightship Terschellingerbank has reported 12 Beaufort a few times and a comparison of the applied Beaufort estimates with measured data of coastal stations during the storm of 3 Jan. 1976 showed that during three hours a mean wind speed of 31 m/s has occurred in the coastal area between IJmuiden and Terschelling, in agreement with the estimated value in table 11. This should remind us of the problem of the relation between Beaufort wind force estimates and measured wind speeds; see conclusion of section 5.3.2..

6.3.2. Wave data.

Table 12 shows that wave conditions were nearly stationary between 7.00 and 21.00 GMT.

Table 12. Wave height H_{m_0} and wave period T_{m02} on January 3, 1976 7.00 - 21.00 GMT.

GMT	H_{m_0}/m	T_{m02}/s	GMT	H_{m_0}/m	T_{m02}/s
7.00	6.5	8.4	15.00	7.1	8.8
8.00	7.1	8.5	16.00	7.6	9.2
9.00	7.0	8.4	17.00	6.3	8.5
10.00	7.0	9.4	18.00	6.5	8.6
11.00	6.5	8.3	19.00	7.4	9.2
12.00	7.3	8.7	20.00	6.8	8.6
13.00	6.1	8.2	21.00	6.4	8.1
14.00	6.6	8.4			

We also have found that the variability of the corresponding values of m_0 during that period was consistent with the equivalent number of degrees of freedom, edf, corresponding with m_0 which has been calculated for each individual measurement; values of edf varied between 118 and 238. Also, running mean values of H_{m_0} over, say, 5 hours vary only slightly around the overall mean 6.8 m. This, and the nature of the wave spectra during this period, see section 6.3.3, suggest a rather abrupt limitation of wave growth due to limited fetch and/or duration of the wind field with extreme wind speeds, in contradiction with the actual wind field during this storm. Therefore this limitation must be due to the bottom topography in the area. This also can be concluded from numerical hindcasts of this storm by others who ignored any bottom influence; this led to values of H_{m_o} in the area up to 12 m!

In most cases the wave length to depth ratio is small, so that any limitation of wave height due to the bottom topography will be absent. Only during a very small fraction of time H_{m_o} = 6 m is exceeded; then this bottom effect becomes increasingly important. However, estimates of extreme wave heights are based on extrapolations of wave data without explicitly taking into account the bottom influence. In the following a rough sketch of the "real" probability of extreme waves will be attempted, using the data of the January 3, 1976 storm.

Using from table 9 the transformed H_{m_o} 50-year exceedance value 8.2 m, with Weibull parameters (equation (8)) k = 1.41 and v = 1.45, we derive that the probability of exceedance of H_{m_o} = 6.8 m is 1 - P = 32 hours/25 years. However, it is likely that the storm on January 3, 1976 that has been extreme both in intensity and in duration, even surpassing the famous storm of Fenruary 1, 1953 in this area, has contributed most of the actual exceedance of this level. During about half of the 15 hours period on January 3, 1976, H_{m_o} = 6.8 m has been exceeded, so that due to this storm alone the actual probability of exceedance would be 1 - P = 7.5 hours/25 years. Considering that the 1949/75 wind data series of lightship Texel - without this storm - yielded approximately the same exceedance level for 25 years as this storm alone (see previous section, table 11), we may take into account at most about the same number of exceedances of the 6.8 m level in the past 25 years. This finally leads to 1 - P = 15 hours/25 years for H_{m_o} = 6.8 m, which can be considered as a high (conservative) guess but which is distinctly lower than the value given above.

One of the consequences of the adjustment of the probability of exceedance 1 - P is a considerable reduction of the 50-year exceedance level of H_{m_o} to 7.5 m, with a corresponding maximum wave height for depths of about 30 m (H_{max}) of 13.5 m, using equation (18). Figure 14 illustrates how the probability distribution has been adjusted. The two lines I and II represent Weibull functions with k_I = 1.41, v_I = 1.45 m (as quoted above), and k_{II} = 1.68, v_{II} = 1.76 m.

The latter values were determined using the probability of 15 hours within 25 years for the exceedance of H_{m_0} = 6.8 m and assuming that line II intersects with line I at H_{m_0} = 5 m. The reasoning is that when H_{m_0} is exceeding this value at a water depth of about 30 m, the probability of exceedance is extra reduced due to the increasing proportion of long, low-frequency wave components in the spectrum reducing the effective length of fetch and increasing the effect of bottom friction.

A further reduction of the exceedance level is obtained if we assume the duration of the exceedance to be 12 hours instead of 4.4 hours; this could be more realistic because wave growth needs a certain duration of the wind. However, a virtual prolongation of the fetch due to the propagation speed of the storm field can reduce the duration that is needed locally; in extreme cases, however, advection into the area concerned of external wave energy is of minor importance. This could mean that even the 50-year exceedance level of H_{m_0} = 7.5 m is a conservative (high) estimate.

Note that we do not look at short individual wave records but at running mean values for periods of 4.4 hours (or longer); values of H_{m_0} for such records have a variability that is determined by the number of degrees of freedom of the corresponding wave spectra as has been shown before. For example, for one of the records H_{m_0} = 7.6 m! On the other hand, the ratio between the expected value of the maximum wave height, $\langle H_{max} \rangle$, and H_{m_0} is lower for an individual record than for a series of records together; for one record of, say, 20 minutes

$$\langle H_{max} \rangle \simeq 1.5\ H_{m_0}.$$

6.3.3. Spectral behaviour of the waves.

Before we look at the wave spectra of 3 Jan. 1976 themselves, the relation between H_{m_0} and T_{m02} during that day will be considered. Figure 15 illustrates that H_{m_0} and T_{m02} are closely related, with least-square fit

$$T_{m02}/s = 0.79\ H_{m_0}/m + 3.17.$$

Hence it appears that the "wave age" remains virtually constant, suggesting a fetch-limited wave growth, despite the actual fetch

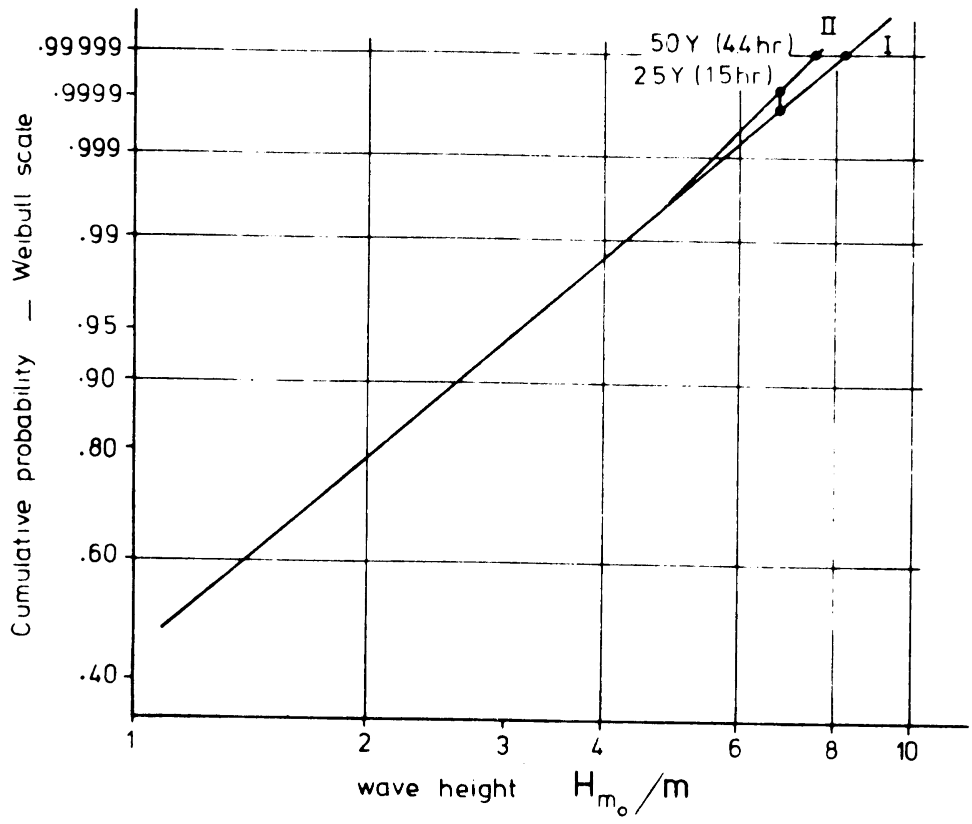


figure 14. Adjustment of the propability of exceedance of extreme wave heights, considering the effect of bottom depth on waves with $H_{m_0} > 5$ m, depth being about 30 m.

Line I : $P = 1 - \exp(-(x/1.45)^{1.41})$,
Line II : $P = 1 - \exp(-(x/1.76)^{1.68})$,
where $x = H_{m_0}/m$.
50 y (4.4 hr) denotes the exceedance level with return period of 50 years, lasting 4.4 hours.

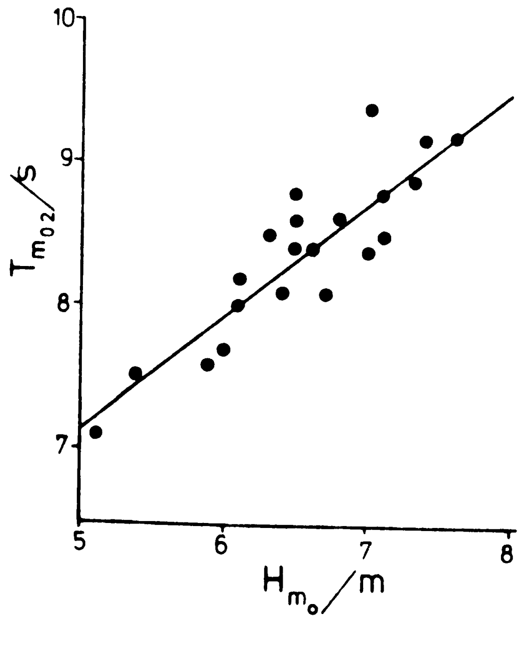


figure 15. Wave heights and periods on 3 January 1976.

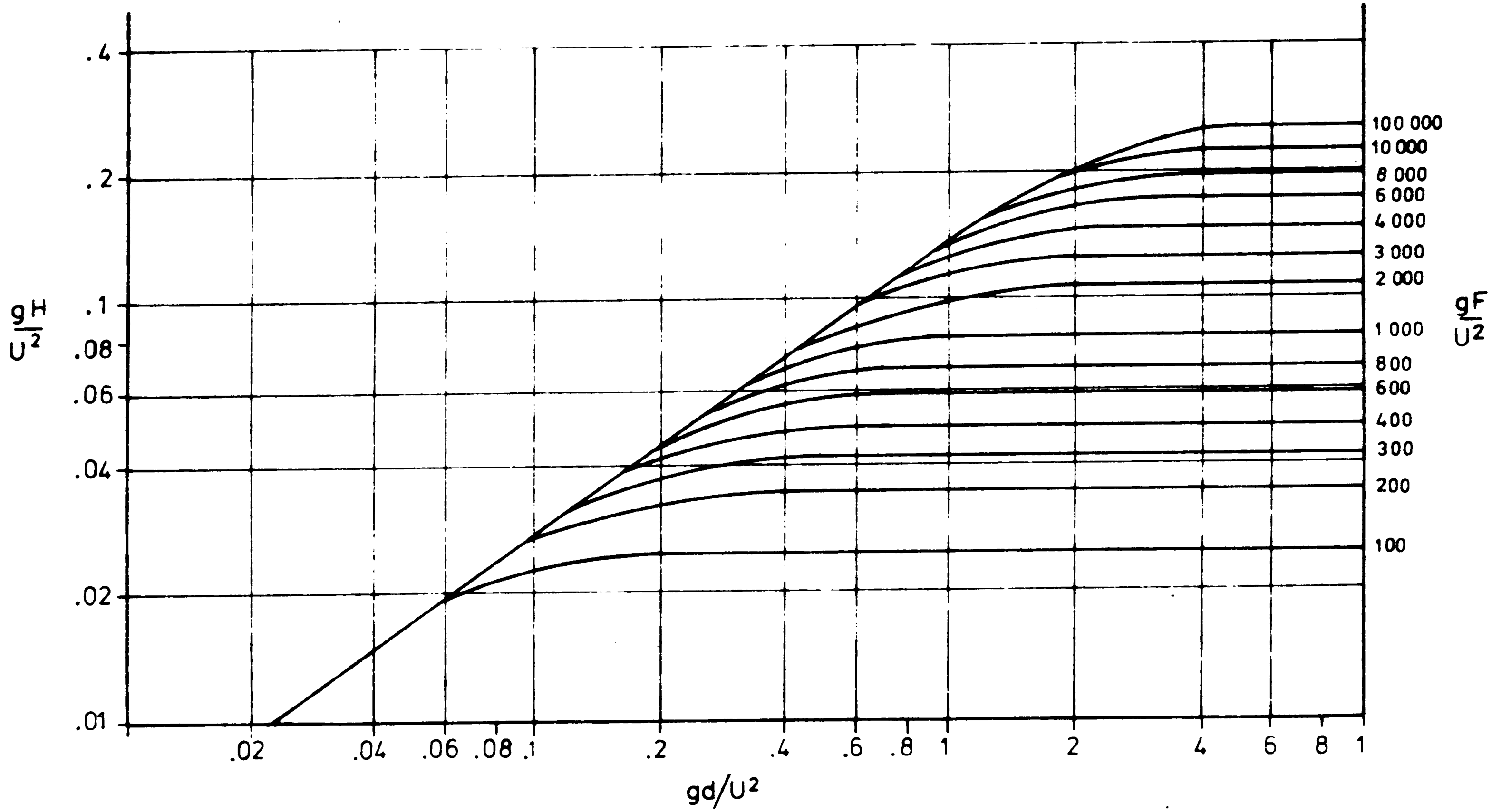


figure 16. Generation of wind waves over a bottom of constant depth for unlimited duration presented as dimensionless parameters (Bretschneider, 1954).

H : significant wave height, U : wind speed, F : fetch length,

d : water depth, g : acceleration of gravity.

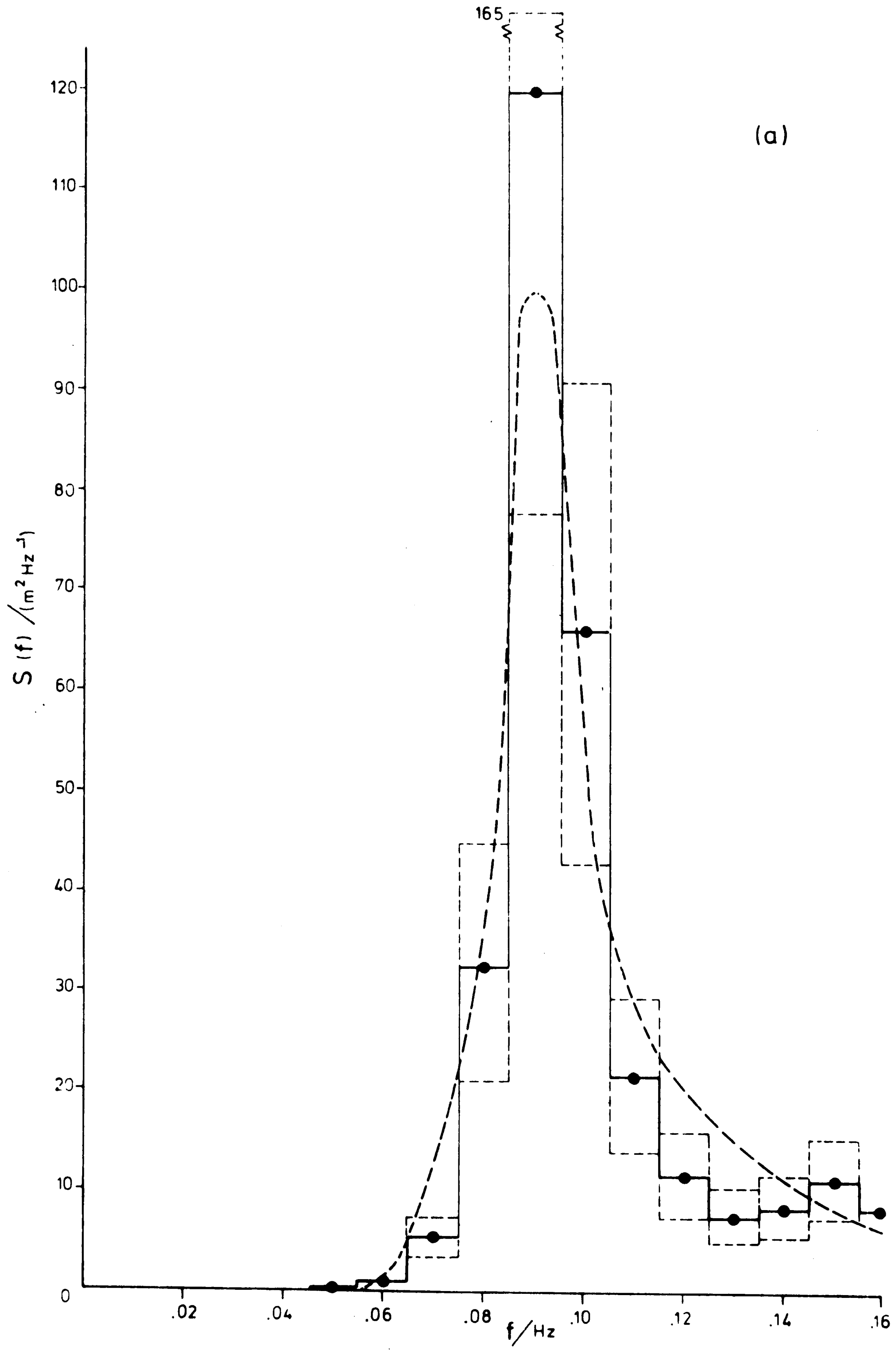
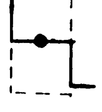


figure 17. Wave spectra on 3 January 1976, compared with deep water JONSWAP spectrum, equations (1) - (4).



: measured spectrum, with 80% confidence interval, corresponding with 24 degrees of freedom,

— — — : JONSWAP spectrum $S_J(f)$, equations (1) - (4).

(see also legend on next page, figure 17(b)).

length for north-westerly winds. This phenomenon is attributed to some sort of equilibrium between input from the wind, advection of wave energy and dissipation of the waves in the relatively shallow area between the Dogger Bank and the wave station.

The limitation of the effective fetch length by the bottom depth has also been predicted by Bretschneider (1954); one of his diagrams - for constant depth - is reproduced in figure 16. According to that diagram, for a wind speed U = 28 m/s and a depth of about 40 m (the average depth between Dogger Bank and Lightship Texel) the wave height would become 6.8 m for any fetch F longer than 200 km.

No detailed analysis of all wave spectra has been carried out, apart from the relation between H_{m_0} and T_{m02}. We just selected two spectra, see figure 17. These have been compared with the JONSWAP spectrum, specified by equations (1-4). Since the JONSWAP spectrum is valid in deep water some adjustments were necessary; for example, wind speed U had to be reduced to 20 m/s in order to get appropriate wave height to period relationships. Apart from this, the spectral shape looks quite similar to the JONSWAP spectrum which might seem surprising. No least-square fit has been carried out to obtain the spectral parameters; values of wind speed and fetch for the JONSWAP spectra in figure 17 (see figure caption) indicate orders of magnitude only.

Overvik (1975) has presented a table of γ, α and f_p depending on H_{m_0} and T_{m02}, jointly based on spectra of a series of wave measurements; this table has been presented by P. Bruun et al (1976). Interpolated values of γ, α and f_p according to Overvik's table are given in table 13 for comparison with the spectra in figures 17(a) and (b).

Table 13. Spectral parameters γ, α and f_p derived from table 1 in P. Bruun et al. (1976) for two cases shown in figure 17.

Case	H_{m_0}/m	T_{m02}/s	γ	α	f_p/Hz
fig.17(a)	7.1	8.5	3.8	0.010	0.084
fig.17(b)	7.6	9.2	3.3	0.011	0.092

The values of α and f_p of the spectra shown in figure 17 are almost identival to Overvik's, only γ is about 25% lower than according to table 13.
Note, however, that γ has a standard deviation of about 35% of the mean in Hasselmann et al. (1973).
One might expect that the JONSWAP spectral shape does not hold in shallow water in view of the increasing dissipation of longer waves i.e. lower frequencies leading to a flattened shape more alike the Pierson-Moskowitz spectrum. Apparently nonlinear interactions maintaining the JONSWAP shape seem to be more powerful than the frequency-dependent wave dissipation. Only γ seems to be reduced somewhat; however, a detailed analysis has not been done here. It would be interesting to know if nonlinear interaction between waves is enhanced in shallow water as has been suggested recently, leading to a redistribution within the spectrum towards the JONSWAP shape.

The most important conclusion of the results shown in figures 15 and 17 is that knowledge of extreme values of H_{m_0} is sufficient for deriving the wave spectrum, due to the fact that in this part of the North Sea extreme wave heights only do occur in extreme gales, implying close relationships between U, H_{m_0} and T_{m02}, and a similar shape of the spectrum. Both spectra that have been shown in figure 17 can be considered as being representative for such conditions.

It should be noted that the spectral density of the higher frequency part of extreme wave-height spectra can be exceeded by peak values of spectra with lower H_{m_0} due to the "overshoot" of the growth of individual fourier components of the spectrum. Therefore a 50-year wave spectrum is not suitable for indicating maximum spectral densities for higher values of f_p.

7. Summary and conclusions.

A lot of obstacles have been met during the acquisition of wind and wave data for the KNMI-NOGEPA wind and wave climate study, March 1973 to February 1976. The objective, to establish a set of regularly measured wind and wave data that are supposed to be representative for areas 2 and 3 (see figure 1), has only been met to some extent; only from area 2 (block L) a sufficient amount of wave data has been acquired; however, serious gaps occur particularly during the winter 1974/75 (see figure 4). Apart from this, a thee-year observation period is obviously too short for establishing a climatology. However, thanks to the close correlation existing between wave parameters and wind speeds, climatological wave parameters could reasonably well be estimated by use of wind data over 27 years.

It has been shown in table 3, section 6.1, that the average wind speed, particularly during autumns and winters, has been greater during the data acquisition period than during the standard wind data period, 1949 to 1975. In addition, figure 11 shows that particularly north-westerly gales occurred more frequently than normal. In table 3 also averages of wave heights and periods have been presented, and the available number of wave data. From this it appears that more measured wave data are needed, particularly of the period November to February when gales occur most frequently. Considering these restrictions on the straightforward use of the statistical data, a discussion has been added of waves in shallow water from a physical point of view, without going into detailed model developments.

The cumulative Weibull distribution function has been fitted to cumulative wind and wave distributions; the lower parts of these have been ignored to avoid bad fits to the highest values of the distributions which have the greatest significance for estimating the probability of extreme values.

Very close fits have been obtained of Lightship Texel wind speed data 1949/75; also the continuous wind data 1973/76 fitted reasonably well. Fits of wave data and related wind data were less good; however, it has appeared, that the wave distributions quite improved by estimating the "real" probability of exceedances, by comparing related wind data with the 1949/75 distributions of lightship Texel. A simplified method, which approximately gives the same 50-year exceedance values as a more elaborate transformation of wave distributions, has been used (section 4.2). Because of the high frequency of occurrence of extreme wind speeds and wave heights during the data acquisition period, this transformation has led to considerable reductions of the 50-year exceedance wave heights (and periods). This has been shown in table 9, section 6.2.2. For example, for all seasons H_{m_0} (50 yr) = 8.2 m and T_{m02} (50 yr) = 10.0 s. The 50-year wind speed at 20 m height is 31.0 m/s which is equivalent to 12 Beaufort, according to the CMM-scale adopted in this report. Because our wind data are based on Beaufort estimates (without using instruments) of the lightships, higher exceedance values which seem to be likely during shorter periods than 4.4 hours (= 0.05% of one year) have not been produced here; wind speed estimates of this kind are strongly related to the sea state, so that short events with extreme wind speeds e.g. during the passage of a front or in showers will be lost.

It is likely that the actual wave height exceedance values are somewhat lower than those included in table 9. It is practically impossible to infer reliable estimates of 50-year exceedance levels from statistical data alone, due to the small amount of wave data with $H_{m_0} > 5$ m, when the influence of the bottom depth on the probability of wave height exceedance gradually becomes significant. However, the probability of $H_{m_0} > 5$ m is about 0.33%. In section 6.3.2 an additional estimate of the probability of extreme wave heights has been attempted, using special wave data obtained near lightship Texel during the storm of January 3, 1976.

An important feature of the wave climate in the area between 53^o and 54^o North latitude is the dominant role of wind waves, particularly during extreme conditions. It has been shown in section 4.1 that strong attenuation of swell originating from wave fields in the northern North Sea from the Dogger Bank onwards practically excludes advection of large amplitude swell into the area; remaining swell usually is masked and sometimes even cancelled by the local wind waves.Also the effective fetch length is limited to about 250 km at most due to the limiting depths, 20 to 40 m. On January 3, 1976 the mean estimated wind speed was about 28 m/s with a mean direction of about 320^o during the period when the wave height was stationary, H_{m_o} = 6.8 m and T_{m02} = 8.6 s, on average. The remaining variability could be attributed to the limited duration of the records. This suggests a certain constraint to wave growth by the depth in the area.

In section 6.3.2 we have estimated from the 1949/75 wind data that H_{m_o}> 6.8 m may have occurred only during 15 hours within 25 years; then H_{m_o} (50 yr) becomes 7.5 m (instead of 8.2 m), see also figure 14.

The spectral behaviour during these extreme conditions has been discussed in section 6.3.3. During the 15 hours period with stationary wave height the spectral shape was quite similar to the JONSWAP-type wind wave spectrum in deep water, see figure 17. This has been related to a rather strong correlation between H_{m_o} and T_{m02}, see figure 15. Combining this with H_{m_o}(50 yr) = 7.5 m the exceedance level of the mean wave period T_{m02} becomes about 9 seconds (instead of 10 s). Design wave heights usually are assumed to be twice the significant wave height, according to the Rayleigh distribution of heights of individual waves. However, it has been found that $H_{m_o} = 1.05\ \overline{H_{1/3}}$; also the distribution of wave heights may be slightly modified in water depths of about 30 m in extreme conditions. If H_{m_o}(50 yr) is assumed to be 7.5 m, the 50-year maximum wave height becomes 13.5 m.

On the other hand, it should be noted that due to a combination of factors, for example the propagation speed of a small but active front or trough just fitting the speed of the waves, H_{m_o} may become extreme during a short time locally, without the occurrence of extreme wind speeds in a larger area. This introduces an extra amount of variability of the wave height that cannot be predicted from space and time averaged wind fields.

Estimates by Draper (1972) in his figure 1 and 2 of design wave heights and periods (50-year return period, lasting 12 hours) for the area of this study (block L) seem to be far too high: H_{max} (50 yr) ≈ 18 m, $\overline{T}_z$ (50 yr) ≈ 12 s ($\overline{T}_z$ equivalent to T_{m02}). Estimates by others (non-published reports) that have been obtained by interpolating the wave data distributions of this study without further precautions also become too high, partly because of the occurrence of an extraordinary high amount of extreme conditions between 1973 and 1976, see e.g. figure 11.

On the other hand, good agreement with extreme wave heights in Dorrestein (1967) has been found, taking into account the assumed overrating by 10-20% of visually observed extreme wave heights.

The maximum amplitude of the orbital velocity at the bottom (to which the velocity of the tidal current and wind-related currents should be added) may already exceed 1 m/s with 7 or 8 Beaufort and $H_{m_0} \simeq 4$ m. (The mean absolute orbital velocity at the bottom is roughly five times smaller than the maximum amplitude).

8. Future work.

This study has produced a considerable amount of data and experience. Like in most research work, however, more problems arise than are solved. Some of these problems are listed below.

- Wind data of lightship Texel have been used for this work;however, wind speed data based on Beaufort estimates will no longer be available for this station, since the manned service of the lightship has been terminated on July 21, 1977. Comparisons of nearby stations such as in West Terschelling with lightship Texel are required, preferably for the period 1973/76.
- More information on spatial variability of wind climate in area 2 is needed, from platform K-13 until West-Terschelling.
- Various kinds of wind speed data from platforms exist, that must be converted to disturbance-free standard height wind speed. However, the air flow in the vicinity of the wind sensor can be seriously disturbed by its surroundings, so that the output may become nonlinear. For one particular platform indications of this kind have been found.
- Knowledge of the marine boundary layer is still insufficient, for example to predict wind profiles, and gust factors at various heights under different conditions.
- We have assumed here that measurements from stations 29, 3 and 4 are representative for most of blocks K and L; the instalment of wind and wave sensors at the K-13 platform gives the opportunity to test this assumption, particularly between October and March.
- The amount of wind and wave data from the northern part of the Netherlands sector of the North Sea (south of Dogger Bank) is still insufficient.
- The problem of extreme wind waves over a shallow bottom has been treated roughly here; a more elaborate study seems worth while. For example, it has been stated that for extreme wind conditions in a shallow area the wave height has a unique relationship with the wave spectrum. However, if the wind is less extreme and a large anount of swell is penetrating the area from the north, the wave spectra will become quite different from the JONSWAP shape.
- In most wave prediction models sub-grid scale processes like showers are neglected. Wind fields that are derived from pressure fields do not contain direct information about the gustiness of the wind, apart from air-sea temperature differences. On the other hand, empirical data usually show considerable scatter around the

predicted values that is probably partly due to the lack of a complete specification of the wind, also including small-scale effects. This problem may seem relevant only for short-term wave predictions. However, wave models will often be needed for wave climate studies, when empirical data are not available.

- A more detailed analysis of the relation of the orbital velocity at the sea bottom to wave height or wind speed might be useful; this should be combined with research of velocity fields in waves and sediment transport.
- Apart from usual quantities such as design wave height also knowledge of distributions of wave <u>directions</u> is essential; the mean direction of wind waves generally is equal to the mean direction of the wind.

  However, little is known in detail of the directional spread of the waves in extreme cases, let alone over a shallow bottom, mainly because of the lack of instruments that can detect wave directions with sufficient accuracy under all conditions. For example, a drawback of stereophotography (which is one of the most promising techniques), is that most gales occur in the darkest months, November to January.

Acknowledgements.

The KNMI-NOGEPA wind and wave climate study has been a joint effort of the Koninklijk Nederlands Meteorologisch Instituut, De Bilt, and the Netherlands Oil and Gas Exploration and Production Association and some of its members.

The cooperation of many people has been essential to obtain the wave data. Once more it has been demonstrated, that collecting data at sea is more difficult than usually is realized.

The hourly wave data of 3 January 1976, which have been acquired by a waverider of Rijkswaterstaat, Studiedienst Hoorn, appeared to be most valuable for this work.

Thanks are due to Prof. R. Dorrestein for many helpful comments on the manuscript.

Notes:

1. The overshoot can be of practical importance for design of structures; though occasionally wind waves may be small, the intensity of particular frequency components may cause as much damage as heavy sea or swell due to this phenomenon.

2. If wave lengths L are greater than 150 m in water of less than 30 m deep (d), with significant wave height 7 m, so that individual waves may become 11 m high (H), then parameter $L^2.H/d^3$ will increase to values that suffice to get cnoidal waves. These conditions did occur at 3 January 1976.

3. Some confusion is possible, when the JONSWAP spectrum is compared with the Pierson-Moskowitz spectrum for fully developed waves (Pierson and Moskowitz, 1964). The shape of both spectra becomes equal when $\gamma = 1$; the term $\exp\{-1.25\ (f_p/f)^4\}$ in equation (1) can be compared with the term $\exp\{-0.74\ (f_o/f)^4\}$, where $f_o = g/2\pi U$, in Pierson and Moskowitz, 1964, but is not the same, strictly speaking.

4. In this report "wave height" H is equivalent with "significant wave height" H_{m_o}, from here on.

5. From now on $H_e = H_{e,true}$ and $T_e = T_{e,true}$, using the reduced exceedance values obtained with equations (11) and (11a).

6. A "wave" is defined by two consecutive zero-upcrossings; the number of waves in a record is then about equal to the number of zero-upcrossings.

7. It has been found from a large number of KNMI-waverider data that on average $H_{m_o}/\overline{H}_{1/3} = 1.05$, in agreement with Wilson and Baird (1972) who found on average $\overline{H}_{1/3}/H_{m_o} = 0.94$, defining H_{m_o} and $\overline{H}_{1/3}$ in the same way as we did.

8. Data of wind stations on land have been corrected for variable exposure from different wind directions, using Wieringa (1976).

9. If this storm would have been included in the 1949/75 wind data series, the predicted exceedance levels x_e in the second line of table 11 would have been increased somewhat, thus increasing the probability of s storm of this kind.

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List of Symbols.

f	(a) frequency of spectral component, in Hz; (b) distributive probability function.
f_p	peak frequency of wind wave spectrum.
H_{m_o}	significant wave height, in m, $H_{m_o} = 4\sqrt{m_o}$.
H_{max}	maximum wave height during conditions that are specified by H_{m_o}, in m; H_{max} is used in particular for extreme conditions, denoting the height of the highest individual wave. (Sometimes H_{max} is also used denoting the highest wave of a record of, say, 15 minutes).
m_n	n-th moment, $m_n = \int S(f)\, f^n df$; moments are calculated for the frequency interval 0.045 - 0.505 Hz, to eliminate instrumental errors.
P	cumulative probability distribution function, in particular:
P_w	Weibull-type function.
$S(f)$	wave variance density spectrum, in $m^2\ Hz^{-1}$.
T_{m02}	mean period of zero-upcrossing waves, in s; $T_{m02} = \sqrt{m_o/m_2}$.
U	wind speed (in $m\ s^{-1}$) at standard height, in this report at 20 m.
(1949/75)	period January 1949 - December 1975.
(1973/76)	period March 1973 - February 1976.

Appendix A. Compilation of all statistical data, which previously were presented in three-monthly summaries of KNMI-NOGEPA wind and wave climate study.

A.1. Introduction, conversion of wind speeds.

Five compilations of probability distributions - winter, spring, summer, autumn, all seasons - are presented. The lay-out of these compilations is mainly similar to that of the the quarterly summaries that have been distributed to NOGEPA members and some other interested agencies.

There is one important difference, however, that must be notified; this concerns the distributions of wind speeds. In section 5.3.2. the problem of translating Beaufort wind force estimates to wind speed has been discussed; more realistic wind speed distributions are believed to be obtained by using the socalled CMM-scale. In the original quarterly summaries that form the input data for this analysis the wind speed class division was in m/s, assuming that 2 knots ≃ 1 m/s. After addition of the summary data, all tables in which wind speed occurs have been converted according to the CMM-scale.

A.2. Decription of tables.

a. Header.

The first four summaries each are compilations of three quarterly summaries, indicated by:

AREA 2 SER.NR.YYMM ...WAVE OBS. ... WIND OBS.

where YYMM: first year and month of season; e.g. winter 1974/75 is indicated by YYMM = 7412; then a list of locations of observations is given, similar to the original summaries.

b. Frequency distributions.

The distributions have not been reduced to e.g. parts per thousand; the numbers of occurrences have been given simply, like in the quarterly summaries. Note, that the total amount of wind data is not exactly equal to the sum of all occurrences divided over the classes of wind speed due to small round-off errors connected with the conversion to the CMM-scale.

WIND DIRECTIONS, divided in 17 classes, CALM and 16 wind directions; main directions E, S, W and N are 30° wide, other directions 20° only;

WIND SPEED, divided in 42 classes, 0-40 m/s and >40 m/s (CALM includes not only 0 m/s, but also part of 1 m/s, because of wind force 0 equivalent to 0-2 knots);

SIGNIFICANT WAVE HEIGHT HMO, divided in 42 classes, 0-20 m and >20 m:

0 m	means	≤ 0.2 m
0.5 m	"	0.3 - 0.7 m
1 m	"	0.8 - 1.2 m, etc. until
20 m	"	19.8 -20.2 m
20 m	"	≥ 20.3 m

MEAN ZERO CROSSING PERIOD, divided in 17 classes: from 0 until 15 seconds, and greater than 15 seconds.

Example: the cases in class of 4 seconds had periods between 3.5 and 4.4 seconds.

EPSILON, divided in 11 classes: from 0 until 1.

c. Two-dimensional frequency distributions.

The division in classes per parameter is equivalent to what has been described in the preceding section.

Successively the following distributions are given:

wind directions	- wave heights
wave heights	- wave periods
wave heights	- wind speeds
wind directions	- wind speeds (only when simultaneous wave height data are available)
wind directions	- wind speeds (all wind data, independent from wave data)
significant wave height	- maximum wave height (correspond with HMO and HMAX, the highest wave of a record).

Explanations.

1. Wave height.

"Wave height" denotes significant wave height HMO $\equiv H_{m_0}$.
If digital records are available HMO = $4\sqrt{m_0}$, otherwise HMO is estimated from stripcharts using Tucker's method; here the difference between the highest crest and the lowest trough is measured and multiplied with a factor which is a function of the zero crossing period; this method is based on the statistical properties of water waves.

2. Differences between single and two-dimensional distributions.

Single frequency distributions contain all occurrences. However, joint distributions need both parameters to be present simultaneously.
Differences between the two types of distributions are caused by incompleteness of the data.

3. Two different distributions of wind directions - wind speeds.

The wind directions-wind speeds frequency distribution for simultaneous wave data is an example of what is explained about differences between single and two-dimensional distributions. Here three parameters must be present at the same time; if there are serious gaps in the wave data, comparison with the other wind directions-wind speeds distribution may give an impression of the influence of these gaps on the statistics; the distributions with simultaneous wave data have also been used for transforming wave height probability distributions according to standard probability distributions of wind speed (see appendix B, wind data of lightship Texel 1949/75).

d. Persistence of significant wave height.

The persistence table presents for 10 wave conditions the number of occurrences with indicated persistence delimited by real changes of conditions (left column), or the number of occurrences with minimal persistences when the real duration is unknown due to gaps in, or start or end of wave measurements (right column).
The 10 persistence conditions of wave height are: less than or equal to 1,2,3,4 or 5 meters, and greater than 1,2,3,4 or 5 meters.
The duration is indicated by the left column under TIME PERIOD (DAYS).
The classes of durations are (three-hourly measurements):

0.5	≤ 0.5 day , or ≤ 4 observations	
1.0	0.5 - 1 day , or 5-8 "	, etc., until
20.0	19.5 - 20 days, or 157-160 "	
20.0	more than 160 observations.	

The persistence table is followed by a table showing the frequency of occurrence of segment lengths; segments are defined as noninterrupted series of wave height data, limited either by the start or end of the three-months period or by breaks in between.

AREA 2   SER.NR.7312   438 WAVE OBS.   2160 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
245	53:29.0 N	4:46.0 E	0	0	0	WIND
245	53:29.0 N	4:46.0 E	0	0	0	WIND
245	53:29.0 N	4:46.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS: 2160 2160 438 432 423

2-DIM.TOTAL NUMBERS: 437 432 437 437 2160

HMAX TOTAL NUMBERS: 232 232

AREA 2   SER.NR.7412   0 WAVE OBS.   2160 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS: 2160 2160 0 0 0

2-DIM.TOTAL NUMBERS: 0 0 0 0 2160

AREA 2   SER.NR.7512   215 WAVE OBS.   2184 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
4	53:29.0 N	4:46.0 E	23	2	3	WAVES
3	53: 2.0 N	4:17.0 E	27	34	34	WAVES
3	53: 2.0 N	4:17.0 E	27	51	52	WAVES
29	53:24.5 N	4:12.0 E	25	61	85	WAVES
29	53:24.5 N	4:12.0 E	25	89	90	WAVES
220	53: 1.0 N	4:22.0 E	0	1	91	WIND

1-DIM.TOTAL NUMBERS: 2184 2184 221 221 203

2-DIM.TOTAL NUMBERS: 221 221 221 221 2184

FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS

CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
80	74	115	105	422	225	283	203	664	522	694	640	1193	442	502	172	168	6504

WIND SPEED

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 M/S
58	56	87	166	260	396	608	583	563	665	565	460	414	423	309	207	148	138	106	83	53

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40 M/S	ALL SPEEDS
46	48	26	9	5	6	5	5	6	5	0	0	0	0	0	0	0	0	0	0	0	6504

SIGNIFICANT WAVE HEIGHT HMO

0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 M
0	59	115	176	121	99	35	21	9	1	7	7	1	5	2	1	0	0	0	0	0

10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	>20.0 M	ALL HEIGHTS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	659

MEAN ZERO CROSSING PERIOD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15 S	ALL PERIODS
0	0	0	26	185	293	108	23	14	4	0	0	0	0	0	0	0	653

EPSILON,SPECTRAL WIDTH FROM M0,M2 AND M4

0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	ALL EPS
0	0	0	2	41	258	280	45	0	0	626

2-DIMENSIONAL FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS - WAVE HEIGHTS

HMO[M]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.5	2	.	.	.	11	2	18	5	9	9	2	.	1	.	.	.	.	59
1.0	.	1	.	2	14	9	16	10	23	16	8	7	7	1	.	.	1	115
1.5	.	.	.	2	12	11	9	8	32	23	19	14	29	5	7	2	2	175
2.0	.	2	3	8	15	2	2	4	24	9	14	3	23	6	1	2	3	121
2.5	.	.	2	.	9	2	.	1	13	9	15	11	25	6	5	1	.	99
3.0	.	1	1	.	2	1	.	.	4	4	4	5	4	2	7	.	.	35
3.5	.	.	1	.	.	.	.	.	2	7	3	.	3	3	1	.	1	21
4.0	.	.	.	.	.	.	.	.	2	2	.	2	2	.	.	1	.	9
4.5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
5.0	.	.	.	.	.	.	.	.	.	.	2	.	.	3	2	.	.	7
5.5	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	.	.	7
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1	.	5
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMO	2	4	7	12	63	27	45	28	109	79	67	42	94	33	32	7	7	658

WAVE HEIGHTS - WAVE PERIODS

TZ[S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	24	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	26
4	.	31	87	61	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	185
5	.	2	23	99	103	63	3	.	.	.	.	.	.	.	.	.	.	.	.	.	293
6	.	2	2	10	10	34	28	18	4	.	.	.	.	.	.	.	.	.	.	.	108
7	.	.	.	1	2	2	4	3	5	.	5	1	.	.	.	.	.	.	.	.	23
8	.	.	.	.	.	.	.	.	.	1	2	6	1	3	1	.	.	.	.	.	14
9	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	.	.	.	.	4
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL PER.	.	59	114	171	121	99	35	21	9	1	7	7	1	5	2	1	.	.	.	.	653

LEAST SQUARE FIT OF MEAN WAVE PERIOD TZ(HMO[M])[S] : TZ= 0.79 *HMO + 3.46 RES.VARIANCE = 0.291

WAVE HEIGHTS - WIND SPEEDS

WIND[M/S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
1	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
2	.	2	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
3	.	5	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
4	.	15	5	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	23
5	.	15	14	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37
6	.	15	34	20	5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	74
7	.	4	21	25	5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58
8	.	1	20	29	8	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	60
9	.	.	9	36	13	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	61
10	.	.	3	24	18	7	3	1	.	.	.	.	.	.	.	.	.	.	.	.	56
11	.	.	.	15	24	14	1	.	.	.	.	.	.	.	.	.	.	.	.	.	54
12	.	.	1	4	22	18	3	1	.	.	.	.	.	.	.	.	.	.	.	.	48
13	.	.	1	4	16	26	6	1	.	.	.	.	.	.	.	.	.	.	.	.	53
14	.	.	.	3	7	16	9	3	1	.	.	.	.	.	.	.	.	.	.	.	39
15	.	.	.	.	.	5	3	5	1	1	.	.	.	.	.	.	.	.	.	.	16
16	.	.	.	1	.	4	4	3	.	.	.	.	.	.	.	.	.	.	.	.	13
17	.	.	.	.	.	2	3	2	1	.	.	.	.	.	.	.	.	.	.	.	7
18	.	.	.	.	.	1	2	2	1	.	1	1	.	.	.	.	.	.	.	.	7
19	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	3
20	.	.	.	.	.	.	.	1	1	.	1	1	.	.	.	.	.	.	.	.	4
21	.	.	.	.	.	.	.	1	1	.	1	2	.	.	.	.	.	.	.	.	4
22	.	.	.	.	.	.	.	.	2	.	1	1	.	.	.	.	.	.	.	.	4
23	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2
24	.	.	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	3
25	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	3
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	3
30	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	.	59	115	175	121	99	35	21	9	1	7	7	1	5	2	1	.	.	.	.	658

LEAST SQUARE FIT OF WIND SPEED FF(HMO[M])[M/S] : FF= 3.60 *HMO + 3.11 RES.VARIANCE = 4.725

WIND DIRECTION - WIND SPEED , FOR SIMULTANEOUS WAVE HEIGHT DATA ONLY

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
1	1	.	.	.	1	.	.	.	.	2	1	1	1	.	.	.	.	5
2	.	.	.	.	.	.	.	.	1	3	.	.	1	.	.	.	.	6
3	.	.	.	.	1	.	1	.	2	4	.	.	2	.	.	.	.	11
4	.	.	.	.	3	.	5	2	4	3	1	2	2	1	.	.	.	23
5	.	.	.	.	3	3	10	2	5	5	3	1	3	2	.	1	1	37
6	.	.	.	2	10	8	12	4	10	5	3	3	7	6	5	.	1	74
7	.	2	1	2	5	2	4	4	6	8	3	8	8	.	2	1	1	58
8	.	.	.	1	5	5	4	3	10	7	10	5	5	1	1	.	.	60
9	.	1	.	2	3	.	4	3	11	9	9	2	13	.	.	.	2	61
10	.	.	.	2	3	2	1	4	14	3	5	2	15	2	2	.	.	56
11	.	.	1	.	6	1	1	1	15	5	5	2	11	2	2	1	.	54
12	.	.	2	1	2	1	1	2	11	7	5	3	7	3	1	1	1	48
13	.	.	1	1	5	3	.	1	10	5	8	5	9	1	4	1	.	53
14	.	1	.	1	4	1	1	1	6	4	7	3	4	2	3	1	.	39
15	.	.	.	.	2	.	.	.	2	1	3	1	3	2	.	.	1	16
16	.	.	1	.	6	.	.	.	.	3	1	1	1	.	.	.	.	13
17	.	.	.	.	3	1	.	.	1	2	.	1	.	.	.	.	.	7
18	.	.	.	.	1	.	.	.	1	1	1	.	2	1	1	.	.	7
19	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	3
20	.	.	.	.	.	.	.	.	1	1	.	.	.	1	1	.	.	4
21	.	.	.	.	.	.	.	.	1	.	.	.	.	3	1	.	.	4
22	.	.	.	.	.	.	.	.	.	2	.	.	.	2	.	.	.	4
23	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	2
24	.	.	.	.	.	.	.	.	.	.	2	.	.	.	1	.	.	3
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
28	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	3
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3
30	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	2	4	7	12	63	27	45	28	109	79	67	42	94	33	32	7	7	658

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	58	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58
1	22	2	1	1	2	2	2	2	4	6	2	2	2	1	1	1	2	56
2	.	3	2	1	5	3	5	6	12	12	8	8	8	3	6	1	4	87
3	.	6	4	3	10	4	13	10	22	17	13	15	21	4	13	3	8	166
4	.	9	7	4	21	9	27	11	35	13	14	18	45	7	19	5	14	260
5	.	4	14	6	38	22	46	23	41	29	33	39	39	20	18	10	14	396
6	.	7	16	22	61	40	56	23	61	30	48	58	83	30	50	9	16	608
7	.	8	15	14	57	28	42	23	58	58	61	59	85	20	27	10	17	583
8	.	5	9	11	57	28	26	25	38	52	69	55	95	19	39	23	12	563
9	.	12	14	15	38	22	22	28	75	50	87	75	123	32	42	14	16	665
10	.	7	7	12	31	21	10	20	65	29	61	65	138	34	39	15	11	565
11	.	3	8	9	20	6	11	12	68	39	40	42	114	41	28	11	8	460
12	.	1	5	4	13	8	8	6	57	46	48	38	99	43	23	9	7	414
13	.	.	5	2	19	15	6	6	41	46	65	41	92	34	30	14	6	423
14	.	2	3	2	11	8	6	5	36	31	45	29	63	30	21	9	8	309
15	.	2	2	.	9	2	2	.	13	18	36	22	53	16	15	4	13	207
16	.	.	2	.	20	2	.	.	13	12	17	18	39	5	14	4	3	148
17	.	.	1	1	9	3	1	1	10	11	17	28	26	11	14	3	5	138
18	.	.	.	.	3	.	.	.	3	4	8	15	21	18	24	7	3	106
19	.	2	1	.	.	.	.	.	2	1	5	6	14	15	28	7	.	83
20	.	2	.	.	.	.	.	.	2	1	3	2	12	15	12	4	1	53
21	.	.	.	.	.	.	.	.	5	2	1	2	7	20	6	3	.	46
22	.	.	.	.	.	.	.	.	2	10	4	2	7	13	7	2	.	48
23	.	.	.	.	.	.	.	.	.	5	4	1	2	6	8	.	.	26
24	.	.	.	.	.	.	.	.	.	.	3	.	.	.	6	.	.	9
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	1	.	5
26	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	2	.	6
27	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	.	.	5
28	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	2	.	5
29	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5	.	.	6
30	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.	5
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	40	74	115	105	422	225	283	203	664	522	694	640	1193	442	502	172	168	6504

SIGNIFICANT WAVE HEIGHT - MAXIMUM WAVE HEIGHT

HMAX[M]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.5	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
1.0	.	3	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
1.5	.	.	21	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28
2.0	.	.	11	29	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	42
2.5	.	.	1	29	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38
3.0	.	.	.	8	16	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	31
3.5	.	.	.	1	15	17	1	.	.	.	.	.	.	.	.	.	.	.	.	.	34
4.0	.	.	.	.	1	16	2	.	.	.	.	.	.	.	.	.	.	.	.	.	19
4.5	.	.	.	.	1	6	3	1	.	.	.	.	.	.	.	.	.	.	.	.	11
5.0	.	.	.	.	.	3	2	3	.	.	.	.	.	.	.	.	.	.	.	.	8
5.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.0	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	2
6.5	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	2
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
8.0	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
>10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
ALL HMAX	.	6	41	74	43	48	10	7	.	.	1	1	.	1	.	.	.	.	.	.	232

LEAST SQUARE FIT OF MAX.WAVE HEIGHT HMAX(HMO[M])[S] : HMAX= 1.53 *HMO + 0.00 RES.VARIANCE = 0.238

PERSISTENCE OF SIGNIFICANT WAVE HEIGHT

DURATION OF PERIODS WITH SIGNIFICANT WAVE HEIGHT:

TIME PERIOD [DAYS]	LE 1		LE 2		LE 3		LE 4		LE 5		GT 1		GT 2		GT 3		GT 4		GT 5 [M]	
0.5	11	3	15	3	2	5	.	3	.	4	5	.	19	3	12	1	2	.	3	.
1.0	2	1	6	1	3	3	.	3	.	3	1	3	8	2	1	2	1	2	1	1
1.5	2	.	4	1	1	.	.	.	.	.	1	.	4	.	1	.	.	.	.	.
2.0	1	.	2	.	1	1	.	2	.	2	.	1	3	1	1	.	.	.	.	.
2.5	.	.	1	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.
3.0	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.5	.	.	1	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.
4.0	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.5	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
5.0	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.5	.	1	.	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.
6.0	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
6.5	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
7.0	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.0	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.5	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.5	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.5	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
18.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 20.0	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.	.	.	.	.

FIRST COLUMN OF EACH CLASS CONTAINS OCCURRENCES OF PERIODS LIMITED BY CLASS CRITERION AT BOTH SIDES WITHIN ONE SEGMENT,
SECOND COLUMN OCCURRENCES OF PERIODS LIMITED BY SEGMENT LIMITS AT ONE SIDE OR BOTH.
LE : NOT GREATER THAN , GT : GREATER THAN.

SEGMENT LENGTHS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19[DAYS]
1	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2

AREA 2 SER.NR.7303 508 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS: 2204 2204 508 499 508

2-DIM.TOTAL NUMBERS: 506 499 506 506 2204

HMAX TOTAL NUMBERS: 324 324

AREA 2 SER.NR.7403 585 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
245	53:29.0 N	4:46.0 E	0	0	0	WIND
245	53:29.0 N	4:46.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS: 2208 2208 585 574 454

2-DIM.TOTAL NUMBERS: 585 574 585 585 2208

HMAX TOTAL NUMBERS: 13 13

AREA 2 SER.NR.7503 436 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:22.9 N	4:20.8 E	30	0	0	WAVES
0	53:22.9 N	4:20.8 E	30	0	0	WAVES
0	53:22.9 N	4:20.8 E	30	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS: 2205 2208 436 386 386

2-DIM.TOTAL NUMBERS: 436 386 436 436 2208

HMAX TOTAL NUMBERS: 0 0

FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS

CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
216	328	693	462	633	189	208	155	330	337	489	257	486	230	606	399	602	6620

WIND SPEED

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 M/S
156	122	160	317	543	796	863	895	803	613	405	296	226	182	123	48	24	19	6	12	10

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40 M/S	ALL SPEEDS
5	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6620

SIGNIFICANT WAVE HEIGHT HMO

0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 M	
4	316	509	326	199	119	38	12	5	5	2	2	1	1	0	0	0	0	0	0	0	
10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	>20.0 M	ALL HEIGHTS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1529

MEAN ZERO CROSSING PERIOD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15 S	ALL PERIODS
0	0	0	94	537	537	238	42	9	2	0	0	0	0	0	0	0	1459

EPSILON,SPECTRAL WIDTH FROM MO,M2 AND M4

0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	ALL EPS
0	0	0	11	146	560	524	107	0	0	1348

2-DIMENSIONAL FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS - WAVE HEIGHTS

HMO[M]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0.0	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1	4
0.5	29	12	32	18	38	18	23	11	16	18	22	9	22	7	15	15	11	316
1.0	17	26	53	35	64	15	21	11	35	28	35	27	46	23	23	23	27	509
1.5	7	20	39	37	49	9	4	13	11	14	20	16	19	10	26	9	23	326
2.0	.	9	25	14	15	9	4	1	1	12	14	4	17	4	23	9	27	188
2.5	.	3	10	12	13	4	.	1	1	5	5	1	9	3	26	18	8	119
3.0	.	1	1	3	1	.	.	.	.	.	5	.	4	1	13	5	4	38
3.5	.	.	1	3	.	.	.	.	.	1	.	.	.	.	2	2	3	12
4.0	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	2	1	5
4.5	.	.	.	.	.	.	.	.	.	2	.	.	.	.	1	.	1	4
5.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2
5.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMO	53	72	161	122	180	55	52	37	65	80	102	57	117	48	134	86	106	1527

WAVE HEIGHTS - WAVE PERIODS

TZ[S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	1	82	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	94
4	2	163	286	83	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	537
5	.	46	172	171	108	39	1	.	.	.	.	.	.	.	.	.	.	.	.	.	537
6	.	8	17	37	67	73	29	6	1	.	.	.	.	.	.	.	.	.	.	.	238
7	.	4	3	5	2	4	8	6	4	4	2	.	.	.	.	.	.	.	.	.	42
8	.	.	1	2	1	.	.	.	.	1	.	2	1	1	.	.	.	.	.	.	9
9	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL PER.	3	304	490	299	180	117	38	12	5	5	2	2	1	1	.	.	.	.	.	.	1459

LEAST SQUARE FIT OF MEAN WAVE PERIOD TZ(HMO[M])[S] : TZ= 0.85 *HMO + 3.60 RES.VARIANCE = 0.488

WAVE HEIGHTS - WIND SPEEDS

WIND[M/S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	21	12	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38
1	.	20	9	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33
2	.	20	13	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37
3	1	35	26	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	69
4	2	63	42	14	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	124
5	.	49	88	31	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	176
6	1	53	92	35	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	190
7	.	31	87	51	23	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	197
8	.	22	75	52	29	13	3	1	.	.	.	.	.	.	.	.	.	.	.	.	195
9	.	2	52	53	23	15	2	.	.	.	.	.	.	.	.	.	.	.	.	.	147
10	.	.	9	35	35	15	4	.	1	.	.	.	.	.	.	.	.	.	.	.	99
11	.	.	4	24	19	15	5	.	.	.	.	.	.	.	.	.	.	.	.	.	68
12	.	.	.	10	14	20	7	2	1	1	.	.	.	.	.	.	.	.	.	.	55
13	.	.	.	2	11	21	8	3	1	1	.	.	.	.	.	.	.	.	.	.	46
14	.	.	.	2	9	12	5	2	.	.	.	.	.	.	.	.	.	.	.	.	30
15	.	.	.	.	3	3	3	.	1	1	.	.	.	.	.	.	.	.	.	.	12
16	.	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	4
17	.	.	.	.	1	.	.	1	1	1	.	1	.	.	.	.	.	.	.	.	4
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
19	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	2
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ALL WINDS	4	316	509	326	188	119	38	12	5	4	2	2	1	1	.	.	.	.	.	.	1527

LEAST SQUARE FIT OF WIND SPEED FF(HMO[M])[M/S] : FF= 3.10 *HMO + 2.99 RES.VARIANCE = 5.494

WIND DIRECTION - WIND SPEED , FOR SIMULTANEOUS WAVE HEIGHT DATA ONLY

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38
1	15	.	1	2	2	1	2	1	2	1	1	.	3	1	1	1	.	33
2	.	1	2	3	4	2	2	1	4	2	4	.	4	2	1	2	3	37
3	.	3	4	4	7	4	2	3	5	4	8	2	7	2	3	4	7	69
4	.	7	8	9	17	6	6	5	6	5	9	9	14	5	6	7	5	124
5	.	7	11	9	23	7	11	8	14	7	7	11	16	10	11	14	8	176
6	.	9	15	10	25	9	13	2	13	6	19	9	19	5	14	9	15	190
7	.	11	21	10	20	3	7	7	8	14	13	12	17	5	16	9	24	197
8	.	15	26	20	21	2	3	3	8	15	13	6	10	5	22	12	15	195
9	.	8	24	17	18	9	3	3	2	7	5	2	8	7	15	10	7	147
10	.	5	19	12	13	1	2	1	1	5	6	1	4	3	14	4	8	99
11	.	2	11	5	13	2	.	.	1	3	5	2	3	.	12	3	5	68
12	.	2	7	8	6	3	.	1	1	4	6	1	3	.	8	2	4	55
13	.	1	8	5	5	2	1	1	1	2	4	1	2	1	4	4	4	46
14	.	.	5	4	6	2	.	.	.	1	1	1	3	2	2	2	1	30
15	.	1	.	2	1	.	.	.	.	1	1	.	2	.	1	.	1	12
16	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	4
17	.	.	.	1	.	.	.	.	.	1	1	.	.	.	.	1	.	4
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
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ALL WINDS	53	72	161	122	180	55	52	37	65	80	102	57	117	48	134	86	106	1527

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	156	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	156
1	60	1	2	5	5	5	5	4	8	2	4	1	8	1	3	4	4	122
2	.	6	11	7	17	12	7	10	19	7	13	5	15	5	8	8	11	160
3	.	15	25	12	37	21	13	17	33	17	28	13	29	11	14	14	21	317
4	.	30	44	27	59	28	27	16	45	35	51	34	58	15	20	24	29	543
5	.	38	66	33	78	29	41	28	69	38	54	44	65	28	66	57	63	796
6	.	49	83	45	88	22	39	24	57	35	72	35	74	41	79	33	88	863
7	.	65	77	44	71	14	38	25	35	58	75	46	50	27	103	51	115	895
8	.	55	118	64	63	13	13	16	26	54	53	26	35	35	95	50	87	803
9	.	25	95	61	54	19	14	8	20	33	32	18	41	26	66	44	56	613
10	.	25	51	44	45	3	5	3	8	19	23	11	24	15	42	40	48	405
11	.	8	38	35	38	8	.	.	6	11	20	12	21	6	42	27	24	296
12	.	6	24	29	28	9	1	1	2	7	26	5	16	1	28	21	21	226
13	.	2	23	21	27	5	3	3	3	3	14	3	19	3	15	15	21	182
14	.	2	11	15	22	3	2	1	1	2	9	4	24	3	9	6	10	123
15	.	2	5	7	2	.	.	.	.	7	4	.	6	4	4	2	5	48
16	.	.	3	6	.	.	.	.	.	5	3	.	1	5	1	1	.	24
17	.	.	2	5	.	.	.	.	.	3	4	.	.	4	.	1	.	19
18	.	.	2	1	.	.	.	.	.	1	3	.	.	.	.	.	.	6
19	.	.	5	.	.	.	.	.	.	.	1	.	.	.	5	.	.	12
20	.	.	7	1	.	.	.	.	.	.	.	.	.	.	2	1	.	10
21	.	.	2	.	.	.	.	.	.	.	.	.	.	.	2	.	.	5
22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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ALL WINDS	216	328	693	462	633	189	208	155	330	337	489	257	486	230	606	399	602	6620

SIGNIFICANT WAVE HEIGHT - MAXIMUM WAVE HEIGHT

HMAX[M]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.5	.	22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22
1.0	.	45	43	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	88
1.5	.	2	76	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	93
2.0	.	.	13	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48
2.5	.	.	.	21	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	28
3.0	.	.	.	2	12	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
3.5	.	.	.	1	4	7	2	.	.	.	.	.	.	.	.	.	.	.	.	.	14
4.0	.	.	.	.	1	4	4	.	.	.	.	.	.	.	.	.	.	.	.	.	9
4.5	.	.	.	.	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	4
5.0	.	.	.	.	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	6
5.5	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.5	.	.	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	3
7.0	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	4
7.5	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
>10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMAX	.	69	132	74	24	12	11	4	3	2	2	2	1	1	.	.	.	.	.	.	337

LEAST SQUARE FIT OF MAX.WAVE HEIGHT HMAX(HMO[M])[S] : HMAX= 1.34 *HMO + 0.11 RES.VARIANCE = 0.135

PERSISTENCE OF SIGNIFICANT WAVE HEIGHT

DURATION OF PERIODS WITH SIGNIFICANT WAVE HEIGHT:

TIME PERIOD [DAYS]	LE 1		LE 2		LE 3		LE 4		LE 5		GT 1		GT 2		GT 3		GT 4		GT 5 [M]	
0.5	27	1	11	4	2	.	.	.	1	.	30	2	18	4	6	2	2	.	2	.
1.0	7	3	1	2	2	1	1	2	.	.	4	4	8	1	2	.	1	.	.	.
1.5	6	2	.	.	.	.	.	.	.	.	4	2	3	.	1	.	.	.	.	.
2.0	3	.	3	.	.	.	.	.	.	.	4	2	2	2	.	.	.	.	.	.
2.5	3	.	1	3	.	2	.	2	.	3	3	2	.	1	.	.	.	.	.	.
3.0	5	.	2	1	.	1	.	1	.	1	2	2	1	1	.	.	.	.	.	.
3.5	1	.	2	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.
4.0	3	.	3	1	1	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.
4.5	1	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.
5.0	1	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
5.5	1	.	.	1	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.
6.0	.	.	1	2	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
6.5	.	.	1	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
7.0	.	.	.	1	1	2	.	2	.	1	.	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	2	.	2	.	3	.	.	.	.	.	.	.	.	.	.
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.5	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.5	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
12.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.5	.	.	.	.	.	1	.	1	.	2	.	.	.	.	.	.	.	.	.	.
13.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.5	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.0	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.5	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.5	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
16.0	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
16.5	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
17.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.5	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
20.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 20.0	.	.	.	.	.	1	.	2	.	2	.	.	.	.	.	.	.	.	.	.

FIRST COLUMN OF EACH CLASS CONTAINS OCCURRENCES OF PERIODS LIMITED BY CLASS CRITERION AT BOTH SIDES WITHIN ONE SEGMENT,
SECOND COLUMN OCCURRENCES OF PERIODS LIMITED BY SEGMENT LIMITS AT ONE SIDE OR BOTH.
LE : NOT GREATER THAN , GT : GREATER THAN.

SEGMENT LENGTHS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19[DAYS]
0	0	1	2	0	0	0	2	1	1	1	0	2	0	0	1	1	1	0	1	2

AREA 2 SER.NR.7306 694 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS:	2208	2208	694	684	681
2-DIM.TOTAL NUMBERS:	693	684	693	693	2208
HMAX TOTAL NUMBERS:	600	600			

AREA 2 SER.NR.7406 361 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS:	2208	2208	361	345	332
2-DIM.TOTAL NUMBERS:	360	345	360	360	2208
HMAX TOTAL NUMBERS:	0	0			

AREA 2 SER.NR.7506 490 WAVE OBS. 2208 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
29	53:22.9 N	4:20.8 E	30	1	10	WAVES
29	53:22.9 N	4:20.8 E	30	12	21	WAVES
29	53:22.9 N	4:20.8 E	30	25	38	WAVES
29	53:22.9 N	4:20.8 E	30	60	92	WAVES
220	53: 1.0 N	4:22.0 E	0	1	92	WIND

1-DIM.TOTAL NUMBERS:	2208	2208	504	499	475
2-DIM.TOTAL NUMBERS:	503	499	503	503	2208

FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS

CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
348	422	572	280	486	187	132	78	251	336	785	431	696	344	483	213	580	6624

WIND SPEED

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 M/S	
251	219	254	450	714	950	930	848	673	545	305	173	137	100	50	20	5	4	2	4	0	
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40 M/S	ALL SPEEDS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6624

SIGNIFICANT WAVE HEIGHT HMO

0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 M	
13	637	481	266	107	35	13	7	0	0	0	0	0	0	0	0	0	0	0	0	0	
10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	>20.0 M	ALL HEIGHTS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1559

MEAN ZERO CROSSING PERIOD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15 S	ALL PERIODS
0	0	0	226	691	495	111	4	1	0	0	0	0	0	0	0	0	1528

EPSILON,SPECTRAL WIDTH FROM MO,M2 AND M4

0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	ALL EPS
0	0	0	38	312	638	448	51	1	0	1488

2-DIMENSIONAL FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS - WAVE HEIGHTS

HMO[M]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0.0	3	5	1	.	2	.	.	.	1	.	.	.	.	.	1	.	.	13
0.5	51	52	66	35	89	31	26	11	24	15	34	22	42	29	39	10	60	636
1.0	8	38	43	25	37	6	1	3	15	26	55	31	65	20	37	20	50	480
1.5	4	10	22	5	3	.	.	.	5	20	36	19	37	20	33	11	41	266
2.0	.	3	1	.	.	1	1	.	2	7	10	7	13	17	26	1	17	106
2.5	.	.	.	.	.	.	.	.	4	4	8	5	7	3	1	3	.	35
3.0	.	.	.	.	.	.	.	.	1	2	1	.	1	1	3	3	1	13
3.5	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	5	.	7
4.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
4.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMO	66	108	133	65	131	38	28	14	52	75	144	84	165	91	140	53	169	1556

WAVE HEIGHTS - WAVE PERIODS

TZ[S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	1	208	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	226
4	12	338	269	71	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	691
5	.	69	158	171	74	22	1	.	.	.	.	.	.	.	.	.	.	.	.	.	495
6	.	11	24	21	27	12	11	5	.	.	.	.	.	.	.	.	.	.	.	.	111
7	.	1	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	4
8	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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ALL PER.	13	629	468	263	102	34	13	7	.	.	.	.	.	.	.	.	.	.	.	.	1528

LEAST SQUARE FIT OF MEAN WAVE PERIOD TZ(HMO[M])[S] : TZ= 0.88 *HMO + 3.45 RES.VARIANCE = 0.425

WAVE HEIGHTS - WIND SPEEDS

WIND[M/S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	2	37	6	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48
1	3	33	6	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	44
2	3	50	10	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	66
3	3	91	23	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	122
4	1	121	49	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	178
5	.	135	74	15	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	229
6	1	89	101	25	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	221
7	.	53	76	42	17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	188
8	.	19	65	54	16	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	156
9	.	10	43	68	12	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	134
10	.	1	21	25	18	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	68
11	.	.	5	11	13	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	36
12	.	.	1	5	11	8	4	2	.	.	.	.	.	.	.	.	.	.	.	.	31
13	.	.	.	1	6	10	4	2	.	.	.	.	.	.	.	.	.	.	.	.	22
14	.	.	.	.	2	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	8
15	.	.	.	.	.	3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	6
16	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
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33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	13	636	480	265	106	35	13	7	.	.	.	.	.	.	.	.	.	.	.	.	1556

LEAST SQUARE FIT OF WIND SPEED FF(HMO[M])[M/S] : FF= 3.50 *HMO + 2.58 RES.VARIANCE = 4.507

WIND DIRECTION - WIND SPEED , FOR SIMULTANEOUS WAVE HEIGHT DATA ONLY

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	48	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48
1	18	6	2	1	2	1	.	.	2	1	.	2	1	.	2	1	7	44
2	.	9	4	3	7	2	2	1	5	2	3	5	6	2	3	2	9	66
3	.	12	9	6	15	5	5	4	9	4	8	8	13	6	5	3	12	122
4	.	13	21	6	23	8	7	6	11	5	14	6	17	10	11	4	14	178
5	.	13	30	12	29	14	9	2	3	7	20	10	24	9	22	4	21	229
6	.	17	23	12	27	7	3	1	10	12	16	14	18	11	21	4	27	221
7	.	15	18	6	17	1	1	.	4	8	18	10	25	13	19	9	24	188
8	.	12	12	7	7	.	.	.	1	4	16	6	21	16	22	5	26	156
9	.	10	10	9	1	.	.	.	1	13	13	7	17	4	16	8	22	134
10	.	1	5	2	4	.	.	.	1	10	17	3	8	4	7	3	4	68
11	.	1	.	1	.	.	.	.	1	3	8	2	6	4	6	1	2	36
12	.	.	1	.	.	.	.	.	1	2	6	3	4	5	3	5	1	31
13	.	.	.	.	.	.	.	.	2	2	3	3	4	2	3	3	1	22
14	.	.	.	.	.	.	.	.	2	2	2	1	1	1	1	.	.	8
15	.	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	6
16	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	2
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	66	108	133	65	131	38	28	14	52	75	144	84	165	91	140	53	169	1556

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	251	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	251
1	97	16	10	5	11	4	3	4	8	4	3	8	14	4	7	3	17	219
2	.	28	18	10	25	8	10	8	20	13	14	13	26	13	16	7	27	254
3	.	38	33	17	48	16	20	14	33	27	34	21	46	25	29	12	39	450
4	.	39	74	30	80	29	31	24	37	39	62	38	82	32	48	15	56	714
5	.	58	107	47	91	47	31	10	47	38	119	56	118	31	58	25	69	950
6	.	74	100	54	94	47	18	12	40	41	103	64	82	35	65	23	79	930
7	.	66	89	35	78	21	15	5	24	32	96	57	85	53	73	34	86	848
8	.	61	64	26	31	8	4	.	9	26	95	41	71	53	73	22	91	673
9	.	31	42	33	11	1	.	2	9	33	76	44	60	41	55	32	73	545
10	.	8	17	16	15	2	1	.	9	28	64	25	43	22	27	8	22	305
11	.	3	11	3	2	4	1	.	5	16	35	19	31	14	13	4	13	173
12	.	1	7	2	.	1	.	.	3	12	32	20	19	14	9	14	5	137
13	.	1	2	2	.	.	.	.	5	13	22	10	16	5	8	14	3	100
14	.	.	.	1	.	.	.	.	3	12	13	10	6	1	2	2	1	50
15	.	.	.	.	.	.	.	.	.	3	10	5	.	.	1	.	.	20
16	.	.	.	.	.	.	.	.	.	1	.	2	.	2	.	.	.	5
17	.	.	.	.	.	.	.	.	.	.	2	.	1	1	.	.	.	4
18	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	2
19	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	4
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	348	422	572	280	486	187	132	78	251	336	785	431	696	344	483	213	580	6624

SIGNIFICANT WAVE HEIGHT - MAXIMUM WAVE HEIGHT

HMAX[M]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0.0	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
0.5	1	137	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	138
1.0	.	98	59	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	157
1.5	.	.	109	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	118
2.0	.	.	29	53	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	92
2.5	.	.	.	32	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	42
3.0	.	.	.	3	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
3.5	.	.	.	.	12	12	1	.	.	.	.	.	.	.	.	.	.	.	.	.	25
4.0	.	.	.	.	.	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	8
4.5	.	.	.	.	.	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	5
5.0	.	.	.	.	.	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	6
5.5	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	3
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
>10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMAX	1	236	197	97	34	20	9	6	.	.	.	.	.	.	.	.	.	.	.	.	690

LEAST SQUARE FIT OF MAX.WAVE HEIGHT HMAX(HMO[M])[S] :   HMAX= 1.50 *HMO +-0.06   RES.VARIANCE = 0.101

PERSISTENCE OF SIGNIFICANT WAVE HEIGHT

DURATION OF PERIODS WITH SIGNIFICANT WAVE HEIGHT:

TIME PERIOD [DAYS]	LE 1		LE 2		LE 3		LE 4		LE 5		GT 1		GT 2		GT 3		GT 4		GT 5 [M]	
0.5	19	3	7	3	1	3	.	3	.	3	19	5	15	.	6	.	.	.	.	.
1.0	7	1	.	.	2	.	.	.	.	.	11	.	4	.	1	.	.	.	.	.
1.5	6	2	4	1	.	.	.	.	.	.	1	3	1	.	.	.	.	.	.	.
2.0	1	.	.	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.	.	.
2.5	5	.	.	2	.	2	.	1	.	1	2	2	1	.	.	.	.	.	.	.
3.0	2	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
3.5	.	1	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
4.0	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
4.5	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.0	.	.	1	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
5.5	.	.	.	1	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
6.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
6.5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.0	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.5	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.0	2	.	1	.	.	1	.	1	.	1	1	.	.	.	.	.	.	.	.	.
8.5	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	1	.	1	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
10.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.0	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.5	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.0	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.5	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.0	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.0	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 20.0	.	.	.	2	.	3	.	5	.	5	.	.	.	.	.	.	.	.	.	.

FIRST COLUMN OF EACH CLASS CONTAINS OCCURRENCES OF PERIODS LIMITED BY CLASS CRITERION AT BOTH SIDES WITHIN ONE SEGMENT,
SECOND COLUMN OCCURRENCES OF PERIODS LIMITED BY SEGMENT LIMITS AT ONE SIDE OR BOTH.
LE : NOT GREATER THAN , GT : GREATER THAN.

SEGMENT LENGTHS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19[DAYS]
2	2	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	5

AREA 2 SER.NR.7309 706 WAVE OBS. 2184 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS:	2183	2183	706	706	706
2-DIM.TOTAL NUMBERS:	704	706	704	704	2183
HMAX TOTAL NUMBERS:	417	417			

AREA 2 SER.NR.7409 256 WAVE OBS. 2184 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
0	53:24.6 N	4:12.9 E	26	0	0	WAVES
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND
220	53: 1.0 N	4:22.0 E	0	0	0	WIND

1-DIM.TOTAL NUMBERS:	2184	2184	256	248	248
2-DIM.TOTAL NUMBERS:	256	248	256	256	2184
HMAX TOTAL NUMBERS:	0	0			

AREA 2 SER.NR.7509 695 WAVE OBS. 2183 WIND OBS.

LOCATIONS OF WIND AND WAVE STATIONS

STATION	LATITUDE	LONGITUDE	DEPTH/HEIGHT	DATE-DATE		KIND
29	53:22.9 N	4:20.8 E	10	1	89	WAVES
220	53: 1.0 N	4:22.0 E	0	1	91	WIND

1-DIM.TOTAL NUMBERS:	2183	2183	708	708	679
2-DIM.TOTAL NUMBERS:	707	708	707	707	2183

FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS

CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
158	120	193	180	439	178	229	188	491	416	771	553	816	404	656	312	446	6550

WIND SPEED

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 M/S	
114	96	135	262	425	623	659	602	541	610	453	362	341	362	297	186	115	97	68	67	45	
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40 M/S	ALL SPEEDS
32	18	23	9	9	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6550

SIGNIFICANT WAVE HEIGHT HMO

0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 M	
2	251	444	320	213	149	106	75	49	33	9	12	5	2	0	0	0	0	0	0	0	
10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	>20.0 M	ALL HEIGHTS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1670

MEAN ZERO CROSSING PERIOD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15 S	ALL PERIODS
0	0	0	81	566	562	289	134	28	2	0	0	0	0	0	0	0	1662

EPSILON,SPECTRAL WIDTH FROM MO,M2 AND M4

0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	ALL EPS
0	0	0	12	166	650	696	109	0	0	1633

2-DIMENSIONAL FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS - WAVE HEIGHTS

HMO[M]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0.0	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	2
0.5	13	3	14	7	20	12	28	18	26	20	25	11	25	9	13	4	2	250
1.0	5	8	12	27	58	25	32	24	55	31	31	37	25	11	33	16	13	443
1.5	3	6	11	16	33	12	7	8	21	18	52	22	26	11	33	15	25	319
2.0	.	7	9	7	6	4	3	1	10	15	32	22	42	11	15	9	20	213
2.5	.	8	2	1	1	.	.	.	3	7	19	23	30	10	19	7	19	149
3.0	.	4	2	.	.	.	.	.	3	5	10	8	25	10	16	8	15	106
3.5	.	2	5	1	2	.	.	.	.	3	4	3	12	8	14	8	13	75
4.0	.	.	.	.	.	.	.	.	.	3	6	2	4	8	14	6	6	49
4.5	.	.	.	.	.	.	.	.	.	.	2	3	5	6	11	3	3	33
5.0	.	.	.	.	.	.	.	.	.	.	.	2	4	.	3	.	.	9
5.5	.	.	.	.	.	.	.	.	.	.	.	.	3	2	3	4	.	12
6.0	.	.	.	.	.	.	.	.	.	.	.	1	.	.	3	.	1	5
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	2
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMO	21	38	55	59	120	54	70	51	118	102	182	134	201	87	178	80	117	1667

WAVE HEIGHTS - WAVE PERIODS

TZ[S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	.	75	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	81
4	2	167	304	90	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	566
5	.	9	121	194	171	61	5	1	.	.	.	.	.	.	.	.	.	.	.	.	562
6	.	.	7	33	34	83	85	36	11	.	.	.	.	.	.	.	.	.	.	.	289
7	.	.	.	1	5	5	16	33	38	29	5	1	1	.	.	.	.	.	.	.	134
8	.	.	.	.	.	.	.	5	.	4	4	11	4	.	.	.	.	.	.	.	28
9	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	2
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL PER.	2	251	438	318	213	149	106	75	49	33	9	12	5	2	.	.	.	.	.	.	1662

LEAST SQUARE FIT OF MEAN WAVE PERIOD TZ(HMO[M])[S] : TZ= 0.86 *HMO + 3.44 RES.VARIANCE = 0.288

WAVE HEIGHTS - WIND SPEEDS

WIND[M/S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	9	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
1	.	10	7	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20
2	.	18	12	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36
3	.	36	20	9	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	67
4	2	60	29	13	3	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	109
5	.	61	79	25	3	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	173
6	.	36	76	42	4	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	161
7	.	16	78	47	18	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	161
8	.	5	62	41	21	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	136
9	.	.	47	55	31	12	7	4	.	.	.	.	.	.	.	.	.	.	.	.	157
10	.	.	20	40	31	16	7	2	1	.	.	.	.	.	.	.	.	.	.	.	117
11	.	.	7	23	38	13	8	7	1	.	.	.	.	.	.	.	.	.	.	.	96
12	.	.	2	7	32	26	12	5	5	2	.	.	.	.	.	.	.	.	.	.	91
13	.	.	2	5	19	32	18	11	6	3	.	.	.	.	.	.	.	.	.	.	95
14	.	.	1	2	5	20	23	17	7	1	.	3	.	.	.	.	.	.	.	.	78
15	.	.	.	.	6	8	11	6	4	4	1	1	.	.	.	.	.	.	.	.	43
16	.	.	.	1	.	6	4	6	6	2	.	1	1	.	.	.	.	.	.	.	26
17	.	.	.	.	.	3	6	6	5	3	1	1	1	.	.	.	.	.	.	.	25
18	.	.	.	.	.	2	1	5	4	4	1	1	.	.	.	.	.	.	.	.	19
19	.	.	.	.	.	.	.	1	2	3	1	1	.	1	.	.	.	.	.	.	10
20	.	.	.	.	.	.	1	1	2	3	1	1	.	.	.	.	.	.	.	.	8
21	.	.	.	.	.	.	.	1	3	3	1	.	.	1	.	.	.	.	.	.	9
22	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	5
23	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
24	.	.	.	.	.	.	.	.	.	1	1	1	2	.	.	.	.	.	.	.	5
25	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	3
26	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	2	250	443	319	213	149	106	75	49	33	9	12	5	2	.	.	.	.	.	.	1667

LEAST SQUARE FIT OF WIND SPEED FF(HMO[M])[M/S] : FF= 3.15 *HMO + 3.21 RES.VARIANCE = 6.271

WIND DIRECTION - WIND SPEED , FOR SIMULTANEOUS WAVE HEIGHT DATA ONLY

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
1	6	1	.	.	2	1	1	.	1	1	1	2	1	.	3	1	.	20
2	.	1	1	1	3	2	3	.	4	3	3	3	5	.	4	1	1	36
3	.	2	3	2	6	3	5	2	8	6	4	4	10	2	5	3	2	67
4	.	3	5	2	12	6	8	8	10	10	7	7	9	5	8	6	3	109
5	.	3	7	10	14	7	14	12	14	10	16	8	13	7	20	8	7	173
6	.	4	6	6	15	13	10	9	13	5	18	14	14	6	10	8	12	161
7	.	3	6	8	15	8	10	5	10	11	16	17	9	7	15	6	12	161
8	.	5	4	5	15	2	4	6	16	8	13	10	8	5	15	6	14	136
9	.	2	6	8	13	3	10	4	10	10	25	11	18	5	12	3	15	157
10	.	3	7	6	13	2	3	2	17	5	15	5	16	3	8	5	7	117
11	.	2	5	3	7	3	3	2	4	7	9	7	15	7	10	6	6	96
12	.	3	1	4	2	2	.	.	4	6	10	10	19	8	9	3	9	91
13	.	2	1	1	2	2	.	.	3	6	9	15	20	5	14	4	10	95
14	.	3	2	1	2	.	.	.	2	2	7	11	16	8	13	7	6	78
15	.	.	.	.	.	.	.	.	1	2	12	1	3	3	13	4	2	43
16	.	.	.	1	.	.	.	.	.	2	4	3	4	3	3	3	3	26
17	.	.	.	.	.	.	.	.	1	3	4	.	4	3	5	3	3	25
18	.	.	.	.	.	.	.	.	.	2	3	2	1	4	4	1	1	19
19	.	.	.	.	.	.	.	.	.	1	2	.	4	.	1	.	1	10
20	.	.	.	.	.	.	.	.	.	1	.	.	3	1	1	1	2	8
21	.	.	.	.	.	.	.	.	.	.	2	.	3	3	.	.	.	9
22	.	.	.	.	.	.	.	.	.	.	1	1	2	1	.	.	.	5
23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
24	.	.	.	.	.	.	.	.	.	.	.	3	1	.	1	.	.	5
25	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	3
26	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	21	39	55	59	120	54	70	51	118	102	182	134	201	87	178	80	117	1667

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	114	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	114
1	44	4	3	.	8	3	2	2	3	4	4	3	4	3	5	2	3	96
2	.	4	8	2	16	5	10	5	12	7	10	7	20	7	10	5	7	135
3	.	4	15	6	30	10	19	10	25	15	18	13	39	14	19	11	13	262
4	.	7	20	8	50	24	26	22	36	35	28	21	42	32	34	20	20	425
5	.	17	26	25	55	21	49	38	47	42	61	40	58	31	67	21	24	623
6	.	19	18	23	61	44	26	33	66	36	66	61	55	30	41	39	44	659
7	.	15	26	26	38	25	26	25	55	32	67	65	44	28	54	29	46	602
8	.	16	19	20	52	13	18	16	55	38	62	41	47	16	42	28	57	541
9	.	7	18	26	41	7	27	17	55	40	83	45	75	30	48	28	63	610
10	.	5	16	15	36	8	12	9	45	32	56	32	80	18	45	22	20	453
11	.	4	14	9	29	7	8	6	14	21	50	35	57	26	38	21	23	362
12	.	8	3	9	10	4	4	4	17	21	47	47	56	27	38	12	32	341
13	.	4	4	4	6	5	1	2	16	22	53	53	68	22	58	14	33	362
14	.	4	2	3	7	2	1	.	11	17	43	37	54	26	50	18	21	297
15	.	4	.	2	1	1	.	.	15	10	43	12	21	16	39	15	10	186
16	.	1	.	2	.	.	.	.	8	8	21	7	17	17	14	9	11	115
17	.	.	.	.	.	.	.	.	6	14	20	1	12	11	19	7	8	97
18	.	.	.	.	.	.	.	.	2	8	11	7	12	10	11	3	4	68
19	.	.	.	.	.	.	.	.	2	10	11	5	15	11	8	1	5	67
20	.	.	.	.	.	.	.	.	1	5	4	2	14	8	7	2	2	45
21	.	.	.	.	.	.	.	.	.	1	5	2	9	10	3	2	.	32
22	.	.	.	.	.	.	.	.	.	.	4	2	6	4	2	.	.	18
23	.	.	.	.	.	.	.	.	.	.	1	7	2	8	2	1	1	23
24	.	.	.	.	.	.	.	.	.	.	.	6	2	.	1	.	.	9
25	.	.	.	.	.	.	.	.	.	.	.	1	6	.	1	.	.	9
26	.	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.	3
27	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	158	120	193	180	439	178	229	188	491	416	771	553	816	404	656	312	446	6550

SIGNIFICANT WAVE HEIGHT - MAXIMUM WAVE HEIGHT

HMAX[M]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
0.5	.	46	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46
1.0	.	39	28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	67
1.5	.	.	72	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	74
2.0	.	.	16	28	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46
2.5	.	.	1	31	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	42
3.0	.	.	.	1	25	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
3.5	.	.	.	1	16	16	2	.	.	.	.	.	.	.	.	.	.	.	.	.	35
4.0	.	.	.	.	2	18	9	.	1	.	.	.	.	.	.	.	.	.	.	.	30
4.5	.	.	.	.	.	5	5	2	1	1	.	.	.	.	.	.	.	.	.	.	14
5.0	.	.	.	.	.	1	5	4	.	3	.	.	.	.	.	.	.	.	.	.	13
5.5	.	.	.	.	.	1	.	1	1	1	.	.	.	.	.	.	.	.	.	.	4
6.0	.	.	.	.	.	1	.	2	.	3	1	1	.	.	.	.	.	.	.	.	8
6.5	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
7.0	.	.	.	.	.	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	3
7.5	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	3
8.0	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	2
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
>10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMAX	.	85	117	63	55	45	21	10	3	9	3	5	1	.	.	.	.	.	.	.	417

LEAST SQUARE FIT OF MAX.WAVE HEIGHT HMAX(HMO[M])[S] : HMAX= 1.37 *HMO + 0.16 RES.VARIANCE = 0.210

PERSISTENCE OF SIGNIFICANT WAVE HEIGHT

DURATION OF PERIODS WITH SIGNIFICANT WAVE HEIGHT:

TIME PERIOD [DAYS]	LE 1		LE 2		LE 3		LE 4		LE 5		GT 1		GT 2		GT 3		GT 4		GT 5 [M]	
0.5	40	.	20	6	13	6	9	5	1	5	26	5	25	2	30	2	19	1	8	1
1.0	14	.	10	1	5	1	2	1	1	1	16	3	6	1	5	.	4	1	.	.
1.5	4	.	4	2	5	2	.	.	.	.	9	1	10	.	3	2	.	.	.	.
2.0	3	1	2	1	1	1	.	1	.	1	3	2	1	2	1	.	.	.	.	.
2.5	2	.	1	1	3	1	.	.	.	.	1	.	3	.	.	.	.	.	.	.
3.0	1	.	1	.	1	1	.	.	.	.	.	1	1	.	.	.	.	.	.	.
3.5	1	.	2	.	1	.	.	2	.	1	.	.	3	1	1	.	.	.	.	.
4.0	1	.	.	.	.	.	.	2	.	1	1	1	.	.	.	1	.	.	.	.
4.5	.	.	.	1	.	1	2	.	.	.	1	.	.	1	.	.	.	.	.	.
5.0	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
5.5	.	.	1	.	2	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.
6.0	1	.	.	1	.	.	.	1	.	.	1	.	1	.	.	.	.	.	.	.
6.5	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.
7.0	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
7.5	.	.	.	.	.	.	.	1	.	1	1	1	.	.	.	.	.	.	.	.
8.0	1	.	2	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
9.0	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
9.5	.	.	1	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.5	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
12.0	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
12.5	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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13.5	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
14.0	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
14.5	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
15.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
18.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 20.0	.	.	1	.	1	1	1	2	1	3	.	.	.	.	.	.	.	.	.	.

FIRST COLUMN OF EACH CLASS CONTAINS OCCURRENCES OF PERIODS LIMITED BY CLASS CRITERION AT BOTH SIDES WITHIN ONE SEGMENT,
SECOND COLUMN OCCURRENCES OF PERIODS LIMITED BY SEGMENT LIMITS AT ONE SIDE OR BOTH.
LE : NOT GREATER THAN , GT : GREATER THAN.

SEGMENT LENGTHS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19[DAYS]
13	3	0	0	2	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	3

COMPILATION OF WIND AND WAVE DATA,
MARCH 1973 - FEBRUARY 1976.

AREA 2 SER.NRS. 7303 7306 7309 7312 7403 7406
7409 7412 7503 7506 7509 7512

(for numbers of observations and locations of wind are wave stations see the seasonal compilations.)

FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS

CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
802	944	1573	1027	1980	779	852	624	1736	1611	2739	1881	3191	1420	2247	1096	1796	26298

WIND SPEED

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 M/S	
577	494	636	1195	1942	2766	3061	2928	2580	2433	1728	1290	1119	1067	779	460	292	258	183	165	109	
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	>40 M/S	ALL SPEEDS
83	67	50	18	13	10	7	5	6	5	0	0	0	0	0	0	0	0	0	0	0	26298

SIGNIFICANT WAVE HEIGHT HMO

0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0 M	
19	1263	1549	1088	630	402	192	115	63	39	18	21	7	8	2	1	0	0	0	0	0	
10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	>20.0 M	ALL HEIGHTS
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5417

MEAN ZERO CROSSING PERIOD

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>15 S	ALL PERIODS
0	0	0	427	1979	1887	746	203	52	8	0	0	0	0	0	0	0	5302

EPSILON,SPECTRAL WIDTH FROM M0,M2 AND M4

0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	ALL EPS
0	0	0	63	665	2106	1948	312	1	0	5095

2-DIMENSIONAL FREQUENCY DISTRIBUTIONS

WIND DIRECTIONS - WAVE HEIGHTS

HMO[M]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0.0	3	6	1	.	2	1	.	.	2	.	1	.	.	.	1	1	1	19
0.5	95	67	112	60	158	63	95	45	75	62	83	42	90	45	67	29	73	1261
1.0	30	73	108	89	173	55	70	48	128	101	129	102	143	55	93	59	91	1547
1.5	14	36	72	60	97	32	20	29	69	75	127	71	111	46	99	37	91	1086
2.0	.	21	38	29	36	16	10	6	37	43	70	36	95	38	65	21	67	628
2.5	.	11	14	13	23	6	.	2	21	25	47	40	71	22	51	29	27	402
3.0	.	6	4	3	3	1	.	.	8	11	20	13	34	14	39	16	20	192
3.5	.	2	7	4	2	.	.	.	2	12	7	3	15	12	17	15	17	115
4.0	.	.	.	.	.	.	.	.	2	5	7	4	6	8	15	9	7	63
4.5	.	.	.	.	.	.	.	.	.	2	2	3	5	7	12	3	4	38
5.0	.	.	.	.	.	.	.	.	.	.	2	2	4	3	7	.	.	18
5.5	.	.	.	.	.	.	.	.	.	.	.	.	3	6	7	5	.	21
6.0	.	.	.	.	.	.	.	.	.	.	.	1	.	1	3	1	1	7
6.5	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5	1	.	8
7.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	2
7.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
8.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMO	142	222	356	258	494	174	195	130	344	336	495	317	577	259	484	226	399	5408

WAVE HEIGHTS - WAVE PERIODS

TZ[S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3	2	389	36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	427
4	16	699	946	305	12	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1979
5	.	126	474	635	456	185	10	1	.	.	.	.	.	.	.	.	.	.	.	.	1887
6	.	21	50	101	138	202	153	65	16	.	.	.	.	.	.	.	.	.	.	.	746
7	.	5	3	7	9	11	29	44	47	33	12	2	1	.	.	.	.	.	.	.	203
8	.	1	1	2	1	.	.	5	.	6	6	19	6	4	1	.	.	.	.	.	52
9	.	1	.	1	.	.	.	.	.	.	.	.	.	4	1	1	.	.	.	.	8
10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL PER.	18	1242	1510	1051	616	399	192	115	63	39	18	21	7	8	2	1	.	.	.	.	5302

LEAST SQUARE FIT OF MEAN WAVE PERIOD TZ(HMO[M])[S] : TZ= 0.83 *HMO + 3.51 RES.VARIANCE = 0.389

WAVE HEIGHTS - WIND SPEEDS

WIND[M/S]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0	2	68	22	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	102
1	3	65	23	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	102
2	3	90	38	12	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	145
3	4	167	73	21	3	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	269
4	4	259	124	36	8	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	434
5	.	260	256	78	15	5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	615
6	2	191	302	122	24	3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	646
7	.	104	262	165	62	8	4	.	.	.	.	.	.	.	.	.	.	.	.	.	605
8	.	47	222	177	74	20	6	1	.	.	.	.	.	.	.	.	.	.	.	.	546
9	.	12	151	211	80	31	10	4	.	.	.	.	.	.	.	.	.	.	.	.	499
10	.	1	53	125	102	41	13	3	2	.	.	.	.	.	.	.	.	.	.	.	340
11	.	.	17	73	94	46	15	8	1	.	.	.	.	.	.	.	.	.	.	.	254
12	.	.	3	26	79	72	26	10	5	3	.	.	.	.	.	.	.	.	.	.	225
13	.	.	2	11	51	88	36	17	8	4	.	.	.	.	.	.	.	.	.	.	217
14	.	.	1	7	23	51	40	22	8	1	.	3	.	.	.	.	.	.	.	.	156
15	.	.	.	1	9	20	19	12	6	6	1	1	.	.	.	.	.	.	.	.	76
16	.	.	.	2	.	11	8	12	6	3	.	2	1	.	.	.	.	.	.	.	45
17	.	.	.	.	1	4	8	9	6	4	1	1	1	.	.	.	.	.	.	.	35
18	.	.	.	.	.	2	4	7	6	5	2	2	.	.	.	.	.	.	.	.	28
19	.	.	.	.	.	.	.	2	4	3	3	2	.	1	.	.	.	.	.	.	16
20	.	.	.	.	.	.	1	2	3	3	2	2	.	1	.	.	.	.	.	.	13
21	.	.	.	.	.	.	.	2	4	3	2	2	.	1	.	.	.	.	.	.	13
22	.	.	.	.	.	.	.	.	3	2	2	1	1	.	.	.	.	.	.	.	10
23	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	4
24	.	.	.	.	.	.	.	.	.	1	3	1	2	1	.	.	.	.	.	.	8
25	.	.	.	.	.	.	.	.	.	1	.	1	1	1	.	.	.	.	.	.	4
26	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2
27	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	3
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	3
30	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	19	1261	1547	1086	628	402	192	115	63	38	18	21	7	8	2	1	.	.	.	.	5408

LEAST SQUARE FIT OF WIND SPEED FF(HMO[M])[M/S] : FF= 3.35 *HMO + 2.85 RES.VARIANCE = 5.445

WIND DIRECTION - WIND SPEED , FOR SIMULTANEOUS WAVE HEIGHT DATA ONLY

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	102	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	102
1	40	7	2	3	7	2	4	1	5	5	2	4	5	1	5	2	7	102
2	.	11	7	7	15	6	7	3	13	10	10	8	17	4	9	5	14	145
3	.	17	16	11	28	12	13	9	24	17	20	15	33	10	14	10	21	269
4	.	24	33	17	55	21	27	21	30	23	30	24	42	21	26	18	21	434
5	.	23	48	32	69	32	45	24	35	28	45	31	56	29	54	27	38	615
6	.	30	43	30	76	36	38	16	45	28	56	39	57	28	49	21	55	646
7	.	31	46	26	57	16	21	16	29	41	50	48	60	26	52	25	61	605
8	.	31	42	33	48	10	11	13	36	34	51	27	44	27	59	24	55	546
9	.	22	41	37	35	12	17	11	24	40	53	23	57	17	43	22	46	499
10	.	9	30	21	33	5	6	7	33	23	44	12	43	12	31	12	20	340
11	.	4	17	10	26	6	5	3	20	18	27	13	36	13	29	12	13	254
12	.	5	10	13	11	5	1	2	17	19	27	17	33	17	21	11	15	225
13	.	3	11	6	12	7	1	2	16	15	24	24	35	9	25	13	14	217
14	.	5	6	6	11	3	1	2	10	9	17	15	23	12	19	10	7	156
15	.	1	1	3	3	.	.	.	4	6	17	5	9	6	15	4	4	76
16	.	.	1	2	6	.	.	.	.	7	5	5	5	3	3	3	3	45
17	.	.	.	1	3	1	.	.	2	6	4	1	4	3	5	3	3	35
18	.	.	.	.	1	.	.	.	1	4	5	2	3	6	5	1	1	28
19	.	.	.	.	.	.	.	.	.	2	2	1	4	.	5	.	1	16
20	.	.	.	.	.	.	.	.	1	2	.	.	3	2	3	1	2	13
21	.	.	.	.	.	.	.	.	1	.	2	.	3	6	1	.	.	13
22	.	.	.	.	.	.	.	.	.	2	1	1	2	3	.	1	.	10
23	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	4
24	.	.	.	.	.	.	.	.	.	.	2	3	1	.	2	.	.	8
25	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2	.	.	4
26	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	2
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
28	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	3
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3
30	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	142	222	356	258	494	174	195	130	344	336	495	317	577	259	484	226	399	5408

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA

WIND(M/S)	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	577	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	577
1	225	23	16	11	26	14	12	12	23	16	14	14	28	9	16	9	26	494
2	.	40	38	21	64	28	32	28	61	40	45	33	69	27	39	21	49	636
3	.	62	77	38	124	51	65	51	113	76	94	63	135	54	74	39	81	1195
4	.	85	146	69	210	90	110	73	153	121	155	111	227	85	122	65	119	1942
5	.	116	213	111	262	119	166	100	204	147	268	179	280	110	208	113	170	2766
6	.	148	216	143	304	154	140	91	224	143	289	218	294	135	235	102	227	3061
7	.	154	207	119	243	88	121	78	171	181	300	228	263	128	257	124	265	2928
8	.	137	210	121	203	62	60	58	127	169	280	163	249	123	249	123	247	2580
9	.	75	170	135	145	48	63	55	159	157	278	182	299	129	211	119	208	2433
10	.	44	90	86	128	34	28	32	127	108	204	133	284	89	153	85	102	1728
11	.	17	71	56	89	25	20	18	93	87	145	109	222	87	121	64	67	1290
12	.	17	39	44	51	22	14	11	80	86	154	109	190	84	98	56	64	1119
13	.	6	34	30	52	24	10	11	65	84	155	107	195	63	111	57	63	1067
14	.	8	16	20	40	13	9	6	51	61	110	80	147	60	82	36	40	779
15	.	8	8	9	11	3	2	.	28	37	93	39	81	36	58	21	27	460
16	.	1	5	8	20	2	.	.	22	25	42	26	57	28	29	14	14	292
17	.	.	3	6	9	3	1	1	16	28	43	29	39	27	33	10	13	258
18	.	.	2	1	3	.	.	.	5	12	23	22	33	30	34	11	7	183
19	.	2	6	.	.	.	.	.	4	11	21	11	29	26	42	8	5	165
20	.	2	7	1	.	.	.	.	2	7	7	5	26	23	21	7	2	109
21	.	.	2	.	.	.	.	.	5	3	6	4	16	30	11	5	.	83
22	.	.	.	.	.	.	.	.	2	10	7	5	13	17	10	3	.	67
23	.	.	.	.	.	.	.	.	.	5	6	8	5	14	10	1	1	50
24	.	.	.	.	.	.	.	.	.	.	3	6	2	.	7	.	.	18
25	.	.	.	.	.	.	.	.	.	.	.	1	7	.	5	1	.	13
26	.	.	.	.	.	.	.	.	1	1	1	.	2	1	2	2	.	10
27	.	.	.	.	.	.	.	.	.	.	.	.	2	2	3	.	.	7
28	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	2	.	5
29	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5	.	.	6
30	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	.	.	5
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	802	944	1573	1027	1980	779	852	624	1736	1611	2739	1881	3191	1420	2247	1096	1796	26298

SIGNIFICANT WAVE HEIGHT - MAXIMUM WAVE HEIGHT

HMAX[M]	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	>9.0[M]	ALL H
0.0	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	
0.5	1	208	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
1.0	.	185	138	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	209
1.5	.	2	278	33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	323
2.0	.	.	69	145	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	313
2.5	.	.	2	113	35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	218
3.0	.	.	.	14	65	10	1	.	.	.	.	.	.	.	.	.	.	.	.	.	150
3.5	.	.	.	3	47	52	6	.	.	.	.	.	.	.	.	.	.	.	.	.	90
4.0	.	.	.	.	4	45	16	.	1	.	.	.	.	.	.	.	.	.	.	.	108
4.5	.	.	.	.	1	12	13	6	1	1	.	.	.	.	.	.	.	.	.	.	66
5.0	.	.	.	.	.	4	12	12	2	3	.	.	.	.	.	.	.	.	.	.	34
5.5	.	.	.	.	.	1	2	2	2	1	.	.	.	.	.	.	.	.	.	.	33
6.0	.	.	.	.	.	1	1	3	.	3	1	1	.	.	.	.	.	.	.	.	8
6.5	.	.	.	.	.	.	.	4	.	1	.	1	.	.	.	.	.	.	.	.	10
7.0	.	.	.	.	.	.	.	.	.	2	2	3	.	.	.	.	.	.	.	.	6
7.5	.	.	.	.	.	.	.	.	.	.	3	1	1	.	.	.	.	.	.	.	7
8.0	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	5
8.5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	3
9.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
9.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
>10.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL HMAX	1	396	487	308	156	125	51	27	6	11	6	8	2	1 2	.	.	.	.	.	.	1 1596

LEAST SQUARE FIT OF MAX.WAVE HEIGHT HMAX(HHO[M])[S] : HMAX= 1.43 *HHO + 0.05 RES.VARIANCE = 0.164

PERSISTENCE OF SIGNIFICANT WAVE HEIGHT

DURATION OF PERIODS WITH SIGNIFICANT WAVE HEIGHT:

TIME PERIOD [DAYS]	LE 1		LE 2		LE 3		LE 4		LE 5		GT 1		GT 2		GT 3		GT 4		GT 5 [M]	
0.5	97	7	53	16	18	14	9	11	2	12	80	12	77	9	54	5	23	2	13	1
1.0	30	5	17	4	12	5	3	6	1	4	32	10	26	4	9	2	6	3	1	1
1.5	18	4	12	4	6	2	.	.	.	.	15	6	18	.	5	2	.	.	.	.
2.0	8	1	7	1	2	2	.	3	.	3	11	6	6	5	2	.	.	.	.	.
2.5	10	.	3	6	3	5	.	3	.	4	8	5	4	1	.	.	.	.	.	.
3.0	8	.	5	1	1	3	.	1	.	1	3	3	2	1	.	.	.	.	.	.
3.5	2	1	5	.	1	.	.	2	.	1	3	4	4	1	1	.	.	.	.	.
4.0	4	.	6	1	1	1	.	2	.	1	3	2	.	.	.	1	.	.	.	.
4.5	4	.	.	1	.	2	2	.	.	.	3	.	.	1	.	.	.	.	.	.
5.0	1	.	3	2	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
5.5	1	1	1	2	2	.	1	1	.	1	6	1	.	.	.	.	.	.	.	.
6.0	1	.	2	3	.	1	.	1	.	.	2	1	1	.	.	.	.	.	.	.
6.5	1	.	1	.	.	1	.	.	1	1	1	2	.	.	.	.	.	.	.	.
7.0	.	.	.	2	1	2	.	2	.	1	1	1	.	.	.	.	.	.	.	.
7.5	1	.	.	1	.	2	.	3	.	4	1	1	.	.	.	.	.	.	.	.
8.0	3	.	3	.	1	2	.	1	.	1	2	.	.	.	.	.	.	.	.	.
8.5	1	.	.	2	2	1	.	.	.	.	2	.	.	.	.	.	.	.	.	.
9.0	.	1	1	2	.	1	.	2	.	1	.	.	.	.	.	.	.	.	.	.
9.5	.	.	1	1	.	3	.	1	.	1	1	1	.	.	.	.	.	.	.	.
10.0	.	.	.	1	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
10.5	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
11.5	.	.	.	.	1	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
12.0	.	.	.	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
12.5	.	.	1	.	.	1	.	1	.	2	.	.	.	.	.	.	.	.	.	.
13.0	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
13.5	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
14.0	.	.	.	.	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.
14.5	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
15.0	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
15.5	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
16.0	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
16.5	.	.	.	1	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.
17.0	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
17.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
18.0	.	.	.	1	.	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.
18.5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.0	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
19.5	.	.	.	.	.	1	.	1	.	1	.	.	.	.	.	.	.	.	.	.
20.0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 20.0	.	.	1	2	1	5	2	10	2	11	.	.	.	.	.	.	.	.	.	.

FIRST COLUMN OF EACH CLASS CONTAINS OCCURRENCES OF PERIODS LIMITED BY CLASS CRITERION AT BOTH SIDES WITHIN ONE SEGMENT.
SECOND COLUMN OCCURRENCES OF PERIODS LIMITED BY SEGMENT LIMITS AT ONE SIDE OR BOTH.
LE : NOT GREATER THAN , GT : GREATER THAN.

SEGMENT LENGTHS

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	>19[DAYS]
16	10	2	3	2	0	0	4	2	2	2	0	2	1	0	1	2	1	0	1	12

Appendix B. Joint frequency distribution tables of wind direction and speed at lightship Texel, 1949-1975.

B.1. Introduction.

Three-hourly wind observations of lightship Texel, January 1949 - December 1975 have been compiled. Wind speed data originally are expressed in knots, according to the official WMO-Beaufort scale that has been adopted in 1946. However, in this appendix, like in appendix A, wind speed has been expressed in m/s according to the CMM-scale. See appendix A for definitions of classes of direction and speed applied in the five tables, concerning winter, spring, summer, autumn and all seasons together, and section 5.3.2. for background information on the choice of the CMM-scale of wind force.

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA L.S.TEXEL 1949 - 1975 DEC.-FEBR.

WIND[M/S]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	498	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	498
1	194	13	15	8	29	13	18	12	25	11	11	8	16	10	13	8	12	416
2	.	16	17	14	46	30	31	25	40	21	30	19	32	18	27	12	19	397
3	.	19	20	22	68	48	50	43	61	35	56	33	61	29	41	18	28	635
4	.	30	37	31	103	51	83	67	99	57	83	49	111	41	41	40	41	964
5	.	33	50	57	159	82	103	104	141	90	104	80	151	47	65	42	60	1368
6	.	41	61	88	195	127	169	116	247	138	152	129	166	96	98	65	70	1959
7	.	41	43	75	232	140	148	132	207	155	172	130	202	109	96	86	86	2053
8	.	54	51	61	195	109	153	105	229	131	161	167	241	102	122	71	79	2032
9	.	49	53	65	176	62	98	84	211	133	150	142	206	98	117	76	70	1790
10	.	34	37	51	131	55	71	82	141	112	136	120	207	87	97	52	59	1470
11	.	16	24	39	113	49	41	39	135	102	105	121	180	75	88	48	46	1222
12	.	12	15	39	108	35	30	25	107	96	95	82	162	73	76	43	45	1041
13	.	14	10	32	83	22	21	18	76	93	77	72	144	54	76	55	42	890
14	.	14	11	21	89	24	16	12	69	100	86	60	105	50	72	37	30	795
15	.	12	8	16	50	11	4	7	43	65	74	47	112	32	43	15	22	561
16	.	7	7	9	35	4	3	5	35	40	41	34	70	22	27	13	12	365
17	.	8	4	8	31	6	1	3	27	39	33	31	54	28	25	17	11	325
18	.	3	3	2	13	4	4	.	20	26	21	24	53	31	21	11	8	245
19	.	2	1	3	11	1	.	.	12	21	21	14	51	20	18	13	2	190
20	.	.	2	3	3	.	.	.	9	7	9	4	28	8	6	4	3	86
21	.	.	.	1	1	.	.	.	5	5	6	9	23	13	5	2	.	70
22	.	.	.	.	1	.	.	.	1	4	4	6	14	7	7	1	.	46
23	.	1	.	.	.	.	.	.	.	2	4	1	10	7	3	.	.	30
24	.	.	.	.	.	.	.	.	.	.	.	.	8	2	.	.	.	10
25	.	.	.	.	.	.	.	.	.	.	1	.	3	1	2	.	1	8
26	.	.	.	.	.	.	.	.	.	.	.	.	7	4	4	1	.	16
27	.	.	.	.	.	.	.	.	.	.	.	.	4	3	3	.	.	10
28	.	.	.	.	.	.	.	.	.	.	.	.	.	2	3	.	.	5
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	692	418	469	644	1871	871	1042	879	1939	1483	1631	1385	2419	1068	1197	728	746	19482

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA L.S.TEXEL 1949 - 1975 MARCH-MAY

WIND[M/S]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	728	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	728
1	283	20	23	16	34	16	29	19	43	31	29	20	29	17	16	20	29	674
2	.	39	40	29	64	37	40	35	67	45	47	34	49	28	23	30	45	649
3	.	63	57	44	102	65	59	53	99	61	73	52	77	42	35	40	65	996
4	.	88	120	64	140	88	112	71	150	94	120	81	123	67	68	49	97	1532
5	.	120	153	129	217	102	126	97	184	145	181	115	187	86	106	86	154	2189
6	.	164	218	178	259	110	128	88	194	216	243	161	219	108	148	117	229	2780
7	.	166	227	155	254	92	101	72	138	179	246	132	198	93	170	120	222	2563
8	.	120	196	127	210	73	52	43	117	155	223	109	179	82	122	114	193	2116
9	.	95	132	105	178	37	33	25	82	125	177	98	132	70	101	111	171	1672
10	.	60	109	72	104	33	22	11	49	81	131	67	97	49	98	84	113	1180
11	.	29	68	48	92	20	14	9	21	60	109	55	65	37	71	59	85	842
12	.	20	37	43	52	14	7	6	15	46	75	39	60	22	62	46	56	599
13	.	9	23	26	36	17	5	4	13	24	54	37	55	20	46	39	42	452
14	.	8	13	27	27	21	6	2	7	30	42	28	38	32	29	28	29	366
15	.	9	5	15	14	7	2	.	8	22	36	13	26	17	22	7	22	224
16	.	3	5	10	16	4	.	.	2	7	12	9	12	9	12	4	4	109
17	.	1	3	4	17	1	1	.	1	4	11	3	13	4	6	6	5	82
18	.	.	3	2	9	4	.	.	.	6	6	5	11	5	6	3	1	61
19	.	1	3	1	10	1	.	.	.	.	2	4	4	3	5	4	2	41
20	.	.	2	1	1	1	.	.	1	.	2	1	2	1	3	2	1	16
21	.	.	.	.	.	3	1	.	.	.	1	.	2	.	1	2	.	13
22	.	.	.	.	.	2	.	.	.	.	.	1	2	1	.	1	.	6
23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
28	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	1011	1013	1447	1096	1834	745	735	533	1188	1329	1817	1063	1578	794	1149	972	1566	19870

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA L.S.TEXEL 1949 - 1975 JUNE-AUG.

WIND[M/S]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	1075	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1076
1	418	31	23	19	31	15	17	13	31	19	30	22	38	20	26	16	41	811
2	.	50	46	35	57	27	35	22	53	39	47	39	66	34	38	28	67	684
3	.	75	75	56	92	40	56	34	86	67	77	65	101	51	52	45	98	1073
4	.	119	123	75	134	46	71	53	140	98	152	109	148	77	77	69	136	1626
5	.	154	193	100	172	77	86	51	160	150	247	162	268	121	154	90	221	2406
6	.	132	239	125	178	73	64	49	146	198	363	247	318	147	168	117	272	2886
7	.	160	222	121	170	48	54	32	105	178	362	263	349	144	178	117	206	2709
8	.	113	143	69	116	30	24	22	70	152	308	206	248	121	168	119	176	2084
9	.	73	89	50	60	21	8	13	54	101	244	154	213	94	128	105	125	1530
10	.	42	38	26	31	8	5	11	44	80	199	107	147	66	90	65	78	1035
11	.	14	16	22	7	4	2	3	18	52	129	71	98	52	59	53	49	647
12	.	10	11	15	3	2	3	4	17	32	100	55	76	39	48	35	21	470
13	.	7	7	6	1	.	2	1	11	26	67	38	53	24	36	20	10	309
14	.	2	4	1	3	.	.	.	7	24	55	26	49	17	32	14	8	244
15	.	.	.	.	1	.	.	.	2	12	32	16	26	13	15	3	2	122
16	.	.	.	.	.	.	.	.	.	6	11	6	12	13	10	6	1	67
17	.	.	.	.	.	.	.	.	1	12	9	3	7	8	4	3	1	48
18	.	.	.	.	.	.	.	.	.	4	6	5	8	4	4	1	.	32
19	.	.	.	.	.	.	.	.	.	.	2	3	6	1	6	2	.	20
20	.	.	.	.	.	.	.	.	.	.	1	2	3	1	2	1	.	9
21	.	.	.	.	.	.	.	.	.	.	2	.	2	1	.	.	.	5
22	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
23	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
24	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
25	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	1493	1030	1230	717	1056	390	427	308	942	1250	2442	1595	2233	1045	1294	908	1509	19869

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA L.S.TEXEL 1949 - 1975 SEPT.-NOV.

WIND[M/S]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	1433	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1433
1	557	14	10	8	23	17	20	16	21	10	19	8	16	10	13	8	14	785
2	.	19	19	19	46	22	35	25	42	20	33	16	33	16	22	16	24	406
3	.	25	32	32	77	35	57	39	69	36	50	29	56	27	33	27	38	660
4	.	39	54	37	110	89	88	65	97	68	68	55	82	52	41	40	63	1049
5	.	48	71	55	179	91	131	88	135	86	113	86	134	52	95	51	100	1517
6	.	72	82	80	184	110	151	124	225	95	163	125	184	81	90	69	119	1954
7	.	73	73	74	183	131	148	85	201	142	180	158	224	90	97	76	133	2067
8	.	59	55	61	176	102	107	69	215	120	161	116	231	96	115	91	126	1899
9	.	28	45	46	125	74	83	87	156	115	156	126	206	106	98	81	82	1612
10	.	22	29	32	102	60	56	48	150	92	163	109	177	70	85	60	63	1317
11	.	16	17	19	61	37	30	33	100	82	115	95	160	85	81	54	47	1033
12	.	12	14	24	35	22	21	25	77	69	96	85	137	73	74	46	40	849
13	.	8	13	13	31	17	17	19	67	64	88	93	122	52	69	44	38	755
14	.	8	7	12	29	11	21	12	70	55	98	92	123	55	67	37	32	729
15	.	5	6	8	14	5	3	12	44	48	73	49	72	39	41	17	23	460
16	.	.	5	5	11	5	4	6	30	34	46	30	45	22	24	21	18	307
17	.	1	2	3	7	2	4	6	24	25	34	29	50	20	24	17	14	263
18	.	.	1	1	3	1	2	3	11	26	24	28	38	29	23	7	9	207
19	.	.	4	7	4	1	.	2	8	11	23	20	25	24	22	9	7	166
20	.	1	2	5	2	.	.	.	6	6	10	5	18	12	8	6	2	83
21	.	.	1	.	.	.	.	.	1	2	5	4	13	13	5	1	3	48
22	.	.	.	.	.	.	.	.	.	.	3	4	5	4	4	.	2	21
23	.	.	.	.	.	.	.	.	1	2	2	2	2	4	1	2	1	18
24	.	.	.	.	.	.	.	.	.	1	.	3	1	.	2	2	2	12
25	.	.	.	.	.	.	.	.	.	.	2	1	2	2	2	.	.	10
26	.	.	.	.	.	.	.	.	.	1	1	.	3	1	1	1	1	8
27	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	2
28	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	1990	449	540	542	1400	831	975	764	1750	1210	1723	1367	2159	1035	1137	782	999	19653

WIND DIRECTION - WIND SPEED , ALL AVAILABLE WIND DATA L.S.TEXEL 1949 - 1975 ALL MONTHS

WIND[M/S]	CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	ALL DIR.
0	3734	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	3735
1	1452	79	71	51	116	61	84	60	119	71	89	59	99	58	68	52	97	2686
2	.	123	122	97	213	115	141	107	203	125	157	108	180	95	110	86	155	2136
3	.	181	198	154	339	188	222	170	316	201	256	178	294	149	161	130	228	3364
4	.	277	334	206	488	274	354	257	486	317	422	294	464	237	227	198	338	5172
5	.	355	467	340	727	352	446	340	620	472	646	444	739	305	420	269	536	7480
6	.	459	600	471	816	419	512	377	812	647	921	662	887	432	504	368	690	9578
7	.	439	565	425	839	411	450	321	651	654	960	682	972	437	541	398	646	9392
8	.	346	445	319	697	314	336	239	631	558	853	599	898	401	526	394	574	8131
9	.	245	319	266	539	193	222	209	501	473	727	520	757	369	444	373	447	6604
10	.	158	212	180	368	156	153	152	384	365	628	403	627	272	370	260	314	5003
11	.	75	126	128	273	110	86	83	274	296	458	341	503	249	299	213	228	3743
12	.	53	77	121	197	72	61	60	216	242	366	262	434	207	259	171	162	2960
13	.	37	54	77	153	57	45	42	167	208	285	239	375	150	226	158	131	2406
14	.	32	34	61	148	56	44	26	153	208	281	207	315	154	201	116	99	2133
15	.	25	19	40	78	24	8	20	96	147	215	125	236	100	121	43	68	1366
16	.	10	17	24	63	12	7	11	67	87	111	79	140	66	73	45	35	848
17	.	10	9	15	55	9	6	9	53	80	87	67	124	60	60	43	31	717
18	.	4	8	5	25	9	6	3	31	62	57	62	110	68	55	22	18	546
19	.	3	7	11	25	3	.	2	20	32	48	41	85	49	51	28	11	418
20	.	1	6	9	5	1	.	.	16	13	21	11	51	22	19	13	6	194
21	.	.	1	2	2	3	1	.	6	7	14	14	39	26	11	5	4	136
22	.	.	.	.	1	2	.	.	1	5	7	11	20	12	11	2	2	75
23	.	1	.	.	.	.	.	.	1	4	6	4	12	12	5	2	1	49
24	.	.	.	.	.	.	.	.	.	1	.	3	10	2	2	2	2	23
25	.	.	.	.	.	.	.	.	.	.	3	1	5	3	5	1	1	19
26	.	.	.	.	.	.	.	.	.	1	1	.	10	5	6	2	1	25
27	.	.	.	.	.	.	.	.	.	.	.	.	5	4	4	.	.	13
28	.	.	.	.	.	.	.	.	.	.	.	.	1	2	3	.	.	6
29	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
31	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
32	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
37	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
39	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
> 40	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ALL WINDS	5186	2910	3686	2999	6161	2837	3179	2484	5819	5272	7613	5410	8389	3942	4777	3390	4820	78874

Appendix C. Persistence of wind force exceedances at lightship Texel.

C.1. Introduction.

The same data that have been used for estimating the probability distributions of wind directions and wind speeds (appendix B) have also been used for establishing the persistence of exceedances of wind forces 7 - 12 Beaufort. The problem of choosing the appropriate Beaufort scale has been avoided here by expressing the exceedance levels in Beaufort scale units (the observations are based on sea-state estimates, see section 5.3.2.).
When exceedances have been interrupted by two observations at most with lower wind force, such interruptions have been ignored.
It appears from these data, that wind force 12 (hurricane) never was reached since 1949 (not even at 3 January 1976; this storm has not been included in the 1949 - 1975 data).

C.2. Description of tables.

a. For each exceedance level - Beaufort 7 (8,9,10,11,12) or more - two tables are printed; the left table contains all data, the right table is confined to November, December and January.
b. Each table contains 13 columns, preceded or followed by a column denoted by DUR. indicating durations (hours); "60 hours" denotes ≥ 60 hours durations.
c. There are 12 overlapping classes of wind directions of 60° wide and one class of all directions (0 - 360). Note that values in the 0 - 360 column are not sums of values in the 12 other columns; some durations may be composed of periods divided over several directions, thus emergeing at different directions with lower durations.

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	27	21	21	26	91	147	158	150	121	104	93	58	245
6	15	16	18	17	39	74	109	87	67	57	36	19	143
9	5	6	3	6	26	51	67	68	56	41	22	12	112
12	7	4	5	5	14	46	45	51	40	41	20	11	102
15	6	6	3	1	6	23	36	31	33	24	16	5	55
18	6	4	1	2	4	19	27	20	35	14	13	6	58
21	3	6	3	4	3	10	17	20	21	20	4	2	44
24	3	2	2	1	2	10	15	7	11	14	11	5	46
27	1	2	2	0	2	2	7	10	14	7	3	2	26
30	0	5	4	0	1	8	8	13	6	5	3	1	31
33	1	2	1	0	0	3	6	7	10	0	1	1	17
36	0	2	2	1	0	1	7	3	3	1	2	0	12
39	0	0	1	0	1	3	1	4	1	4	2	0	21
42	0	0	3	2	0	1	1	6	3	5	0	0	14
45	1	3	2	0	1	0	1	2	1	4	0	0	11
48	0	1	0	0	0	0	3	1	2	0	1	0	4
51	1	1	0	0	0	0	0	1	5	1	0	0	9
54	1	0	1	0	0	0	0	5	1	0	1	0	6
57	0	0	0	0	0	1	0	2	0	1	0	0	11
60	0	5	4	0	0	1	2	2	4	0	0	0	36

WIND FORCE 7 BEAUFORT OR MORE

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	9	6	10	11	58	62	70	58	54	41	44	25	87	3
	9	5	10	9	27	38	44	40	28	23	9	10	60	6
	1	5	2	5	19	29	33	30	21	23	8	6	49	9
	5	2	0	4	10	23	22	28	19	14	13	9	45	12
	3	5	2	1	3	13	16	12	15	12	7	0	26	15
	3	2	1	2	3	8	20	9	16	6	5	3	29	18
	1	4	2	3	3	6	9	9	12	9	2	0	22	21
	1	0	2	1	2	8	5	3	7	8	6	3	22	24
	0	1	2	0	2	2	4	7	8	3	2	1	9	27
	0	2	4	0	1	7	6	8	5	2	1	0	20	30
	0	2	1	0	0	1	2	8	8	0	0	0	11	33
	0	1	2	1	0	0	4	2	1	1	1	0	9	36
	0	0	0	0	1	3	0	3	0	2	1	0	9	39
	0	0	1	1	0	1	1	4	2	3	0	0	8	42
	1	3	2	0	1	0	0	1	1	2	0	0	9	45
	0	1	0	0	0	0	3	1	1	0	1	0	2	48
	0	1	0	0	0	0	0	1	3	1	0	0	7	51
	1	0	0	0	0	0	0	4	1	0	0	0	4	54
	0	0	0	0	0	0	0	1	0	1	0	0	8	57
	0	1	1	0	0	1	1	0	3	0	0	0	20	60

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	16	10	10	5	40	78	85	66	58	54	36	28	118
6	7	8	4	6	17	38	57	58	45	43	29	7	92
9	5	5	1	2	10	27	36	38	28	25	9	6	59
12	1	3	4	0	5	18	22	24	30	16	10	2	47
15	4	2	1	3	2	12	14	18	26	9	6	4	35
18	0	4	2	0	0	4	14	11	11	11	2	0	29
21	1	1	3	0	0	3	3	7	6	11	3	1	29
24	0	0	0	0	1	1	4	7	11	6	3	1	18
27	0	0	3	0	0	1	1	4	2	2	3	0	15
30	1	2	1	0	0	0	2	4	7	1	1	0	14
33	0	2	0	0	0	1	2	3	4	2	0	0	9
36	0	1	0	1	0	0	2	2	1	1	0	0	9
39	0	1	1	0	0	1	0	1	0	3	0	0	7
42	0	0	0	0	0	0	0	0	1	0	0	0	0
45	0	0	1	0	0	0	0	2	2	1	1	0	4
48	0	0	0	0	0	0	0	0	1	0	0	0	4
51	0	0	0	0	0	0	0	0	0	0	0	0	4
54	0	0	0	0	0	0	0	0	0	0	0	0	2
57	0	0	0	0	0	0	0	0	0	0	0	0	2
60	0	0	0	0	0	0	0	0	0	0	0	0	1

WIND FORCE 8 BEAUFORT OR MORE

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	8	5	7	4	31	50	50	37	27	21	15	17	58	3
	5	7	3	5	11	17	36	30	22	22	15	4	55	6
	2	3	1	2	7	16	20	24	17	15	8	3	33	9
	1	2	3	0	4	13	12	15	19	8	4	1	27	12
	2	0	1	3	0	6	8	7	12	6	1	0	16	15
	0	2	0	0	0	2	9	7	7	5	1	0	16	18
	0	0	2	0	0	1	2	5	5	7	3	1	15	21
	0	0	0	0	1	1	2	4	7	5	0	1	8	24
	0	0	2	0	0	1	1	4	2	1	1	0	10	27
	1	2	1	0	0	0	1	3	5	1	1	0	12	30
	0	1	0	0	0	1	1	3	4	1	0	0	6	33
	0	1	0	0	0	0	1	0	0	0	0	0	6	36
	0	0	0	0	0	1	0	1	0	1	0	0	4	39
	0	0	0	0	0	0	0	0	0	0	0	0	0	42
	0	0	0	0	0	0	0	2	2	1	1	0	2	45
	0	0	0	0	0	0	0	0	1	0	0	0	0	48
	0	0	0	0	0	0	0	0	0	0	0	0	4	51
	0	0	0	0	0	0	0	0	0	0	0	0	2	54
	0	0	0	0	0	0	0	0	0	0	0	0	2	57
	0	0	0	0	0	0	0	0	0	0	0	0	1	60

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975 — WIND FORCE 9 BEAUFORT OR MORE

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	6	3	2	0	15	36	34	36	39	38	24	16	73
6	3	3	1	0	7	14	14	23	28	16	9	2	40
9	1	2	0	0	0	3	10	12	17	9	4	0	23
12	1	1	2	0	0	3	10	11	8	6	0	0	20
15	0	0	0	0	0	1	2	2	9	4	1	1	10
18	0	1	1	1	0	1	1	4	2	3	1	0	13
21	1	1	0	0	0	0	0	1	2	4	0	0	6
24	0	0	0	0	0	0	0	3	4	1	1	0	7
27	0	0	0	0	0	0	0	3	2	1	0	0	3
30	0	0	0	0	0	0	0	0	0	0	0	0	1
33	0	0	0	0	0	0	0	0	1	0	0	0	1
36	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	1	0	0	0	2
42	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	1
48	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	3	2	1	0	11	22	21	22	15	21	12	8	36	3
	2	3	1	0	5	11	12	14	15	7	3	1	23	6
	1	0	0	0	0	1	7	6	12	8	3	0	14	9
	0	1	2	0	0	2	7	9	7	3	0	0	13	12
	0	0	0	0	0	1	0	0	6	2	0	1	6	15
	0	1	0	0	0	1	1	4	2	3	0	0	9	18
	1	1	0	0	0	0	0	0	1	3	0	0	3	21
	0	0	0	0	0	0	0	3	4	0	1	0	6	24
	0	0	0	0	0	0	0	3	2	0	0	0	3	27
	0	0	0	0	0	0	0	0	0	0	0	0	1	30
	0	0	0	0	0	0	0	0	0	0	0	0	1	33
	0	0	0	0	0	0	0	0	0	0	0	0	0	36
	0	0	0	0	0	0	0	0	1	0	0	0	1	39
	0	0	0	0	0	0	0	0	0	0	0	0	0	42
	0	0	0	0	0	0	0	0	0	0	0	0	1	45
	0	0	0	0	0	0	0	0	0	0	0	0	0	48
	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	0	0	0	0	0	0	0	0	0	0	0	0	0	54
	0	0	0	0	0	0	0	0	0	0	0	0	0	57
	0	0	0	0	0	0	0	0	0	0	0	0	0	60

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975 — WIND FORCE 10 BEAUFORT OR MORE

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	2	0	0	0	1	9	13	25	17	13	10	5	20
6	0	0	0	0	0	4	8	6	7	9	4	2	22
9	0	0	0	0	0	0	1	1	6	3	0	0	5
12	0	0	0	0	0	0	0	1	2	3	0	0	3
15	0	0	0	0	0	0	0	0	2	2	1	0	5
18	0	0	0	0	0	0	0	2	4	1	0	0	5
21	0	0	0	0	0	0	0	1	2	1	0	0	1
24	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	1	0	0	0	0	0
30	0	0	0	0	0	0	0	0	1	0	0	0	2
33	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	2	0	0	0	1	7	10	19	10	11	5	3	14	3
	0	0	0	0	0	2	4	3	6	6	3	2	13	6
	0	0	0	0	0	0	1	0	6	3	0	0	4	9
	0	0	0	0	0	0	0	1	2	2	0	0	3	12
	0	0	0	0	0	0	0	0	1	2	1	0	4	15
	0	0	0	0	0	0	0	2	4	1	0	0	5	18
	0	0	0	0	0	0	0	1	2	0	0	0	1	21
	0	0	0	0	0	0	0	0	0	0	0	0	0	24
	0	0	0	0	0	0	0	1	0	0	0	0	0	27
	0	0	0	0	0	0	0	0	0	0	0	0	1	30
	0	0	0	0	0	0	0	0	0	0	0	0	0	33
	0	0	0	0	0	0	0	0	0	0	0	0	0	36
	0	0	0	0	0	0	0	0	0	0	0	0	0	39
	0	0	0	0	0	0	0	0	0	0	0	0	0	42
	0	0	0	0	0	0	0	0	0	0	0	0	0	45
	0	0	0	0	0	0	0	0	0	0	0	0	0	48
	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	0	0	0	0	0	0	0	0	0	0	0	0	0	54
	0	0	0	0	0	0	0	0	0	0	0	0	0	57
	0	0	0	0	0	0	0	0	0	0	0	0	0	60

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975 WIND FORCE 11 BEAUFORT OR MORE

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	0	0	0	0	0	0	0	7	8	7	5	1	11
6	0	0	0	0	0	0	0	0	1	2	0	0	2
9	0	0	0	0	0	0	0	0	1	0	0	0	1
12	0	0	0	0	0	0	0	1	2	2	0	0	2
15	0	0	0	0	0	0	0	0	1	0	0	0	1
18	0	0	0	0	0	0	0	0	1	1	0	0	1
21	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	0	0	0	0	0	0	0	6	7	8	4	0	9	3
	0	0	0	0	0	0	0	0	2	2	0	0	3	6
	0	0	0	0	0	0	0	0	1	0	0	0	1	9
	0	0	0	0	0	0	0	1	2	1	0	0	2	12
	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	0	0	0	0	0	0	0	0	0	0	0	0	0	18
	0	0	0	0	0	0	0	0	0	0	0	0	0	21
	0	0	0	0	0	0	0	0	0	0	0	0	0	24
	0	0	0	0	0	0	0	0	0	0	0	0	0	27
	0	0	0	0	0	0	0	0	0	0	0	0	0	30
	0	0	0	0	0	0	0	0	0	0	0	0	0	33
	0	0	0	0	0	0	0	0	0	0	0	0	0	36
	0	0	0	0	0	0	0	0	0	0	0	0	0	39
	0	0	0	0	0	0	0	0	0	0	0	0	0	42
	0	0	0	0	0	0	0	0	0	0	0	0	0	45
	0	0	0	0	0	0	0	0	0	0	0	0	0	48
	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	0	0	0	0	0	0	0	0	0	0	0	0	0	54
	0	0	0	0	0	0	0	0	0	0	0	0	0	57
	0	0	0	0	0	0	0	0	0	0	0	0	0	60

DISTRIBUTION OF STORM DURATIONS AT LIGHT SHIP TEXEL 1949 - 1975 WIND FORCE 12 BEAUFORT OR MORE

ALL MONTHS

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0
DUR.TILL	75	105	135	165	195	225	255	285	315	345	15	45	360
3	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0

NOVEMBER DECEMBER JANUARY

FROM	15	45	75	105	135	165	195	225	255	285	315	345	0	
TILL	75	105	135	165	195	225	255	285	315	345	15	45	360	DUR.
	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	0	0	0	0	0	0	0	0	0	0	0	0	0	9
	0	0	0	0	0	0	0	0	0	0	0	0	0	12
	0	0	0	0	0	0	0	0	0	0	0	0	0	15
	0	0	0	0	0	0	0	0	0	0	0	0	0	18
	0	0	0	0	0	0	0	0	0	0	0	0	0	21
	0	0	0	0	0	0	0	0	0	0	0	0	0	24
	0	0	0	0	0	0	0	0	0	0	0	0	0	27
	0	0	0	0	0	0	0	0	0	0	0	0	0	30
	0	0	0	0	0	0	0	0	0	0	0	0	0	33
	0	0	0	0	0	0	0	0	0	0	0	0	0	36
	0	0	0	0	0	0	0	0	0	0	0	0	0	39
	0	0	0	0	0	0	0	0	0	0	0	0	0	42
	0	0	0	0	0	0	0	0	0	0	0	0	0	45
	0	0	0	0	0	0	0	0	0	0	0	0	0	48
	0	0	0	0	0	0	0	0	0	0	0	0	0	51
	0	0	0	0	0	0	0	0	0	0	0	0	0	54
	0	0	0	0	0	0	0	0	0	0	0	0	0	57
	0	0	0	0	0	0	0	0	0	0	0	0	0	60