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ANEP-II
Edition I

STANDARDIZED WAVE AND WIND ENVIRONMENTS FOR NATO OPERATIONAL AREAS

(SOURCE DOCUMENT FOR STANAG 4194)

APRIL 1983

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NATO INTERNATIONAL STAFF · DEFENCE SUPPORT DIVISION

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ANEP-11
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I

II   ANEP-11
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NORTH ATLANTIC TREATY ORGANIZATION

MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULGATION

April 1983

1.   ANEP-11 (Standardized Wave and Wind Environments for NATO Operational Areas) specifies wave and wind conditions for those regions considered appropriate for joint operations of NATO Naval Forces, and is the Source Document for STANAG 4194 on Standardized Wave and Wind Environments and Shipboard Reporting of Sea Conditions. It is a NATO UNCLASSIFIED Publication.

2.   ANEP-11 is effective upon receipt.

3.   ANEP-11 has been developed by the David Taylor Naval Ship Research and Development Centre for AC/141 Information Exchange Group 6, and contains only factual information. Changes to this ANEP are not subject to the ratification procedures; they will be promulgated on receipt from the nations concerned.

J.J.A. DOUCET,
Major-General, CAAR
Chairman, MAS

III   ANEP-11

RECORD OF CHANGES

Change Date	Date Entered	Effective Date	By Whom Entered

III

TABLE OF CONTENTS

N A T O   U N C L A S S I F I E D

Page

LIST OF FIGURES

N A T O   U N C L A S S I F I E D

Page

LIST OF TABLES

ABSTRACT

This report is a source document for specifying wind and wave conditions for those regions considered appropriate for joint operations of NATO naval forces. The areas considered are the North Atlantic Ocean northward from the Tropic of Cancer, the Mediterranean Sea, and coastal or landlocked areas such as the North, Baltic and Black Seas. The report provides seasonal and geographic distributions of wind and wave parameters and specifies mathematical models by which wave spectra, required by any ship seakeeping performance methodology, can be developed. Portions of the data contained herein are derived from the U.S. Navy's emerging Twenty Year Hindcast Wind and Wave Climatology, and are considered to be far superior to data previously available for those operating areas.

ADMINISTRATIVE INFORMATION

This report was prepared under the sponsorship of the Naval Sea Systems Command (NAVSEA), Code 3213 Work Request Number WR91589, the Ship Performance and Hydromechanics Program funded under Program Element 62543N and Block Number ZF 43 421 001, and the Surface Wave Spectra for Ship Design Program under Program Element 62759N and Project Number SF 59 557 695. It is identified by Work Unit Numbers 1568-823-01, 1500-104-26, 1568-838-03, and 1500-300-37 at the David W. Taylor Naval Ship Research and Development Center (DTNSRDC).

BACKGROUND

In 1978, NATO Information Exchange Group 6 (IEG/6), Sub-Group 5 (SG/5), whose purpose is to develop a Standard Agreement (STANAG) between NATO nations for assessing destroyer and frigate seakeeping properties, identified the need to also develop a STANAG which provides the appropriate natural environment inputs to the seakeeping methodology and provides a standard for observing sea conditions during NATO ship trials or operational evaluations. The U.S. delegate to the sub-group volunteered to explore such an effort, and a tentative approach was proposed to the group at the April 1979 meeting held at DTNSRDC in Bethesda, Maryland. The approach was subsequently approved, and this report has been developed as the source document of wave and wind statistics required to develop the STANAG.

APPROACH

The procedure followed is broken into four succinct steps. They are

1. Define operational areas

2. Develop wind and wave statistical data bases

3. Develop wave spectral families

4. Show sample methodology application

The definition of operational areas is straightforward and dependent only upon the proximity and geographic locations of the NATO nations. Figure 1 identifies the three generic operational areas that are readily identifiable. They are

1. Open ocean North Atlantic from the Tropic of Cancer northward

2. Mediterranean Sea

3. Coastal and landlocked waters (e.g., North, Baltic and Black Seas)

As the statistical data bases and the wave spectral families appropriate for each area may vary, subsequent sections of this report deal with each region separately. The data for each region is provided in Appendices A to E. Appendix F provides a description of the data formats which have been employed. Appendix G provides the relative wind envelopes for VTOL aircraft operations. Appendices H and I provide computer FORTRAN subroutines for calculating the recommended wave spectra for each operational area.

OPEN OCEAN NORTH ATLANTIC

WAVE AND WIND STATISTICS

The open ocean region identified on Figure 1 spans the North Atlantic from the latitudes of the Northeast Trade Winds (up to about 30° N) through those of the prevailing Westerlies (30 - 60° N) and into the Polar Northeasterlies (above 60° N), so that it is not surprising that the climatology of the operational area is strongly a function of northerly location or latitude. Additionally, the influence of land mass, currents, continental shelf, and local storm tracks each cause a similar climatology variation with longitude. Therefore, it is considered appropriate to divide the open ocean area into sub-areas which are identified in Figure 2. Because of the previous wide usage of the wave statistics provided by Hogben and Lumb, see Reference 1*, it was decided to adopt their definition of geographic zones where

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*A complete listing of references is given on pages 13 and 14.

possible. Areas 1, 2, 3, 4, 6, 7, 8, 9, 10, and 11 are taken as defined by Hogben and Lumb. Areas 15, 16, 17, and 18 are also taken as defined by Hogben and Lumb but truncated at the Tropic of Cancer (23° N). Areas 00 and 0 are new areas which have been added to span the more northerly operational regions.

While Reference 1 provided the previous standard for developing wave statistics for the North Atlantic Basin, a new data base is now emerging which will become a primary source of environmental data for ship seakeeping analyses. This new data set has been under development by the U.S. Navy since 1976, and as it is well treated in Reference 2, will only be briefly described here.

In short, the Spectral Ocean Wave Model (SOWM), documented in Reference 3 and based on the work of Pierson and his associates, see Reference 4, is being used to hindcast wave conditions throughout the Northern Hemisphere. The model utilizes archived and well-refined wind fields, see Reference 5, from which directional wave spectra are hindcast at six-hour intervals for a continuous period of 20 years. The hindcasts reflect the propagation of wave energy from one location to another as well as the growth and decay of the seaway with local winds.

A typical hindcast directional spectrum is given in Table 1. From the set of such spectra, a series of parameters are derived which provide a simple summary of the character (height, period, and direction) of the seaway and which can be used to define families of representative wave spectra. As the wind speed and direction is carried along with the data set, joint distributions of wind and wave parameters are also constructed.

The darkened circles about the grid points within each area on Figure 2 indicate the SOWM grid points included in this work. Ultimately the data may be expanded to include at least the circled grid points. Table 2 provides a summary of the points currently included. The parameter sets that are developed are

1. Significant wave height vs. modal wave period
2. Significant wave height vs. wind speed
3. Significant wave height vs. primary wave direction
4. Wind speed vs. wind direction
5. Significant wave height vs. wind speed (using World Meteorological Organization Standard Sea State definition)
6. Persistence of significant wave height
7. Persistence of significant wind speed

Other parameter distributions (e.g., primary spectral width vs. primary wave direction, primary wave direction vs. secondary wave direction, directional spread about primary wave direction vs. directional spread about secondary direction) can be added to this source document as computer resources permit. While these data distributions are developed for the ten year period from September 1959 to August 1969, it is noted that seasonal parameter distributions are also of interest and should be utilized in the seakeeping performance assessment methodology.

Appendix A provides the data base of open ocean wind and wave conditions derived from the Ten Year Hindcast Wind and Wave Climatology. Tables are provided for areas identified in the North Atlantic open ocean region. Areas included are provided in Table 2. Both annual and seasonal distributions are provided. In keeping with Reference 1, the seasons are defined by

1. Winter - December to February
2. Spring - March to May
3. Summer - June to August
4. Fall - September to November

However, an ongoing evaluation of a dynamic season definition (for example, of varying length for each year) may indicate the need to revise these definitions of season at a later time. Figure 3, from Reference 2, illustrates the seasonal variation of mean significant wave height at the selected location in Area 2. Clearly, the duration of more severe conditions can occur at varying times in different yearly cycles. Therefore, cumulating data for a fixed calendar span (e.g., all December to Februarys) would produce a somewhat different worst season than if a sliding seasonal definition were used.

Figure 4, from Reference 2, provides a comparison of some of the newly developed Area 2 (grid point 127) data with that provided previously by Reference 1. This latter data has been converted from observed to significant values by application of the Nordenström relationship* described in a draft "Sea Environment Manual for Ship Design"** and developed in Reference 6. The wave height occurrences for grid point 127, if taken collectively over the ten year sample, are fairly typical for the

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*The Nordenström relationship is given by
$$(\tilde{\zeta}_w)_{1/3} = 1.68 \, (\zeta_{obs})^{0.75} \quad \text{meters}$$

**Report DTNSRDC/SPD-0720-01 to be published in 1982.

entire region bounded by Area 2. The hindcast data set is without fair weather and observer skill biases which may be at least partially surmised from the figure. For example, the hindcast data set provides a greater statistical occurrence of all waves exceeding about 2 meters. The highest significant wave height in this ten year sample of hindcasts is 17.8 meters and the correspondong mode of the directional spectrum is about 23 seconds. On the other hand, the highest observed wave in the Hogben-Lumb sample is about 12.8 meters and its observed mode is between 10 and 11 seconds. Clearly, the hindcast data set provides the naval architect with important new wave statistics which will hopefully improve the realism of seakeeping perform- ance assessments. It is noted that the modal periods developed in this work are reflective of the peak of the primary direction of tne (density) directional spectrum. Very often this coincides with the peak of the primary direction as well as the entire spectrum.

With regard to wave periods, the hindcasts generally indicate longer wave periods for given heights. This is not surprising as it is difficult to observe them at sea and even the codes used to record observed occurrences on board ship are inadequate in this regard. Very often, the naval architect uses the most probable modal or peak wave period for several varying wave heights. In this work, the modal periods, being longer, will cause larger responses to be calculated for the longer ships. Figure 5 shows a comparison of the new (tentative) most probable period - significant wave height relationship with the previously used one recommended in the "Sea Environment Manual for Ship Design." Clearly, for waves in excess of about 6.5 meters, tne hindcast periods are from 0.5 to 3 seconds longer.

Without doubt, the most severe wave conditions which NATO fleets will encounter are in the North Atlantic. Figure 6 presents an annual comparison of significant wave height occurrences for the five generic operational areas. As might be expected, the North Sea is ranked second most severe with the Black Sea third, the Mediterranean Sea fourth, and the Baltic Sea fifth. When only worst seasons are compared the ranking is the same as for the annual occurrences, see Figure 7.

Figures 8 and 9 provide a more detailed illustration of annual and worst season occurrences for the areas defined in Table 2 in the North Atlantic. These data are based on the occurrences provided in Appendix A. Generally, the severer conditions prevail between 50 and 60° N with the western portions indicating somewhat worsened conditions.

Figure 10, from Reference 2, defines regions of extreme seas in the North
Atlantic. Extreme seas are defined to be those with significant wave heights of
10 meters or more. The figure was constructed by tabulating all extreme occurrences
for the circled 65 grid points in the ten year sample. Clearly, ship operations
conducted between about 55 and 60° N will generally encounter more severe conditions,
though occasional occurrences are noted as far south as the Tropic of Cancer.

WAVE SPECTRAL FAMILY

In keeping with the recommendations of the International Ship Structures
Congress (ISSC) and the International Towing Tank Conference (ITTC), as well as
current U.S. Navy design practice ("Sea Environment Manual for Ship Design"), the
two-parameter Bretschneider spectral formulation is recommended for use for the
open ocean North Atlantic. The spectrum can be written in the form

$$S_\zeta(\omega) = A\omega^{-5} \exp[-B/\omega^4] \quad m^2 \, sec$$

where

$$A = 483.5 \, (\tilde{\zeta}_w)^2_{1/3} / T_o^4 \quad m^2/sec^4$$

and

$$B = 1944.5/T_o^4 \quad 1/sec^4 \tag{1}$$

The two defining parameters of the spectrum are the significant wave height,
$(\tilde{\zeta}_w)_{1/3}$, in meters and the modal or peak wave period, T_o, in seconds. The parameters
can be taken from the data base provided in Appendix A, see Appendix F for data
format description. As indicated in the Appendix, the frequency distribution, being
fixed in SOWM, permits only certain modal period values in the parameterization of
the spectra. The periods are shown on Table 3 and are defined at the peak of the
primary direction of the directional spectrum (converted to densities). Very often
this peak occurs at the same frequency as that for the point spectrum and the total
directional wave spectrum. Figure 11 provides a selection of Bretschneider spectra
for the case when the significant wave height is defined as 0.30 m (1 ft).

The effect of wave directionality on predicted ship response can be substantial.
Figure 12, from Reference 7, illustrates this effect for roll motion for a conven-
tional destroyer hull. Uni-directional or long-crested seas permit much more severe
motion, in the worst case, than multi-directional or short-crested seas. As short-
crested seas occur most frequently in nature, it is recommended that they be used in

most seakeeping analyses. However, in certain investigations, e.g. of head sea pitch and heave motions, which require worst case values, long-crested seas should be used.

The state-of-the-art for modeling short-crested seas, is to apply a ±90 degree cosine squared spreading function to the individual frequency components of the uni-directional wave spectrum, for example see Equation (1). The function can be written

$$S_\zeta(\omega,\nu) = (2/\pi) \cos^2 (\nu - \mu) S_\zeta(\omega) \tag{2}$$

where ν represents the secondary wave directions, μ is the predominant wave direction and angles are measured in radians. In applying Equation (2), it is assumed that energy is constant across directional bands equivalent to the increment across successive ν's and that it is constant for all wave frequencies. The spreading function is generally applied about ±90 degrees and at 15-degree increments from the predominant wave direction. A generalization of this directionality model to a ±ν^* cosine squared spreading function, see Reference 8, has been developed and may be applicable as more conclusions are derived from the Twenty Year Hindcast Climatology. For purposes of this report, it is recommended that the equation be applied for ±90 degrees, and at 15-degree increments. Effectively,

$$S_\zeta(\omega,\nu) = W \cdot S_\zeta(\omega)$$

and

$$W = \frac{\alpha}{\nu^*} \cos^2 \left[\frac{90}{\nu^*} \nu - \mu\right] \tag{3}$$

where angles are measured in degrees.

Table 4 provides values for W for various ν^* values. In this case, ν^* should be taken as 90 and α as 15, so that the W values under the "90" column are to be used.

Preliminary results reported in Reference 2 (for grid point 127 in Area 2) indicate that

1. Uni-directional seas are rare

2. Spreading using a cosine squared function about ±90 degrees may represent the most frequent case

3. Spreading as narrow as ±60 degrees and as broad as ±120 degrees is not rare

MEDITERRANEAN SEA

WAVE AND WIND STATISTICS

Wave and wind statistics for the Mediterranean Sea are provided in Appendix B for both annual and seasonal time spans. Frequencies of occurrence, developed from Reference 9, are provided for the three areas (29, 30, 31) identified on Figure 13. Parameters included are

1. Significant wave height vs. modal wave period
2. Significant wave height vs. wind speed
3. Significant wave height vs. primary wave direction
4. Wind speed vs. wind direction

The seasons are defined as for the open ocean North Atlantic case.

As indicated in Reference 2, the Twenty Year Hindcast Climatology will eventually be extended to include the Mediterranean Basin using an operational model, with a grid spacing of about 40 miles, currently in use by the U.S. Navy, see Reference 10. Hence, the data given in Appendix B will eventually be replaced with distributions similar to those of Appendix A. Additionally, the basin will be divided into operational areas such as is done in the North Atlantic.

WAVE SPECTRAL FAMILY

As the three Mediterranean areas noted on Figure 13 are in sufficiently deep water and with sufficiently long fetches, the Bretschneider Spectral Family discussed previously, should be used. In keeping with the range of values given in Appendix B, modal periods up to 13 seconds together with the appropriate significant heights, should be used to define the spectra. The same recommendations with regard to directionality as made for the open ocean are also applicable here.

COASTAL AND LANDLOCKED AREAS

WAVE AND WIND STATISTICS

Wave and wind statistics for coastal and landlocked operating areas are provided in Appendices C, D, and E.

Appendix C, developed from the Twenty Year Hindcast Climatology, provides data for the North Sea. Parameter distributions are similar to those provided for the open ocean in Appendix A and are for grid point 124 in Area 4 on Figure 2. A summary of some wave occurrences in this area is provided in Figures 6 and 7. The same

parameter sets and seasonal definitions as for the open ocean North Atlantic are also applicable here.[*]

Appendix D provides wave and wind statistics for the Baltic Sea, including the Gulf of Bothnia, which are derived from References 9, 11, 12, and 13. The specific operating areas included are noted on Figure 14. The same parameter sets and seasonal definitions as used for the Mediterranean are also applicable here.

Appendix E provides wave and wind statistics for the Black Sea derived from Reference 14. Figure 15 defines the specific operating area included. The eastern part of the Black Sea was not treated as the prevailing conditions there are less severe than the more western area shown in the figure. The parameter sets are the same as used for the Mediterranean while the seasons are defined as for the open ocean North Atlantic case.

WAVE SPECTRAL FAMILY

As all of these operating regions are relatively shallow[**] and at least partially surrounded by land, the Bretschneider spectral formulation is not recommended for use here. Instead, the mean JONSWAP spectrum is recommended here. This formulation was developed by Hasselmann in order to model fetch-limited, shallow water wave conditions, see Reference 15.

The JONSWAP spectrum is a generalization of the Pierson-Moskowitz form by inclusion of fetch as an additional parameter to wind speed. As it is usually written, the mean JONSWAP spectrum is dependent on the two parameters wind speed and fetch. However, for simplicity, as well as consistency with the current state-of-the-art in seakeeping performance assessment, a JONSWAP expression which is dependent only on the two parameters, significant wave height and modal wave period, is desirable. Such an expression is derived in Reference 16 and given by

$$S_\zeta(\omega) = \beta g^2 \, \omega^{-5} \exp\left[-1.25 \left(\frac{\omega T_o}{2\pi}\right)^{-4}\right] 3.3^{\exp\left[-\frac{1}{2\sigma^2}\left(\frac{\omega T_o}{2\pi} - 1\right)^2\right]} \quad m^2 sec \qquad (5)$$

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[*]It should be noted that this Appendix will eventually be replaced by one consisting of hindcast data, under development by the German Navy, for a fine grid spacing throughout the North Sea.

[**]The Black Sea is actually of greater depth than the North or Baltic Seas, but no data have been found with which to determine the most appropriate wave spectral family.

where

$$\sigma = 0.07 \text{ for } \frac{\omega}{2\pi} \leq \frac{1}{T_o} \qquad (6)$$

or

$$\sigma = 0.09 \text{ for } \frac{\omega}{2\pi} > \frac{1}{T_o} \qquad (7)$$

and where ω is the circular wave frequency in radians per second. β is a constant dependent on the significant wave height, $(\tilde{\zeta}_w)_{1/3}$, and the modal wave period, T_o. β was developed to replace the α parameter given in the usual JONSWAP formulation and to correct for the parameter's nonuniversality. The inconsistency in the usual JONSWAP formulation arises for relatively high waves with long periods. Figure 16 provides an illustration of the difficulty for winds of 20 and 30 knots. The solid line represents the theoretical relationship between significant wave height and fetch for those wind speeds. The dashed line represents the values which are actually computed from the spectral area when the given fetch and wind speed are specified in the usual JONSWAP formulation. The difference between the solid and dashed lines represents a rather noticeable increase in significant wave height for fetches above about 40 nautical miles.

Figures 17 and 18 from Reference 16 permit the determination of β for given values of significant wave height and modal wave period. The wave parameter ranges are deliberately broad in anticipation of extreme occurrences which may be hindcast for the North Sea. The height and period ranges were determined by examination of the data sets in Appendices C, D, and E.

Figures 19 and 20 provide sample modified JONSWAP spectra for significant wave heights of 2, 3, 5, and 7 m and a range of modal wave periods. As is the case with the Bretschneider formulation, Equation (5) can be applied without special regard to fetch or wind speed. However, as those values could be of interest in some seakeeping analyses, Figures 21 and 22 are included to provide a comparison with corresponding height and period ranges.

As with the usual JONSWAP formulation, the modified expression given in Equation (5) is for long-crested seas. While there is limited experimental verification, the cosine squared spreading function is recommended for use with the JONSWAP spectral formulation at this time.

TOTAL MARINE ENVIRONMENT

The overall mission effectiveness of a naval ship is dependent on the total natural environment that the ship encounters.* While the functional relationships between the ship (including all of its combat and support systems) and the natural environment are not completely understood, some consideration of these factors may be appropriate. While this document emphasizes wave and wind phenomena, it is recognized that other environmental occurrences may be equally important to the ship's performance. Table 5, adopted from Reference 17, identifies a number of natural environment parameters that may impact performance of certain missions. In recognition of this, a summary table providing data for many of these parameters is given in Appendices A to E. The data, developed for annual occurrences, provides ranges of values expected for each parameter and is described in detail in Appendix F.

Figures 23 to 26, adopted from Reference 18, provide seasonal (February, May, August, and November) variations of surface currents (directional and speed) throughout the NATO operational areas. Limits of ice coverage are also indicated for more northerly latitudes.

EXTREME SEAS

The recommendations for the use of various wave spectral formulations generally reflect moderate to heavy weather operations (e.g., up to Sea State 6). Most naval missions to which this report is directed will be conducted in no more severe conditions than these. However, the occasion may arise when extreme conditions should be considered, particularly in the context of mobility mission requirements in the open ocean North Atlantic. For this case it is not clear whether the available Bretschneider or the JONSWAP spectral formulations are more appropriate. While Bretschneider spectra appear to be too broad (against frequency) and of insufficient peak definition, the JONSWAP formulation has not yet been well established as a model for extreme seas, particularly in the open ocean. What is more certain is that the directionality model associated with extreme seas should represent multi-directional, confused seas, see Reference 19. Future investigations will perhaps identify the more appropriate spectral formulation.

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*Of course, it is also dependent on the man-made threat environment which is present.

ACKNOWLEDGMENTS

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Figure 1 - Generic Naval Operational

Areas for NATO Forces

N A T O   U N C L A S S I F I E D

Figure 2 - Definition of Representative Areas in the North Atlantic Basin

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16
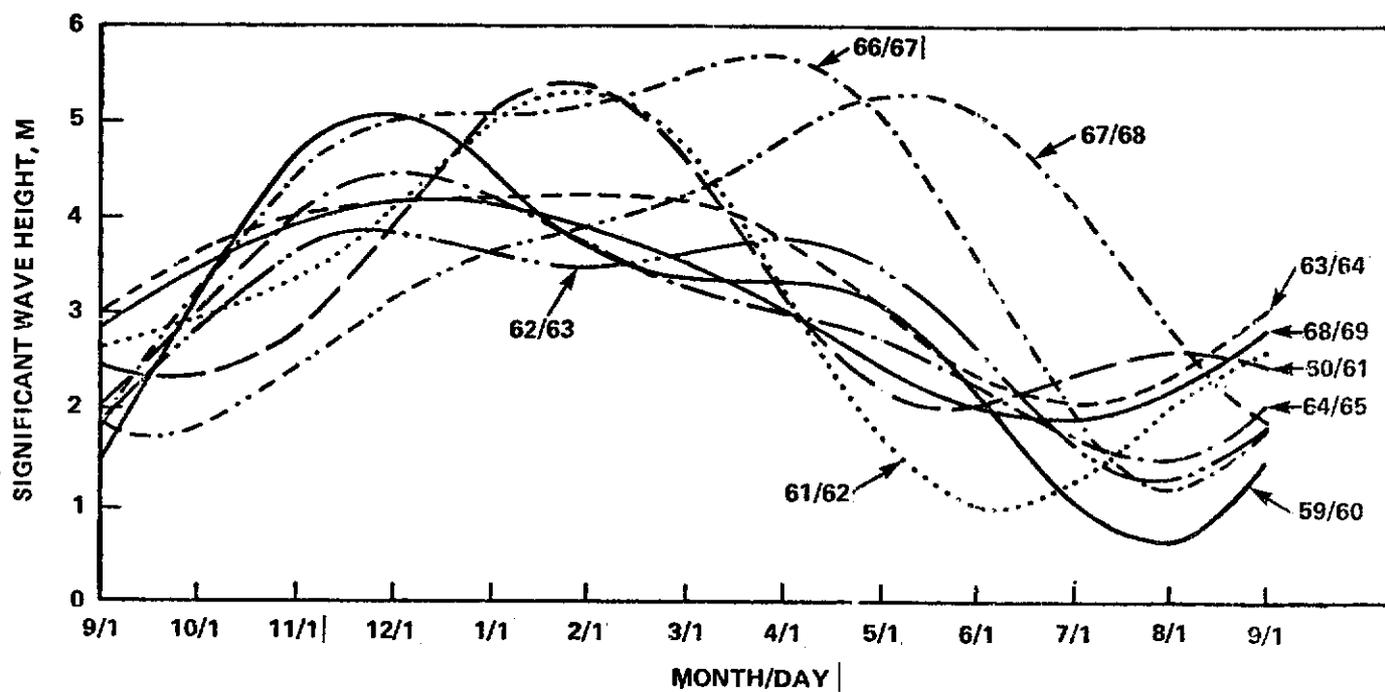
Figure 3 - Seasonal Variation of Significant Wave Height at
Grid Point 127, Area 2, for Years 1959/60
to 1968/69 (Reference 2)
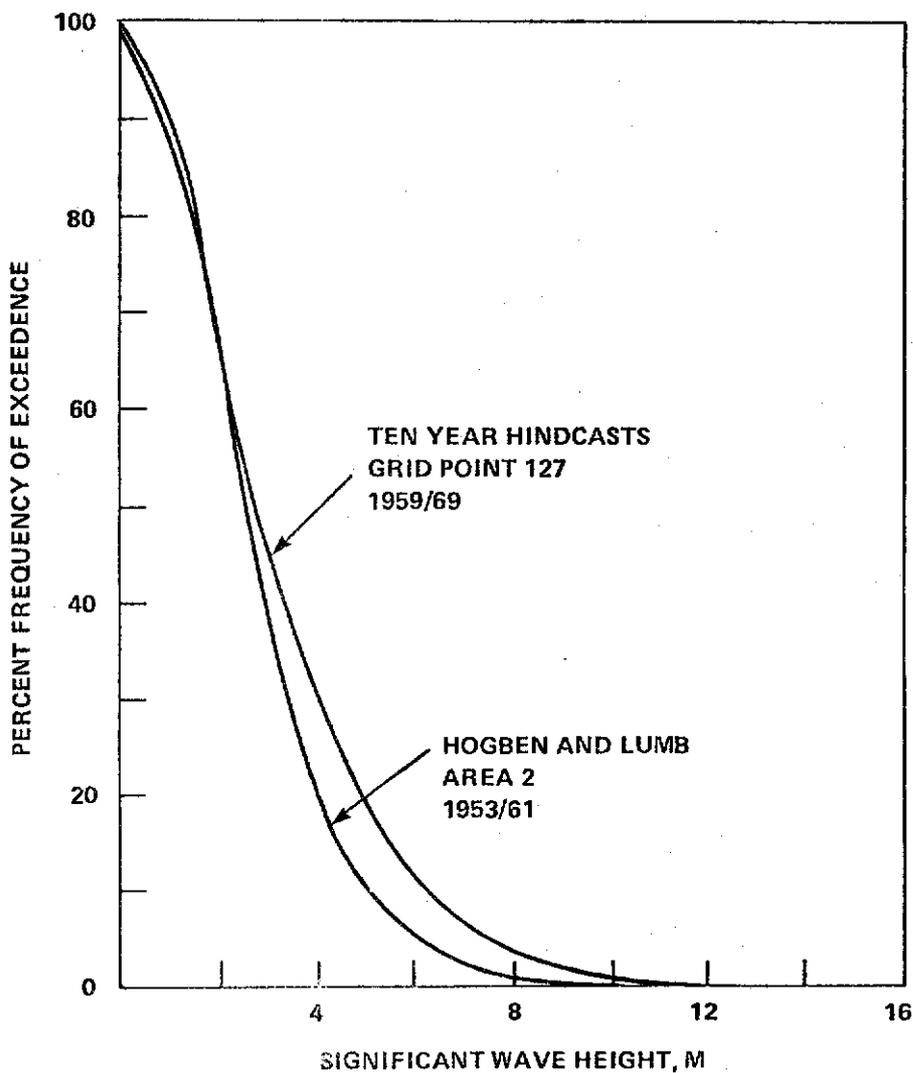
Figure 4 - Comparison of Hindcast and Observed Wave Height
Occurrences (Reference 2)

Figure 5 - Comparison of Hindcast and Observed Modal Periods, Given Height, for the North Atlantic Basin (Reference 2)

N A T O   U N C L A S S I F I E D
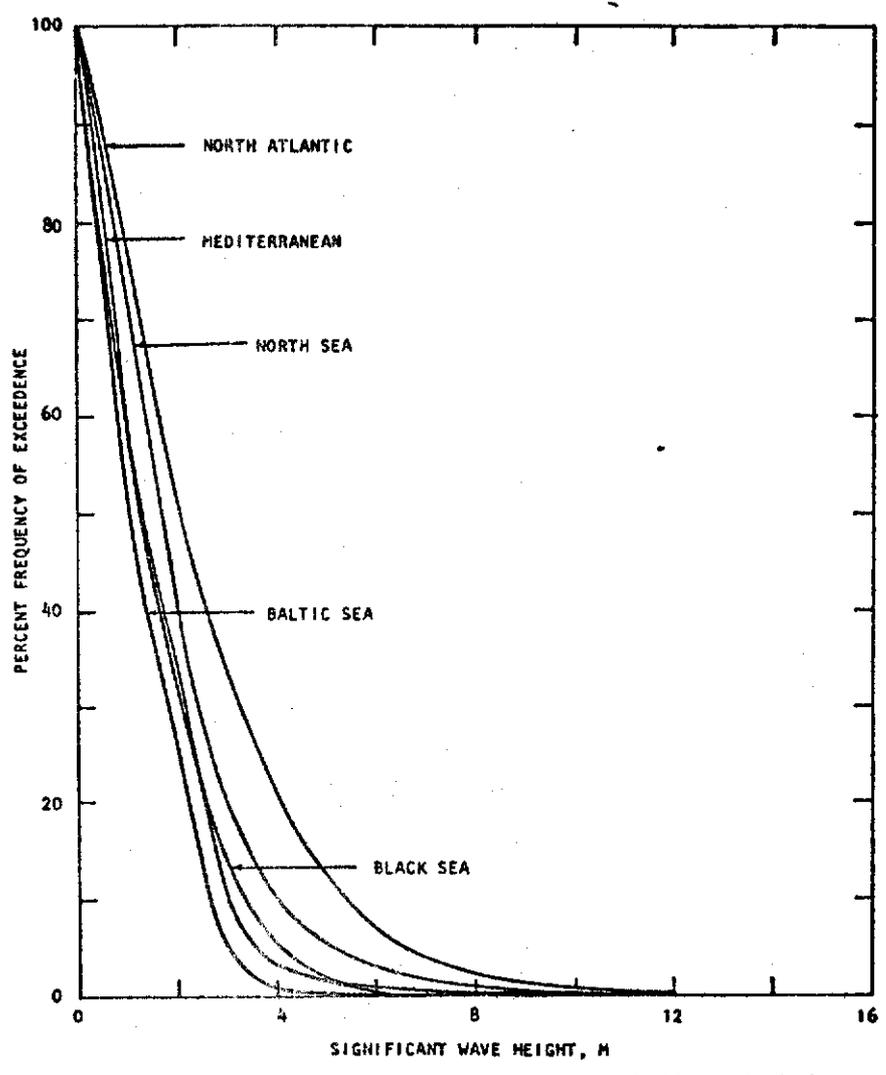
Figure 6 - Comparison of Annual Wave Height
Exceedences of All Locations
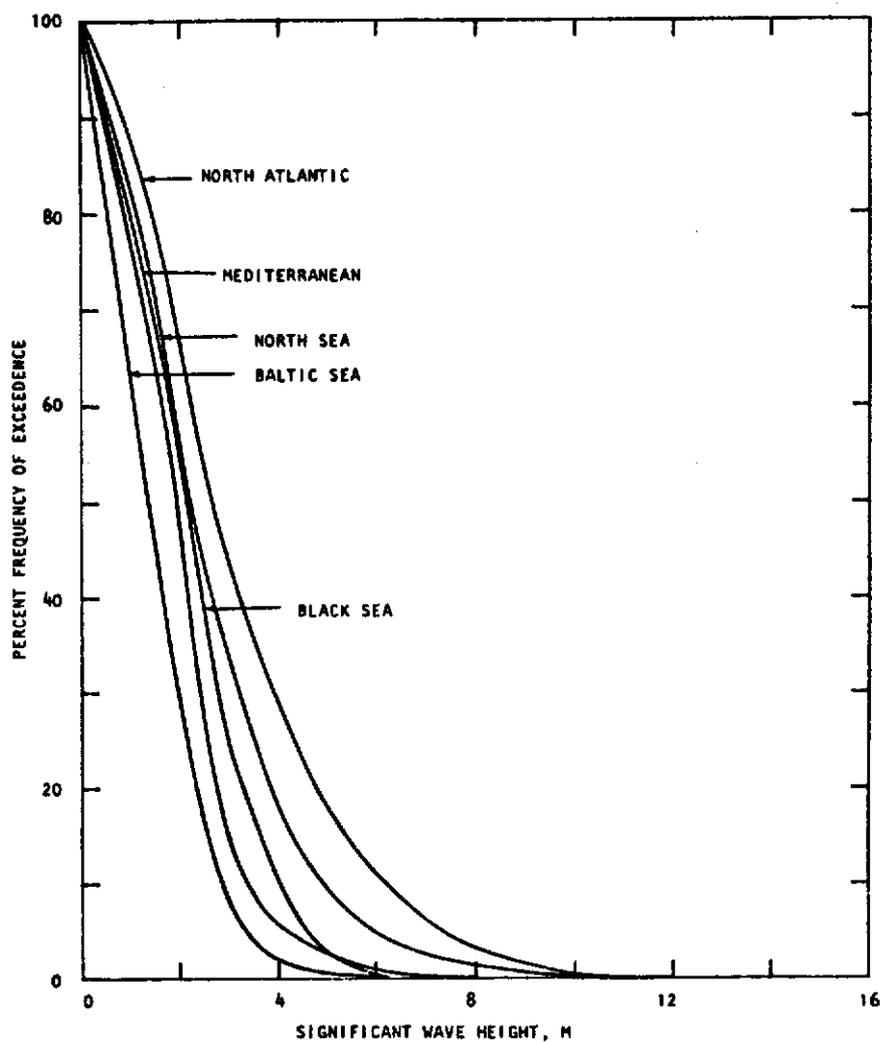
Figure 7 - Comparison of Worst Season Wave
Height Exceedences of All Locations
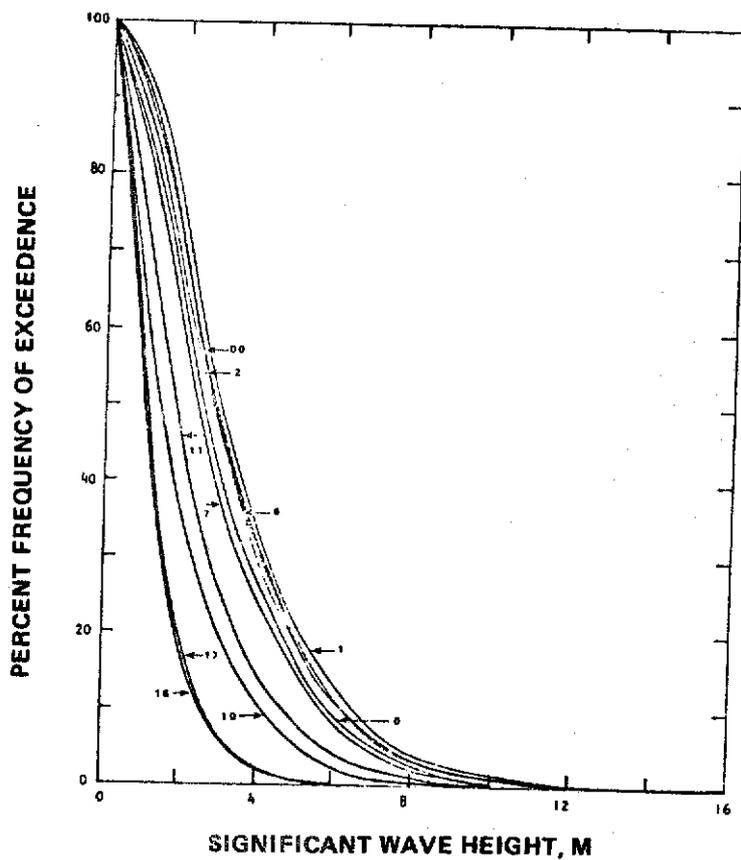
Figure 8 - Annual Significant Wave Height Exceedences
Hindcast for Selected North Atlantic Points
Defined on Table 2 for 1959 to 1969

SIGNIFICANT WAVE HEIGHT, M

Figure 9 - Worst Season Significant Wave Height Exceedences
Hindcast for Selected North Atlantic Points Defined
on Table 2 for 1959 to 1969

Figure 10 - Contours of 10 Meter or Greater Significant Wave
Height Occurrences During 1959 to 1969 (Reference 2)

Figure 11 - Bretschneider Two-Parameter Spectral Family

Figure 12 - Comparison of Roll Motion for Long- and
Short-Crested Seas (Reference 7)

N A T O   U N C L A S S I F I E D

Figure 13 - Definition of Representative Areas in the Mediterranean Sea

27

Figure 14 - Definition of Representative Areas in the
Baltic Sea (Including Gulf of Bothnia)

Figure 15 - Definition of Representative Area in the Black Sea

29

Figure 16 – Comparisons of JONSWAP Theoretical and Actual Significant
Wave Height and Fetch Relationships (Reference 16)

Figure 17 – Determination of β for Modified JONSWAP Spectrum (Reference 16)

SIGNIFICANT WAVE HEIGHT, M

β

SIGNIFICANT WAVE HEIGHT, M

Figure 18 - Determination of Small β for Modified JONSWAP Spectrum (Reference 16)

Figure 19 – Typical Modified JONSWAP Spectra for Significant
Wave Height of 2 and 5 M (Reference 16)
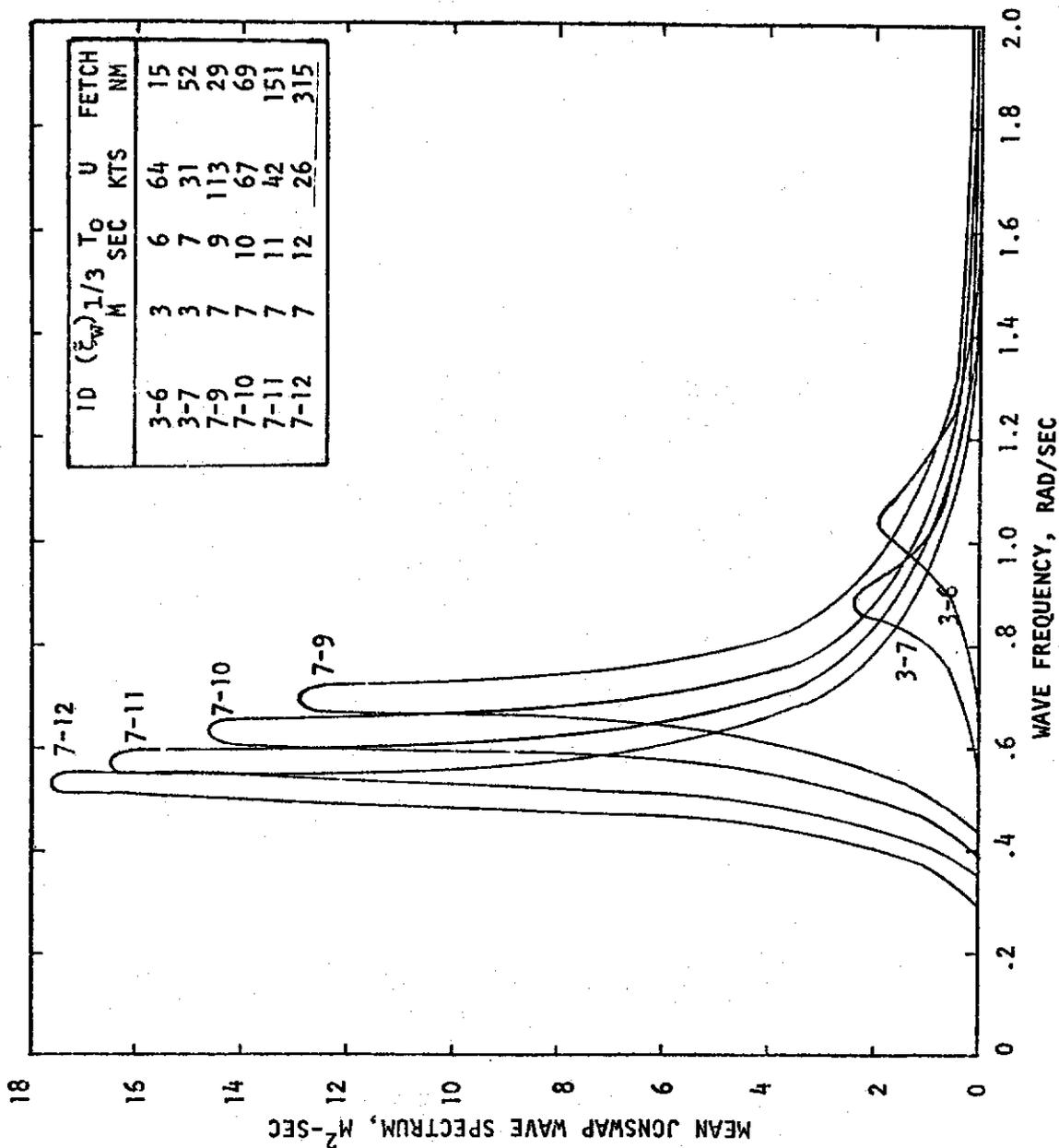
Figure 20 — Typical Modified JONSWAP Spectra for Significant
Wave Heights of 3 and 7 M (Reference 16)

34
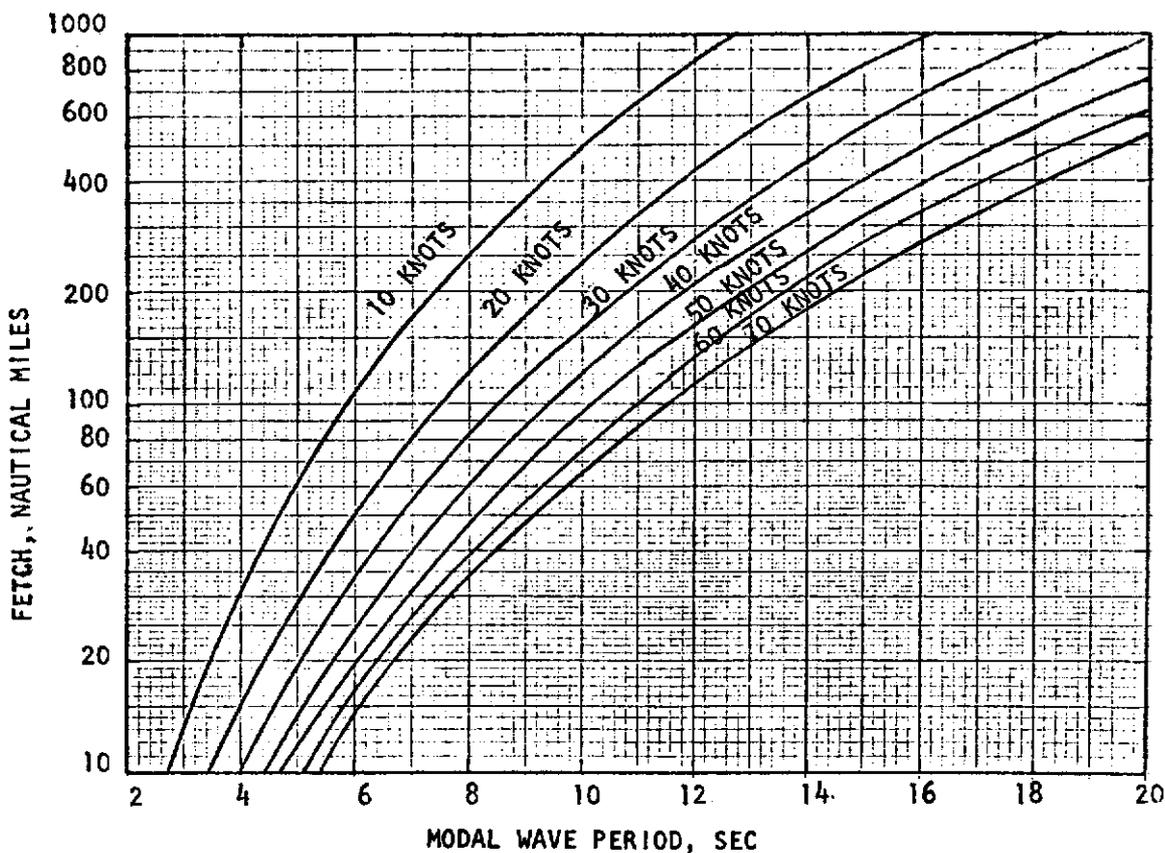
Figure 21 - Modified JONSWAP Spectral Relationships Between Modal
Wave Period, Fetch, and Wind Speed (Reference 16)
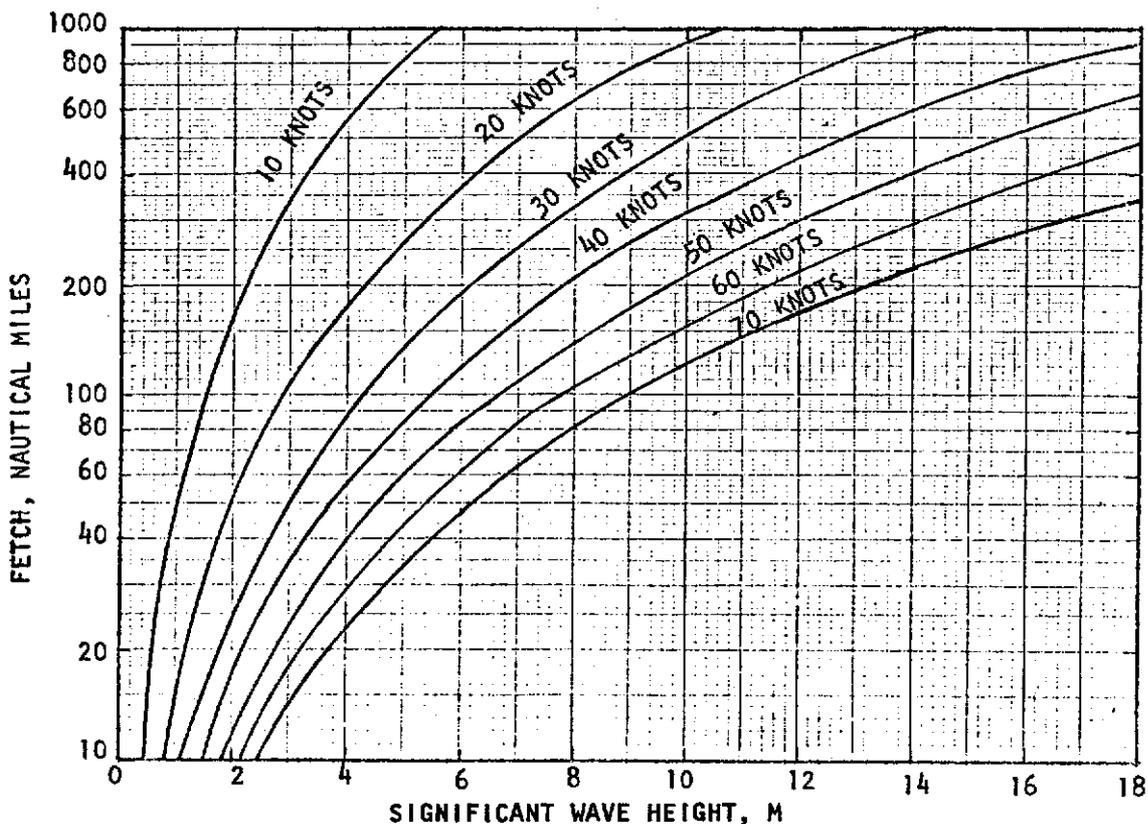
Figure 22 - Modified JONSWAP Spectral Relationships Between Significant
Wave Height, Fetch, and Wind Speed (Reference 16)
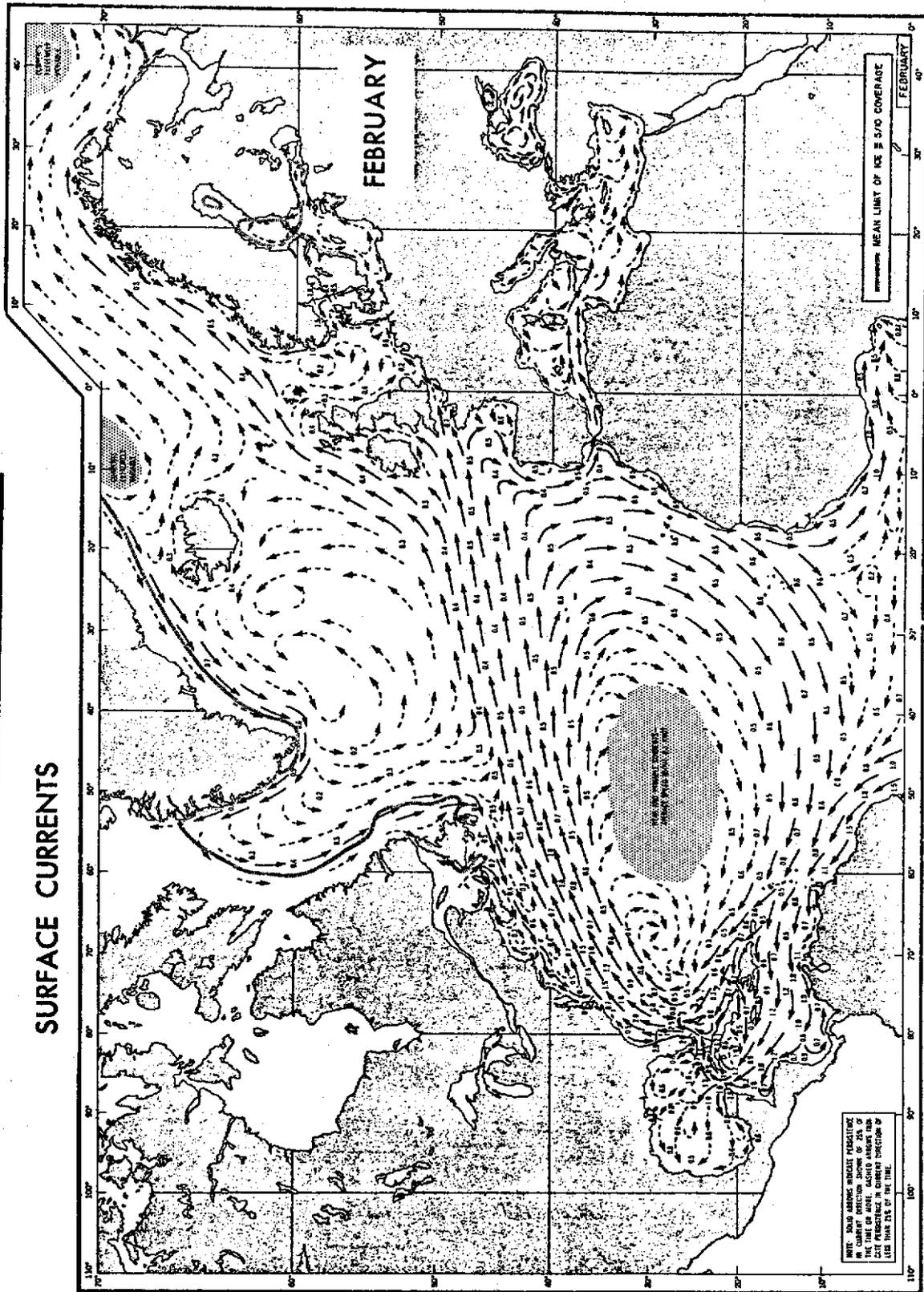
Figure 23 - Generalized Ocean Currents for the NATO Operational Areas for February (Reference 18)
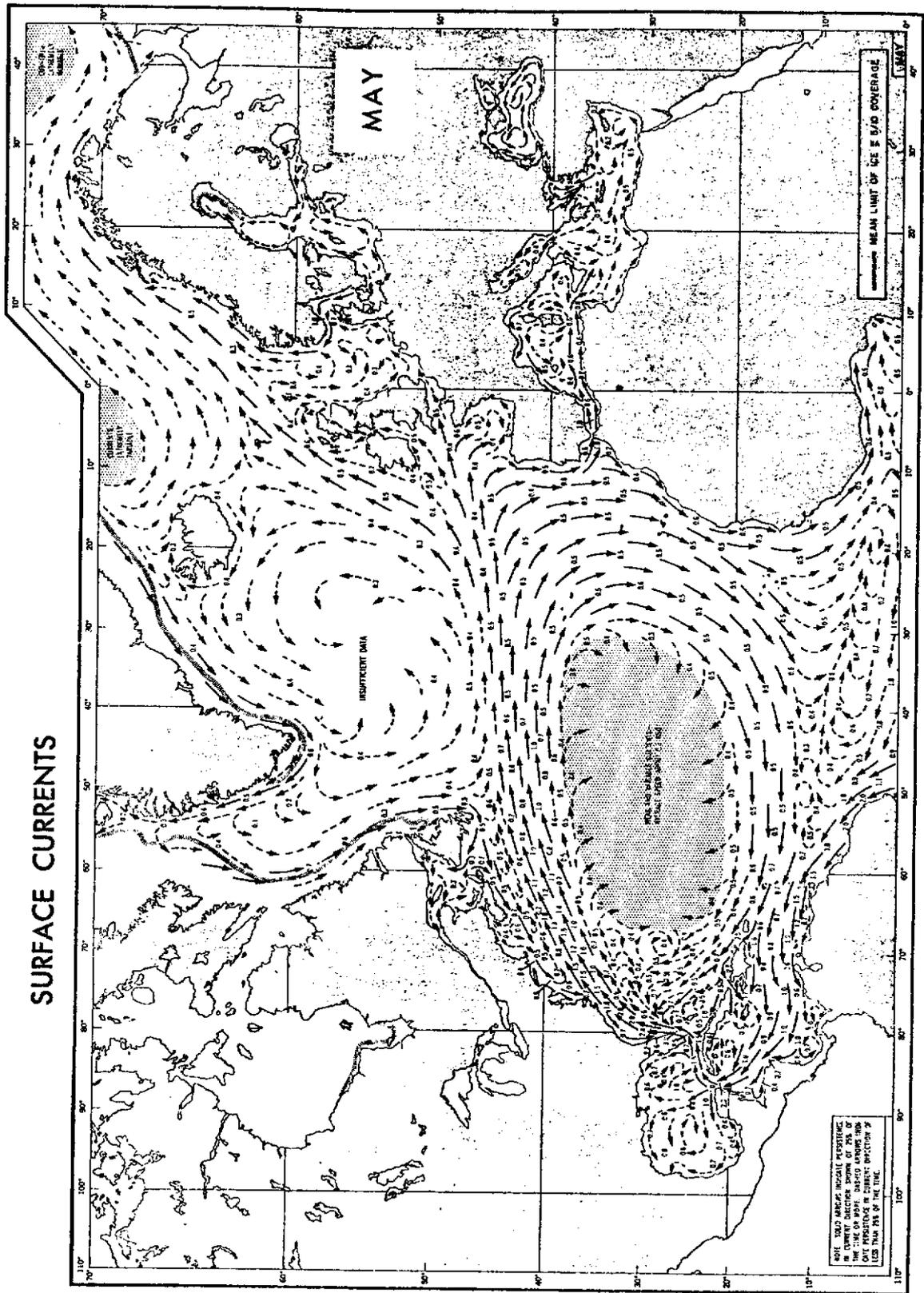
Figure 24 - Generalized Ocean Currents for the NATO Operational Areas for May (Reference 18)

37

SURFACE CURRENTS
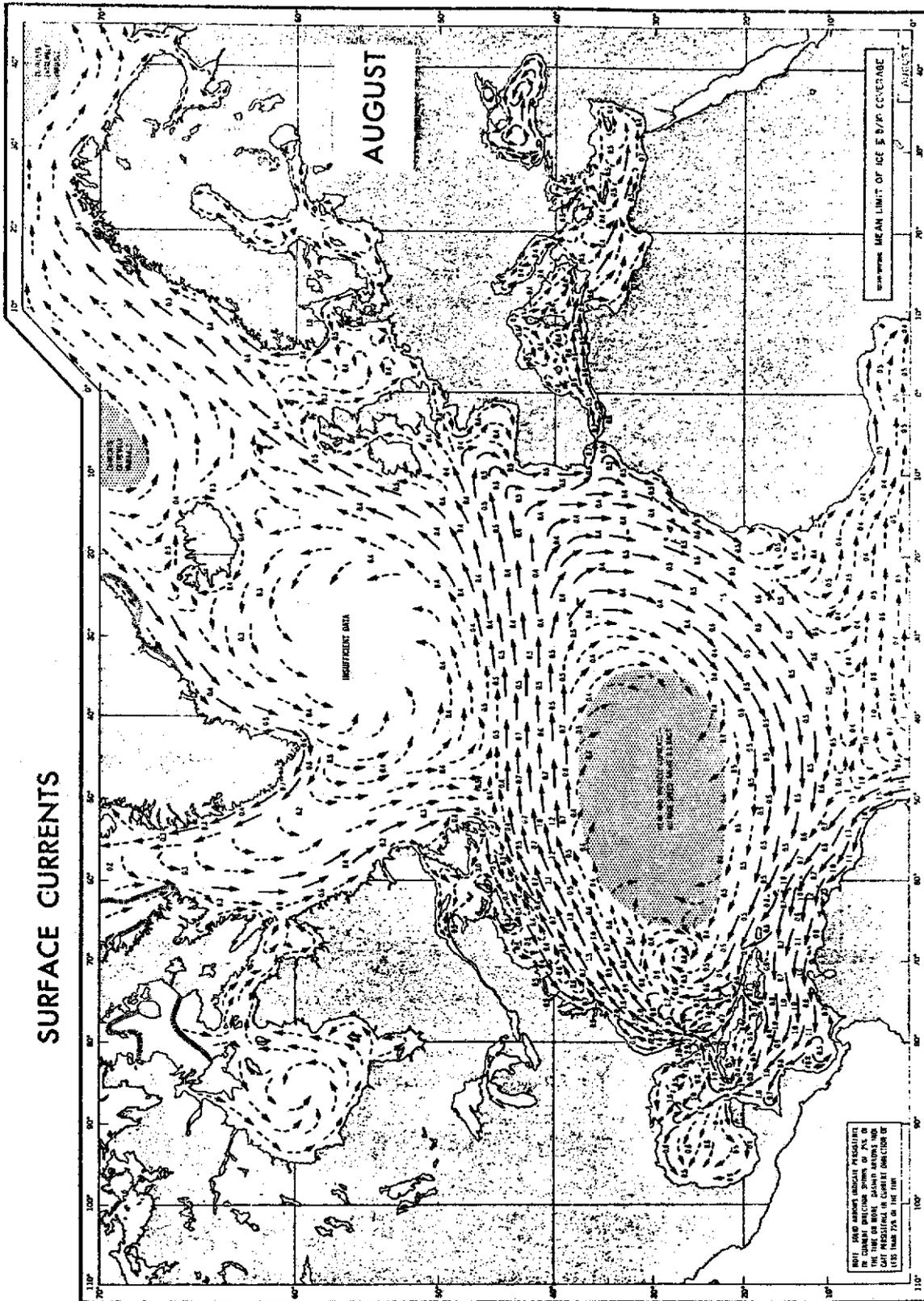
AUGUST

Figure 25 - Generalized Ocean Currents for the NATO Operational Areas for August (Reference 18)
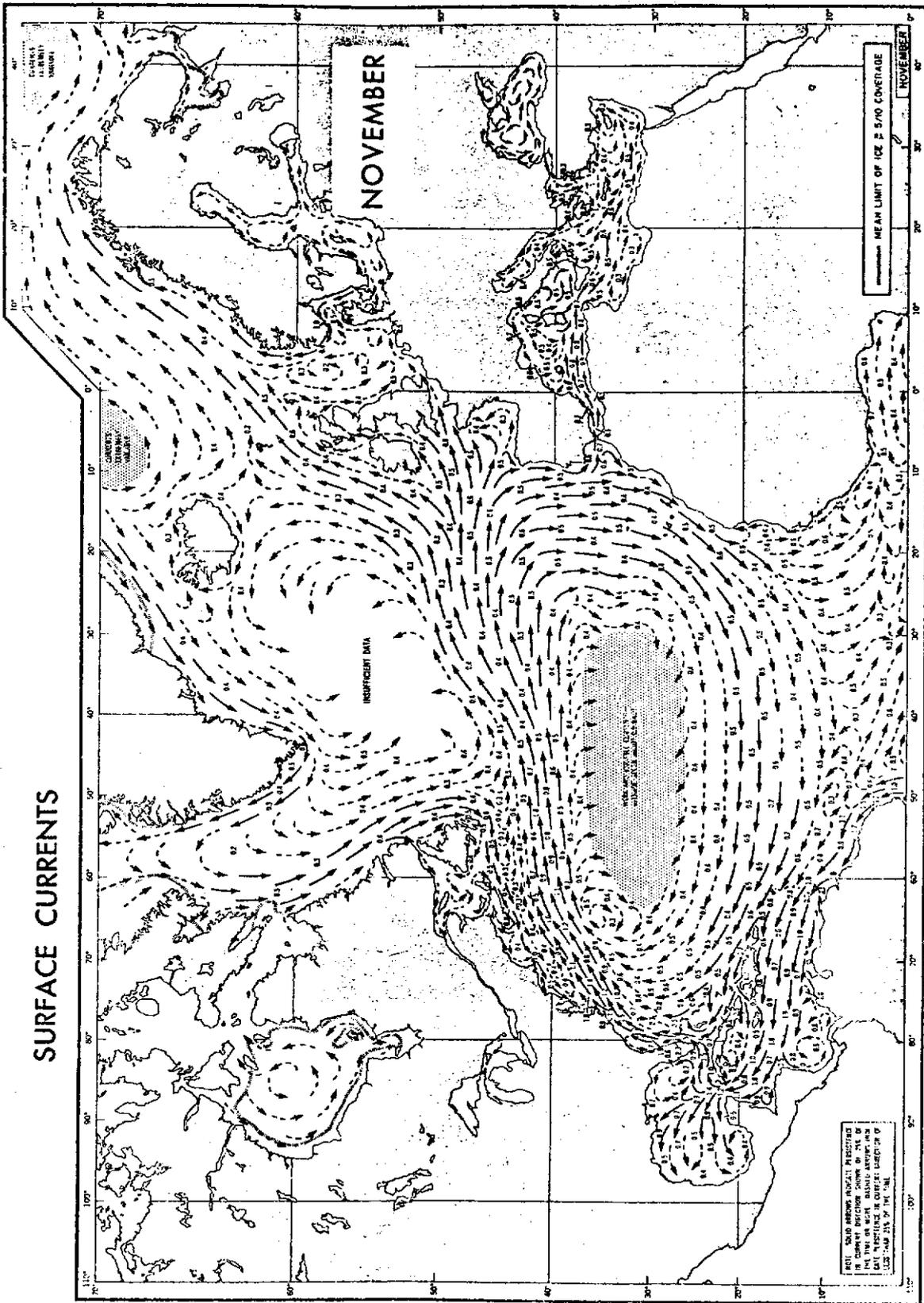
Figure 26 - Generalized Ocean Currents for the NATO Operational Areas for November (Reference 18)

39

TABLE 1 – TYPICAL HINDCAST DIRECTIONAL SPECTRUM (VARIANCES) (REFERENCE 2)

DATETIME: 9Z 31 MAR 68

LOCATION: 58.292N 12.297W

WIND DIR 267.6   WIND SPD 22.6   WHITE CPS .0   USTR .31

WIND DIRECTION AND SPEED, WHITECAP PERCENTAGE, FRICTIONAL WIND VELOCITY

VARIANCE ENERGY

WAVE FREQUENCY / FREQ	.308	.208	.158	.133	.117	.103	.092	.081	.072	.067	.061	.056	.050	.044	.039	DIR (FROM)
	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.1	6.58
	.0	.1	.2	.2	.2	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.7	336.58
	.1	.2	.3	.3	.3	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.3	306.58
	.1	.2	.4	.4	.6	.4	.3	.0	.0	.0	.0	.0	.0	.0	.0	2.3	276.58
	.1	.2	.3	.3	.4	.1	.2	.1	.0	.0	.0	.0	.0	.0	.0	1.6	246.58
	.0	.1	.2	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.7	216.58
POINT SPECTRUM	.2	.8	1.3	1.2	1.6	.8	.5	.2	.1	.0	.0	.0	.0	.0	.0	6.7	WAVE DIRECTIONS

TOTAL ENERGY

H1/3 10.35 FT (3.2 M)

SIGNIFICANT WAVE HEIGHT

40

TABLE 2 - LOCATIONS DEFINING NORTH ATLANTIC OCEAN AREAS IN CURRENT STUDY

NATO Area	Subprojection/GP	Latitude (° N)	Longitude (° W)
00	3/110	60.696	33.123
0	3/84	62.851	3.916
1	3/169	52.755	33.765
2	3/127	58.292	12.297
4	3/124	55.870	4.391E
6	2/279	46.191	44.891
7	3/216	45.199	21.648
10	2/228	34.097	52.857
11	3/244	39.912	21.794
16	2/224	29.748	66.526
17	2/182	26.694	48.502

TABLE 3 – MODAL WAVE PERIOD VALUES FOR SEAKEEPING PERFORMANCE ASSESSMENTS

f (SOWM) Hertz	T Seconds
.039	25.6
.044	22.7
.050	20.0
.056	17.8
.061	16.4
.067	14.9
.072	13.9
.081	12.3
.092	10.9
.103	9.7
.113	8.8
.117	8.5
.158	6.3
.208	4.9
.308	3.2

TABLE 4 - SAMPLE SPREADING WEIGHTS (α OF 15 DEGREES AND
ν OF 0 DEGREES) (REFERENCE 8)

W	ν*	90	75	60	45	30	15	0
	-90	0.000	—	—	—	—	—	—
	-75	0.011	0.000	—	—	—	—	—
	-60	0.042	0.019	0.000	—	—	—	—
	-45	0.083	0.069	0.037	0.000	—	—	—
	-30	0.125	0.131	0.125	0.083	0.000	—	—
	-15	0.156	0.181	0.213	0.250	0.250	0.000	0.000
WAVE ANGLES, ν	0 (μ)	0.167	0.200	0.250	0.333	0.500	1.000	1.000
	15	0.156	0.181	0.213	0.250	0.250	0.000	0.000
	30	0.125	0.131	0.125	0.083	0.000	—	—
	45	0.083	0.069	0.037	0.000	—	—	—
	60	0.042	0.019	0.000	—	—	—	—
	75	0.011	0.000	—	—	—	—	—
	90	0.000	—	—	—	—	—	—

TABLE 5 - NATURAL ENVIRONMENT VERSUS SHIP FUNCTION

	Mobility	Detection and Communication Systems (Radar, Sonar, Helo, etc.)	Defense (Weapons)	Ship Tactics*
Sea Surface Wave height, period, direction (currents)	X	X	X	X
Surface Winds Wind speed, direction	X	X	X	X
Visibility		X	X	X
Cloud Cover		X	X	X
Ceiling Height		X		X
Precipitation		X	X	X
Fog		X	X	X
Humidity		X	X	X
Temperature		X		X
Sea Level Pressure		X		X
Storm	X	X	X	X
Ice Concentration	X			X
Superstructure Icing	X	X	X	X
Refractivity Profile		X		X
Ducting		X		X
Ionospheric Data		X		X

*Nominally, ship tactical decisions can be influenced by any environmental parameter which impacts any ship function.

APPENDIX A
SEASONAL CLIMATOLOGY OF THE NORTH ATLANTIC OCEAN

The following data graphs are derived primarily from the Ten Year Hindcast Climatology, see Reference 2. Tables A-(0,00,1,2,4,6,7,10,11,16,17)-1-1 are developed from Reference 9.
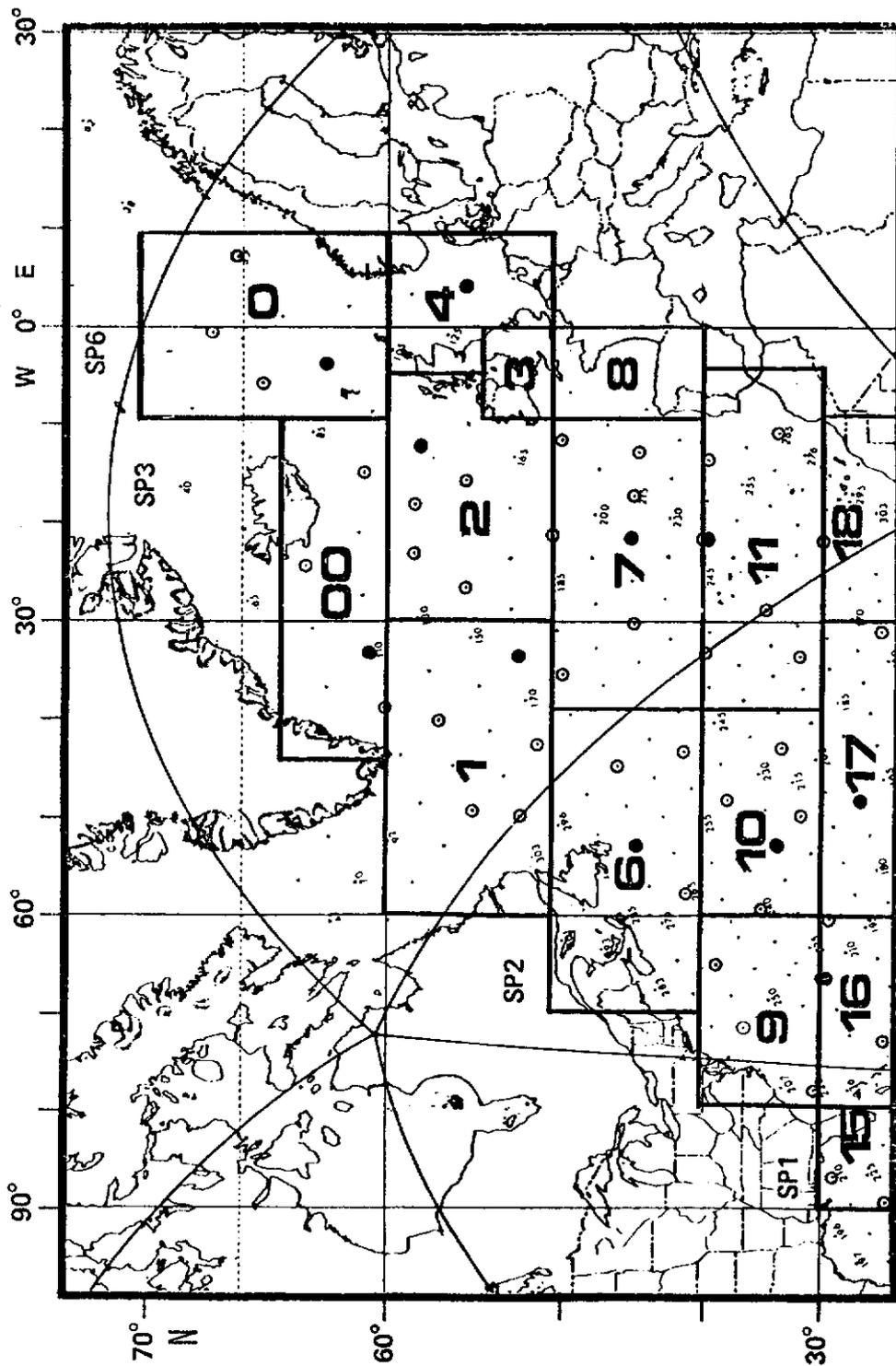
Figure A-1- Selection of Representative Areas in the
North Atlantic Basin
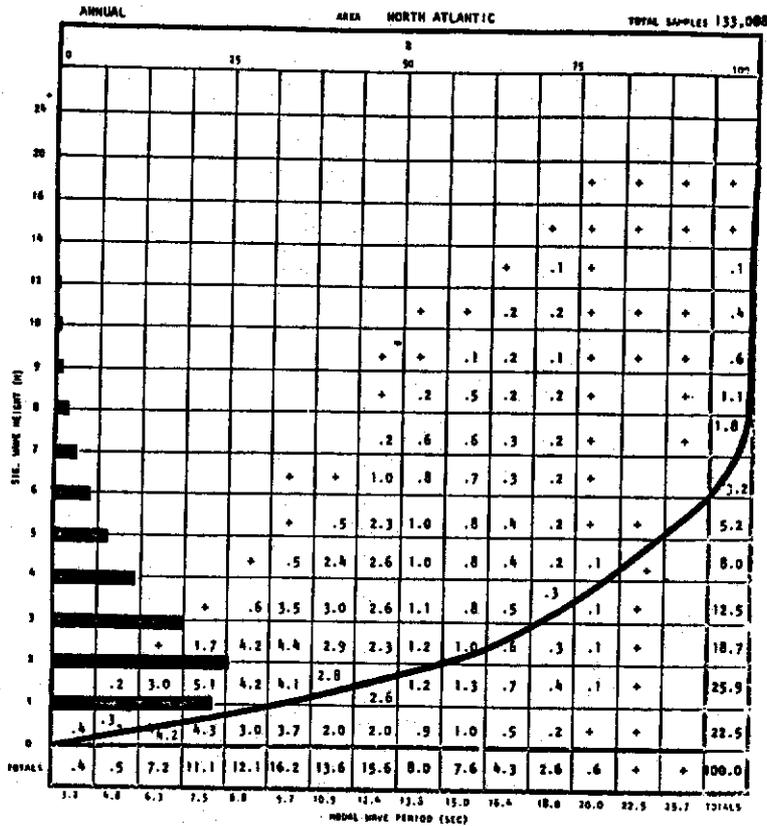
Figure A-2 Significant Wave Height
by Modal Wave Period
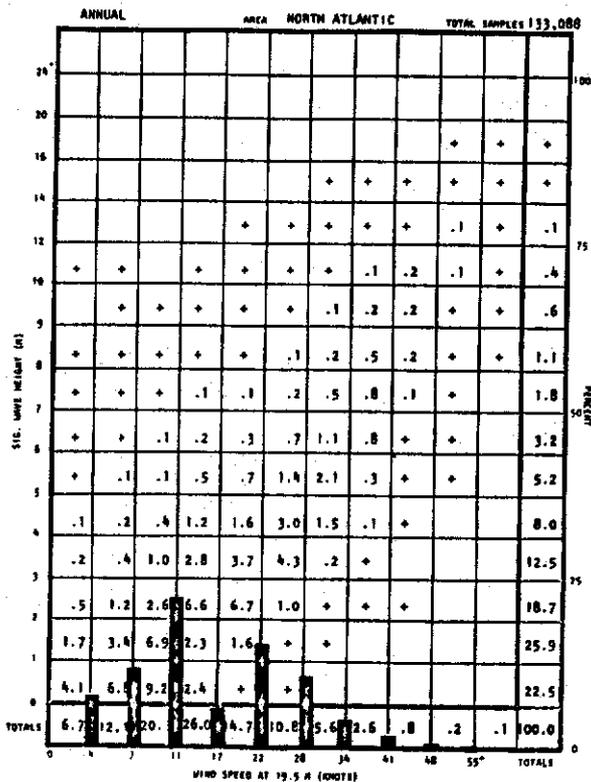
Figure A-3 Significant Wave
Height by Wind Speed
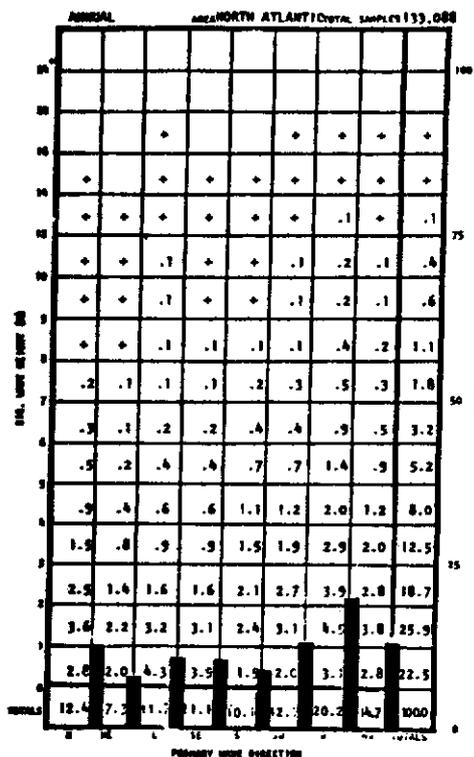
Figure A-4 Significant Wave
Height by Wave Direction
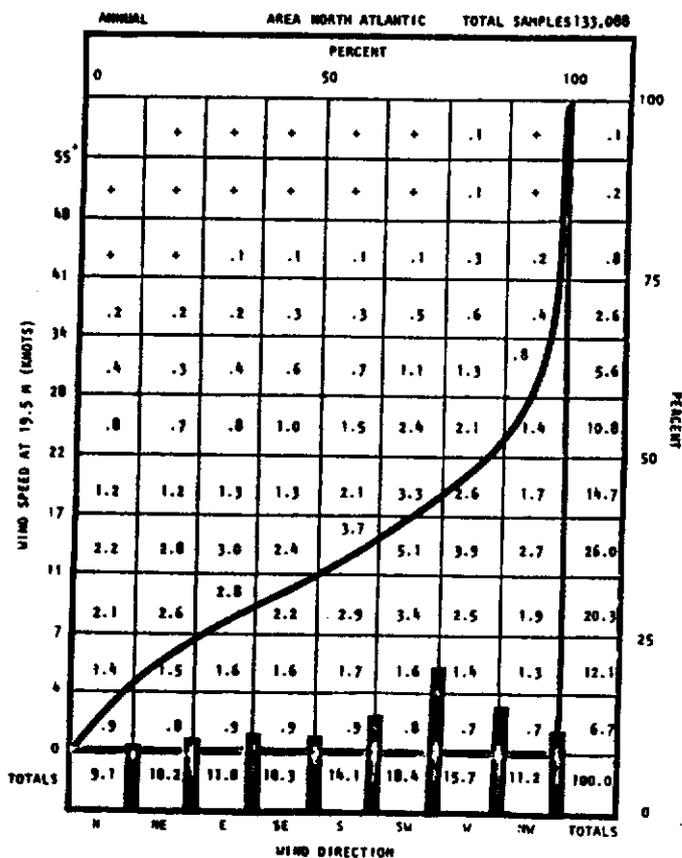
Figure A-5 Wind Speed by
Wind Direction
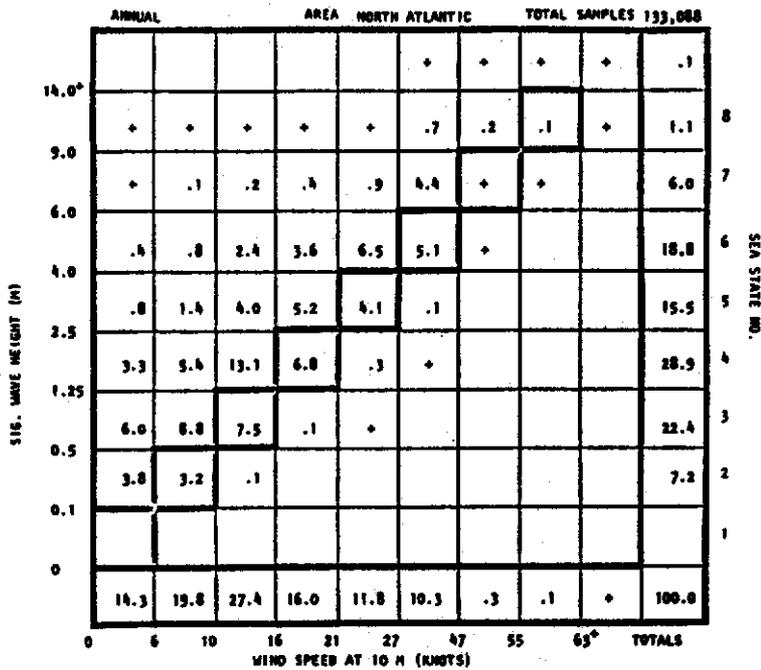
Figure A-6 Significant Wave Height by Wind Speed (WMO Sea State Chart)
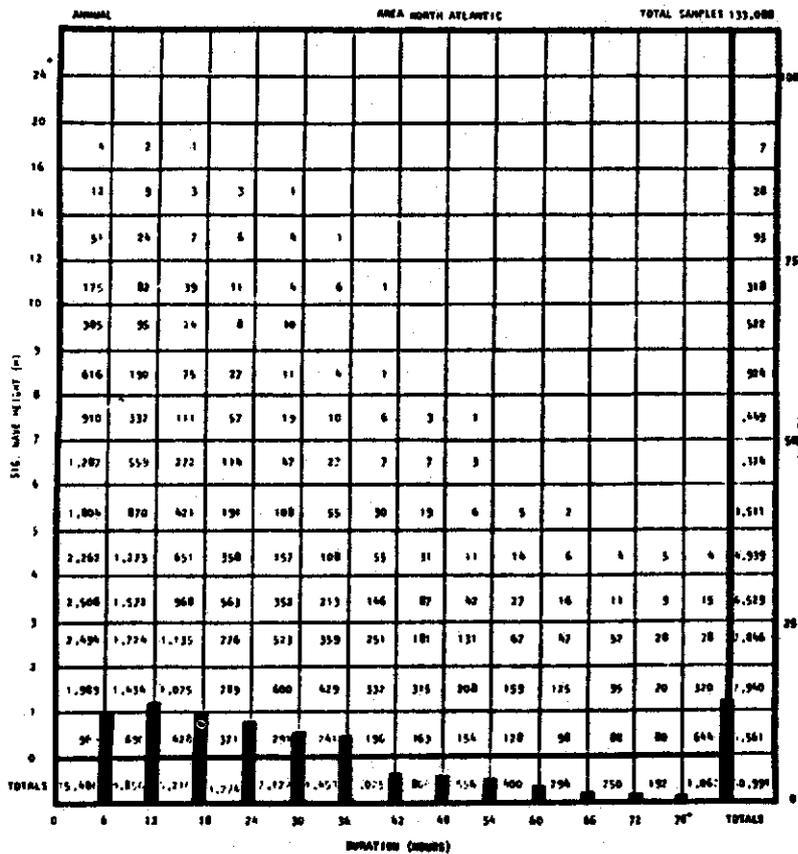
Figure A-7 Persistence of Significant Wave Height

ANNUAL   AREA   NORTH ATLANTIC   TOTAL SAMPLES 133,088

WIND SPEED AT 19.5M (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+	33	13	9	7	4									66
48	140	42	19	3	2	1								207
41	421	157	66	23	7	5	1			1				681
34	1119	510	202	77	39	14	8	2		1				1972
28	2329	966	415	201	77	39	22	13	5	2				4069
22	3849	1793	823	408	171	127	42	25	25	6	5	1	1	7278
17	5931	2403	1127	521	252	139	75	46	17	8	6	5	2	10534
11	6457	3356	1787	1016	609	388	242	136	113	76	39	31	27	14300
7	6945	2999	1388	716	423	262	128	102	54	29	22	20	8	13105
4	515	2101	887	408	189	129	47	32	19	9	4	4	2	9035
0	246	98	484	245	140	87	45	23	23	17	12	7	6	4546
TOTALS	3488	15324	7207	3625	1913	1191	610	379	256	148	89	68	46	65793

DURATION (HOURS)

Figure A-8 Persistence of
Wind Speed
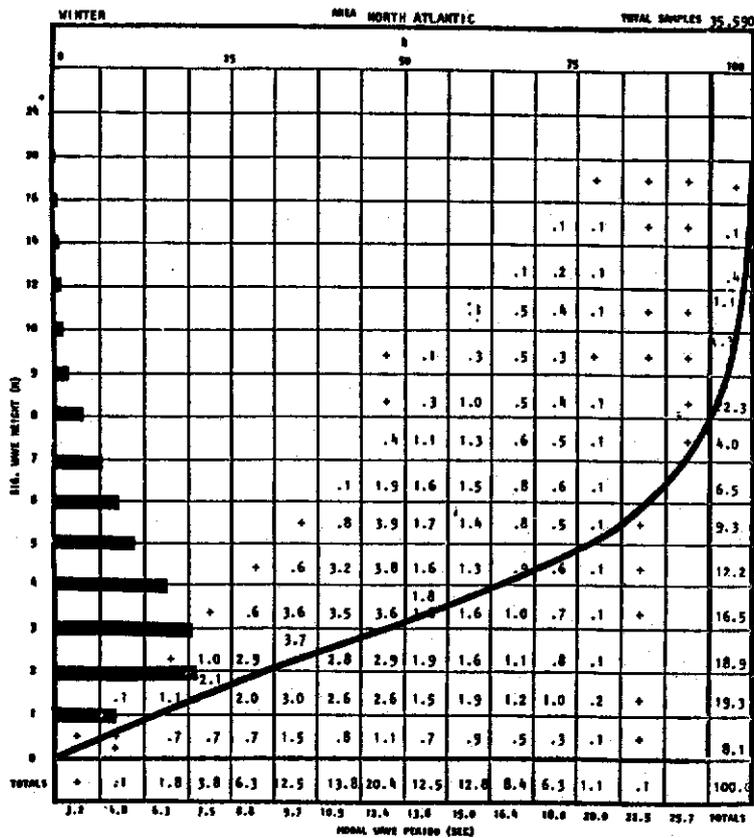
Figure A-9 Significant Wave Height
by Modal Wave Period
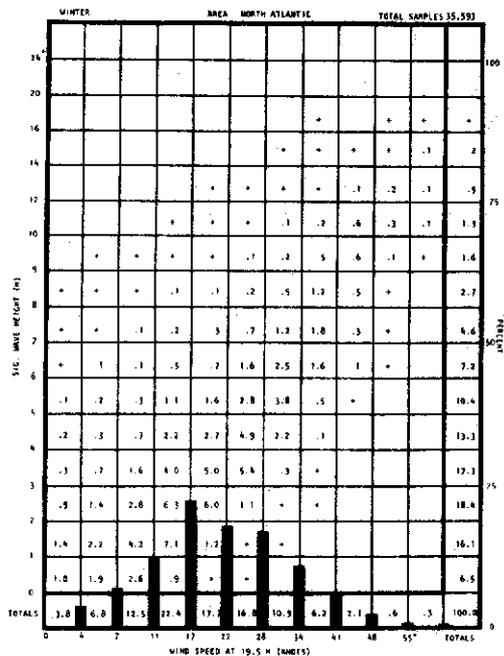
Figure A-10 Significant Wave
Height by Wind Speed

AREA NORTH ATLANTIC   TOTAL SAMPLES 35,590

SIG. WAVE HEIGHT (M)

	N	NE	E	SE	S	SW	W	NW	Totals
			+				+	+	+
		+	+	+	+	.1	+	.1
	+	+	.1	+		.2	.1	.4
	+	+	.1		.1	.1	.4	.2	1.1
	+	+	.2	.1	.1	.2	.4	.3	1.1
	.2	+	.2	.2	.2	.1	.8		2.3
	.4	.2	.3	.3	.1	.5	1.1	.7	4.0
	.5	.3	.6	.6	.9	.9	1.6	1.0	6.5
	.9	.4	.8	.9	1.2	1.4	2.2	1.4	9.3
	1.5	.7	.9	1.1	1.7	1.8	2.6	1.8	12.2
	2.2	1.3	1.5	1.3	1.9	2.4	3.3	2.6	16.5
	3.2	1.8	1.9	1.7	1.7	2.3	3.2	3.1	18.9
	3.5	1.7	2.3	2.4	1.3	1.9	2.5	3.7	9.3
	1.5	.9	.0	.3	.4	.5		.4	9.1
TOTALS	13.5	7.5	10.0	10.1	10.4	12.4	19.4	16.7	100.0

PRIMARY WAVE DIRECTION

Figure A-11 Significant Wave Height by Wave Direction

WINTER   AREA NORTH ATLANTIC   TOTAL SAMPLES 35,590

PERCENT

WIND SPEED AT 19.5 M (KNOTS)

	N	NE	E	SE	S	SW	W	NW	TOTALS
55+		+	+	+	+	+	.2	+	.3
48	+	+	.1			.1	.2	.1	.5
41	.1	.1	.2	.3	.2	.2	.5	.3	1.8
34	.3	.3	.4	.7	.7	.5	1.2	.6	5.3
28	.7	.6	.8	1.1	1.3	1.9	2.0	1.1	9.7
22	1.0	.9	1.4	1.5	2.1	3.4	2.9	1.8	15.0
17	1.3	1.6	1.5	1.4	2.4	3.6	2.9	1.9	16.7
11	2.1	2.6	2.6	2.1	3.2	4.5	3.6	2.7	23.4
7	1.8	2.0	1.8	1.6	1.8	2.1	1.8	1.7	14.6
4	1.0	1.1	1.0	1.0	1.1	1.0	.9	1.0	8.1
0	.7	.5	.5	.6	.6	.5	.5	.5	4.5
TOTALS	9.1	9.7	10.3	10.3	13.6	18.3	16.8	11.8	100.0

WIND DIRECTION

Figure A-12 Wind Speed by Wind Direction

AREA NORTH ATLANTIC   TOTAL SAMPLES 35.590

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+						+	+	.1	.1	.2	
9.0		+	+	+	.1	1.8	.6	.2	+	2.7	8
6.0	.1	.2	.6	.9	1.9	9.0	.1			12.8	7
4.0	.8	1.5	4.2	5.5	9.4	7.8				29.2	6
2.5	1.3	1.9	5.0	5.8	4.1	.1				18.2	5
1.25	3.3	5.1	10.3	5.2	.3	+				24.2	4
0.5	3.5	4.6	3.4	.1	+					11.6	3
0.1	.6	.4	+							1.0	2
0											1
TOTALS	9.5	13.8	23.5	17.6	15.8	18.8	.7	.2	.1	100.0	

WIND SPEED AT 10 M (KNOTS)

Figure A-13 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-0-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 62.851° N, 3.916° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	3	7	3	2
Wave Period, sec	6	10	16.5	11.5	9.5
Direction	-	-	-	-	SW - W - N
Winds					
Speed, knots	4	15	33	16	14
Corresponding Mean Sig. Wave Height, m.	1	2.5	6.5	2.5	2.5
Direction	-	-	-	-	S - SW
Visibility, nautical miles	2	10	25	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	1	7	8	-	-
Low clouds, in eighths of sky obscured	1	6	8	-	-
Precipitation (Occurrence)	All precipitation - 22% of the time		Snow - 9% of the time (Dec - Mar)		
Relative Humidity, %	64	84	97	-	-
Air Temperature, °C	3.5	8	12.5	8	-
Surface Water Temperature, °C	6.5	9	12	-	-
Sea Level Pressure, millibars	993	1,008	1,028	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	319	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	None

Figure A-0-1-1 Significant Wave
Height by Modal Wave Period

Figure A-0-1-2 Significant Wave
Height by Wind Speed
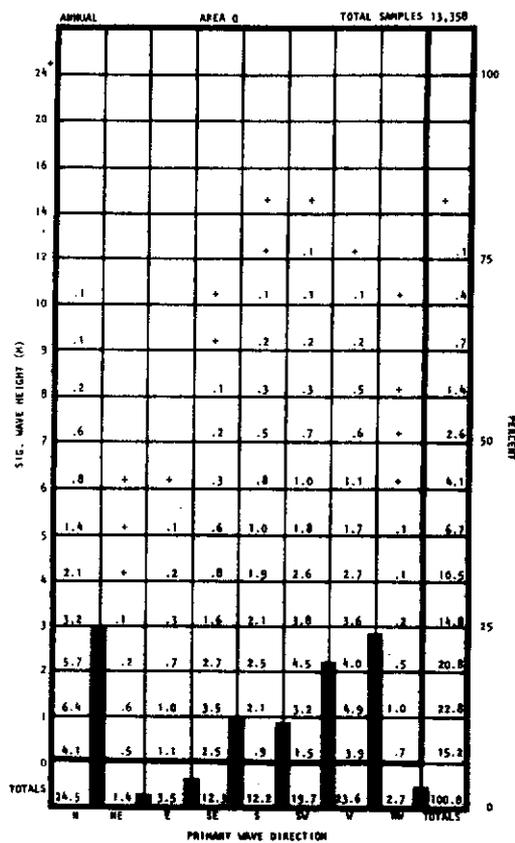
Figure A-0-1-3 Significant Wave
Height by Wave Direction
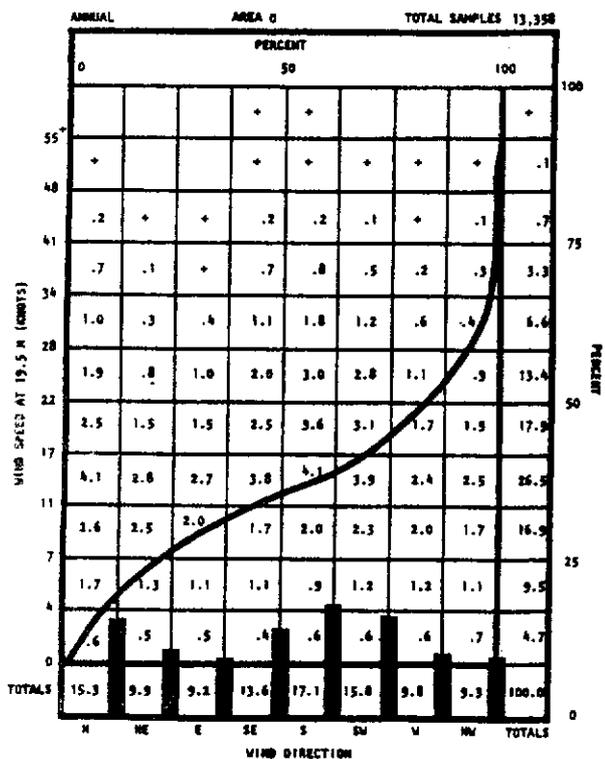
Figure A-0-1-4 Wind Speed by
Wind Direction

ANNUAL   AREA 0   TOTAL SAMPLES 13,358

SIG. WAVE HEIGHT (M) — SEA STATE NO.

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+						+		+		+	
9.0	+	+	+	+	.1	.8	.1	+		1.1	8
6.0	+	.1	.3	.6	1.1	5.6	+			7.7	7
4.0	.5	.9	3.1	4.8	8.3	5.9				23.5	6
2.5	.8	1.5	4.5	6.1	4.6	+				17.6	5
1.25	2.9	5.1	13.1	7.2	.2					20.6	4
0.5	4.4	6.6	6.2	.1						17.3	3
0.1	2.0	2.2	.1							4.2	2
0											1
TOTALS	10.7	16.4	27.4	18.8	14.2	12.3	.2	+		100.0	

WIND SPEED AT 10 M (KNOTS)
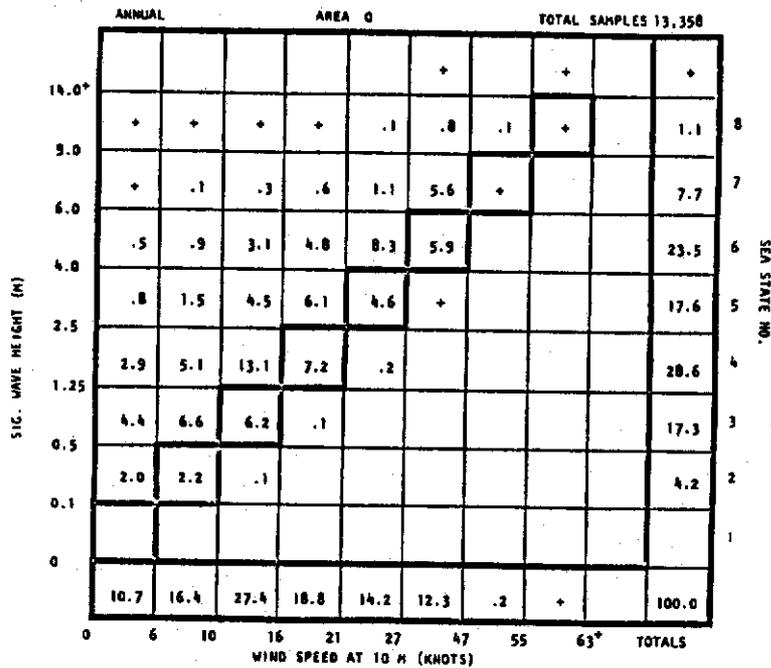
Figure A-0-1-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

ANNUAL   AREA 0   TOTAL SAMPLES 13,358

SIG. WAVE HEIGHT (M) — DURATION (HOURS) — PERCENT

SIG. WAVE HEIGHT (M)	6	12	18	24	30	36	42	48	54	60	66	72	78	TOTALS
24														
20														
16														
14		2												2
12	3	2	2											7
10	20	10	5											35
9	48	12	1	3										64
8	84	27	8	2	1	1	1							124
7	113	63	17	6	3		1							203
6	160	83	34	15	1	3	2	2						298
5	211	112	54	23	15	7	4	5	1	1				435
4	266	153	86	46	27	18	4	4	1	4		3	1	2	613
3	264	148	127	59	34	21	20	14	10		4		6	3	710
2	239	175	107	96	45	43	28	22	20	6	6	3	5	14	810
1	151	101	113	84	59	47	37	34	17	11	9	9	2	20	694
0	50	49	43	29	24	14	25	15	17	8	1	8	10	28	328
TOTALS	1609	939	599	362	206	154	124	96	66	30	27	28	24	67	4331

DURATION (HOURS)

Figure A-0-1-6 Persistence of Significant Wave Height

ANNUAL   AREA 0   TOTAL SAMPLES 13,753

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

(knots)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+			1											1
48	10	1	1											12
41	38	14	6		2	1								61
34	108	65	23	14	6	3	2							221
28	275	137	42	25	7	8	4							458
22	465	238	99	62	11	13	5	5	6	1			1	906
17	678	306	145	75	30	19	4	3	3	2	1		2	1268
11	654	406	182	113	59	29	15	10	8	7	2	6	7	3	1541
7	726	281	115	79	29	11	6	7	2	2	1		2	1	1262
4	473	174	63	30	11	7	2	2						762
0	222	67	34	24	6	4	1			1				359
TOTALS	3685	1689	711	422	161	95	39	27	20	12	4	6	9	7	6891

DURATION (HOURS)
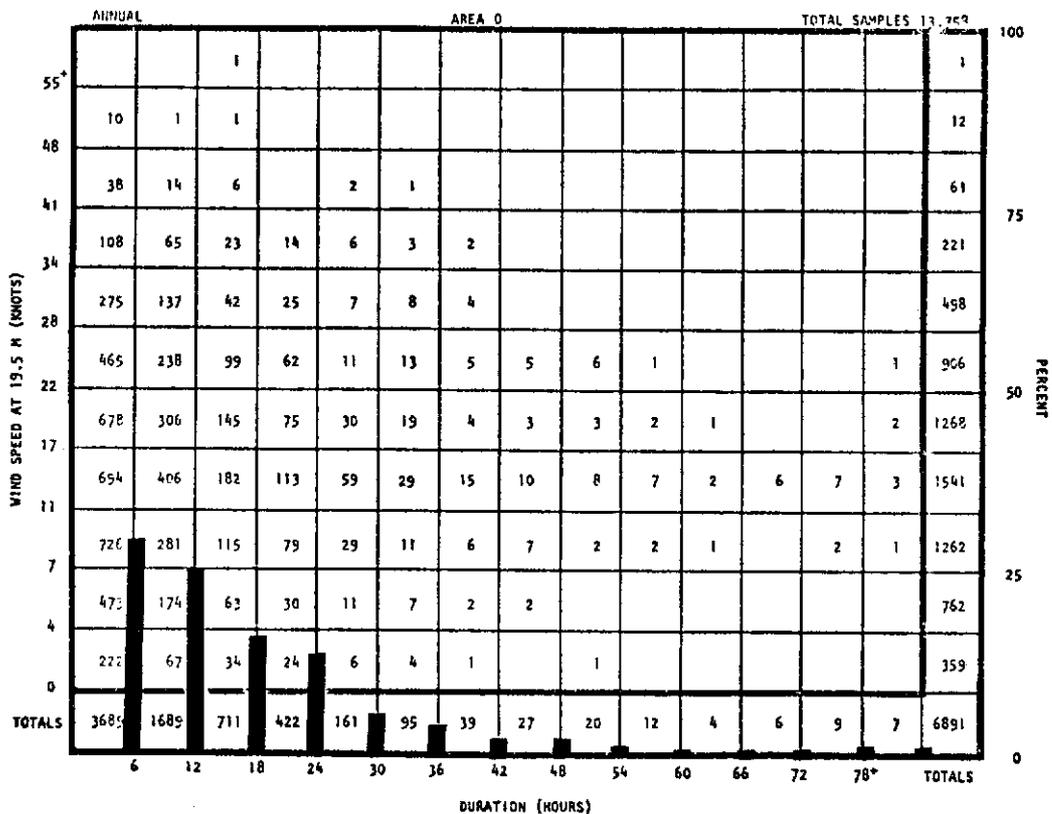
Figure A-0-1-7 Persistence of
Wind Speed
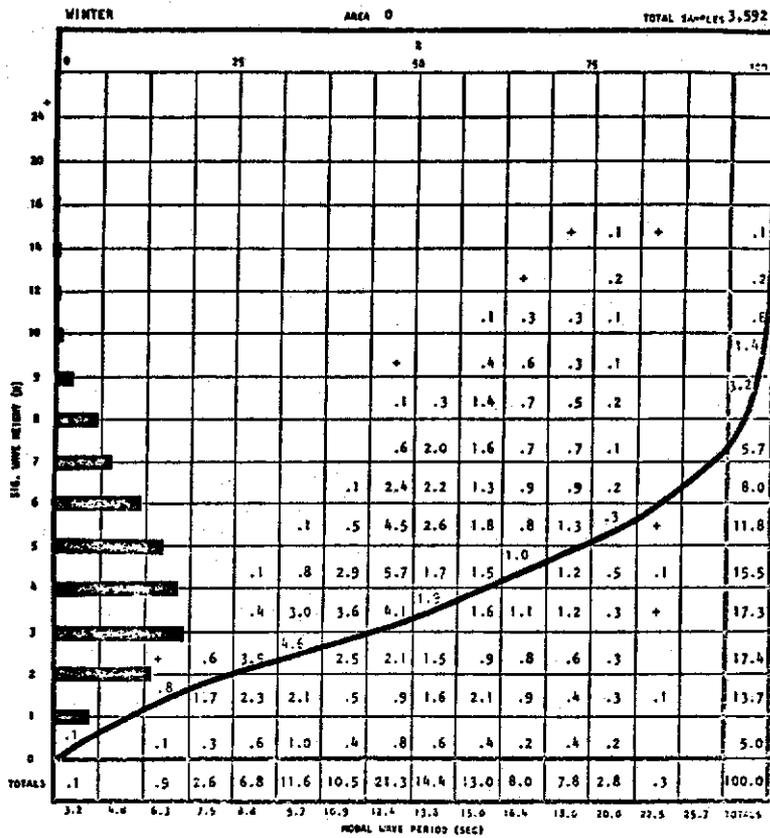
Figure A-0-2-1 Significant Wave
Height by Modal Wave Period
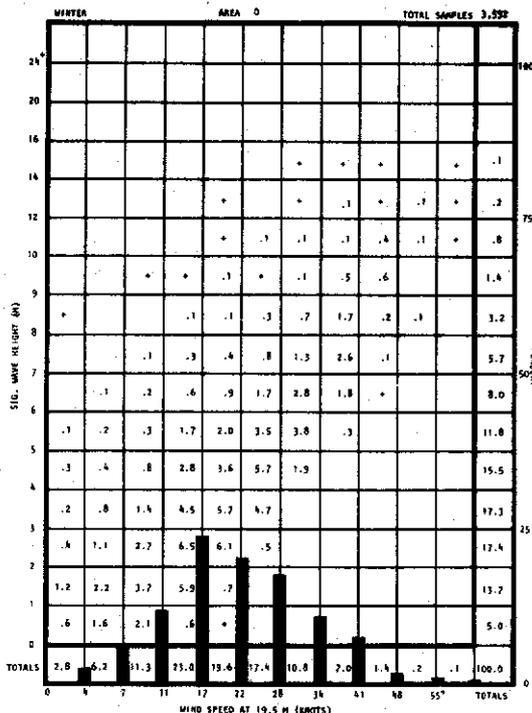
Figure A-0-2-2 Significant Wave
Height by Wind Speed
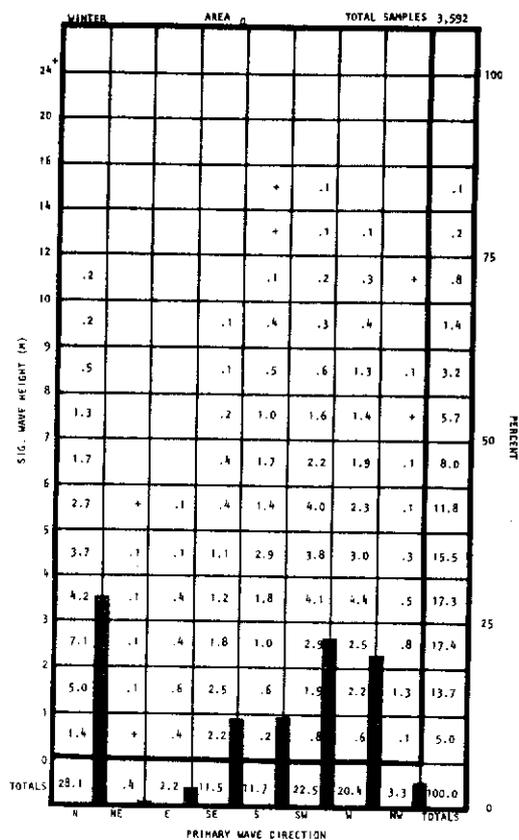
Figure A-0-2-3 Significant Wave
Height by Wave Direction
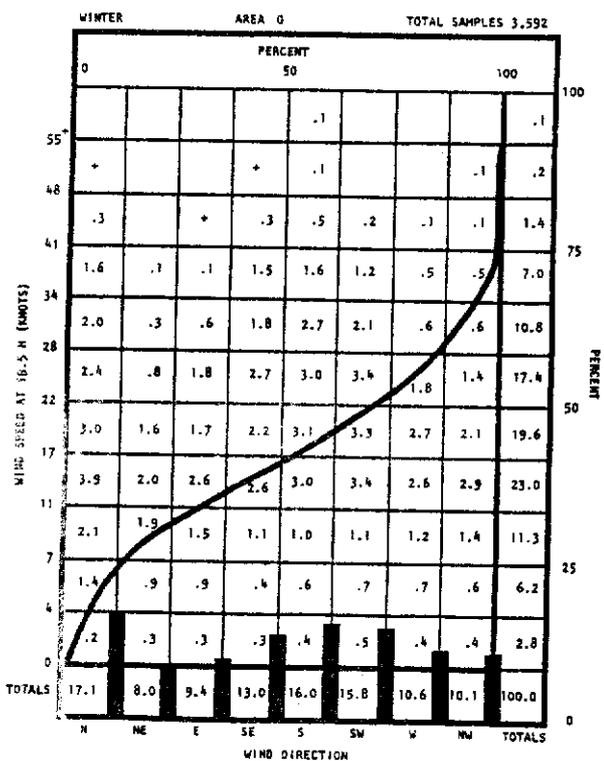
Figure A-0-2-4 Wind Speed by
Wind Direction

WINTER   AREA 0   TOTAL SAMPLES 3,592

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+						.1		+		.1	
9.0		+	+	.1	.1	1.8	.3	.1		2.4	8
6.0	.1	.2	.8	1.4	2.4	12.0	.1			16.9	7
4.0	.8	1.6	5.6	7.6	11.7	8.1				35.4	6
2.5	1.0	1.8	5.1	6.7	3.5					18.2	5
1.25	2.5	3.6	8.6	4.4	.2					19.2	4
0.5	2.1	3.2	1.8	.1						7.1	3
0.1	.4	.3								.7	2
0											1
TOTALS	6.8	10.7	22.0	20.2	17.9	22.0	.4	.1		100.0	

WIND SPEED AT 10 M (KNOTS)
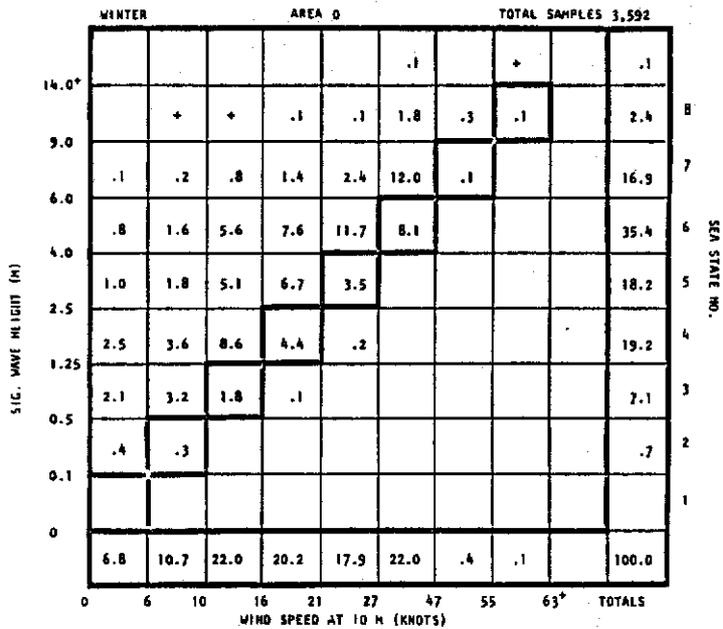
Figure A-0-2-5 Significant Wave Height by
Wind Speed   (WMO Sea State Chart)
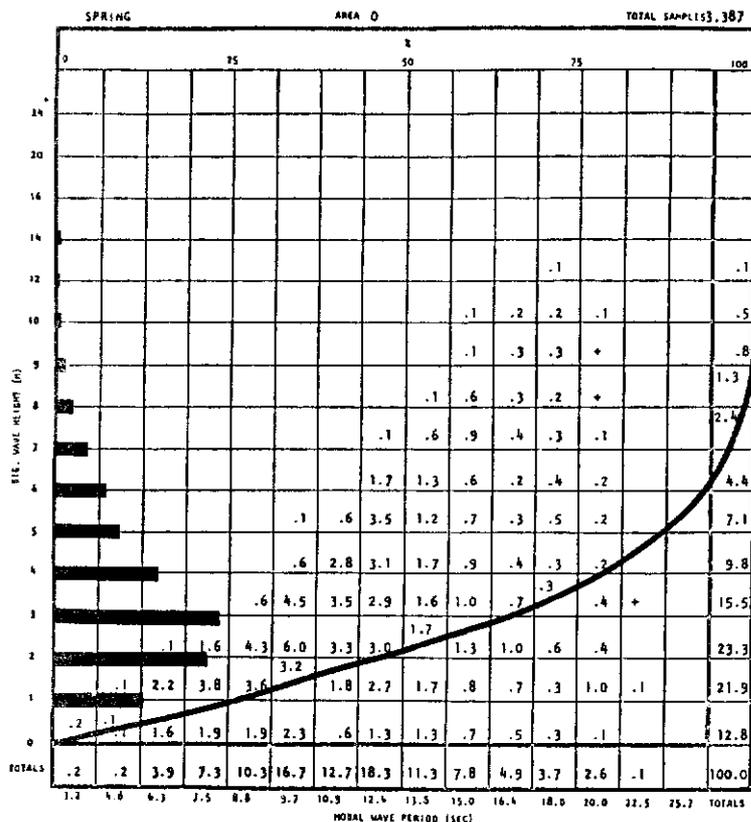
Figure A-0-3-1 Significant Wave
Height by Modal Wave Period
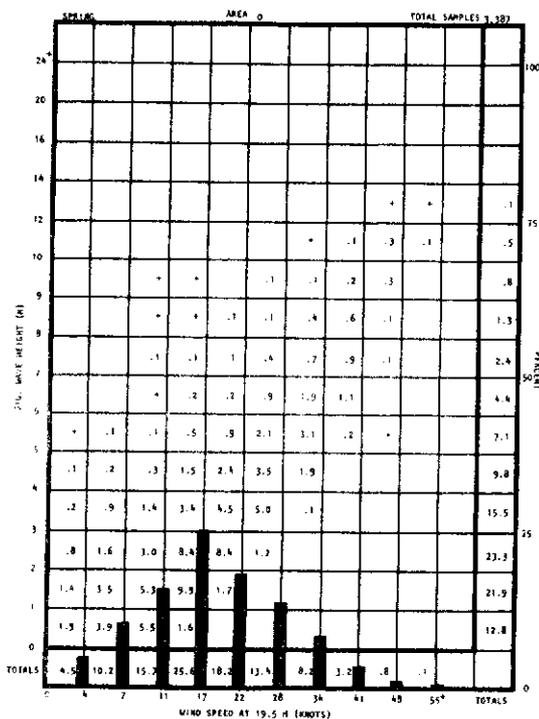
Figure A-0-3-2 Significant Wave
Height by Wind Speed

SPRING · AREA O · TOTAL SAMPLES 3,387

SIG. WAVE HEIGHT (M) — PERCENT

SIG. WAVE HEIGHT	N	NE	E	SE	S	SW	W	NW	TOTALS
13							.1		.1
11.5	.1			+		.1	.3	.1	.5
10	.1			+	.1	.2	.3		.8
9	.3			.1	.1	.2	.5	+	1.3
8	.5			.2	.6	.5	.6	+	2.4
7	.8			.6	1.0	.9	1.1	.1	4.4
6	1.5		.1	1.1	1.3	1.3	1.7	.2	7.1
5	2.1		.2	.9	1.3	2.2	3.1		9.8
4	4.0	.2	.5	1.7	2.0	3.6	3.6	.1	15.5
3	6.7	.2	1.0	3.9	2.7	5.0	3.5	.3	23.3
2	6.9	.4	1.2	4.3	2.5	3.0	2.8	1.0	21.9
1	2.7	.3	1.1	3.2	.5	1.4	2.5	1.2	12.8
TOTALS	25.5	1.0	4.0	16.0	12.1	18.2	20.1	3.0	100.0

PRIMARY WAVE DIRECTION
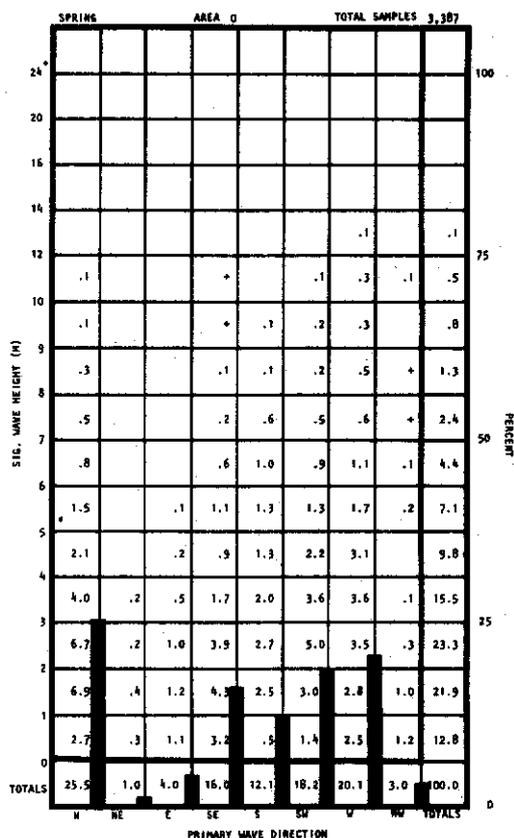
Figure A-0-3-3 Significant Wave Height by Wave Direction

SPRING · AREA O · TOTAL SAMPLES 3,387

PERCENT 0   50   100

WIND SPEED AT 19.5 M (KNOTS) — PERCENT

WIND SPEED	N	NE	E	SE	S	SW	W	NW	TOTALS
55					+	+	+		.1
48	.1			.1	.1	.1	.1	.1	.8
41	.6	.1		.9	.5	.4	.2	.5	3.2
34	1.0	.1	.6	1.7	2.1	1.2	1.0	.6	8.2
28	2.0	.8	1.1	2.3	2.5	2.2	1.4	1.1	13.4
22	3.1	1.6	2.2	3.1	3.2	2.6	1.3	1.3	18.2
17	4.0	2.5	3.0	5.0	3.6	3.0	1.8	2.5	25.6
11	2.7	2.4	1.9	1.5	2.1	1.8	1.2	2.0	15.7
7	1.9	1.6	1.2	1.4	1.1	1.0	.9	1.1	10.2
4	.6	.4	.6	.6	.7	.5	.5	.6	4.5
TOTALS	16.2	5.8	10.6	16.5	5.8	12.8	8.6	9.7	100.0
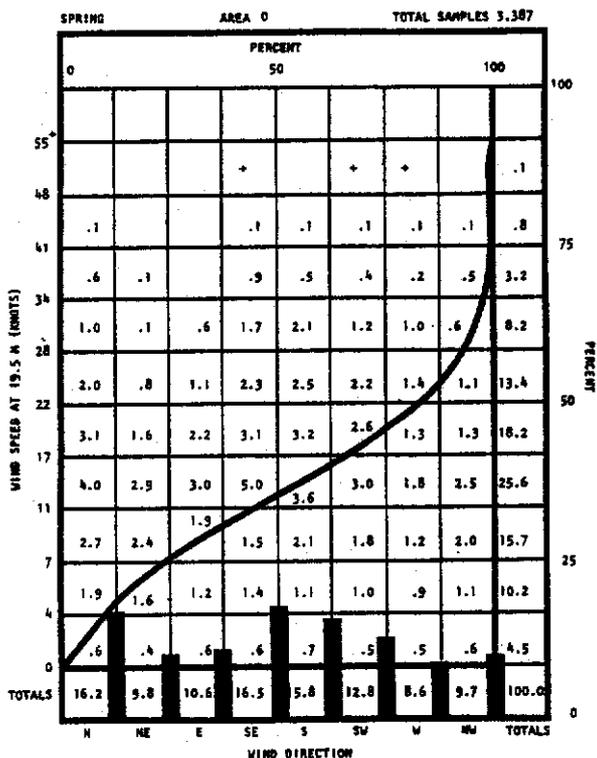
WIND DIRECTION

Figure A-0-3-4 Wind Speed by Wind Direction
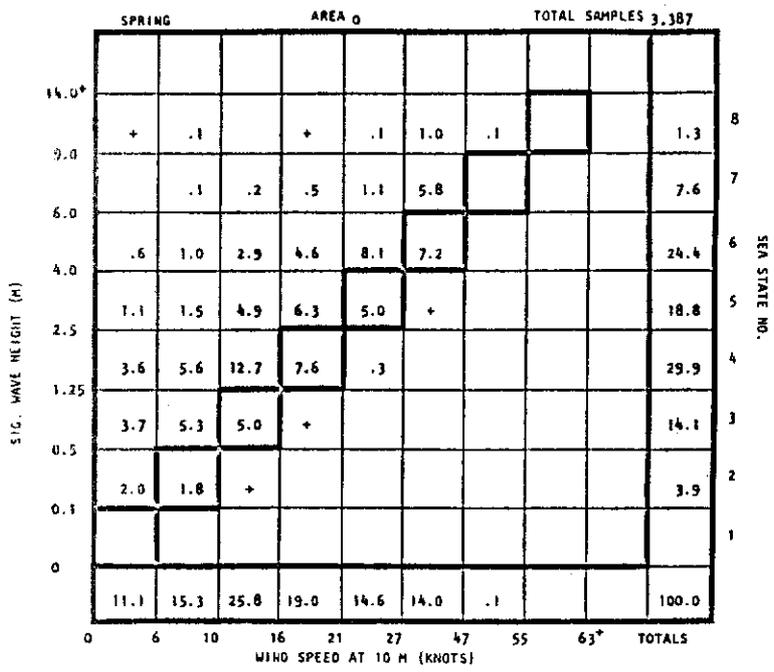
Figure A-0-3-5 Significant Wave Height by Wind Speed (WMC Sea State Chart)
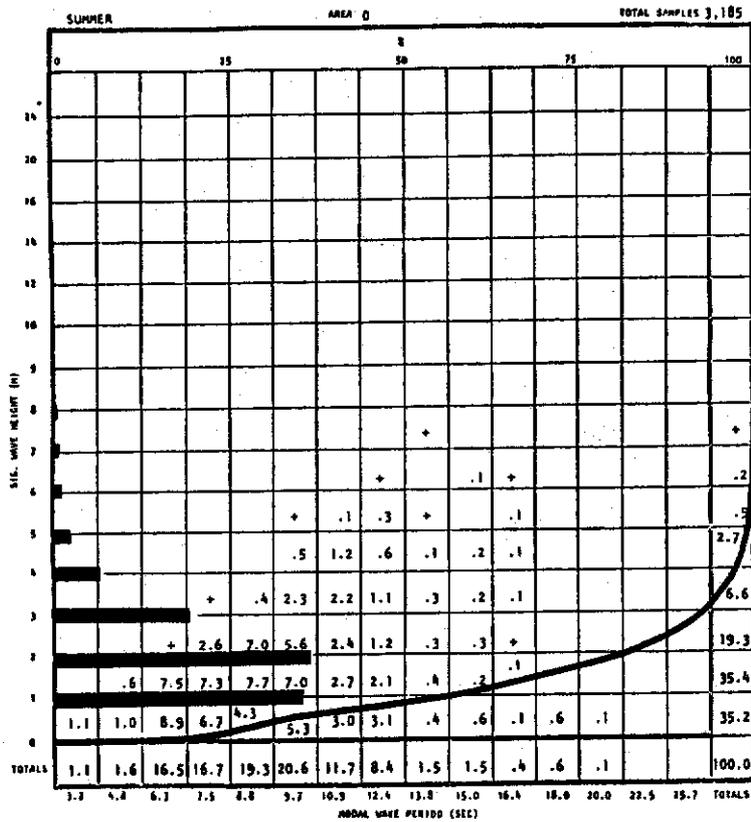
Figure A-0-4-1 Significant Wave
Height by Modal Wave Period
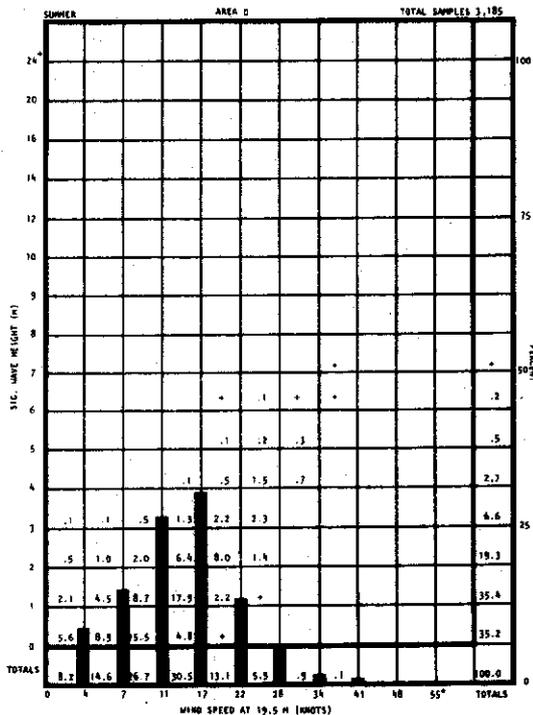
Figure A-0-4-2 Significant Wave
Height by Wind Speed

SUMMER   AREA 0   TOTAL SAMPLES 3,185

SIG. WAVE HEIGHT (M) — PERCENT

Ht	N	NE	E	SE	S	SW	W	NW	TOTALS
7					+		+		.2
6					.1	.1	+		.2
5	.1				.1	.2	.1		.5
4	+		+	.1	.9	.8	.8		2.7
3	.4		.1	.4	1.2	2.0	2.4		6.6
2	3.0	.3	.8	1.1	2.8	5.5	5.5	.4	19.3
1	8.3	1.4	2.0	3.4	2.9	5.7	11.0	.7	35.4
0	9.7	1.5	3.3	3.2	2.4	3.1	10.8	1.2	35.2
TOTALS	21.5	3.1	6.2	8.2	10.4	17.4	30.7	2.3	100.0

PRIMARY WAVE DIRECTION
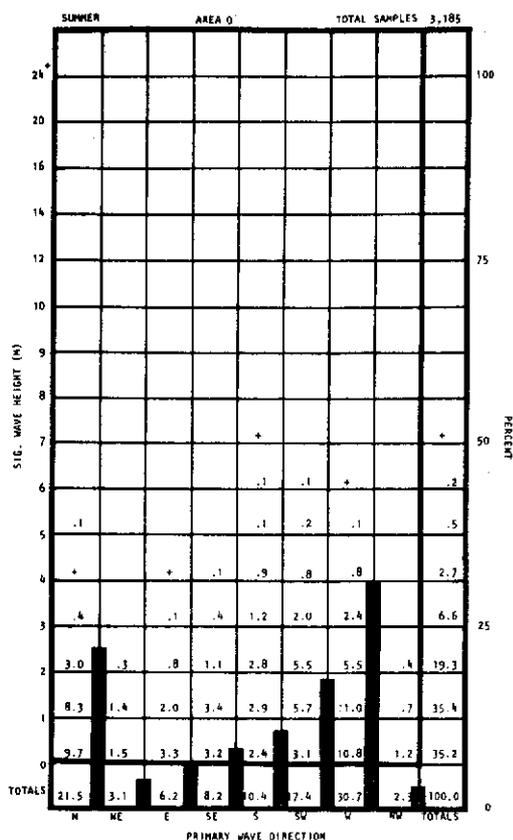
Figure A-0-4-3 Significant Wave
Height by Wave Direction

SUMMER   AREA 0   TOTAL SAMPLES 3,185

PERCENT   0   50   100

WIND SPEED AT 19.5 M (KNOTS) — PERCENT

Spd	N	NE	E	SE	S	SW	W	NW	TOTALS
34					.1				.1
28	.1			+	.5	.2	.1		.9
22	.7	.1	.3	.8	2.0	.9	.3	.5	5.5
17	1.6	1.2	.7	2.0	3.0	2.3	1.1	1.1	13.1
11	5.5	4.1	2.0	3.5	5.1	4.8	2.9	2.6	30.5
7	3.9	4.2	2.9	2.6	2.6	4.6	3.5	2.4	26.7
4	2.1	2.1	1.5	1.6	1.2	2.3	2.1	1.6	14.6
0	1.4	.9	1.0	.5	1.0	1.2	1.0	1.4	8.2
TOTALS	15.4	12.6	8.5	11.0	15.5	16.3	11.1	9.7	100.0
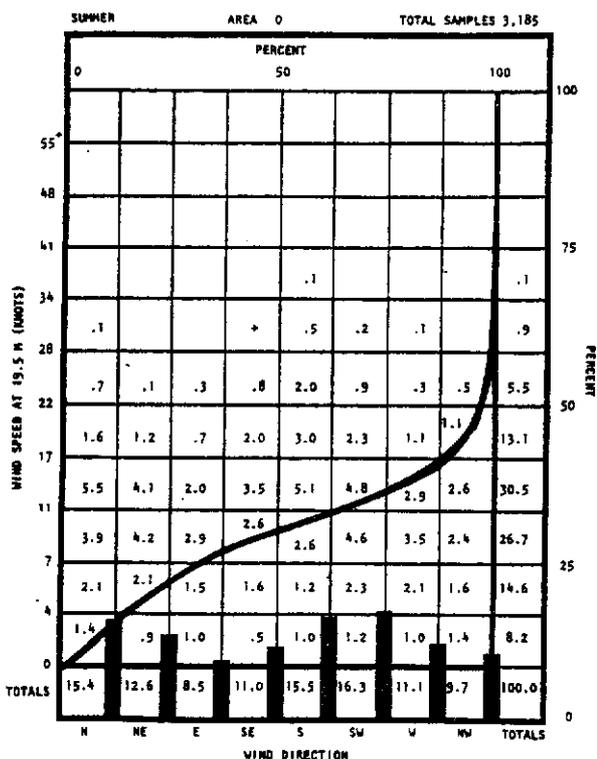
WIND DIRECTION

Figure A-0-4-4 Wind Speed by
Wind Direction

SUMMER			AREA 0				TOTAL SAMPLES 3,185			

Figure A-0-4-5 Significant Wave Height by Wind Speed   (WMO Sea State Chart)

FALL AREA 0 TOTAL SAMPLES 3,194
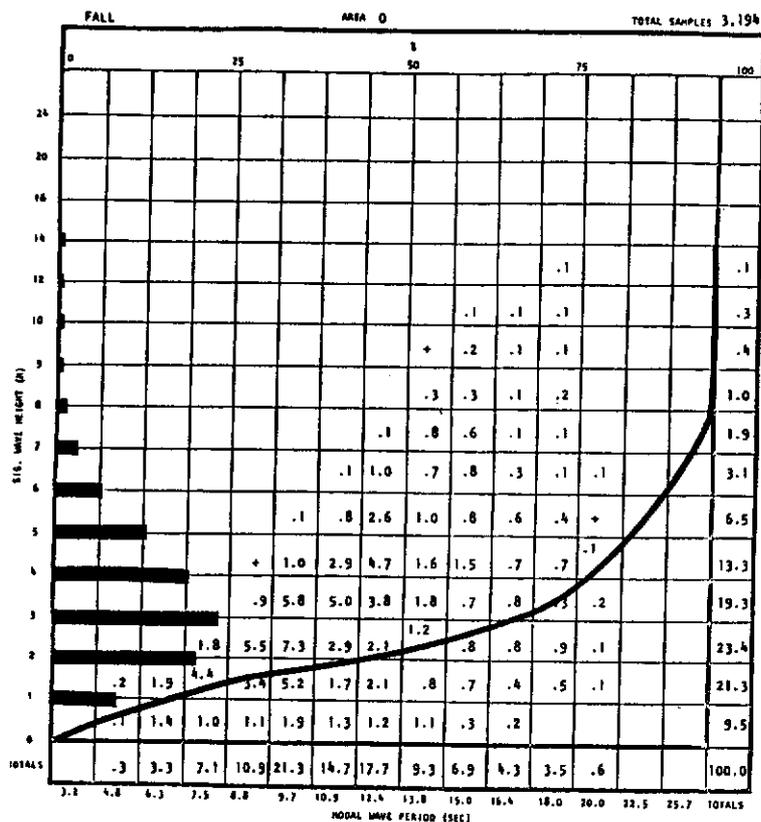
Figure A-0-5-1 Significant Wave Height by Modal Wave Period

SIG. WAVE HEIGHT (M) vs MODAL WAVE PERIOD (SEC)

SIG. WAVE HEIGHT (M)	3.2	4.8	6.3	7.5	8.8	9.7	10.5	12.4	13.8	15.0	16.4	18.0	20.0	22.5	25.7	TOTALS
12											.1					.1
10										.1	.1	.1				.3
9									+	.2	.1	.1				.4
8									.3	.3	.1	.2				1.0
7								.1	.8	.6	.1	.1				1.9
6							.1	1.0	.7	.8	.3	.1	.1			3.1
5						.1	.8	2.6	1.0	.8	.6	.4	+			6.5
4					+	1.0	2.9	4.7	1.6	1.5	.7	.7	.1			13.3
3					.9	5.8	5.0	3.8	1.8	.7	.8	.3	.2			19.3
2				1.8	5.5	7.3	2.9	1.2	.8	.8	.9	.1				23.4
1		.2	1.5	4.4	3.4	5.2	1.7	2.1	.8	.7	.4	.5	.1			21.3
0		.1	1.4	1.0	1.1	1.9	1.3	1.2	1.1	.3	.2					9.5
TOTALS	.3	3.3	7.1	10.9	21.3	14.7	17.7	9.3	6.9	4.3	3.5	.6				100.0

FALL AREA 0 TOTAL SAMPLES 3,194
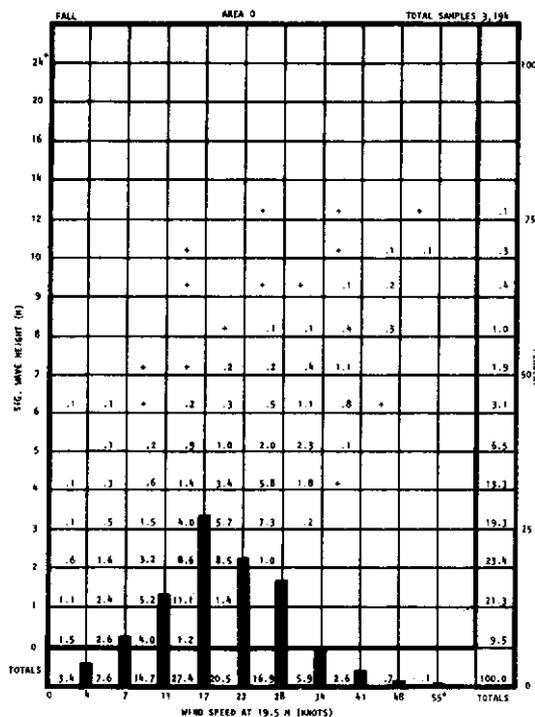
Figure A-0-5-2 Significant Wave Height by Wind Speed

SIG. WAVE HEIGHT (M) vs WIND SPEED AT 19.5 M (KNOTS)

SIG. WAVE HEIGHT (M)	0	4	7	11	17	23	28	34	41	48	55	TOTALS
12					+		+		+			.1
10				+			+	.1	.1			.3
9				+	+	+	.1	.2				.4
8				+	.1	.1	.4	.3				1.0
7			+	+	.2	.2	.4	1.1				1.9
6	.1	.1	+	.2	.3	.5	1.1	.8	+			3.1
5		.1	.2	.9	1.0	2.0	2.3	.1				6.5
4	.1	.3	.6	1.4	3.4	5.8	1.0	+				13.1
3	.1	.5	1.5	4.0	5.7	7.3	.2					19.1
2	.6	1.6	3.2	8.6	8.5	1.0						23.4
1	1.1	2.4	5.2	11.1	1.4							21.3
0	1.5	2.6	4.0	1.2								9.5
TOTALS	3.4	7.6	14.7	27.4	20.5	16.9	5.9	2.6	.7	.1		100.0
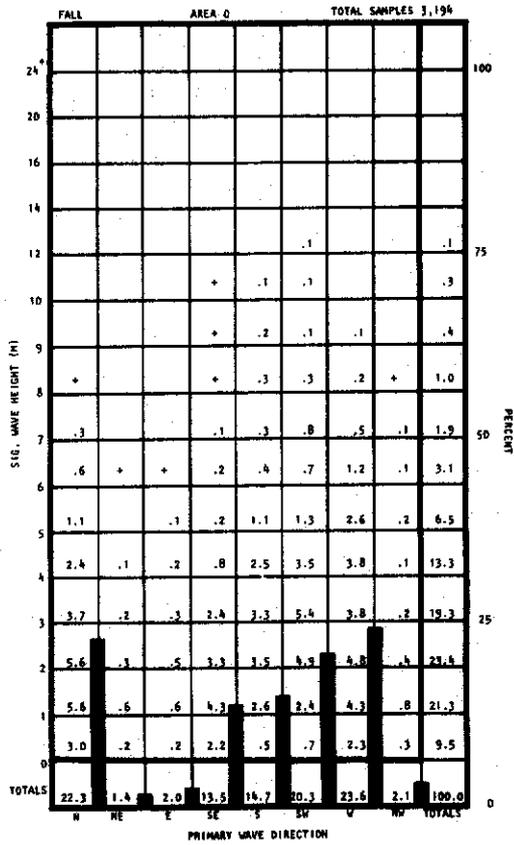
Figure A-0-5-3 Significant Wave
Height by Wave Direction
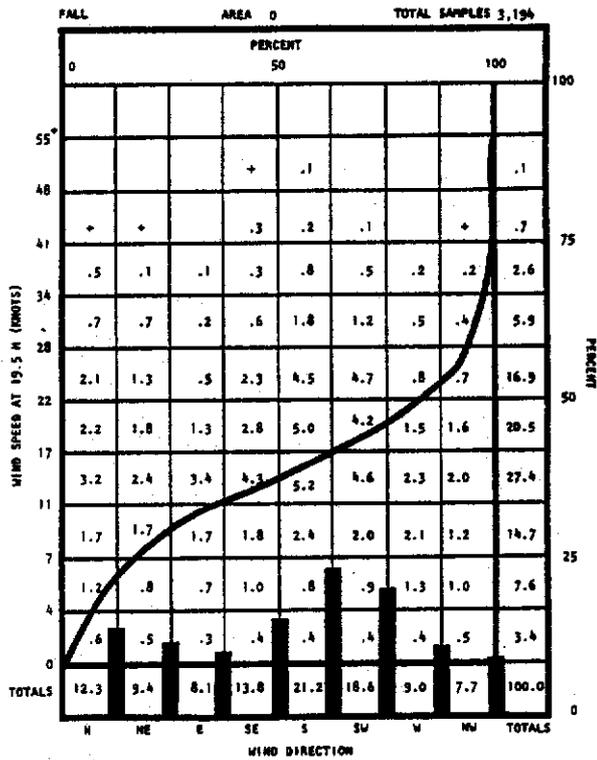
Figure A-0-5-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

FALL			AREA 0					TOTAL SAMPLES 3,194		
SIG. WAVE HEIGHT (M)			WIND SPEED AT 10 M (KNOTS)							SEA STATE NO
14.0+										
			+	+	+	.5	.2		.7	8
9.0	.1	.1	.2	.4	.7	4.1			5.7	7
6.0	.5	1.0	3.3	5.8	11.2	6.5			28.3	6
4.0	.8	2.0	5.5	7.1	6.0				21.4	5
2.5	2.8	4.9	13.5	7.5	.1				28.9	4
1.25	3.5	5.0	4.7	.1					13.3	3
0.5	.8	.9							1.7	2
0.1										1
0										
	8.5	13.8	27.4	20.9	18.1	11.1	.2		100.0	
	0	6	10	16	21	27	47	55	63+	TOTALS

Figure A-0-5-5 Significant Wave Height by
Wind Speed   (WMO Sea State Chart)

TABLE A-00-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 60.696° N, 33.123° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2.5	7	3.5	2
Wave Period, sec	6.5	10	16	10.5	9.5
Direction	-	-	-	-	E - S - W
Winds					
Speed, knots	5	16	35	18	14
Corresponding Mean Sig. Wave Height, m.	1	2.5	7	3	2.5
Direction	-	-	-	-	NE
Visibility, nautical miles	1.5	10	24	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	1	7	8	-	-
Low clouds, in eighths of sky obscured	.5	6	8	-	-
Precipitation (Occurrence)	All precipitation - 25% of the time		Snow - 13% of the time (Dec - Mar)		
Relative Humidity, %	63	83	97	-	-
Air Temperature, °C	.5	5	10	5.5	-
Surface Water Temperature, °C	5	6.5	10.5	-	-
Sea Level Pressure, millibars	981	1,005	1,026	-	-
Ice	Moderate* superstructure icing - 3% of the time (Dec - Mar)				
Refractivity					
Mean Surface Refractivity	-	-	-	316	-
Sub-Refraction (1 km, Annual)	-	-	-	-	None
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	None

*Buildup of less than 1/10 in. per hour (derived from observations with temperature < -2.2°C and wind speed ≥ 13 knots).

A-28
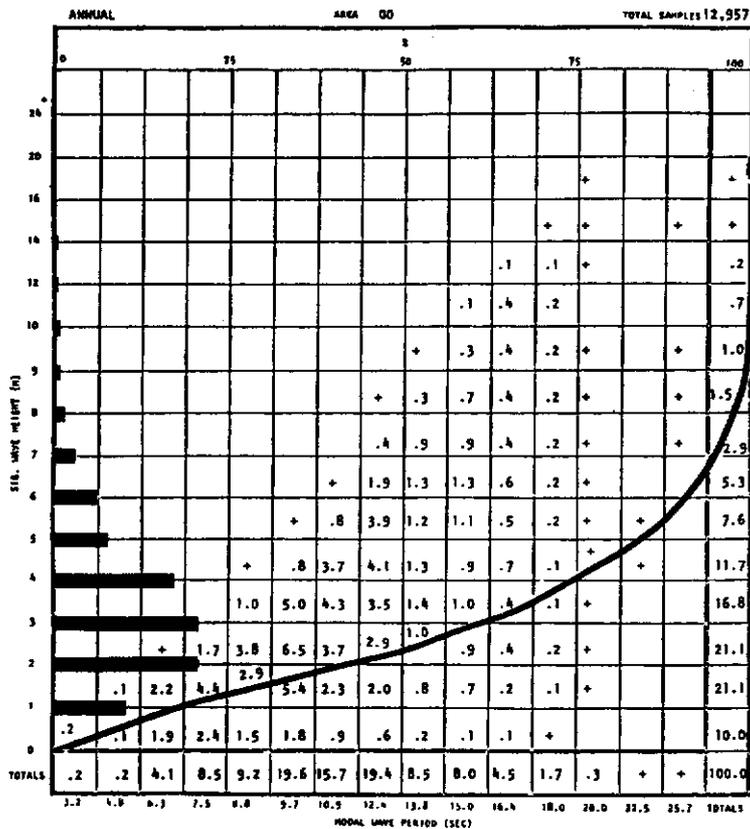
Figure A-00-1-1 Significant Wave
Height by Modal Wave Period
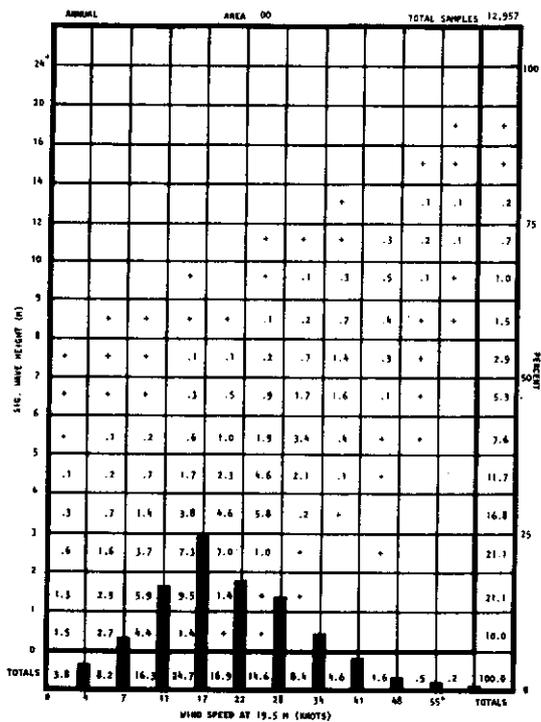
Figure A-00-1-2 Significant Wave
Height by Wind Speed

ANNUAL   AREA 00   TOTAL SAMPLES 12,957

SIG. WAVE HEIGHT (M)

	N	NE	E	SE	S	SW	W	NW	TOTALS
			+					+	
	+		+	+				+	
	+	+	.1			+	.1		.2
	+	+	.3	.1	+	.1	.2		.7
	+	.1	.3	.2	+	.1	.2	+	1.0
	.1	.1	.5	.2	.1	.2	.4	+	1.5
	.1	.3	.7	.4	.3	.3	.7	+	2.9
	.1	.6	1.3	.8	.8	.5	1.0	.1	5.3
	.3	1.0	1.7	1.0	1.4	.6	1.5	.1	7.6
	.6	1.5	2.5	1.8	2.3	1.0	2.0	.2	11.7
	1.2	2.4	3.0	1.9	3.1	1.8	3.2	.3	16.8
	1.9	3.0	3.5	2.1	3.9	2.4	3.9	.5	21.1
	2.6	3.2	3.1	1.5	4.1	2.5	3.4	.7	21.1
	.1	2.5	1.1	.3	1.7	1.5	1.4	.2	10.0
TOTALS	8.1	14.8	18.1	10.3	17.6	10.8	17.8	2.2	100.0

PRIMARY WAVE DIRECTION
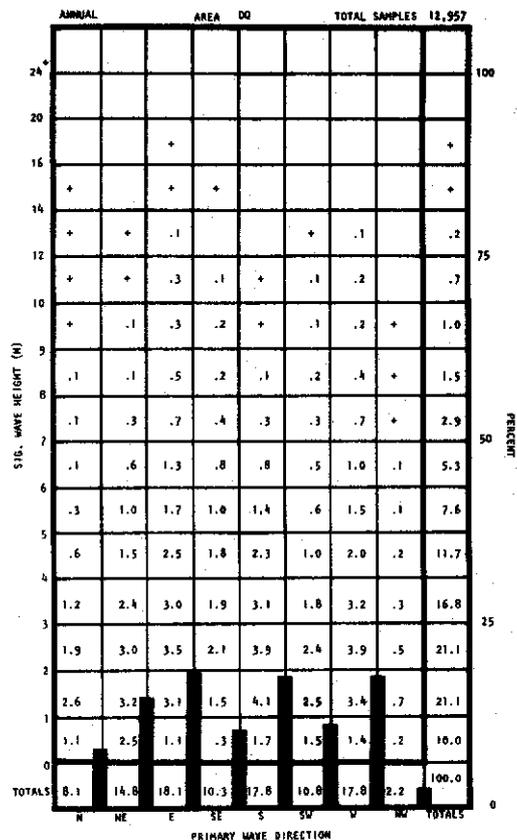
Figure A-00-1-3 Significant Wave Height by Wave Direction

ANNUAL   AREA 00   TOTAL SAMPLES 12,957

PERCENT   0   50   100

WIND SPEED AT 19.5 M (KNOTS)

	N	NE	E	SE	S	SW	W	NW	TOTALS
		+	+			+	.1	+	.2
	+	.2	.1	+	+	.1	.1	.1	.5
	+	.3	.3	.2	.1	.2	.4	.1	1.6
	.2	1.1	.7	.5	.3	.5	.9	.3	4.6
	.6	1.9	1.4	1.0	.5	1.0	1.3	.6	8.4
	1.7	3.0	1.8	1.5	1.4	1.9	2.2	1.4	14.6
	2.0	2.9	2.3	1.8	1.7	2.2	2.0	1.9	16.9
	2.9	4.4	2.5	2.4	2.9	3.5	3.3	2.8	24.7
	2.6	2.3	1.9	1.8	1.8	2.0	1.8	2.0	16.3
	1.3	1.0	.9	.9	1.0	1.1	.9	1.0	8.2
	.5	.5	.4	.5	.4	.5	.4	.5	3.8
TOTALS	12.0	17.8	12.3	10.7	10.1	12.9	13.5	10.8	100.0
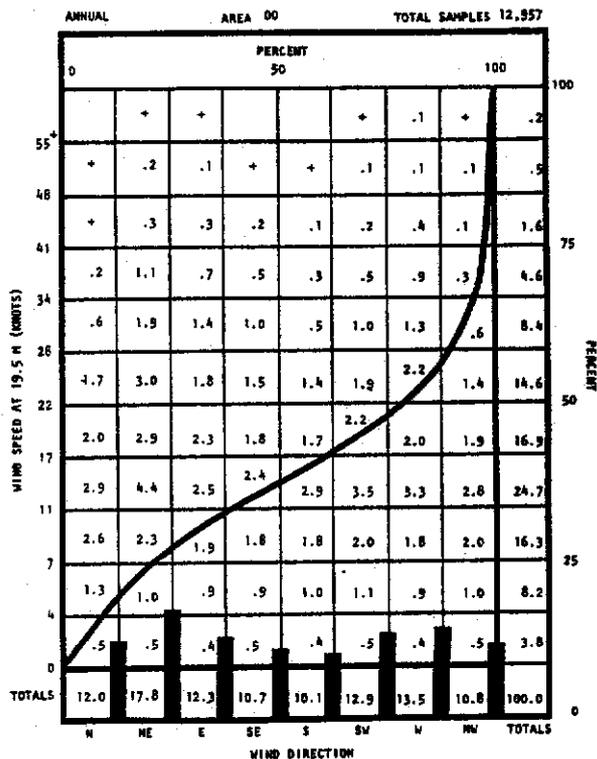
WIND DIRECTION

Figure A-00-1-4 Wind Speed by Wind Direction
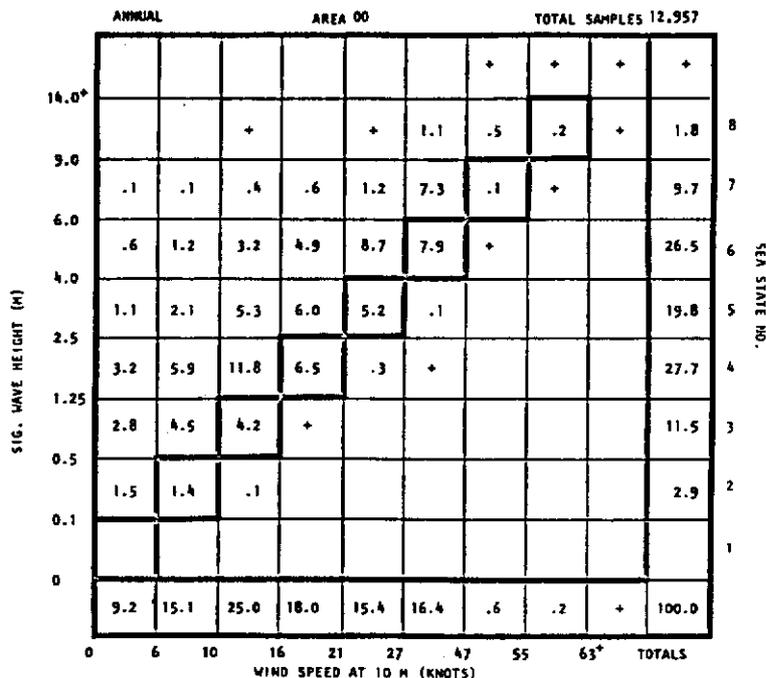
Figure A-00-1-5 Significant Wave Height by
Wind Speed   (WMO Sea State Chart)
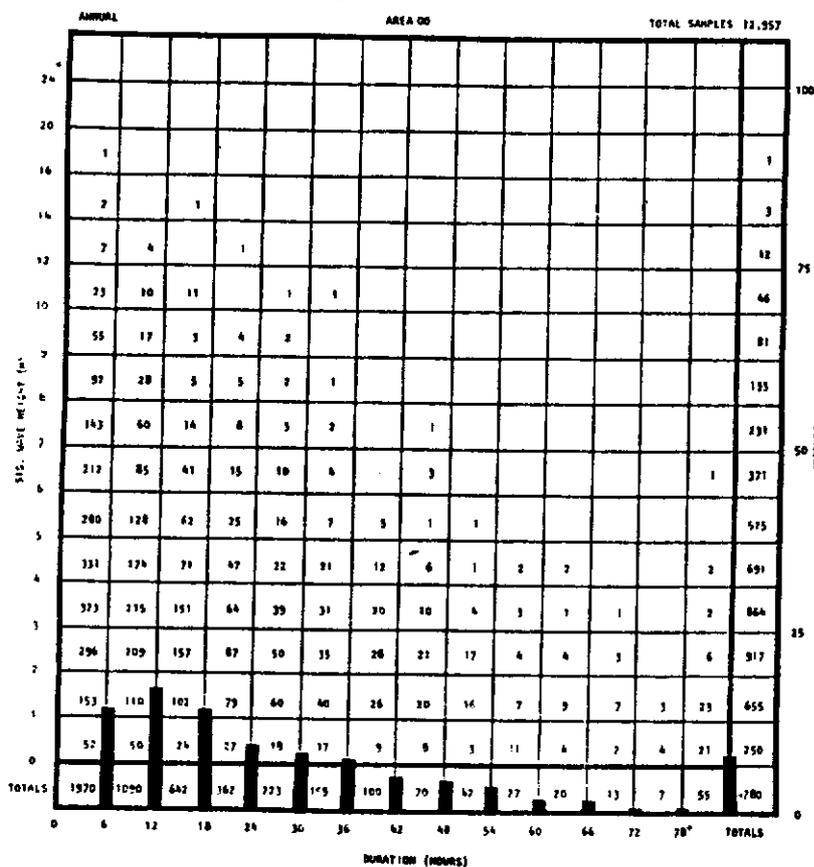
Figure A-00-1-6 Persistence of
Significant Wave Height

ANNUAL						AREA 00				TOTAL SAMPLES 12,957					
4	6	1	1	1											13
21	8	3	1	1	1										35
82	29	17	3	1											132
165	88	30	19	3	2	1	1		1						330
381	143	65	30	14	4	2									639
554	234	108	46	24	15	5	6	2	1	2					997
754	307	133	43	24	12	2	6								1281
784	360	177	81	48	29	17	12	10	6	1	2	1	1		1529
710	264	104	56	37	11	2	6	3							1193
450	145	59	19	6	4	2	1								686
218	59	20	13	6	5	2	2								325
TOTALS 4143	1643	717	312	165	83	33	34	15	8	3	2	1	1		7160

WIND SPEED AT 19.5 M (KNOTS): 55+ 48 41 34 28 22 17 11 7 4 0

DURATION (HOURS): 6 12 18 24 30 36 42 48 54 60 66 72 78+ TOTALS

PERCENT: 100 75 50 25 0
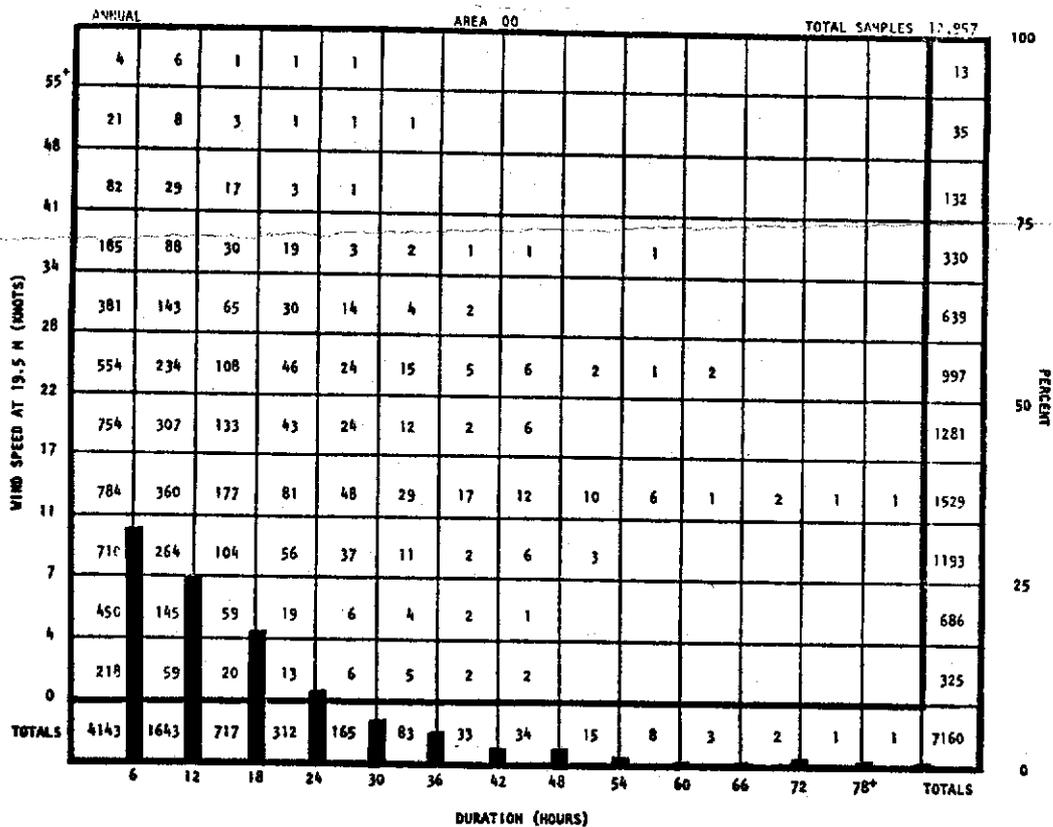
Figure A-00-1-7 Persistence of Wind Speed

A-32

WINTER AREA 00 TOTAL SAMPLES 3,584
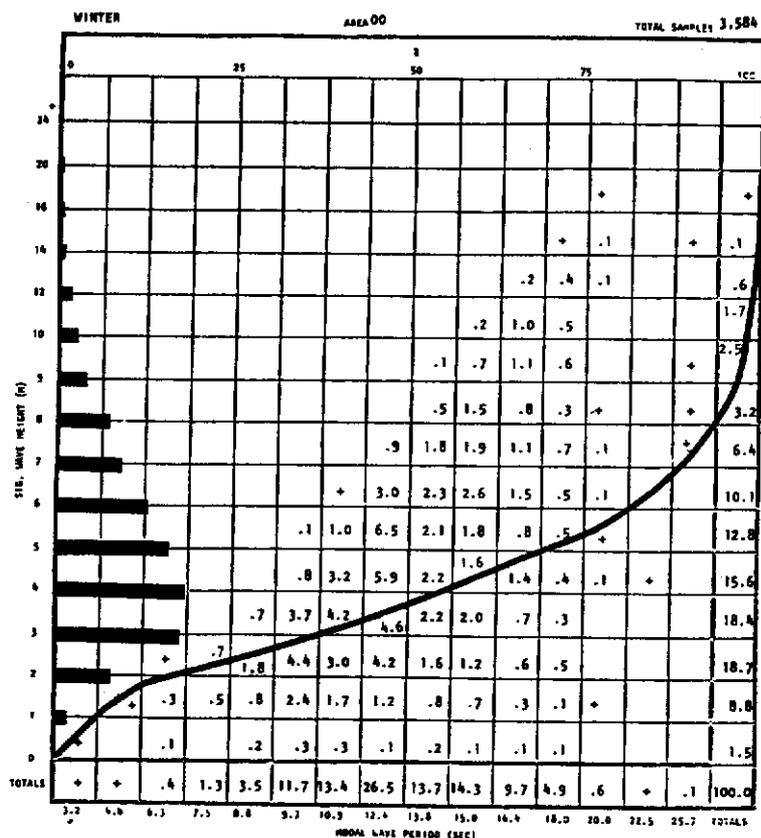
Figure A-00-2-1 Significant Wave
Height by Modal Wave Period

WINTER AREA 00 TOTAL SAMPLES 3,584
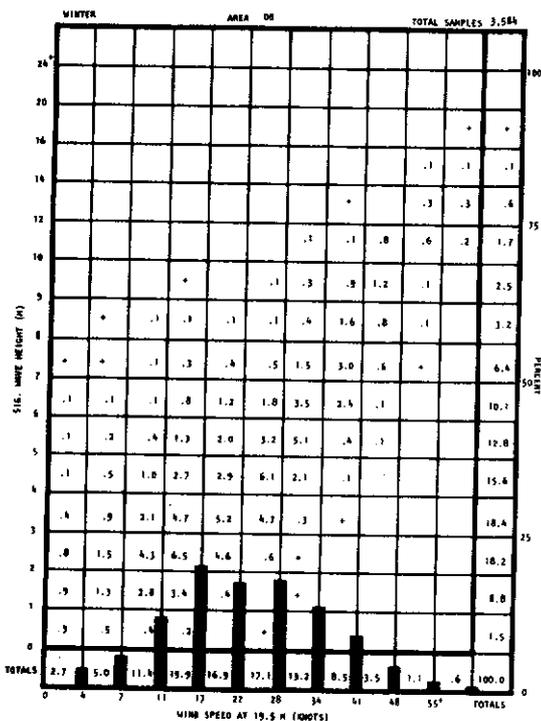
Figure A-00-2-2 Significant Wave
Height by Wind Speed

WINTER AREA 00 TOTAL SAMPLES 3,584
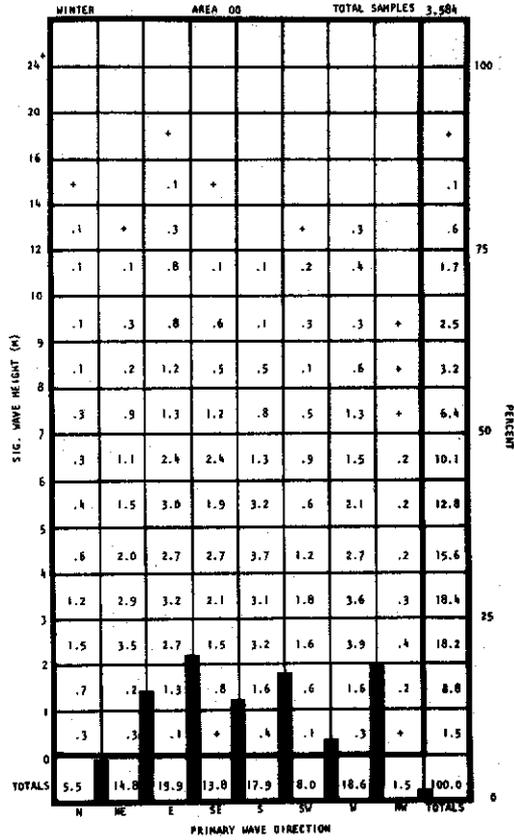
Figure A-00-2-3 Significant Wave
Height by Wave Direction

WINTER AREA 00 TOTAL SAMPLES 3,584
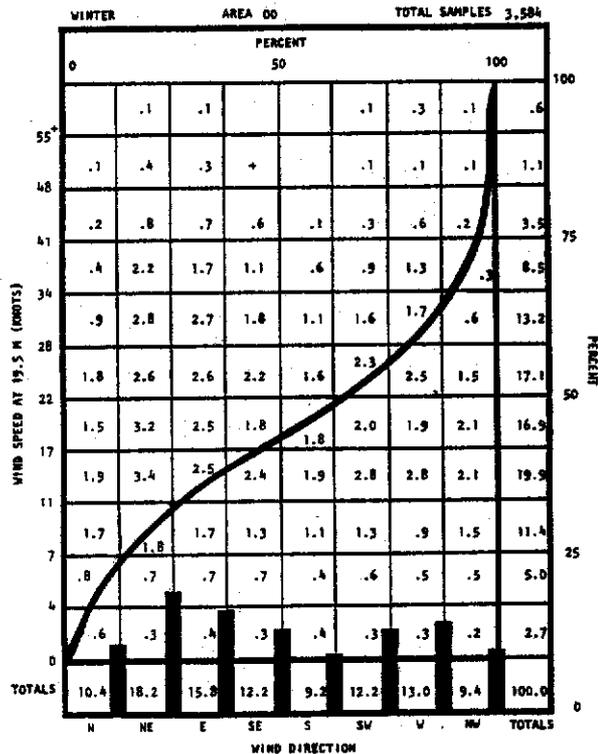
Figure A-00-2-4 Wind Speed by
Wind Direction

WINTER   AREA 00   TOTAL SAMPLES 3,584

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63	63+	TOTALS	SEA STATE NO.
14.0+							.1	.1	.1	.2	
9.0			+		.1	3.0	1.3	.4	.1	4.9	8
6.0	.2	.2	1.0	1.4	2.5	14.2	.2			19.6	7
4.0	1.3	2.0	5.6	6.9	11.0	10.1				37.0	6
2.5	1.2	2.9	6.0	5.2	3.7	.2				19.1	5
1.25	2.2	3.5	6.7	3.1	.1	+				16.1	4
0.5	1.1	1.1	.7	+	+					.3	3
0.1		+								+	2
0											1
TOTALS	6.1	10.2	20.0	16.7	17.4	27.5	1.5	.5	.1	100.0	

WIND SPEED AT 10 M (KNOTS)
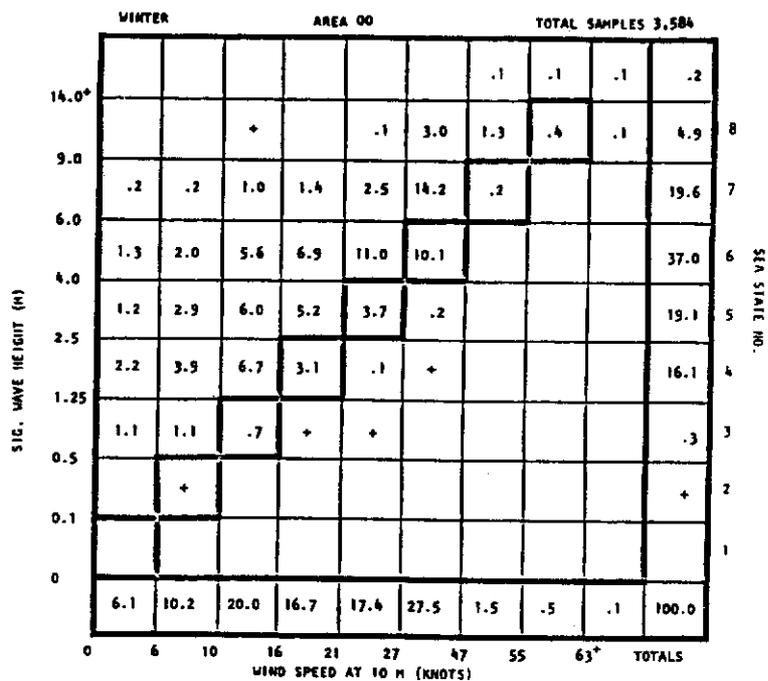
Figure A-00-2-5 Significant Wave Height by Wind Speed   (WMO Sea State Chart)
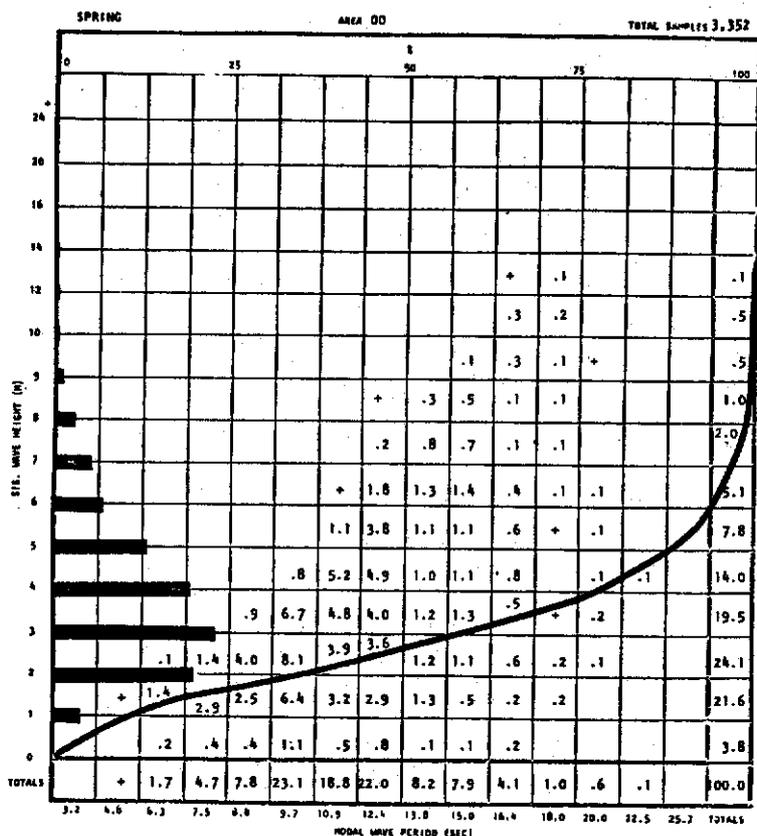
Figure A-00-3-1 Significant Wave
Height by Modal Wave Period
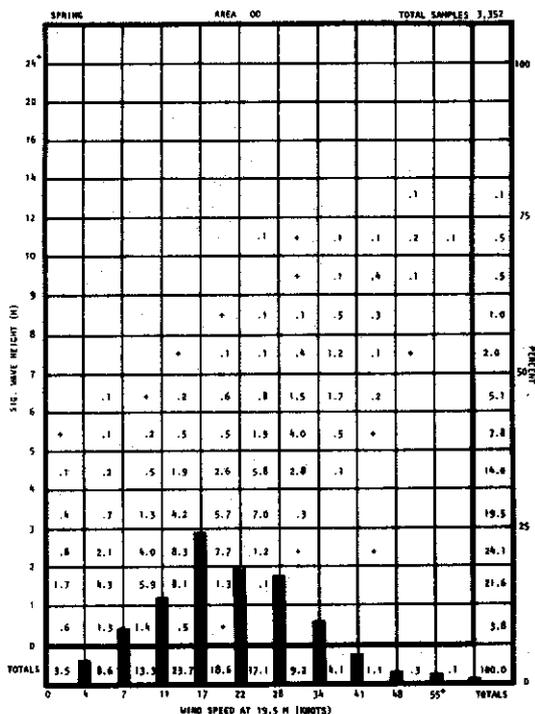
Figure A-00-3-2 Significant Wave
Height by Wind Speed

SPRING **AREA 00** **TOTAL SAMPLES 3,352**

SIG. WAVE HEIGHT (M) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
			.1						.1
			.2	.2		.1	.1		.5
	+		.2	.1	+	+	+	.1	.5
	.1		.4	.1		.2	.1		1.0
		.1	1.0	.2	.1	.1	.4	+	2.0
	.1	.4	2.1	.4	1.0	.4	.7	.1	5.1
	.4	1.0	2.1	1.2	1.1	.7	1.1	.1	7.8
	.5	1.9	4.2	2.0	2.7	1.0	1.5	.1	14.0
	1.5	3.0	4.1	2.7	3.9	1.5	2.7	.2	19.5
	2.3	3.6	4.5	3.3	5.0	2.1	2.4	.6	24.1
	2.9	4.0	2.9	2.1	4.5	1.6	3.0	.6	21.6
	.5	1.3	.5	.1	.8	.3	.2	.1	3.8
TOTALS	8.5	15.3	22.6	12.4	19.1	8.0	12.2	1.9	100.0

PRIMARY WAVE DIRECTION
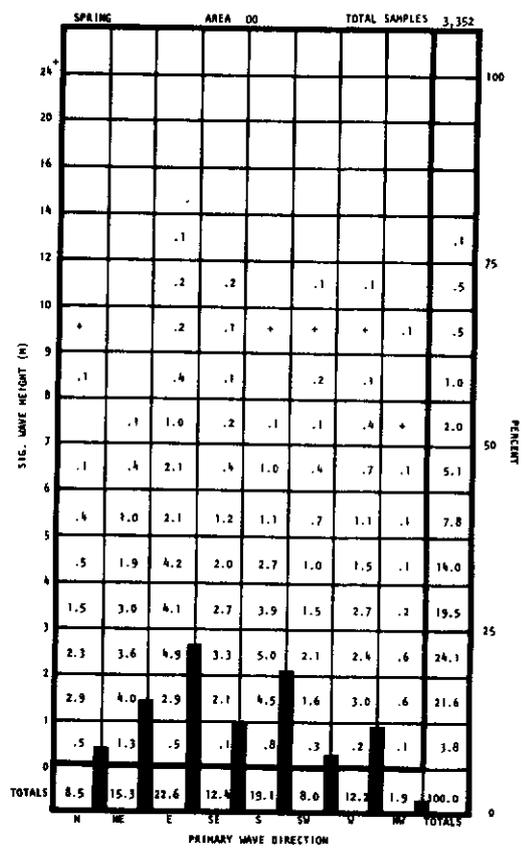
Figure A-00-3-3 Significant Wave Height by Wave Direction

SPRING **AREA 00** **TOTAL SAMPLES 3,352**

PERCENT 0 50 100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
		.1					.1		.1
		.1	+	.1	+	.1	+		.3
	.1	.2	.3	.1		+	.2	.2	1.1
		1.1	.7	.6	.2	.3	1.0	.1	4.1
	.9	2.5	1.6	1.0	.4	.9	1.2	.7	9.2
	2.1	4.8	2.3	1.6	1.5	1.8	1.5	1.0	17.7
	2.4	3.7	3.2	2.1	2.1	1.9	1.8	1.5	18.6
	3.6	5.2	2.6	2.4	2.6	2.4	2.6	2.4	23.7
	1.8	2.4	1.6	2.0	1.6	1.4	1.1	1.4	13.3
	1.1	.9	1.0	1.0	1.4	1.4	.8	1.0	8.6
	.4	.6	.2	.3	.5	.6	.4	.4	3.5
TOTALS	12.3	21.7	13.5	11.2	10.5	10.8	11.1	8.9	100.0
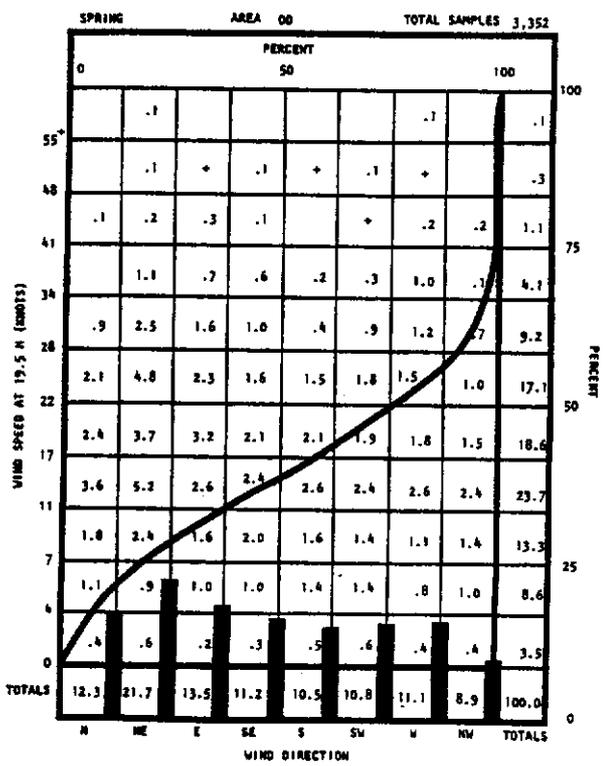
WIND DIRECTION

Figure A-00-3-4 Wind Speed by Wind Direction

SPRING				AREA 00				TOTAL SAMPLES 3.352		

SIG. WAVE HEIGHT (H)												SEA STATE NO.
14.0+												
9.0						.7	.3	.1		1.1	8
	.1	+	.2	.4	1.1	6.2	.1			8.1	7
6.0	.4	1.0	3.0	5.0	10.3	9.8				29.6	6
4.0	1.6	1.8	6.3	7.6	6.5					23.9	5
2.5	4.4	7.1	11.9	5.8	.4	.1				29.7	4
1.25	2.2	3.0	2.0	.1						7.2	3
0.5	.2	.2								.4	2
0.1											1
0											
	9.0	13.1	23.4	19.0	18.2	16.8	.4	.1		100.0	
	0 6 10 16 21 27 47 55 63+ TOTALS										

WIND SPEED AT 10 M (KNOTS)
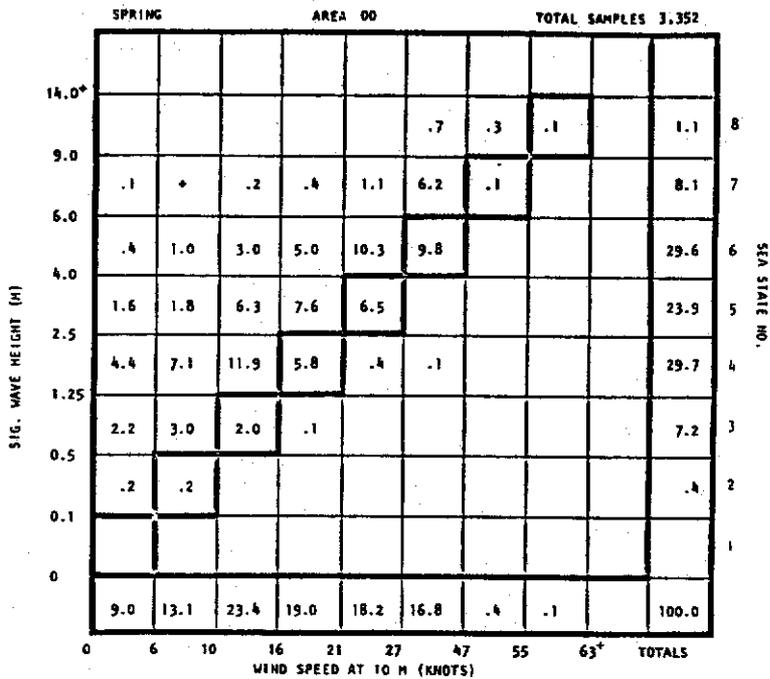
Figure A-00-3-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

SUMMER   AREA 00   TOTAL SAMPLES 2,826
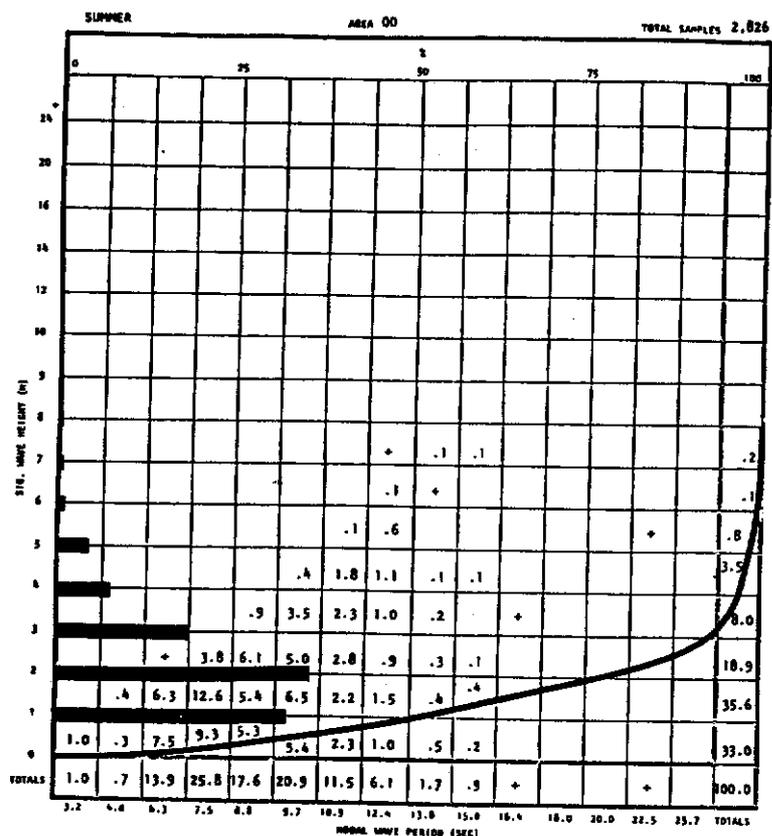
Figure A-00-4-1 Significant Wave
Height by Modal Wave Period

SUMMER   AREA 00   TOTAL SAMPLES 2,826
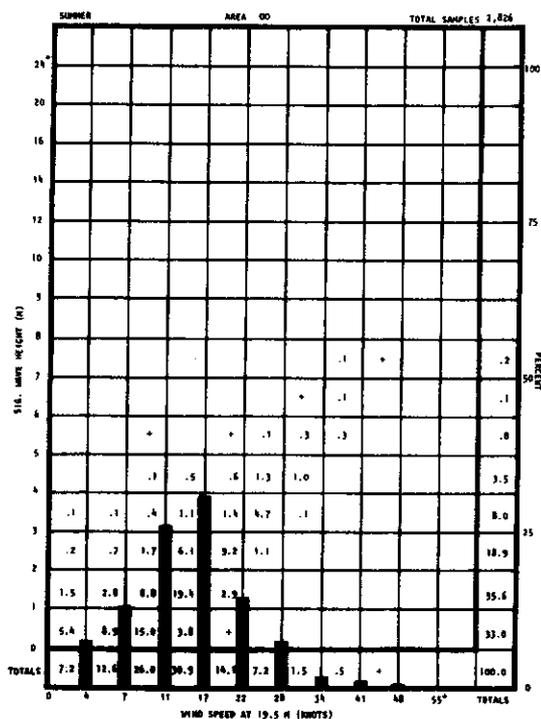
Figure A-00-4-2 Significant Wave
Height by Wind Speed

SUMMER — AREA 00 — TOTAL SAMPLES 2,826

SIG. WAVE HEIGHT (M)

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
7	.1				+	.1			.2
		+				.1			.1
6		+	.1		+	.2	.3	.1	.8
5	.1	.2	.5	1.0	.7	.4	.6	.1	3.5
4	.4	.9	.8	.9	2.0	1.4	1.2	.3	8.0
3	1.7	1.5	2.5	2.1	4.5	3.4	2.5	.6	18.9
2	4.0	4.4	4.2	2.3	8.0	6.7	4.4	1.7	35.6
1	3.5	8.5	3.6	1.3	5.8	5.6	4.1	.7	33.0
TOTALS	9.8	15.6	11.8	7.5	21.0	17.8	13.1	3.4	100.0

PRIMARY WAVE DIRECTION
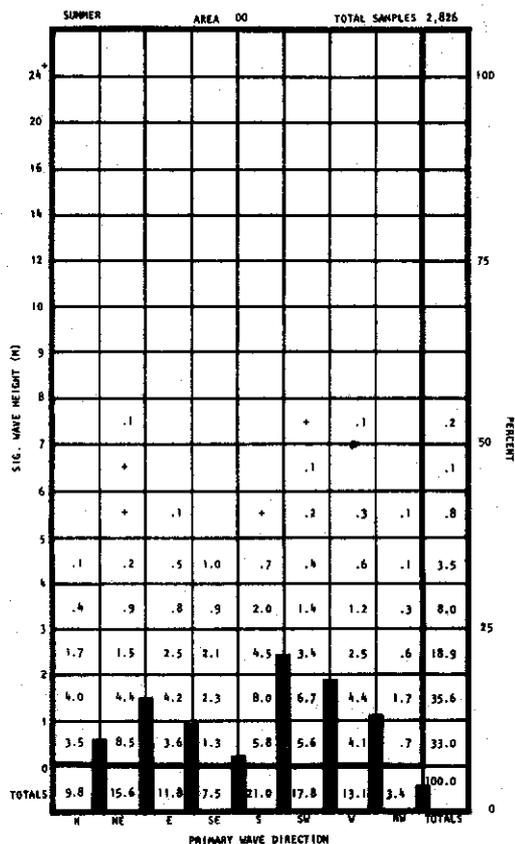
Figure A-00-4-3 Significant Wave Height by Wave Direction

SUMMER — AREA 00 — TOTAL SAMPLES 2,826

PERCENT   0   50   100

WIND SPEED AT 19.5 M (KNOTS)

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
48		+							+
41		1			.1	.2	.1		.5
34	+	.4	.1	.2		.3	.3	.1	1.5
28	.3	1.5	.7	.7	.7	1.2	1.2	.8	7.2
22	1.8	2.4	1.5	1.6	1.3	2.1	2.2	1.3	14.1
17	3.8	4.6	2.4	3.3	4.1	5.5	3.7	3.5	30.9
11	5.2	3.4	2.7	2.5	2.7	3.2	2.9	3.5	26.0
7	2.0	1.6	1.2	1.3	1.6	1.5	1.7	1.7	12.6
4	.7	1.0	.8	1.2	.6	.7	.8	1.3	7.1
TOTALS	13.8	15.1	9.3	10.8	11.0	14.6	13.0	12.3	100.0
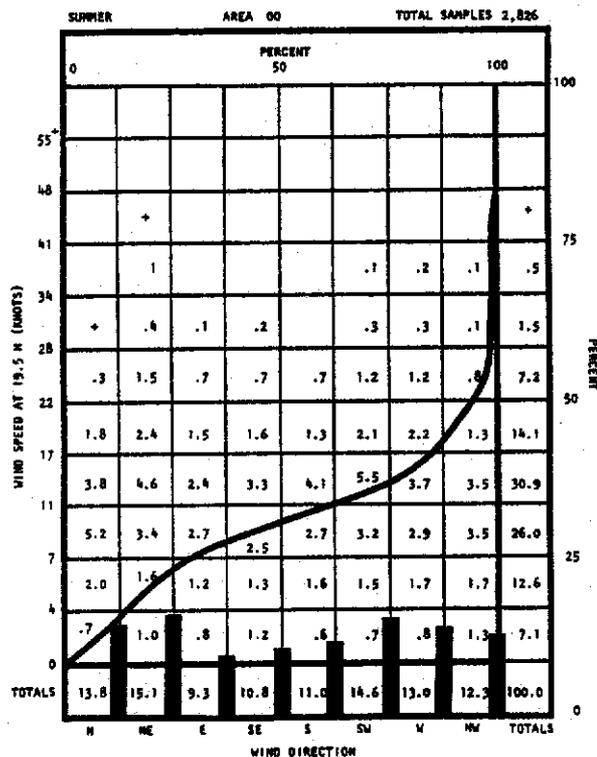
WIND DIRECTION

Figure A-00-4-4 Wind Speed by Wind Direction

	SUMMER		AREA 00					TOTAL SAMPLES 2,826			
14.0⁺											8
9.0											
6.0						.3			.3		7
4.0	.1	.2	.5	.9	2.8	2.5			7.0		6
2.5	.4	.6	2.7	3.8	5.2	.1			12.7		5
1.25	2.1	5.6	17.3	12.6	.6				38.2		4
0.5	6.6	12.1	11.2	.1					30.0		3
0.1	5.8	5.8	.3						11.9		2
0											1
	14.8	24.4	31.9	17.3	8.6	2.9			100.0		

SIG. WAVE HEIGHT (M)

SEA STATE NO.

0   6   10   16   21   27   47   55   63⁺   TOTALS

WIND SPEED AT 10 M (KNOTS)
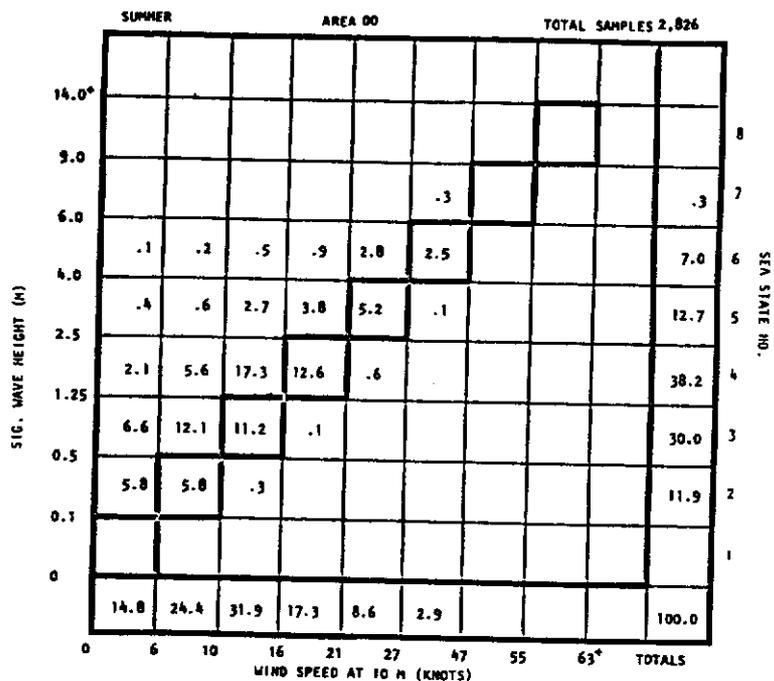
Figure A-00-4-5 Significant Wave Height by
Wind Speed   (WMO Sea State Chart)
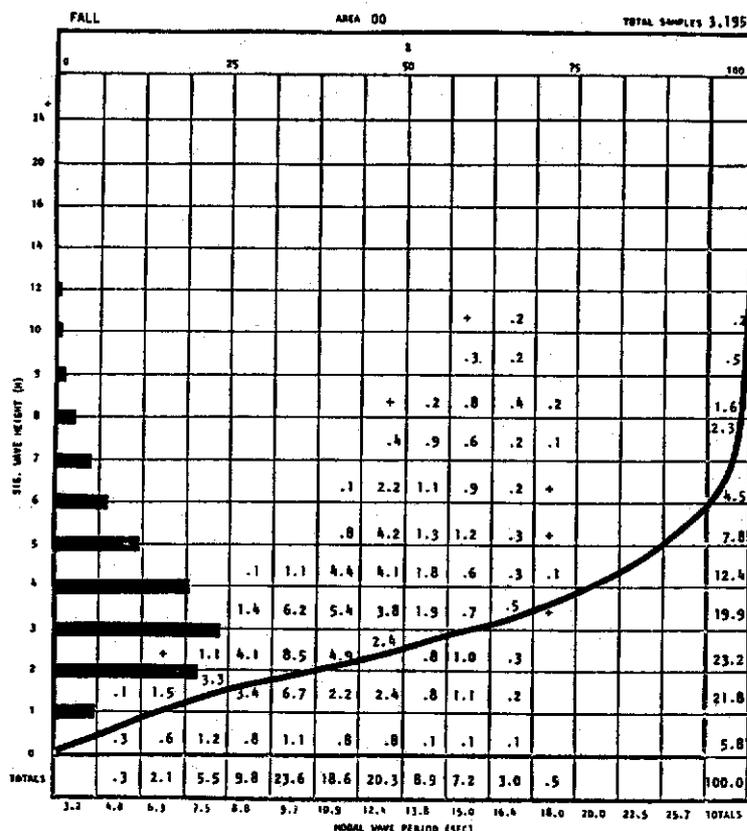
Figure A-00-5-1 Significant Wave
Height by Modal Wave Period
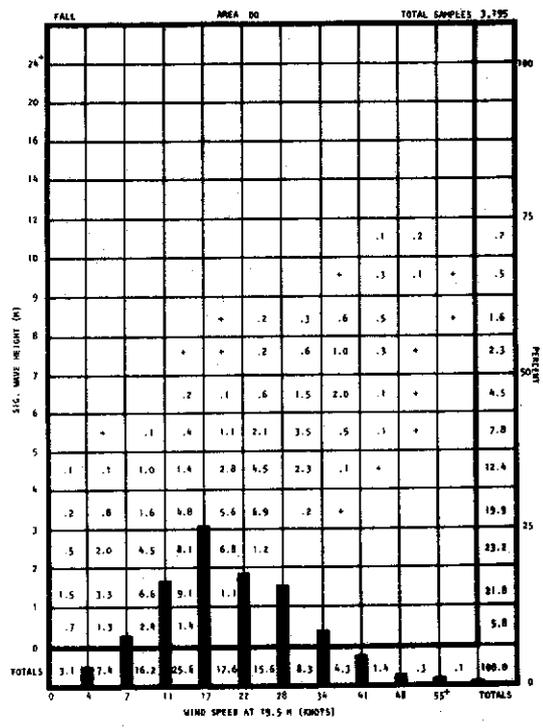
Figure A-00-5-2 Significant Wave
Height by Wind Speed

FALL · AREA 00 · TOTAL SAMPLES 3,195

SIG. WAVE HEIGHT (M)

	N	NE	E	SE	S	SW	W	NW	TOTALS
12		*				*		.2	.2
10		.1	.1			.1	.3		.5
9	.1	.2	.3		.1	.3	.7		1.6
8	.1	.1	.4	.3	.2	.4	.7	*	2.3
7	.2	.7	.4	.3	.9	.4	1.5	.1	4.5
6	.5	1.2	1.4	.7	1.0	.8	2.1	.2	7.8
5	1.0	1.7	2.3	1.2	1.8	1.2	2.9	.4	12.4
4	1.6	2.4	3.5	1.5	3.1	2.3	5.1	.5	19.9
3	2.0	3.0	3.7	1.7	2.9	2.7	6.8	.3	23.2
2	3.0	2.8	4.4	1.1	2.9	1.8	5.2	.6	21.8
1	.8	1.0	.8	.2	.7	.8	1.3	.2	5.8
TOTALS	9.1	13.3	17.2	6.9	13.6	10.8	26.9	2.3	100.0

PRIMARY WAVE DIRECTION
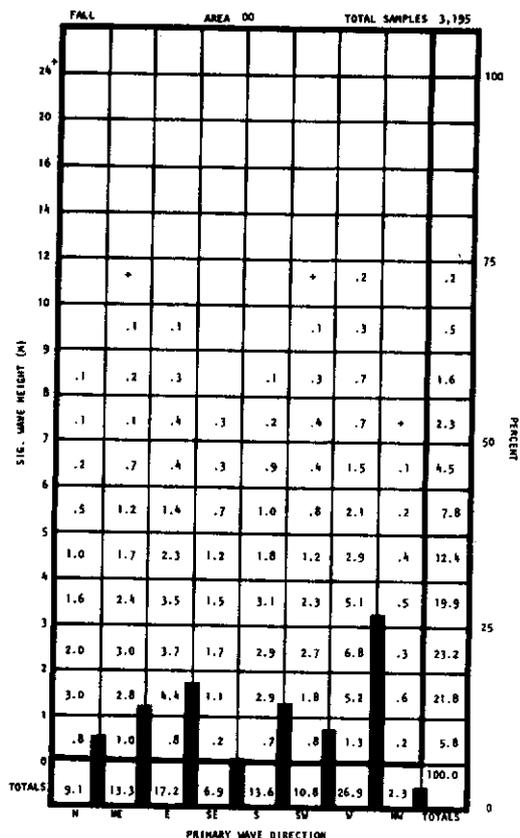
Figure A-00-5-3 Significant Wave
Height by Wave Direction

FALL · AREA 00 · TOTAL SAMPLES 3,195

PERCENT 0 — 50 — 100

WIND SPEED AT 19.5 M (KNOTS)

	N	NE	E	SE	S	SW	W	NW	TOTALS
55+		.1							.1
48		.1			.1	.1	.1		.3
41	.1	.2	.1	.1	.1	.2	.6	.1	1.4
34	.4	.7	.3	.3	.3	.6	1.2	.5	4.3
28	.8	1.6	.8	.7	.5	1.1	1.9	1.0	8.3
22	1.8	2.7	1.2	1.2	1.6	2.2	2.8	2.1	15.6
17	2.5	2.4	1.9	1.7	1.4	2.8	2.3	2.6	17.6
11	2.6	4.6	2.6	1.7	3.2	3.6	4.2	3.2	25.6
7	2.4	1.9	1.6	1.6	1.9	2.3	2.3	2.1	16.2
4	1.3	.8	.8	.8	.8	1.0	.9	.9	7.4
0	.5	.4	.4	.4	.2	.4	.4	.4	3.1
TOTALS	12.3	15.5	9.6	8.5	10.0	14.3	16.8	12.9	100.0
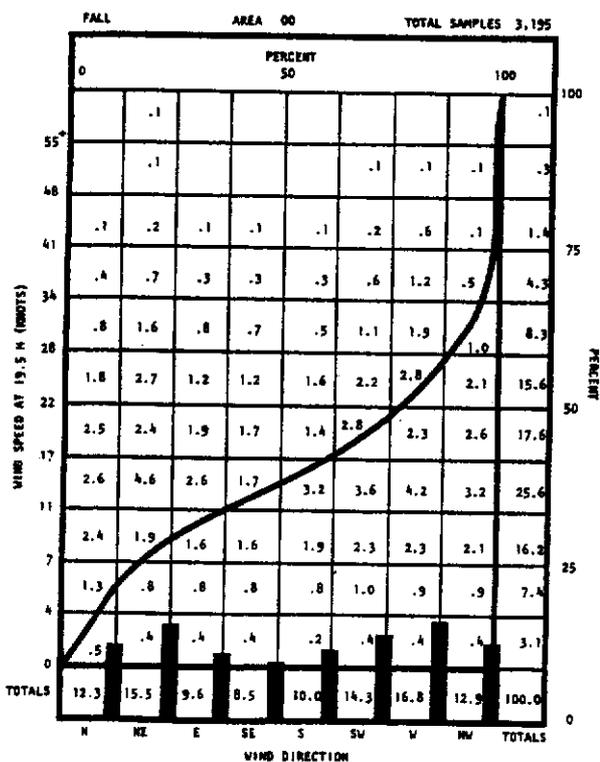
WIND DIRECTION

Figure A-00-5-4 Wind Speed by
Wind Direction

FALL   AREA 00   TOTAL SAMPLES 3.195

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+											
9.0						.4	.3	+		.7	8
6.0			.1	.3	.8	7.0	.1	+		8.4	7
4.0	.5	1.3	3.3	6.0	9.7	8.0	+			28.8	6
2.5	1.0	2.6	6.0	7.2	5.6	.1				22.6	5
1.25	3.8	7.2	12.5	5.7	.2					29.3	4
0.5	2.0	3.2	4.2	+						9.3	3
0.1	.4	.4	+							.9	2
0											1
	7.8	14.6	26.0	19.2	16.4	15.5	.5	.1		100.0	

WIND SPEED AT 10 M (KNOTS)
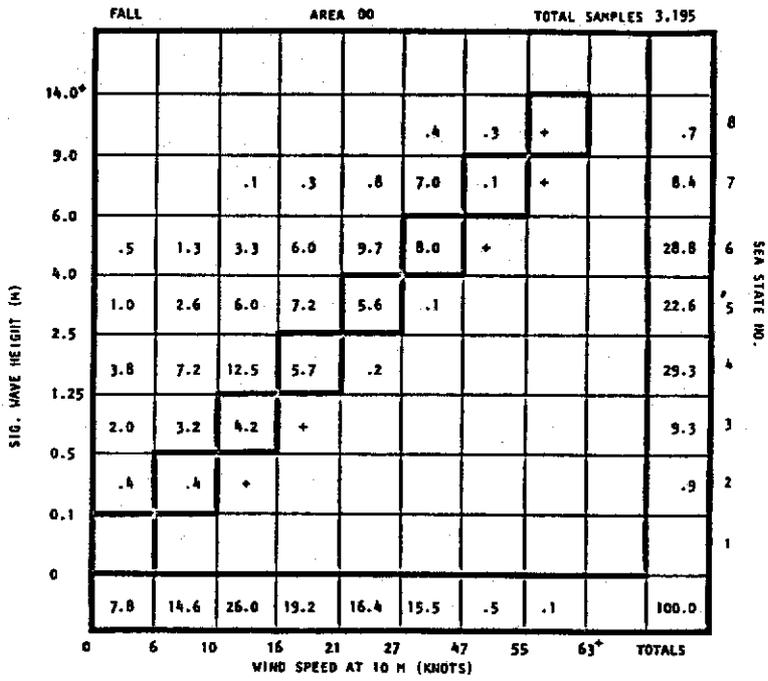
Figure A-00-5-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

TABLE A-1-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 52.755° N, 33.765° W.

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	1	3	7.5	3.5	2.5
Wave Period, sec	6.5	10.5	16	11	12.5
Direction	-	-	-	-	S - W
Winds					
Speed, knots	5	17	36	18	14
Corresponding Mean Sig. Wave Height, m.	1.5	3	7.5	3	2.5
Direction	-	-	-	-	SW - W
Visibility, nautical miles	1.5	9	22	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	-	7	8	-	-
Low clouds, in eighths of sky obscured	1	6.5	8	-	-
Precipitation (Occurrence)	All precipitation - 25% of the time		Snow - 6% of the time (Dec - Mar)		
Relative Humidity, %	60	82	98	-	-
Air Temperature, °C	3.5	8	12.5	8	-
Surface Water Temperature, °C	6	8.5	13	-	-
Sea Level Pressure, millibars	987	1,009	1,028	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	322	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	None

Figure A-1-1-1 Significant Wave
Height by Modal Wave Period

Figure A-1-1-2 Significant Wave
Height by Wind Speed
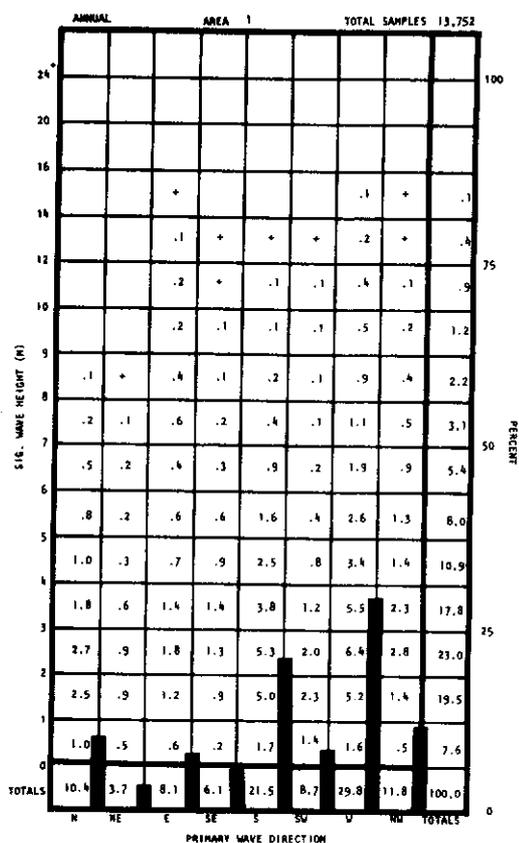
Figure A-1-1-3 Significant Wave
Height by Wave Direction
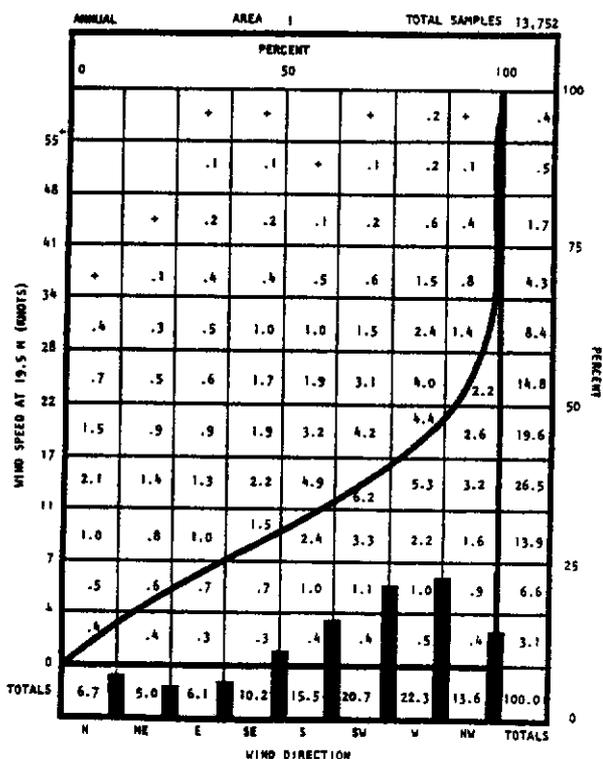
Figure A-1-1-4 Wind Speed by
Wind Direction

ANNUAL					AREA 1				TOTAL SAMPLES 15,752	
						◆	.1	.1	.1	
14.0⁺			◆	◆	◆	1.6	.6	.3		2.6	8
9.0											
	.1	.1	.4	.7	1.5	8.1	.1		11.1	7
6.0											
	.5	1.2	3.6	5.7	9.9	6.9			27.9	6
4.0											
	.9	1.8	5.7	7.8	4.8	.1			21.3	5
2.5											
	2.6	4.5	12.2	6.3	.2	◆			25.8	4
1.25											
	2.2	3.7	3.6	◆					9.5	3
0.5											
	.8	.7	◆						1.6	2
0.1											
										1
0											
	7.3	12.1	25.7	20.6	16.5	16.8	.7	.3	.1	100.0

SIG. WAVE HEIGHT (M) — SEA STATE NO.

WIND SPEED AT 10 M (KNOTS): 0   6   10   16   21   27   47   55   63⁺   TOTALS
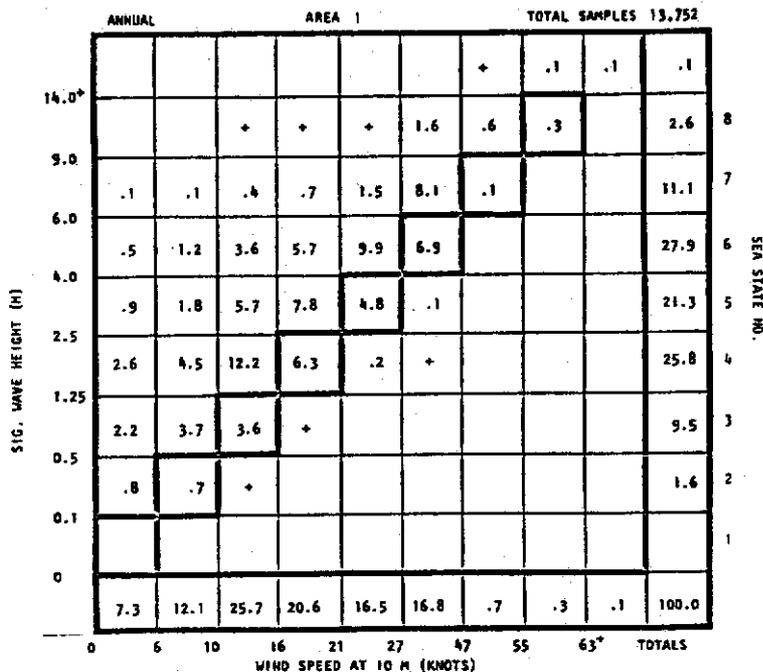
Figure A-1-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
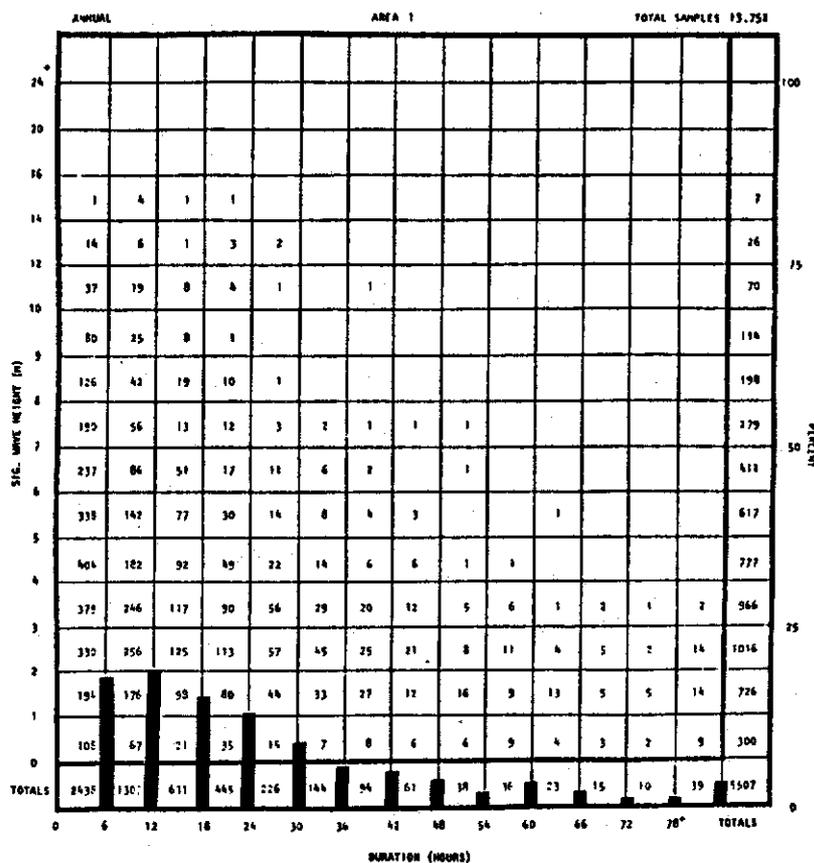
Figure A-1-1-6 Persistence of
Significant Wave Height

A-48

ANNUAL   AREA I   TOTAL SAMPLES 12,752

Wind Speed (knots)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+	12	3	3	4	1									23
48	35	8	3	1	1									48
41	79	38	14	5		1				1				138
34	209	84	33	9	10	2								347
28	382	132	68	35	8	7	4	1		1				638
22	578	253	114	61	27	14	4	2	1					1054
17	791	306	164	79	34	19	12	3		2		1		1411
11	795	394	188	104	56	44	25	10	4	6	2	2	2	2	1634
7	682	257	120	38	24	11	3	2		2		1		1140
4	415	157	56	21	6	1	1	1						658
0	203	84	48	5	4	1		2						347
TOTALS	4181	1716	811	362	171	100	49	21	5	11	3	4	2	2	7438

WIND SPEED AT 19.5 M (KNOTS)

DURATION (HOURS)

PERCENT
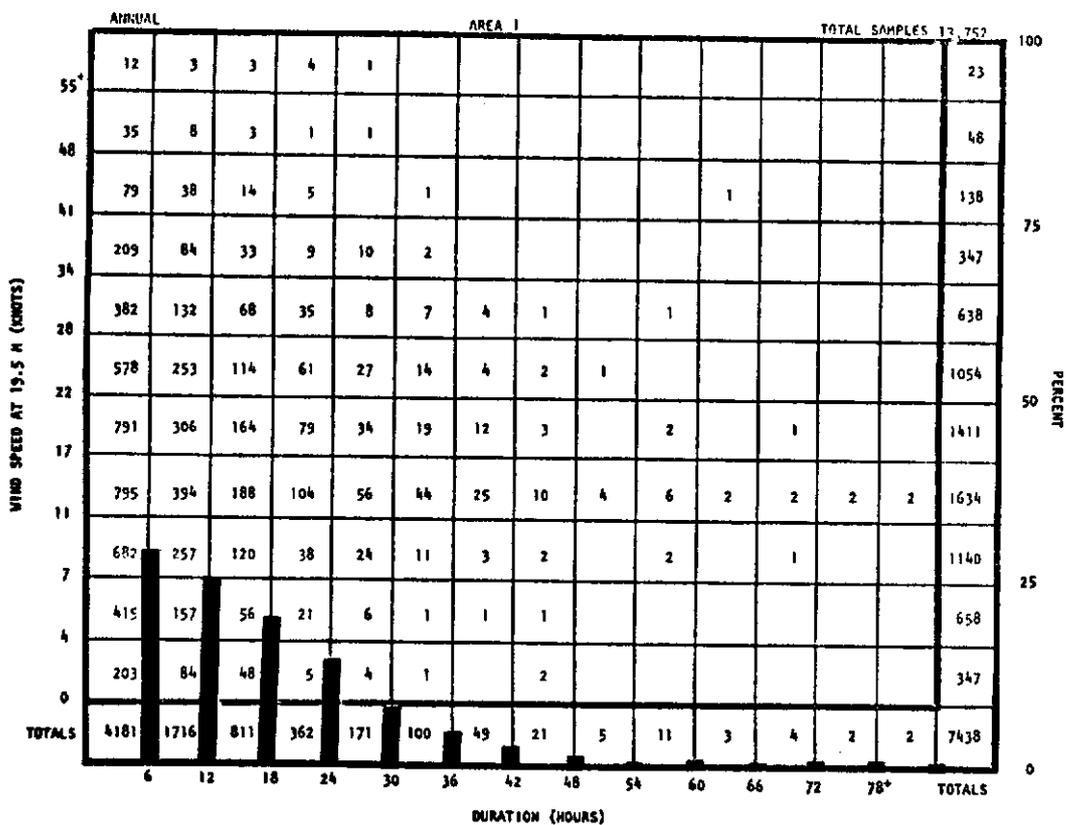
Figure A-1-1-7 Persistence of
Wind Speed
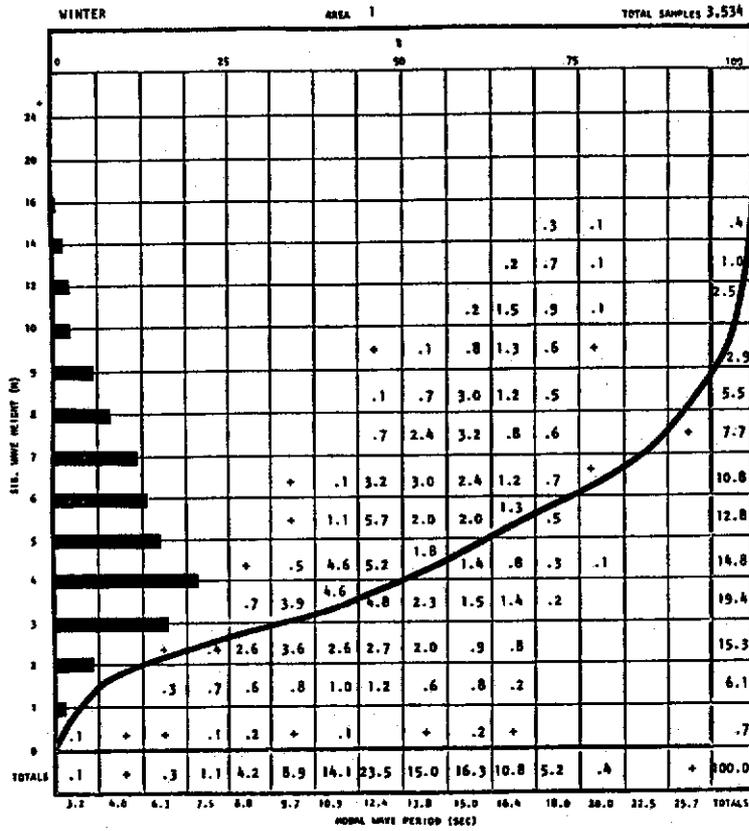
Figure A-1-2-1 Significant Wave
Height by Modal Wave Period
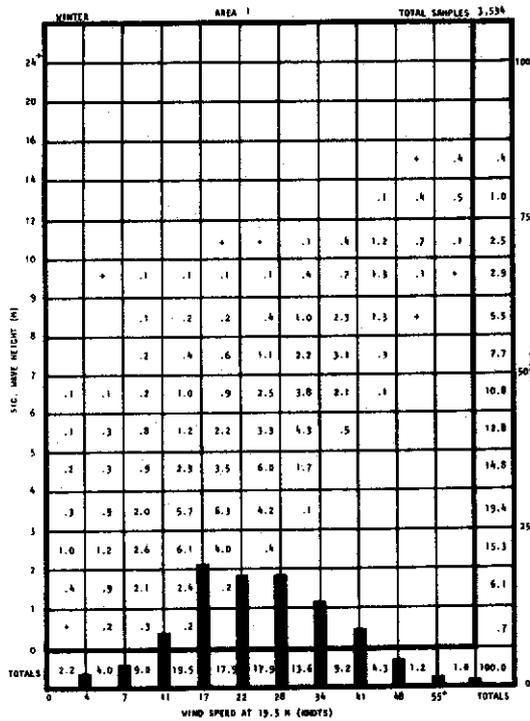
Figure A-1-2-2 Significant Wave
Height by Wind Speed

WINTER   AREA 1   TOTAL SAMPLES 3,534

SIG. WAVE HEIGHT (H)	N	NE	E	SE	S	SW	W	NW	TOTALS
15			.1				.3		.4
13			.2	+	+	+	.7	.1	1.0
11			.7	+	.2	.2	1.1	.3	2.5
10			.8	.2	.2	.1	1.0	.5	2.9
9	.4	+	1.1	.4	.5	.2	2.2	.7	5.5
8	.6	.2	1.7	.5	1.1	.4	2.5	1.0	7.7
7	1.3	.6	1.2	1.0	2.0	.4	3.0	1.3	10.8
6	1.2	.3	1.5	1.6	2.7	.8	3.2	1.6	12.8
5	1.4	.2	1.4	1.7	3.3	1.2	3.9	1.6	14.8
4	2.7	.9	2.6	1.6	4.4	1.1	4.3	1.8	19.4
3	2.1	.8	2.3	1.4	3.7	.9	2.8	1.4	15.3
2	.8	.3	.8	.6	1.0	.4	1.6	.5	6.1
1	.4		.1	.1	.2		+		.7
TOTALS	10.6	3.3	14.5	9.1	19.4	5.7	26.7	10.8	100.0

PRIMARY WAVE DIRECTION
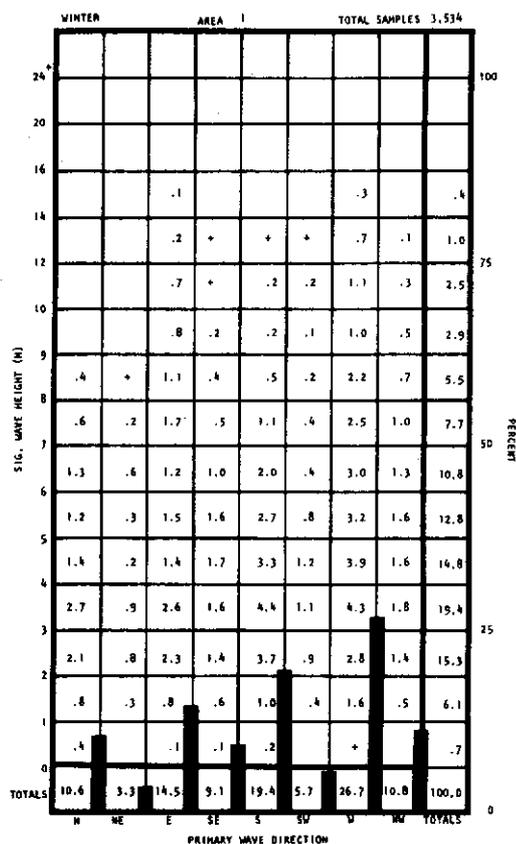
Figure A-1-2-3 Significant Wave
Height by Wave Direction

WINTER   AREA 1   TOTAL SAMPLES 3,534

PERCENT   0   50   100

WIND SPEED AT 19.5 m (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
55+			.2	.1		+	.7	.1	1.0
48			.3	.2	+	.2	.4	.2	1.2
41			.7	.6	.3	.5	1.3	1.0	4.3
34	+	.1	1.2	1.3	1.3	1.4	2.5	1.3	9.2
28	.7	.6	1.2	2.3	1.7	2.3	3.5	1.5	13.6
22	.8	1.0	1.2	2.2	2.6	4.2	3.2	1.8	17.9
17	1.5	2.0	1.2	2.3	3.1	3.6	2.7	1.5	17.9
11	1.6	2.1	2.0	2.0	2.7	4.0	3.1	2.0	19.5
7	1.0	.7	1.0	1.3	1.3	1.4	1.2	1.0	9.0
4	.5	.5	.5	.5	.6	.4	.5	.5	4.0
0	.3	.1	.3	.2	.3	.4	.5	.2	2.2
TOTALS	6.5	7.0	9.7	12.9	13.8	18.4	20.6	11.1	100.0
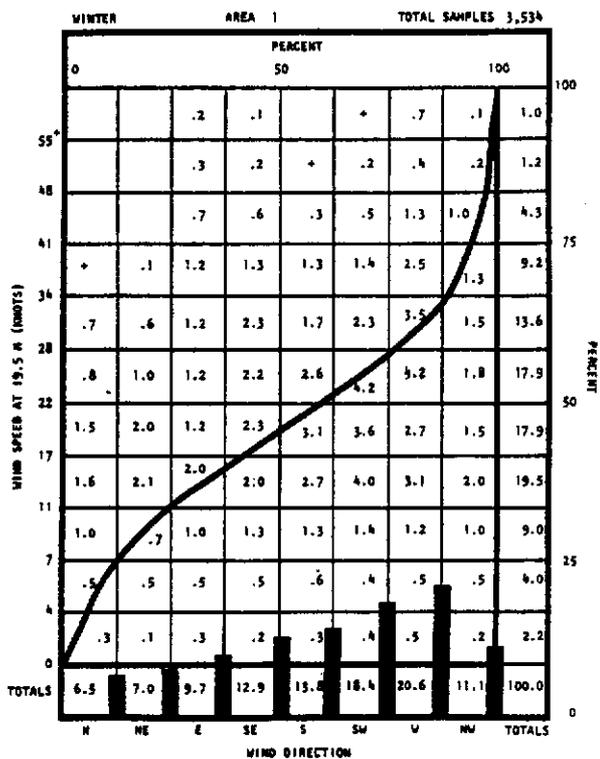
WIND DIRECTION

Figure A-1-2-4 Wind Speed by
Wind Direction

WINTER   AREA 1   TOTAL SAMPLES 3,534

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63	63+	TOTALS	SEA STATE NO.
14.0+							+	.2	.2	.4	
9.0	.1	.1	.1	.1	4.0	1.5	.7	+		6.6	8
6.0	.2	.4	1.2	1.7	3.6	16.7	.1			23.9	7
4.0	1.0	2.5	5.3	7.8	11.7	8.5				36.8	6
2.5	1.2	1.8	5.9	6.5	3.3	+				18.9	5
1.25	1.5	2.7	5.4	1.9	.2					11.8	4
0.5	.3	.7	.5	+						1.6	3
0.1	+	.1	+							.1	2
0											1
TOTALS	4.3	8.2	18.5	18.0	18.9	29.3	1.7	.8	.2	100.0	

WIND SPEED AT 10 M (KNOTS)
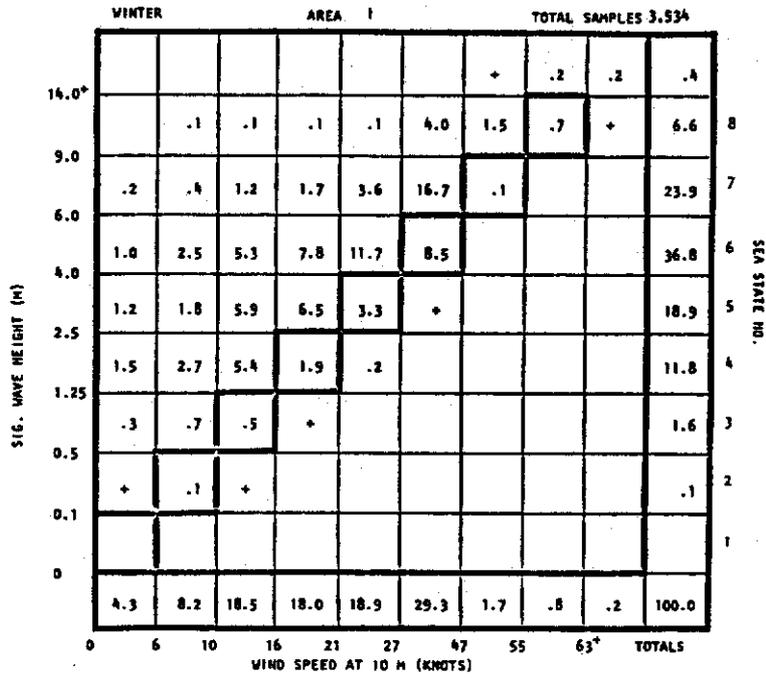
Figure A-1-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

SPRING   AREA 1   TOTAL SAMPLES 3,381

												TOTALS
									.1			.1
							.1	.2				.3
						+	.4	.1	+			.6
					+	.2	.5	.2				.9
			+		+	.3	.7	.3	.1			1.5
				.1	.6	1.2	.2	.1				2.2
			+	1.3	1.3	1.3	.1	.1				4.3
		+	1.1	3.7	1.8	1.0	.6	+	+			8.2
		.7	3.8	5.1	1.6	.8	.8	.1				12.8
	+	1.1	6.3	6.0	5.7	1.7	.8	.6	.2			22.6
	1.3	5.7	6.9	4.5	3.9	1.3	.6	.3	.1			24.7
+	.8	3.2	4.8	3.1	2.5	2.4	.7	.3	.4	.1		18.2
.3	.4	.5	1.3	.3	.5	.2	.2	.1				3.6
TOTALS +	1.1	4.9	12.1	18.4	18.3	22.6	9.6	7.2	4.4	1.2	.1	100.0
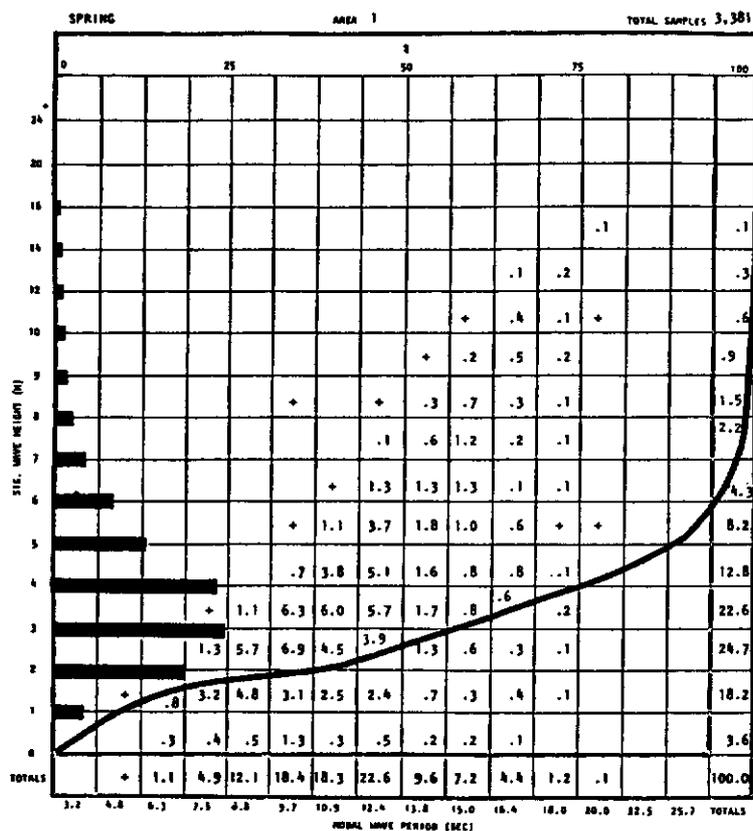
Figure A-1-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 1   TOTAL SAMPLES 3,381

											TOTALS
							+	.1			.1
						+	+	.1	.1		.3
				.1	.1	.1	.1	.2	.1		.6
			+	.1	.1	.2	.4	.1	+		.9
			+	.1	.2	.6	.5	.1			1.5
	.1		+	.1	.3	.7	.9	.1			2.2
+	.1	+	.2	.4	.8	1.7	1.0	+			4.3
+	.1	.2	.9	.5	2.8	2.8	.3				8.2
.1	.2	.7	1.7	3.0	5.0	2.2	+				12.8
.5	.8	2.2	4.5	7.2	6.9	.1					22.6
1.0	1.6	4.5	9.4	7.6	.6						24.7
1.6	3.6	5.1	7.0	.9	+						18.2
.7	1.5	1.0	.5								3.6
TOTALS 3.7	7.5	13.6	24.6	20.2	16.7	8.0	3.3	.1	.4	.3	100.0
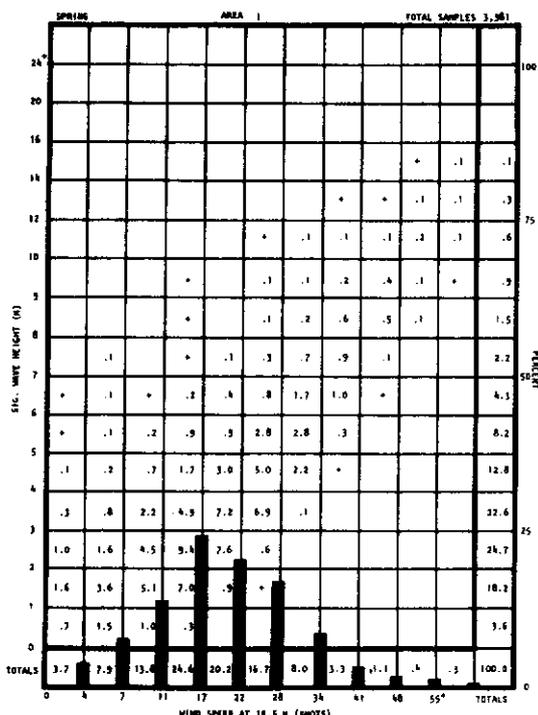
Figure A-1-3-2 Significant Wave
Height by Wind Speed
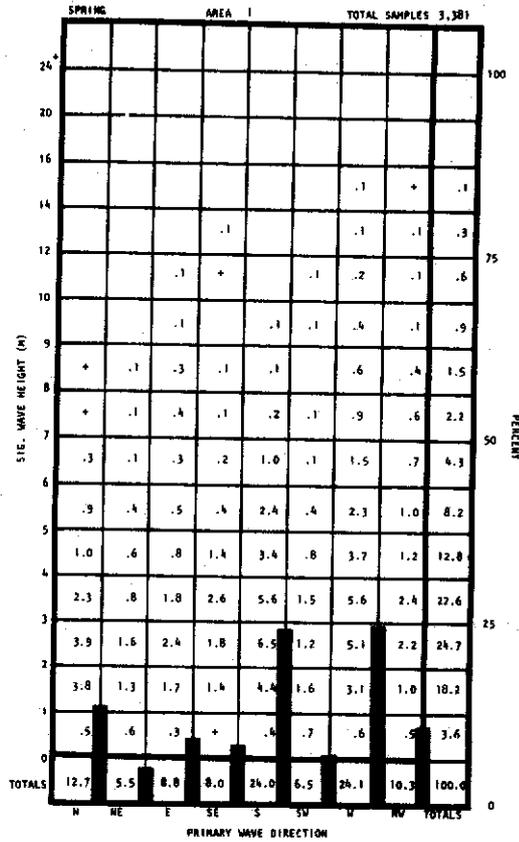
Figure A-1-3-3 Significant Wave
Height by Wave Direction
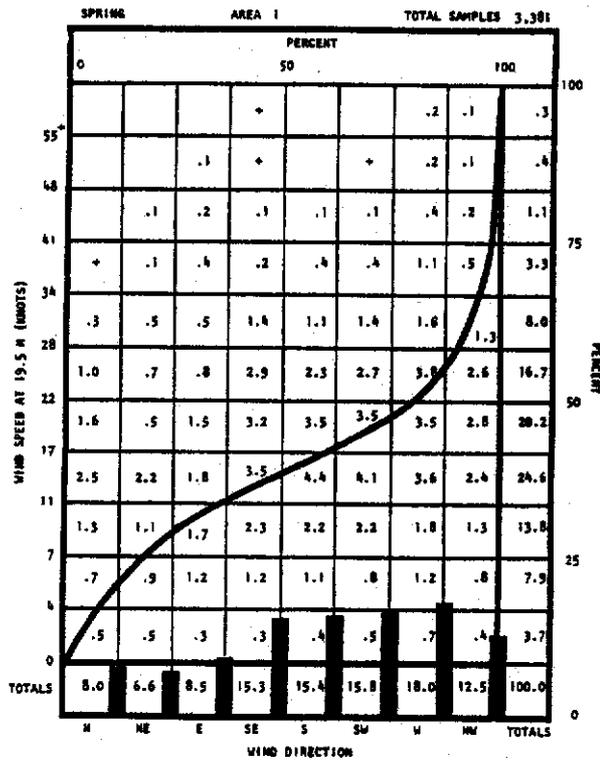
Figure A-1-3-4 Wind Speed by
Wind Direction

SPRING **AREA 1** **TOTAL SAMPLES 3,381**

SIG. WAVE HEIGHT (H)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63+	TOTALS	SEA STATE NO.
14.0+							+	+	.1	
9.0		+		.1	1.0	.3	.2		1.7	8
6.0	.1	.2	.2	.5	1.0	5.8	.2		7.9	7
4.0	.7	1.2	4.4	6.3	11.0	7.4			31.0	6
2.5	1.3	2.7	7.3	8.8	5.5	+			25.6	5
1.25	4.2	5.7	11.7	5.4	+	+			26.9	4
0.5	2.4	2.7	1.4						6.4	3
0.1	.3	.1							.3	2
0										1
TOTALS	8.9	12.4	25.0	21.0	17.6	14.3	.5	.3	100.0	

WIND SPEED AT 10 M (KNOTS)
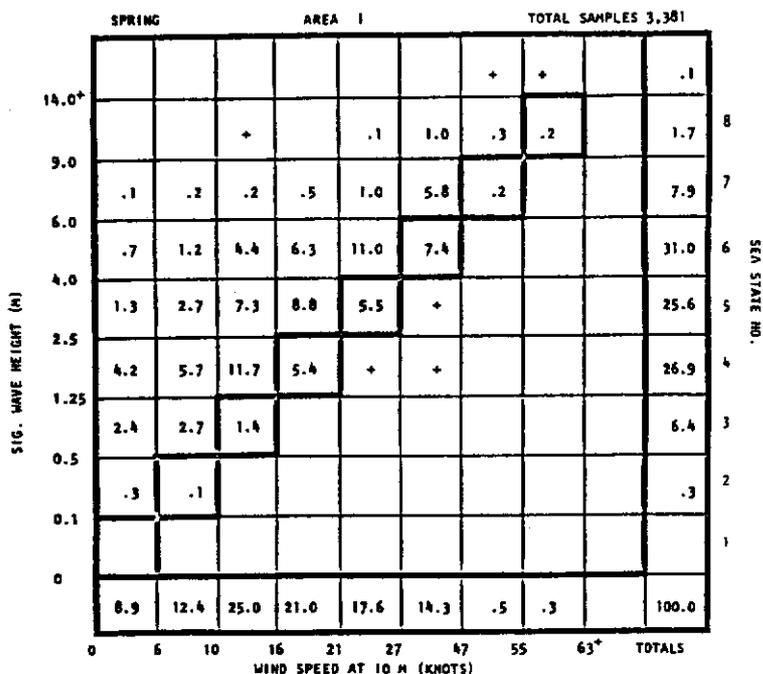
Figure A-1-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
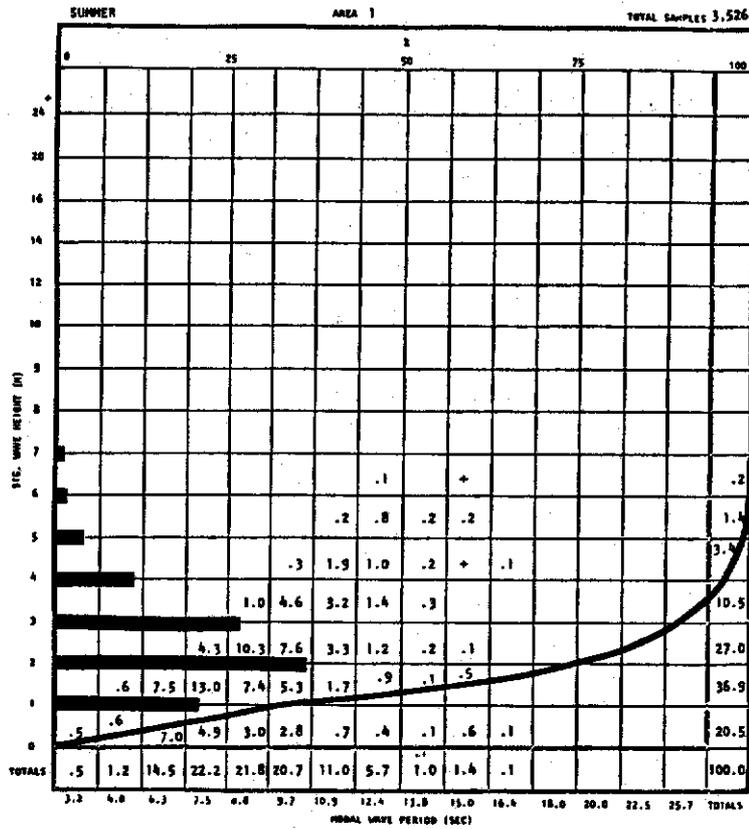
Figure A-1-4-1 Significant Wave
Height by Modal Wave Period
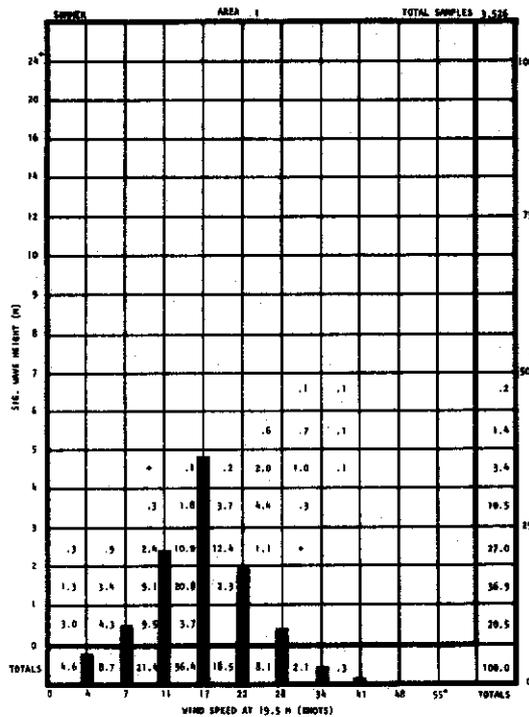
Figure A-1-4-2 Significant Wave
Height by Wind Speed

SUMMER AREA 1 TOTAL SAMPLES 3,526

SIG. WAVE HEIGHT (M) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
				+	.2				.2
	.3	.2		.1	.1	.1	.7	.1	1.4
	.2		.1	.2	.7	.4	1.5	.4	3.4
	.5	.1	.3	.6	1.6	1.3	4.5	1.7	10.5
	1.5	.3	.8	.8	6.3	4.0	9.8	3.5	27.0
	3.8	1.0	1.8	.9	10.3	6.3	10.3	2.5	36.9
	2.6	1.0	1.4	.7	4.7	4.7	4.3	1.0	20.5
TOTALS	8.9	2.6	4.3	3.3	23.6	16.8	31.2	9.3	100.0

PRIMARY WAVE DIRECTION
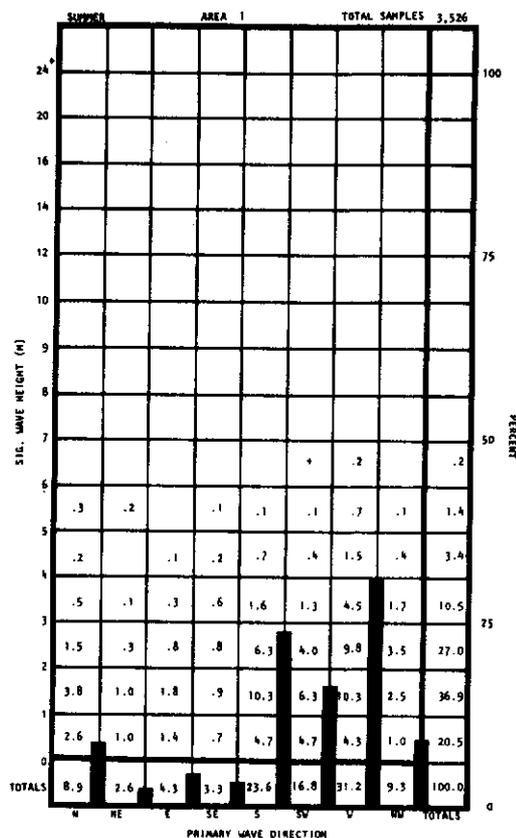
Figure A-1-4-3 Significant Wave
Height by Wave Direction

SUMMER AREA 1 TOTAL SAMPLES 3,526

PERCENT 0 50 100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
	+				.1	.1	.1		.3
	.1	.1		.2	.3	.3	.7	.5	2.1
	.2	.1	.1	.8	.7	1.7	2.8	1.6	8.1
	.6	.3	.3	.9	2.9	5.3	5.7	2.5	18.5
	2.0	.9	.7	2.0	7.3	10.8	8.7	4.0	36.4
	1.1	.8	.7	1.7	4.0	6.8	3.8	2.4	21.4
	.8	.5	.7	.7	1.7	1.8	1.3	1.2	8.7
	.6	.6	.5	.5	.5	.6	.6	.7	4.6
TOTALS	5.5	3.2	2.9	6.9	17.5	27.4	23.7	12.9	100.0
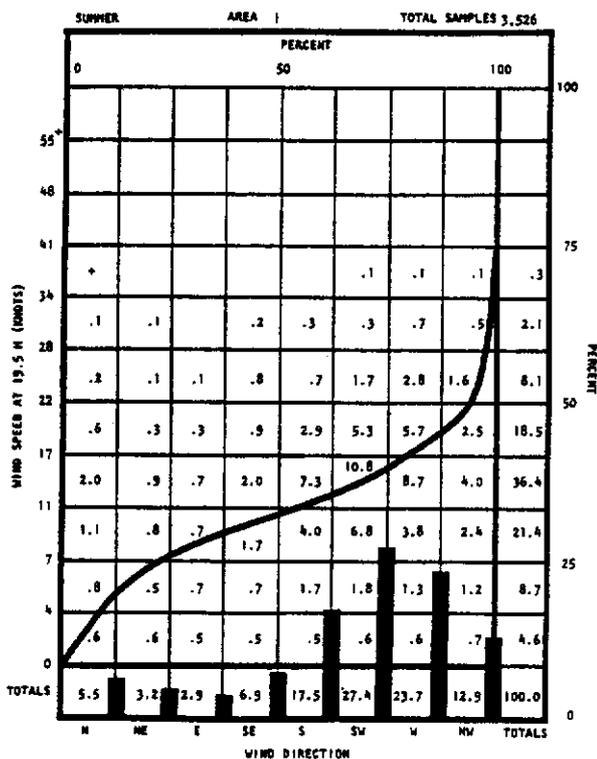
WIND DIRECTION

Figure A-1-4-4 Wind Speed by
Wind Direction
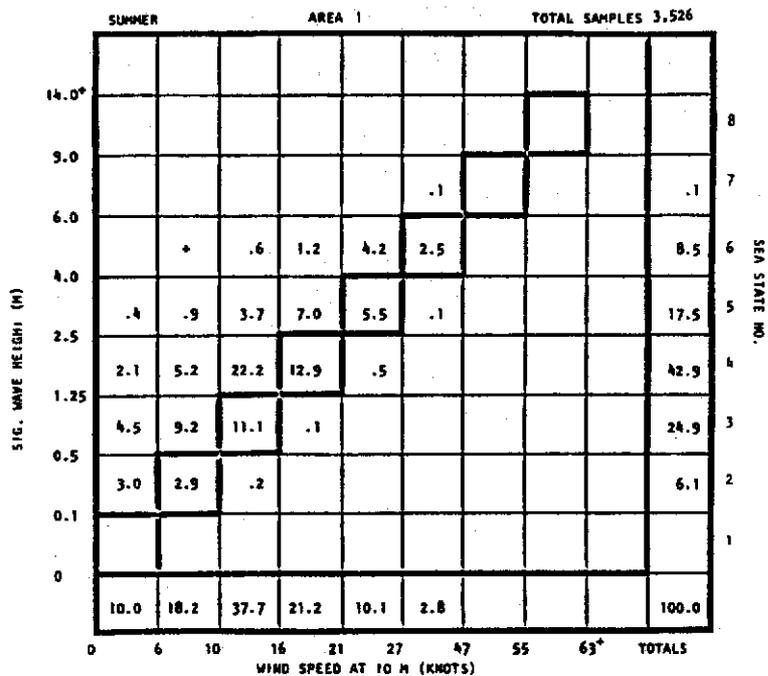
Figure A-1-4-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

FALL   AREA 1   TOTAL SAMPLES 3.311
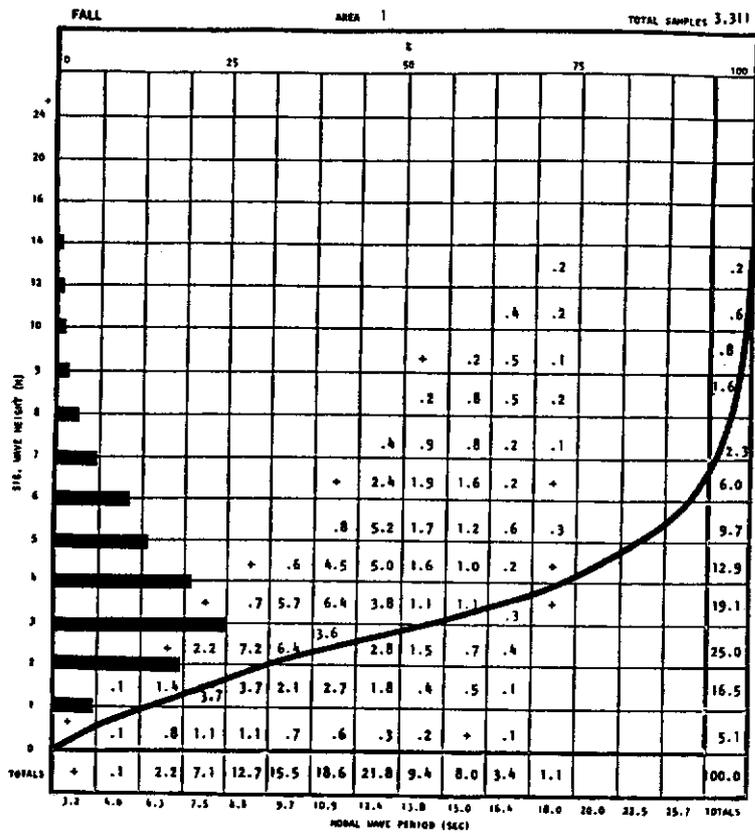
Figure A-1-5-1 Significant Wave
Height by Modal Wave Period

FALL   AREA 1   TOTAL SAMPLES 3.311
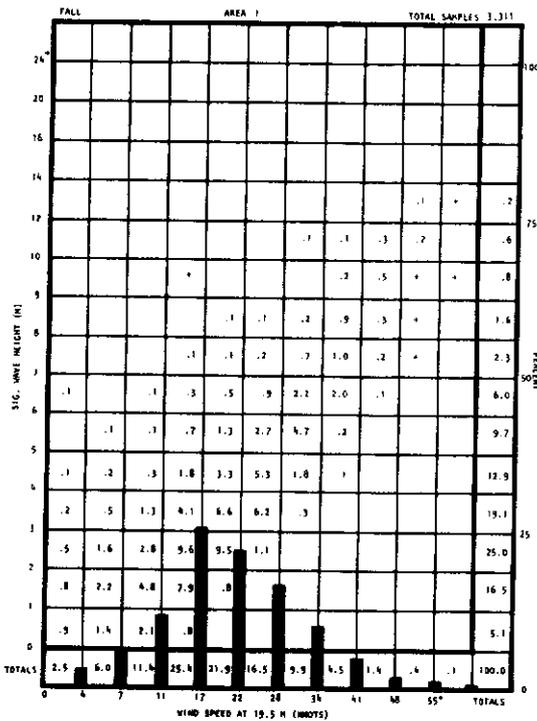
Figure A-1-5-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

A-59
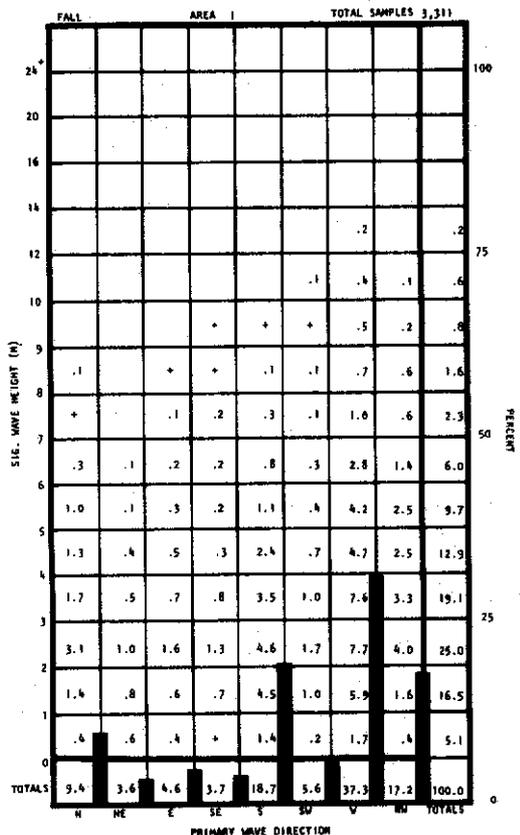
Figure A-1-5-3 Significant Wave
Height by Wave Direction
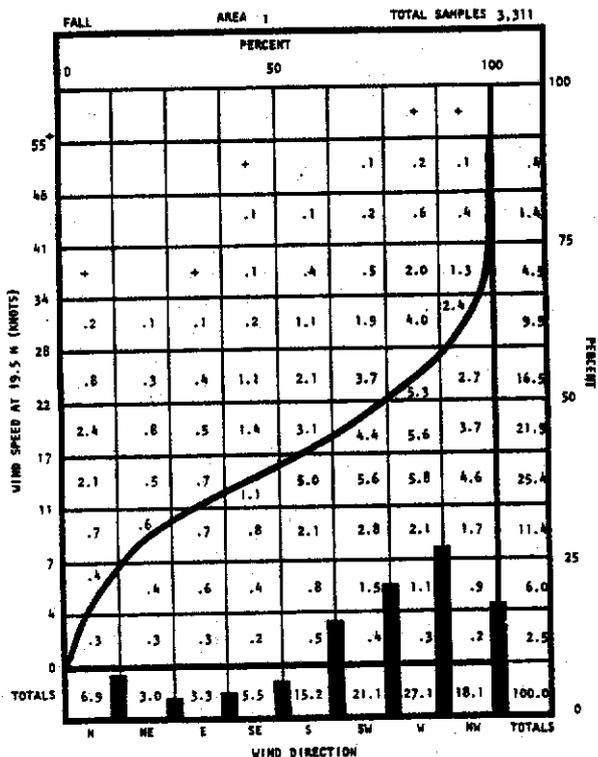
Figure A-1-5-4 Wind Speed by
Wind Direction

FALL				AREA 1				TOTAL SAMPLES 3,311		
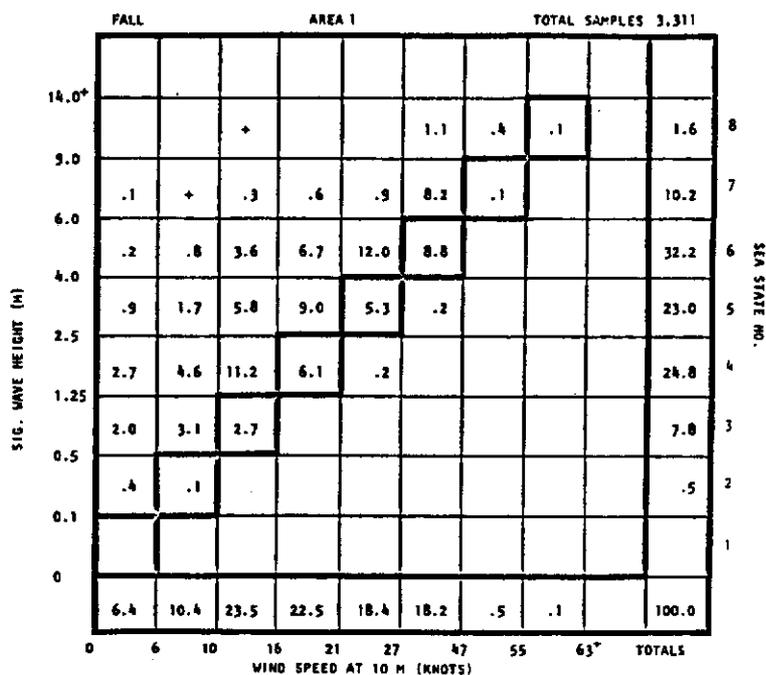
Figure A-1-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-2-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 58.3°N, 12.3°W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	3	7.5	3	2
Wave Period, sec	6.5	11	16	11	12.5
Direction	-	-	-	-	SW - W
Winds					
Speed, knots	5	16	40	18	15
Corresponding Mean Sig. Wave Height, m.	1	2.5	7.5	3	2.5
Direction	-	-	-	-	SW
Visibility, nautical miles	3	10	25	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	1	6.5	8	-	-
Low clouds, in eighths of sky obscured	1	5.5	8	-	-
Precipitation (Occurrence)	All precipitation - 22% of the time		Snow - 5% of the time (Dec-Mar)		
Relative Humidity, %	63	85	98	-	-
Air Temperature, °C	6	9.5	14.5	10	-
Surface Water Temperature, °C	9	10.5	14	-	-
Sea Level Pressure, millibars	990	1,011	1,028	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	320	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	None

A-62

ANNUAL   AREA 2   TOTAL SAMPLES 13,303

SIG. WAVE HEIGHT (M)	3.2	4.6	6.3	7.5	8.8	9.7	10.9	12.4	13.8	15.0	16.4	18.0	20.0	22.5	25.7	TOTALS
16													+	+		+
15												+	.1	+		.1
14											.2	+				.2
12								+	.3	.4	.1					.8
10							+	.1	.4	.3	+	+				.9
9						+	.2	.7	.4	.3	.1			+		1.7
8							.1	.9	.8	.7	.3	+		+		2.8
7						+	1.1	1.2	1.2	.7	.3	+				4.5
6					.5	3.0	1.8	1.4	.6	.3	.1	+				7.7
5				.5	3.5	4.1	1.4	1.2	.6	.3	.2	+				11.8
4			.7	3.8	3.7	3.7	1.2	1.1	.7	.2	.2	+				15.3
3		+	1.3	4.8	4.4	3.2	2.7	1.6	1.4	.6	.2	.3	+			20.5
2	.2	2.0	3.1/3.9	3.2	2.5	2.5	1.3	1.4	.6	.2	.4	+				21.3
1	.3	1.8	1.9	1.3	2.0	1.6	1.5	.4	.5	.4	.1	+				12.4
TOTALS	.4	.5	3.8	7.2	9.9	13.9	15.0	18.7	10.1	9.8	5.9	3.0	1.6	.1	+	100.0

MODAL WAVE PERIOD (SEC)

Figure A-2-1-1 Significant Wave
Height by Modal Wave Period

ANNUAL   AREA 2   TOTAL SAMPLES 13,303

SIG. WAVE HEIGHT (M)	0	4	7	11	17	22	28	34	41	48	55	TOTALS
16								+	+	+		
14						+	+	+	+			.1
12				+	+	+	.1	.1	+			.2
10			+	+	+	.1	.1	.4	.1	+		.8
9		+	+	+	+		.1	.3	.3	+		.9
8		+	+	.1	.1	.1	.3	.7	.4	+		1.7
7		+	+	.1	.1	.6	.7	1.2	.2	+		2.8
6	+	+	.1	.3	.4	.1	1.5	1.1	+	+		4.5
5	.1	.1	.2	.6	1.1	2.2	2.8	.6	+			7.7
4	.1	.2	.6	1.6	2.1	4.5	2.6	.1	+			11.8
3	.2	.5	.9	3.1	4.5	5.5	.4					15.3
2	.4	1.0	2.4	7.2	7.8	1.6	+					20.5
1	1.4	2.3	5.4	10.3	1.8	+						21.3
	1.8	3.4	5.2	1.8	+							12.4
TOTALS	3.9	7.5	14.9	25.1	17.9	15.5	8.6	4.2	1.6	.3	.1	100.0

WIND SPEED AT 19.5 M (KNOTS)
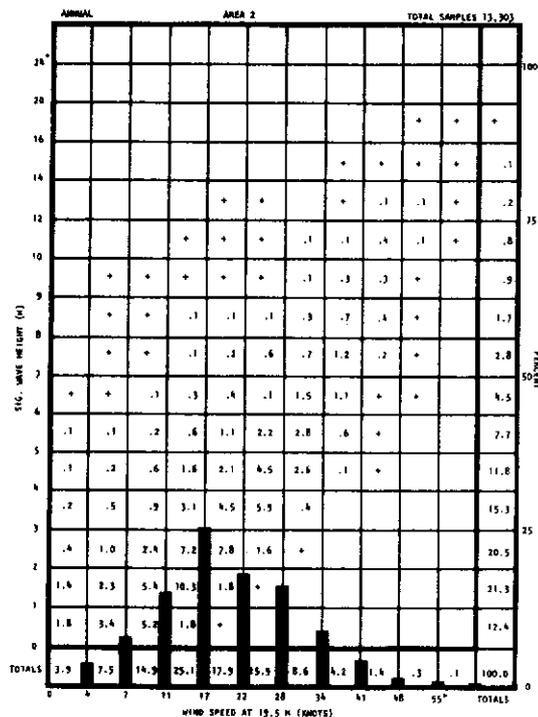
Figure A-2-1-2 Significant Wave
Height by Wind Speed

ANNUAL   AREA 2   TOTAL SAMPLES 13,303

SIG. WAVE HEIGHT (M)

PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
						+	+		+
					.1	+			.1
				+	.1	+		.2	
+			+	+	.3	.4	+	.8	
+			+	.1	.3	.4	+	.9	
+			.1	.1	.6	.8	.1	1.7	
.1	+	+	.3	.2	.9	1.2	.2	2.8	
.3	.1	+	.4	.4	1.5	1.5	.3	4.5	
.4	.4	.1	.7	.7	2.4	2.5	.4	7.7	
1.0	.8	.2	1.2	1.2	3.8	3.0	.6	11.8	
1.7	1.2	.2	1.5	1.6	4.9	3.3	.9	15.3	
2.3	2.0	.5	1.9	2.2	6.6	4.1	.9	20.5	
3.3	3.0	.6	1.6	1.8	5.8	4.2	.9	21.3	
2.2	2.4	.3	.5	1.5	2.8	1.9	.8	12.4	
TOTALS 11.3	10.0	1.9	8.2	9.9	30.1	23.5	5.1	100.0	

PRIMARY WAVE DIRECTION

Figure A-2-1-3 Significant Wave Height by Wave Direction

ANNUAL   AREA 2   TOTAL SAMPLES 13,303

PERCENT

WIND SPEED AT 19.5 M (KNOTS)

PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
				+	+	.1		.1	
+			+	+	.1	.2	+	.3	
.1		.1	.2	.2	.2	.5	.1	1.4	
.7	.1	.3	.6	.6	.8	1.0	.6	4.2	
.5	.3	.7	1.3	1.6	1.9	1.6	.6	8.6	
.8	.6	1.3	2.0	2.9	4.2	2.8	1.4	15.9	
1.4	.9	2.0	2.3	3.1	4.3	2.5	1.4	17.9	
2.7	2.5	2.8	2.8	4.1	4.7	3.2	2.4	25.1	
1.9	2.1	1.7	1.5	1.8	2.2	2.1	1.6	14.9	
1.0	.9	.8	.9	1.1	1.1	.8	.9	7.5	
.5	.5	.5	.5	.5	.4	.5	.5	3.9	
TOTALS 9.1	7.8	10.1	12.2	15.9	20.1	15.4	5.4	100.0	

WIND DIRECTION

Figure A-2-1-4 Wind Speed by Wind Direction
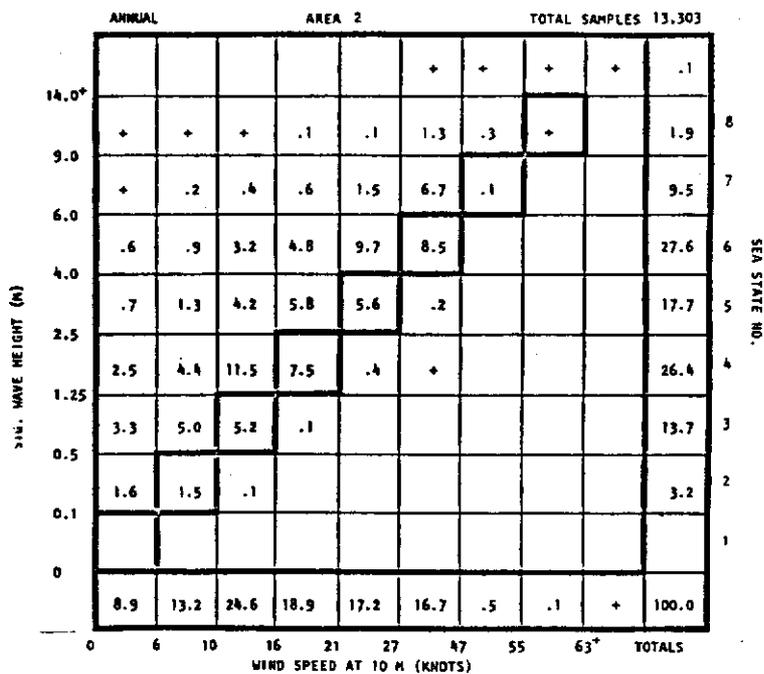
Figure A-2-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
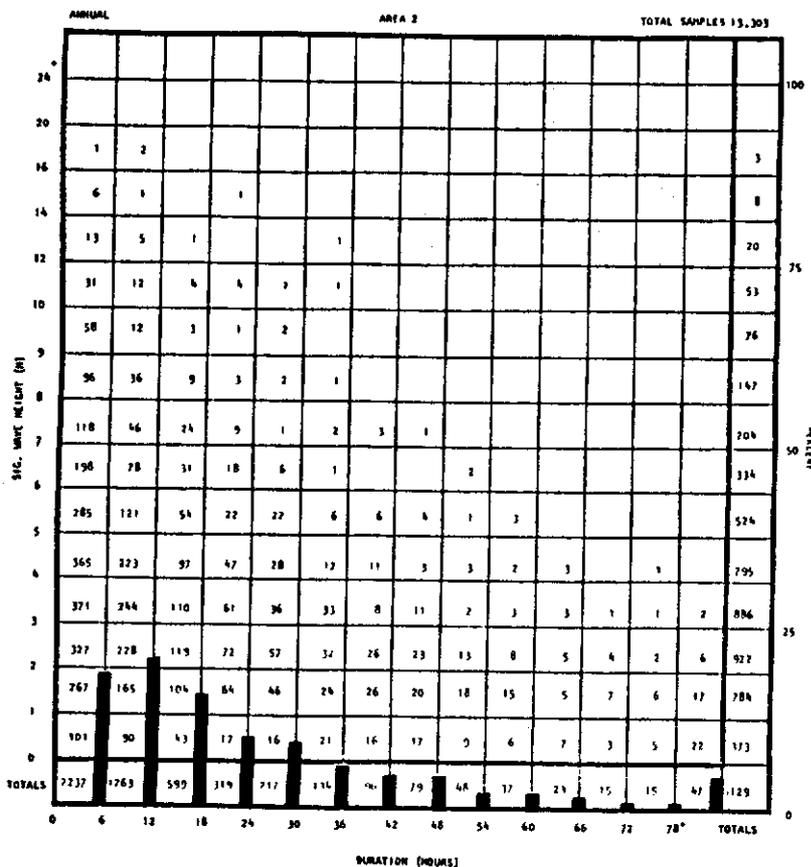
Figure A-2-1-6 Persistence of
Significant Wave Height

ANNUAL | AREA 2 | TOTAL SAMPLES 13,303

Wind Speed	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+	8		1	1										10
48	22	4	4											30
41	52	22	10	7	1	1	1							94
34	154	67	36	12	9	2	4	1						285
28	317	149	67	36	7	5	3	4	1	1				590
22	483	258	120	57	24	18	7	5	7					979
17	752	312	130	49	31	13	11	8	3			2		1311
11	679	376	167	91	51	29	26	10	7	7	3	2	2	1452
7	619	271	104	45	21	14	7	5	2	1	1	2		1092
4	453	172	35	13	16	5	2	2	1	1	1			706
0	250	110	32	12	8	3	2		1	1	1	1		421
TOTALS	3794	1741	706	323	168	90	63	35	22	11	6	7	2	6970

DURATION (HOURS)
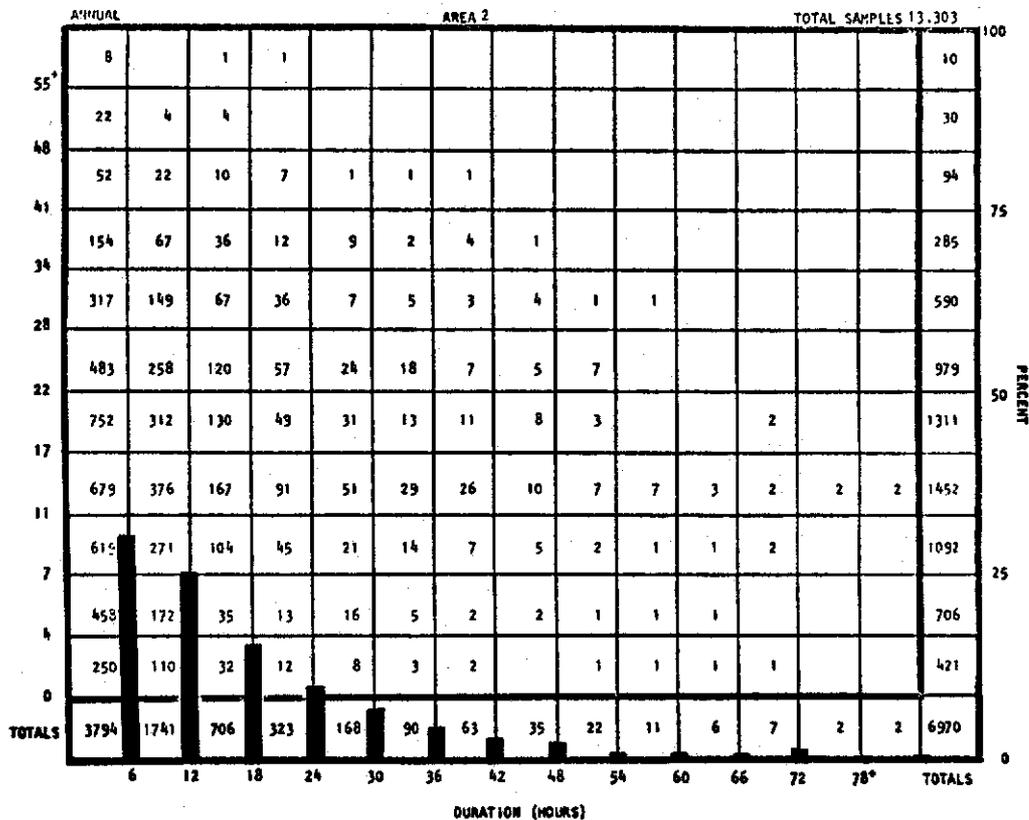
Figure A-2-1-7 Persistence of
Wind Speed

A-66
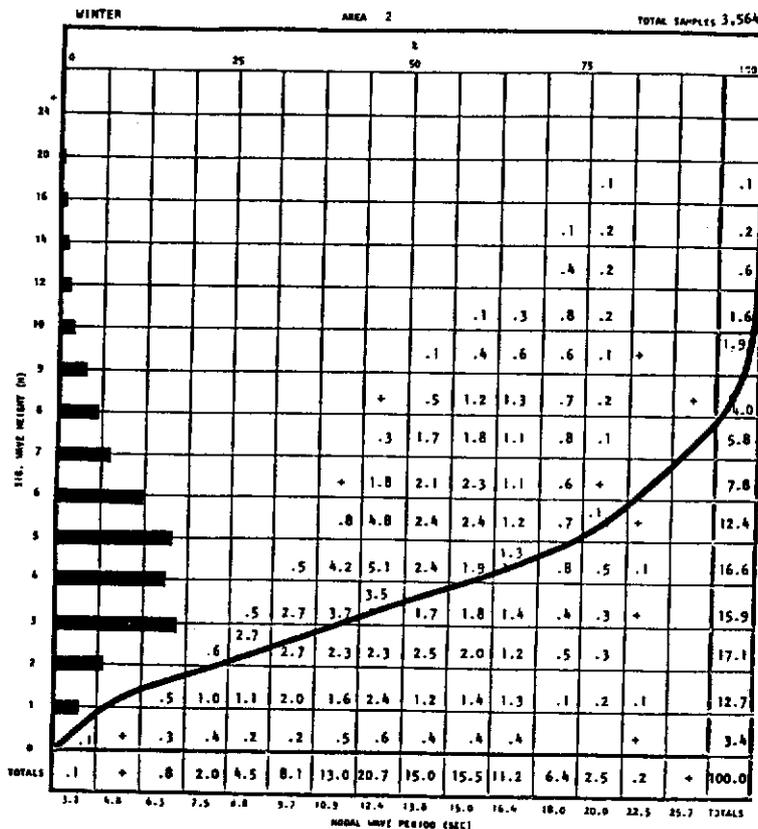
Figure A-2-2-1 Significant Wave
Height by Modal Wave Period
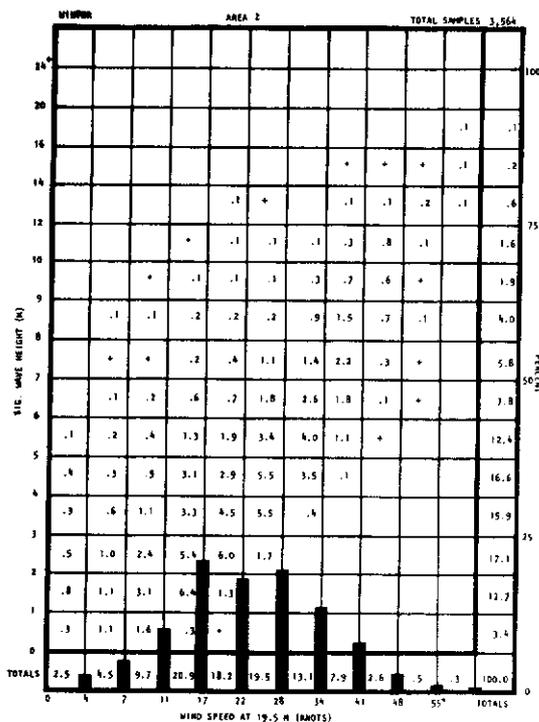
Figure A-2-2-2 Significant Wave
Height by Wind Speed

WINTER — AREA 2 — TOTAL SAMPLES 3,564

SIG. WAVE HEIGHT (M) / PERCENT

Height	N	NE	E	SE	S	SW	W	NW	TOTALS
20							.1		.1
16				+	.1		.1		.2
14					.2		.3	+	.6
12				+	+	.7	.8	.1	1.6
10				.1	.1	.5	1.1	.1	1.9
9	.1			.3	.1	1.4	1.9	.2	4.0
8	.3	.1		.6	.7	2.0	1.9	.2	5.8
7	.7	.2	+	.7	1.1	2.9	1.9	.3	7.8
6	.8	.7	.4	.9	1.3	4.2	3.5	.5	12.4
5	1.9	1.1	.4	1.7	2.0	5.7	3.0	.9	16.6
4	3.0	1.5	.3	1.4	2.5	4.3	2.0	.9	15.9
3	3.4	2.6	.5	1.7	1.7	4.0	2.7	.4	17.1
2	3.5	1.5	.3	1.4	1.7	2.6	1.5	.3	12.7
1	.6	.6	+	.2	.8	.5	.6		3.4
TOTALS	14.1	8.4	2.0	9.0	12.2	29.3	21.2	3.8	100.0

PRIMARY WAVE DIRECTION
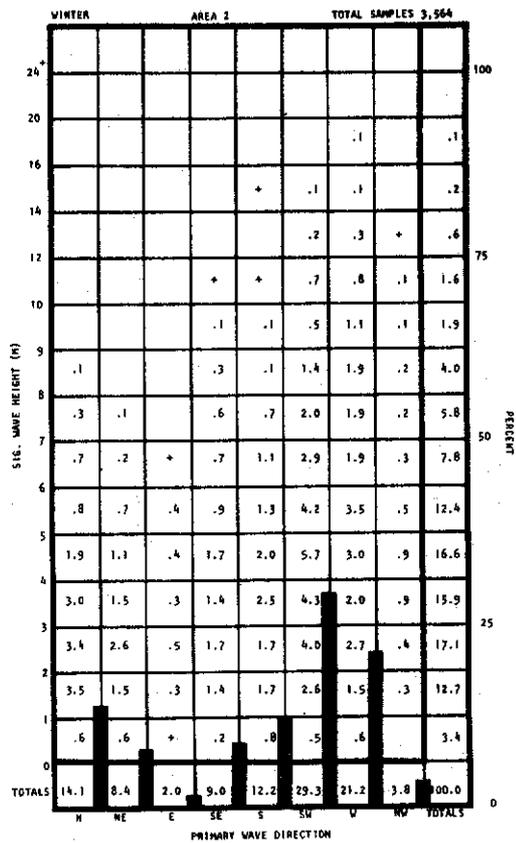
Figure A-2-2-3 Significant Wave Height by Wave Direction

WINTER — AREA 2 — TOTAL SAMPLES 3,564

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

Speed	N	NE	E	SE	S	SW	W	NW	TOTALS
					+	+	.3		.3
55+				.1		.1	.3	.1	.5
48	+		.1	.5	.5	.5	.7	.3	2.6
41	.3	.3	.7	1.1	1.6	1.6	1.7	.7	7.9
34	.8	.3	1.2	1.9	2.9	2.8	2.4	.8	13.1
28	.9	.7	2.2	2.5	3.8	4.6	3.0	1.9	15.5
22	1.8	1.3	3.0	2.4	2.9	3.1	2.2	1.4	18.2
17	2.6	2.3	2.8	2.3	3.0	3.7	2.3	1.9	20.9
11	1.4	1.2	1.0	1.1	1.3	1.2	1.3	1.2	9.7
7	.5	.6	.5	.6	.8	.8	.4	.3	4.5
4	.2	.4	.3	.3	.6		.2	.3	2.5
TOTALS	8.7	7.1	11.8	12.7	17.5	18.5	14.8	8.9	100.0
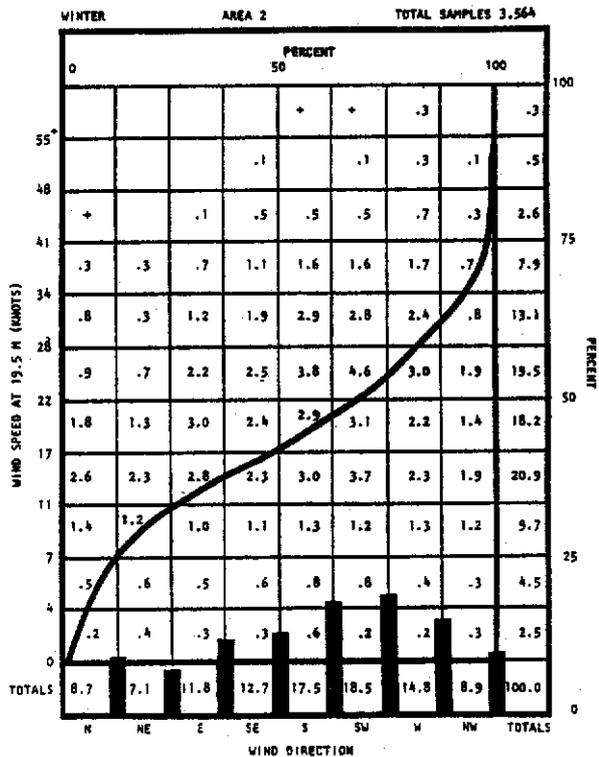
WIND DIRECTION

Figure A-2-2-4 Wind Speed by Wind Direction

WINTER   AREA 2   TOTAL SAMPLES 3,564

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63	63+	TOTALS	SEA STATE NO.
(above 14.0+)						1	+	.1	.1	.3	
14.0+		+	.1	.1	.2	2.7	.5	.1		3.8	8
9.0	.1	.4	.9	1.2	2.6	12.3	.2			17.6	7
6.0	1.1	1.2	5.0	6.6	11.4	11.1				36.6	6
4.0	.9	1.4	3.8	5.2	5.4	.2				16.9	5
2.5	2.0	2.6	8.1	6.0	.3					19.1	4
1.25	1.0	2.1	1.9	+						5.1	3
0.5	.4	.1	.1							.6	2
0.1											1
0											
TOTALS	5.6	7.9	19.8	19.2	19.9	26.4	.7	.2	.1	100.0	

WIND SPEED AT 10 M (KNOTS)
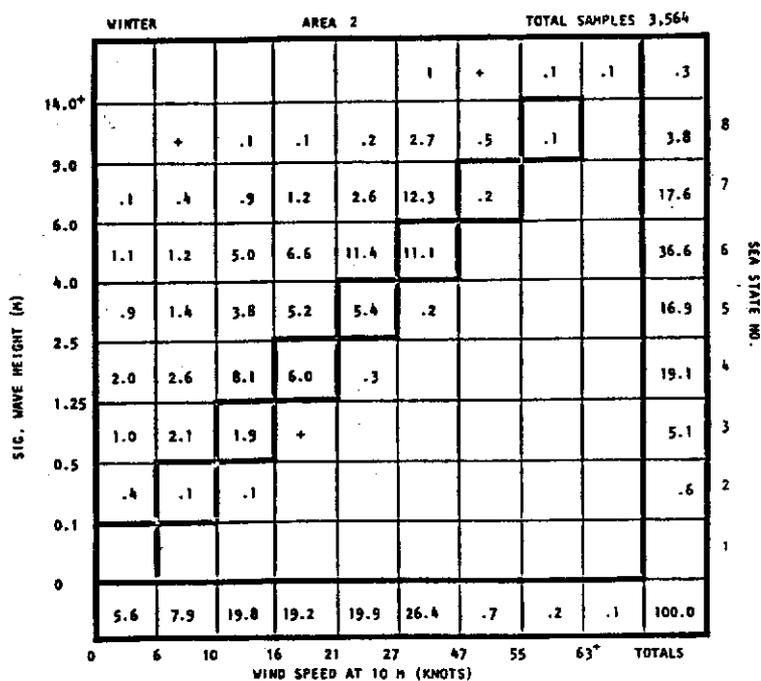
Figure A-2-2-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

N A T O U N C L A S S I F I E D

SPRING   AREA 2   TOTAL SAMPLES 3,371
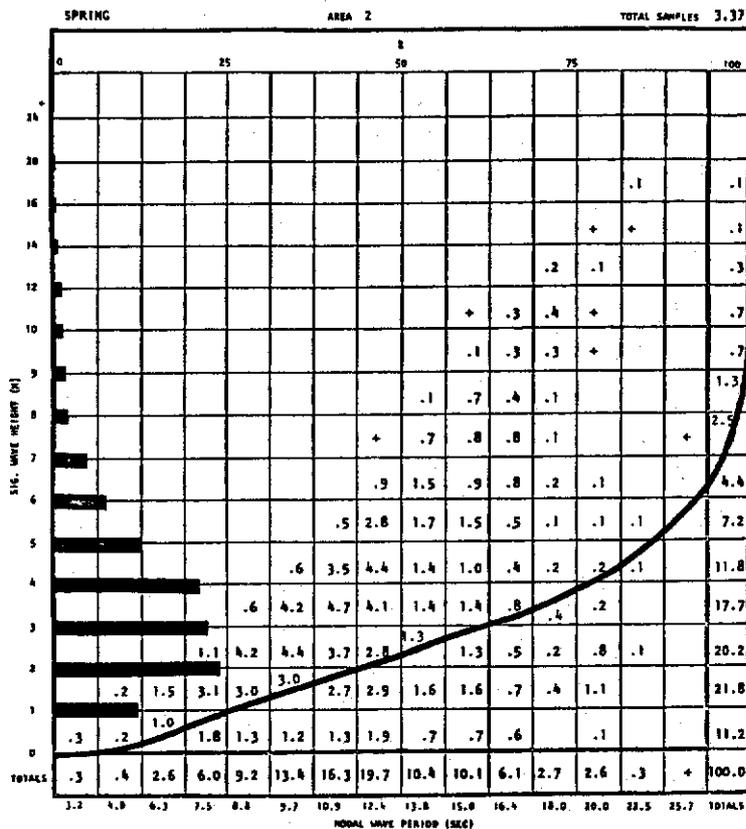
Figure A-2-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 2   TOTAL SAMPLES 3,371
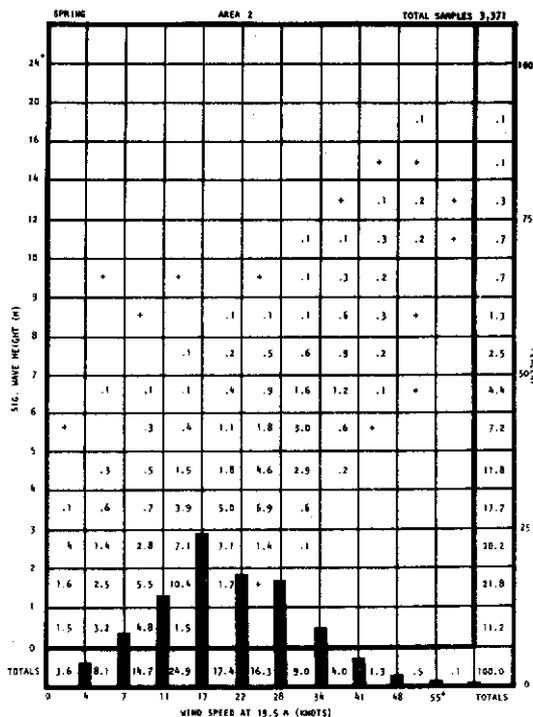
Figure A-2-3-2 Significant Wave
Height by Wind Speed

N A T O U N C L A S S I F I E D

A-70

SPRING   AREA 2   TOTAL SAMPLES 3,371
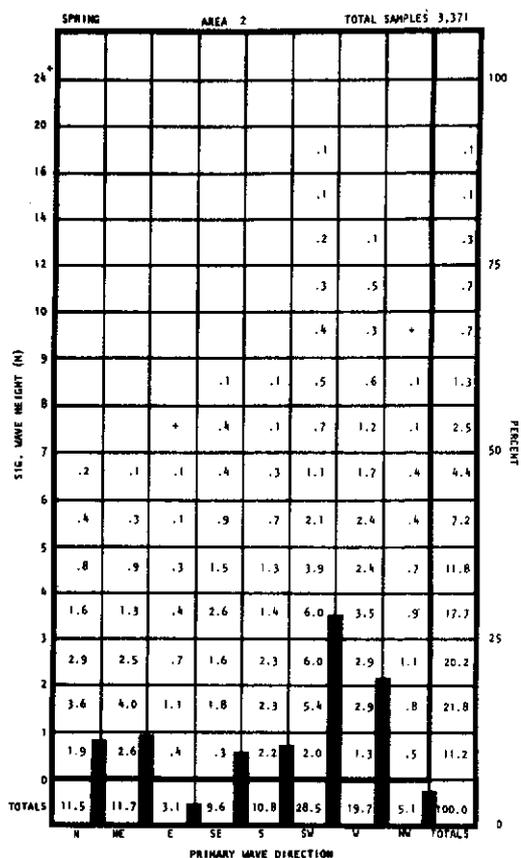
Figure A-2-3-3 Significant Wave
Height by Wave Direction

SPRING   AREA 2   TOTAL SAMPLES 3,371
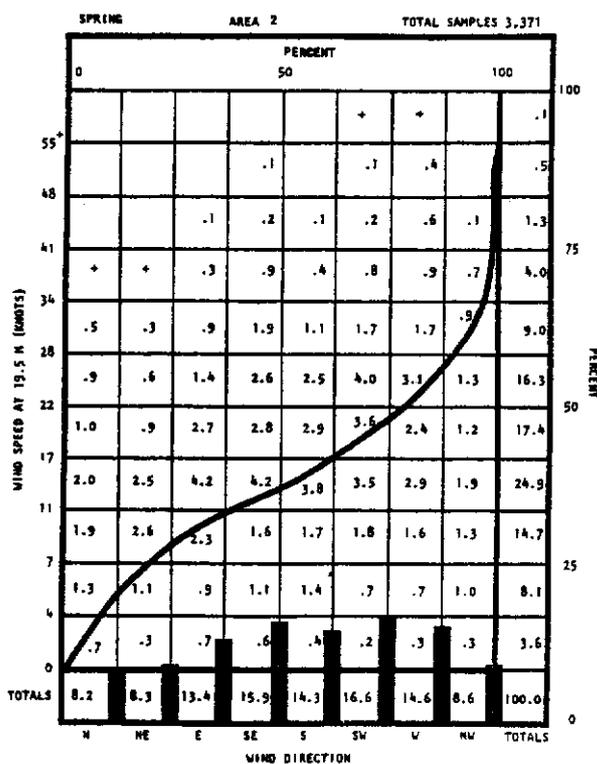
Figure A-2-3-4 Wind Speed by
Wind Direction

SPRING   AREA 2   TOTAL SAMPLES 3,371

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63+	63+	TOTALS	SEA STATE NO.
14.0+						*	.1			.1	
9.0	*		*		*	1.2	.5	.1		1.8	8
6.0	*	.1	.2	.5	1.5	5.7	.1			8.2	7
4.0	.3	.9	3.1	4.7	10.4	9.3				28.7	6
2.5	.9	1.3	4.8	5.5	5.6	.2				18.2	5
1.25	2.6	5.1	11.7	6.9	.6	*				26.9	4
0.5	2.7	5.3	4.8	.1						12.9	3
0.1	1.5	1.6	.1							3.1	2
0											1
TOTALS	8.1	14.3	24.7	17.7	18.1	16.4	.7	.1		100.0	

WIND SPEED AT 10 M (KNOTS)
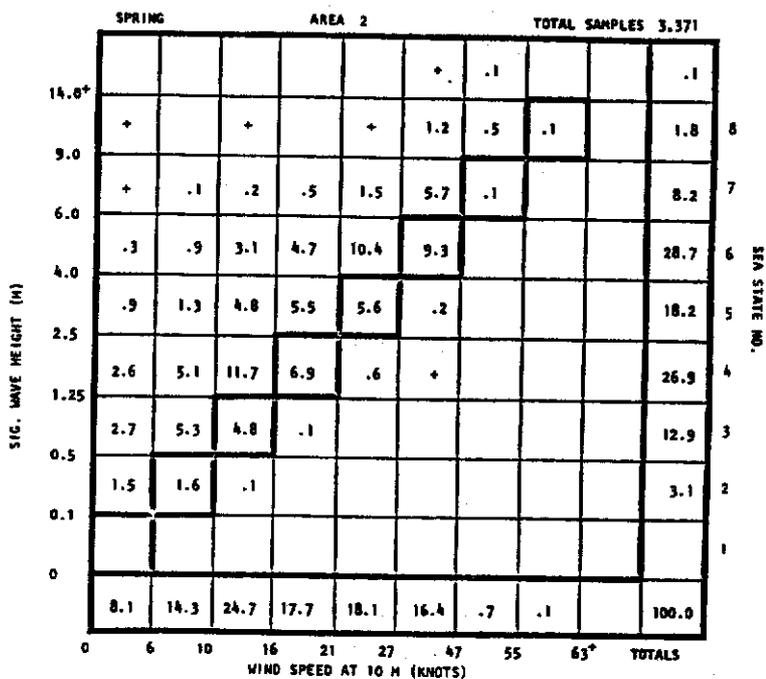
Figure A-2-3-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

Figure A-2-4-1 Significant Wave
Height by Modal Wave Period
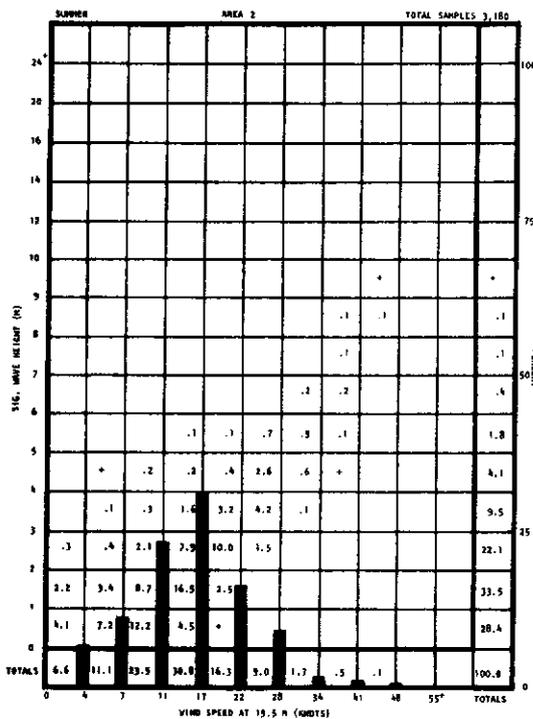
Figure A-2-4-2 Significant Wave
Height by Wind Speed
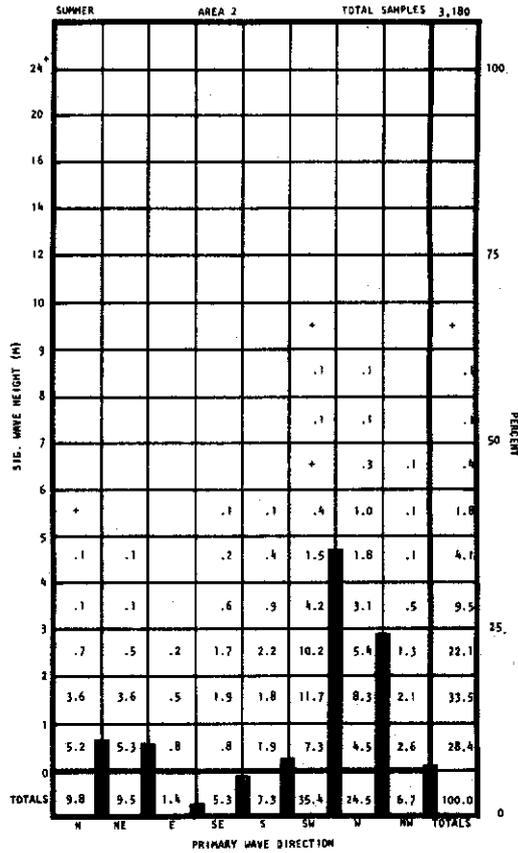
Figure A-2-4-3 Significant Wave
Height by Wave Direction
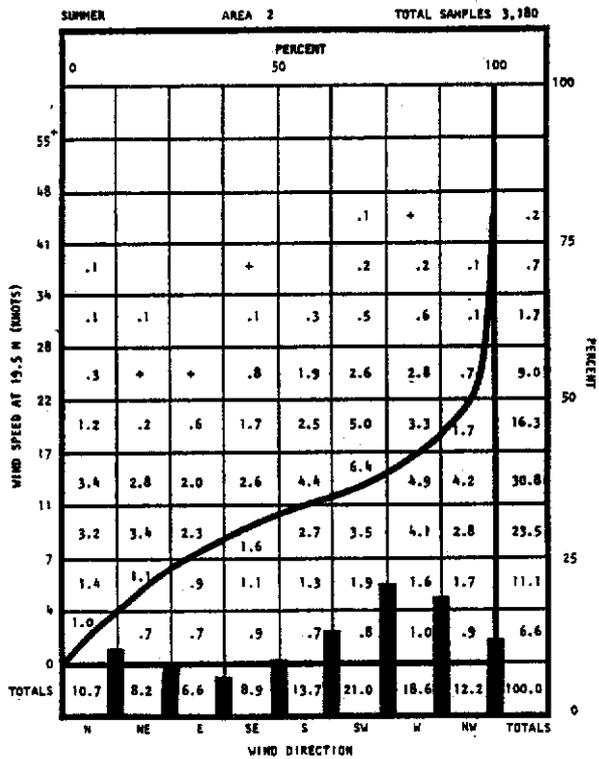
Figure A-2-4-4 Wind Speed by
Wind Direction

SUMMER   AREA 2   TOTAL SAMPLES 3,180

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+											
9.0						+				+	8
6.0						.6				.6	7
4.0		.3	.6	1.3	4.3	2.1				8.6	6
2.5	.1	.5	3.0	6.3	5.2	+				15.2	5
1.25	3.3	6.2	16.6	10.7	.4					37.2	4
0.5	7.6	10.8	11.8	.2						30.4	3
0.1	4.1	3.6	.4							8.1	2
0											1
TOTALS	15.1	21.4	32.4	18.4	10.0	2.7				100.0	

WIND SPEED AT 10 M (KNOTS)
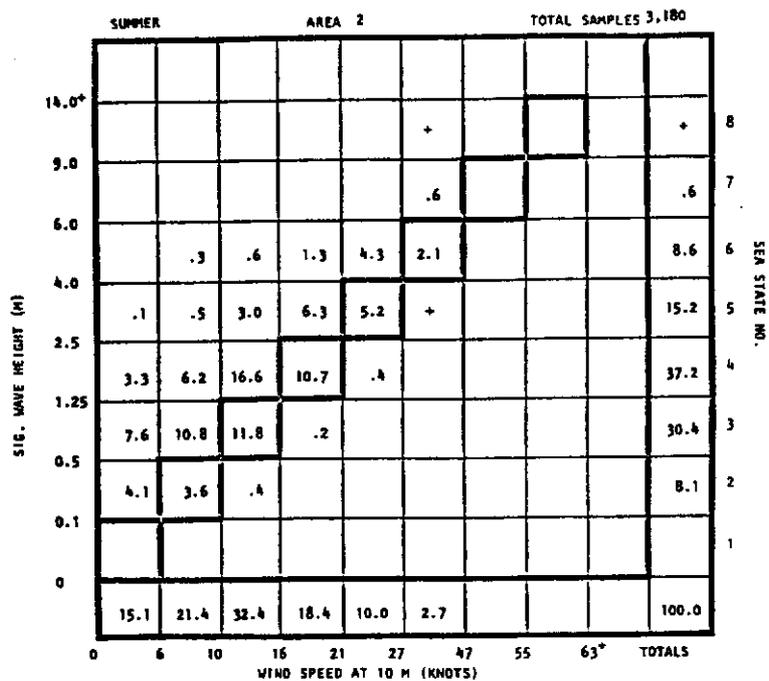
Figure A-2-4-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

Figure A-2-5-1 Significant Wave
Height by Modal Wave Period
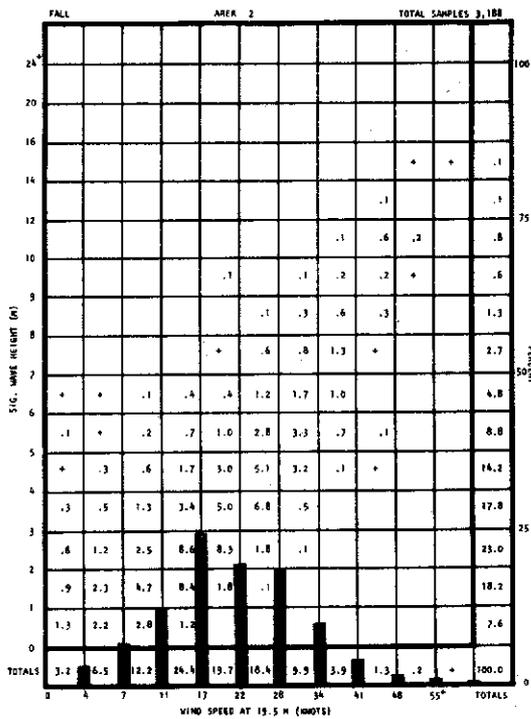
Figure A-2-5-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

A-76
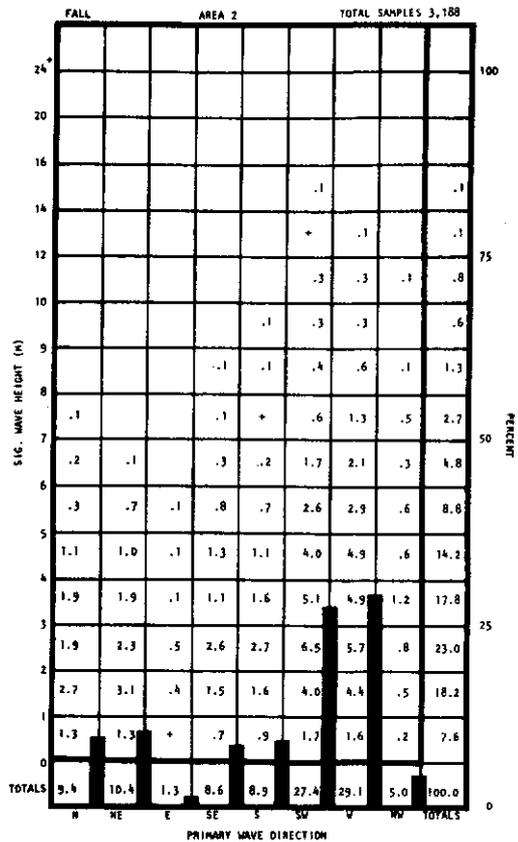
Figure A-2-5-3 Significant Wave
Height by Wave Direction
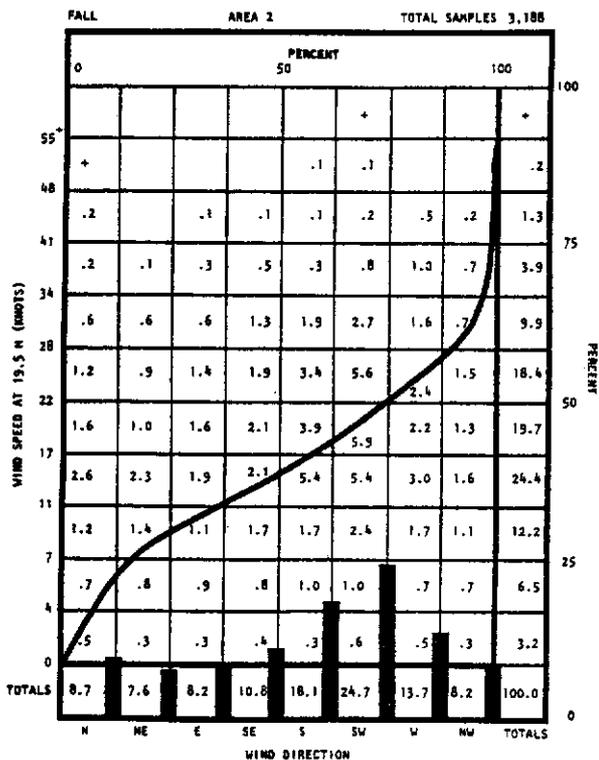
Figure A-2-5-4 Wind Speed by
Wind Direction
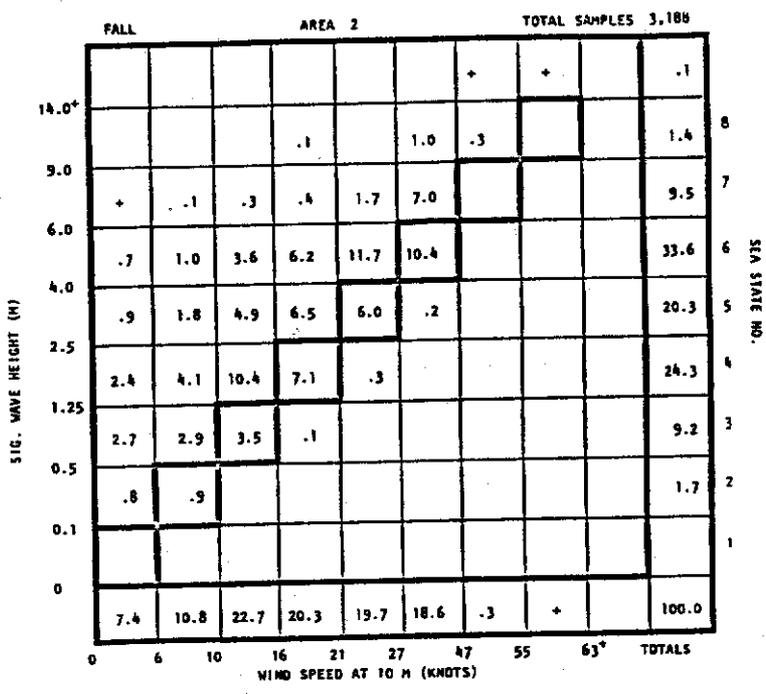
Figure A-2-5-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

TABLE A-6-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 46.191° N, 44.891° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	3	7.5	3.5	2
Wave Period, sec	6	10	15.5	10.5	12.5
Direction	-	-	-	-	W
Winds					
Speed, knots	5	16	35	18	14
Corresponding Mean Sig. Wave Height, m.	1.8	2.5	7.5	3	2.5
Direction	-	-	-	-	SW - W - NW
Visibility, nautical miles	1.5	12	25	-	-
Cloud Cover					
Total clouds, In eighths of sky obscured	Nil	6.5	8	-	-
Low clouds, In eighths of sky obscured	Nil	6	8	-	-
Precipitation (Occurrence)	All precipitation - 15% of the time		Snow - 2% of the time (Dec-Mar)		
Relative Humidity, %	65	86	98	-	-
Air Temperature, °C	1.5	10	20	10	-
Surface Water Temperature, °C	3	10.5	21	-	-
Sea Level Pressure, millibars	999	1,016	1,030	-	-
Ice	Moderate superstructure - 1% of the time (Dec -Mar)				
Refractivity					
Mean Surface Refractivity	-	-	-	336	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

Figure A-6-1-1 Significant Wave
Height by Modal Wave Period

Figure A-6-1-2 Significant Wave
Height by Wind Speed

ANNUAL   AREA 6   TOTAL SAMPLES 13,553
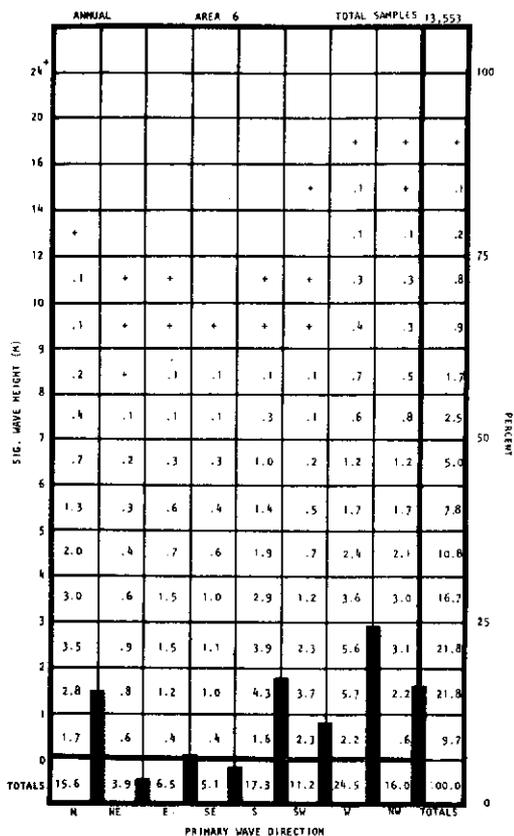
Figure A-6-1-3 Significant Wave
Height by Wave Direction

ANNUAL   AREA 6   TOTAL SAMPLES 13,553
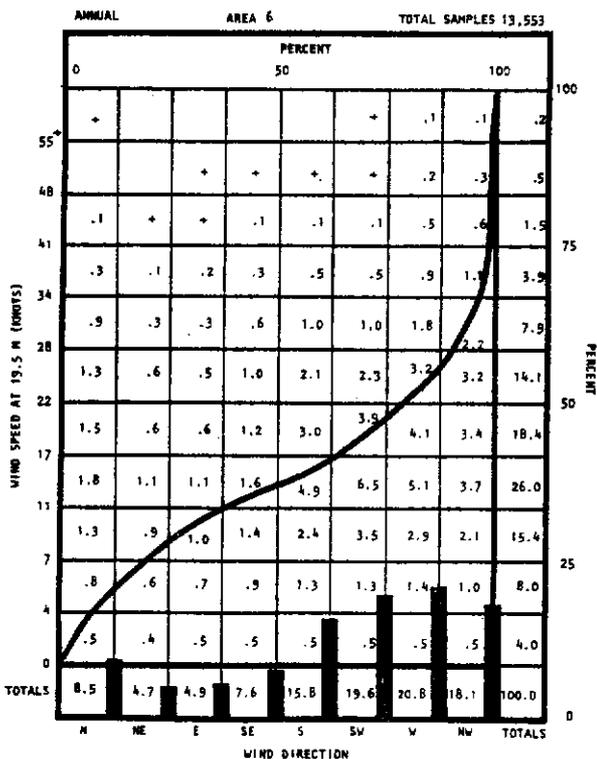
Figure A-6-1-4 Wind Speed by
Wind Direction

ANNUAL   AREA 6   TOTAL SAMPLES 13.553

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+						+	+	.1	+	.1	
9.0		+	+		.1	1.2	.5	.1	+	2.0	E
6.0	.1	.1	.4	.6	1.3	6.5	.1	+		9.1	7
4.0	.5	1.4	3.8	4.8	8.5	7.0				26.1	6
2.5	1.2	2.0	4.7	6.3	5.2	.1				19.5	5
1.25	3.1	5.1	12.7	7.7	.3	+				28.9	4
0.5	3.0	4.4	4.8	.1						12.3	3
0.1	1.1	.9	+							2.1	2
0											1
TOTALS	9.0	13.9	26.5	19.5	15.3	14.8	.7	.2	.1	100.0	

WIND SPEED AT 10 M (KNOTS)
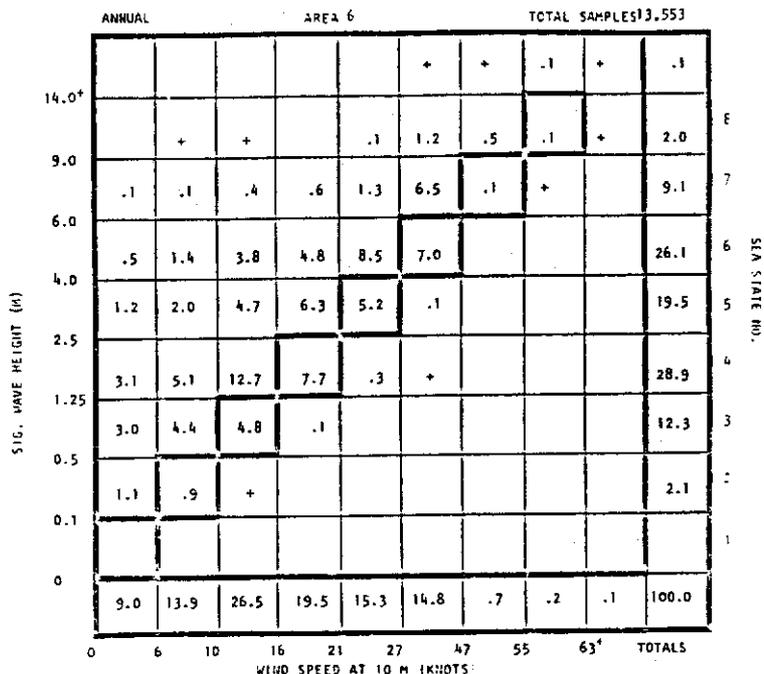
Figure A-6-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

ANNUAL   AREA 6   TOTAL SAMPLES 13.553

SIG. WAVE HEIGHT (M)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
24														
20														
16	2													2
14	2	2		1	1									6
12	9	3	1	1	2									16
10	33	21	4	3		2								63
9	63	15	6	1	2									105
8	109	33	20	2	2									166
7	161	42	21	8	3	1								236
6	195	97	42	19	5	4	3							367
5	204	137	55	32	13	16	2	3	1	1				464
4	297	165	100	41	21	14	10	4	1	2		1		656
3	289	220	122	79	55	35	19	11	4	4	4	4	2	838
2	258	209	163	88	76	44	31	28	18	5	8	3	2	5	933
1	155	143	120	78	61	47	33	26	17	11	10	7	6	28	742
0	52	46	34	30	21	13	9	10	9	6	5	6	4	18	261
TOTALS	1849	1133	686	383	267	168	107	82	50	29	27	18	13	53	4860

DURATION (HOURS)

Figure A-6-1-6 Persistence of
Significant Wave Height

ANNUAL — AREA 6 — TOTAL SAMPLES 13,553

WIND SPEED AT 19.5 M (KNOTS)

	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55	5	4	2	1	2									14
48	33	18	3											54
41	89	35	9	5	3	1								142
34	229	94	31	5	3	3	1							366
28	399	147	55	27	12	4	5	1	2					652
22	581	259	117	53	27	13	5	1	1	1	1			1059
17	827	340	150	62	26	15	7	5	3	1	1			1437
11	903	301	206	107	60	36	20	12	5	4	2	1	2 1	1660
7	74?	221	98	40	23	7	8	5	1	1		1		1150
4	413	170	43	18	4	5	3	2		1				659
0	251	70	33	14	5							1		374
TOTALS	4475	1659	747	332	165	84	49	26	12	8	4	3	2 1	7567

DURATION (HOURS)

PERCENT — 100, 75, 50, 25, 0
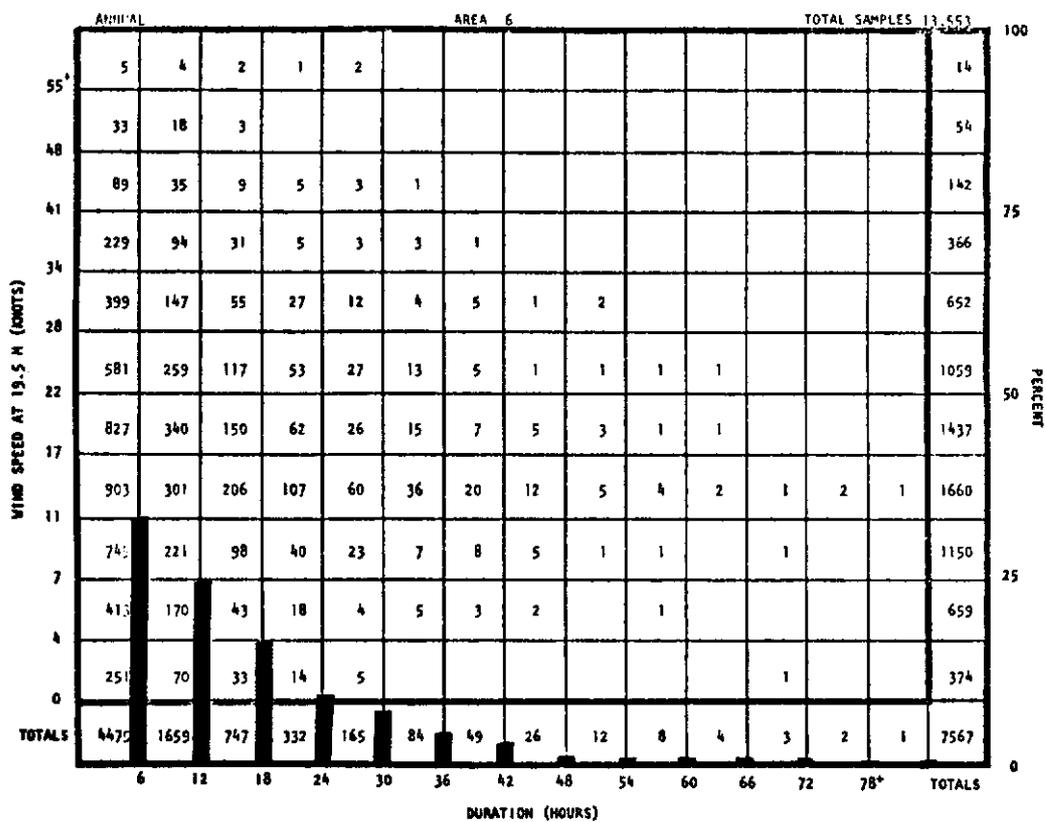
Figure A-6-1-7 Persistence of
Wind Speed
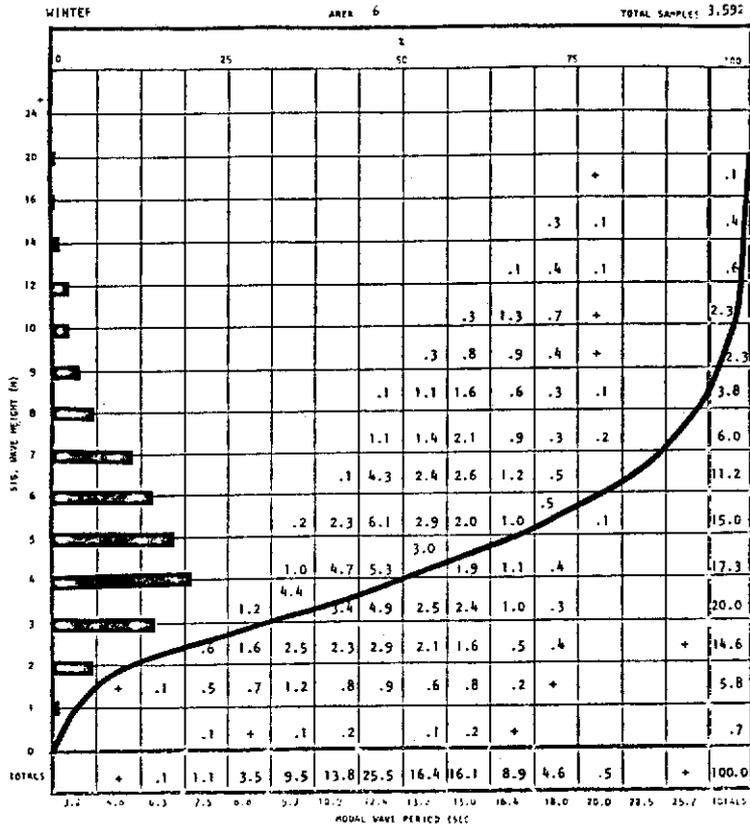
Figure A-6-2-1 Significant Wave
Height by Modal Wave Period

Figure A-6-2-2 Significant Wave
Height by Wind Speed

WINTER AREA 6 TOTAL SAMPLES 3,592

SIG. WAVE HEIGHT (M) — PRIMARY WAVE DIRECTION — PERCENT

Height	N	NE	E	SE	S	SW	W	NW	TOTALS
16							+	+	.1
14							.2	.2	.4
12	+						.3	.3	.6
10	.1	.1			.1	+	1.1	.8	2.3
9	.2	.1		.1	+	.1	.9	.9	2.3
8	.4	+	.1	.2	.2	.4	1.2	1.3	3.8
7	.9	.2	.2	.2	.7	.2	1.4	2.1	6.0
6	1.6	.5	.7	.6	2.2	.4	2.5	2.8	11.2
5	2.4	.9	1.6	.9	2.5	.6	3.0	3.1	15.0
4	3.3	1.0	1.7	1.1	3.2	.9	3.1	3.1	17.3
3	3.3	1.1	3.3	1.4	3.8	1.3	3.1	2.8	20.0
2	2.5	1.0	3.1	.8	2.3	1.2	1.9	1.8	14.6
1	1.0	.5	.6	.7	1.3	.7	.8	.4	5.8
0	.1	.2	+	+	.1	.1			.7
TOTALS	15.9	5.6	11.4	5.9	16.3	5.9	19.5	19.5	100.0

Figure A-6-2-3 Significant Wave
Height by Wave Direction

WINTER AREA 6 TOTAL SAMPLES 3,592

PERCENT 0 50 100

WIND SPEED AT 19.5 M (KNOTS) — WIND DIRECTION — PERCENT

Speed	N	NE	E	SE	S	SW	W	NW	TOTALS
55+						.1	.3	.2	.7
48			+	.1	.1	.1	.5	.7	1.4
41	.4	+	.1	.2	.1	.2	1.3	1.4	3.7
34	.6	.1	.4	.6	1.1	1.1	1.9	2.6	8.4
28	1.4	.7	.6	.9	1.9	1.5	3.0	4.3	14.4
22	2.0	1.3	.8	1.1	3.1	2.7	4.0	4.0	19.0
17	2.0	1.4	1.0	1.2	3.0	2.8	3.1	3.0	17.4
11	1.5	1.1	1.5	1.4	3.3	3.1	2.6	2.8	17.2
7	1.0	1.0	1.0	1.2	1.3	1.5	1.5	1.4	10.1
4	.6	.4	.7	.5	.8	.7	.7	.7	5.1
0	.3	.5	.3	.4	.4	.3	.3	.2	2.7
TOTALS	9.7	6.5	6.5	7.6	15.1	14.1	19.2	21.4	100.0

Figure A-6-2-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

A-85

WINTER				AREA 6			TOTAL SAMPLES 3,592			

Significant Wave Height by Wind Speed

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63⁺	TOTALS
14.0⁺						+	+	.2	.2	.5
9.0			.1		.1	3.2	1.5	.2	+	5.1
6.0	.1	.3	1.1	1.5	3.1	14.5	.4			21.0
4.0	1.2	3.3	6.6	7.5	13.0	11.0				42.6
2.5	2.0	2.6	5.1	5.4	3.1	.1				18.3
1.25	1.9	2.4	4.1	2.3	.2	+				10.9
0.5	.4	.7	.4	.1						1.6
0.1	+	.1								.1
0										
	5.6	9.4	17.3	16.7	19.5	28.8	1.9	.4	.2	100.0

WIND SPEED AT 10 M (KNOTS)

Figure A-6-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

Figure A-6-3-1 Significant Wave
Height by Modal Wave Period

Figure A-6-3-2 Significant Wave
Height by Wind Speed

SPRING AREA 6 TOTAL SAMPLES 3,405

SIG. WAVE HEIGHT (M) / PERCENT

H	N	NE	E	SE	S	SW	W	NW	TOTALS
	+						.1	.1	.3
	.1		.2				.1	.2	.6
	+	+	.1		.1	+	.4	.3	1.0
	.2		.2	.1	.3	.1	.8	.2	1.9
	.3	.1	.2	.2	.3	.2	.6	.6	2.6
	.7	.1	.3	.3	1.3	.4	1.2	1.1	5.4
	1.8	.4	.6	.4	1.8	1.1	1.8	1.9	9.8
	2.2	.4	.7	.9	2.3	.8	3.4	2.4	13.0
	3.9	.5	1.5	1.3	4.2	1.2	5.2	3.6	21.4
	5.2	1.6	1.7	1.8	3.8	2.3	5.0	3.0	24.5
	2.7	.7	1.8	1.4	3.3	2.4	2.8	2.2	17.2
	.5	.3	.1	.1	.5	.4	.3	.2	2.5
TOTALS	17.7	4.1	7.5	6.4	17.9	8.8	21.8	15.8	100.0

PRIMARY WAVE DIRECTION
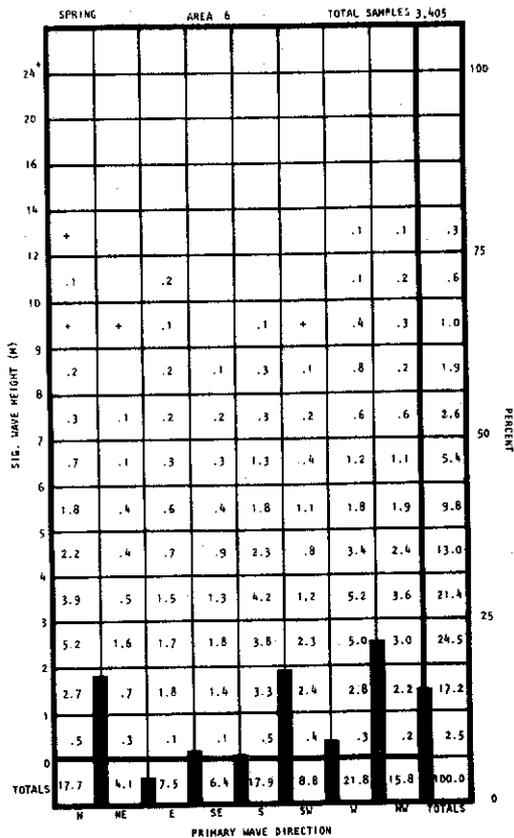
Figure A-6-3-3 Significant Wave
Height by Wave Direction

SPRING AREA 6 TOTAL SAMPLES 3,405

PERCENT 0   50   100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

N	NE	E	SE	S	SW	W	NW	TOTALS
						.1	.1	.2
						.2	.3	.4
.1	.1		.1	.1	+	.3	.5	1.3
.6	.2	.4	.3	.4	.3	.9	1.0	3.9
1.4	.2	.4	.9	.9	1.1	2.2	2.0	9.0
1.8	.4	.8	1.6	1.9	2.4	3.3	4.4	16.7
1.9	.5	.8	1.9	3.3	3.6	4.3	4.6	21.0
1.9	1.6	1.3	2.1	4.9	4.5	4.3	3.8	24.3
.9	.9	1.1	1.4	2.2	2.6	1.9	2.0	13.0
.7	.6	.5	1.0	1.2	.8	1.1	.8	6.7
.3	.4	.6	.4	.4	.4	.3	.5	3.4
TOTALS 9.6	4.9	5.8	9.6	15.4	15.9	18.9	19.9	100.0
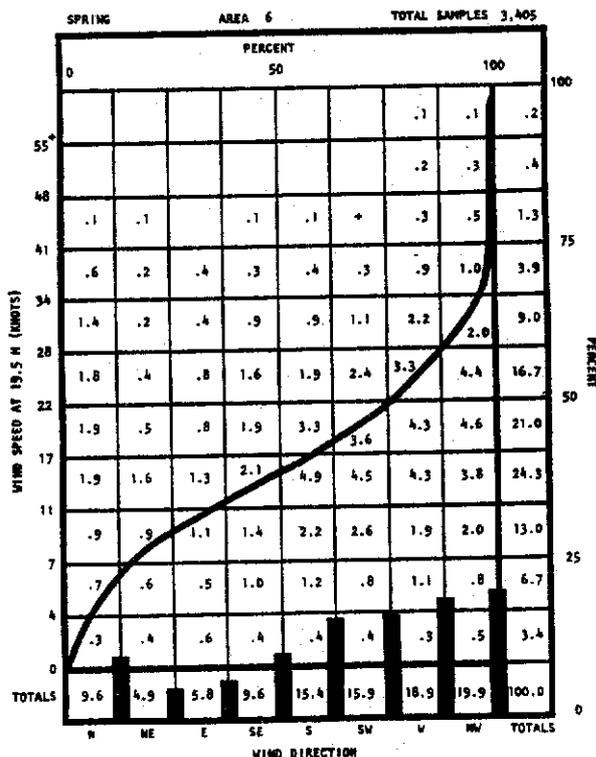
WIND DIRECTION

Figure A-6-3-4 Wind Speed by
Wind Direction

SPRING   AREA 6   TOTAL SAMPLES 3,405

| SIG. WAVE HEIGHT (M)	WIND SPEED AT 10 M (KNOTS)										SEA STATE NO.
	0	6	10	16	21	27	47	55	63+	TOTALS	
14.0+											
9.0		+	+		.1	1.3	.5	.2	+	2.2	8
6.0	.1	.2	.4	.6	1.6	7.4	.1	+		10.4	7
4.0	.5	1.0	5.0	6.9	11.0	8.4				32.9	6
2.5	1.7	2.7	6.2	7.6	5.4	.1				23.6	5
1.25	3.4	5.7	10.5	5.8	.1	+				25.5	4
0.5	1.5	2.0	1.6	.1						5.2	3
0.1	.1									.1	2
0											1
TOTALS	7.4	11.7	23.7	21.0	18.2	17.2	.6	.2	+	100.0	
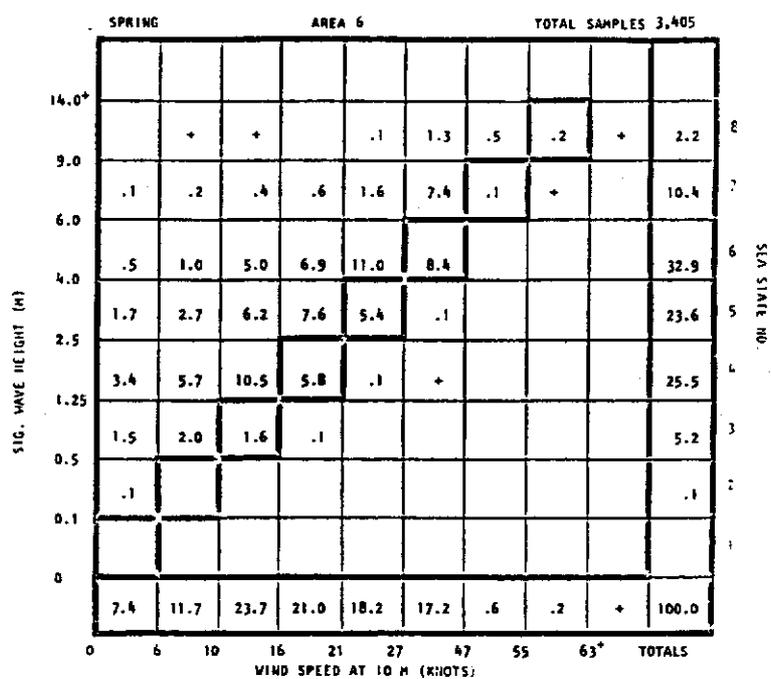
Figure A-6-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

A-89
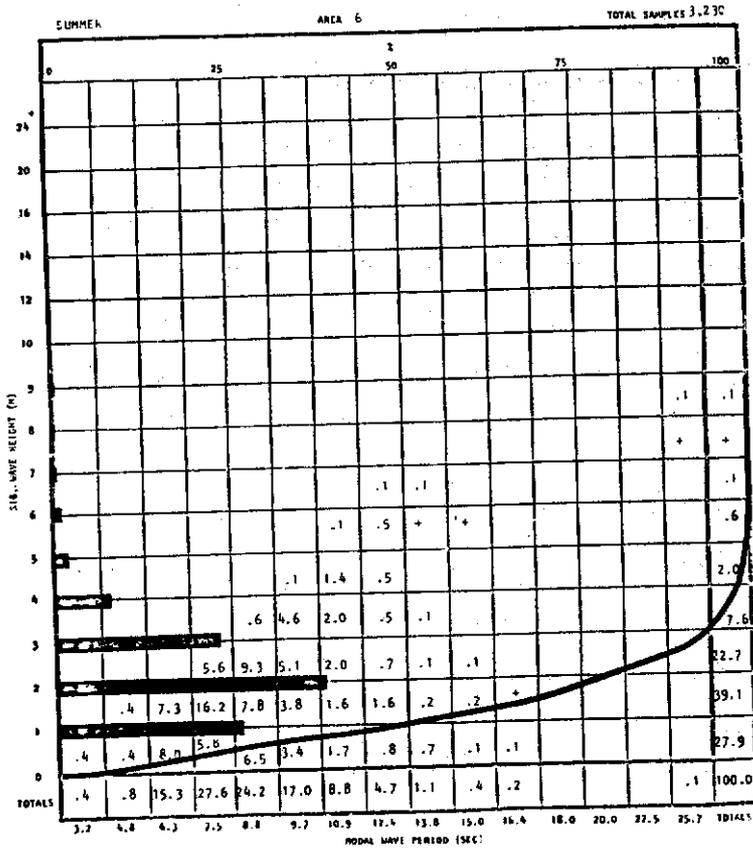
Figure A-6-4-1 Significant Wave
Height by Modal Wave Period
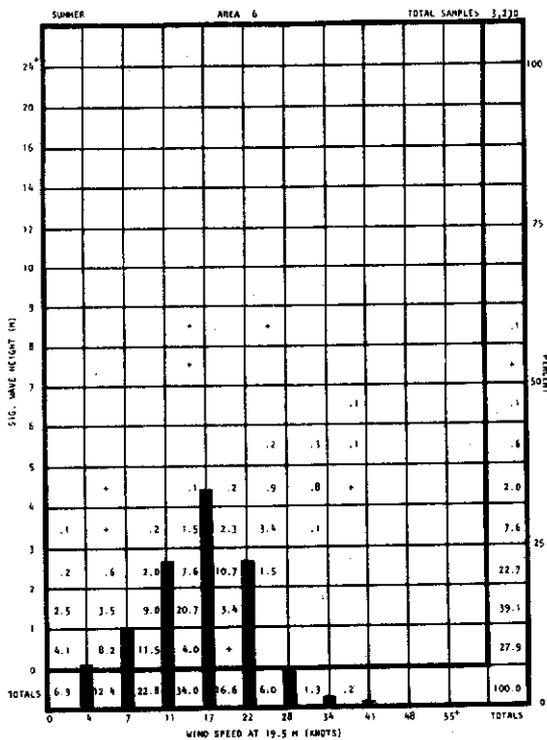

Figure A-6-4-2 Significant Wave
Height by Wind Speed

A-90

SUMMER   AREA 6   TOTAL SAMPLES 3,230

SIG. WAVE HEIGHT (M) / PERCENT

Sig. Wave Height	N	NE	E	SE	S	SW	W	NW	TOTALS
9								.1	
8							+	+	
7							.1	.1	
6					.1		.4	.2	.6
5	.2				.2	.3	.8	.5	2.0
4	1.4			+	1.4	.8	2.9	1.1	7.6
3	1.3	+	.2	.7	5.2	3.9	9.7	1.8	22.7
2	2.9	.3	1.4	1.1	8.2	9.2	13.9	2.1	39.1
1	3.6	1.2	1.0	1.0	5.0	7.9	7.2	1.1	27.9
TOTALS	9.2	1.5	2.6	2.9	20.0	22.0	34.5	6.9	100.0

PRIMARY WAVE DIRECTION
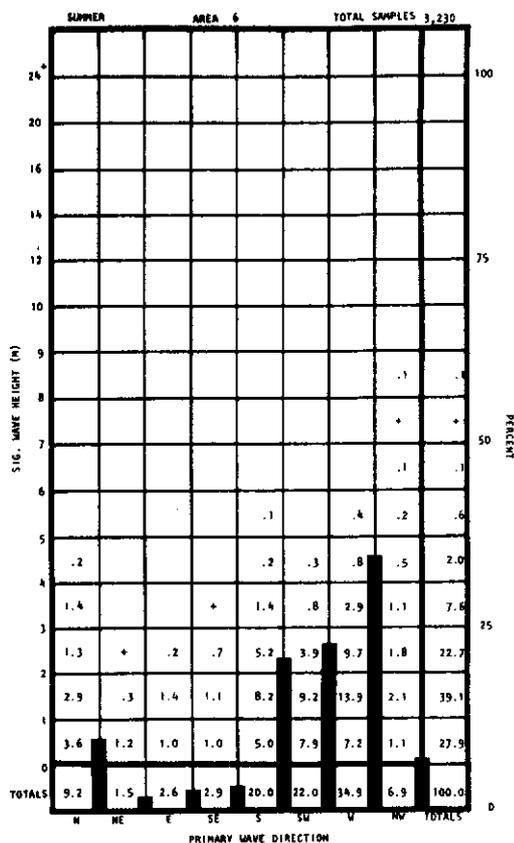
Figure A-6-4-3 Significant Wave Height by Wave Direction

SUMMER   AREA 6   TOTAL SAMPLES 3,230

PERCENT 0   50   100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

Wind Speed	N	NE	E	SE	S	SW	W	NW	TOTALS
34					.1	+		.1	.2
28	.2				+	.3	.4	.5	1.2
22	.4			.2	1.0	1.6	1.9	.9	6.0
17	.5		+	.6	3.0	6.1	4.3	2.0	16.5
11	1.2	.4	.6	1.6	6.8	12.4 / 8.2	2.9	34.0
7	1.3	.6	.7	1.6	4.4	7.1	4.8	2.1	22.8
4	1.0	.7	1.0	1.4	2.2	2.3	2.2	1.6	12.4
0	.7	.7	.7	.9	.9	1.0	1.0	.9	6.9
TOTALS	5.3	2.4	3.1	6.3	18.4	30.8	22.9	10.8	100.0
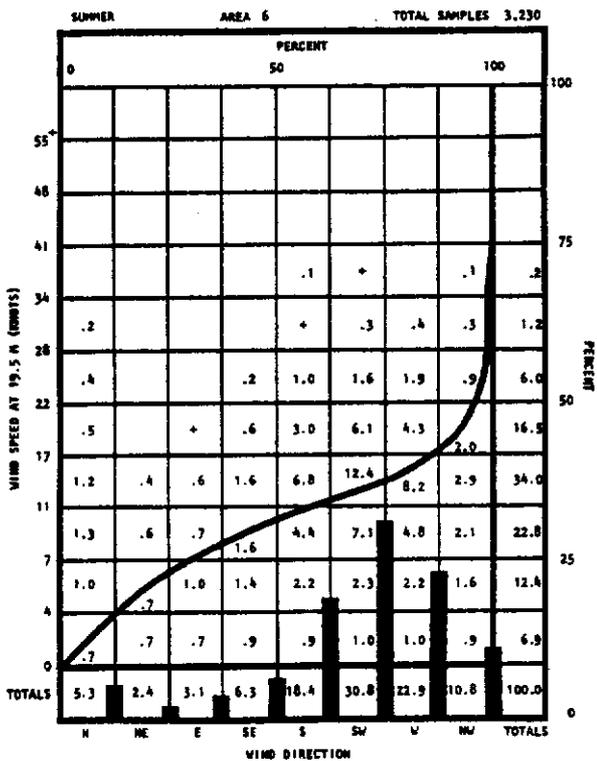
WIND DIRECTION

Figure A-6-4-4 Wind Speed by Wind Direction

A-91
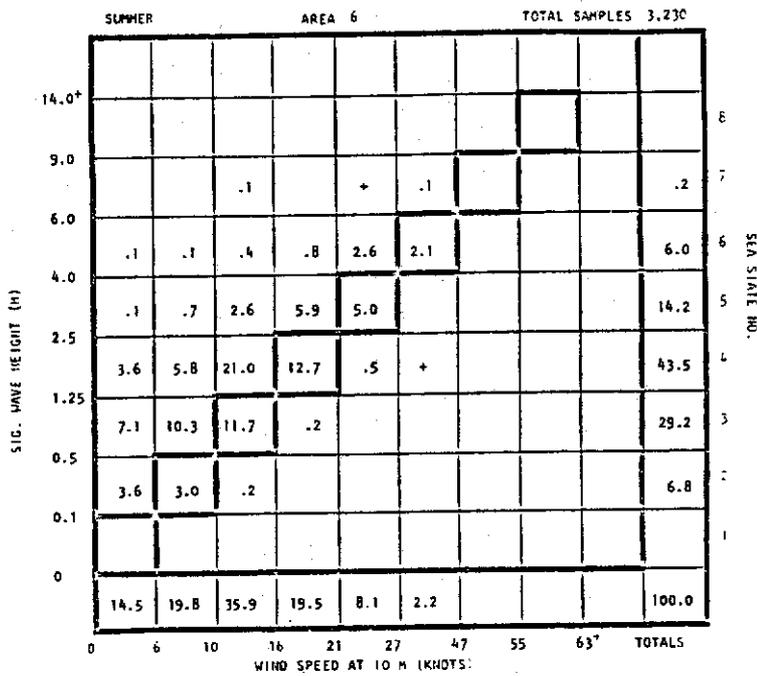
Figure A-6-4-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
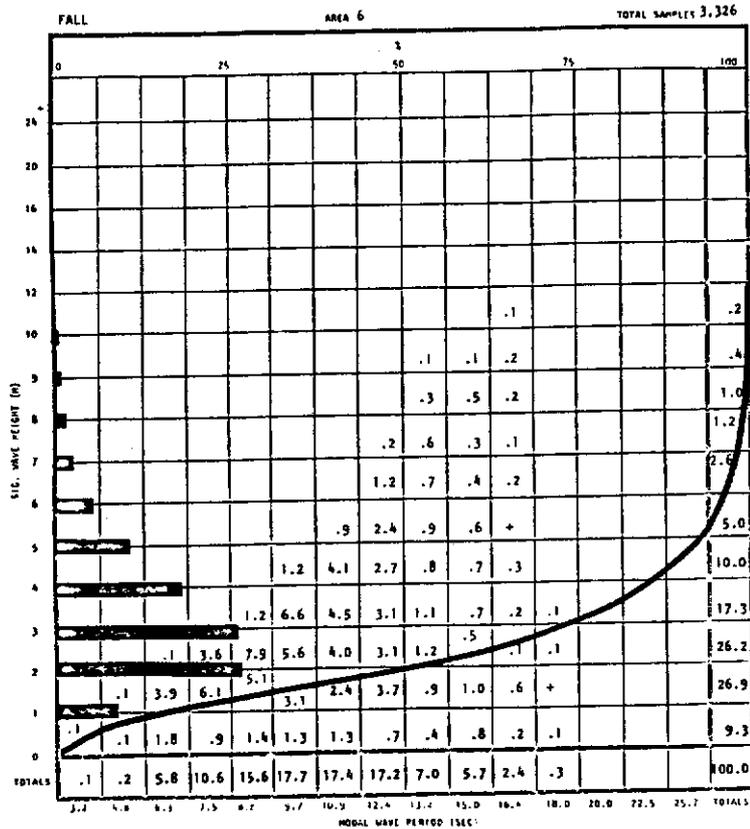
Figure A-6-5-1 Significant Wave
Height by Modal Wave Period
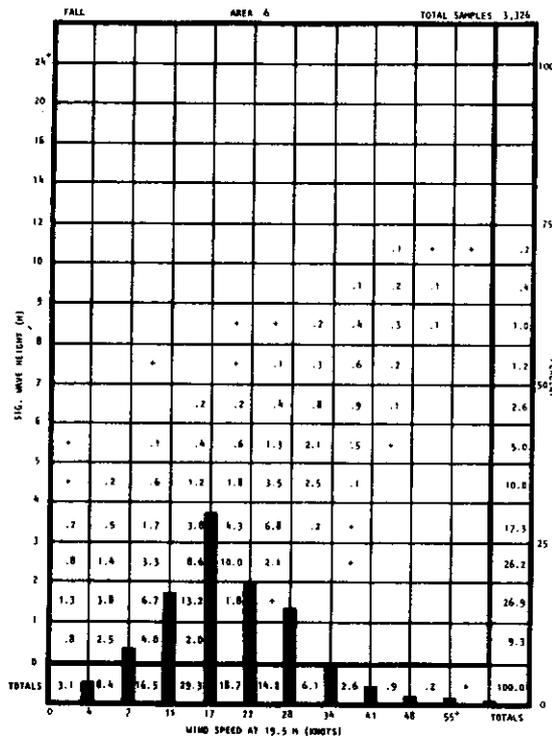
Figure A-6-5-2 Significant Wave
Height by Wind Speed

FALL   AREA 6   TOTAL SAMPLES 3,326

SIG. WAVE HEIGHT (M) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
								.2	.2
	+					+	.2	.1	.4
	+					.1	.6	.4	1.0
	+	+	+	.2	.1	.1	.3	.5	1.2
	.5	+	.2	.1	.3	+	.9	.6	2.6
	.7	+	.1	.2	.5	.2	1.3	1.6	5.0
	2.1	.1	.4	.6	1.9	.6	2.2	2.1	10.0
	3.2	.7	.9	1.4	2.1	1.4	3.2	4.4	17.3
	5.0	.8	1.0	1.1	4.3	2.0	6.2	5.8	26.2
	5.1	1.7	1.3	.8	4.7	2.9	6.1	4.3	26.9
	2.6	.7	.5	.6	.9	1.3	1.4	1.4	9.3
TOTALS	19.2	4.1	4.3	4.9	15.3	8.6	22.5	21.1	100.0

PRIMARY WAVE DIRECTION
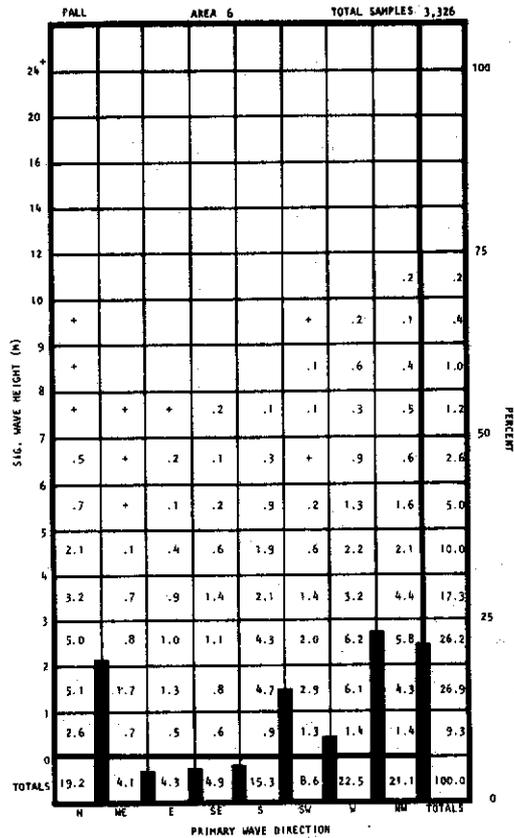
Figure A-6-5-3 Significant Wave Height by Wave Direction

FALL   AREA 6   TOTAL SAMPLES 3,326

PERCENT: 0   50   100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
								+	+
					.1	.1	.1	.2
					.1	.2	.5	.3	.9
	+	.1	+	.4	.3	.4	.8	.5	2.6
	.4	.2	+	.4	1.0	.9	1.5	1.8	6.1
	1.0	.6	.5	1.1	2.3	2.3	3.3	3.2	14.2
	1.6	.6	.5	1.0	2.8	3.4	4.8	3.9	18.7
	2.6	1.3	1.1	1.5	4.8	6.7	5.7	5.5	29.3
	1.9	1.0	1.0	1.2	1.9	3.0	3.6	3.0	16.5
	1.1	.8	.7	.9	.9	1.3	1.7	1.0	8.4
	.6	.3	.5	.3	.4	.4	.5	.3	3.1
TOTALS	9.0	4.8	4.2	6.8	14.4	18.6	22.5	19.6	100.0
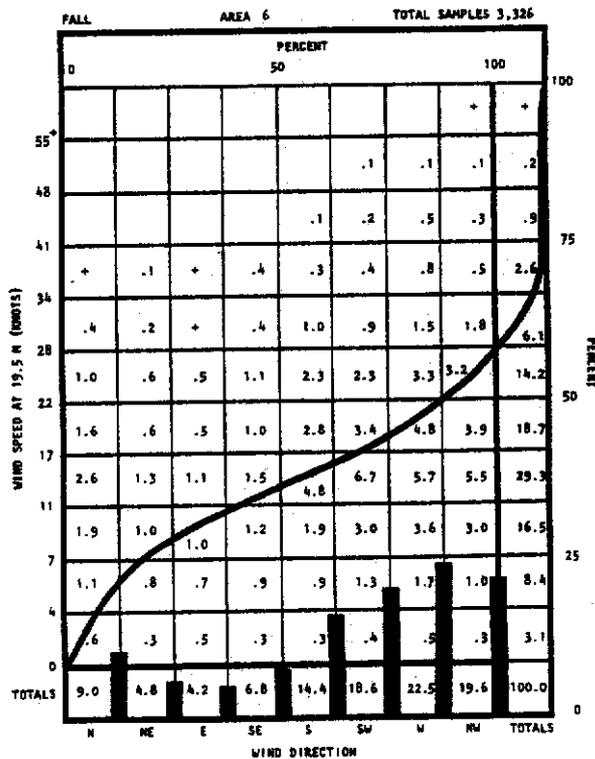
WIND DIRECTION

Figure A-6-5-4 Wind Speed by Wind Direction
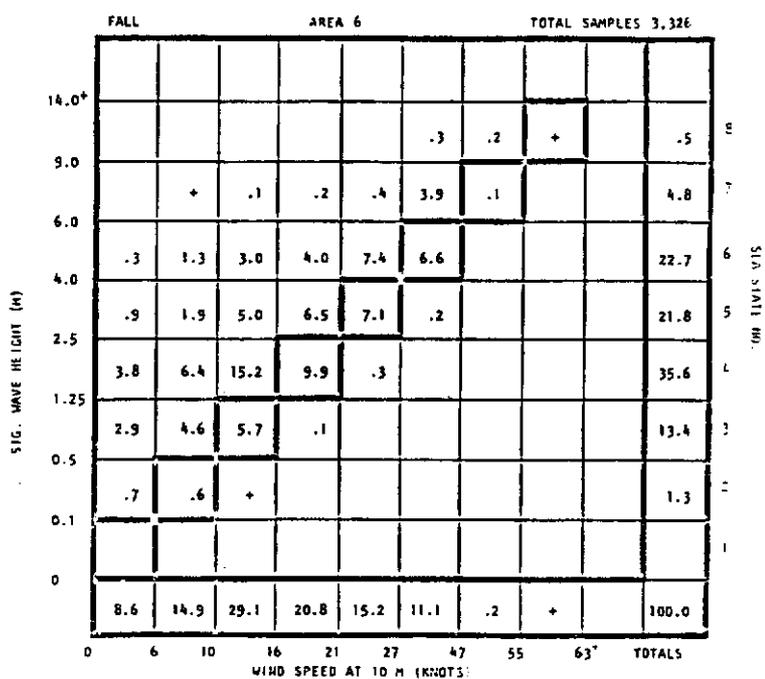
Figure A-6-5-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

TABLE A-7-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 45.199° N, 21.648° W

| Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2.5	7	3	2
Wave Period, sec	6	10	16.5	10.5	12.5
Direction	-	-	-	-	W - NW
Winds					
Speed, knots	4	14	33	16	14
Corresponding Mean Sig. Wave Height, m.	1	2	6	2.5	2
Direction	-	-	-	-	W - SW
Visibility, nautical miles	2	14	25	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	Nil	6	8	-	-
Low clouds, in eighths of sky obscured	Nil	5.5	8	-	-
Precipitation (Occurrence)	All precipitation - 16% of the time		Snow - 1% of the time (Dec - Mar)		
Relative Humidity, %	61	82	97	-	-
Air Temperature, °C	9	13.5	18.5	13.5	-
Surface Water Temperature, °C	11	13.5	18.5	-	-
Sea Level Pressure, millibars	994	1,014	1,032	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	335	-
Sub-Refraction (1 km, Annual)	-	-	-	-	4% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

Figure A-7-1-1 Significant Wave
Height by Modal Wave Period
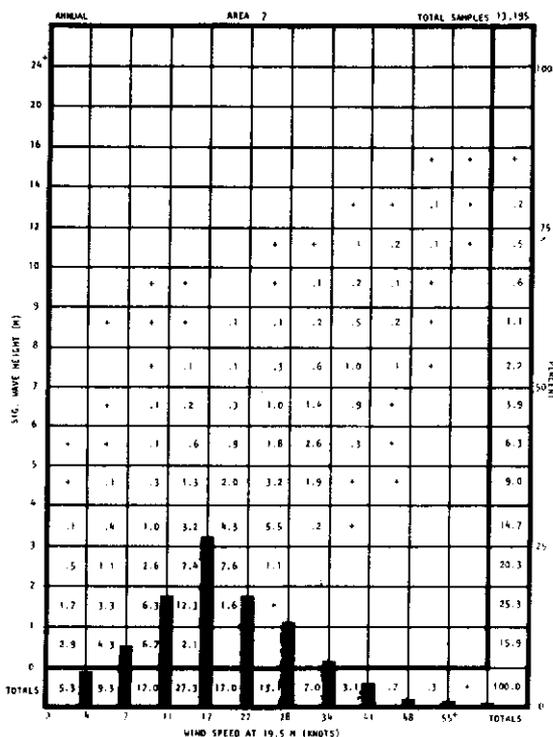
Figure A-7-1-2 Significant Wave
Height by Wind Speed
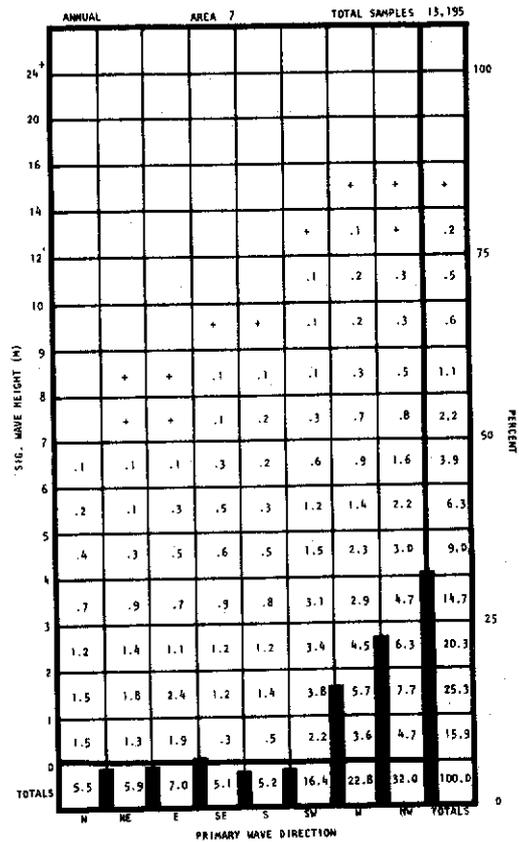
Figure A-7-1-3 Significant Wave
Height by Wave Direction
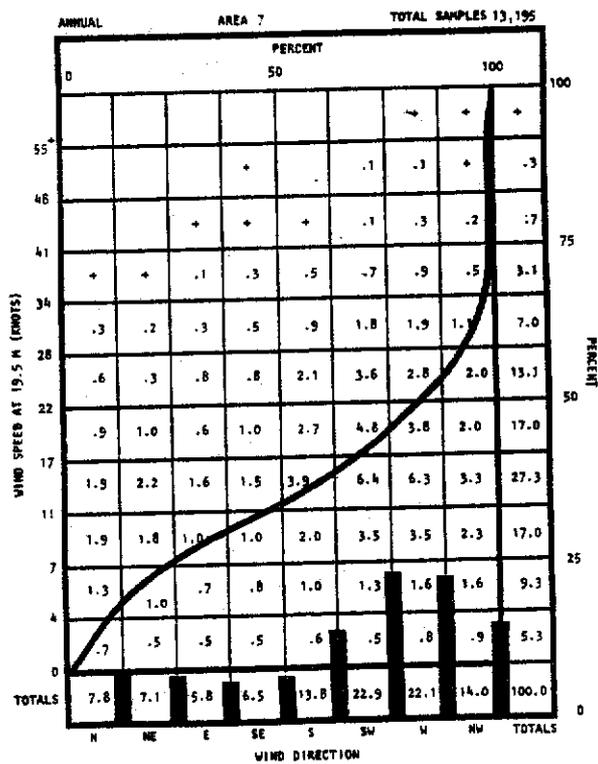

Figure A-7-1-4 Wind Speed by
Wind Direction
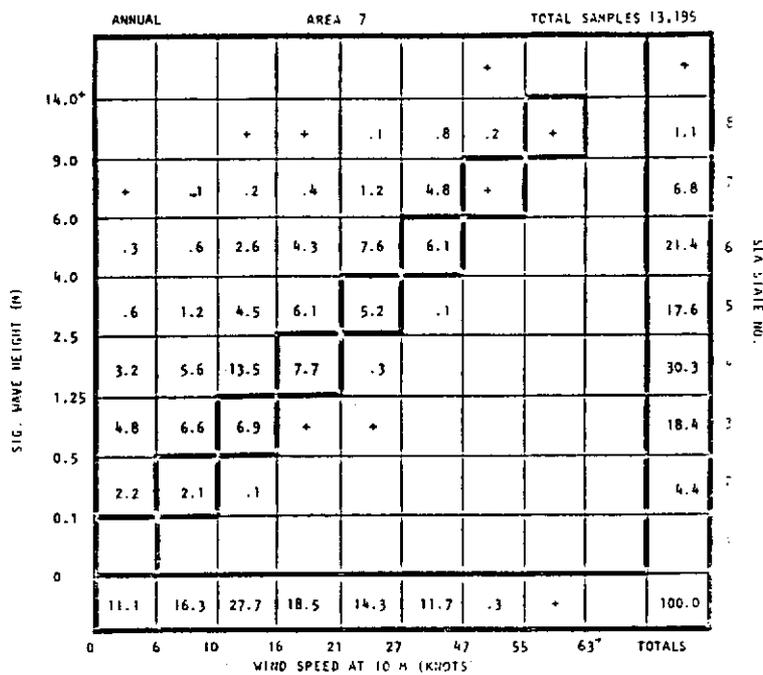
Figure A-7-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
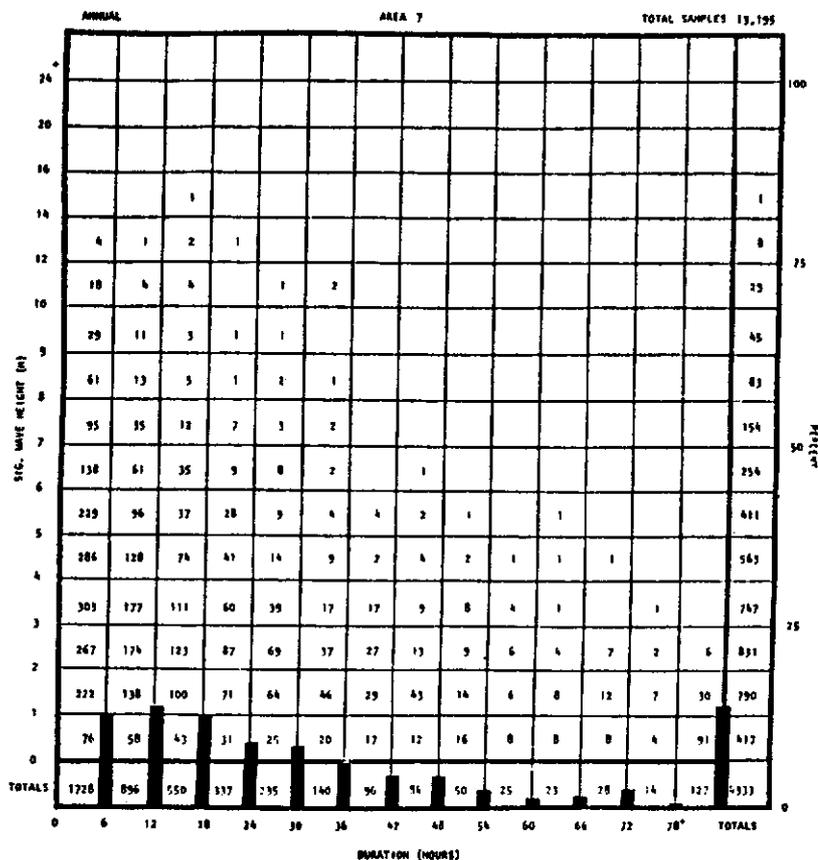
Figure A-7-1-6 Persistence of
Significant Wave Height

ANNUAL   AREA 7   TOTAL SAMPLES 13,195

WIND SPEED (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+	3													3
48	10	3	4	1										18
41	49	9	2			1								61
34	104	54	29	8	3	1	.							199
28	246	108	55	21	12	7	2	2						453
22	485	209	91	44	20	13	6	2	3			1		875
17	647	254	133	52	25	14	12	9	3		1		1	1149
11	641	345	196	116	66	34	25	13	12	8	4	2	2	1465
7	643	291	111	59	33	17	10	8	5	3	2	3	1	1186
4	508	192	66	30	11	11	3		2			1		824
0	260	100	50	14	11	3	1		2		2		1	444
TOTALS	3596	1565	737	345	181	101	59	33	27	11	9	7	4	6677

DURATION (HOURS)

PERCENT — 100, 75, 50, 25, 0
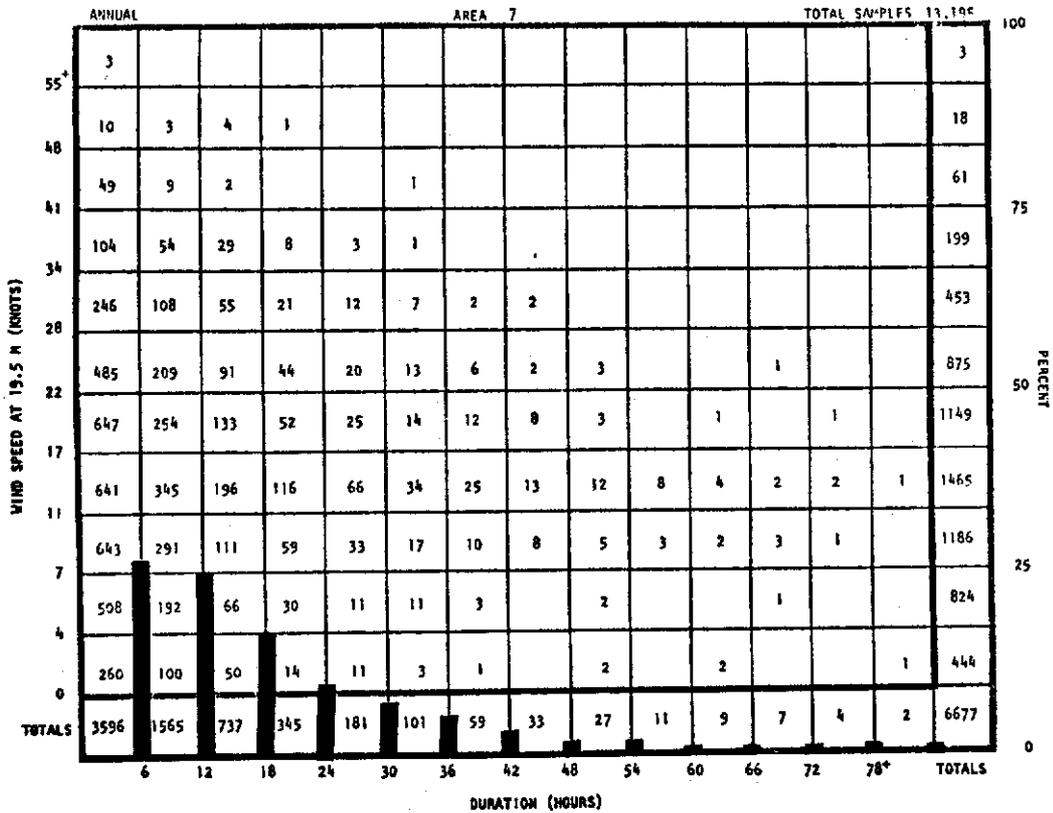
Figure A-7-1-7 Persistence of
Wind Speed

WINTER AREA 7 TOTAL SAMPLES 3,511
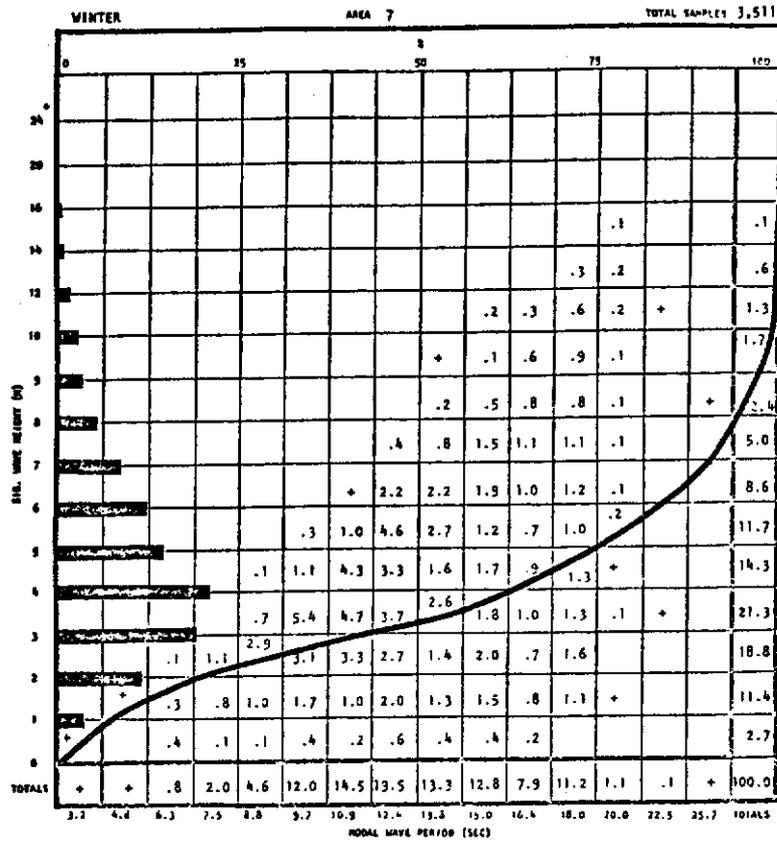
Figure A-7-2-1 Significant Wave
Height by Modal Wave Period

WINTER AREA 7 TOTAL SAMPLES 3,511
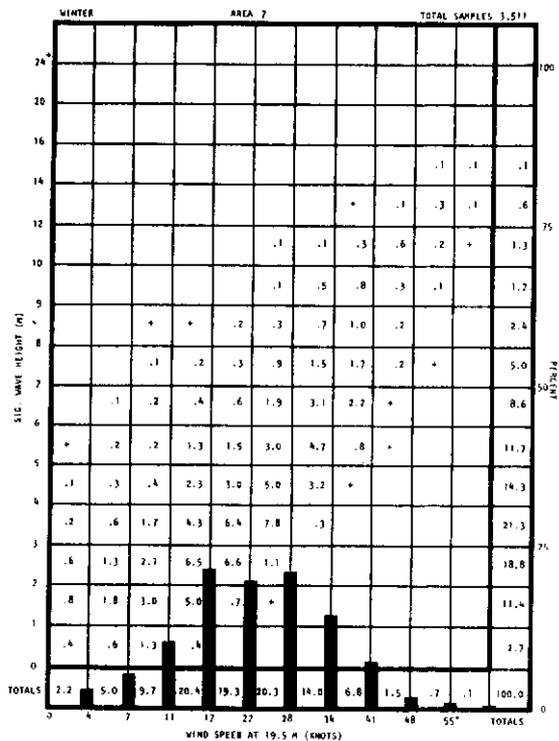
Figure A-7-2-2 Significant Wave
Height by Wind Speed
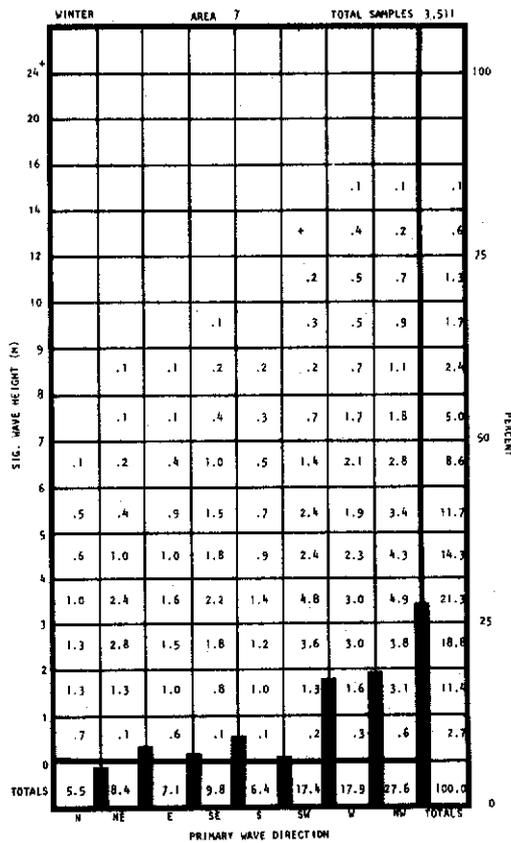
Figure A-7-2-3 Significant Wave
Height by Wave Direction
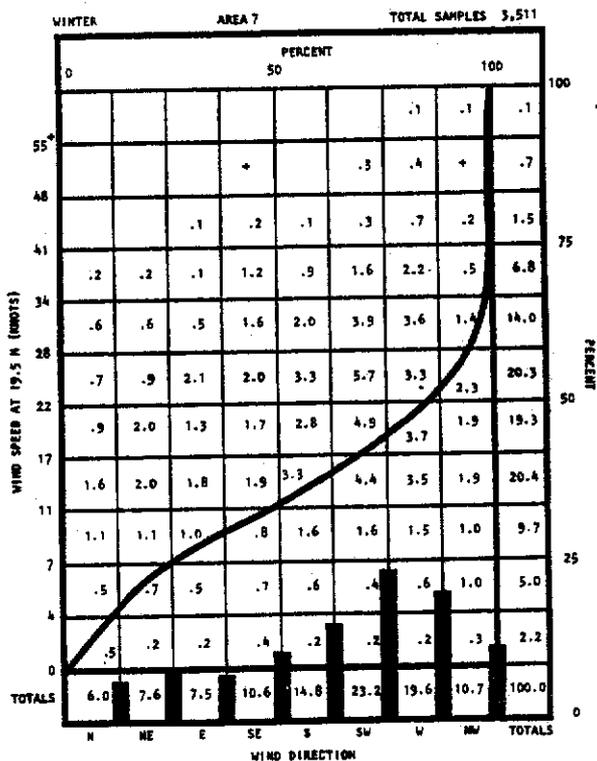
Figure A-7-2-4 Wind Speed by
Wind Direction
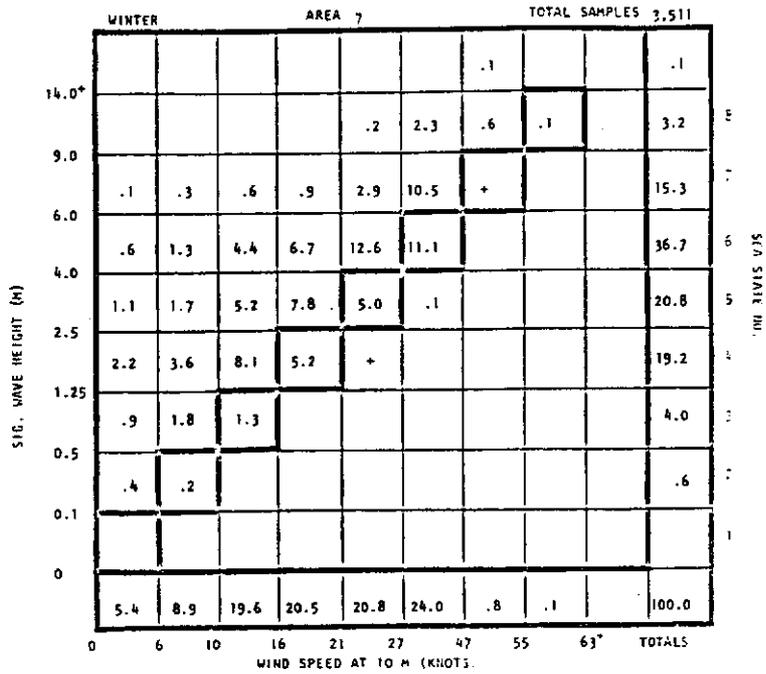
Figure A-7-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

SPRING   AREA 7   TOTAL SAMPLES 3,363

SIG. WAVE HEIGHT (M)														TOTALS
									+	+				.1
							.2	.2	.2	.1				.6
						.2	.4	.2	.3	+				1.1
					.1	1.0	.6	.3	.2					2.3
					1.0	.9	1.1	.3	.5	.1				3.9
				.4	3.1	1.3	.9	.2	.5					6.6
			.4	3.1	3.4	1.6	.8	.6	.3	.1				10.3
		.9	4.2	3.2	3.0	1.5	1.0	.9	.4	.5				15.6
		2.7	6.3	4.2	3.3	2.6	1.5/1.6	.7	.5	.8	+			23.6
	.1	2.2	4.9	4.5/5.0	3.1	2.5	2.0	2.5	.7	1.0	.9			27.3
	.1	1.9	1.2	.8	.7	.8	1.6	.5	.5	.1	.1	.4		8.6
TOTALS	.1	.2	4.1	8.3	12.5	12.5	14.0	17.3	10.6	9.6	4.1	3.8	2.9	+	100.0

MODAL WAVE PERIOD (SEC)
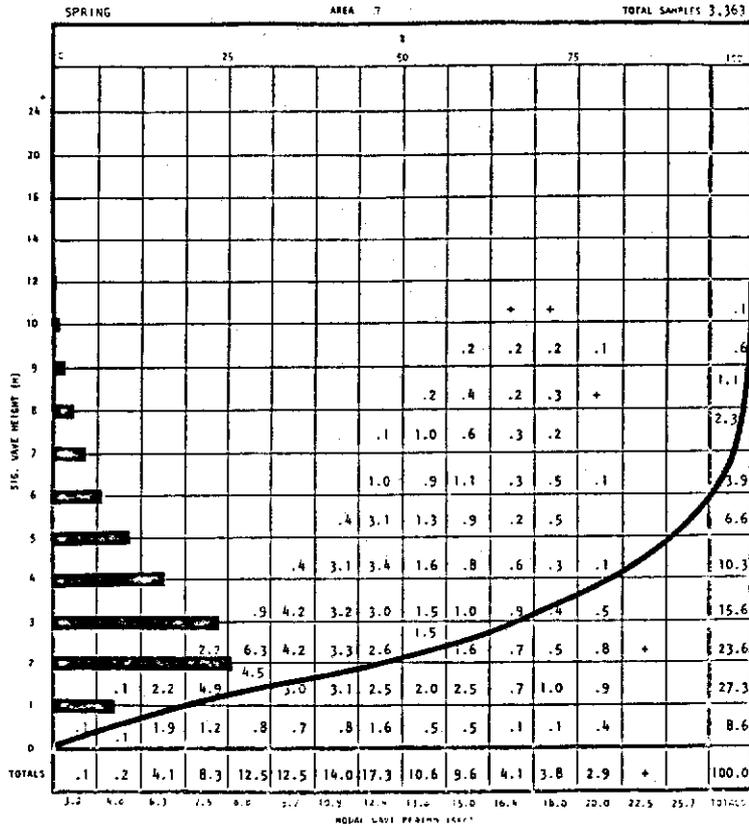
Figure A-7-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 7   TOTAL SAMPLES 3,363

SIG. WAVE HEIGHT (M)											TOTALS
							.1				.1
		.1	.1		+	.1	.1	.2	+		.6
		+		+	.1	+	.1	.6	.3		1.1
		+	.1	+	.2	.5	1.3	.1			2.3
		+	+	.1	.4	1.0	1.3	.9	+		3.9
			.1	.5	1.1	1.7	3.0	.2			6.6
			.1	.4	1.5	2.3	3.8	2.2	+		10.3
		.1	.4	.9	3.7	4.8	5.5	.1	+		15.6
		.5	1.0	2.3	9.0	9.3	1.5				23.6
		2.0	3.3	7.0	13.2	1.7	.1				27.3
		.7	2.0	4.5	1.4						8.6
TOTALS	3.5	7.0	15.4	29.5	19.7	13.9	2.3	3.1	.7	+	100.0

WIND SPEED AT 19.5 M (KNOTS)
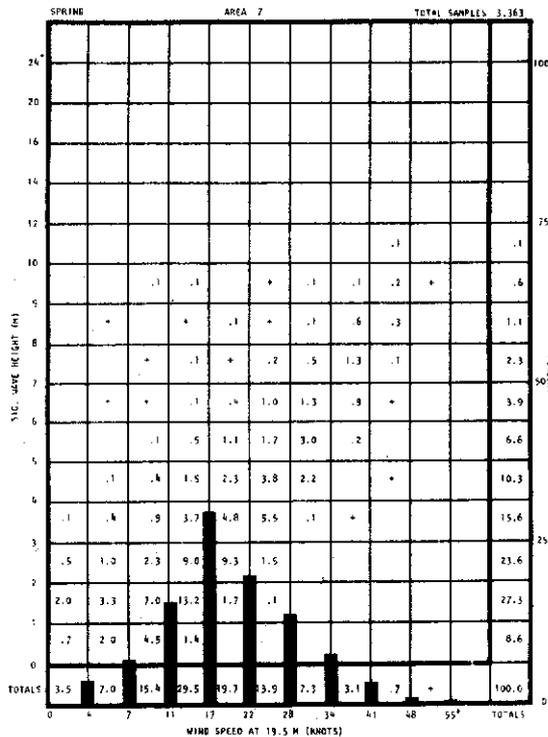
Figure A-7-3-2 Significant Wave
Height by Wind Speed

SPRING AREA 7 TOTAL SAMPLES 3,363

SIG. WAVE HEIGHT (M) / **PRIMARY WAVE DIRECTION**

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
10							.1		.?
9				+	.1	.2	.2		.6
			.1	+	.2	.4	.4		1.1
8			.1	+	.3	.6	.7	.6	2.3
7	.1		.1	.1	.3	.9	1.2	1.4	3.9
6	.1	+	.4	.2	.4	1.4	2.2	1.9	6.6
5	.4	.2	.5	.4	.7	2.0	3.4	2.9	10.3
4	.7	.4	.7	.9	.9	4.0	3.7	4.3	15.6
3	1.7	1.5	1.8	1.7	1.3	4.9	5.2	5.6	23.6
2	1.6	2.2	4.2	1.5	1.8	4.8	4.8	6.5	27.3
1	.3	1.3	1.7	.2	.2	2.1	1.1	1.5	8.6
TOTALS	4.8	5.7	9.4	5.0	6.0	21.0	22.9	25.2	100.0
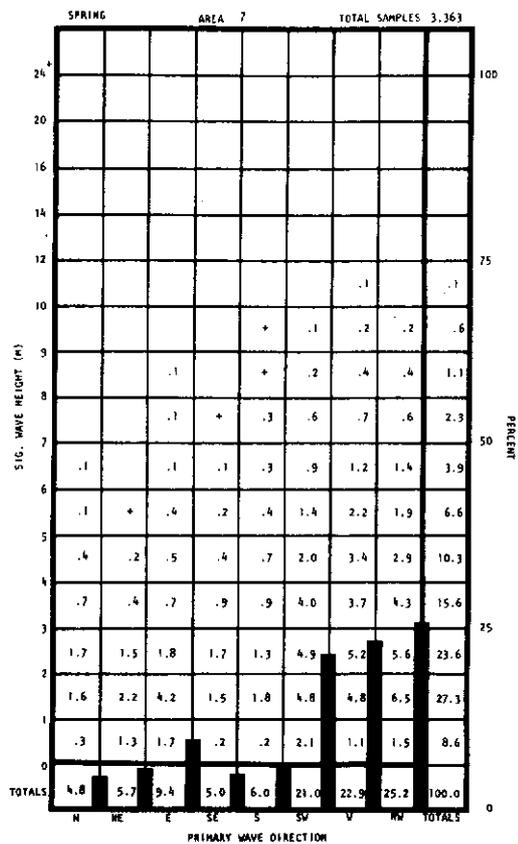
Figure A-7-3-3 Significant Wave Height by Wave Direction

SPRING AREA 7 TOTAL SAMPLES 3,363

PERCENT 0 50 100

WIND SPEED AT 19.5 M (KNOTS) / **WIND DIRECTION**

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
55+						+			+
48			.1		.1	.1	.4	.1	.7
41			.2		.8	.8	.7	.7	3.1
34	.1		.4	.2	1.0	1.8	2.3	1.3	7.3
28	.8	.3	.7	.6	2.9	3.8	2.9	1.8	13.9
22	1.3	1.4	.8	1.0	3.7	5.8	3.6	2.1	19.7
17	2.0	2.6	2.8	1.8	4.9	7.0	5.8	2.6	25.5
11	1.5	1.9	.9	1.2	2.1	3.5	2.3	2.0	15.4
7	.7	.9	.7	.5	.7	1.1	1.0	1.0	7.0
4	.5	.6	.5	.4	.2	.4	.4	.4	8.5
TOTALS	7.1	7.7	7.0	6.1	16.5	24.4	19.2	12.0	100.0
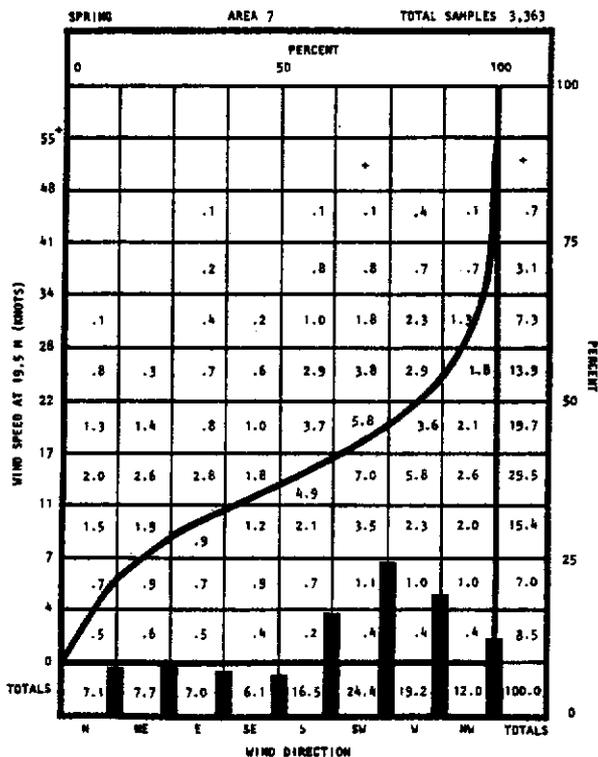
Figure A-7-3-4 Wind Speed by Wind Direction

SPRING | AREA 7 | TOTAL SAMPLES 3,363

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+			.1	+	+	.4	+			.6	8
9.0	+	.1	.2	.4	1.2	4.9				6.9	7
6.0	.4	.7	2.9	4.7	8.1	6.4				23.2	6
4.0	.6	1.1	5.4	7.0	6.2	+				20.3	5
2.5	3.5	5.9	15.1	8.8	.5					33.9	4
1.25	3.3	5.3	5.3		+					13.9	3
0.5	.3	.8	+							1.1	2
0.1											1
0											
TOTALS	8.2	14.0	29.0	21.0	16.1	11.8	+			100.0	

WIND SPEED AT 10 M (KNOTS)

Figure A-7-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
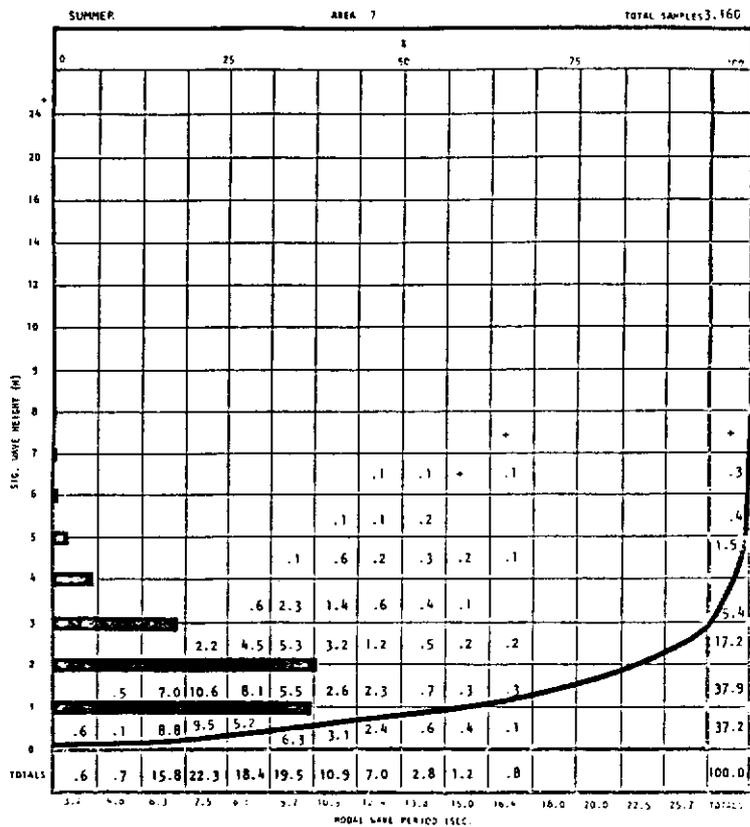
Figure A-7-4-1 Significant Wave
Height by Modal Wave Period
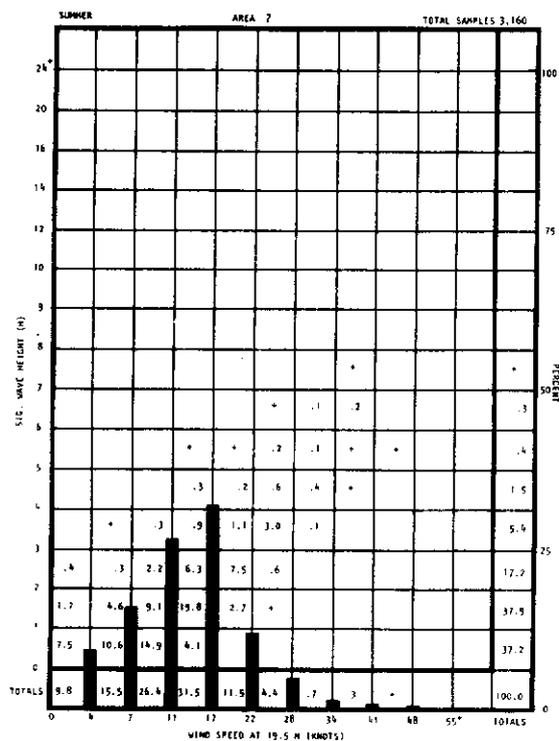
Figure A-7-4-2 Significant Wave
Height by Wind Speed

SUMMER   AREA 7   TOTAL SAMPLES 3,160

SIG. WAVE HEIGHT (M)

PRIMARY WAVE DIRECTION

PERCENT
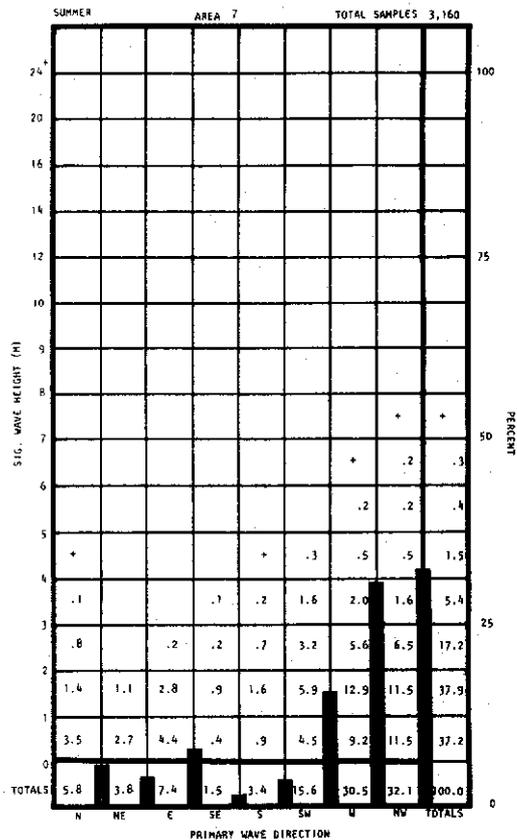
Figure A-7-4-3 Significant Wave
Height by Wave Direction

SUMMER   AREA 7   TOTAL SAMPLES 3,160

PERCENT

WIND SPEED AT 19.5 M (KNOTS)
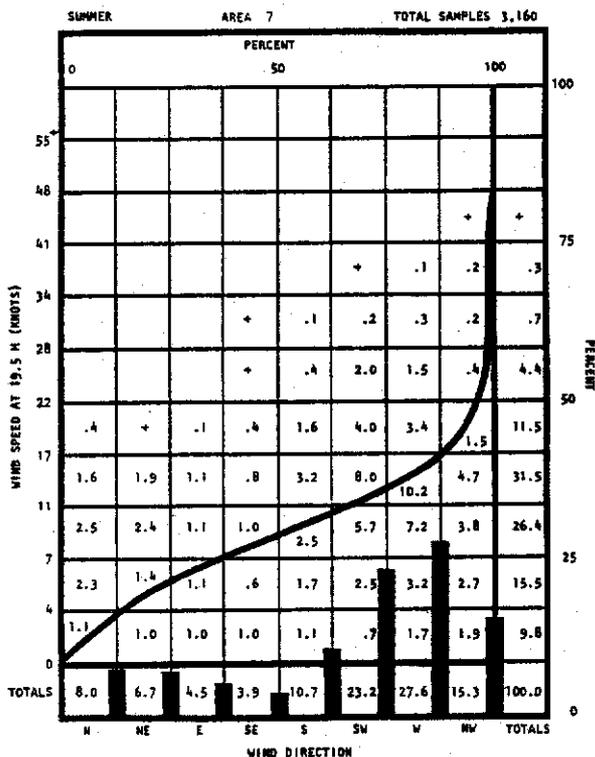
WIND DIRECTION

Figure A-7-4-4 Wind Speed by
Wind Direction

Figure A-7-4-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
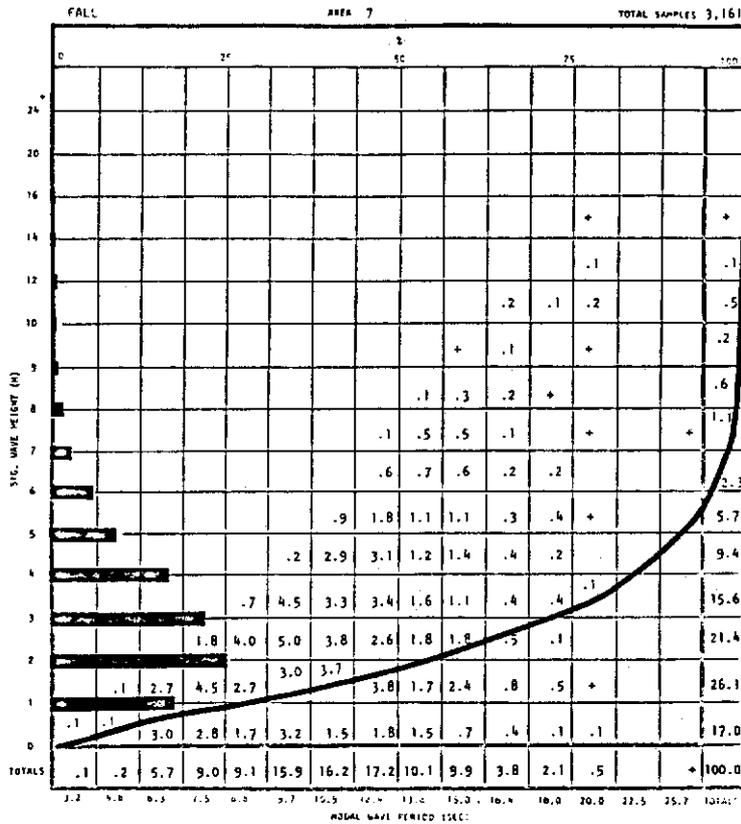
Figure A-7-5-1 Significant Wave
Height by Modal Wave Period
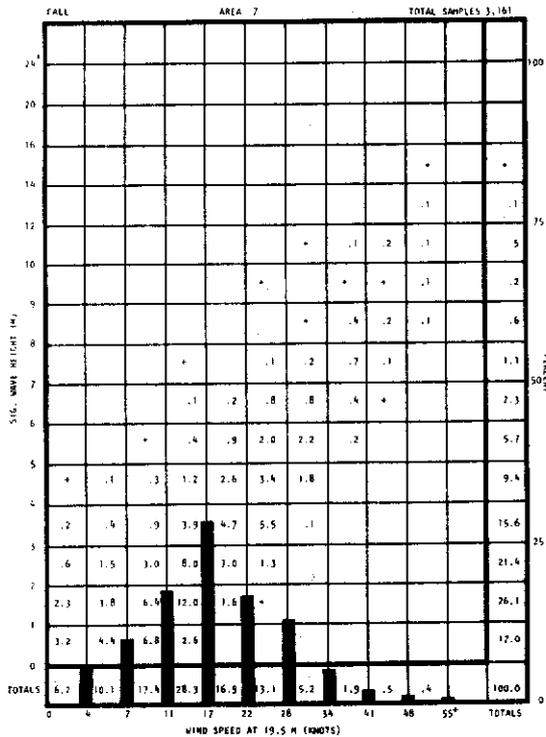
Figure A-7-5-2 Significant Wave
Height by Wind Speed
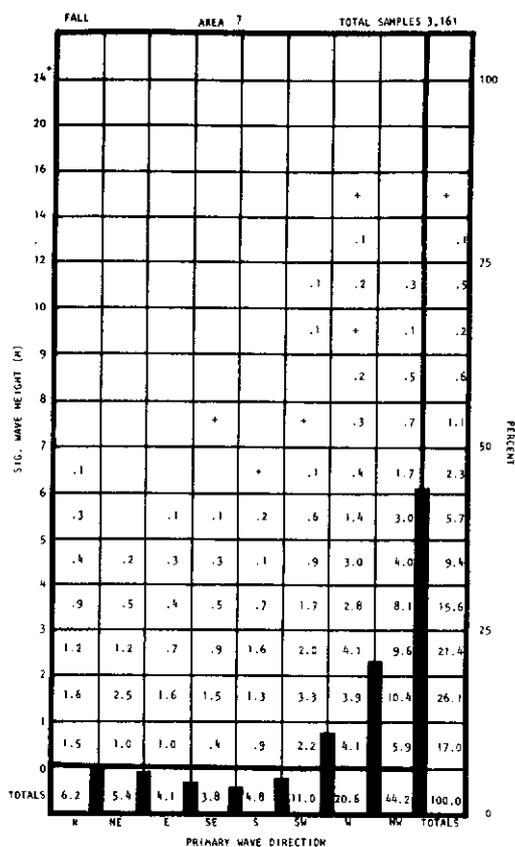
Figure A-7-5-3 Significant Wave
Height by Wave Direction
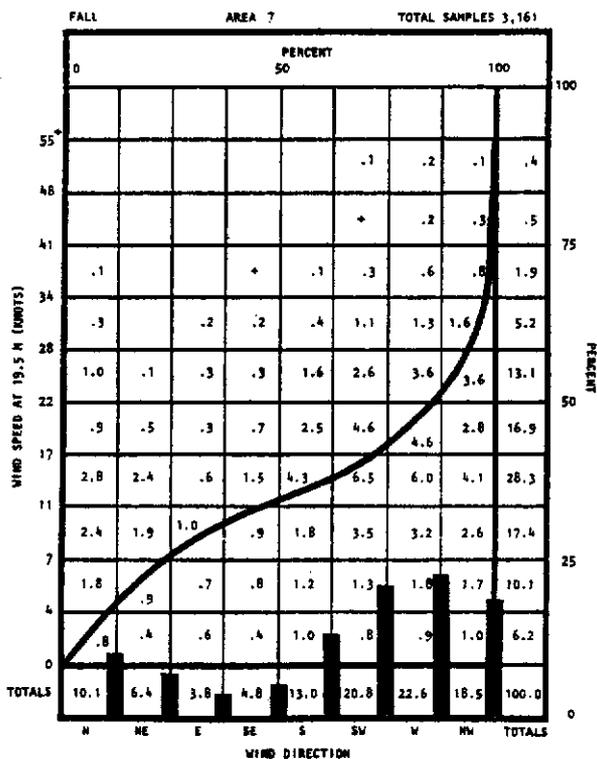
Figure A-7-5-4 Wind Speed by
Wind Direction

Figure A-7-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-10-1-1 – SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 34.097° N, 52.857° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	5.5	2	1
Wave Period, sec	5	9	16	10	9.5
Direction	-	-	-	-	W
Winds					
Speed, knots	2	11	28	13	12
Corresponding Mean Sig. Wave Height, m.	1	1.5	5	2	1.5
Direction	-	-	-	-	SW
Visibility, nautical miles	6	13	24	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	1	6	8	-	-
Low clouds, in eighths of sky obscured	1	3.5	7.5	-	-
Precipitation (Occurrence)	All precipitation – 14% of the time				
Relative Humidity, %	57	76	96	-	-
Air Temperature, °C	15.5	20.5	26	20.5	-
Surface Water Temperature, °C	17.5	21	26	-	-
Sea Level Pressure, millibars	1,007	1,020	1,029	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	353	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

Figure A-10-1-1 Significant Wave
Height by Modal Wave Period

Figure A-10-1-2 Significant Wave
Height by Wind Speed
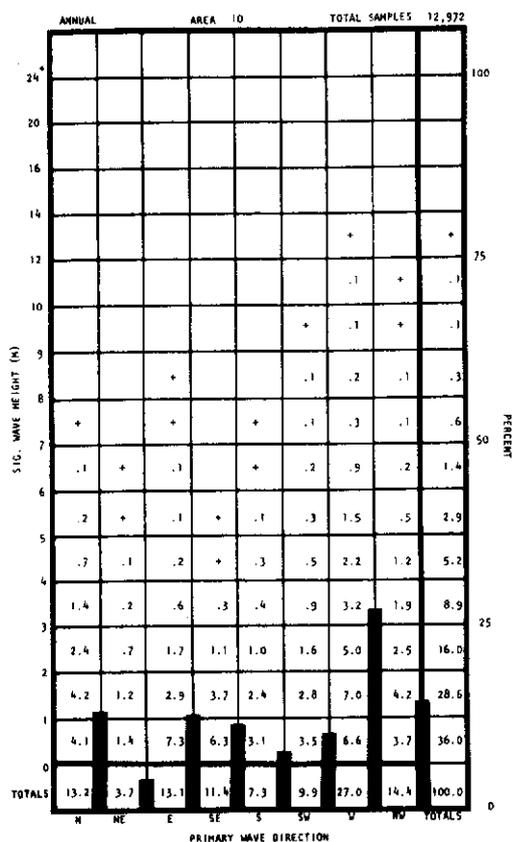
Figure A-10-1-3 Significant Wave
Height by Wave Direction
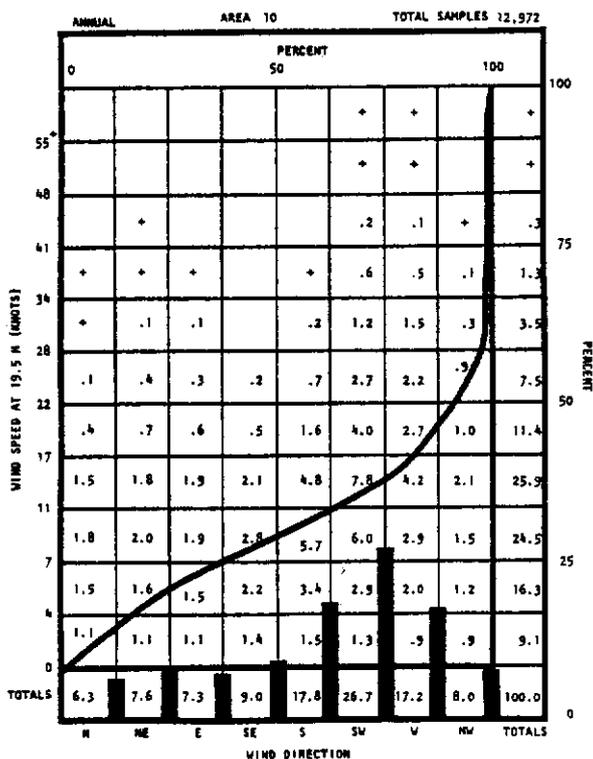
Figure A-10-1-4 Wind Speed by
Wind Direction

ANNUAL   AREA 10   TOTAL SAMPLES 12,972

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+					.2	+	+			.2	8
9.0	+	+	+	.1	.2	1.9	+		.	2.3	7
6.0	.2	.4	1.3	2.1	4.1	3.8				12.0	6
4.0	.7	1.0	2.8	3.8	3.7	.1				12.1	5
2.5	3.6	5.3	13.2	6.8	.4					29.2	4
1.25	7.0	10.7	11.2	.1						29.0	3
0.5	8.0	6.9	.4							15.3	2
0.1											1
0											
TOTALS	19.4	24.3	28.9	12.8	8.4	6.0	+	+		100.0	

WIND SPEED AT 10 M (KNOTS)
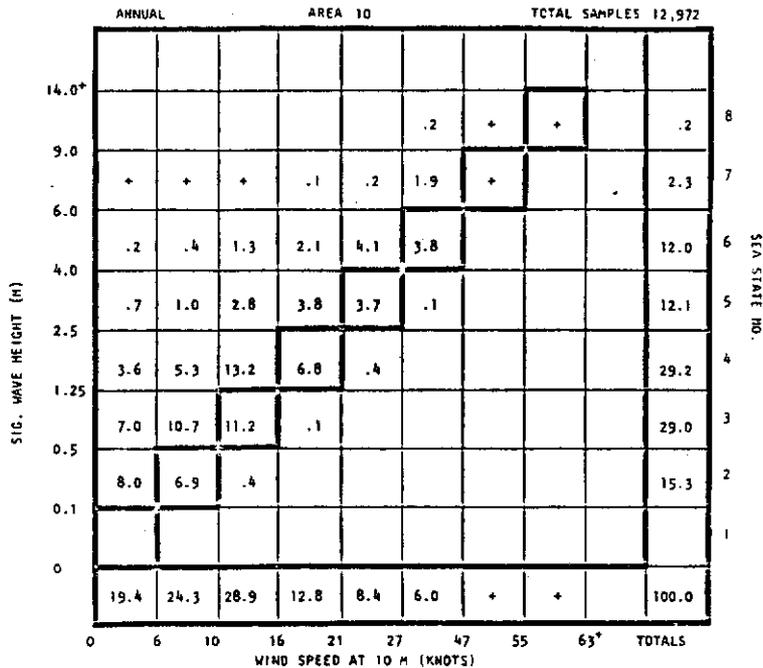
Figure A-10-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
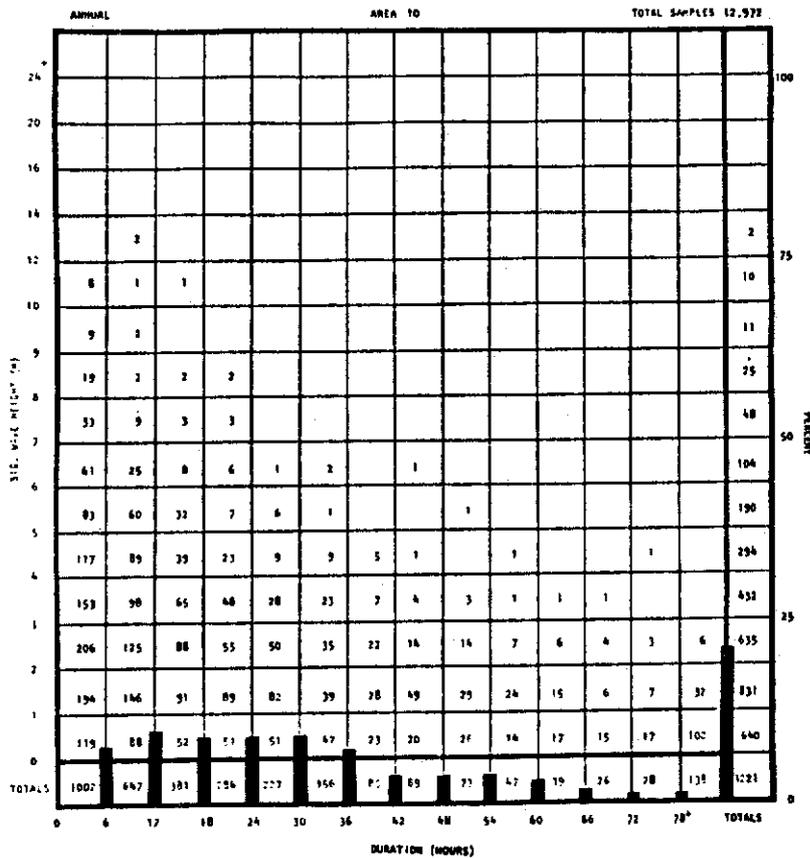
Figure A-10-1-6 Persistence of
Significant Wave Height
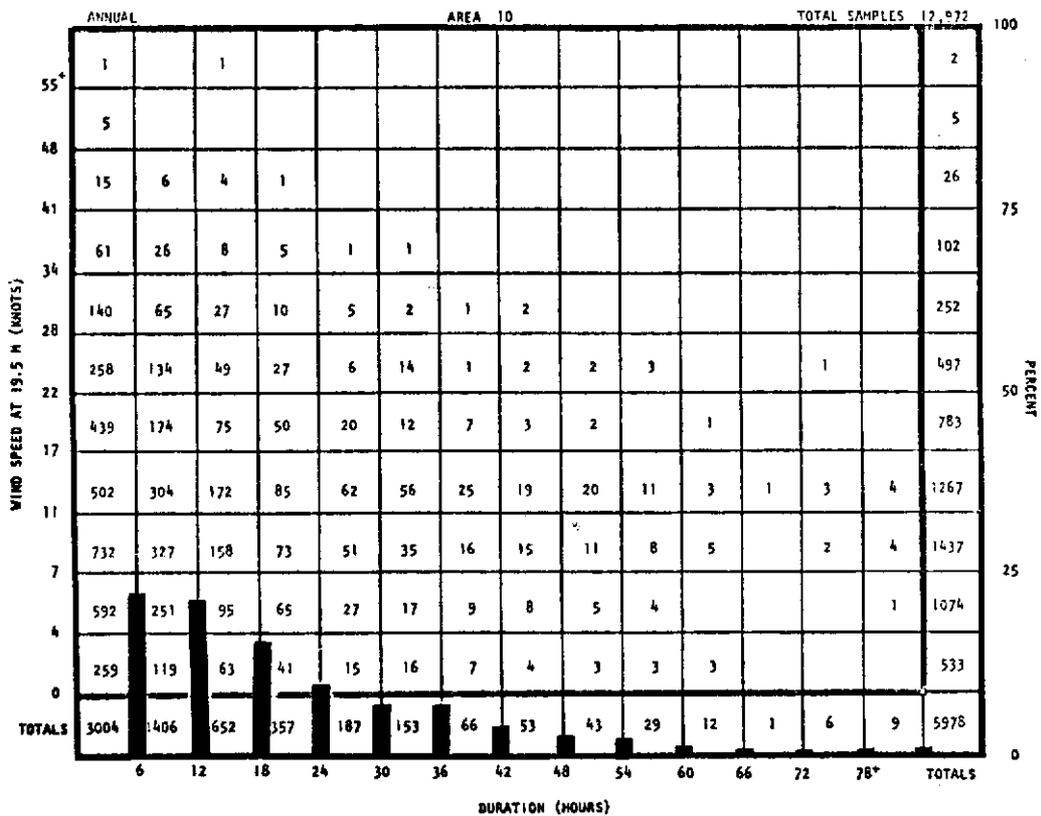
Figure A-10-1-7 Persistence of Wind Speed
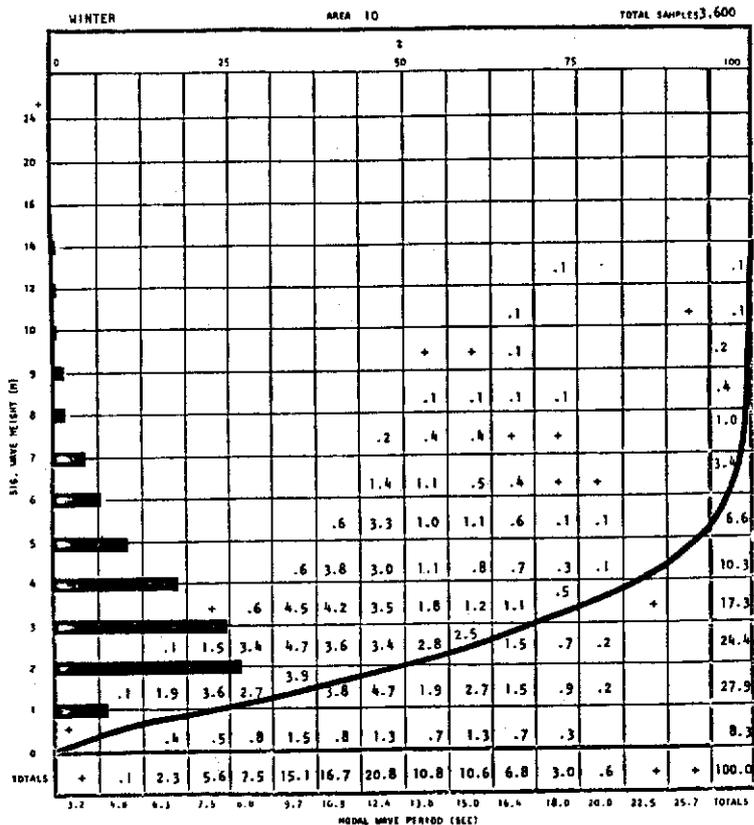
Figure A-10-2-1 Significant Wave
Height by Modal Wave Period
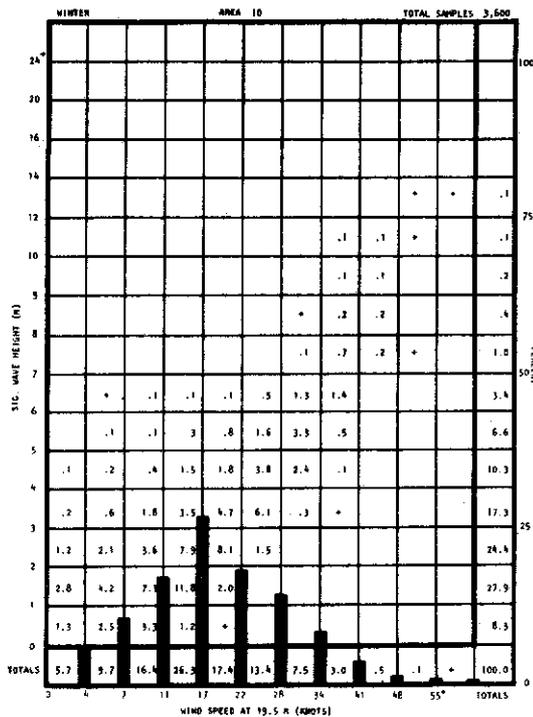
Figure A-10-2-2 Significant Wave
Height by Wind Speed
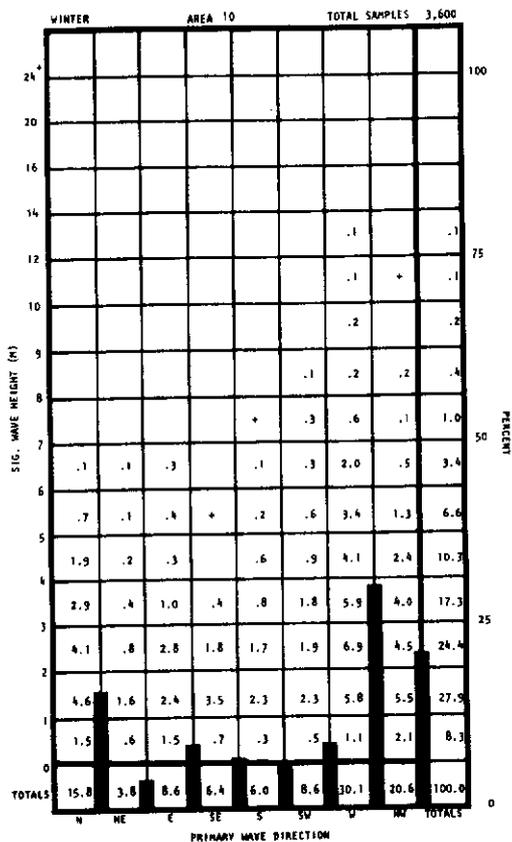
Figure A-10-2-3 Significant Wave
Height by Wave Direction
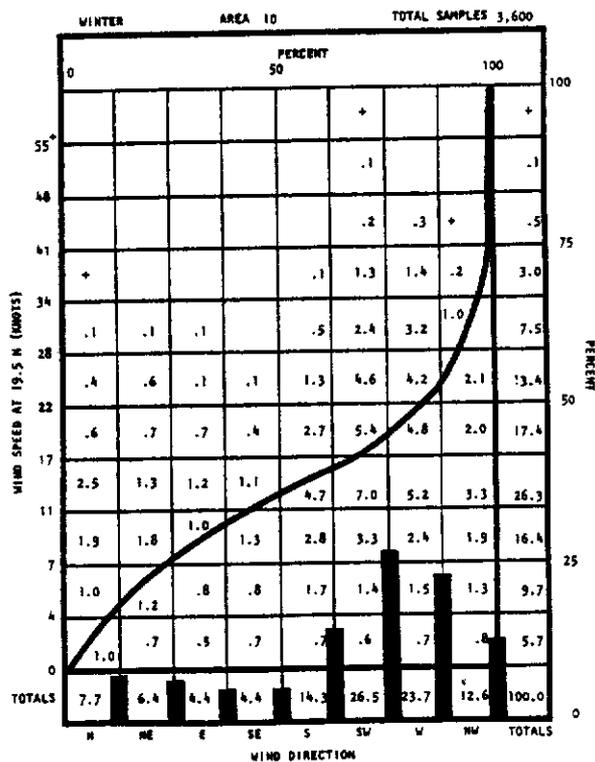
Figure A-10-2-4 Wind Speed by
Wind Direction
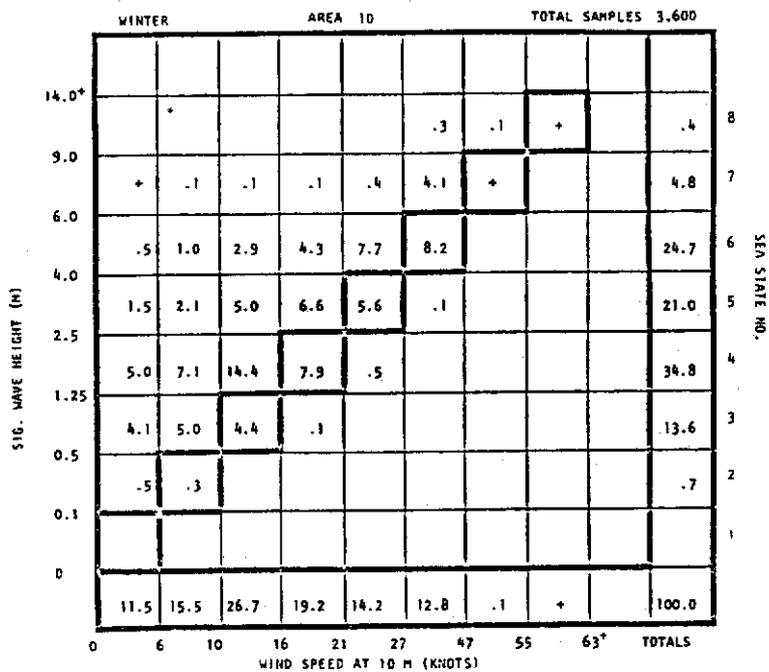
Figure A-10-2-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

SPRING   AREA 10   TOTAL SAMPLES 3,294
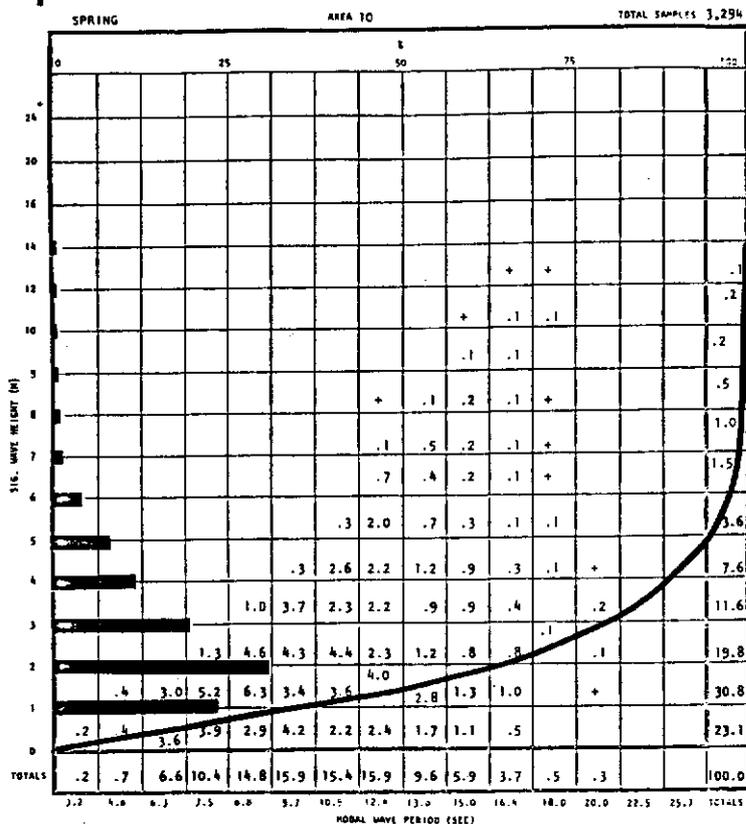
Figure A-10-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 10   TOTAL SAMPLES 3,294
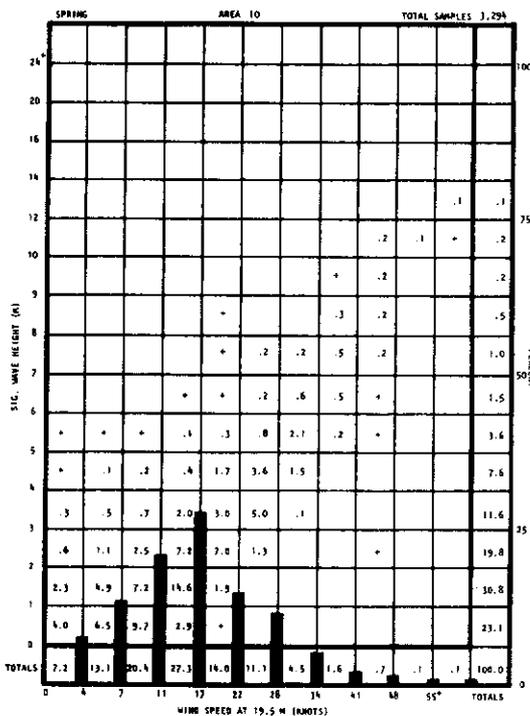
Figure A-10-3-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

A-121

SPRING AREA 10 TOTAL SAMPLES 3,294

Significant Wave Height (M) by Primary Wave Direction — Percent

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
12							.1		.1
							.2		.2
10					+	.1	.1	.2
9					.2	.3	+	.5
8	+			+	.3	.5	.2	1.0
7	.1			.1	.2	1.0	.2	1.5
6	.2	+		+	.5	2.2	.7	3.6
5	.8	+	.2	.4	.8	3.3	2.1	7.6
4	1.5	.1	.4	.3	.5	1.3	5.2	2.3	11.6
3	2.5	.5	1.1	1.3	1.2	1.8	7.9	3.3	19.8
2	4.6	.7	2.2	3.6	2.8	2.6	9.7	4.6	30.8
1	3.3	.9	3.9	2.7	1.5	2.4	5.1	3.4	23.1
TOTALS	13.0	2.2	7.9	7.9	6.5	10.1	35.5	16.9	100.0

PRIMARY WAVE DIRECTION
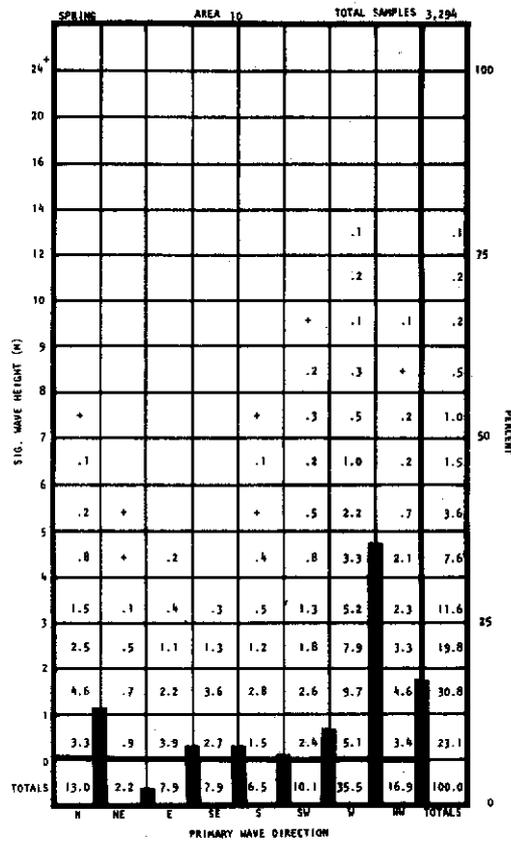
Figure A-10-3-3 Significant Wave Height by Wave Direction

SPRING AREA 10 TOTAL SAMPLES 3,294

Wind Speed at 19.5 M (KNOTS) by Wind Direction — Percent

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
55+					+	.1			.1
						.1			.1
48					.4	.3	.1	.7
41					1.0	.6	+	1.6
34	+	+			.3	1.7	2.2	.2	4.5
28	+	.1	.2	.4	.9	4.7	3.3	1.3	11.1
22	.2	.9	.5	.5	1.9	4.9	3.8	1.3	14.0
17	1.0	1.3	1.3	1.9	5.6	8.7	4.7	2.7	27.3
11	1.9	1.4	1.2	2.6	4.1	4.6	2.9	1.8	20.4
7	1.2	1.1	1.4	2.0	2.2	2.1	2.0	1.1	13.1
4	.5	.9	.5	.8	1.0	1.3	1.0	.9	7.2
TOTALS	5.2	5.6	5.4	8.2	15.9	29.3	20.9	9.4	100.0
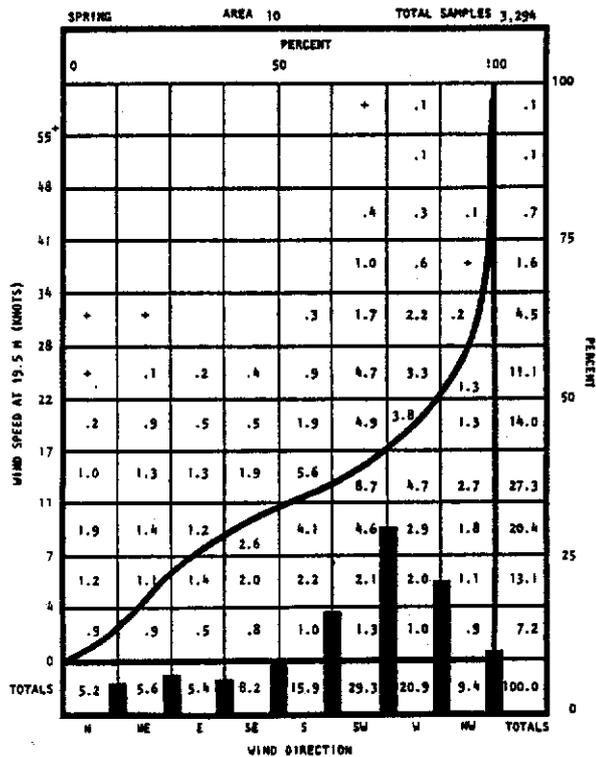
WIND DIRECTION

Figure A-10-3-4 Wind Speed by Wind Direction

SPRING   **AREA 10**   **TOTAL SAMPLES 3,294**

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+						.4	.1	.1		.5	8
9.0			+	.1	.3	2.5				2.9	7
6.0	.3	.5	1.2	2.9	6.2	5.1				16.2	6
4.0	.7	1.1	3.4	4.7	4.9	.1				14.9	5
2.5	4.6	6.4	15.2	7.6	.3					34.1	4
1.25	6.6	10.0	9.1	.1						25.8	3
0.5	3.0	2.5	+							5.5	2
0.1											1
0											
TOTALS	21.?	20.6	28.9	15.4	11.8	8.0	.1	.1		100.0	

WIND SPEED AT 10 M (KNOTS)
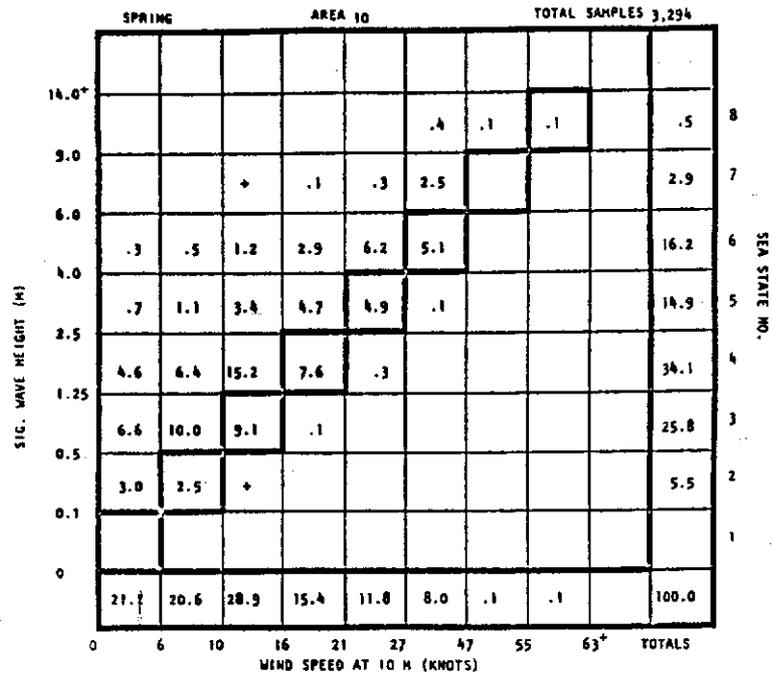
Figure A-10-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

SUMMER   AREA 10   TOTAL SAMPLES 2,815

Figure A-10-4-1 Significant Wave
Height by Modal Wave Period

SUMMER   AREA 10   TOTAL SAMPLES 2,815

Figure A-10-4-2 Significant Wave
Height by Wind Speed
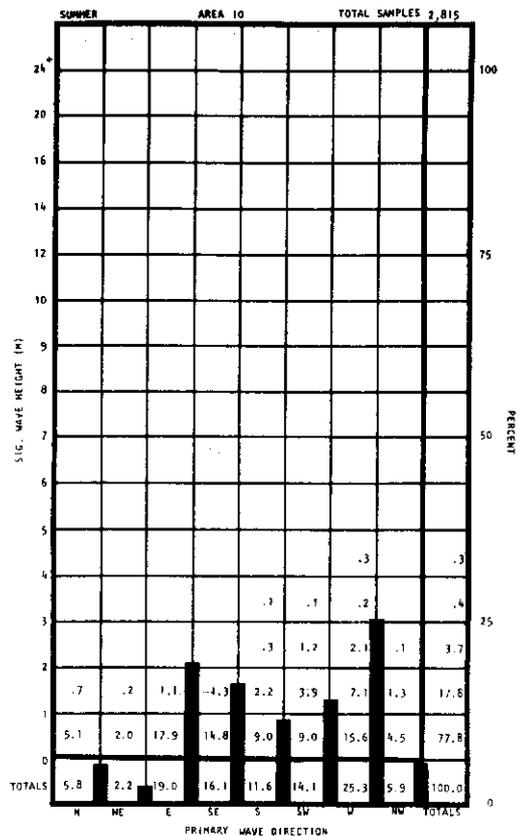
Figure A-10-4-3 Significant Wave
Height by Wave Direction
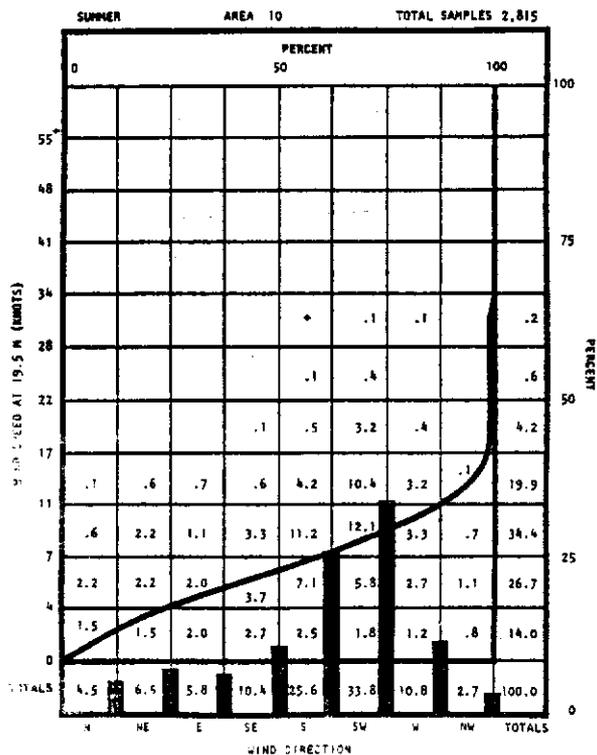
Figure A-10-4-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

A-125
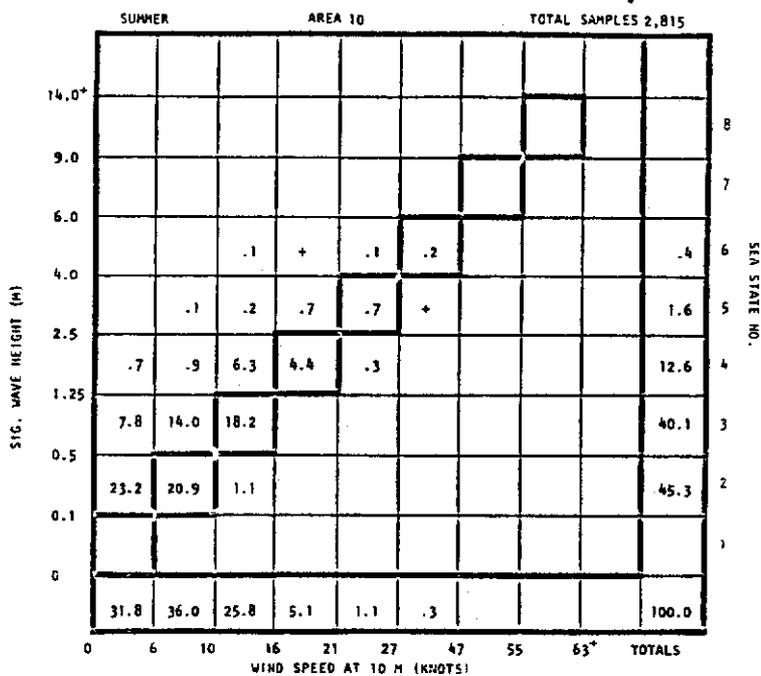
Figure A-10-4-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
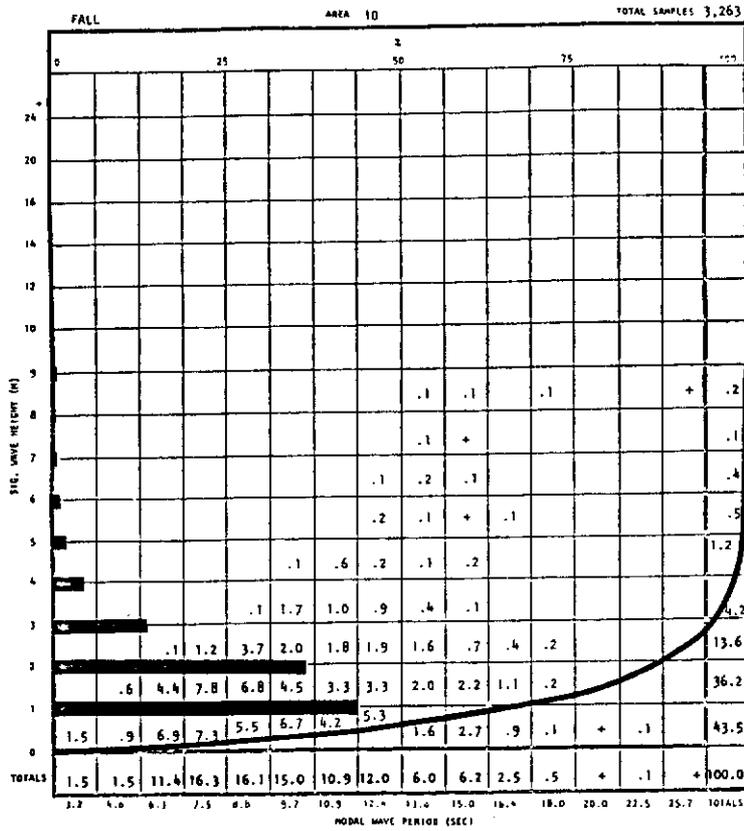
Figure A-10-5-1 Significant Wave
Height by Modal Wave Period
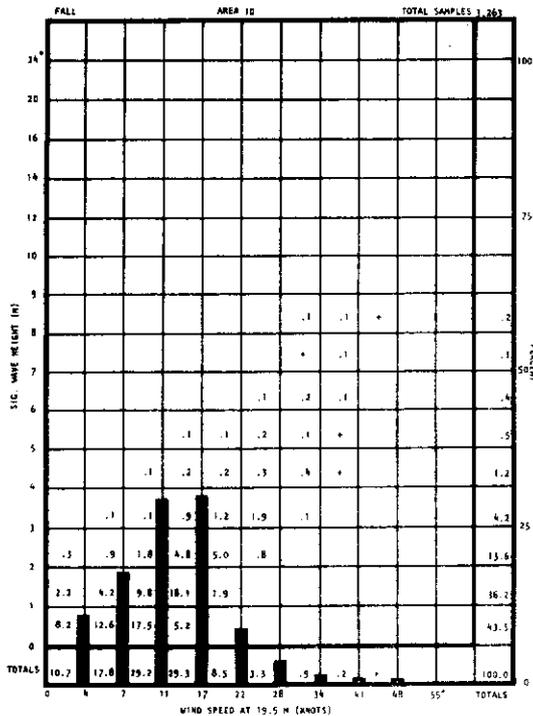
Figure A-10-5-2 Significant Wave
Height by Wind Speed
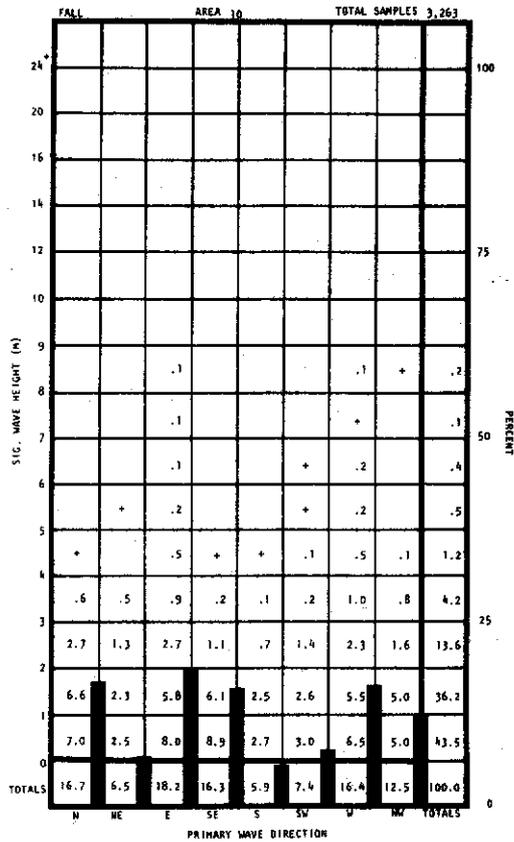
Figure A-10-5-3 Significant Wave
Height by Wave Direction
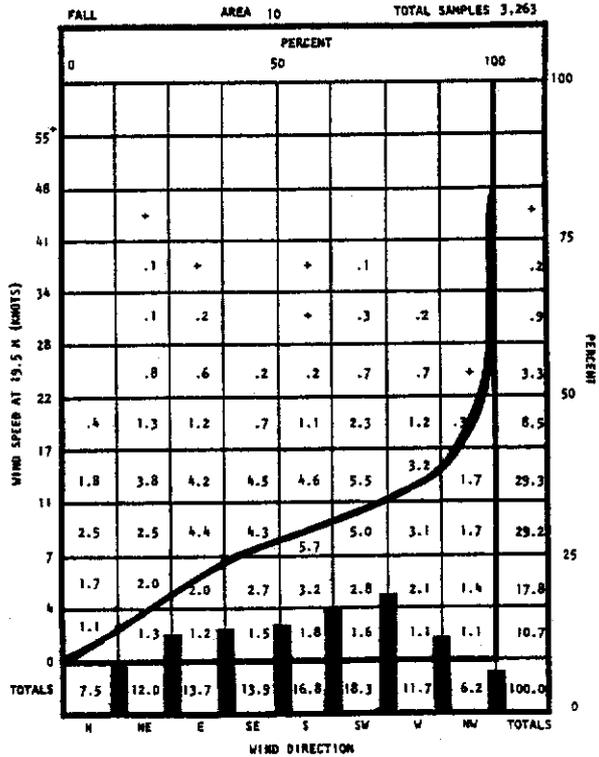
Figure A-10-5-4 Wind Speed by
Wind Direction
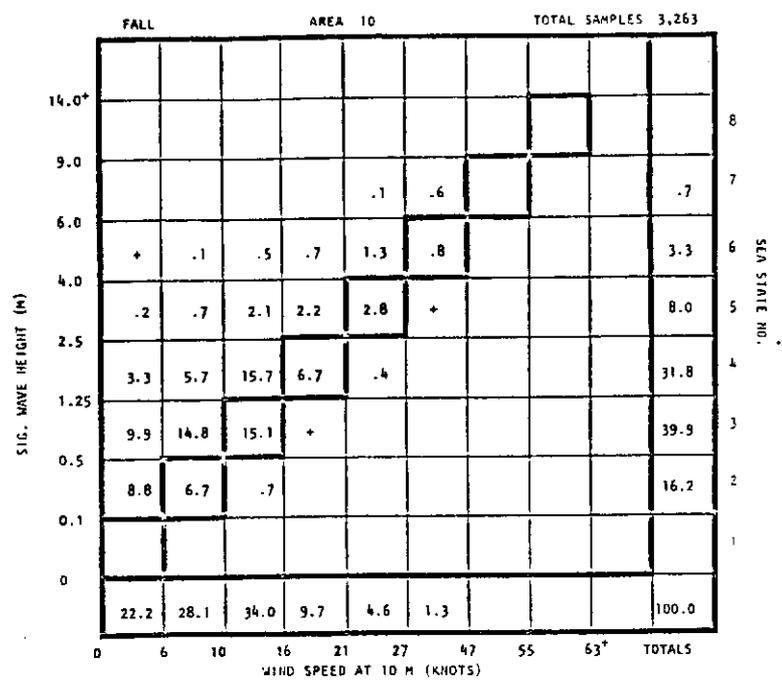
Figure A-10-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-11-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 39.912° N, 21.794° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2	5.5	2.5	1.5
Wave Period, sec	6	10	16	11	12
Direction	-	-	-	-	NW
Winds					
Speed, knots	3	12	28	13	14
Corresponding Mean Sig. Wave Height, m.	1	2	5	2	2
Direction	-	-	-	-	W - NW
Visibility, nautical miles	5.5	17	25	-	-
Cloud Cover:					
Total clouds, in eighths of sky obscured	Nil	5	8	-	-
Low clouds, in eighths of sky obscured	Nil	4	8	-	-
Precipitation (Occurrence)	All precipitation - 10% of the time		Snow - 1% of the time (Dec - Mar)		
Relative Humidity, %	50	80	96	-	-
Air Temperature, °C	13.5	17.5	23	17.5	-
Surface Water Temperature, °C	14	18	23	-	-
Sea Level Pressure, millibars	1,005	1,022	1,032	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity (1 km, Annual)	-	-	-	338	-
Sub-Refraction (1 km, Annual)	-	-	-	-	5% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

Figure A-11-1-1 Significant Wave
Height by Modal Wave Period
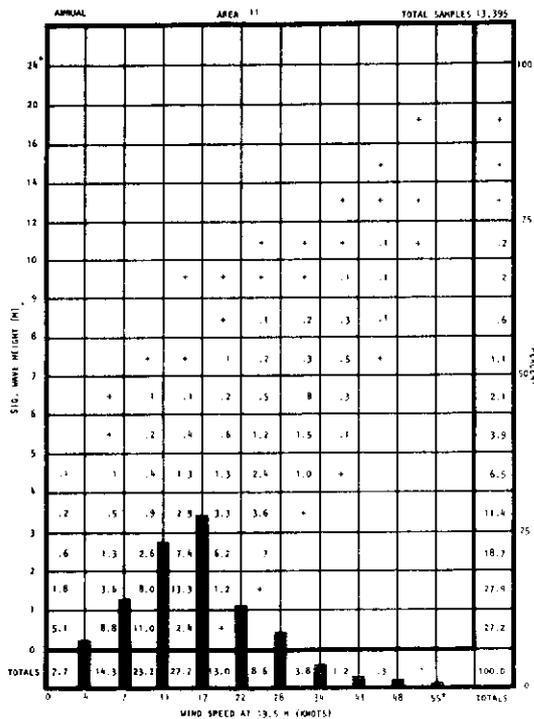
Figure A-11-1-2 Significant Wave
Height by Wind Speed

ANNUAL · AREA 11 · TOTAL SAMPLES 13,395

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
15							+		+
13							.1	.1	.2
10							.1	.1	.2
9				+	+		.2	.3	.6
8	+	+	+	+	+	.1	.3	.6	1.1
7	+	.1	.1	.1		.3	.5	1.0	2.1
6	+	.1	.1	.2	.1	.4	1.0	2.1	3.9
5	.4	.2	.2	.3	.3	.8	1.5	2.5	6.5
4	.5	1.0	.4	.5	.3	1.3	2.7	4.7	11.4
3	1.4	2.2	.5	1.0	.5	2.2	3.6	7.4	18.7
2	1.8	4.4	.9	1.4	1.0	2.4	5.1	11.0	27.5
1	2.3	5.1	.6	.5	1.2	1.8	3.9	11.9	27.2
TOTALS	6.6	13.1	2.7	4.1	3.4	9.2	19.0	42.0	100.0

PRIMARY WAVE DIRECTION

Figure A-11-1-3 Significant Wave Height by Wave Direction

ANNUAL · AREA 11 · TOTAL SAMPLES 13,395

PERCENT

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
55							+	+	.1
48			+	+		+	.2	+	.3
41	+	+	+	.1	.1	.2	.4	.3	1.2
34	.1	.1	.3	.2	.4	1.0	1.0	.8	3.8
28	.4	.3	.6	.5	.9	2.3	2.1	1.4	8.6
22	1.1	.9	.6	.6	1.6	3.2	3.0	2.1	13.0
17	2.9	3.1	1.7	1.4	2.7	5.3	5.6	4.5	27.7
11	3.3	3.4	1.7	1.3	2.1	3.9	4.1	3.3	23.2
7	2.6	1.9	1.1	.9	1.1	1.8	2.2	2.8	14.3
4	1.3	1.0	.9	.7	.8	.9	1.0	1.2	7.7
TOTALS	11.8	10.7	7.0	5.7	9.7	19.2	19.6	16.3	100.0

WIND DIRECTION

Figure A-11-1-4 Wind Speed by Wind Direction

ANNUAL   AREA 11   TOTAL SAMPLES 13,395

	0	6	10	16	21	27	47	55	63⁺	TOTALS
14.0⁺						+	+			+
9.0			+		+	.3	.1			.4
6.0	+	.1	.2	.3	.7	2.8				4.0
4.0	.3	.8	2.7	3.3	5.6	3.6				16.5
2.5	.9	1.4	4.5	5.2	3.6	+				15.5
1.25	3.4	6.0	14.9	6.0	.2					30.6
0.5	6.3	9.5	8.0	+						23.9
0.1	4.9	4.0	.1							9.1
0										
TOTALS	15.7	21.8	30.4	14.9	10.1	6.8	.1			100.0

SIG. WAVE HEIGHT (M) — WIND SPEED AT 10 M (KNOTS) — SEA STATE NO. (8,7,6,5,4,3,2,1)

Figure A-11-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

ANNUAL   AREA 11   TOTAL SAMPLES 13,395
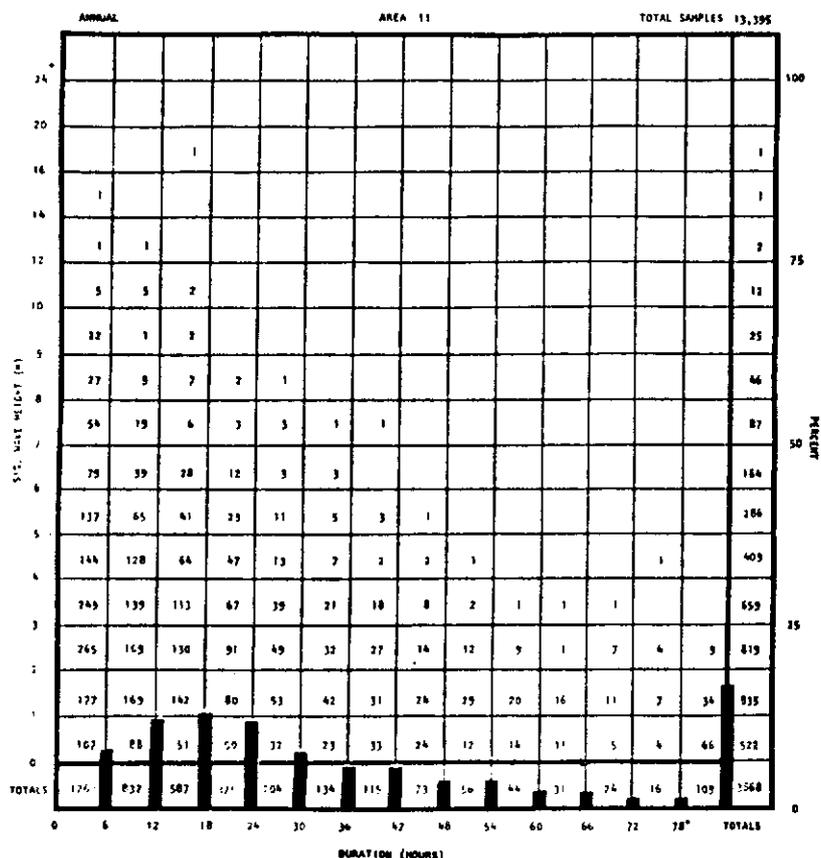
Figure A-11-1-6 Persistence of
Significant Wave Height

ANNUAL — AREA 11 — TOTAL SAMPLES 13,395

WIND SPEED AT 19.5 M (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55+	4		1											5
48	14	3	3	2										22
41	49	25	11	4	3									92
34	132	65	30	15	8	2	1	3	2					258
28	256	125	81	36	19	16	7	2	1					543
22	547	186	90	52	29	19	8	5	2		1	1		940
17	583	346	183	106	69	43	27	15	16	9	5	8		1410
11	689	317	164	84	54	39	17	11	11	3	1	4	1	1355
7	543	220	155	41	29	17	3	5			2	1	1	2	1025
4	269	126	56	33	23	9	12	1	3	1	1		5	3	542
0														
TOTALS	3092	1413	774	373	234	145	75	42	35	13	10	14	7	5	6232

DURATION (HOURS)
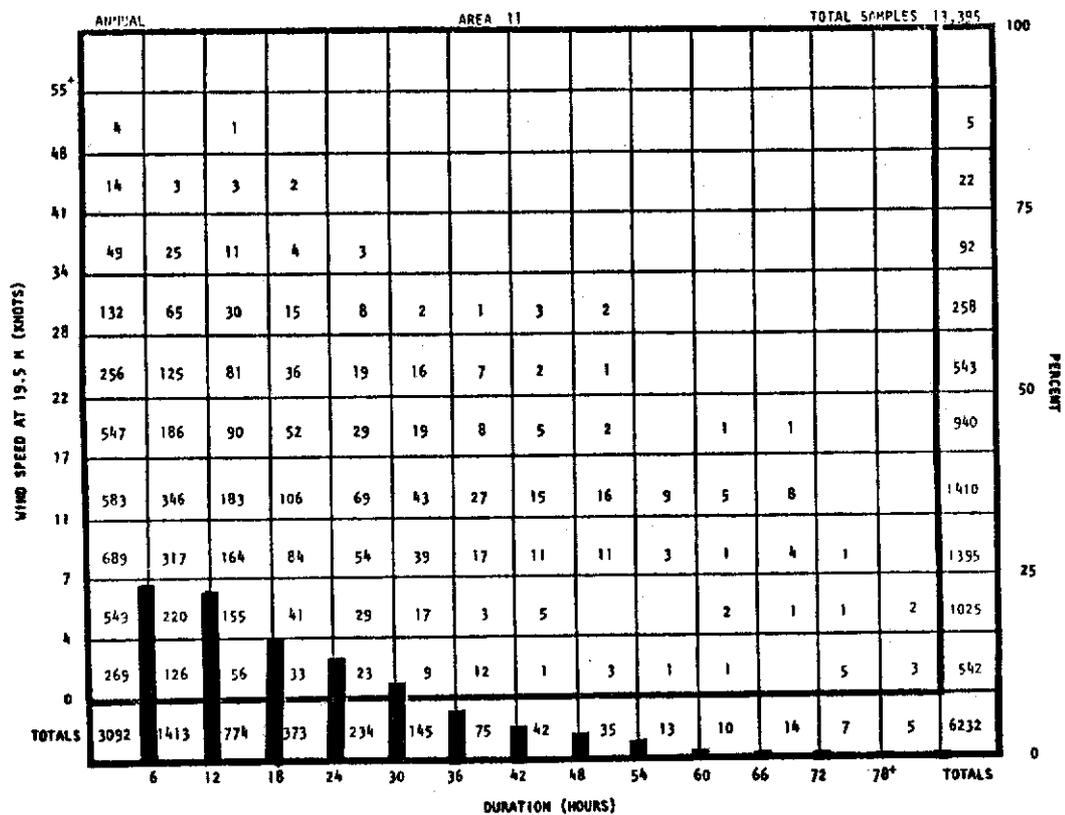
Figure A-11-1-7 Persistence of
Wind Speed

Figure A-11-2-1 Significant Wave
Height by Modal Wave Period

Figure A-11-2-2 Significant Wave
Height by Wind Speed
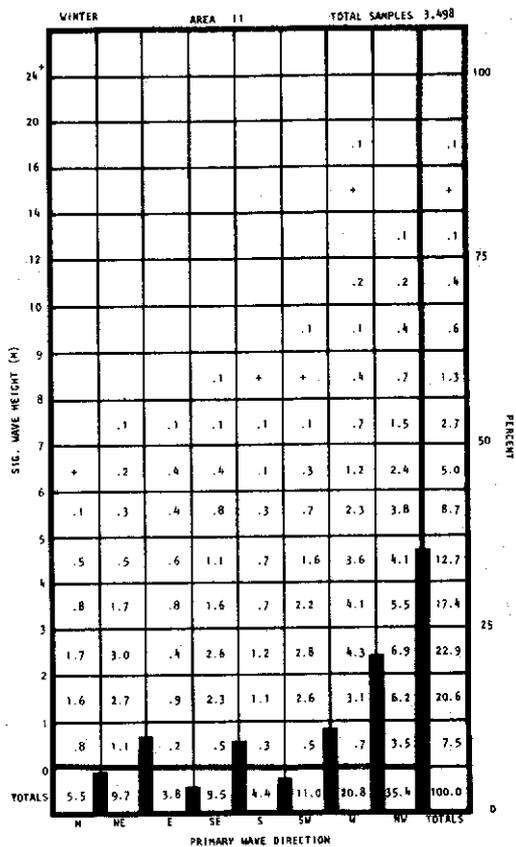
Figure A-11-2-3 Significant Wave
Height by Wave Direction
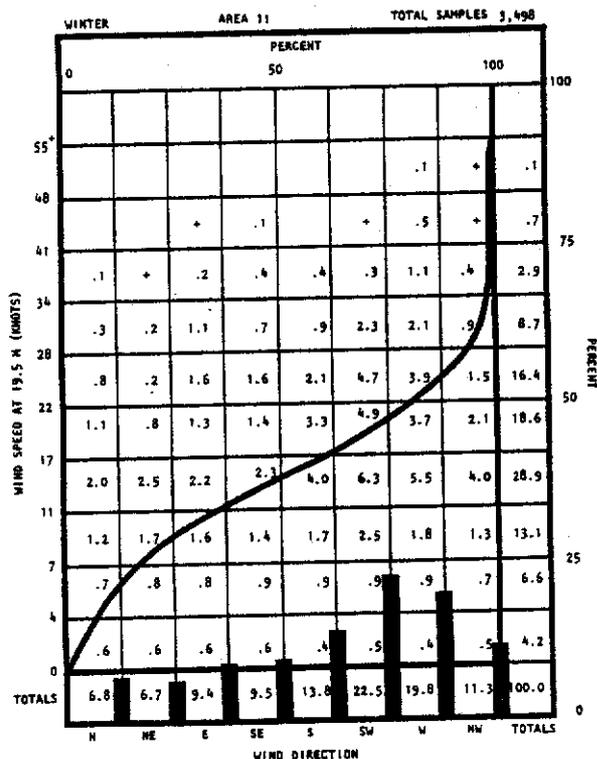
Figure A-11-2-4 Wind Speed by
Wind Direction

WINTER				AREA 11				TOTAL SAMPLES 3,498	

Significant Wave Height (M) vs. Wind Speed at 10 M (Knots) — Sea State No.

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63+	TOTALS	SEA STATE NO.
14.0+						*	.1		.1	
9.0			*		.1	.9	.1		1.1	8
6.0	*	.3	.4	.7	1.8	5.8			9.0	7
4.0	.5	.9	4.6	5.8	10.2	7.7			29.7	6
2.5	1.5	1.5	5.9	7.0	4.8	*			20.7	5
1.25	2.8	4.6	13.0	6.5	.2				27.1	4
0.5	3.0	4.6	14.1	.1					11.8	3
0.1	.1	.3							.4	2
0										1
TOTALS	8.1	12.0	28.1	20.0	17.1	14.5	.2		100.0	

WIND SPEED AT 10 M (KNOTS)
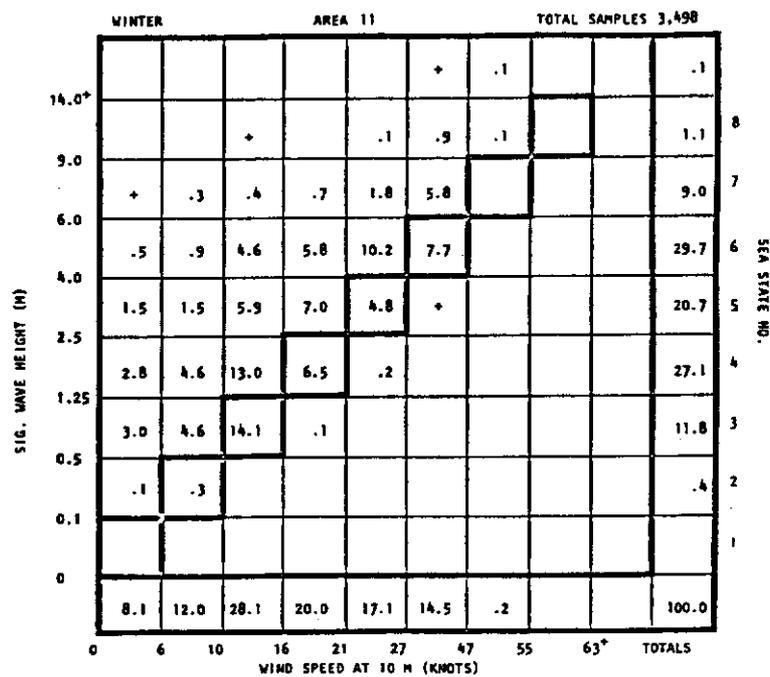
Figure A-11-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
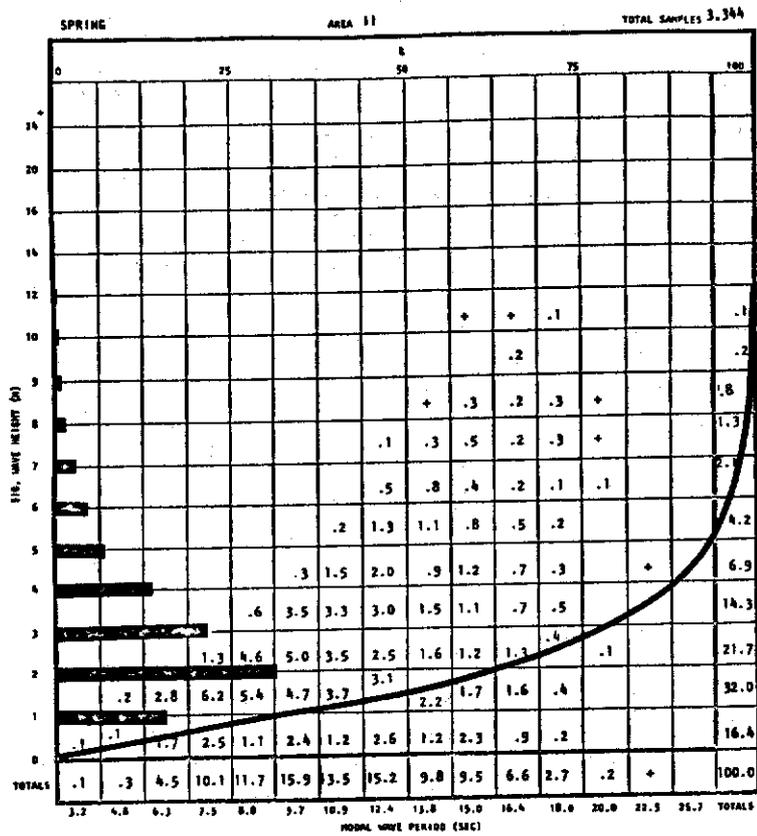
Figure A-11-3-1 Significant Wave
Height by Modal Wave Period
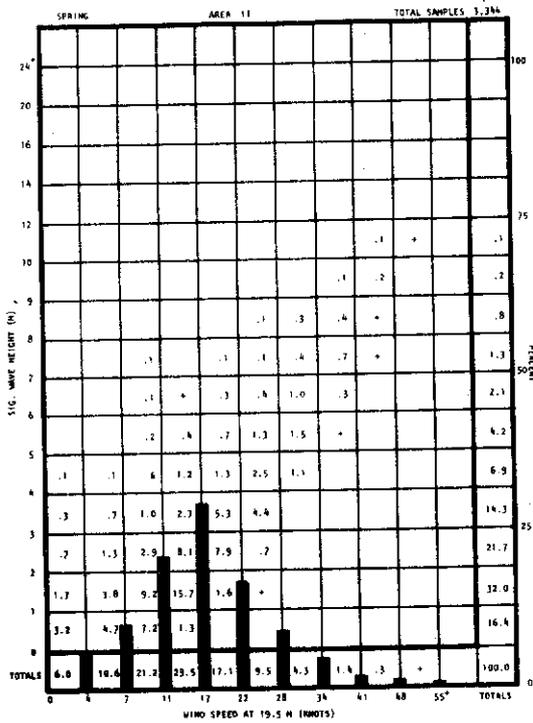
Figure A-11-3-2 Significant Wave
Height by Wind Speed

SPRING   AREA 11   TOTAL SAMPLES 3,344

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
~11							.1	.1	.1
~10							.1	.1	.2
8						.1	.5	.2	.8
7						.3	.6	.4	1.3
6			.1			.6	.8	.7	2.1
5			+		.1	.7	1.3	2.1	4.2
4	.2	.2	.2	.1	.2	.8	1.9	3.3	6.9
3	.7	1.3	.5	.1	.5	1.8	4.4	5.0	14.3
2	1.9	3.5	.8	.4	.5	3.1	5.0	6.4	21.7
1	2.3	6.8	1.5	1.1	1.3	2.3	8.3	8.4	32.0
0	.9	2.8	.6	.4	1.1	2.1	3.3	5.3	16.4
TOTALS	6.1	14.6	3.6	2.2	3.7	11.6	26.2	32.0	100.0

PRIMARY WAVE DIRECTION
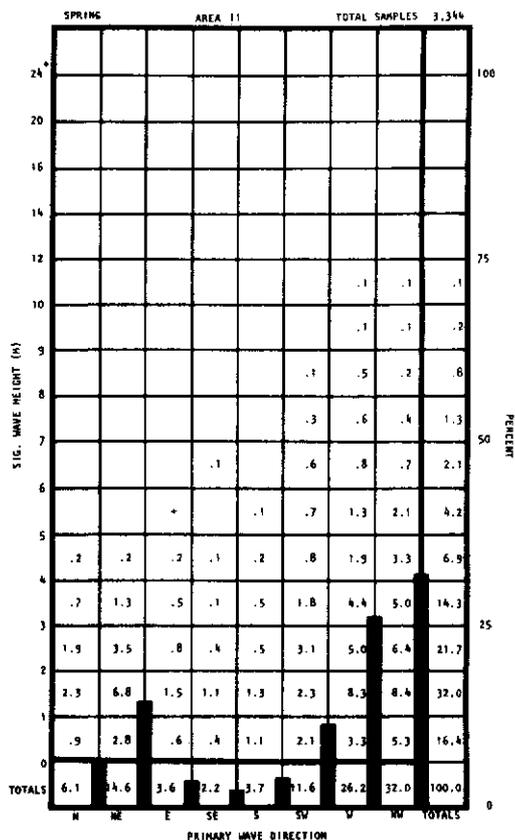
Figure A-11-3-3 Significant Wave
Height by Wave Direction

SPRING   AREA 11   TOTAL SAMPLES 3,344

PERCENT   0   50   100

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
55+							+		+
48							.2	.1	.3
41				+	.1	.6	.4	.3	1.4
34	.1	+	.1	.1	.4	1.3	1.4	.9	4.3
28	.3	.6	.5	.1	1.0	2.7	2.6	1.6	9.5
22	1.6	1.7	.7	.4	1.8	4.1	4.4	2.4	17.1
17	3.4	3.1	2.5	1.2	2.9	6.7	5.7	3.5	29.5
11	3.8	2.7	1.8	1.4	2.4	3.8	2.7	2.8	21.2
7	1.3	1.0	.9	1.1	1.1	1.9	1.9	1.3	10.6
4	1.0	.7	.7	.7	.8	.8	.5	.8	6.0
TOTALS	11.5	9.8	7.3	5.1	10.5	21.9	19.9	14.1	100.0
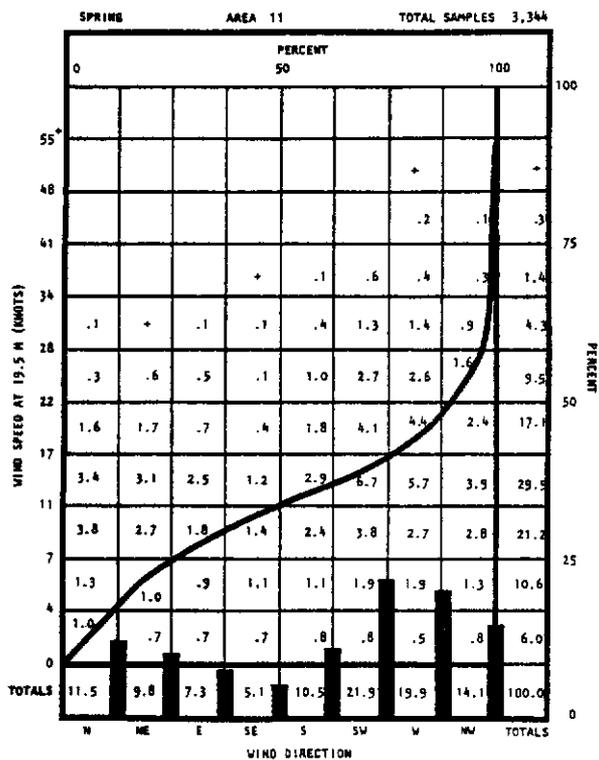
WIND DIRECTION

Figure A-11-3-4 Wind Speed by
Wind Direction

Figure A-11-3-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

SUMMER   AREA 11   TOTAL SAMPLES 3,338

	3.2	4.8	6.3	7.5	8.8	9.2	10.5	12.4	13.8	15.0	16.4	18.0	20.0	22.5	25.7	TOTALS
4+				.1		.1	.1	+	.1							.4
3					.2	.3	.1	.7	.4	.3						2.1
2				.7	2.0	1.4	1.9	1.0	.4	.4						7.8
1		.3	3.8	6.3	6.9	4.1	3.3	2.9	.9	.4	.4					29.3
				14.1	9.8	9.2	6.5	4.7	1.2		.9	.3				60.5
0	1.0	.5	12.3													
TOTALS	1.0	.8	16.0	21.1	19.0	15.1	11.9	9.3	2.9	2.2	.7					100.0

MODAL WAVE PERIOD (SEC)
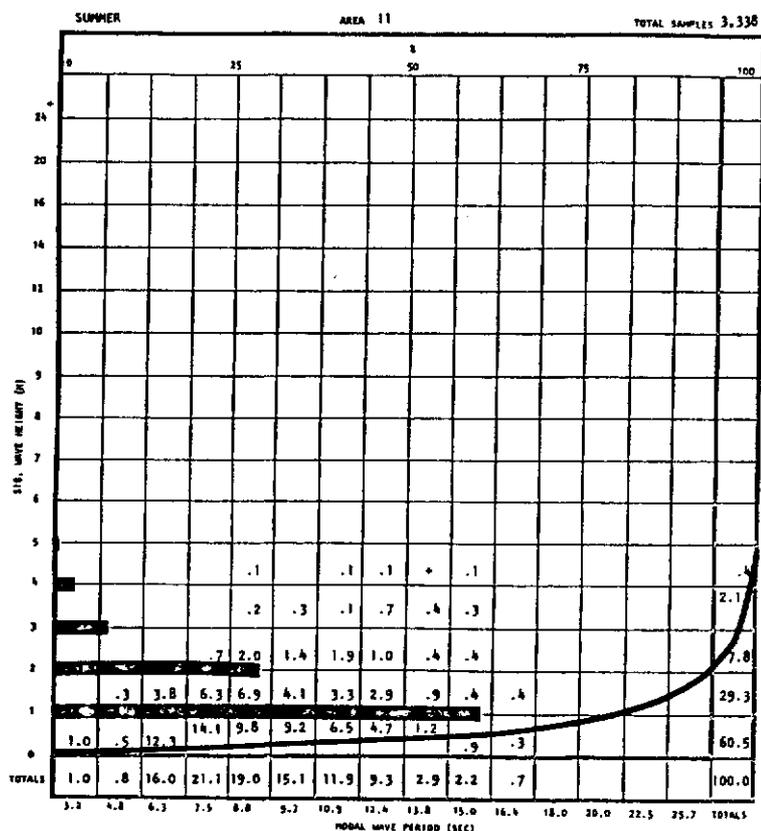
Figure A-11-4-1 Significant Wave
Height by Modal Wave Period

SUMMER   AREA 11   TOTAL SAMPLES 3,338

	0	6	7	11	17	22	28	34	41	48	55+	TOTALS
4			.1	.2	+	+						.4
3	.1	+	.4	.6	.4	.3						2.1
2			1.1	3.2	3.0	.1						7.8
1	2.3	7.2	8.0	14.5	.8							29.3
0	17.8	21.2	12.8	4.6								60.5
TOTALS	14.2	25.9	32.4	23.1	4.0	.4						100.0

WIND SPEED AT 19.5 M (KNOTS)
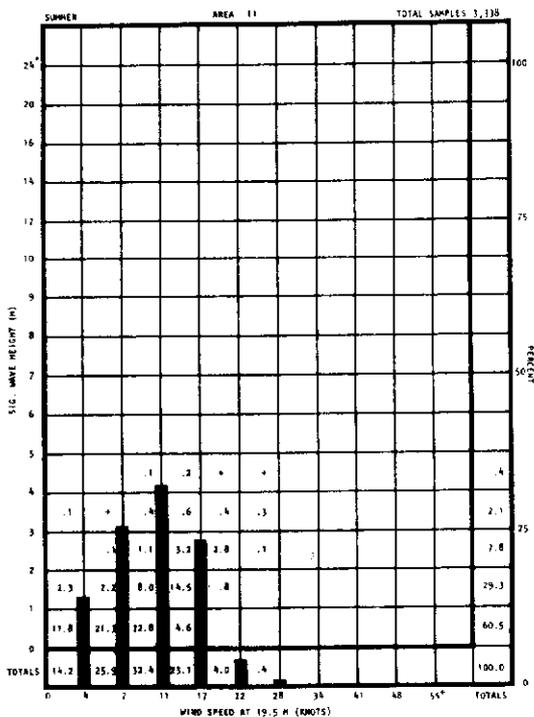
Figure A-11-4-2 Significant Wave
Height by Wind Speed

SUMMER AREA 11 TOTAL SAMPLES 3,338

SIG. WAVE HEIGHT (M) — PRIMARY WAVE DIRECTION

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
~4.5					.1	.1	.3		.4
~3		.1			.1	.6	1.3		2.1
~2.5	.6	.2	+	+		1.1	1.7	4.0	7.8
~1.5	1.6	4.5	.3	.6	.3	1.1	6.6	14.2	29.3
~0.5	4.0	12.8	1.2	.5	1.7	2.8	9.3	28.1	60.5
TOTALS	6.3	17.6	1.6	1.1	2.1	5.2	18.3	47.9	100.0
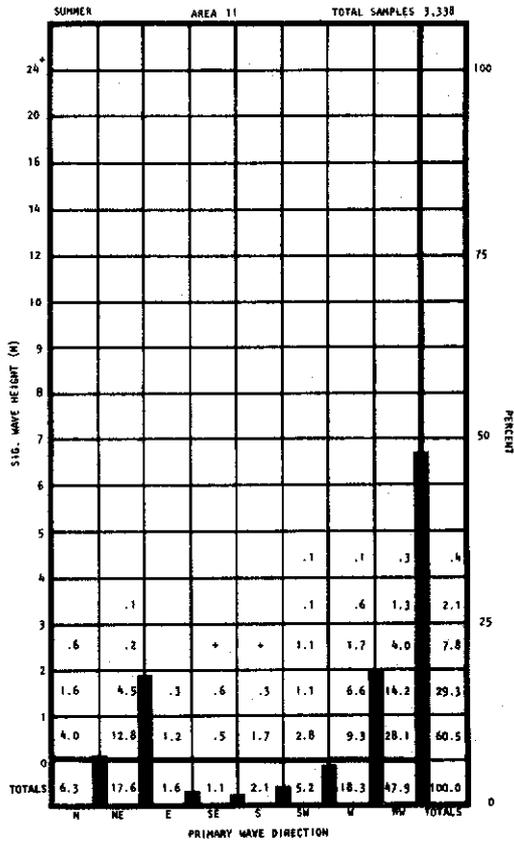
Figure A-11-4-3 Significant Wave
Height by Wave Direction

SUMMER AREA 11 TOTAL SAMPLES 3,338

PERCENT 0   50   100

WIND SPEED AT 19.5 M (KNOTS) — WIND DIRECTION

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
~25	.1	.1					.1	.1	.4
~20	.5	.1		.1	.1	1.3	1.1	.7	4.0
~15	2.6	4.5	.5	.5	.9	5.0	5.2	4.0	23.1
~9	4.4	5.9	1.9	1.0	1.3	4.5	7.7	5.8	32.4
~5.5	5.3	4.3	1.2	1.0	.9	2.5	4.0	6.7	25.9
~2	2.6	2.3	1.6	.6	1.3	1.4	2.2	2.2	14.2
TOTALS	15.5	17.2	5.2	3.3	4.6	14.7	20.1	19.6	100.0
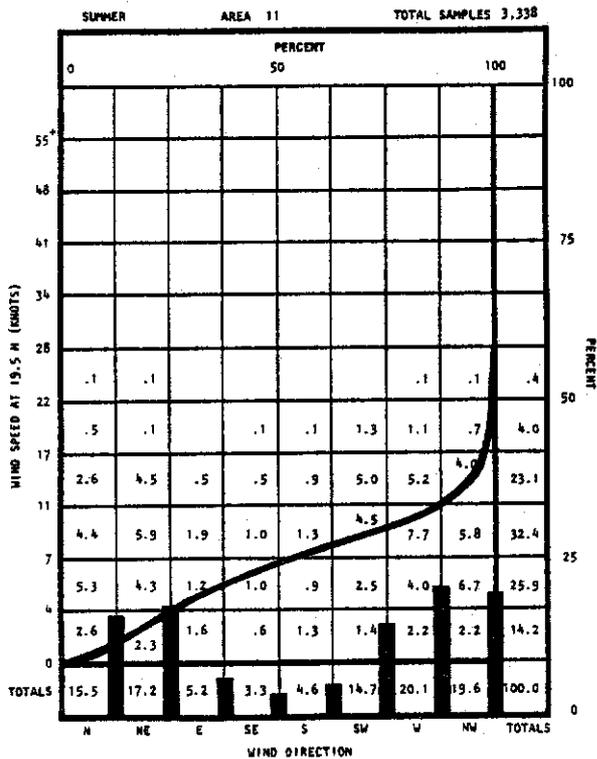
Figure A-11-4-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

A-142
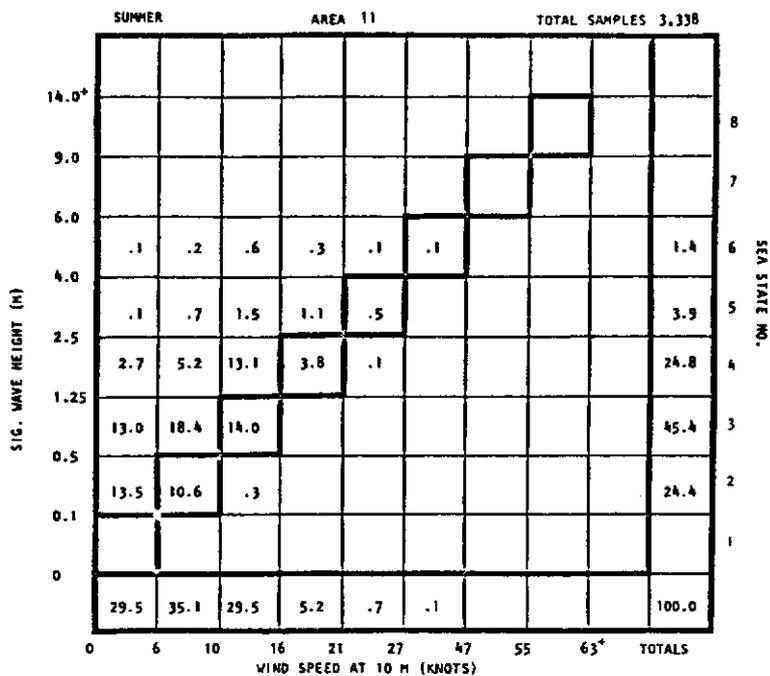
Figure A-11-4-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

FALL   AREA 11   TOTAL SAMPLES 3,215
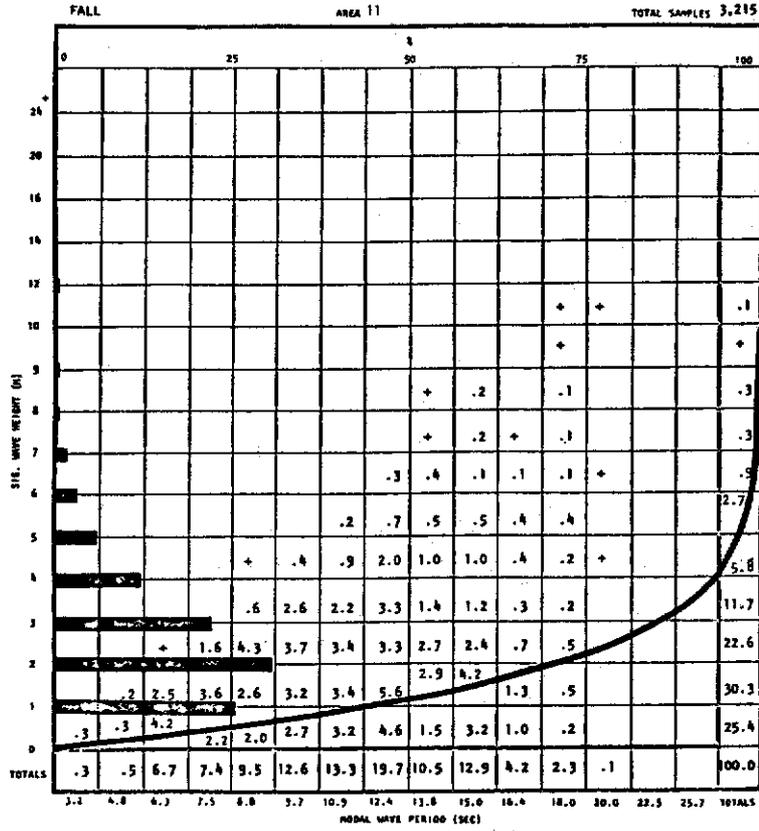
Figure A-11-5-1 Significant Wave
Height by Modal Wave Period

FALL AREA 11 TOTAL SAMPLES 3,215
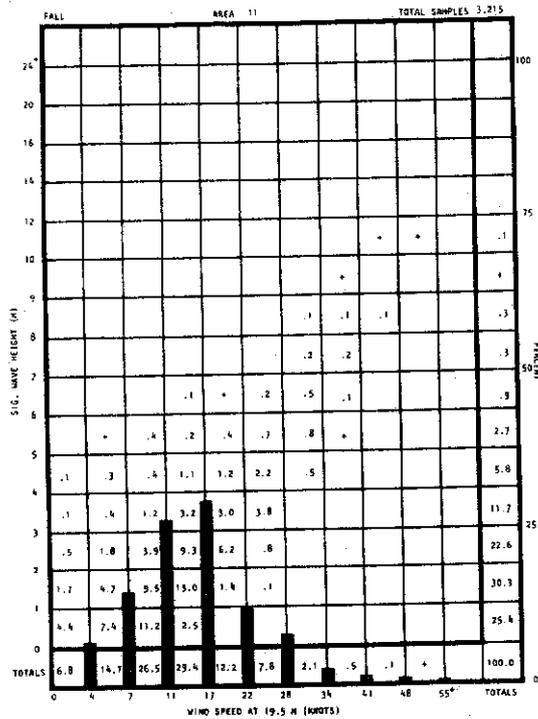
Figure A-11-5-2 Significant Wave
Height by Wind Speed

FALL   AREA 11   TOTAL SAMPLES 3,215
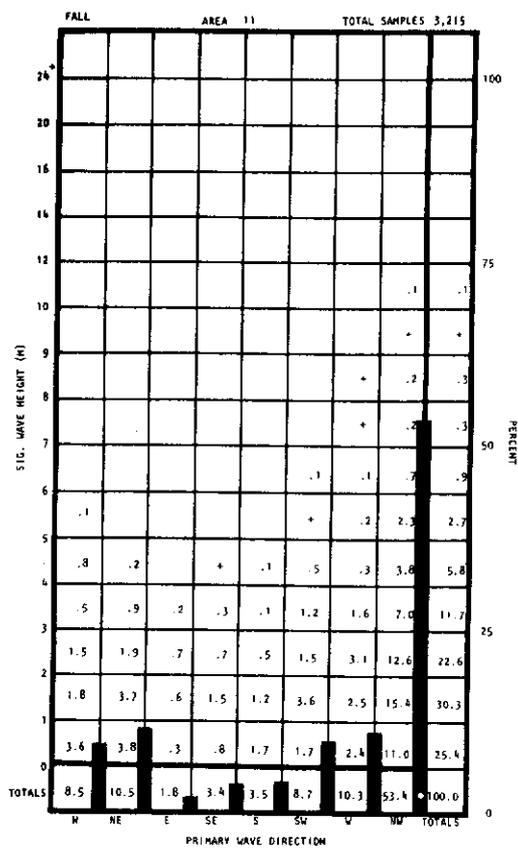
Figure A-11-5-3 Significant Wave
Height by Wave Direction

FALL   AREA 11   TOTAL SAMPLES 3,215
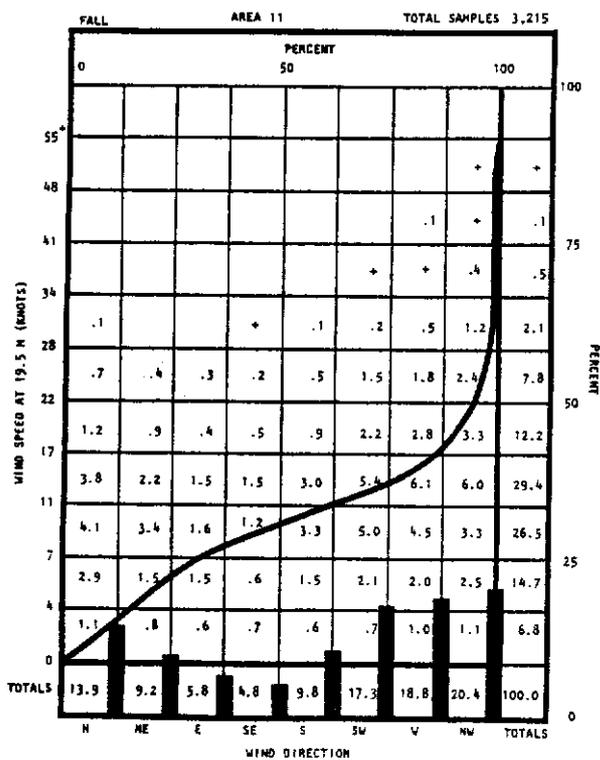
Figure A-11-5-4 Wind Speed by
Wind Direction
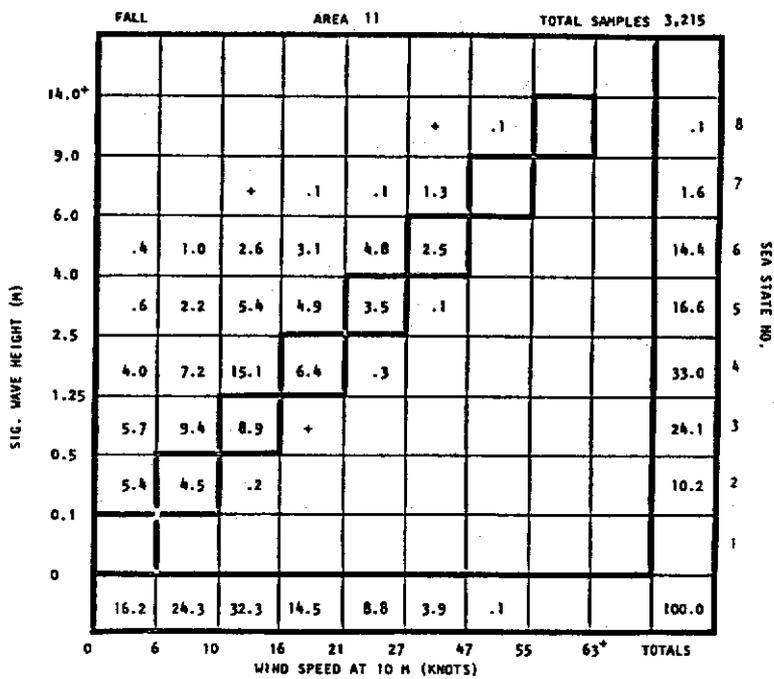
Figure A-11-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-16-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 29.748° N, 66.526° W

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	3.5	1.5	1
Wave Period, sec	5.5	9	14.5	9	9.5
Direction	-	-	-	-	SE
Winds					
Speed, knots	3	9	22	10	9
Corresponding Mean Sig. Wave Height, m.	.5	1	3	1	1
Direction	-	-	-	-	S - SW
Visibility, nautical miles	8	18	25	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	Nil	3.5	7.5	-	-
Low clouds, in eighths of sky obscured	Nil	2.5	6.5	-	-
Precipitation (Occurrence)	All precipitation - 9% of the time				
Relative Humidity, %	58	78	96	-	-
Air Temperature, °C	20	23	26	-	-
Surface Water Temperature, °C	22	25	27	-	-
Sea Level Pressure, millibars	1,010	1,020	1,025	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	327	-
Sub-Refraction (1 km, Annual)	-	-	-	-	2% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

ANNUAL   AREA 16   TOTAL SAMPLES 13,279

Figure A-16-1-1 Significant Wave
Height by Modal Wave Period

ANNUAL   AREA 16   TOTAL SAMPLES 13,279

Figure A-16-1-2 Significant Wave
Height by Wind Speed

Figure A-16-1-3 Significant Wave
Height by Wave Direction
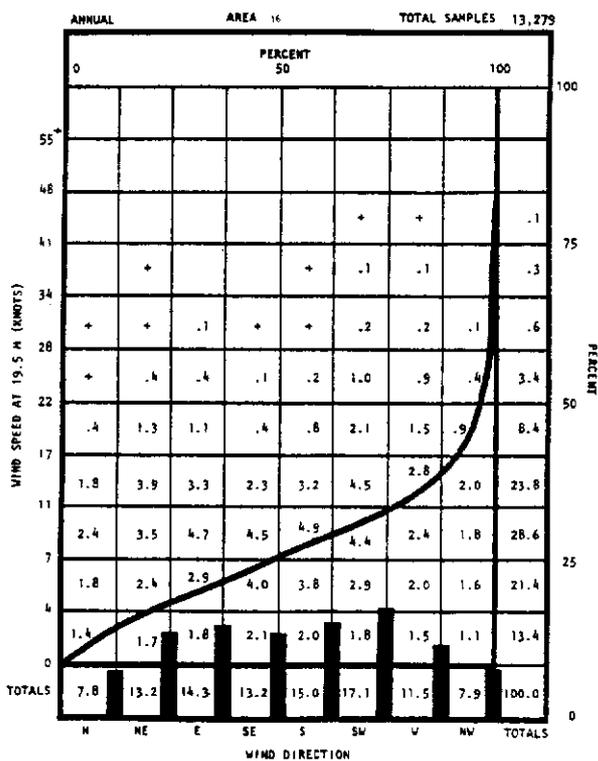
Figure A-16-1-4 Wind Speed by
Wind Direction
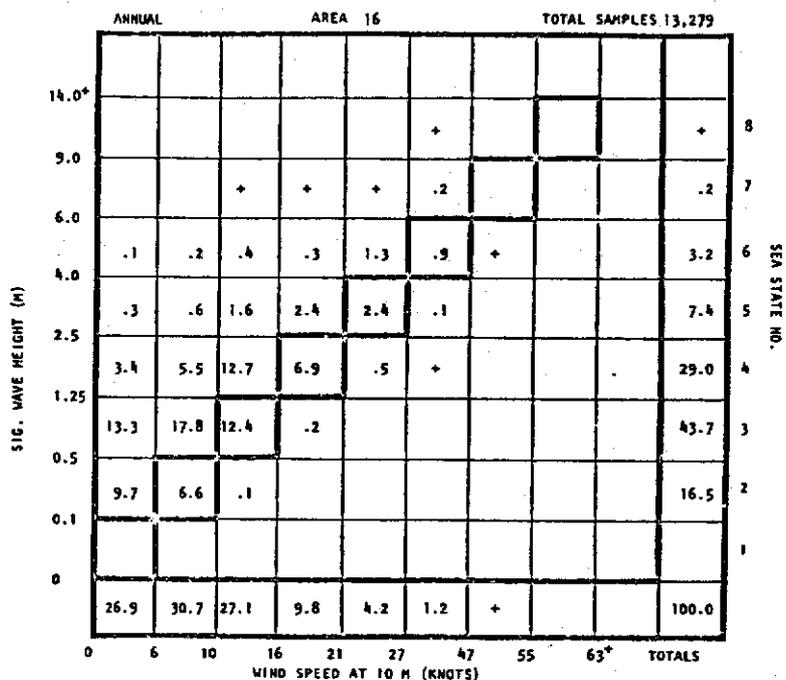
Figure A-16-1-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
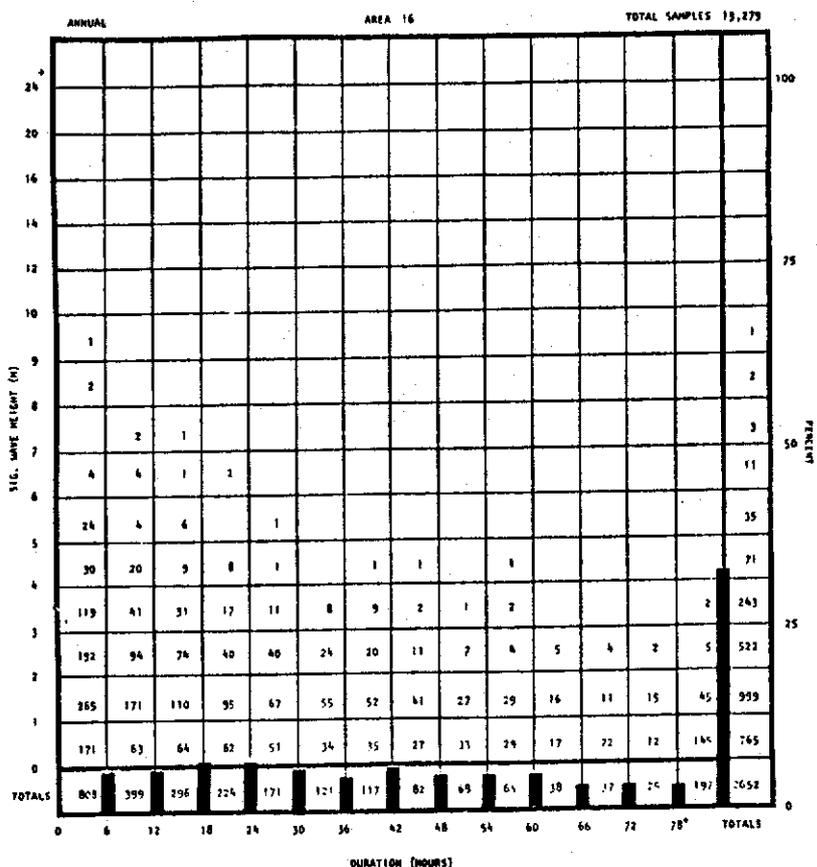
Figure A-16-1-6 Persistence of Significant Wave Height
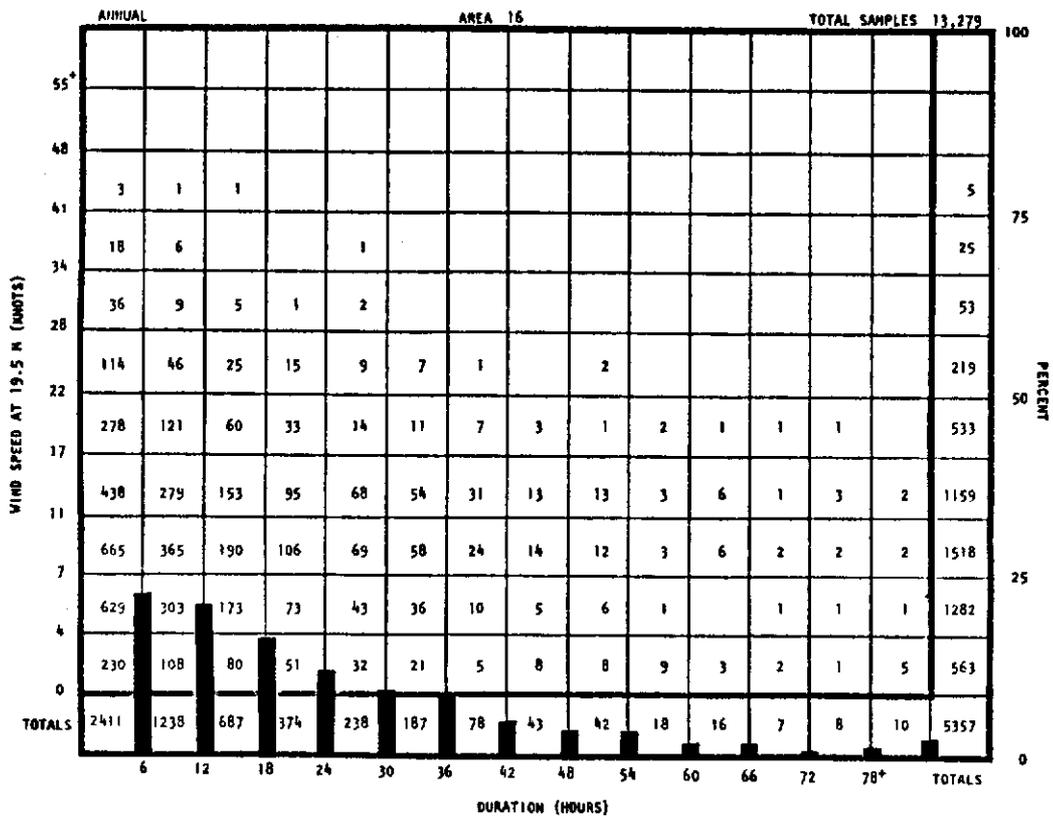
Figure A-16-1-7 Persistence of
Wind Speed
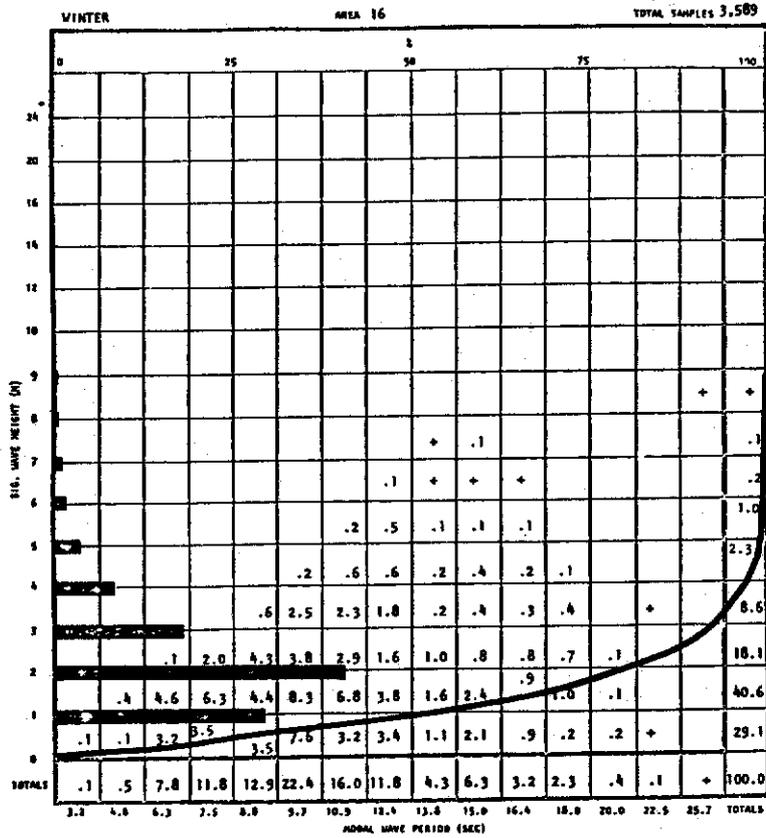
Figure A-16-2-1 Significant Wave
Height by Modal Wave Period
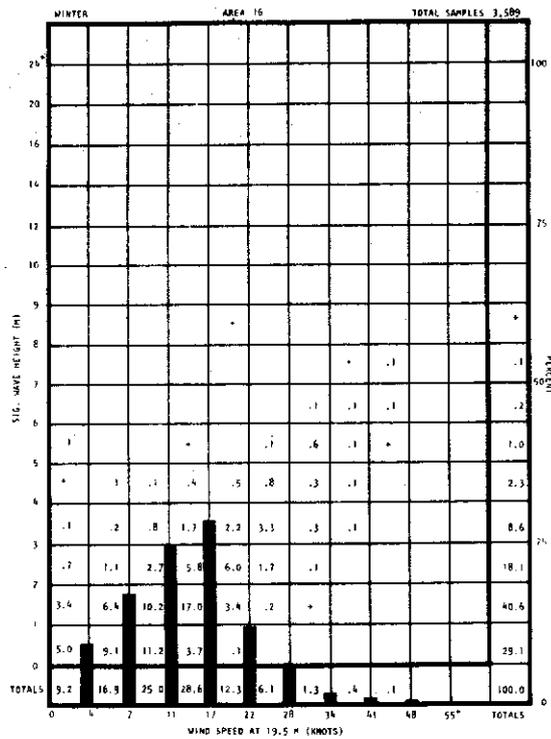
Figure A-16-2-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

A-152

WINTER AREA 16 TOTAL SAMPLES 3,589

SIG. WAVE HEIGHT (M) — PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
8–9								+	+
8							.	.1	.1
7					.1			.1	.2
6	.1	.1			.3	.2	.3		1.0
5	.5	.7			.4	.1	.6		2.3
3–4	2.2	1.4	.1	.2	.2	2.2	.9	1.5	8.6
2–3	4.0	2.5	.4	1.1	.5	3.9	2.0	3.7	18.1
1–2	7.6	4.9	2.3	7.1	1.8	5.6	3.8	7.4	40.6
0–1	5.0	4.8	2.9	7.2	.4	2.5	3.1	3.3	29.1
TOTALS	19.4	14.3	5.8	15.5	2.8	15.0	10.1	17.0	100.0

PRIMARY WAVE DIRECTION
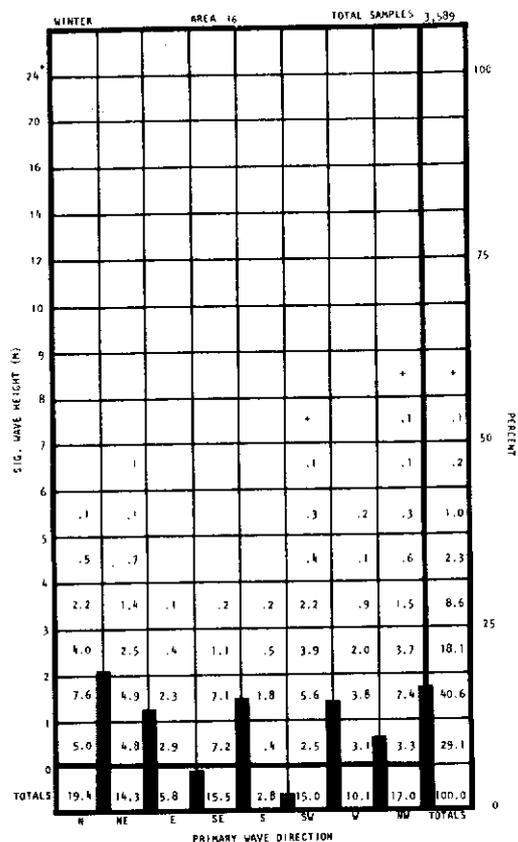
Figure A-16-2-3 Significant Wave
Height by Wave Direction

WINTER AREA 16 TOTAL SAMPLES 3,589

PERCENT 0   50   100

WIND SPEED AT 19.5 M (KNOTS) — PERCENT

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
48							.1		.1
41		+			+	.2	.2		.4
34	+	.1	.1	+	.1	.5	.4	.1	1.3
28	.2	.7	.3	.1	.6	2.1	1.6	.6	6.1
22	1.1	1.3	.4	.2	1.4	3.7	2.8	1.5	12.3
17	2.4	4.7	2.5	1.4	3.8	5.2	4.9	3.6	28.6
11	3.1	3.4	2.6	2.5	3.4	3.5	3.3	3.1	25.0
7	2.3	2.3	1.6	1.9	2.2	2.2	1.8	2.6	16.9
4	1.4	.9	.8	1.2	1.1	1.2	1.6	1.3	9.3
TOTALS	10.4	13.4	8.3	7.3	12.4	18.6	16.6	12.9	100.0
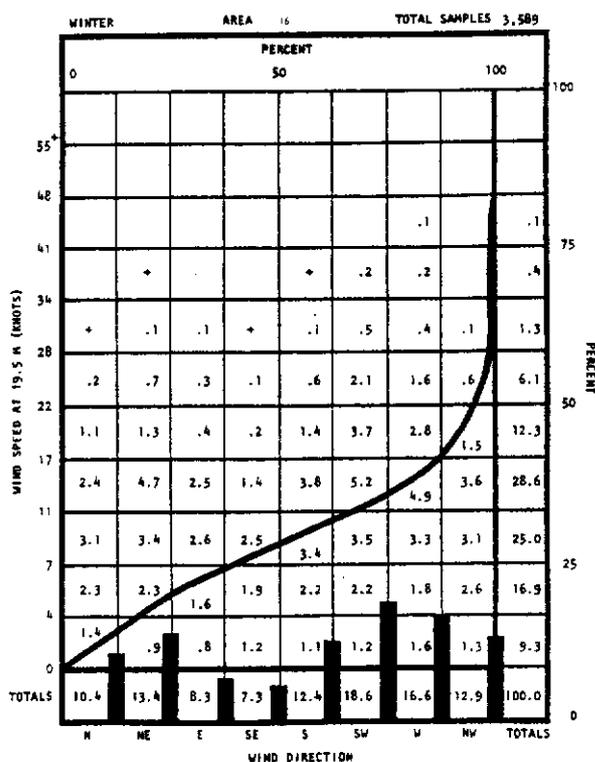
WIND DIRECTION

Figure A-16-2-4 Wind Speed by
Wind Direction

WINTER   AREA 16   TOTAL SAMPLES 3,589

SIG. WAVE HEIGHT (M) / WIND SPEED AT 10 M (KNOTS) / SEA STATE NO.

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+											8
9.0				+		.3				.3	7
6.0	.2	.4	1.1	.7	2.6	1.6				6.7	6
4.0	.5	1.2	3.0	4.0	3.9	.3				12.8	5
2.5	5.3	8.2	15.5	8.8	1.0	.1				38.8	4
1.25	11.0	13.6	11.3	.3						36.2	3
0.5	3.1	2.1								5.2	2
0.1											1
0											
TOTALS	19.9	25.5	30.9	13.9	7.4	2.4				100.0	
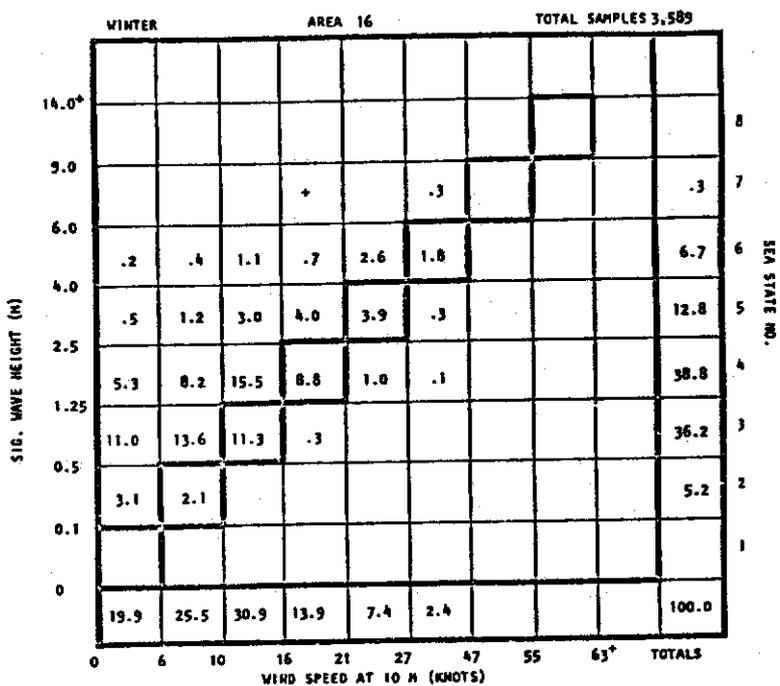
Figure A-16-2-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
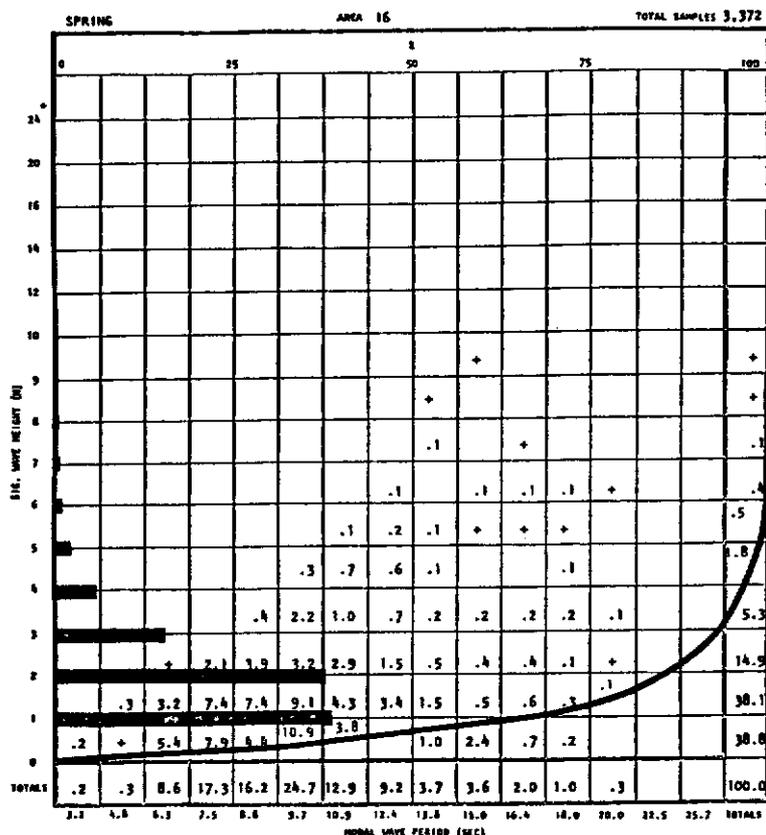
Figure A-16-3-1 Significant Wave
Height by Modal Wave Period
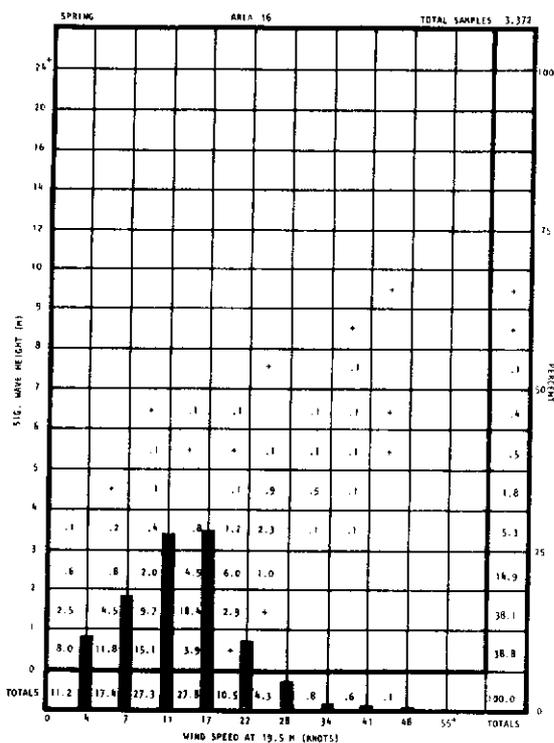
Figure A-16-3-2 Significant Wave
Height by Wind Speed

SPRING AREA 16 TOTAL SAMPLES 3,372

SIG. WAVE HEIGHT (M) / PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
9					+				+
9					+				+
8	+				1				.1
7	.2				.1		.1		.4
6	.1				.2	.1	.1		.5
5	.2				.7	.3	.6		1.8
3	1.1	.6	.4	.2	+	1.2	.7	1.0	5.3
2	4.2	2.3	.7	1.3	.3	2.6	1.7	1.9	14.9
1	7.9	3.7	2.5	9.6	1.0	4.5	3.5	5.4	38.1
0	4.7	3.6	5.3	13.8	.7	2.3	4.2	4.2	38.8
TOTALS	18.4	10.2	9.0	25.0	2.0	11.8	10.4	13.2	100.0

PRIMARY WAVE DIRECTION
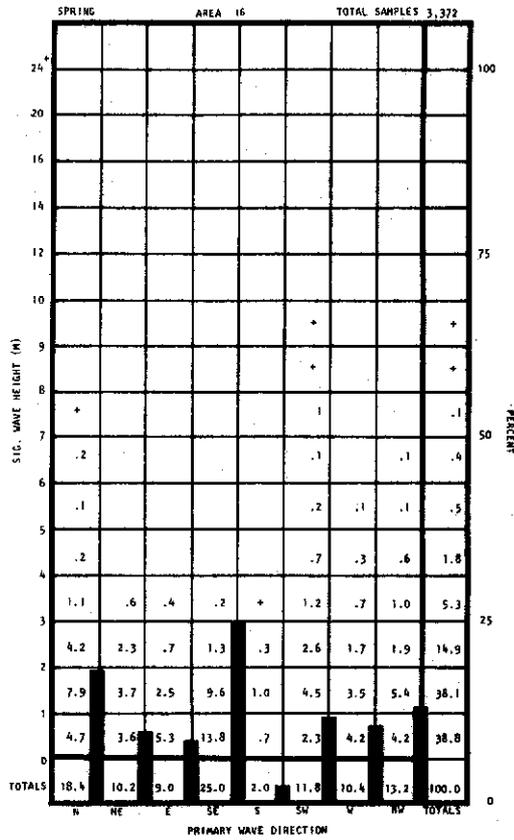
Figure A-16-3-3 Significant Wave Height by Wave Direction

SPRING AREA 16 TOTAL SAMPLES 3,372

PERCENT 0 50 100

WIND SPEED AT 19.5 M (KNOTS) / PERCENT

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
48					.1	+			.1
41					.1	.3	.2		.6
34		+				.3	.4	+	.8
28		.3	.5	.1	.2	1.2	1.4	.6	4.3
22	.4	1.1	1.3	.5	1.0	2.3	2.3	1.6	10.5
17	2.6	3.4	3.0	2.5	3.8	5.0	4.3	3.1	27.8
11	3.0	3.1	3.8	3.4	4.2	4.3	2.8	2.7	27.3
7	2.1	1.8	2.1	2.6	2.8	2.2	2.3	1.6	17.4
4	1.5	1.5	1.2	1.6	1.6	1.6	1.3	1.1	11.2
TOTALS	9.4	11.3	11.9	10.7	13.5	17.4	15.0	10.6	100.0
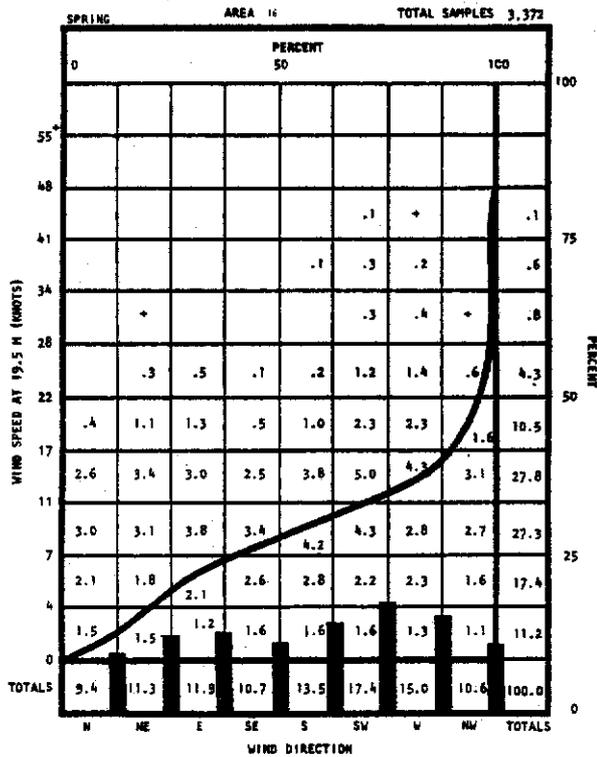
WIND DIRECTION

Figure A-16-3-4 Wind Speed by Wind Direction
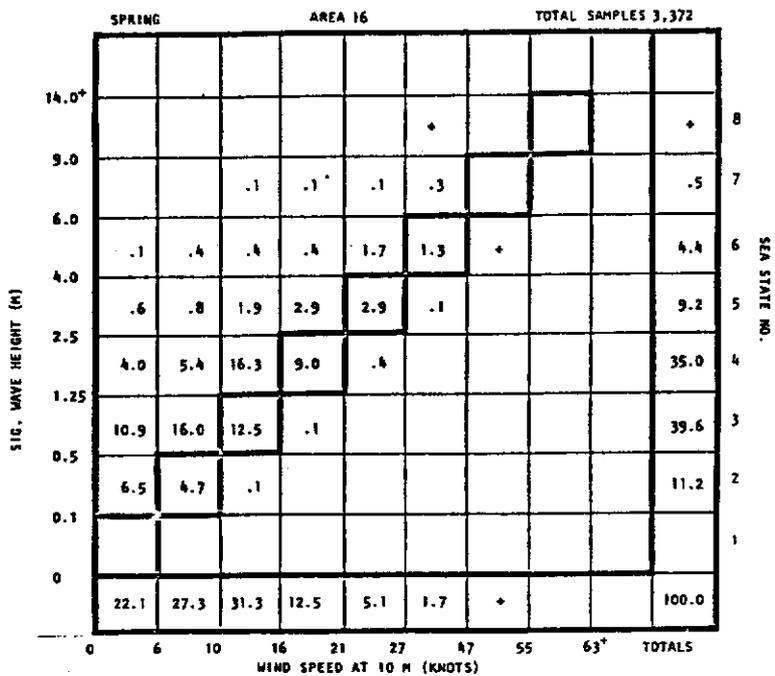
Figure A-16-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
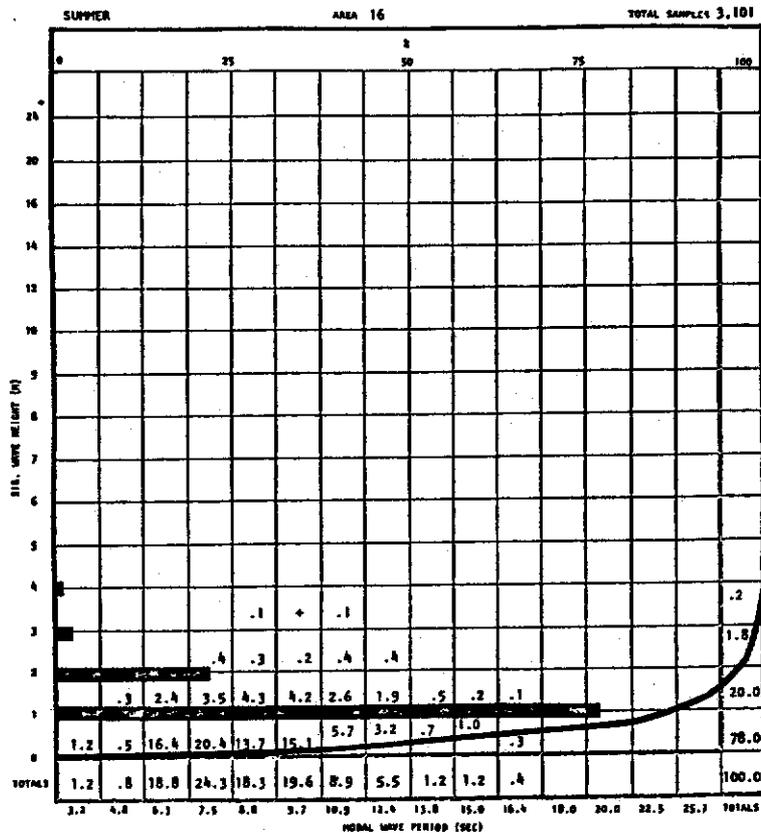
Figure A-16-4-1 Significant Wave
Height by Modal Wave Period
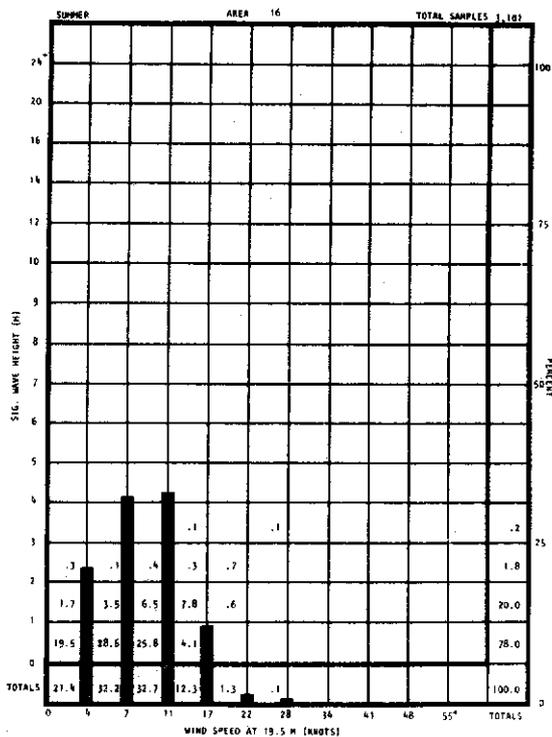
Figure A-16-4-2 Significant Wave
Height by Wind Speed
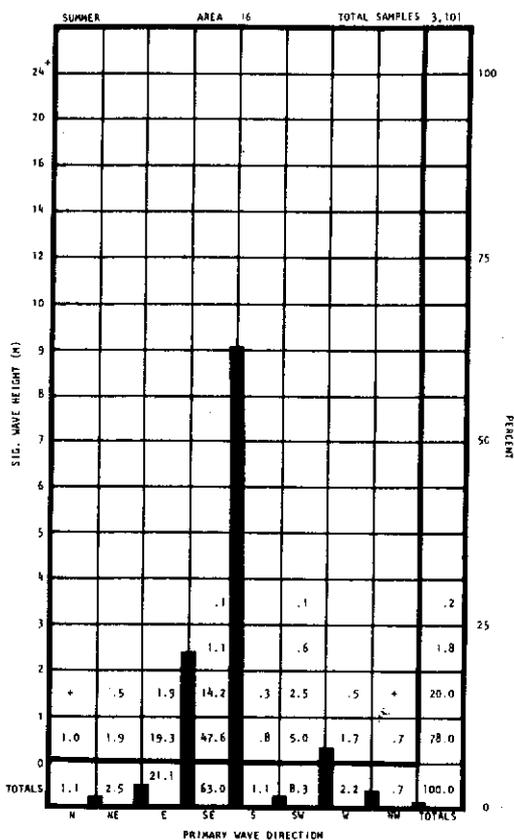
Figure   A-16-4-3 Significant Wave
Height by Wave Direction
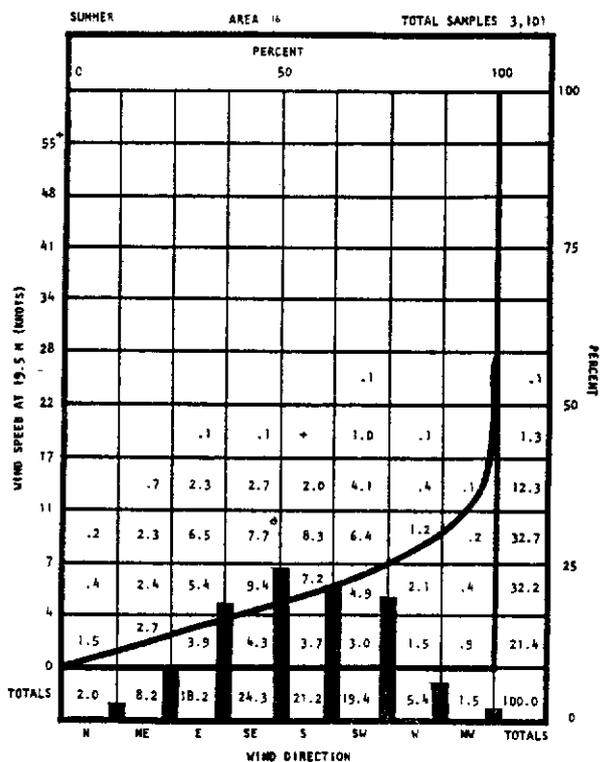
Figure   A-16-4-4 Wind Speed by
Wind Direction
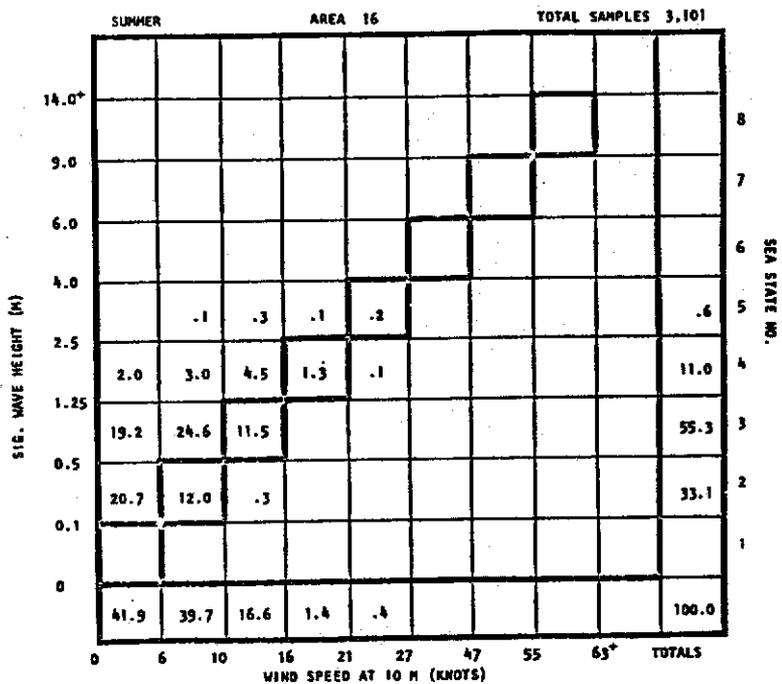
Figure A-16-4-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
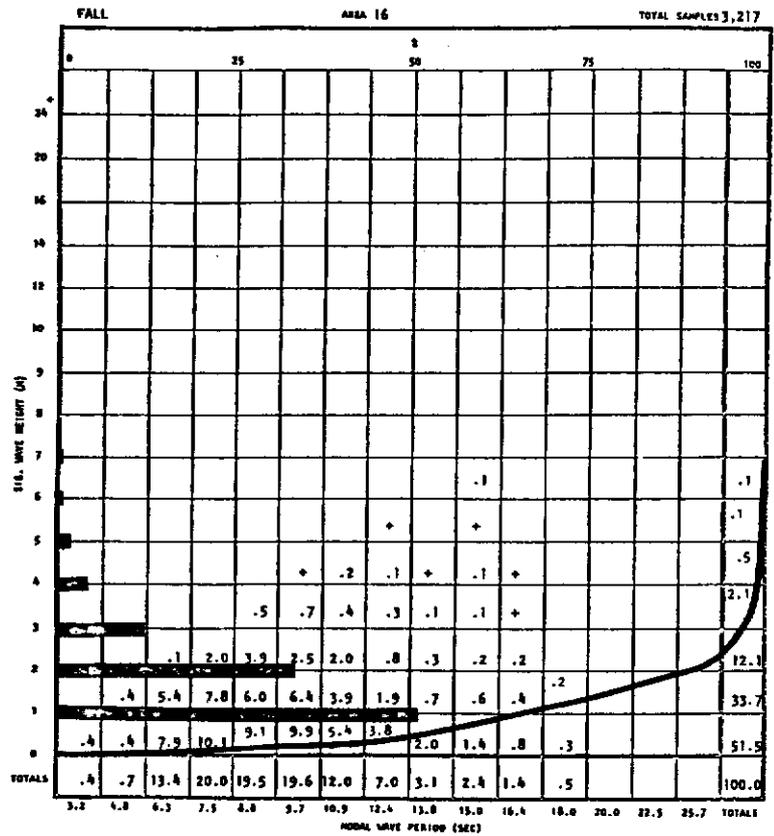
Figure A-16-5-1 Significant Wave
Height by Modal Wave Period
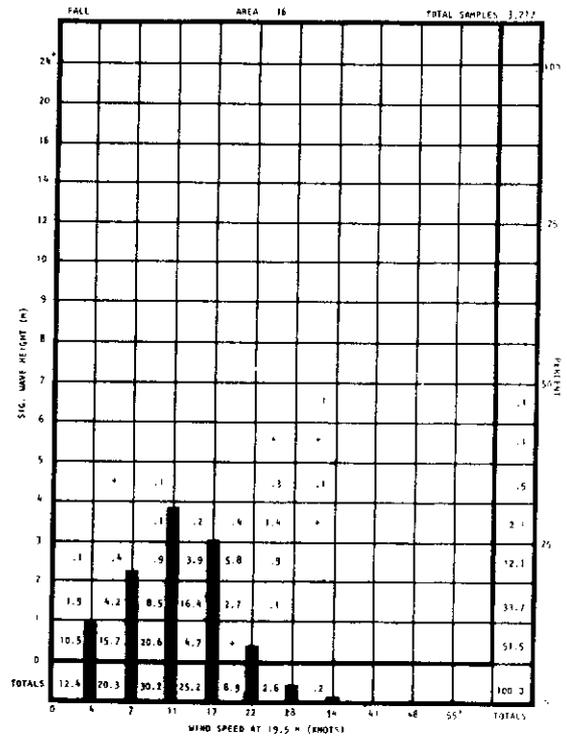
Figure A-16-5-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

A-161
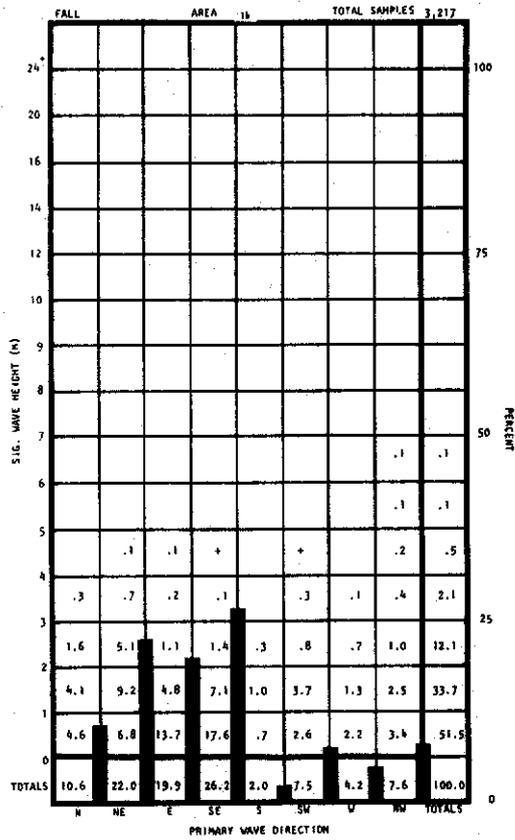
Figure A-16-5-3 Significant Wave
Height by Wave Direction
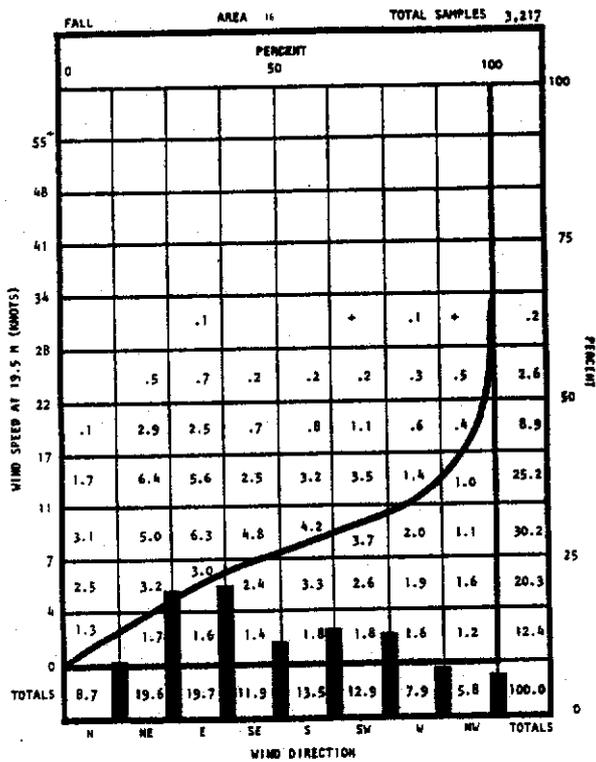
Figure A-16-5-4 Wind Speed by
Wind Direction
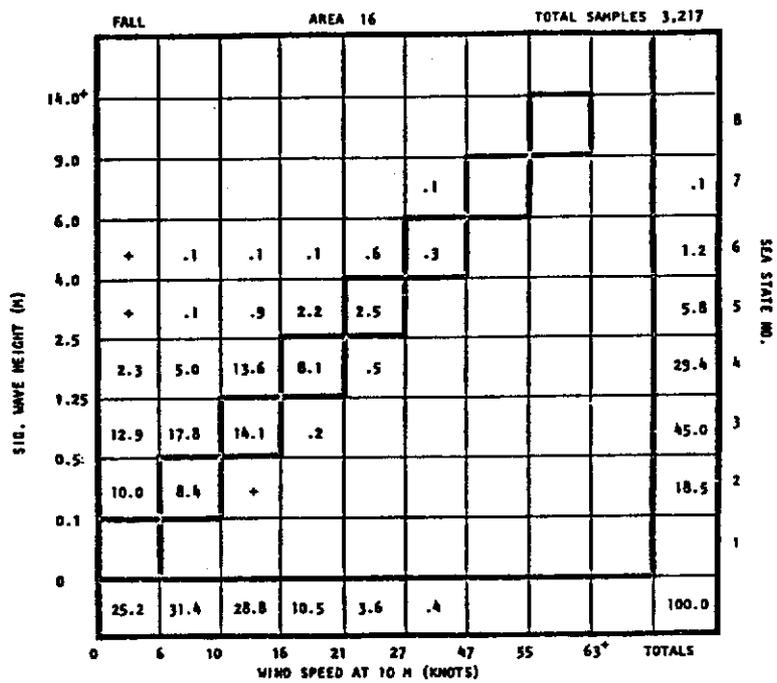
Figure A-16-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

TABLE A-17-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: 26.634° N, 48.502° W

| Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	3.5	2	0.5
Wave Period, sec	6	9	16	9	7.5
Direction	-	-	-	-	E
Winds					
Speed, knots	2	8	19	8	9
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3.5	2	2
Direction	-	-	-	-	E
Visibility, nautical miles	7	20	25	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	1	3.5	8	-	-
Low clouds, in eighths of sky obscured	Nil	3	8	-	-
Precipitation (Occurrence)	All precipitation - 9% of the time				
Relative Humidity, %	58	77	95	-	-
Air Temperature, °C	19.5	23	26.5	23	-
Surface Water Temperature, °C	20.5	23.5	27.5	-	-
Sea Level Pressure, millibars	1,012	1,020	1,026	-	-
Ice	None				
Refractivity					
Mean Surface Refractivity (1 km, Annual)	-	-	-	353	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	3% of the time

A-164

Figure A-17-1-1 Significant Wave
Height by Modal Wave Period
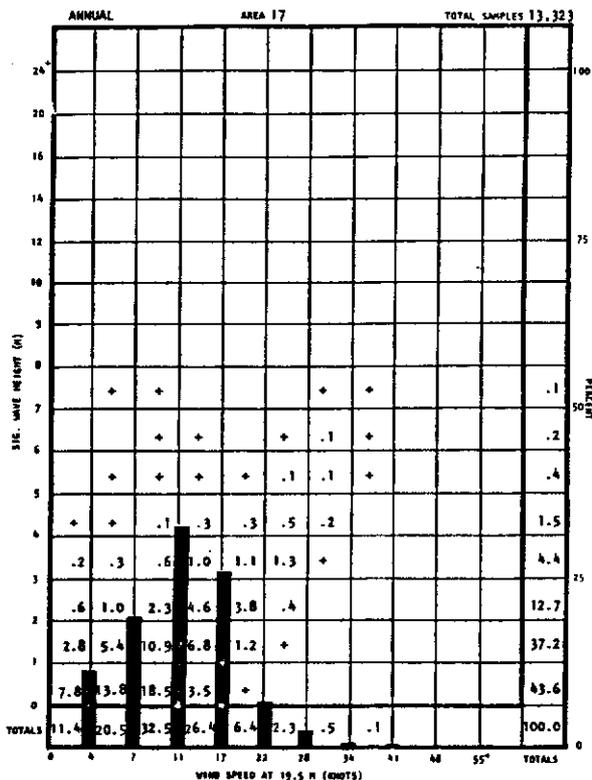
Figure A-17-1-2 Significant Wave
Height by Wind Speed

ANNUAL   AREA 17   TOTAL SAMPLES 13,323

STG. WAVE HEIGHT (M)

PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
						+	+	.1	
						.1	.1	.2	
	+		+		+	.1	.2	.4	
	.2	+	.4		+	.1	.2	.5	1.5
	.6	.3	1.0	.3	.1	.2	.6	1.4	4.4
	1.6	.7	3.7	1.9	.2	.5	1.2	2.8	12.7
	5.3	1.5	15.4	5.9	1.0	.6	1.8	5.6	37.2
	6.0	2.0	19.2	6.7	2.3	.6	3.1	3.7	43.6
TOTALS	13.5	4.6	39.6	14.6	3.6	2.0	7.1	14.3	100.0

PRIMARY WAVE DIRECTION
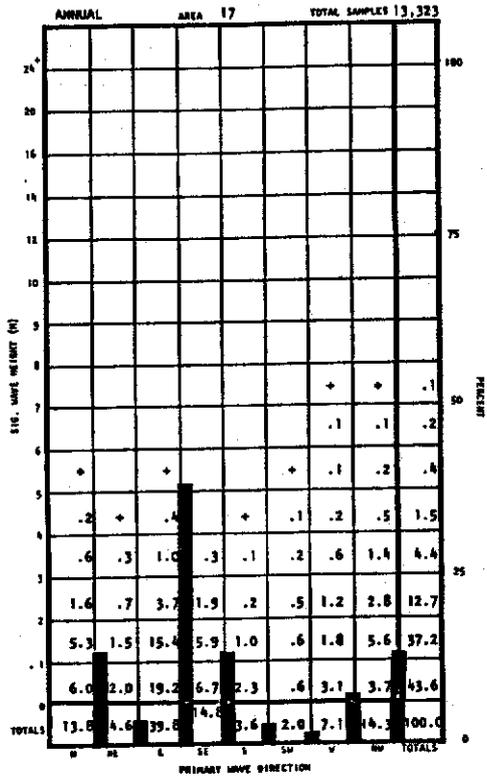
Figure A-17-1-3 Significant Wave
Height by Wave Direction

ANNUAL   AREA 17   TOTAL SAMPLES 13,323

PERCENT

0   50   100

WIND SPEED AT 19.5 M (KNOTS)

PERCENT

	N	NE	E	SE	S	SW	W	NW	TOTALS
55+									
48									
41					+	+	+		.1
34		+	+		+	.2	.1	+	.5
28	+	.3	.6	.1	.1	.5	.5	.2	2.3
22	.2	1.1	2.3	.5	.3	1.0	.7	.4	6.4
17	.8	4.7	10.9	3.3	1.8	2.5	1.6	.5	26.4
11	1.8	6.7	10.5	4.2	3.7	2.9	1.4	1.2	32.5
7	1.5	3.7	3.6	3.2	2.7	1.6	1.2	1.1	20.5
4	1.6	1.7	2.1	1.6	1.5	1.1	.8	1.0	11.4
TOTALS	6.0	18.2	32.0	12.9	10.1	9.8	6.4	4.7	100.0

N   NE   E   SE   S   SW   W   NW   TOTALS
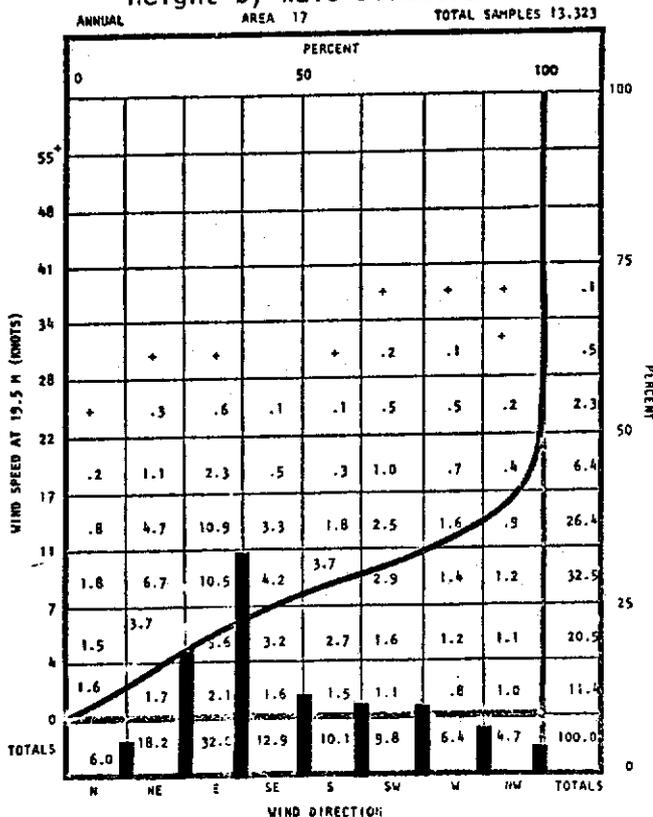
WIND DIRECTION

Figure A-17-1-4 Wind Speed by
Wind Direction
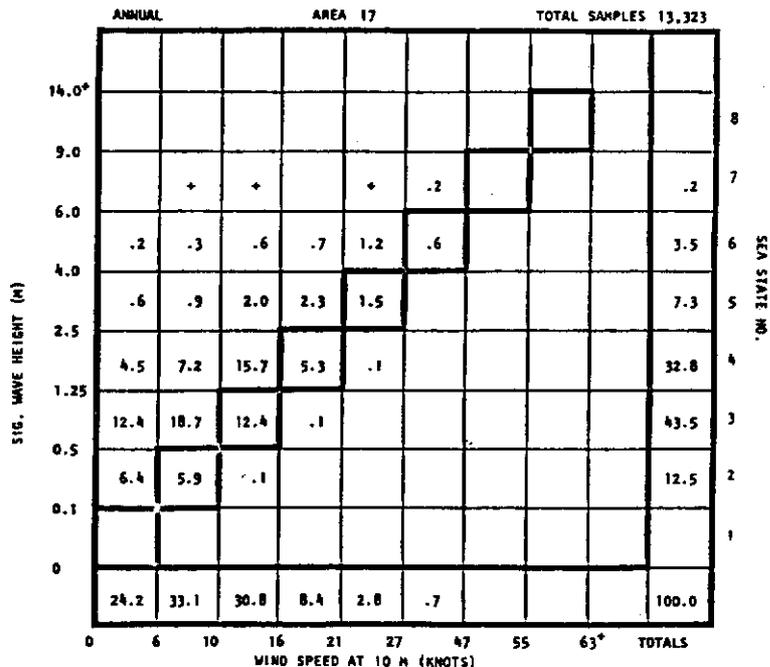
Figure A-17-1-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
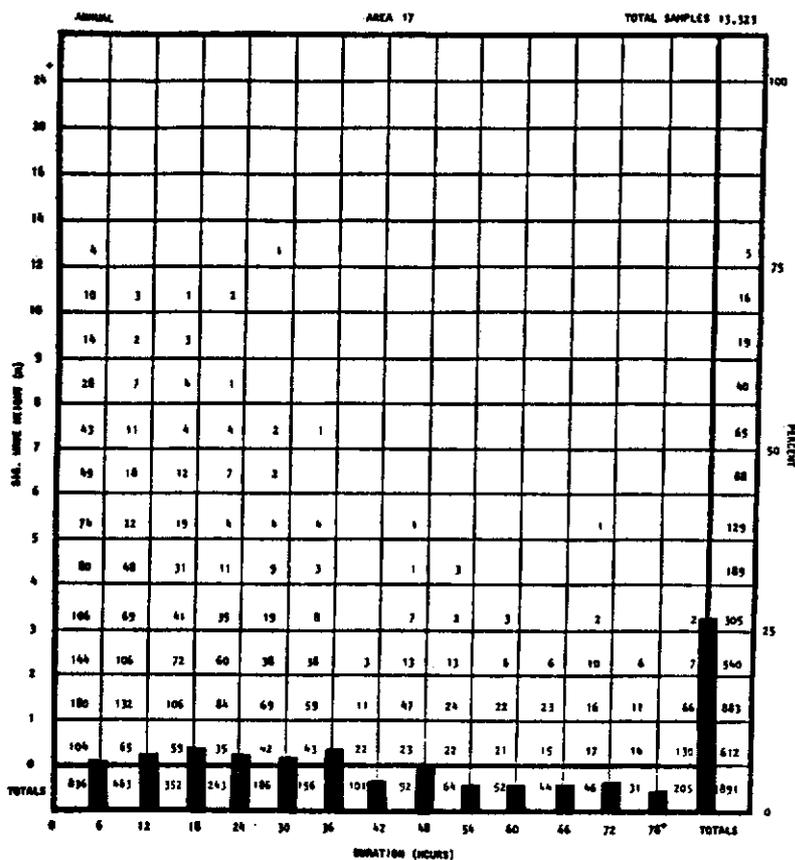
Figure A-17-1-6 Persistence of
Significant Wave Height
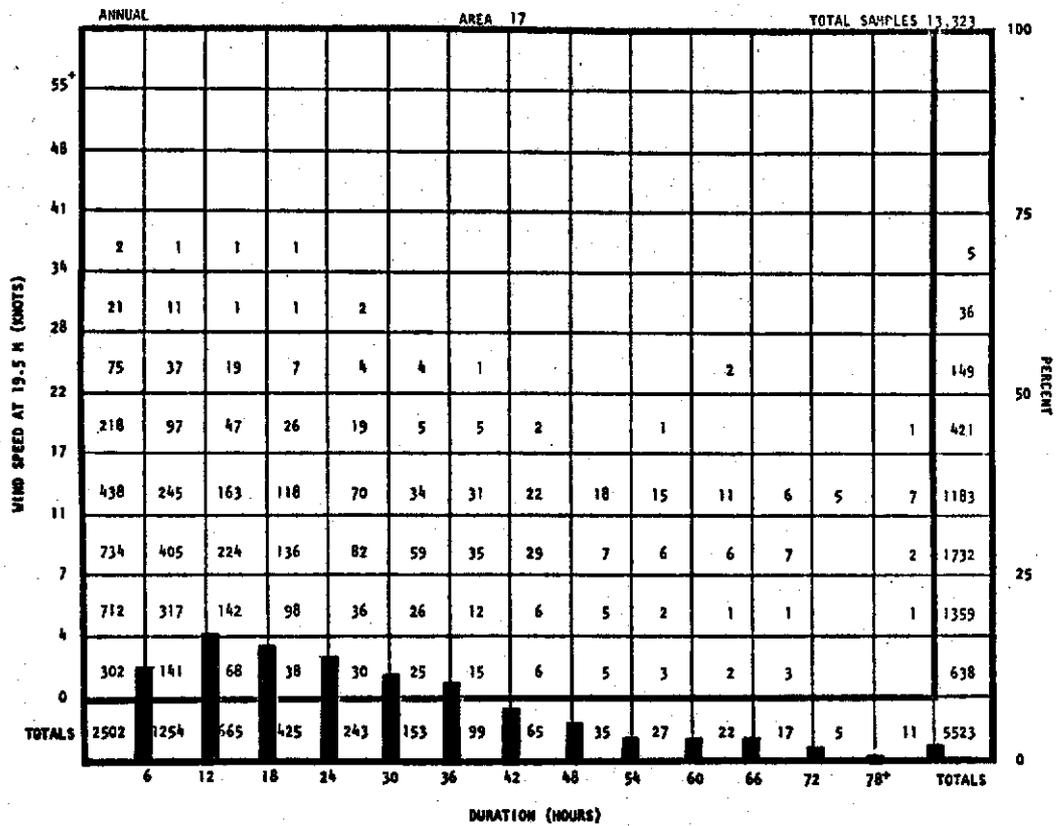
Figure A-17-1-7 Persistence of
Wind Speed

Figure A-17-2-1 Significant Wave
Height by Modal Wave Period

Figure A-17-2-2 Significant Wave
Height by Wind Speed

WINTER　　　AREA 17　　　TOTAL SAMPLES 3,589

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
7							+	.1	
						.2	.4	.6	
	+		.1		.1	.2	.4	.8	
	.5	+	.7		.2	.3	1.2	3.0	
3	1.3	.9	2.0	.6	.1	.3	1.3	3.6	10.0
2	3.7	1.2	4.7	2.0	.2	1.0	2.6	6.7	22.1
	8.6	2.0	12.0	4.5	.8	.9	2.8	11.4	42.5
	3.8	1.5	4.7	2.0	.9	.3	2.1	4.5	20.5
TOTALS	18.0	5.6	24.0	9.9	2.0	2.8	9.4	28.2	100.0

PRIMARY WAVE DIRECTION
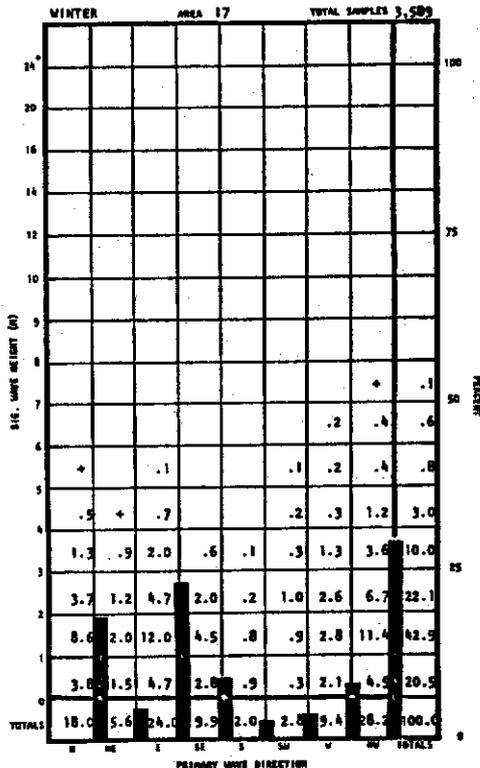
Figure A-17-2-3 Significant Wave Height by Wave Direction

WINTER　　　AREA 17　　　TOTAL SAMPLES 3,589

PERCENT

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
41						.1	+		.1
34		+	+			.3	.2	.2	.8
28	.2	.5	.8	.2	.1	1.0	1.1	.7	4.5
22	.3	1.4	2.0	.5	.2	2.6	1.6	1.2	9.8
17	1.3	4.3	6.6	4.0	1.8	4.5	3.5	2.0	28.0
11	2.9	4.8	5.5	4.4	2.9	3.6	2.5	2.6	29.2
7	2.1	2.7	2.7	2.3	2.6	1.5	1.8	1.6	17.3
4	1.5	1.3	1.4	1.5	1.8	1.0	.8	1.0	10.2
TOTALS	8.1	15.0	19.0	13.0	9.4	14.5	11.6	9.4	100.0
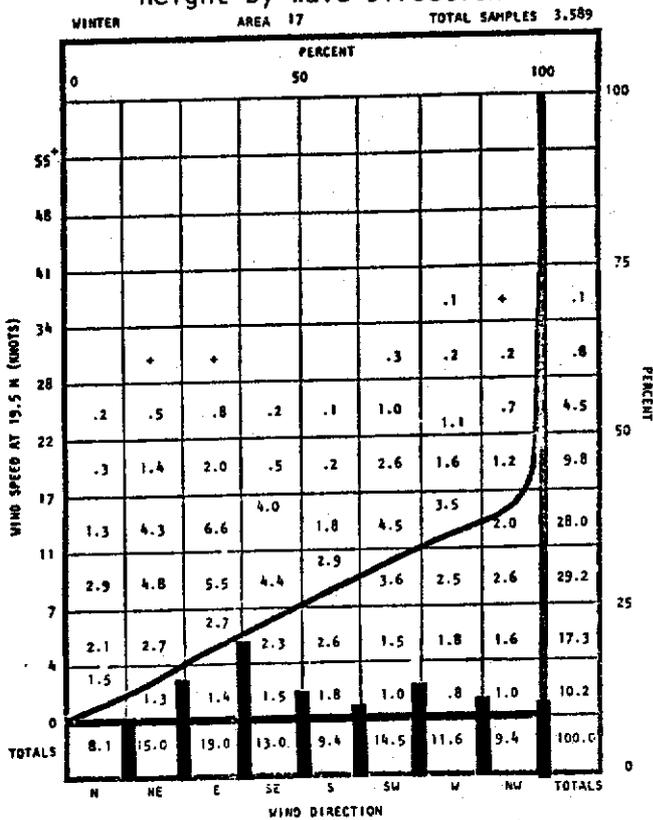
WIND DIRECTION

Figure A-17-2-4 Wind Speed by Wind Direction
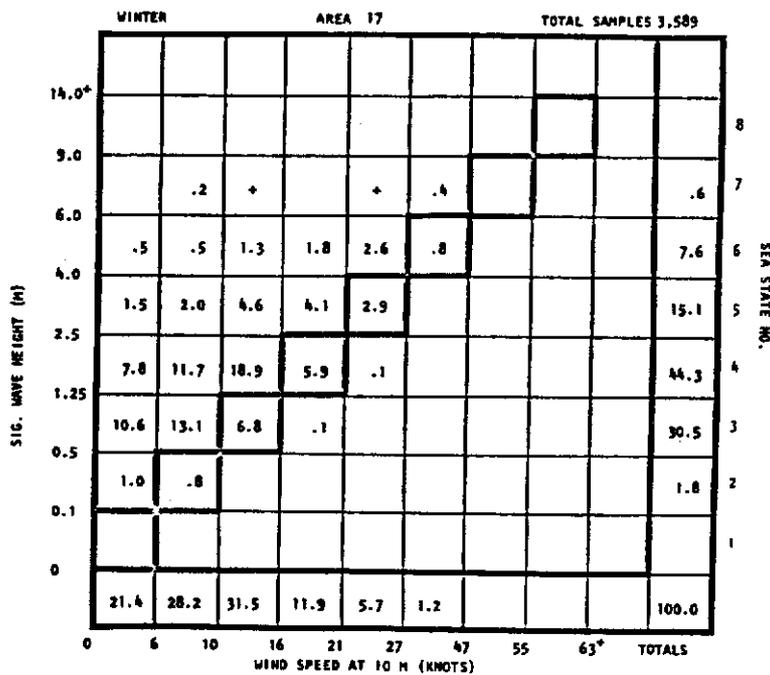
Figure A-17-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

SPRING   AREA 17   TOTAL SAMPLES 3,385
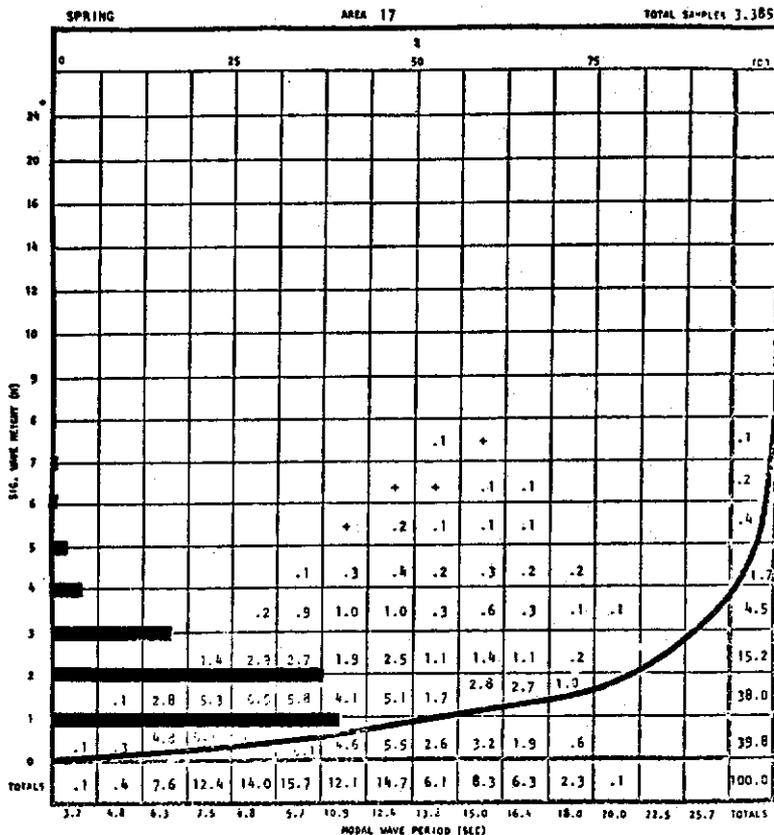
Figure A-17-3-1 Significant Wave
Height by Modal Wave Period
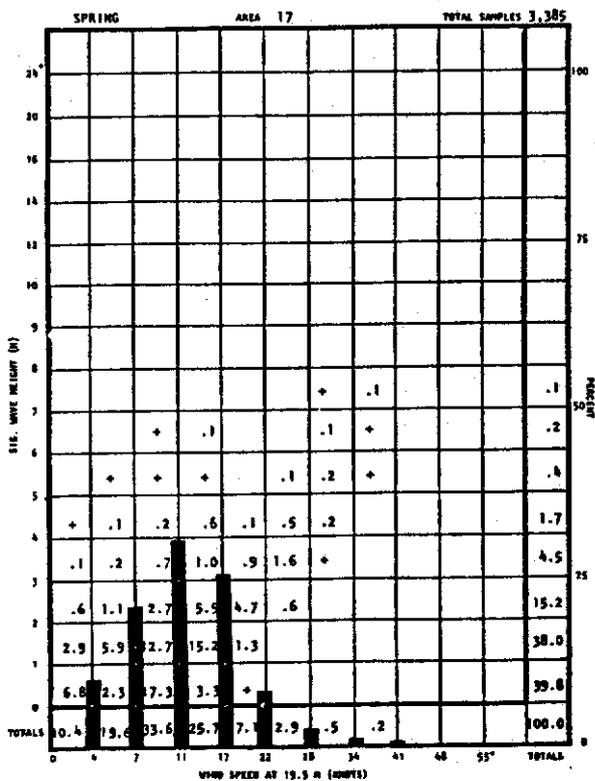
Figure A-17-3-2 Significant Wave
Height by Wind Speed
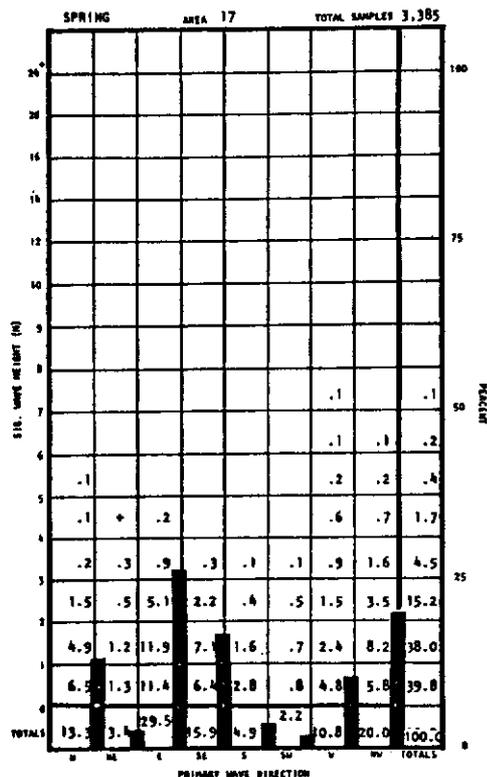
Figure A-17-3-3 Significant Wave
Height by Wave Direction
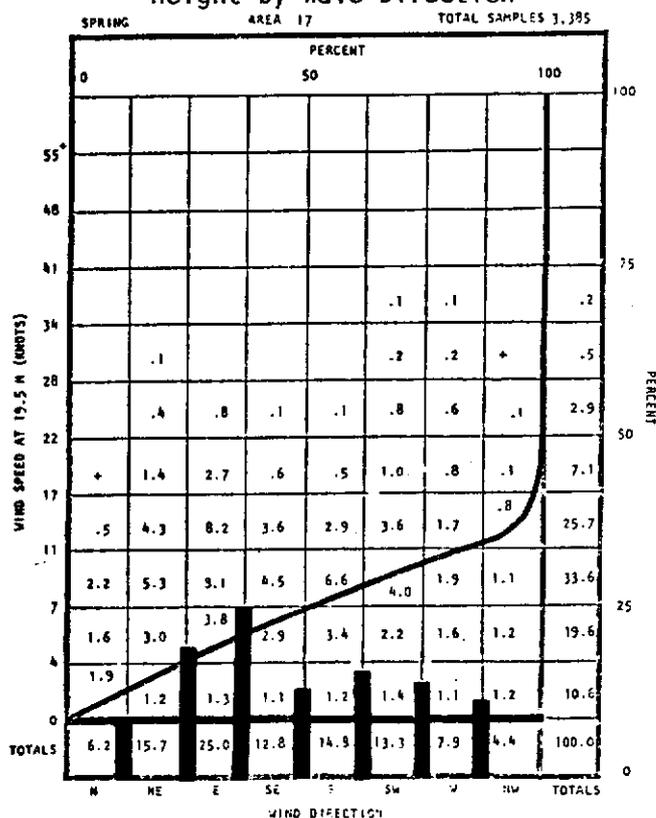
Figure A-17-3-4 Wind Speed by
Wind Direction

SPRING   AREA 17   TOTAL SAMPLES 3,385

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63+	TOTALS	SEA STATE NO.
14.0+										8
9.0										
6.0			.1			.2			.3	7
4.0	.1	.4	.9	.5	1.2	.7			3.9	6
2.5	.7	1.2	2.0	2.5	1.9				8.3	5
1.25	4.6	8.9	15.6	5.6	.3				35.0	4
0.5	12.8	19.8	11.1	.1					43.8	3
0.1	4.2	4.2	.1						8.6	2
0										1
TOTALS	22.5	34.5	29.8	8.8	3.4	1.0			100.0	

0   6   10   16   21   27   47   55   63+   TOTALS
WIND SPEED AT 10 M (KNOTS)

Figure A-17-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
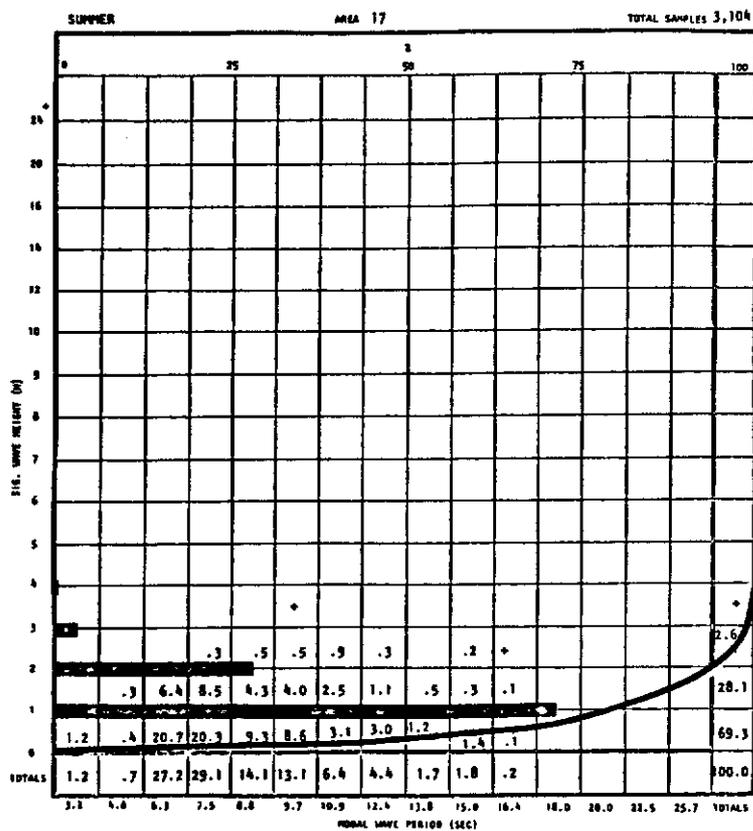
Figure A-17-4-1 Significant Wave
Height by Modal Wave Period
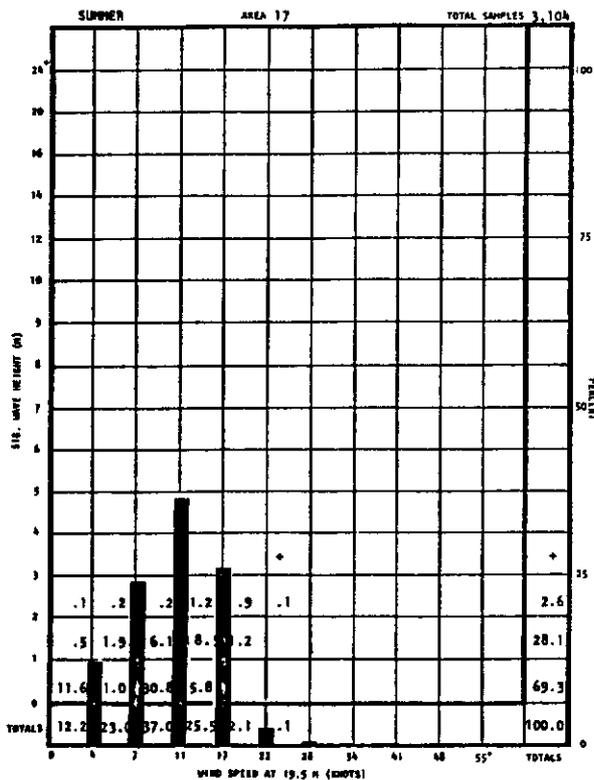
Figure A-17-4-2 Significant Wave
Height by Wind Speed

SUMMER   AREA 17   TOTAL SAMPLES 3,104

SIG. WAVE HEIGHT (M) vs PRIMARY WAVE DIRECTION — PERCENT

SIG. WAVE HEIGHT	N	NE	E	SE	S	SW	W	NW	TOTALS
			+					+	
	.1	1.2	1.5	.1					2.6
	.4	.8	21.1	5.4	.1		.2	.1	28.1
	3.7	3.1	43.7	11.7	3.0	.2	2.4	1.5	69.3
TOTALS	4.1	4.0	66.0	18.3	3.2	.2	2.5	1.6	100.0

Figure A-17-4-3 Significant Wave Height by Wave Direction

SUMMER   AREA 17   TOTAL SAMPLES 3,104

WIND SPEED AT 19.5 M (KNOTS) vs WIND DIRECTION — PERCENT

WIND SPEED	N	NE	E	SE	S	SW	W	NW	TOTALS
			.1						.1
		.5	1.6						2.1
	+	5.9	17.6	1.8		.2	.1		25.5
	.7	11.3	19.3	3.2	1.3		.2	.2	37.0
	.7	5.3	9.6	3.8	1.7	.7	.4	.6	23.0
	1.4	2.5	3.5	1.8	1.3	.6	.6	.5	12.2
TOTALS	2.8	25.5	51.7	10.6	4.3	2.4	1.3	1.3	100.0

Figure A-17-4-4 Wind Speed by Wind Direction

Figure A-17-4-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)

FALL   AREA 17   TOTAL SAMPLES 3,245
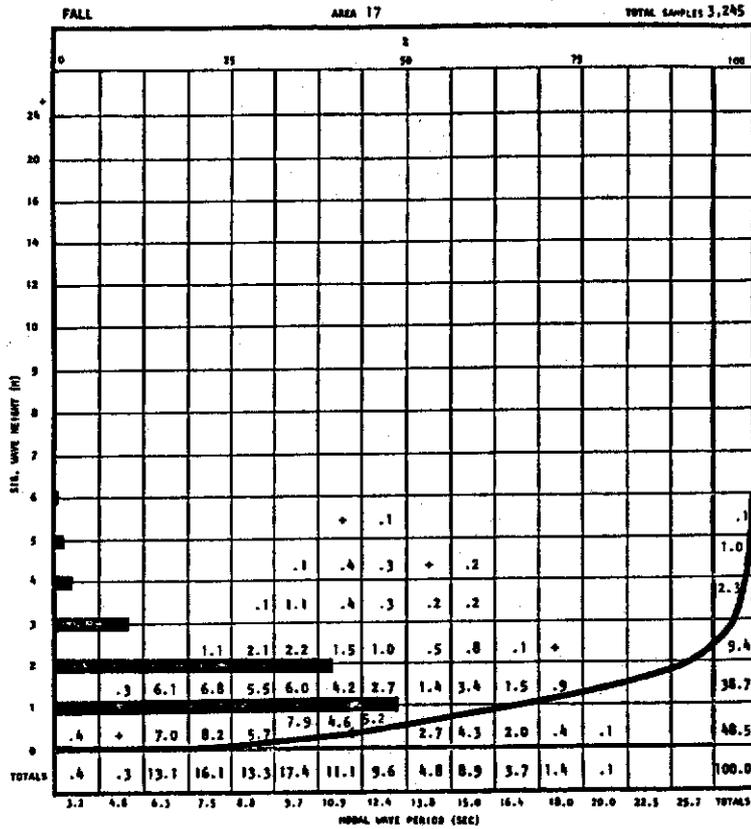
Figure A-17-5-1 Significant Wave
Height by Modal Wave Period

FALL   AREA 17   TOTAL SAMPLES 3,245
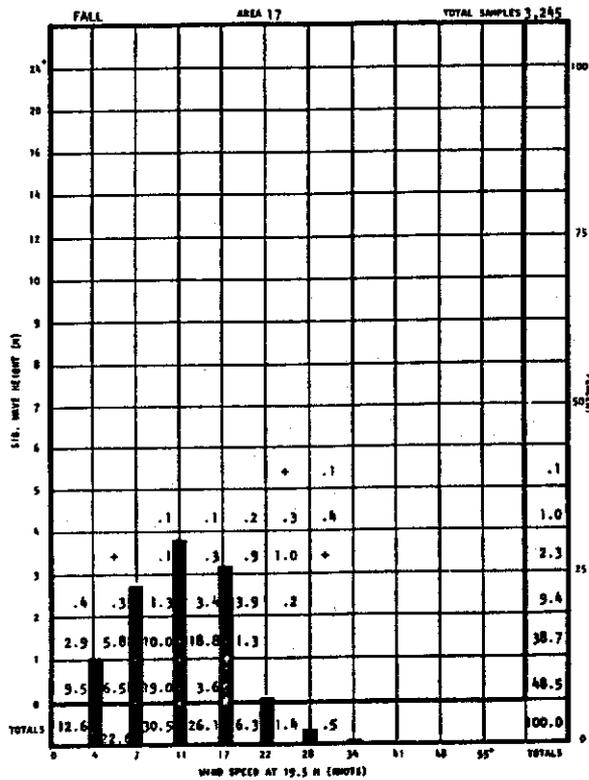
Figure A-17-5-2 Significant Wave
Height by Wind Speed

A-178

FALL   AREA 17   TOTAL SAMPLES 3,245
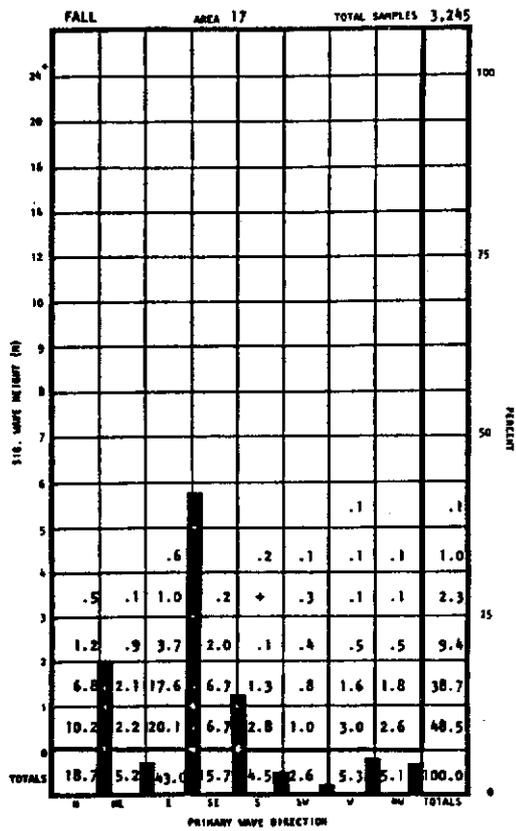
Figure A-17-5-3 Significant Wave
Height by Wave Direction

FALL   AREA 17   TOTAL SAMPLES 3,245
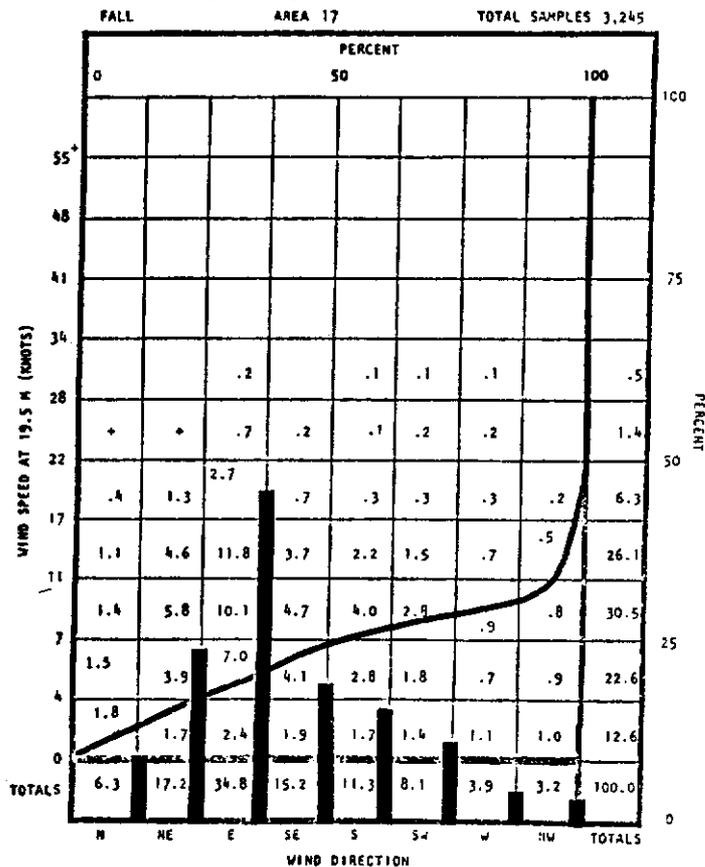
Figure A-17-5-4 Wind Speed by
Wind Direction

FALL   AREA 17   TOTAL SAMPLES 3,161

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63+	TOTALS	SEA STATE NO.
14.0+											
9.0											8
6.0											7
4.0		.1	.1	.5	.6	.6				1.9	6
2.5	.1	.2	.7	2.0	1.0					4.1	5
1.25	4.5	5.5	16.0	6.2	.1					32.2	4
0.5	14.8	20.6	12.5	.1						47.9	3
0.1	7.9	6.0	+							13.9	2
0											1
TOTALS	27.1	32.4	29.4	8.7	1.8	.6				100.0	

WIND SPEED AT 10 M (KNOTS)
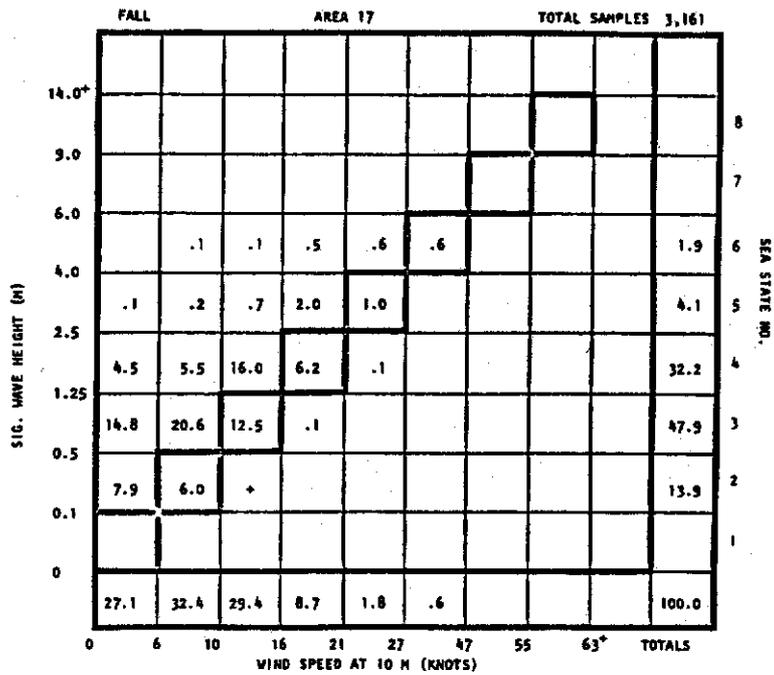
Figure A-17-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

APPENDIX B
SEASONAL CLIMATOLOGY OF THE MEDITERRANEAN SEA

The following data graphs are derived primarily from Reference 13. Figures
B-(29,30,31)-(1,2,3,4,5)-3 and Tables B-(29,30,31)-1-1 are adopted from Reference 9.
All wave data in both References are from the same source, namely, the U.S. Naval
Oceanography Command Detachment, formerly the U.S. Naval Weather Service Command,
in Asheville, North Carolina. However, due to the difficulty of defining the
directionality of low waves, wave data presented in Figures B-(29,30,31)-(1,2,3,4,5)-3
can be misleading because reported observations are only for the relatively higher
waves. Therefore, it is recommended that the wave data in Figures B-(29,30,31)-
(1,2,3,4,5)-3 should not be interpreted as the overall percentage frequency of
occurrence of significant wave heights, rather Figures B-(29,30,31)-(1,2,3,4,5)-1
should be used in this regard.
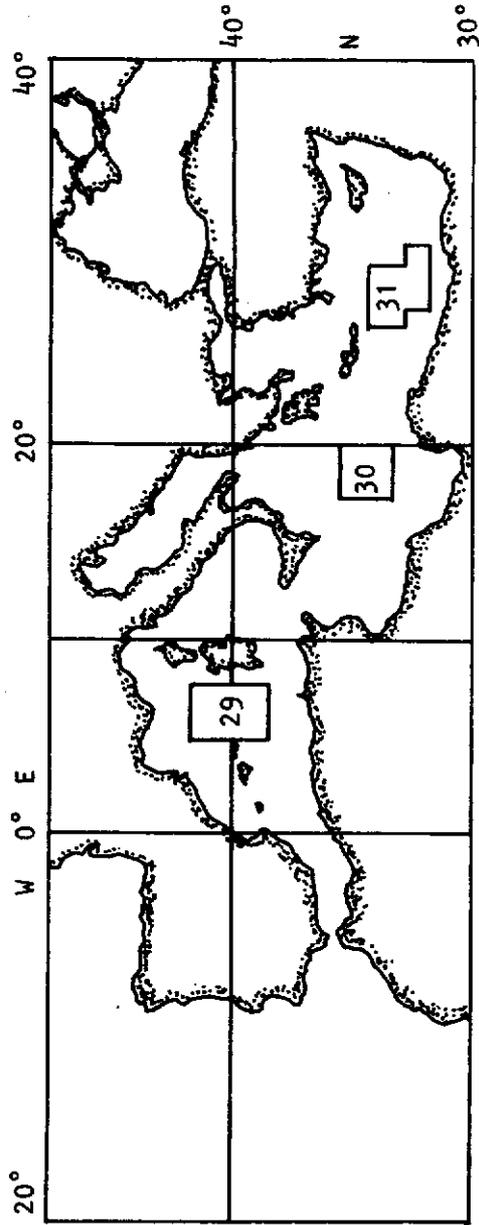
Figure B-1- Definition of Representative Areas in the Mediterranean Sea

B-3

ANNUAL   AREA MEDITERRANEAN TOTAL OBS. 31,522

Figure B-2 data — Significant Wave Height by Modal Wave Period (PERCENT scale 0–100)

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6		.1	+	.1	.1		.3
4	.2	.8	.8	.4	.2	.1	2.5
3	1.1	2.5	2.0	.7	.2	+	6.5
2	9.6	10.9	3.5	.6	.2	.1	24.9
1	19.4	5.9	.7	.2	+	+	26.2
0	37.4	1.6	.3	.1			39.4
TOTALS	67.7	21.8	7.3	2.1	.7	.2	99.8

MODAL WAVE PERIOD (SEC)

Figure B-2 Significant Wave Height by Modal Wave Period

ANNUAL   AREA MEDITERRANEAN TOTAL OBS. 28,815

Figure B-3 data — Significant Wave Height by Wind Speed (PERCENT)

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6			+	+	+	+	
4		.1	.6	.6	+		1.3
3		+	1.1	2.2	.5	+	3.8
2	.1	1.2	11.4	4.8	.5		18.0
1	.9	8.7	15.0	2.4			27.0
0	9.8	30.7	9.6				50.1
TOTALS	10.8	40.6	37.2	10.0	1.6	+	100.2

WIND SPEED AT 10 M (KNOTS)

Figure B-3 Significant Wave Height by Wind Speed

ANNUAL   AREA MEDITERRANEAN   TOTAL OBS. 20,170

Figure B-4 data — Significant Wave Height by Wave Direction (PERCENT)

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+	+							+		+
8	+		+	+	+	+	+	.1		.1
6	1.1	.2	.6	.2	.1	.4	1.2	1.4		5.2
4	2.7	.7	1.0	.5	.7	1.0	3.2	4.3		14.5
3	8.7	2.8	3.4	3.3	3.0	2.9	5.7	13.9		47.7
2	2.6	1.1	1.2	1.1	.9	1.0	2.9	4.2		15.0
1	1.7	.8	.8	.7	.7	.6	1.8	2.8	7.8	17.7
TOTALS	16.8	5.6	7.0	6.2	5.4	5.3	18.8	26.7	7.8	100.2

PRIMARY WAVE DIRECTION
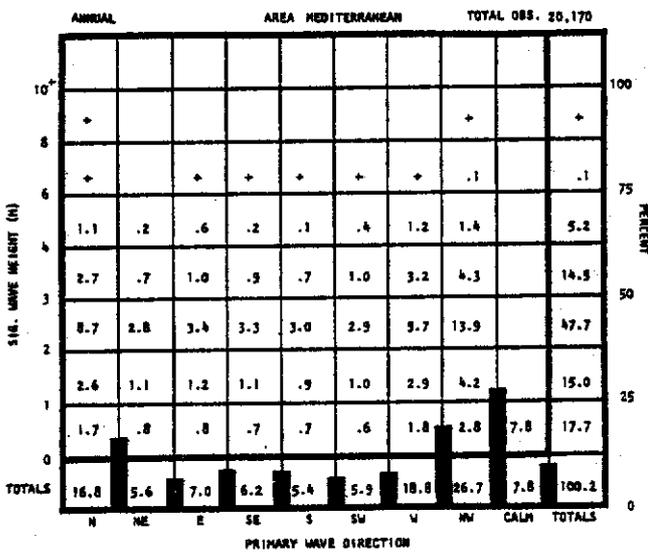
Figure B-4 Significant Wave Height by Wave Direction

ANNUAL   AREA MEDITERRANEAN   TOTAL OBS. 23,307

Figure B-5 data — Wind Speed by Wind Direction (PERCENT)

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+							+			
41	.1	+	+			.1	.2			.4
34	.2	+	.1	+	+	.1	.2	.3		.9
28	.5	.1	.2	.2	.1	.3	.7	.8		3.0
22	.9	.3	.4	.5	.4	.7	1.5	1.4		6.1
17	1.3	.5	.8	.8	.7	1.1	2.7	2.5		10.4
11	3.2	1.4	1.5	1.7	1.7	1.9	3.9	4.3		20.2
7	2.7	1.4	1.6	1.6	1.8	2.3	6.5	5.6		23.5
4	3.2	1.8	1.7	1.7	1.8	2.1	4.7	4.9		21.9
0	1.5	.8	.6	.7	.8	.8	1.6	1.8	5.1	13.9
TOTALS	13.6	6.4	7.1	7.2	7.3	9.3	21.9	22.4	5.1	100.3
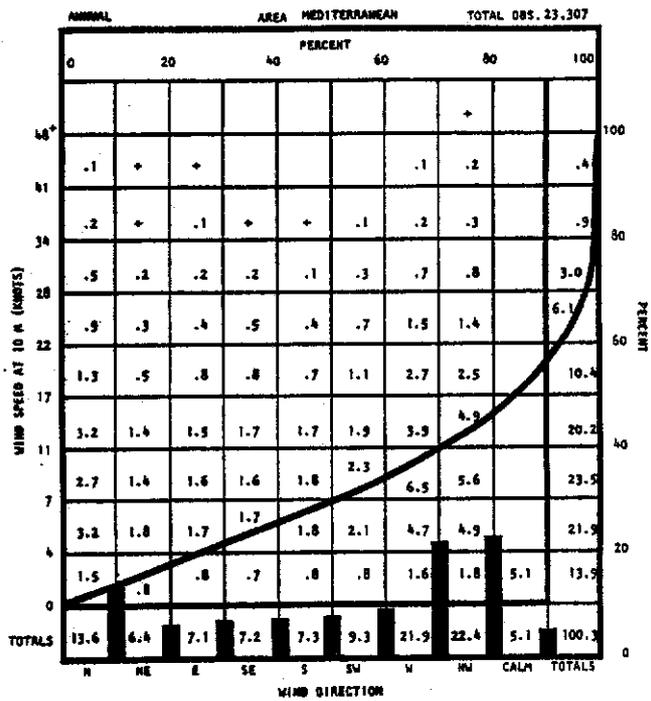
WIND DIRECTION

Figure B-5 Wind Speed by Wind Direction

WINTER   AREA MEDITERRANEAN   TOTAL OBS. 7,614

SIG. WAVE HEIGHT (M) vs MODAL WAVE PERIOD (SEC), PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
10+							
8							
6		.2	.2	+	+	.1	.5
4	.6	1.9	1.3	.9	.2	.1	5.0
3	1.8	3.2	3.7	1.1	.3	.1	10.2
2	11.3	13.4	5.0	1.2	.2	.1	31.2
1	16.8	5.8	1.1	.2		.1	24.0
0	26.7	1.8	.1	.2	+		28.8
TOTALS	57.2	26.3	11.4	3.6	.8	.4	99.7
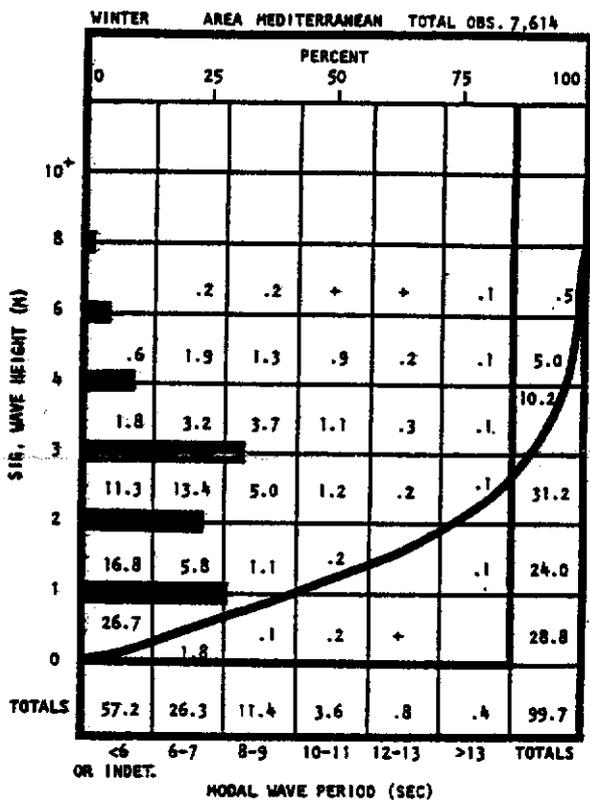
Figure B-6 Significant Wave Height by Modal Wave Period

WINTER   AREA MEDITERRANEAN   TOTAL OBS. 6,970

SIG. WAVE HEIGHT (M) vs WIND SPEED AT 10 M (KNOTS), PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
10+							
8							
6			+	.1			.1
4		.2	1.0	1.1	.1		2.4
3		1.7	3.8	1.0	+		6.5
2	+	.8	15.4	7.6	1.1		24.9
1	.2	7.9	16.5	3.5			28.1
0	5.7	23.0	9.6				38.2
TOTALS	5.9	31.7	43.3	15.9	3.3	.1	100.2
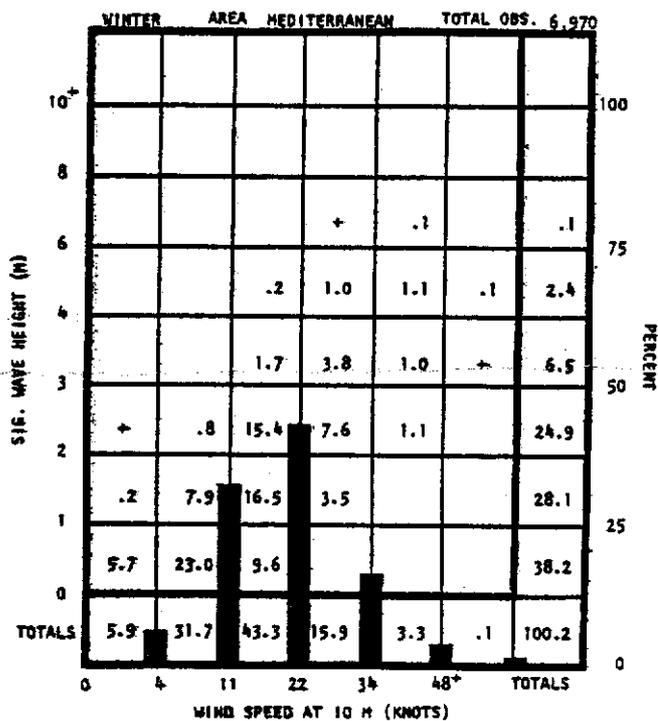
Figure B-7 Significant Wave Height by Wind Speed

WINTER   AREA MEDITERRANEAN   TOTAL OBS. 4,920

SIG. WAVE HEIGHT (M) vs PRIMARY WAVE DIRECTION, PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+	+						+			+
8										
6			+	+	+	.1	+			.2
4	1.6	.5	.3	.1	.1	1.3	3.1	2.9		10.0
3	2.5	1.1	1.5	1.1	1.4	2.9	6.7	5.2		22.5
2	6.5	3.1	2.7	3.5	4.4	5.2	11.5	9.4		46.3
1	1.4	.9	.9	.5	1.0	1.2	1.9	1.7		9.5
0	.9	.6	.6	.5	.7	.8	1.0	.5	5.5	11.4
TOTALS	13.3	6.2	6.0	5.7	7.6	11.4	24.3	20.2	5.5	100.2
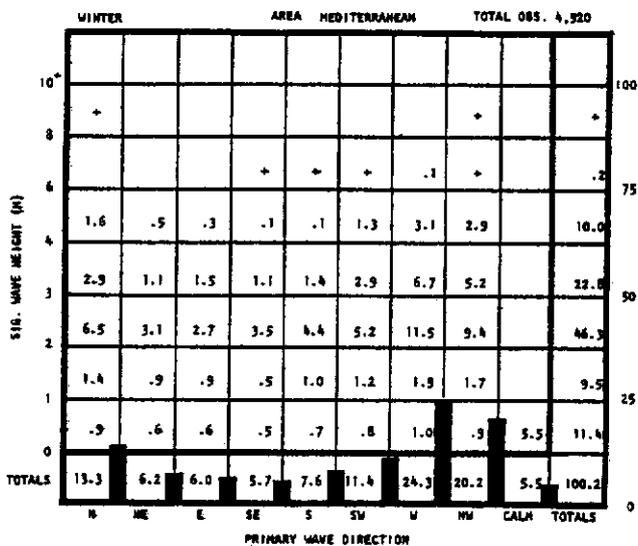
Figure B-8 Significant Wave Height by Wave Direction

WINTER   AREA MEDITERRANEAN   TOTAL OBS. 57,885

WIND SPEED AT 10 M (KNOTS) vs WIND DIRECTION, PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	+					+		.1		.1
41	.2	.1	.1		+	.1	1.0	.3		1.8
34	.6	.1	.1	.1	+	.2	.4	.8		2.3
28	1.0	.3	.3	.2	.3	.8	1.5	1.2		5.6
22	1.6	.4	.4	.5	.8	1.5	2.4	1.9		9.5
17	1.8	.9	1.0	1.0	1.4	2.4	3.7	2.7		14.9
11	3.2	1.4	1.2	1.7	2.4	3.3	5.1	3.7		22.0
7	3.0	2.0	1.5	1.5	2.5	3.1	4.3	3.3		21.2
4	2.3	1.4	1.1	1.3	1.7	1.9	2.5	2.0		14.2
0	.9	.5	.5	.4	.5	.9	.8	3.2		8.2
TOTALS	14.6	7.1	6.2	6.7	9.6	13.8	21.8	16.8	3.2	99.8
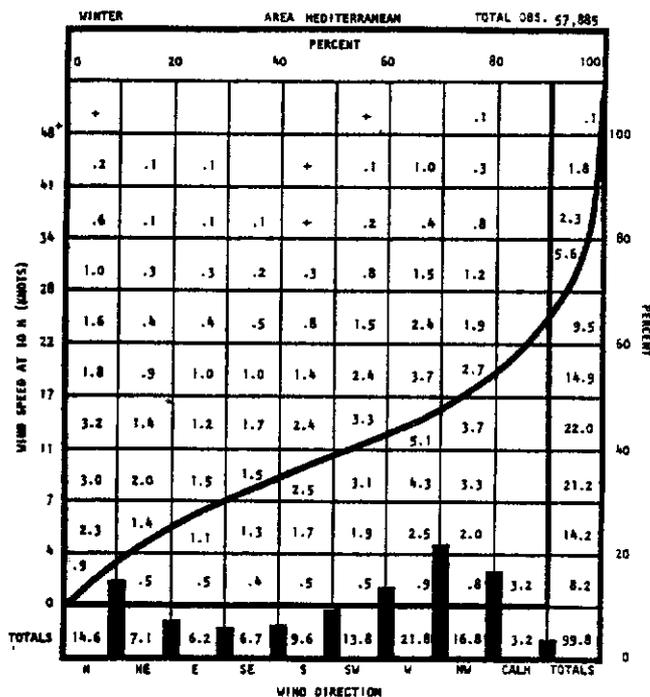
Figure B-9 Wind Speed by Wind Direction

TABLE B-29-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Western Mediterranean Sea, 39° - 41° N, 4° - 6° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2	4	1.5	1.5
Wave Period, sec	2.5	5	9	5	5
Direction	-	-	-	-	N - NW
Winds					
Speed, knots	2	13	30	14	11
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3.5	1.5	1.5
Direction	-	-	-	-	N - NW
Visibility, nautical miles	7	14	25	13	14
Cloud Cover					
Total clouds, in eighths of sky obscured	1	3	8	3.5	1
Low clouds, in eighths of sky obscured	Nil	1.5	7.5	2.5	Nil
Precipitation (Occurrence)	All precipitation - 5.1% of the time				
Relative humidity, %	48	76	95	74	75
Air Temperature, °C	9.5	16	25	17.5	-
Surface Water Temperature, °C	15.5	18.5	21.5	-	-
Sea Level Pressure, millibars	1,004	1,016	1,025	1,016	1,016
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	338	-
Sub-Refraction (1 km, Annual)	-	-	-	-	2% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

ANNUAL   AREA 29   TOTAL OBS. 4,788

Significant Wave Height (M) by Modal Wave Period (SEC) — PERCENT

SIG. WAVE HEIGHT (M)	<6, OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
10+							
8							
6		.1	.1	.2	.1		.5
4	.5	1.3	1.2	.4	.2	.1	3.7
3	1.7	2.6	1.9	.6	.2	.1	7.1
2	9.3	7.7	2.3	.6	.2		20.1
1	18.4	4.9	.7	.3		.1	24.4
0	41.8	1.7	.2	.1			43.8
TOTALS	71.7	18.3	6.4	2.2	.7	.3	99.6

Figure B-29-1-1 Significant Wave Height by Modal Wave Period

ANNUAL   AREA 29   TOTAL OBS. 4,392

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS) — PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
10+							
8							
6			.1	.2	.1		.4
4		.2	1.3	1.4	.1		3.0
3		.1	.9	3.1	1.3	.1	5.5
2	.1	.7	7.5	6.3	.9		15.5
1	.2	4.5	13.6	4.0			22.3
0	7.8	31.0	14.5				53.3
TOTALS	8.1	36.3	36.7	14.8	3.8	.3	100.0

Figure B-29-1-2 Significant Wave Height by Wind Speed

ANNUAL   AREA 29   TOTAL OBS. 1,513

Significant Wave Height (M) by Primary Wave Direction — PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+	.2							.2		.4
8	.2							.1		.3
6	2.6	.3	.3		.1	.3	.8	3.2		7.6
4	3.0	.6	.8	.8	.2	1.0	1.7	4.4		12.5
3	7.2	3.2	2.3	3.6	2.1	3.2	5.3	8.7		35.6
2	2.4	1.8	1.9	2.1	1.4	2.0	1.9	3.2		16.7
1	1.6	1.2	1.2	1.4	1.0	1.4	1.2	2.2	15.6	26.8
TOTALS	17.2	7.1	6.5	7.9	4.8	7.9	10.9	22.0	15.6	100.0

Figure B-29-1-3 Significant Wave Height by Wave Direction

ANNUAL   AREA 29   TOTAL OBS. 26,514

Wind Speed at 10 M (KNOTS) by Wind Direction — PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+								.2		.2
41	.5	.1	.1				.1	1.0		1.8
34	.4						.2	1.5		2.1
28	1.6	.5	.3	.1	.1	.2	.5	2.4		5.7
22	1.7	.6	.4	.3	.3	.6	2.3	3.7		9.9
17	1.8	1.0	.7	.5	.6	1.0	.4	3.0		9.0
11	4.0	2.7	3.2	2.9	3.1	2.8	4.2	4.7		27.6
7	.7	1.7	.7	.8	.7	2.1	2.1	3.0		11.8
4	2.6	2.8	2.9	2.6	2.3	3.0	3.1	3.4		22.7
0	.5	.5	.5	.4	.5	.5	.6	.3	5.4	9.2
TOTALS	13.8	9.8	8.8	7.7	7.6	10.3	13.5	23.2	5.4	100.0

Figure B-29-1-4 Wind Speed by Wind Direction

WINTER AREA 29 TOTAL OBS. 1,106.

Significant Wave Height (M) by Modal Wave Period (SEC) — PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
10+							
8							
6			.1	.2	.4		.6
4	.7	2.1	.9	.9	.5		5.1
3	2.8	2.5	2.1				7.4
2	10.3	8.9	1.6	.2			21.0
1	16.1	4.2					20.3
0	41.3	2.8	.5	.5			45.1
TOTALS	71.2	20.5	5.2	1.8	.9		99.6

Figure B-29-2-1 Significant Wave
Height by Modal Wave Period

WINTER AREA 29 TOTAL OBS. 1,016

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS) — PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
10+							
8							
6					.2		.2
4			.7	1.0	1.9	.6	4.2
3			.6	3.3	3.1		7.0
2		.3	1.0	8.7	5.2	1.6	16.8
1			3.3	12.1	3.8		19.2
0		5.1	33.4	14.1			52.6
TOTALS	5.4	37.7	36.2	13.3	6.8	.6	100.0
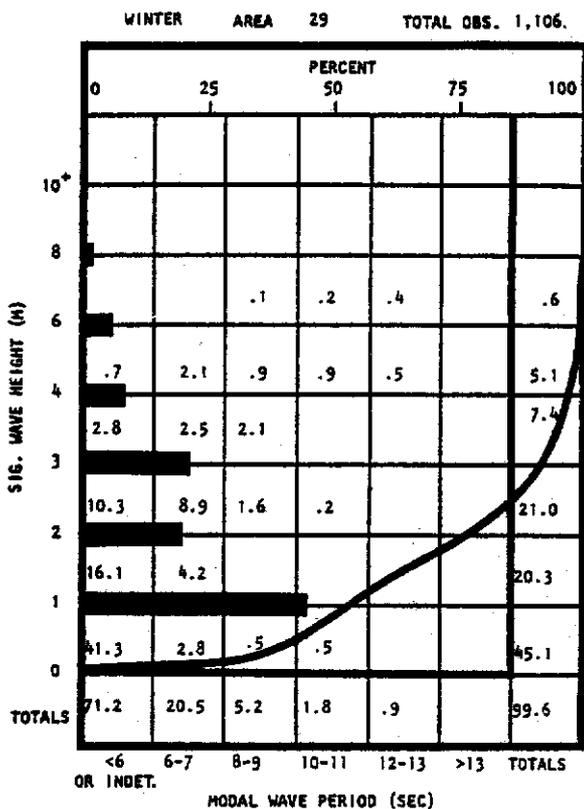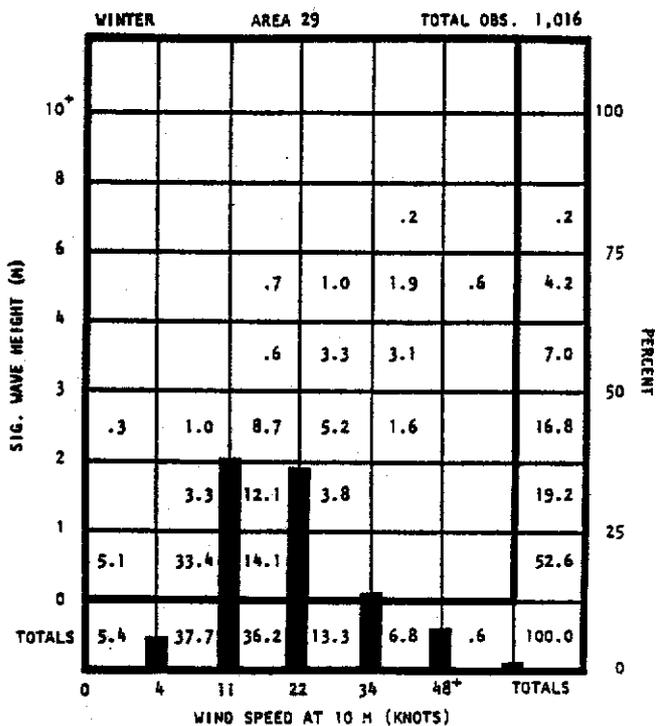
Figure B-29-2-2 Significant Wave
Height by Wind Speed

WINTER AREA 29 TOTAL OBS. 429

Significant Wave Height (M) by Primary Wave Direction — PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+										
8	.3							.3		.6
6								.3		.3
4	3.0	.4	.4				1.0	1.4	4.0	10.2
3	4.7	1.3	2.0	.4	.4	1.3	3.0	5.0		18.1
2	4.3	4.0	3.3	4.0	2.7	3.3	7.3	7.0		35.9
1	2.0	1.6	1.4	1.6	1.2	1.6	1.2	2.0		12.6
0	1.3	1.1	.9	1.1	.8	1.1	.8	1.3	14.0	22.4
TOTALS	15.4	8.4	8.0	7.1	5.1	8.3	13.7	15.9	14.0	100.0
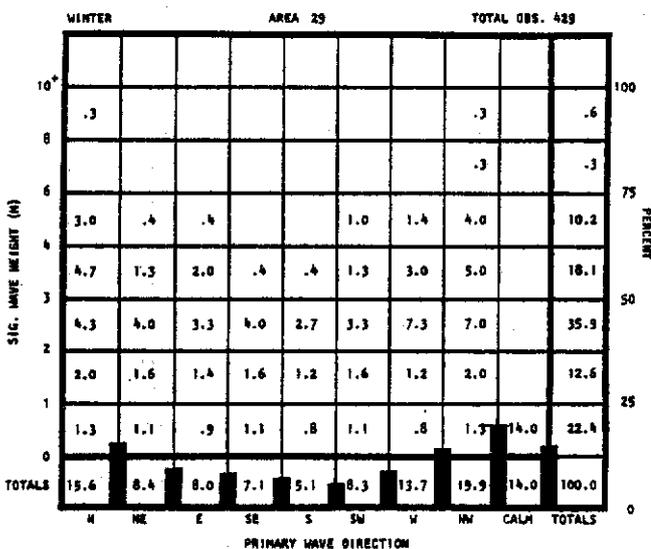
Figure B-29-2-3 Significant Wave
Height by Wave Direction

WINTER AREA 29 TOTAL OBS. 6,228

Wind Speed at 10 M (KNOTS) by Wind Direction — PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.3					.1		.9		1.3
41	.7	.1	.1			.1	.1	1.1		2.2
34	2.0	.6	.1			.1	.5	2.5		5.8
28	1.6	.7	.4		.1	.2	.8	2.9		6.7
22	2.2	1.2	.8	.4	.4	.5	.8	2.8		9.1
17	2.7	1.2	1.0	.9	.7	1.9	1.9	3.3		13.6
11	3.0	2.2	1.5	2.1	2.1	2.8	3.2	3.2		20.1
7	2.9	2.4	1.7	1.7	2.3	2.8	3.1	2.9		19.8
4	1.8	1.7	1.4	1.0	1.1	1.4	2.3	1.7		12.4
0	.8	.9	.4	.3	.7	.6	.7	.8	3.9	9.0
TOTALS	18.0	11.0	7.5	6.4	7.4	10.5	13.3	22.0	3.9	100.0
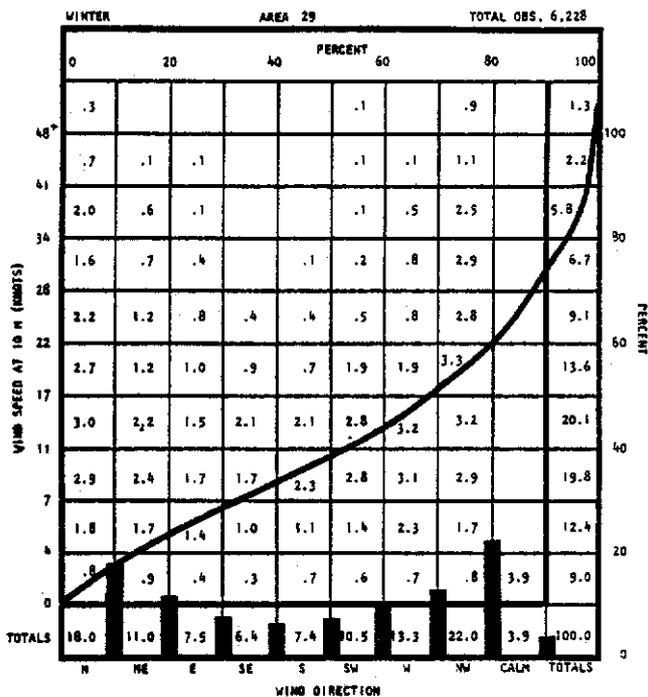
Figure B-29-2-4 Wind Speed by
Wind Direction

Figure B-29-3-1

SPRING   AREA 29   TOTAL OBS. 1,509

PERCENT: 0 — 25 — 50 — 75 — 100

Sig. Wave Height (M)	<6 or Indet.	6-7	8-9	10-11	11-12	>13	Totals
6			.5	.5	.2		1.2
4	.2	1.0	1.2	.9			3.3
3	2.1	2.6	2.1				6.8
	10.6	7.2	2.6	.2			20.6
2	16.7	5.1	1.0				22.8
1	42.0	2.1	.5	.2			44.8
TOTALS	71.6	18.0	7.4	1.8	.5	.2	99.5

MODAL WAVE PERIOD (SEC)

Figure B-29-3-1 Significant Wave Height by Modal Wave Period

Figure B-29-3-2

SPRING   AREA 29   TOTAL OBS. 1,397

Sig. Wave Height (M)	0	4	11	22	34	48+	Totals
6				.4	.5		.9
				1.1	.8		1.9
			1.3	3.8	.3		5.4
2		.2	8.7	6.6	.3		15.8
1	.3	4.0	12.2	3.2			19.7
0	5.8	32.0	18.5				56.3
TOTALS	6.1	36.2	40.7	15.1	1.9		100.0

WIND SPEED AT 10 M (KNOTS)

Figure B-29-3-2 Significant Wave Height by Wind Speed

Figure B-29-3-3

SPRING   AREA 29   TOTAL OBS. 416

Sig. Wave Height (M)	N	NE	E	SE	S	SW	W	NW	CALM	Totals
4	2.2						.7	4.0		6.9
3	3.3	.7	.7	1.2		.8	1.3	5.3		13.3
2	6.7	2.3	2.7	3.0	2.0	4.7	5.7	10.0		37.1
	1.8	2.0	2.6	2.6	1.8	2.8	2.4	3.4		19.4
1	1.2	1.3	1.7	1.7	1.2	1.9	1.6	2.3	10.7	23.6
TOTALS	15.2	6.3	7.7	8.5	5.0	10.2	11.7	25.0	10.7	100.3

PRIMARY WAVE DIRECTION
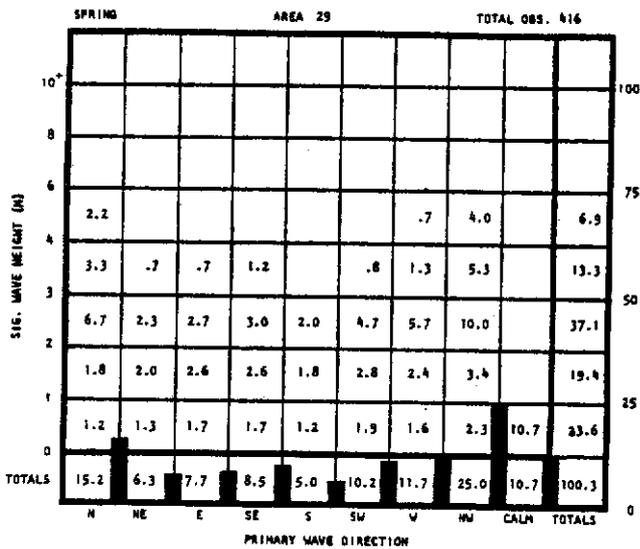
Figure B-29-3-3 Significant Wave Height by Wave Direction

Figure B-29-3-4

SPRING   AREA 29   TOTAL OBS. 6,836

PERCENT: 0 — 20 — 40 — 60 — 80 — 100

Wind Speed at 10 M (Knots)	N	NE	E	SE	S	SW	W	NW	CALM	Totals
48+								.6		.6
41	.2						.1	.6		.9
34	.5						.3	1.9		2.7
28	1.7	.3	.4		.1	.1	.8	2.3		5.7
22	1.6	.3	.5	.2	.2	.3	1.0	3.8		7.9
17	2.3	.8	.5	.4	.5	1.1	1.8	4.8		12.2
11	2.1	2.1	2.0	1.9	1.7	2.4	3.9	4.4		20.5
7	1.8	2.7	2.6	2.1	2.2	3.3	3.5	3.4		21.6
4	1.2	2.4	1.6	1.9	1.6	3.1	2.9	2.5		17.2
0	.7	.5	.8	.6	1.1	.9	.8	1.2	4.3	10.9
TOTALS	12.0	9.2	8.3	7.2	7.4	11.2	15.0	25.5	4.3	100.2
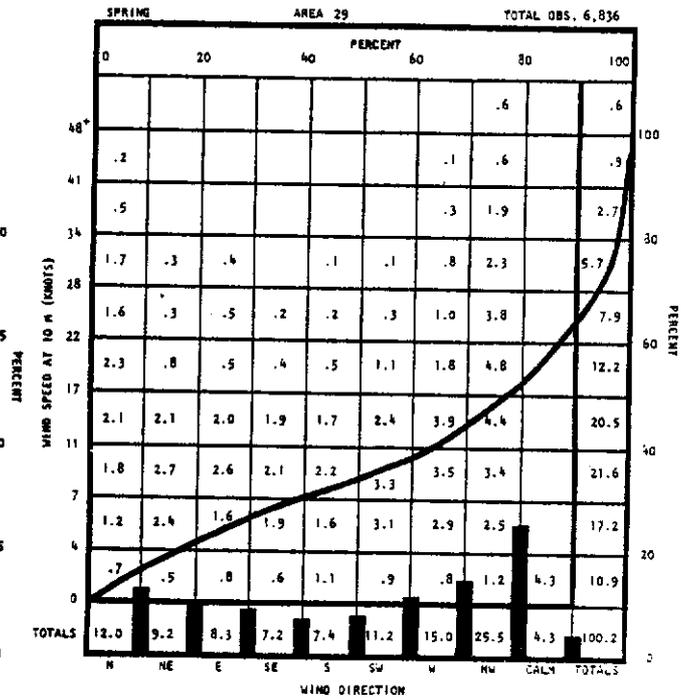
WIND DIRECTION

Figure B-29-3-4 Wind Speed by Wind Direction

Figure B-29-4-1

SUMMER   AREA   29   TOTAL OBS. 1,241

PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.2	.6	.2				1.0
4	.2	1.6	1.2	.6			3.6
3	4.4	5.2	1.9	.2			11.7
2	16.0	6.0	.8				22.8
1	58.4	2.3					60.7
0							
TOTALS	79.2	15.7	4.1	.8			99.8

MODAL WAVE PERIOD (SEC)
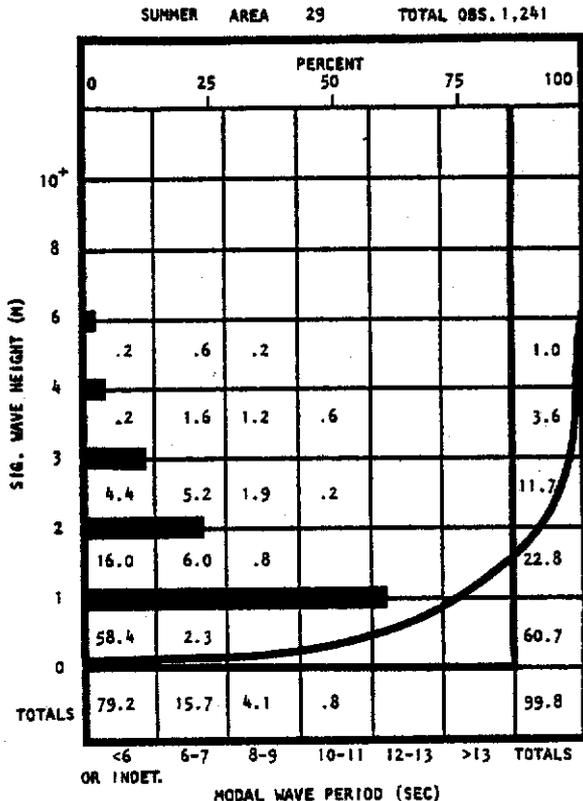
Figure B-29-4-1 Significant Wave
Height by Modal Wave Period

Figure B-29-4-2

SUMMER   AREA 29   TOTAL OBS. 1,131

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6				.4	.7		1.1
4			.9	1.9	.2		3.0
3		.7	5.4	2.5	.4		9.0
2		5.2	13.6	1.8			20.6
1	13.8	37.1	15.4				66.3
0							
TOTALS	13.8	43.0	35.3	6.6	1.3		100.0

WIND SPEED AT 10 M (KNOTS)
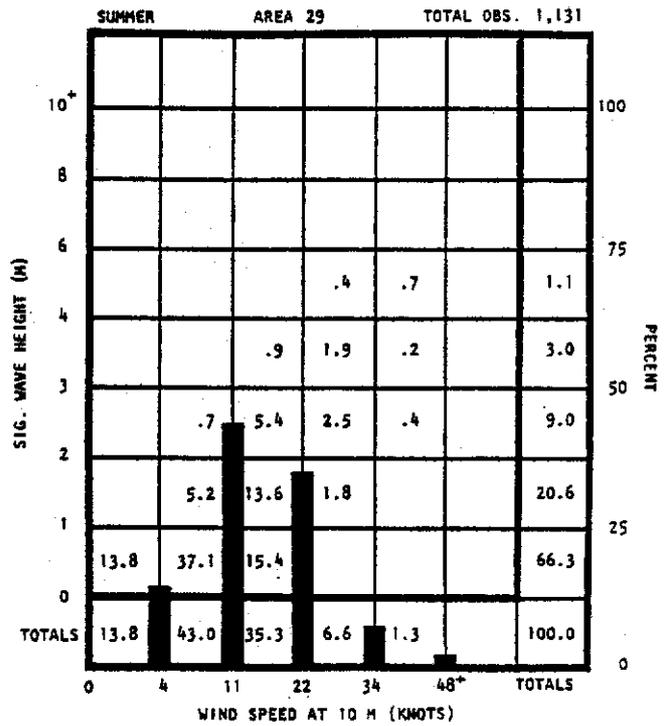
Figure B-29-4-2 Significant Wave
Height by Wind Speed

Figure B-29-4-3

SUMMER   AREA 29   TOTAL OBS. 457

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6	2.3	.2					.3	2.0		4.8
4	2.0	.2		.4	.2		.7	4.3		7.8
3	10.0	2.7	1.0	3.0	1.7		2.0	10.7		31.1
2	3.8	2.4	2.0	2.6	1.6	1.2	2.6	4.4		20.6
1	2.5	1.6	1.3	1.7	1.1	.8	1.7	2.9	22.0	35.6
0										
TOTALS	20.6	7.1	4.3	7.7	4.6	2.0	7.3	24.3	22.0	100.0

PRIMARY WAVE DIRECTION
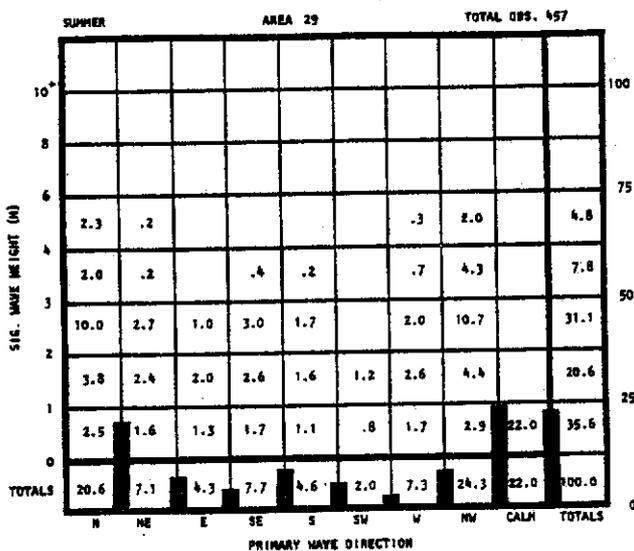
Figure B-29-4-3 Significant Wave
Height by Wave Direction

Figure B-29-4-4

SUMMER   AREA 29   TOTAL OBS. 6,850

PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+								.2		.2
41							.1	.6		.7
34	.4	.1					.3	2.1		2.9
28	1.0	.1	.1				.6	3.6		5.4
22	2.6	.5	.3	.2	.4	.3	1.9	4.2		10.4
17	2.3	1.5	.9	.7	.5	.9	2.8	4.9		14.9
11	2.5	2.9	2.4	2.0	2.0	2.6	3.7	4.3		22.4
7	2.5	1.8	2.3	3.1	1.6	2.9	3.8	2.9		20.9
4	1.8	1.1	1.9	1.6	1.5	2.2	1.8	1.7	8.7	22.5
0										
TOTALS	13.1	8.2	8.0	7.6	6.4	8.9	15.0	24.4	8.7	100.1
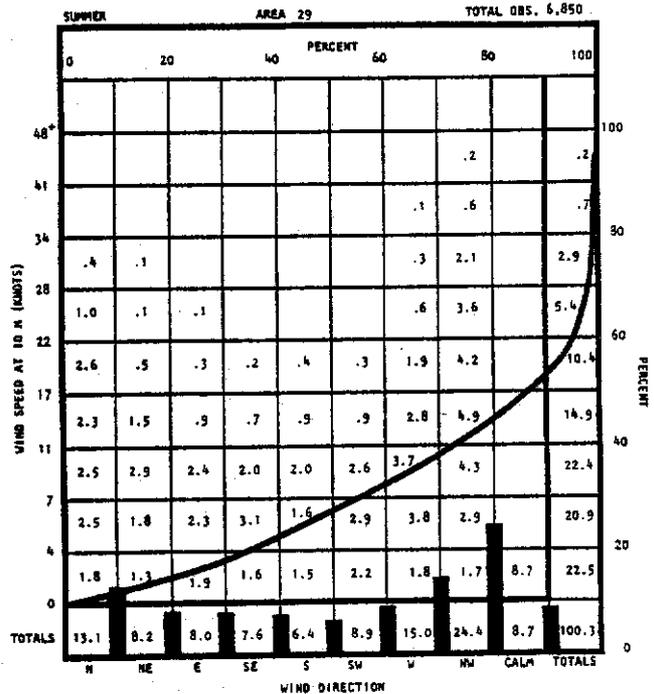
WIND DIRECTION

Figure B-29-4-4 Wind Speed by
Wind Direction
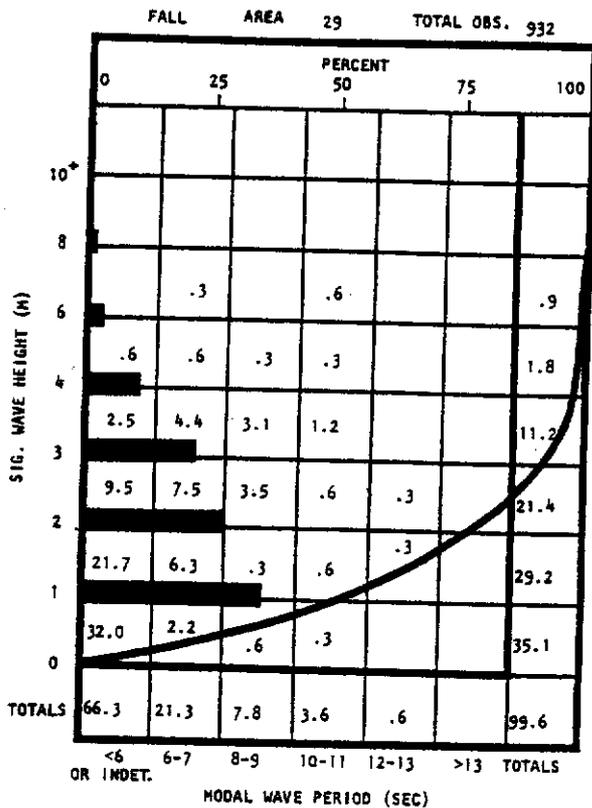
Figure B-29-5-1 Significant Wave
Height by Modal Wave Period
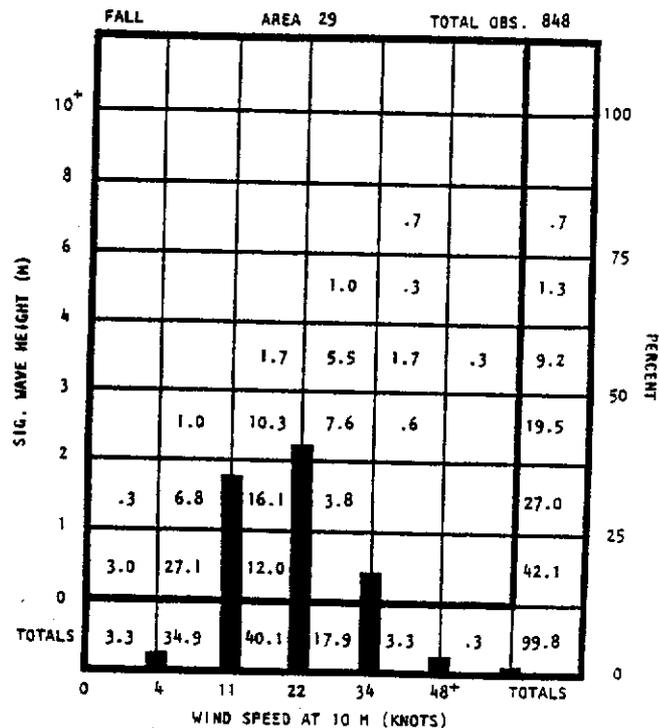
Figure B-29-5-2 Significant Wave
Height by Wind Speed
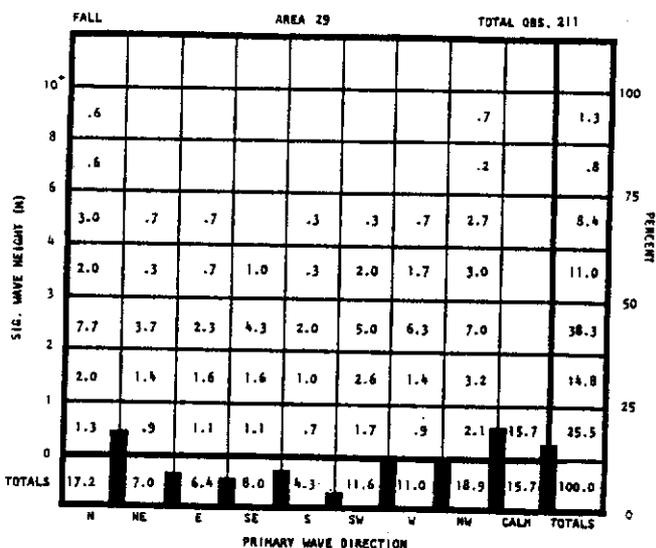
Figure B-29-5-3 Significant Wave
Height by Wave Direction
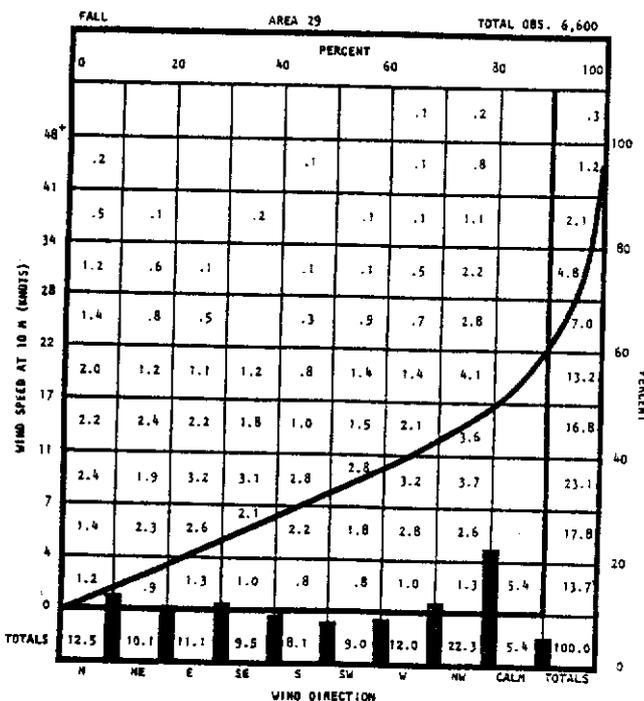
Figure B-29-5-4 Wind Speed by
Wind Direction

TABLE B-30-1-1 – SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Central Mediterranean Sea, 34° - 36° N, 18° - 20° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	3.5	1.5	1.5
Wave Period, sec	2.5	5	9	4.5	4
Direction	-	-	-	-	W - NW
Winds					
Speed, knots	2	9	25	11	9
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3	2	1.5
Direction	-	-	-	-	W - NW
Visibility, nautical miles	7	17	25	16	15
Cloud Cover					
Total clouds, in eighths of sky obscured	1	2.5	8	3	1
Low clouds, in eighths of sky obscured	Nil	1.5	7.5	2	Nil
Precipitation (Occurrence)	All precipitation - 4.2% of the time				
Relative Humidity, %	60	74	95	75	76
Air Temperature, °C	12	19	26.5	19.5	-
Surface Water Temperature, °C	18	20	22	-	-
Sea Level Pressure, millibars	1,006	1,016	1,025	1,015	1,015
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	322	-
Sub-Refraction (1 km, Annual)	-	-	-	-	5% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

ANNUAL **AREA 30** **TOTAL OBS. 15,857**

Figure B-30-1-1 — SIG. WAVE HEIGHT (M) by MODAL WAVE PERIOD (SEC), PERCENT

SIG. WAVE HEIGHT	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
8							
6				.1	.1		.2
4	.2	.7	.8	.3	.2	.2	2.4
3	1.0	2.3	1.9	.7	.2		6.1
2	9.1	10.6	3.3	.6	.1	.1	23.8
1	19.8	5.6	.7	.1			26.2
0	39.2	1.4	.3	.1			41.0
TOTALS	69.3	20.6	7.0	1.9	.6	.3	99.7

Figure B-30-1-1 Significant Wave Height by Modal Wave Period

ANNUAL **AREA 30** **TOTAL OBS. 14,471**

Figure B-30-1-2 — SIG. WAVE HEIGHT (M) by WIND SPEED AT 10 M (KNOTS), PERCENT

SIG. WAVE HEIGHT	0	4	11	22	34	48+	TOTALS
4			.1	.6	.4		1.1
3			1.1	2.0	.4		3.5
2	.1	1.4	10.9	4.6	.5		17.5
1	.3	8.9	14.7	2.5			26.4
0	11.0	31.3	9.3				51.6
TOTALS	11.4	41.6	36.1	9.7	1.3		100.1

Figure B-30-1-2 Significant Wave Height by Wind Speed

ANNUAL **AREA 30** **TOTAL OBS. 8,541**

Figure B-30-1-3 — SIG. WAVE HEIGHT (M) by PRIMARY WAVE DIRECTION, PERCENT

SIG. WAVE HEIGHT	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+	+							+		
8	+		+		+		.1	+		.1
4	.8	.3	1.0	.4	.3	.4	1.4	1.1		5.7
3	2.3	.8	1.6	1.2	.9	1.2	3.2	3.2		14.4
2	8.0	2.8	4.7	3.8	4.0	3.6	9.5	10.5		46.9
1	2.6	1.1	1.4	1.2	1.0	1.0	3.0	3.7		15.0
0	1.8	.6	.8	.7	.6	.6	1.9	2.5	8.4	17.9
TOTALS	15.5	5.6	9.5	7.3	6.8	6.8	19.1	21.0	8.4	100.0
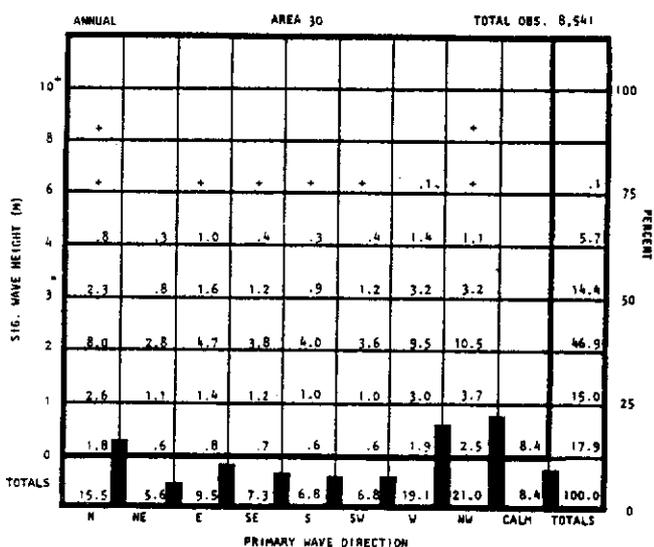
Figure B-30-1-3 Significant Wave Height by Wave Direction

ANNUAL **AREA 30** **TOTAL OBS. 118,795**

Figure B-30-1-4 — WIND SPEED AT 10 M (KNOTS) by WIND DIRECTION, PERCENT

WIND SPEED	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1					.1	.1			.3
41										
34	.1	.1	.2	.1	.1	.1	.3	.1		1.1
28	.4	.1	.2	.1	.3	.7	.5			2.5
22	.5	.3	.6	.6	.7	1.6	.8			5.8
17	1.4	.6	1.0	1.0	.8	1.2	2.6	1.9		10.5
11	2.3	1.2	1.6	1.8	1.9	2.1	4.4	3.5		18.8
7	3.8	1.8	1.8	1.9	2.1	2.6	5.1	5.4		24.5
4	3.6	1.9	1.6	1.6	1.9	2.1	4.3	4.7		21.7
0	1.6	.9	1.0	.8	.9	.9	1.8	1.8	5.1	14.8
TOTALS	13.8	6.9	8.0	8.1	8.4	10.0	20.9	18.8	5.1	100.0

Figure B-30-1-4 Wind Speed by Wind Direction

Figure B-30-2-1 — WINTER · AREA 30 · TOTAL OBS. 3,803

Significant Wave Height (M) by Modal Wave Period (SEC)

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
8							
6		.1	.2		.1		.4
4	.7	2.0	1.6	.9	.3		5.5
3	1.5	3.1	3.9	1.5	.4	.1	10.5
2	11.5	13.1	5.3	1.4	.2	.1	31.6
1	18.8	5.6	1.3	.1		.1	25.9
0	24.4	1.5	.1	.1			26.1
TOTALS	56.9	25.4	12.4	4.0	.9	.4	100.0

Figure B-30-2-1 Significant Wave
Height by Modal Wave Period

Figure B-30-2-2 — WINTER · AREA 30 · TOTAL OBS. 3,487

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS)

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6				.1			.1
4			.2	1.0	1.0		2.2
3			1.9	4.1	.8		6.8
2		1.2	15.5	8.8	1.2		26.7
1		.2	7.6	16.9	4.3		29.0
0		5.7	19.6	9.6			34.9
TOTALS		5.9	28.4	44.1	18.2	3.1	99.7

Figure B-30-2-2 Significant Wave
Height by Wind Speed

Figure B-30-2-3 — WINTER · AREA 30 · TOTAL OBS. 1,897

Significant Wave Height (M) by Primary Wave Direction

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
8	+							+		
6			+	+	+	.3	+			.3
4	1.6	.6	.7	.3	.3	1.0	3.7	2.3		10.7
3	3.7	.7	2.3	1.3	1.7	3.0	7.0	6.0		25.7
2	6.3	2.7	4.0	3.7	5.0	6.3	12.0	7.3		47.3
1	.6	.4	.8	.6	.8	1.2	2.0	1.0		7.4
0	.4	.3	.5	.4	.5	.8	1.0	.7	4.0	8.6
TOTALS	12.6	4.7	8.3	6.3	8.3	12.3	26.0	17.3	4.0	100.0
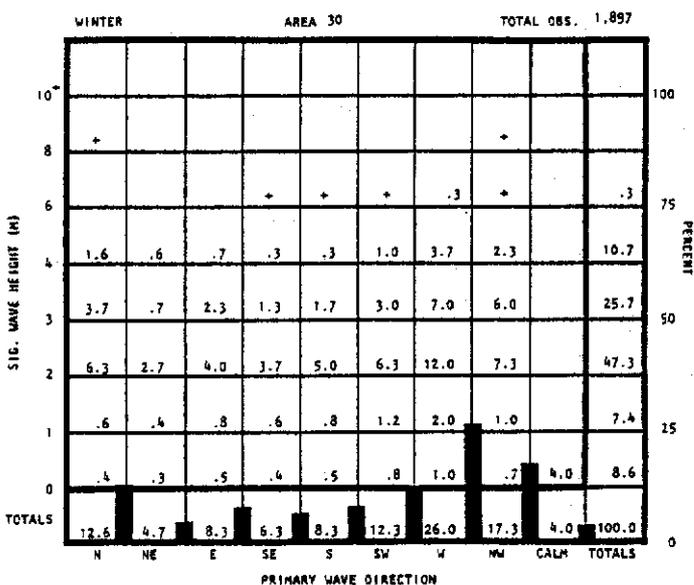
Figure B-30-2-3 Significant Wave
Height by Wave Direction

Figure B-30-2-4 — WINTER · AREA 30 · TOTAL OBS. 29,681

Wind Speed at 10 M (KNOTS) by Wind Direction

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1	.1	.1		.1	.1	.2	.1		.8
41	.3	.1	.1	.2	.1	.2	.5	.4		1.9
34	.8	.3	.6	.3	.4	.8	1.8	.8		5.8
28	1.3	.6	.6	.8	1.1	1.5	2.9	1.8		10.6
22	2.2	1.0	1.3	1.2	1.5	2.5	4.3	2.5		16.5
17	3.1	1.5	1.2	1.8	2.4	3.3	5.7	3.7		22.7
11	3.0	2.0	1.7	1.4	2.5	3.1	4.4	2.9		21.0
7	2.1	1.4	1.0	1.0	1.7	1.8	2.4	1.9		13.3
4	.9	.5	.5	.4	.5	.5	.8	.7	2.6	7.4
TOTALS	13.8	7.5	7.1	7.1	10.3	13.8	23.0	14.8	2.6	100.0
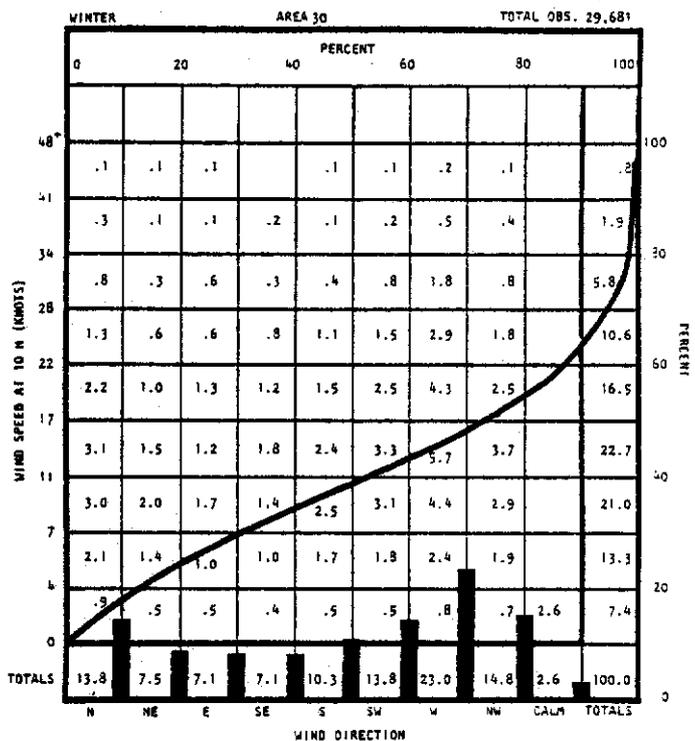
Figure B-30-2-4 Wind Speed by
Wind Direction

SPRING AREA 30 TOTAL OBS. 4,222
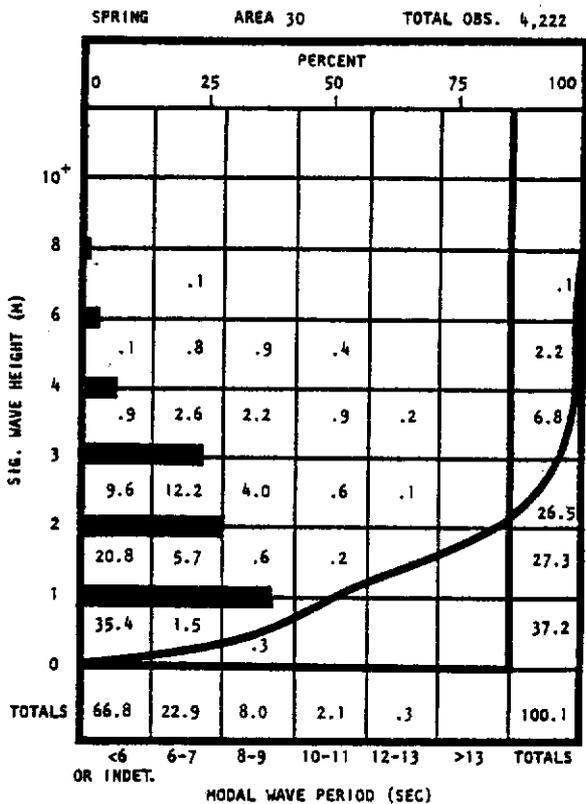
Figure B-30-3-1 Significant Wave
Height by Modal Wave Period

SPRING AREA 30 TOTAL OBS. 3,883
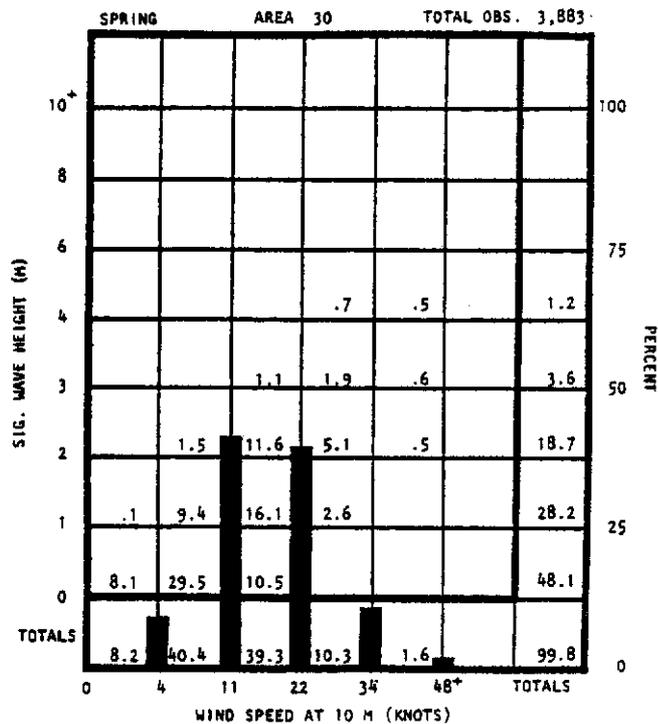
Figure B-30-3-2 Significant Wave
Height by Wind Speed

SPRING AREA 30 TOTAL OBS. 2,655
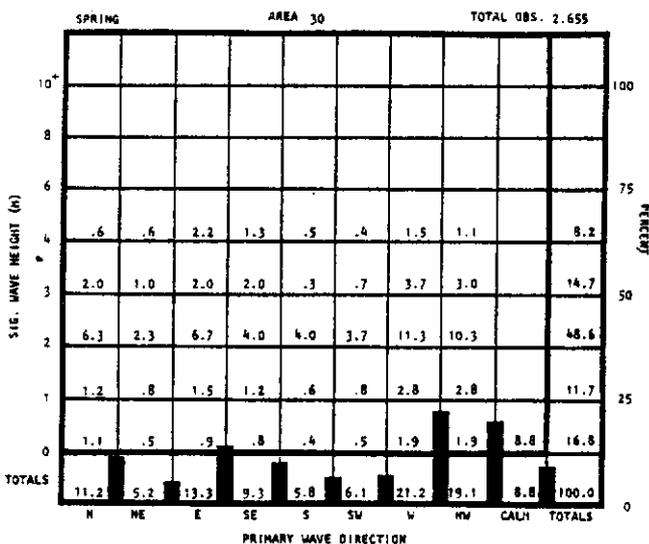
Figure B-30-3-3 Significant Wave
Height by Wave Direction

SPRING AREA 30 TOTAL OBS. 31,480
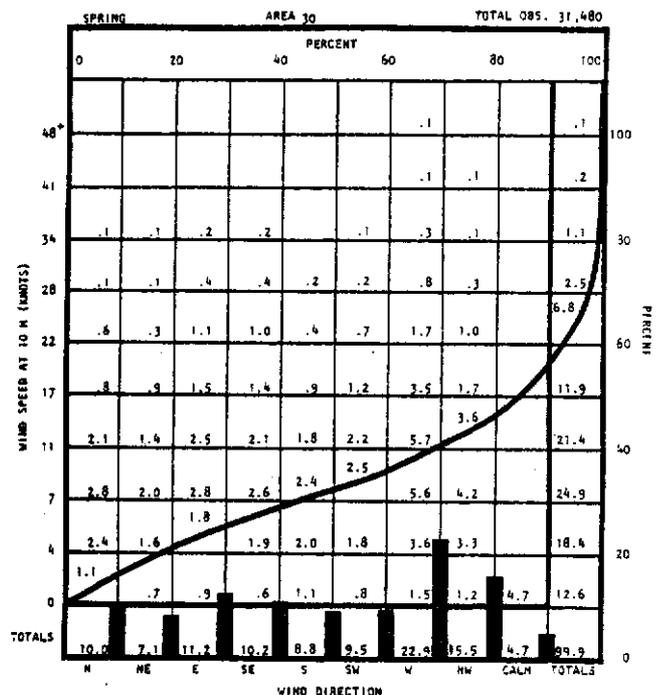
Figure B-30-3-4 Wind Speed by
Wind Direction

SUMMER AREA 30 TOTAL OBS. 3,888

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
5-6	+		+			.1	.2
3-4	.3	.7	.6	.1	.1		1.8
2-3	5.8	6.6	1.6	.3	.1		14.4
1-2	20.4	5.2	.6	.1			26.3
0-1	54.8	1.8	.5	.2	.1		57.4
TOTALS	81.3	14.4	3.3	.7	.3	.1	100.0

MODAL WAVE PERIOD (SEC)
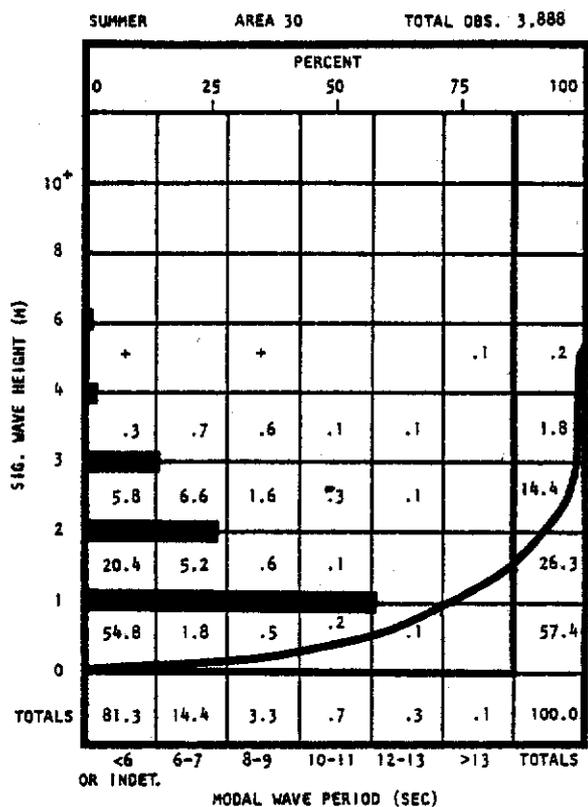
Figure B-30-4-1 Significant Wave
Height by Modal Wave Period

SUMMER AREA 30 TOTAL OBS. 3,572

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4-5			.1	.1			.2
3-4			.4	.3			.7
2-3		1.4	5.4	1.3			8.1
1-2	.5	9.7	10.7	1.0			21.9
0-1	17.4	44.6	7.2				69.2
TOTALS	17.9	55.7	23.7	2.7	.1		100.1

WIND SPEED AT 10 M (KNOTS)
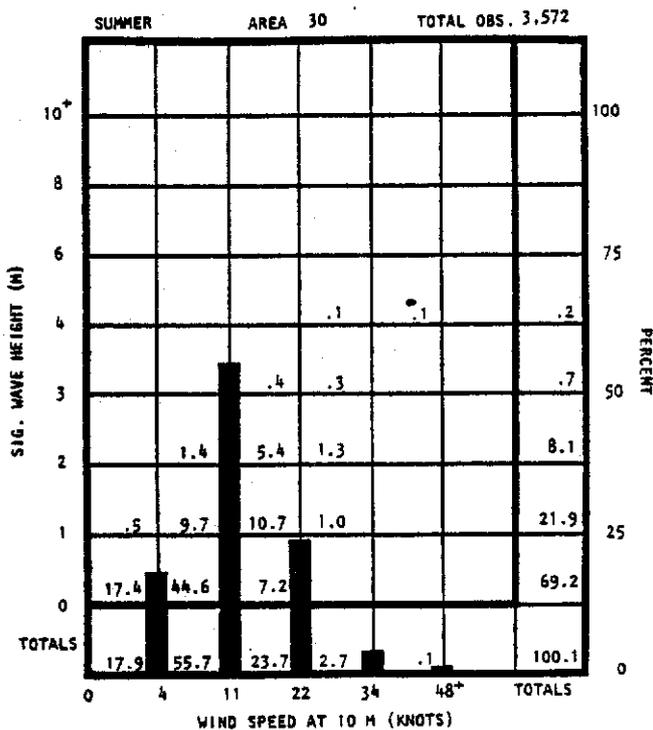
Figure B-30-4-2 Significant Wave
Height by Wind Speed

SUMMER AREA 30 TOTAL OBS. 1,777

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
4-5	+	+	+					+		
3-4	1.6	.6	.3	.3	+	+	.6	1.6		5.0
2-3	12.0	3.0	3.3	1.7	1.3	1.3	8.0	16.3		46.9
1-2	5.8	1.2	1.4	.8	.8	.8	4.2	7.8		22.8
0-1	3.9	.8	.9	.5	.5	.5	2.8	5.2	10.2	25.3
TOTALS	23.3	5.6	5.9	3.3	2.6	2.6	15.6	30.9	10.2	100.0

PRIMARY WAVE DIRECTION
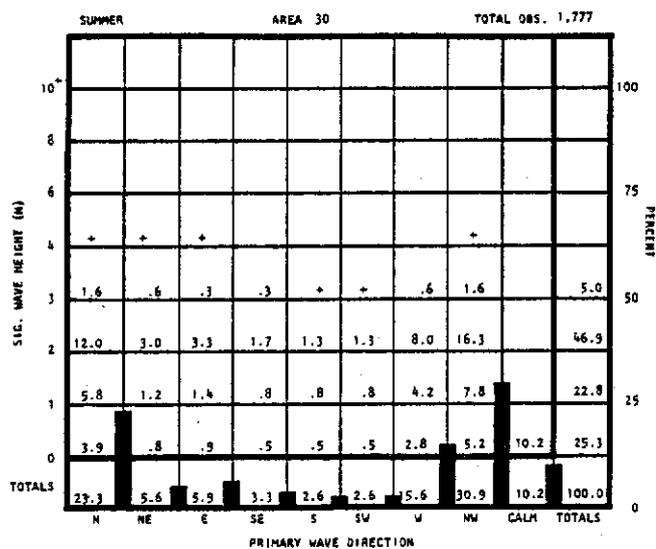
Figure B-30-4-3 Significant Wave
Height by Wave Direction

SUMMER AREA 30 TOTAL OBS. 28,222

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
34-43	.1						.1	.1		.3
28-34	.2	.1		.1			.1	.5		1.0
22-28	.8	.1	.1	.1		.1	.7	1.8		3.7
17-22	2.7	.5	.2	.3	.3	.5	2.9	5.4		12.8
11-17	5.8	1.2	.5	.4	1.0	1.7	6.7	11.5		28.8
7-11	6.5	1.7	1.0	1.0	1.6	2.2	7.6	11.0		32.6
4-7	2.6	.9	1.0	.5	.9	.9	3.6	4.0	6.5	20.9
TOTALS	18.7	4.5	2.8	2.4	3.8	5.4	21.7	34.3	6.5	100.1
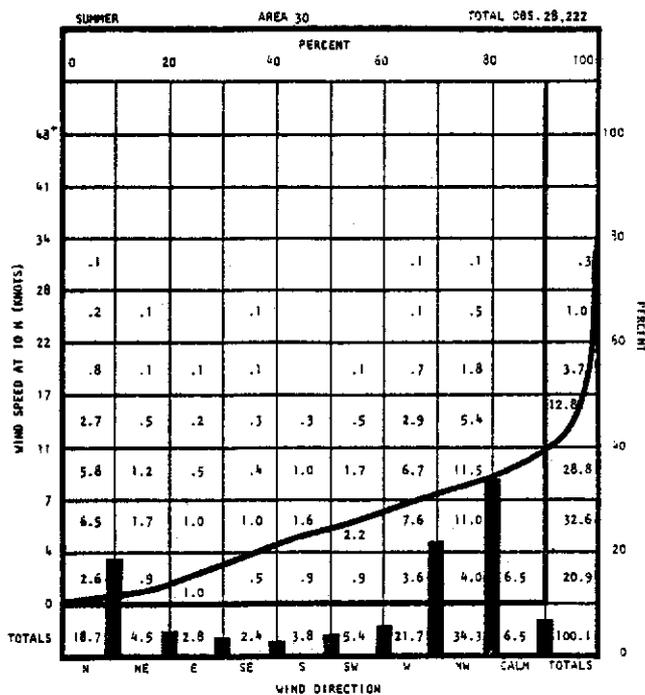
WIND DIRECTION

Figure B-30-4-4 Wind Speed by
Wind Direction

FALL   AREA 30   TOTAL OBS. 3,944

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.3	.4	.3	.3	.2	.1	1.6
4	1.1	2.2	1.6	1.0			5.9
3	9.4	10.3	2.7	.6			23.0
2	19.4	5.4	.8	.1			25.7
1	42.5	1.1	.3	.1			44.0
0							
TOTALS	72.7	19.4	5.7	2.1	.2	.1	100.2

MODAL WAVE PERIOD (SEC)
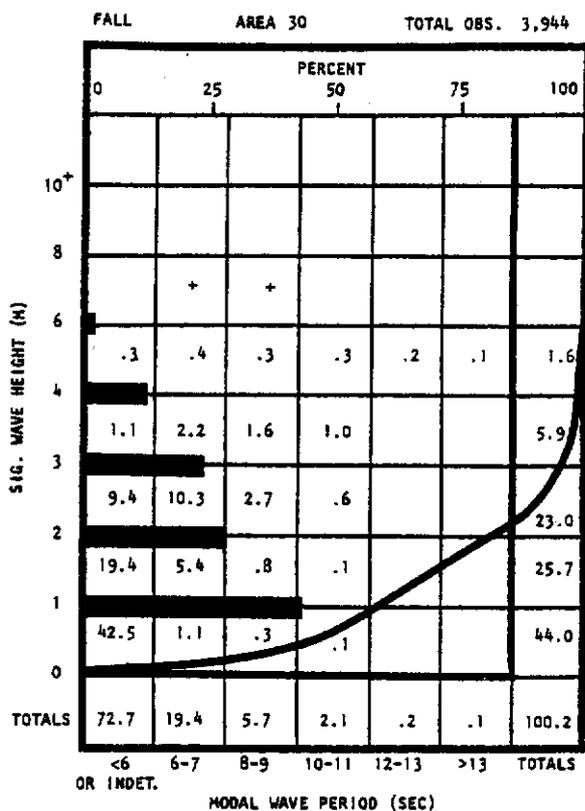
Figure B-30-5-1 Significant Wave Height by Modal Wave Period

FALL   AREA 30   TOTAL OBS. 3,529

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4			.1	.7	.2		1.0
3		.1	.9	1.8	.2		3.0
2	.2	1.5	11.2	3.4	.2		16.5
1	.4	8.7	14.9	2.0			26.0
0	12.7	31.2	9.7				53.6
TOTALS	13.3	41.5	36.8	7.9	.6		100.1

WIND SPEED AT 10 M (KNOTS)
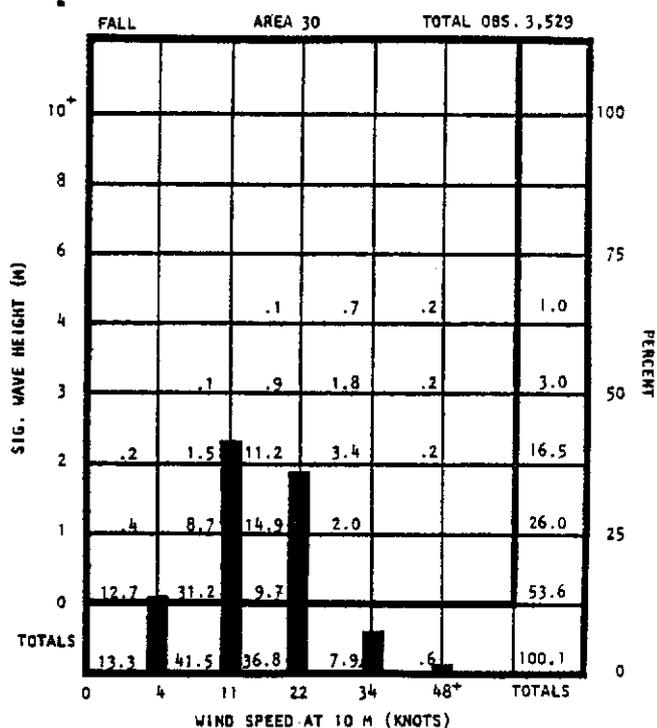
Figure B-30-5-2 Significant Wave Height by Wind Speed

FALL   AREA 30   TOTAL OBS. 2,212

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6			+							
4	1.0	+	.3	+	.4	+	.4	1.0		1.7
3	2.0	.7	1.7	1.4	1.7	1.0	1.7	2.3		12.5
2	7.3	3.3	4.7	5.7	5.7	3.0	6.7	8.0		44.4
1	3.0	1.8	1.8	1.8	1.8	1.2	2.8	3.2		17.4
0	2.0	1.2	1.2	1.2	1.2	.8	1.9	2.1	10.4	22.0
TOTALS	15.3	7.0	10.3	10.2	10.9	6.0	13.5	16.6	10.4	100.0

PRIMARY WAVE DIRECTION
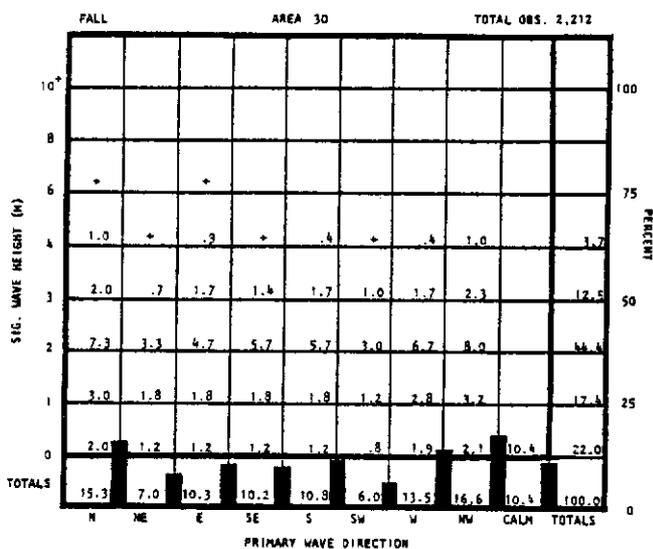
Figure B-30-5-3 Significant Wave Height by Wave Direction

FALL   AREA 30   TOTAL OBS. 29,412

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+			+				+			
34	.1		.2	.1	.1		.2	.2		.9
28	.2	.1	.2	.2	.1	.2	.2	.2		1.4
22	.4	.2	.7	.8	.5	.3	.7	.7		4.3
17	1.0	.6	1.5	1.9	1.3	.8	1.5	1.1		9.7
11	2.6	1.4	2.2	3.1	2.5	1.7	3.2	2.5		19.3
7	1.8	2.2	2.7	3.7	2.7	2.9	4.0	3.6		25.6
4	4.0	2.4	2.3	2.1	2.5	2.4	3.2	3.6		22.5
0	1.5	1.2	1.1	1.0	1.2	1.0	1.5	1.3	6.5	16.3
TOTALS	13.6	8.1	10.9	12.9	10.9	9.3	14.5	13.3	6.5	100.0
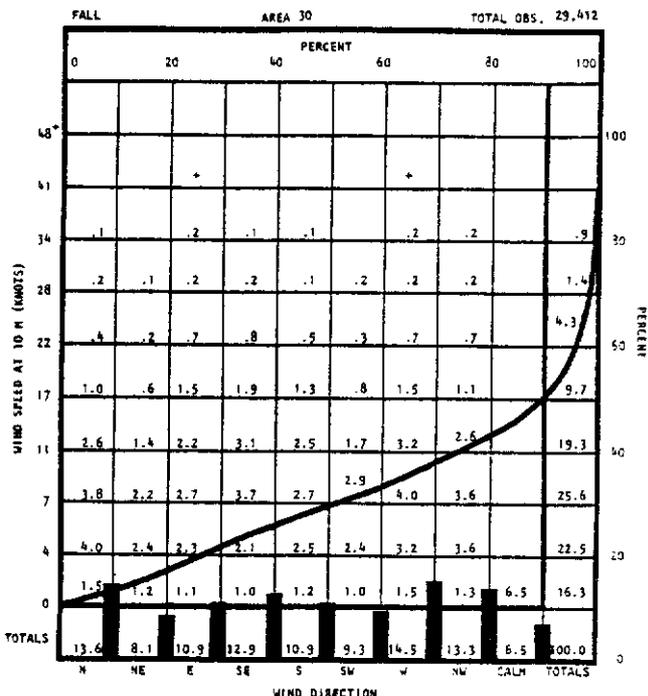
WIND DIRECTION

Figure B-30-5-4 Wind Speed by Wind Direction

TABLE B-31-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Eastern Mediterranean Sea, 32° - 34° N, 29.5° - 30.5° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2	3.5	1.5	1.5
Wave Period, sec	2.5	5	9	5	5
Direction	-	-	-	-	W - NW
Winds					
Speed, knots	2	11	26	12	11
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3	1.5	1.5
Direction	-	-	-	-	W - NW
Visibility, nautical miles	7	15	25	13	15
Cloud Cover					
Total clouds, in eighths of sky obscured	1	2	8	2.5	1
Low clouds, in eighths of sky obscured	Nil	1.5	7	2	Nil
Precipitation (Occurrence)	All precipitation - 2.8% of the time				
Relative Humidity, %	59	75	95	75.5	75
Air Temperature, °C	12.5	20	27	20	-
Surface Water Temperature, °C	18.5	20.5	22.5	-	-
Sea Level Pressure, millibars	1,007	1,016	1,023	1,014	1,014
Ice	None				
Refractivity					
Mean Surface Refractivity	-	-	-	319	-
Sub-Refraction (1 km, Annual)	-	-	-	-	15% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

ANNUAL — AREA 31 — TOTAL OBS. 10,877

Significant Wave Height (M) by Modal Wave Period (SEC) — PERCENT

SIG. WAVE HEIGHT (M)	<6 or INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6		.1					.1
4	.2	.7	.7	.5	.1		2.2
3	.9	2.6	2.1	.7	.2		6.5
2	10.4	12.8	4.1	.7	.2		28.2
1	19.4	7.0	.8	.2	.1		27.5
0	33.1	1.8	.3	.1			35.3
TOTALS	64.0	25.0	8.0	2.2	.6		99.8

Figure B-31-1-1 Significant Wave Height by Modal Wave Period

ANNUAL — AREA 31 — TOTAL OBS. 9,952

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS) — PERCENT

SIG. WAVE HEIGHT (M)	4	11	22	34	48+	TOTALS
4		.1	.7	.4		1.2
3	.1	1.1	2.1	.3		3.6
2	.1	1.5	13.9	4.3	.3	20.1
1	.2	10.0	16.0	1.3		27.5
0	9.1	30.4	7.9			47.4
TOTALS	9.4	42.0	39.0	8.4	1.0	99.8
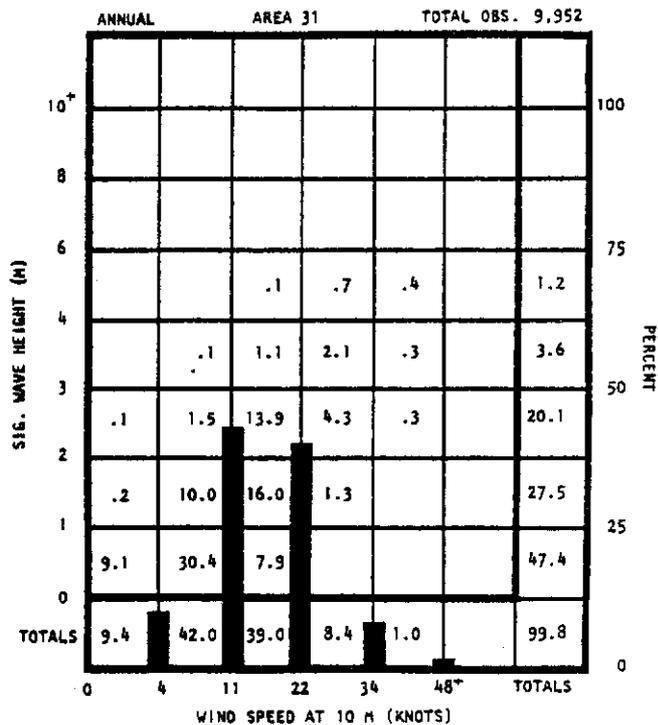
Figure B-31-1-2 Significant Wave Height by Wind Speed

ANNUAL — AREA 31 — TOTAL OBS. 10,116

Significant Wave Height (M) by Primary Wave Direction — PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6								.2		.2
5	1.2	.1	.3	+	+	.4	1.1	1.4		4.4
4	2.9	.7	.5	.5	.5	.9	3.4	5.1		14.5
3	9.6	2.8	2.4	2.7	2.3	2.3	10.6	17.8		50.5
2	2.6	1.0	1.0	.8	.8	.8	3.0	4.7		14.7
1	1.6	.7	.7	.5	.5	.6	1.9	3.0	6.2	15.7
TOTALS	17.9	5.3	4.8	4.5	4.1	5.0	20.0	32.2	6.2	100.0
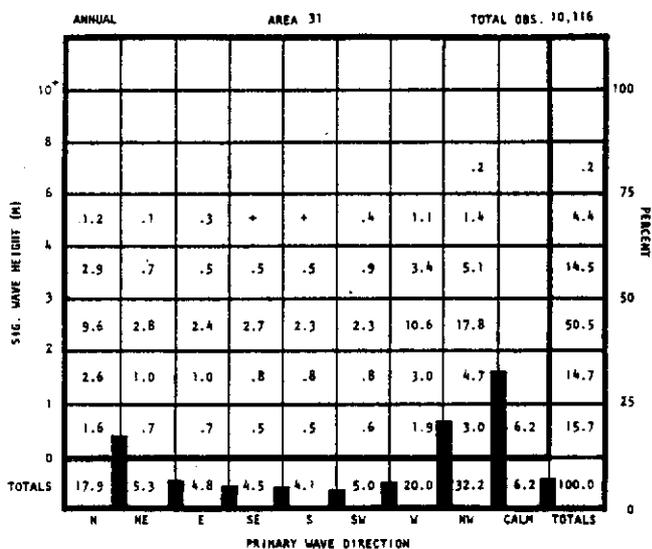
Figure B-31-1-3 Significant Wave Height by Wave Direction

ANNUAL — AREA 31 — TOTAL OBS. 87,761

Wind Speed at 10 M (KNOTS) by Wind Direction — PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+							.1	.1		.2
41	.2			.2	.1		.3			.8
34	.3	.1	.1	.1	.1	.2	.7	.6		2.2
28	1.1	.2	.1	.2	.1	.6	.9	1.6		4.8
22	1.1	.3	.6	.6	.7	.9	3.5	3.1		10.8
17	3.9	1.3	.6	1.1	.9	1.4	3.3	6.8		19.3
11	1.9	.8	1.6	1.5	1.7	2.1	9.9	6.6		26.1
7	2.9	1.4	1.5	1.4	1.5	1.8	5.7	5.7		21.9
4	1.6	.8	.6	.6	.6	.6	1.6	2.2	5.3	13.9
TOTALS	13.0	4.9	5.1	5.5	5.6	7.8	25.8	27.0	5.3	100.0
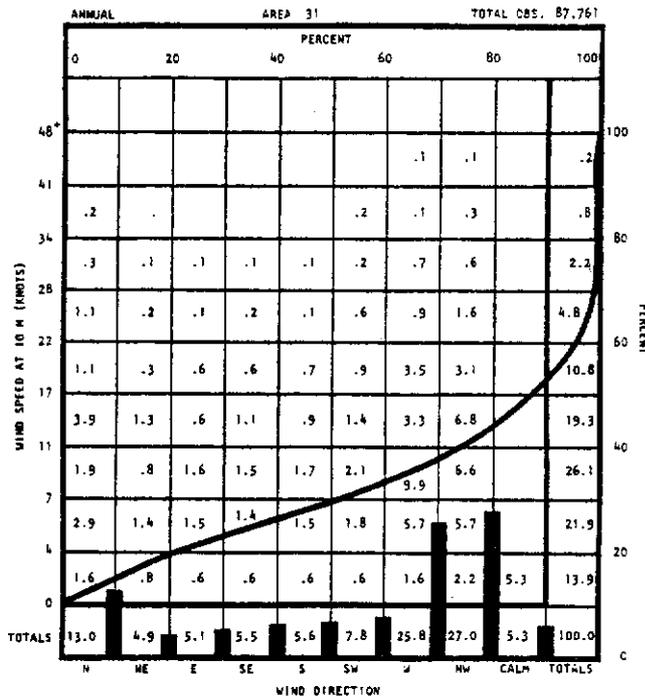
Figure B-31-1-4 Wind Speed by Wind Direction

WINTER   AREA 31   TOTAL OBS. 2,705

PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
8							
6		.3	.1	.1		.1	.6
4	.3	1.7	1.1	1.0		.2	4.3
3	1.7	3.7	4.3	1.0	.2	.1	11.0
2	11.6	15.9	6.1	1.2	.4	.1	35.3
1	14.3	6.7	1.0	.3			22.3
0	23.9	1.7		.2	.1		25.9
TOTALS	51.8	30.0	12.6	3.8	.7	.5	99.4

MODAL WAVE PERIOD (SEC)

Figure B-31-2-1 Significant Wave
Height by Modal Wave Period

WINTER   AREA 31   TOTAL OBS. 2,467

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6			.1	.1			.2
4			.1	1.1	1.0		2.2
3			1.6	3.5	.4	.1	5.6
2		1.9	17.7	6.7	.7		27.0
1	.2	9.7	17.4	1.9			29.2
0	5.9	22.8	7.2				35.9
TOTALS	6.1	34.4	44.0	13.3	2.2	.1	100.1

WIND SPEED AT 10 M (KNOTS)

Figure B-31-2-2 Significant Wave
Height by Wind Speed

WINTER   AREA 31   TOTAL OBS. 2,594

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6					+	+	+			
4	1.5		.4		1.6	3.0	3.0			9.5
3	2.0	1.3	.8	1.0	1.3	3.0	7.0	4.7		21.1
2	7.0	3.3	1.7	3.3	4.3	4.7	12.0	11.3		47.6
1	1.8	1.0	.8	.5	1.2	1.2	2.0	2.0		10.5
0	1.2	.7	.5	.3	.8	.8	1.0	1.0	5.3	11.6
TOTALS	13.5	6.3	4.2	5.1	7.6	11.3	25.0	22.0	5.3	100.3

PRIMARY WAVE DIRECTION

Figure B-31-2-3 Significant Wave
Height by Wave Direction

WINTER   AREA 31   TOTAL OBS. 21,976

PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1					.1		.3		.5
41	.3		.1			.3	.4	.4		1.5
34	.8	.1		.1	.3	1.0	1.3	1.2		4.8
28	1.5	.1	.1	.2	.5	1.9	2.2	1.8		8.3
22	1.7	.6	.7	.9	1.8	2.6	3.7	2.8		14.8
17	3.2	1.3	1.0	1.5	2.4	3.3	5.0	4.2		21.9
11	3.2	1.9	1.3	1.6	2.6	3.3	4.8	4.1		22.8
7	2.5	1.3	1.1	1.6	1.8	2.1	2.9	2.7		16.0
4	.8	.5	.6	.5	.6	.6	1.1	.8	3.7	9.2
TOTALS	14.1	5.8	4.9	6.4	10.0	15.2	21.4	18.3	3.7	99.8

WIND DIRECTION

Figure B-31-2-4 Wind Speed by
Wind Direction

SPRING   AREA 31   TOTAL OBS. 2,930

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6			.1				.1
4		.9	.7	.2	.1	.1	2.0
3	1.0	3.7	1.9	.8	.1		7.5
2	11.1	14.1	4.1	.8			30.1
1	20.0	6.9	.8	.2			27.9
0	30.1	1.5	.5	.1			32.2
TOTALS	62.2	27.1	8.1	2.1	.2	.1	99.8

MODAL WAVE PERIOD (SEC)
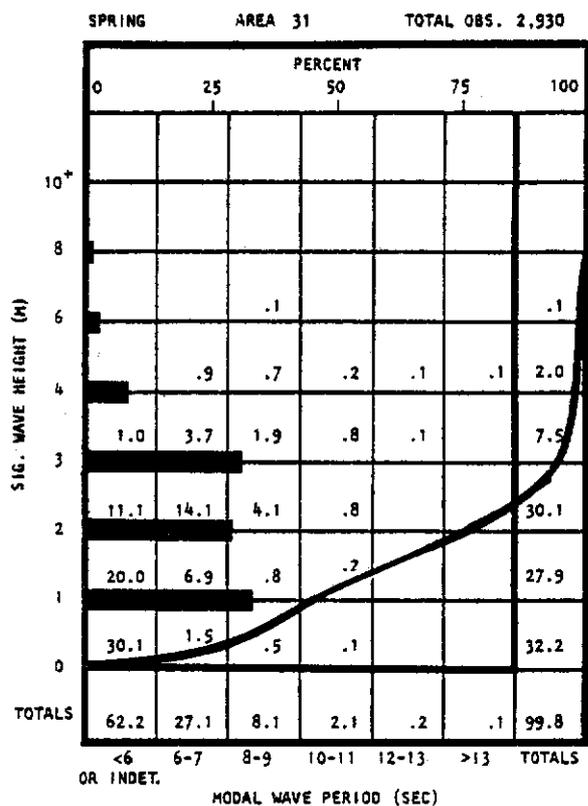
Figure B-31-3-1 Significant Wave Height by Modal Wave Period

SPRING   AREA 31   TOTAL OBS. 2,670

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
5				.6			.6
4			1.0	2.3	.3		3.6
3		.1	1.0	14.1	4.2	.1	19.5
2		.1	9.9	17.9	1.3		29.2
1		7.5	30.6	9.1			47.2
TOTALS	7.7	41.5	42.1	8.4	.4		100.1

WIND SPEED AT 10 M (KNOTS)
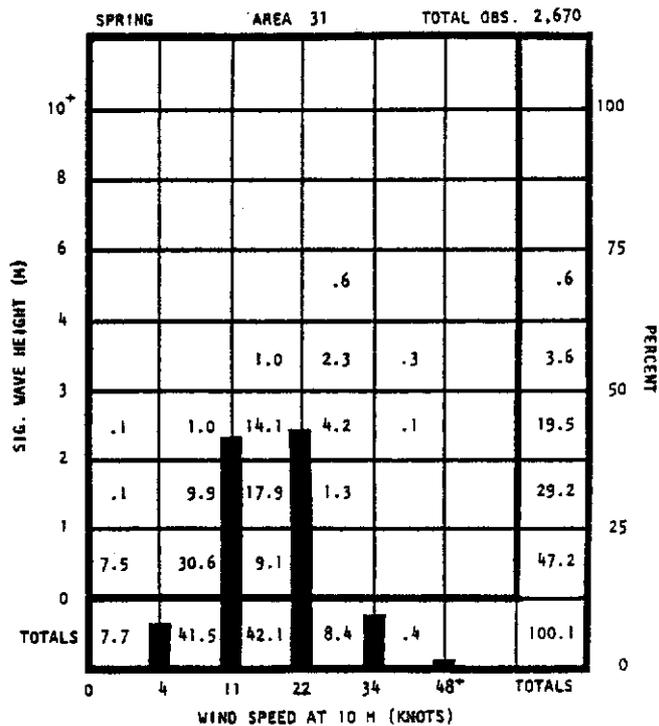
Figure B-31-3-2 Significant Wave Height by Wind Speed

SPRING   AREA 31   TOTAL OBS. 2,956

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6							.3			.3
4	1.5	.3	.2				.8	1.0		3.8
3	2.0	.5	1.3	1.0	.4	.4	4.3	5.3		15.2
2	6.7	2.3	3.7	5.0	3.0	1.7	13.0	15.7		51.1
1	1.8	1.0	1.0	1.4	1.0	.6	2.8	4.2		13.8
0	1.2	.7	.7	.9	.7	.4	1.9	2.8	6.3	15.6
TOTALS	13.3	4.8	6.9	8.3	5.1	3.1	22.8	29.3	6.3	99.8

PRIMARY WAVE DIRECTION
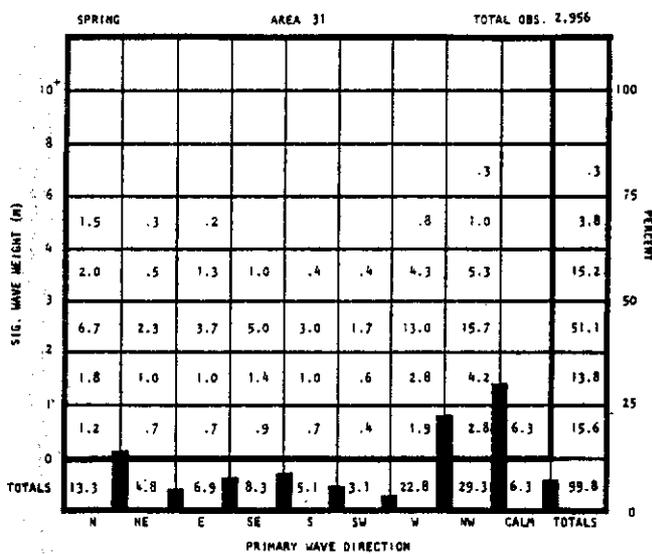
Figure B-31-3-3 Significant Wave Height by Wave Direction

SPRING   AREA 31   TOTAL OBS. 22,840

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
41	.1							.1		.2
34	.2		.2	.1			.7	.7		1.9
28	.6	.2	.3	.3	.1	.3	1.7	1.9		5.4
22	1.0	.2	1.0	1.0	.3	.6	5.0	2.7		11.8
17	1.7	.9	2.1	2.4	1.0	1.5	6.6	5.4		21.6
11	2.2	1.5	2.5	2.9	1.8	1.9	7.1	5.3		25.2
7	2.2	1.6	2.4	2.1	1.9	1.7	4.6	3.9		20.4
4	1.2	.9	1.0	1.0	.9	.6	1.7	1.7	4.4	13.4
TOTALS	9.2	5.3	9.5	9.8	6.0	6.6	27.4	21.7	4.4	99.9
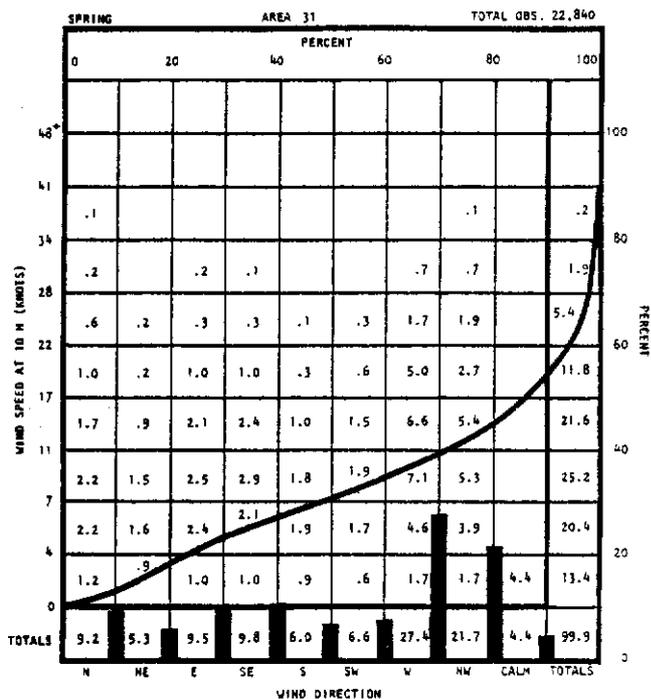
WIND DIRECTION

Figure B-31-3-4 Wind Speed by Wind Direction

SUMMER   AREA 31   TOTAL OBS. 2,680

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6		.1					.1
4	.1	.5	.3	.2	.1		1.2
3	.5	2.1	1.6	.3	.1		4.6
2	11.1	13.2	3.4	.7	.2	.1	28.7
1	22.6	8.2	.8	.1			31.7
0	30.8	2.0	.4				33.2
TOTALS	65.1	26.1	6.5	1.3	.4	.1	99.5

MODAL WAVE PERIOD (SEC)
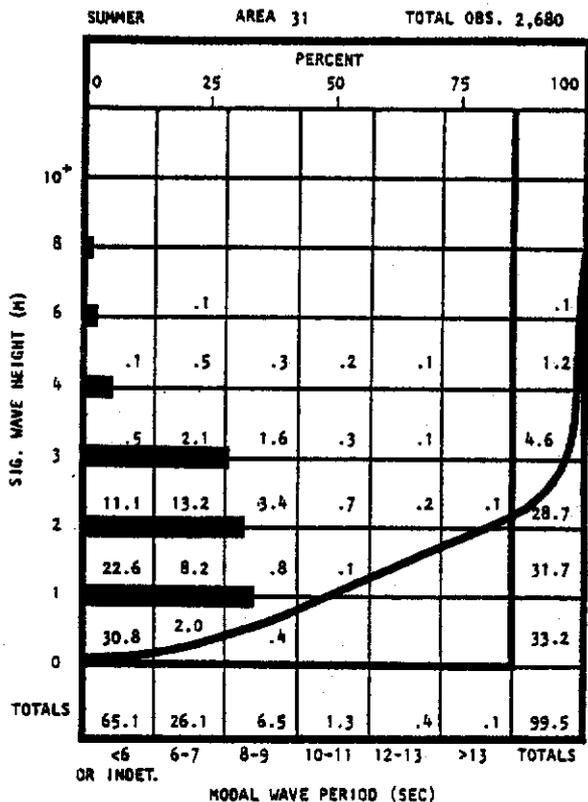
Figure B-31-4-1 Significant Wave Height by Modal Wave Period

SUMMER   AREA 31   TOTAL OBS. 2,477

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4–5			.1	.4	.1		.6
3			1.1	1.6	.2		2.9
2	.1	2.1	12.9	3.0	.1		18.2
1	.3	10.4	17.3	1.2			29.2
0	7.7	32.6	8.6				48.9
TOTALS	8.1	45.1	40.0	6.2	.4		99.8

WIND SPEED AT 10 M (KNOTS)
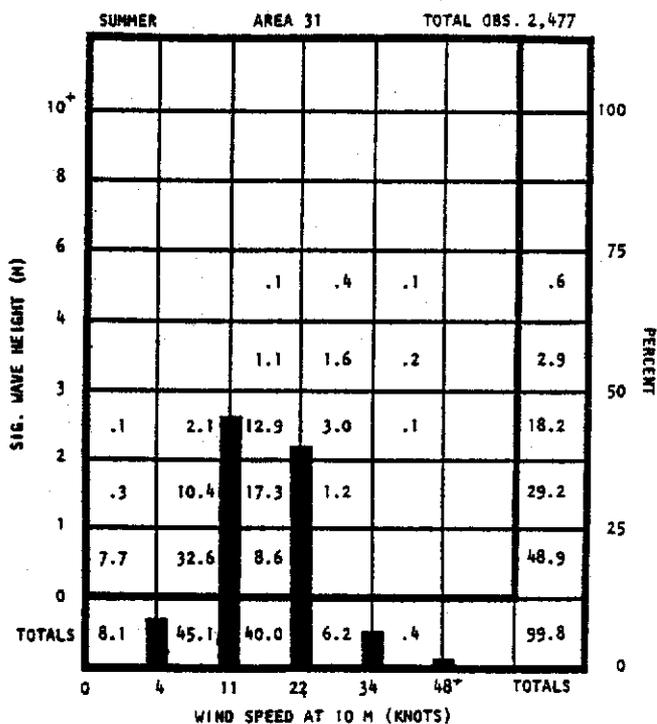
Figure B-31-4-2 Significant Wave Height by Wind Speed

SUMMER   AREA 31   TOTAL OBS. 2,361

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6	1.0							.5		1.5
4	4.0						1.3	6.3		11.6
3	12.0	1.6	.7	.3		.7	10.3	29.3		54.9
2	2.8	.3	.5	.3	.2	.5	4.4	7.4		16.4
1	1.9	.2	.3	.2	.1	.3	2.9	4.9	4.7	15.5
TOTALS	21.7	2.1	1.5	.8	.3	1.5	18.9	48.4	4.7	99.9

PRIMARY WAVE DIRECTION
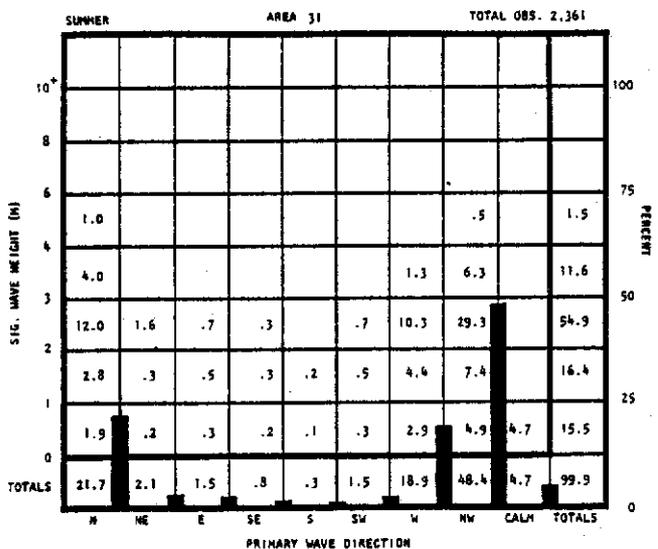
Figure B-31-4-3 Significant Wave Height by Wave Direction
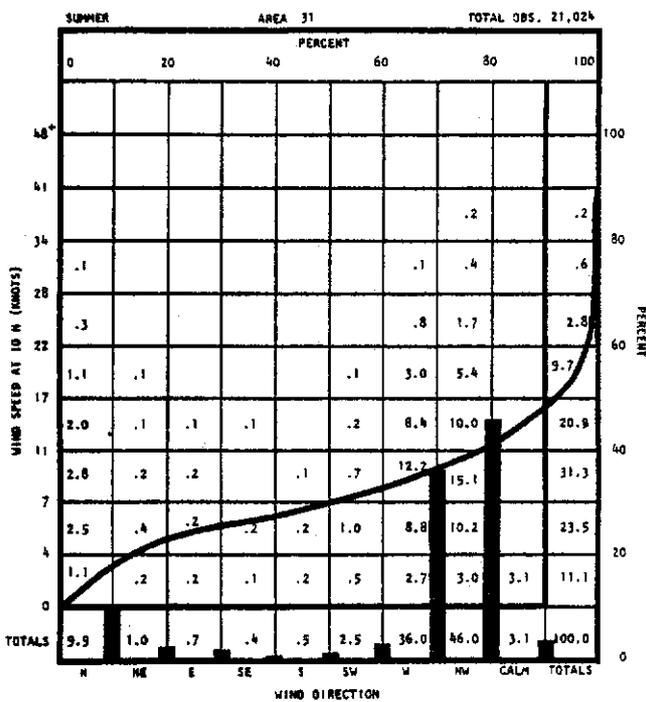
SUMMER   AREA 31   TOTAL OBS. 21,024

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
34								.2		.2
28	.1						.1	.4		.6
22	.3						.8	1.7		2.8
17	1.1	.1				.1	3.0	5.4		9.7
11	2.0	.1	.1	.1		.2	6.4	10.0		20.9
7	2.8	.2	.2		.1	.7	12.2	15.1		31.3
4	2.5	.4	.2		.2	1.0	8.8	10.2		23.5
0	1.1	.2	.2	.1	.2	.5	2.7	3.0	3.1	11.1
TOTALS	9.9	1.0	.7	.4	.5	2.5	36.0	46.0	3.1	100.0

WIND DIRECTION

Figure B-31-4-4 Wind Speed Wind Direction
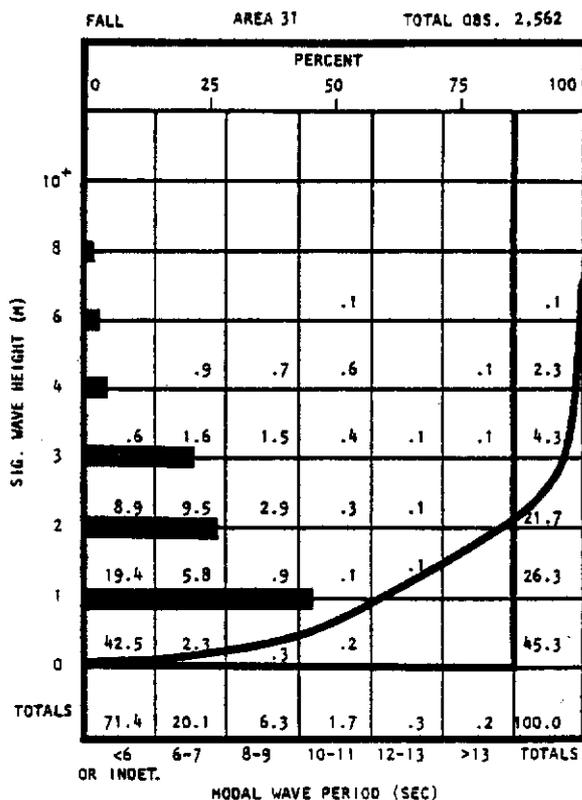
Figure B-31-5-1 Significant Wave
Height by Modal Wave Period
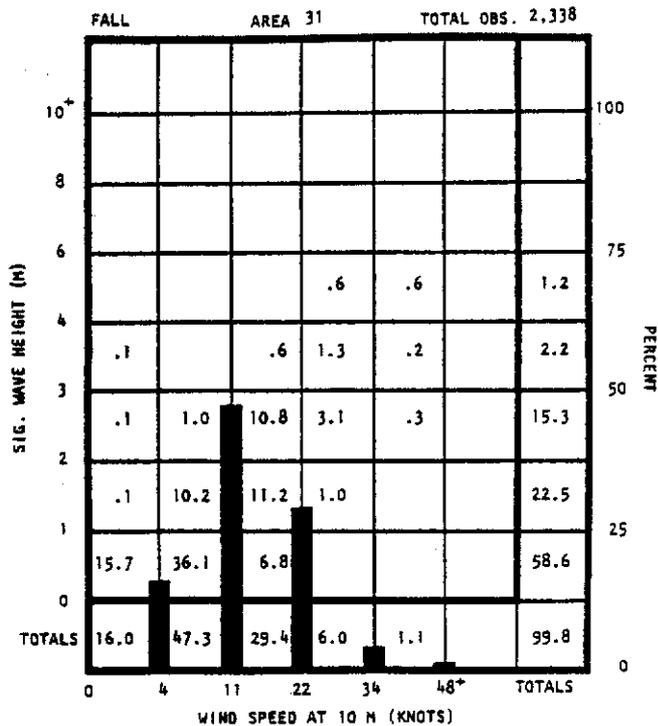

Figure B-31-5-2 Significant Wave
Height by Wind Speed
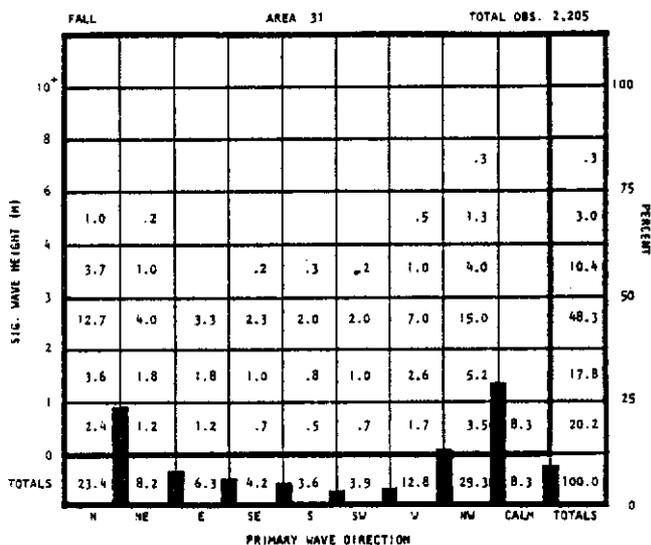
Figure B-31-5-3 Significant Wave
Height by Wave Direction
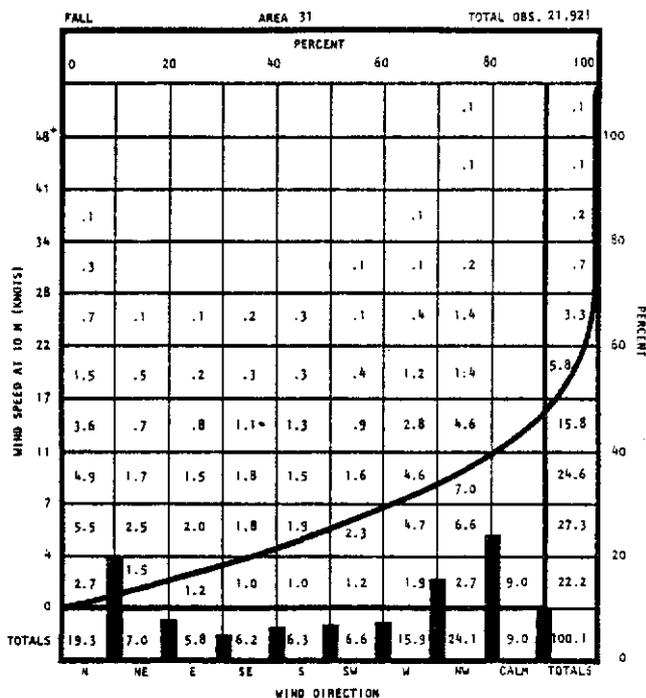
Figure B-31-5-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

B-23

APPENDIX C

SEASONAL CLIMATOLOGY OF THE NORTH SEA

The following data graphs are derived primarily from the Ten Year Hindcast
Climatology, see Reference 2. Table C-4-1-1 is developed from Reference 9.

TABLE C-4-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: North Sea, 56° N, 4.4° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	5	2	1.5
Wave Period, sec	4.5	9	15.5	9.5	9.5
Direction	-	-	-	-	W - NW
Winds					
Speed, knots	5	15	34	17	15
Corresponding Mean Sig. Wave Height, m.	.5	1.5	5	2	1.5
Direction	-	-	-	-	SW - W
Visibility, nautical miles	1.5	9	25	9	10
Cloud Cover					
Total clouds, In eighths of sky obscured	-	6	8	5.5	8
Low clouds, In eighths of sky obscured	Nil	5	8	5	8
Precipitation (Occurrence)	All precipitation - 12.7% of the time		Snow - 4% of the time (Dec - Mar)		
Relative Humidity, %	63	83	98	83	85
Air Temperature, °C	6	9.5	12	9.5	-
Surface Water Temperature, °C	5.5	9	15.5	9.5	-
Sea Level Pressure, millibars	990	1,012	1,032	1,011	1,011
Ice	Moderate superstructure icing - 1.2% of the time (Dec - Mar)				
Refractivity					
Mean Surface Refractivity	-	-	-	322	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1.5% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time
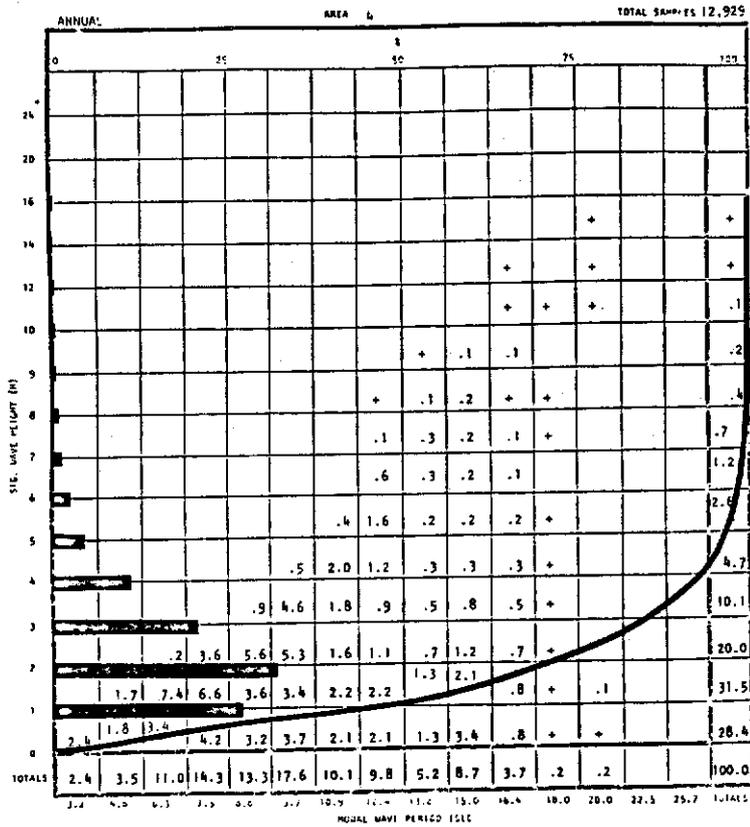
Figure C-4-1-1 Significant Wave
Height by Modal Wave Period
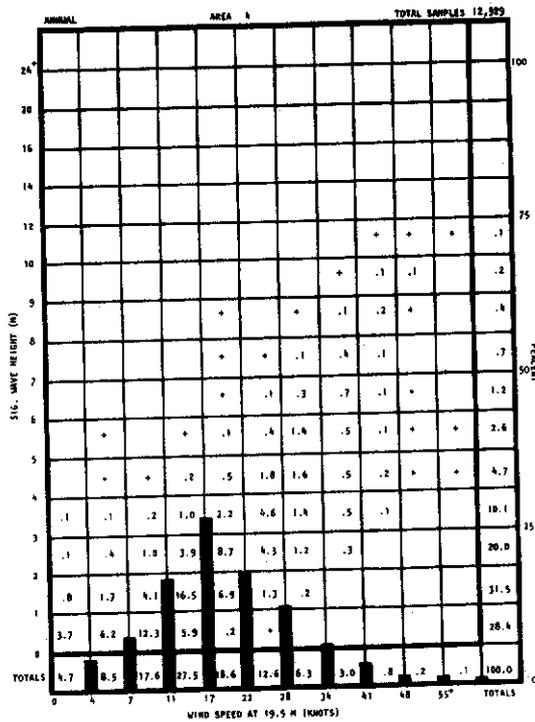
Figure C-4-1-2 Significant Wave
Height by Wind Speed

ANNUAL | AREA 4 | TOTAL SAMPLES 12,929

SIG. WAVE HEIGHT (M) vs PRIMARY WAVE DIRECTION

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	TOTALS
14–16							+	+	
12–14							+	+	
12	+						+	+	.1
10							.1	.1	.2
8–9	+			+			.2	.2	.4
7–8	.1			+	+		.4	.2	.7
6–7	.1	+		+	.1		.6	.3	1.2
5–6	.2		+	+	+	.5	1.1	.7	2.6
4–5	.4		.2	.1	.2	.9	1.6	1.4	4.7
3	1.0	+	.3	.3	1.1	1.7	3.3	2.2	10.1
2	1.6	.3	1.5	1.2	2.3	3.0	6.5	3.6	20.0
1	3.6	1.1	3.8	2.1	3.9	3.0	7.8	6.2	31.5
0	5.1	.9	2.7	1.0	2.0	1.2	6.6	9.1	28.4
TOTALS	12.2	2.3	8.5	4.7	9.6	10.5	28.2	24.0	100.0
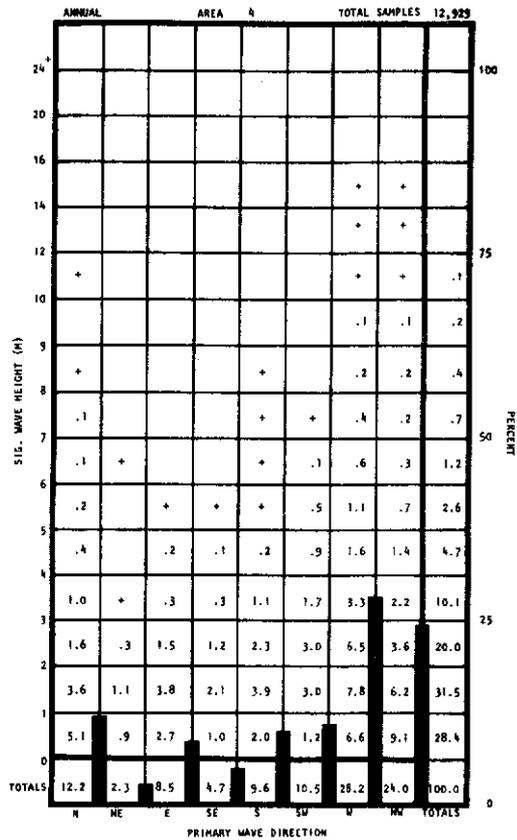
Figure C-4-1-3 Significant Wave Height by Wave Direction

ANNUAL | AREA 4 | TOTAL SAMPLES 12,929

WIND SPEED AT 19.5 M (KNOTS) vs WIND DIRECTION

WIND SPEED AT 19.5 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
58				+	+		+	+	.1
55+				+	+	+	.1	+	.2
48	+		+	.2	.1	.1	.2	.2	.8
41	.1	+	+	.5	.5	.7	.7	.5	3.0
34	.2	+	.3	1.0	1.3	1.2	1.2	1.1	6.3
28	.6	.2	.8	1.6	2.2	3.0	2.2	2.0	12.6
22	1.1	.8	1.3	2.3	2.9	3.9	3.4	3.0	18.6
17	2.4	2.4	2.4	3.1	3.5	5.1	4.9	3.7	27.5
11	1.9	2.0	1.8	1.9	2.0	2.8	2.8	2.4	17.6
7	.9	1.0	.9	.8	1.2	1.1	1.3	1.3	8.5
4	.6	.4	.6	.6	.5	.6	.6	.5	4.7
TOTALS	7.8	6.9	8.2	11.9	14.4	18.6	17.4	14.8	100.0
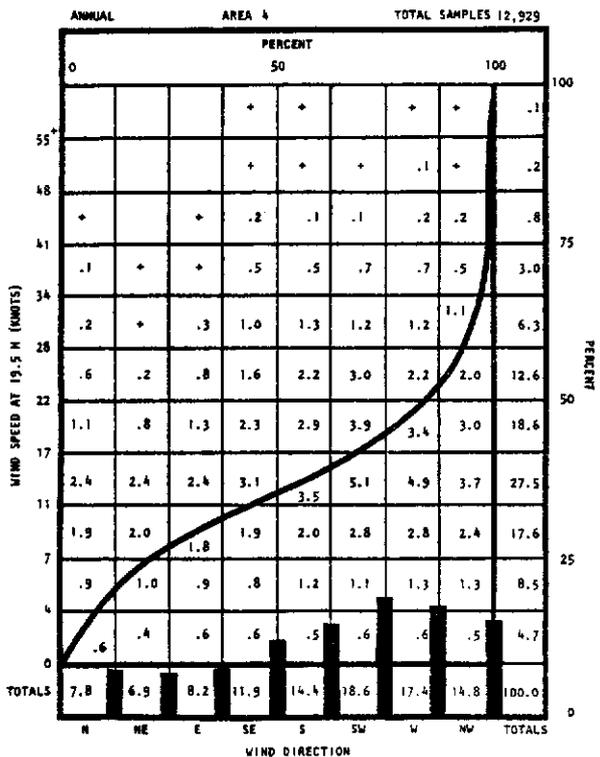
Figure C-4-1-4 Wind Speed by Wind Direction

ANNUAL AREA 4 TOTAL SAMPLES 12,925

SIG. WAVE HEIGHT (m)	0	6	10	16	21	27	47	55	63+	TOTALS
								+	+	+
14.0+						.2	.1	+	+	.3
9.0				+	.1	2.1	.1			2.3
6.0	.1	.1	.4	1.1	3.9	5.9	.1	+		11.6
4.0	.1	.3	1.8	3.6	6.2	2.4				14.4
2.5	1.4	2.7	11.6	13.4	4.2	1.0				34.1
1.25	4.1	6.9	14.1	1.1	.1					26.4
0.5	4.2	6.0	.5							10.8
0.1										
0										
TOTALS	9.9	16.0	28.4	19.3	14.5	11.4	.3	+	+	100.0

WIND SPEED AT 10 M (KNOTS).
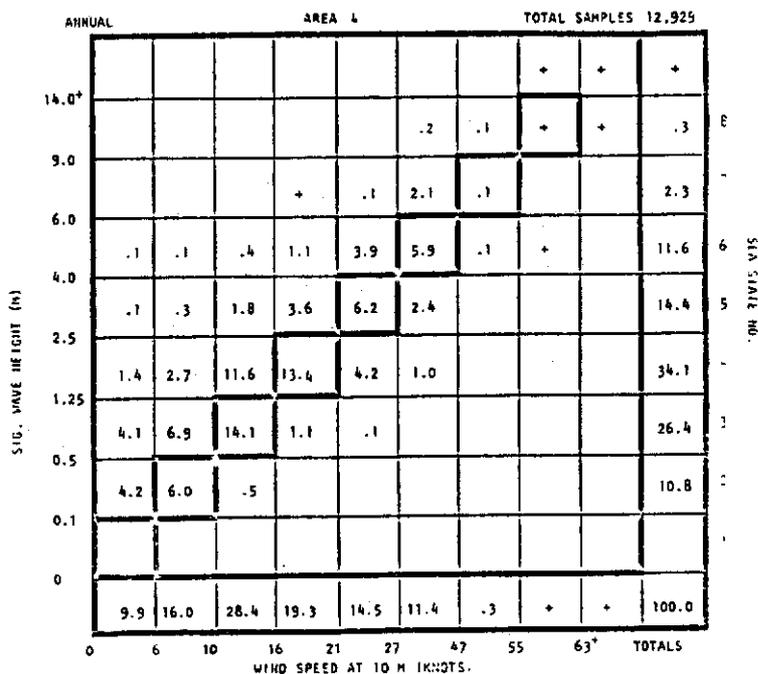
Figure C-4-1-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

ANNUAL AREA 4 TOTAL SAMPLES 12,925

SIG. WAVE HEIGHT (m)	0	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
14	3														3
12	4														4
10	6			1											7
9	9	5	1	1											16
8	24	9	2	1											36
7	42	11	3	2	1										59
6	73	24	7	3	1										108
6	123	50	21	3	5	1	1								204
5	179	99	40	14	5	2	1	1							342
4	225	168	80	48	23	6	3	9	2	1	2			1	568
3	329	196	136	97	73	33	17	17	16	6	1	1	1	3	922
2	287	220	185	107	87	63	38	28	24	11	15	14	8	18	1107
1	134	118	72	59	50	38	34	34	34	18	17	8	9	48	683
TOTALS	1436	900	553	336	245	183	94	90	70	36	17	25	18	70	·056

DURATION (HOURS)
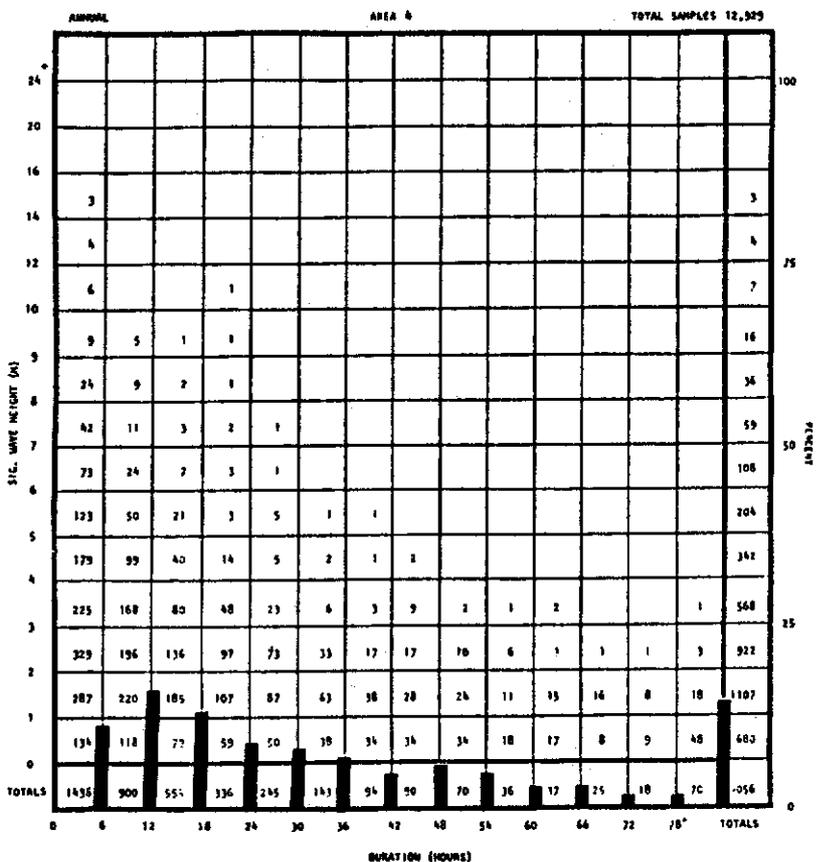
Figure C-4-1-6 Persistence of Significant Wave Height

ANNUAL   AREA 4   TOTAL SAMPLES 12,929

Wind Speed (knots)	6	12	18	24	30	36	42	48	54	60	66	72	78+	TOTALS
55	3			2										5
48	14	7												21
41	44	15	3	2	3									67
34	131	52	27	9	6	1								226
28	273	113	52	23	7	2	1	1						472
22	469	202	91	41	29	9	11	3	1	1				857
17	714	265	132	76	30	17	12	7	6	1		1		1261
11	612	354	200	115	76	42	23	14	7	5	2	4	3	1457
7	631	256	114	74	22	30	12	12	2	3				1156
4	413	155	56	20	17	3	2	2		1				669
0	173	74	28	17	6	7	4	3	2		1			315
TOTALS	3477	1493	703	379	196	111	65	42	18	11	3	5	3	6506

WIND SPEED AT 19.5 M (KNOTS)

DURATION (HOURS)

PERCENT
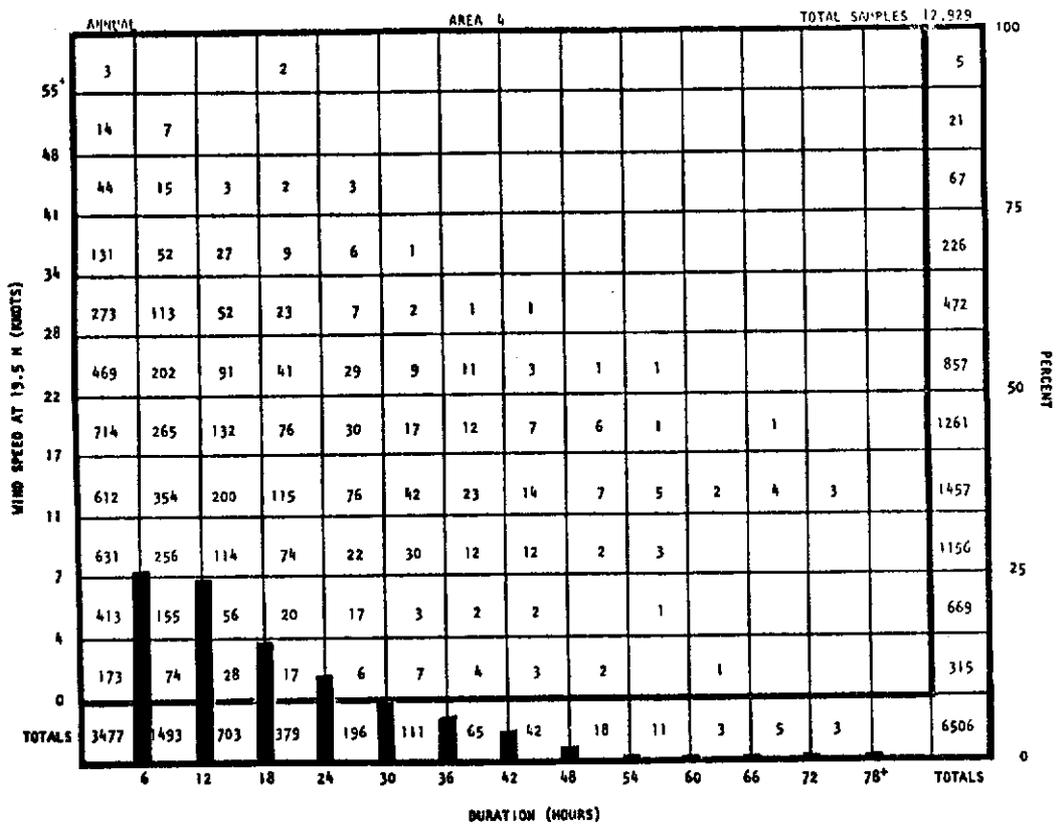
Figure C-4-1-7 Persistence of
Wind Speed

WINTER AREA 4 TOTAL SAMPLES 3,540
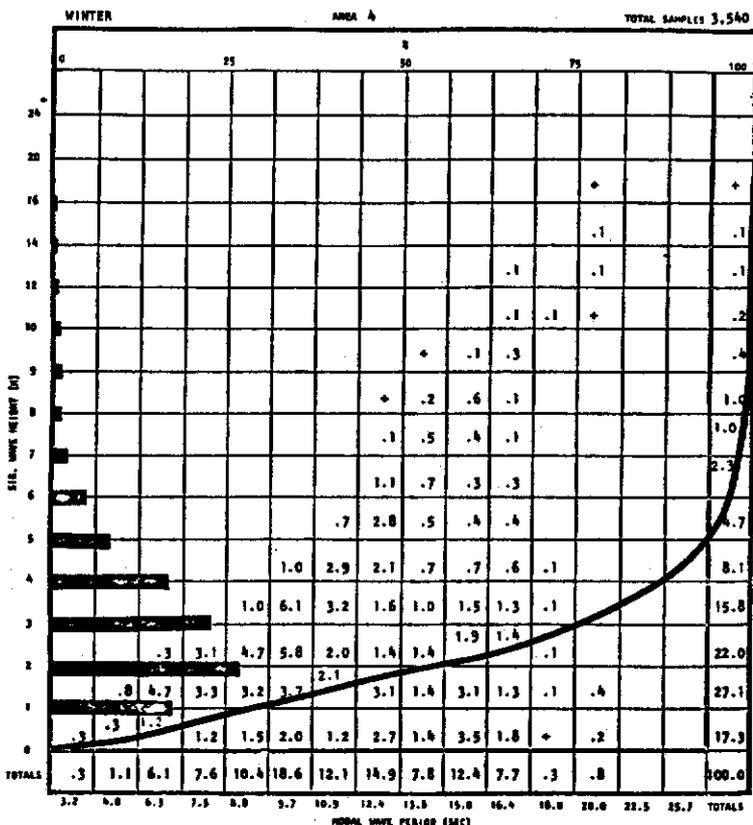
Figure C-4-2-1 Significant Wave
Height by Modal Wave Period

WINTER AREA 4 TOTAL SAMPLES 3,540
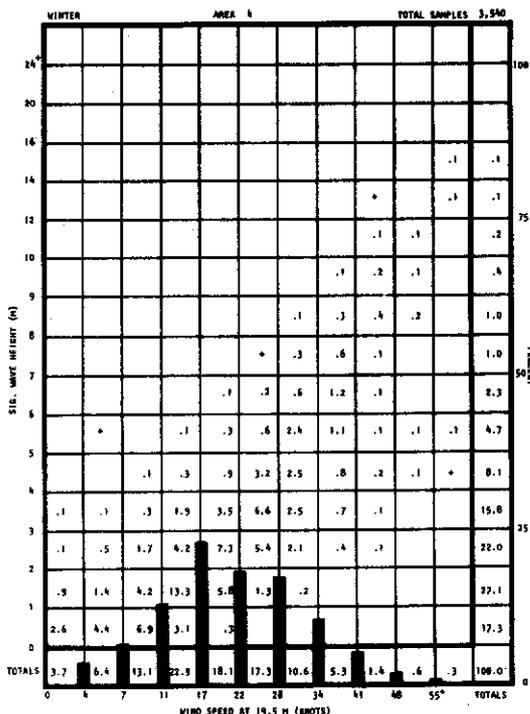
Figure C-4-2-2 Significant Wave
Height by Wind Speed
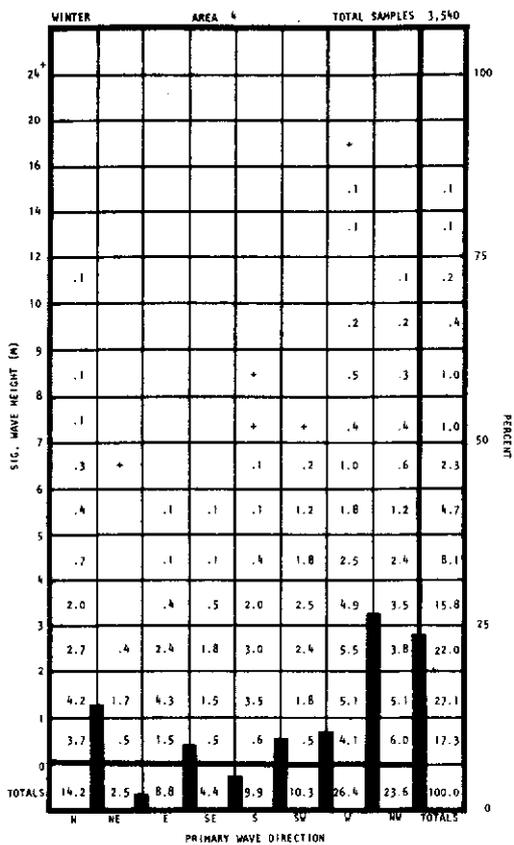
N A T O U N C L A S S I F I E D

Figure C-4-2-3 Significant Wave
Height by Wave Direction
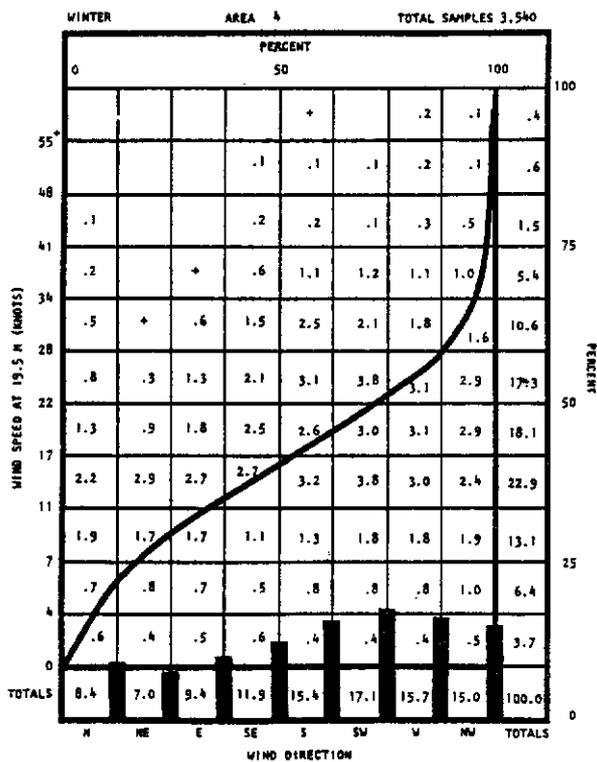
Figure C-4-2-4 Wind Speed by
Wind Direction

WINTER — AREA A — TOTAL SAMPLES 3,540

SIG. WAVE HEIGHT (M)	0	6	10	16	21	27	47	55	63	TOTALS	SEA STATE NO.
14.0+							+	.1	.1		
9.0					.3	.3	+	.1	.7		8
6.0			.1	.2	3.7	.3			4.2		7
4.0	.1	.1	.9	2.0	6.6	9.6	.3	.1		19.7	6
2.5	.3	.7	2.7	4.1	7.5	4.0				19.1	5
1.25	1.6	2.7	10.6	11.0	4.4	1.8				32.1	4
0.5	3.7	5.8	8.9	.9	.1					19.4	3
0.1	2.0	2.5	.1							4.7	2
0											1
TOTALS	7.5	11.9	23.2	18.1	18.8	19.4	.8	.1	.2	100.0	

WIND SPEED AT 10 M (KNOTS)
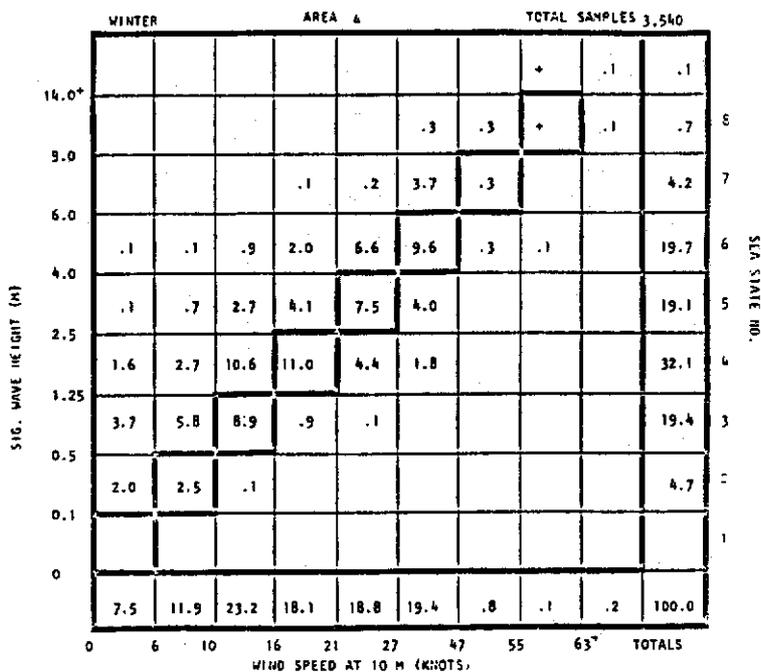
Figure C-4-2-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)
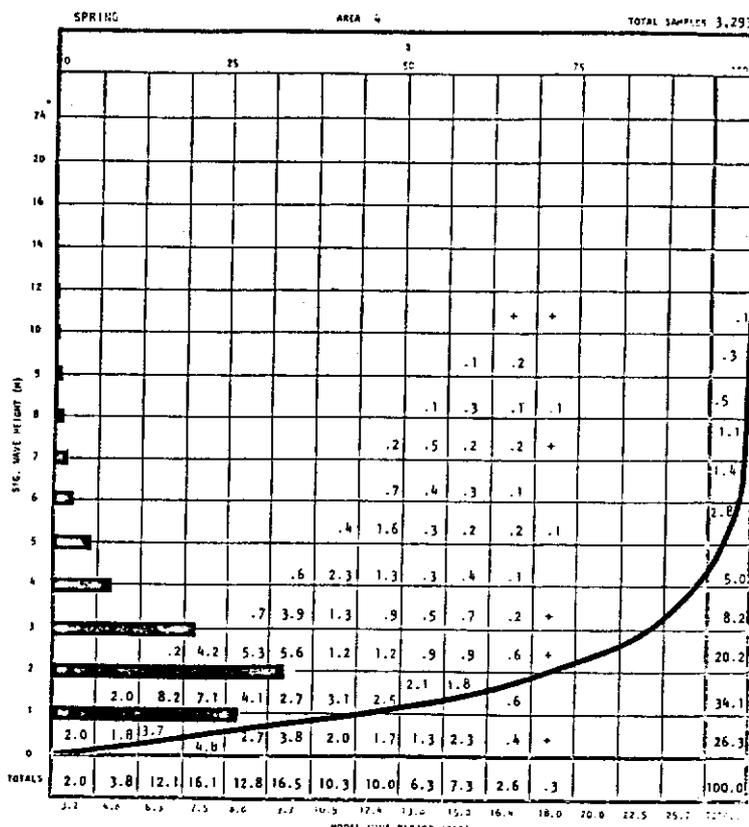
Figure C-4-3-1 Significant Wave
Height by Modal Wave Period
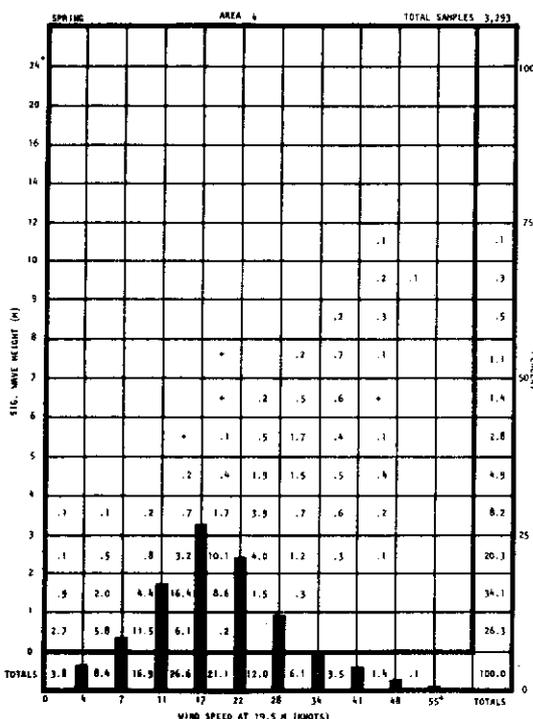
Figure C-4-3-2 Significant Wave
Height by Wind Speed

N A T O   U N C L A S S I F I E D

SPRING   AREA 4   TOTAL SAMPLES 3,293

SIG. WAVE HEIGHT (M)

	N	NE	E	SE	S	SW	W	NW	TOTALS
24+									100
	.							.	.1
							.1	.2	.3
	.						.2	.2	.5
	.						.7	.3	1.1
	.1				.2		.8	.4	1.4
	.1		.1		.3	1.5	.8	2.8	
	.3		.5	.1	.2	.6	1.5	1.7	4.9
	.7	.	.4	.4	.9	.9	3.2	1.6	8.2
	1.7	.4	1.9	1.4	2.3	2.4	7.0	3.1	20.3
	4.3	1.4	5.1	2.9	4.2	2.7	6.2	7.2	34.1
	4.7	.9	3.4	.7	1.7	1.5	4.2	9.3	26.3
TOTALS	12.1	2.7	11.3	5.6	9.3	8.7	25.6	24.9	100.0

PRIMARY WAVE DIRECTION
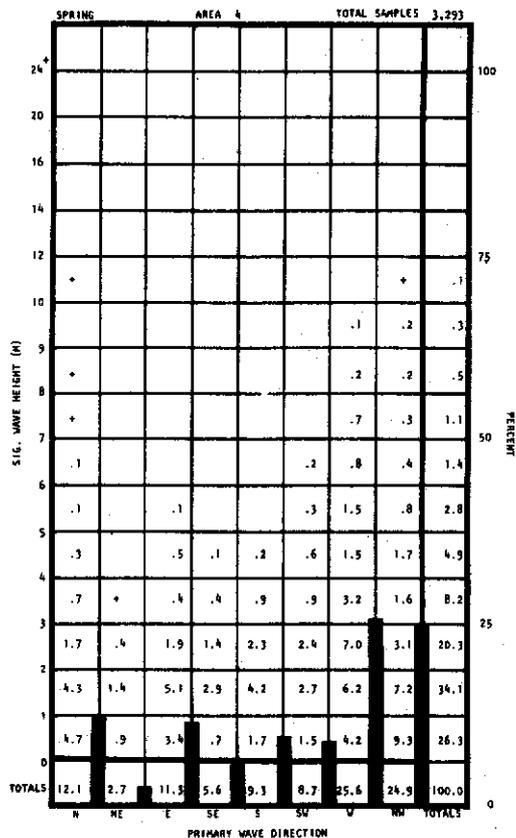
**Figure C-4-3-3 Significant Wave
Height by Wave Direction**

SPRING   AREA 4   TOTAL SAMPLES 3,293

PERCENT
0   50   100

WIND SPEED AT 19.5 M (KNOTS)

	N	NE	E	SE	S	SW	W	NW	TOTALS
55+						.	.1		.1
48	.		.2	.4	.1	.1	.3	.3	1.5
41	.	.	.2	.9	.3	.6	.9	.6	3.5
34	.1	.	.1	1.2	.9	.9	1.7	1.2	6.1
28	.6	.1	1.0	1.9	1.7	2.4	2.2	1.9	12.0
22	1.3	1.0	1.7	3.2	3.9	3.3	3.5	2.6	21.1
17	2.9	3.2	3.0	3.2	3.0	3.3	3.7	3.7	26.6
11	2.0	2.5	2.1	1.8	1.9	1.5	2.2	2.6	16.9
7	.9	1.1	1.3	1.0	1.1	1.1	1.1	1.2	8.4
4	.6	.3	.5	.4	.5	.4	.5	.5	3.8
TOTALS	8.5	8.3	10.0	14.0	13.3	15.3	16.1	14.5	100.0
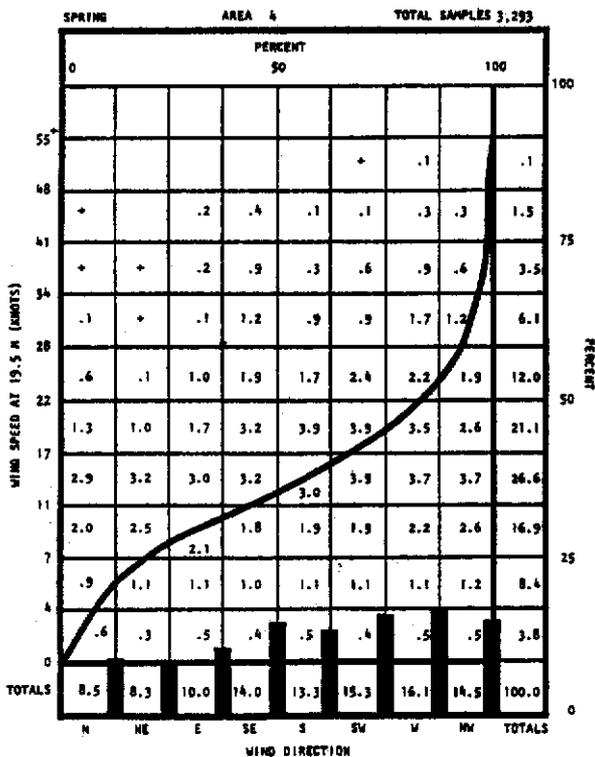
WIND DIRECTION

**Figure C-4-3-4 Wind Speed by
Wind Direction**

Figure C-4-3-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

Figure C-4-4-1 Significant Wave
Height by Modal Wave Period

Figure C-4-4-2 Significant Wave
Height by Wind Speed
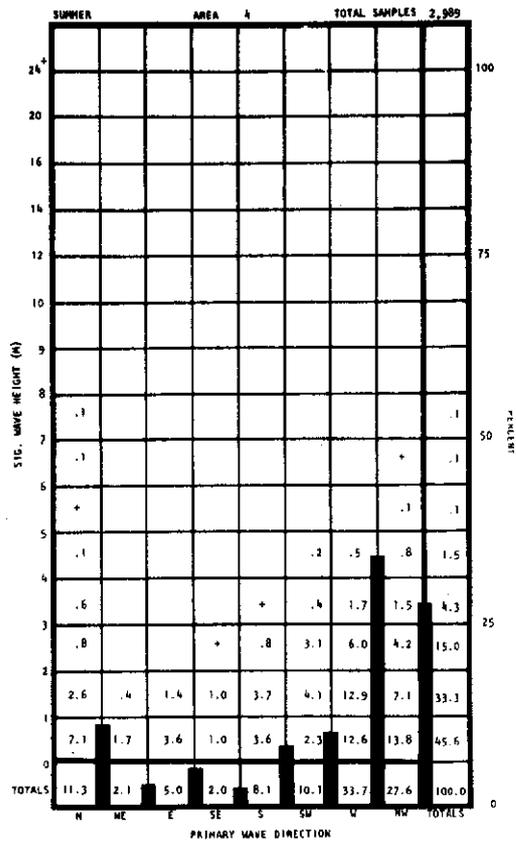
Figure C-4-4-3 Significant Wave
Height by Wave Direction
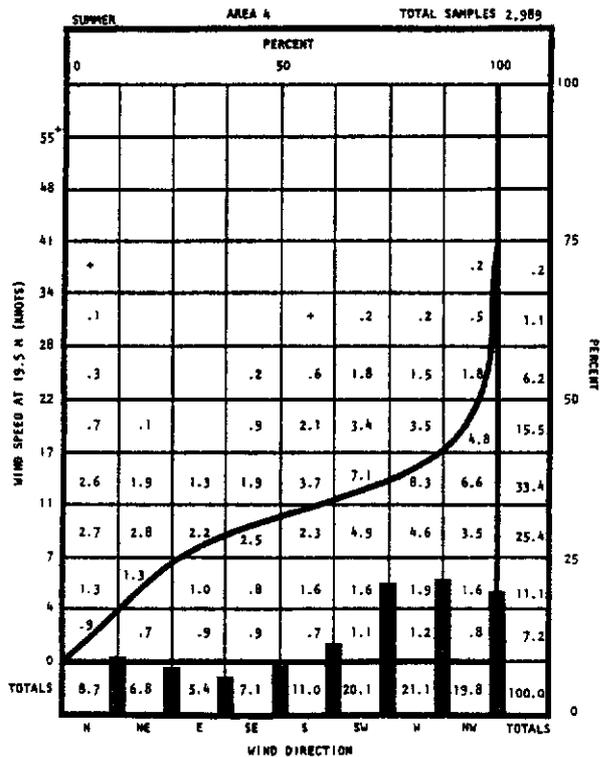
Figure C-4-4-4 Wind Speed by
Wind Direction
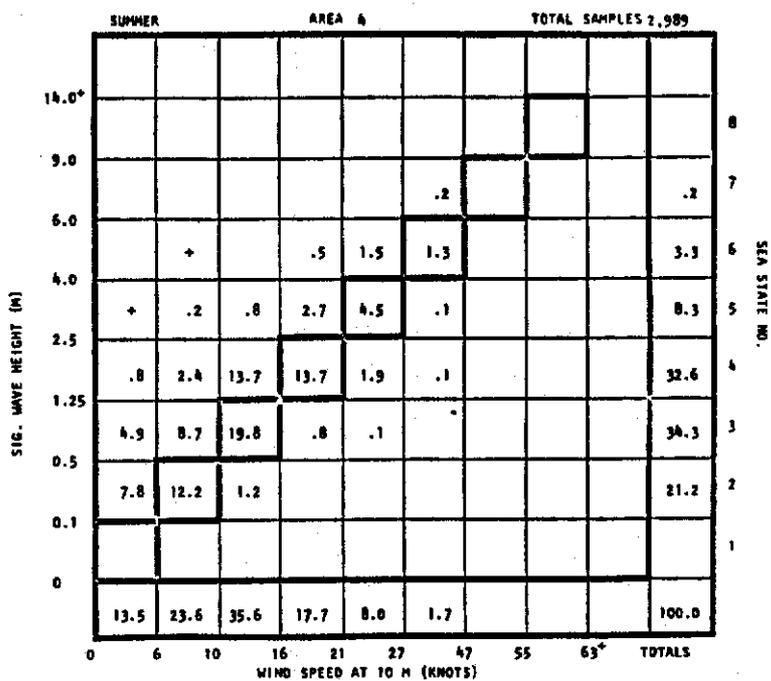
Figure C-4-4-5 Significant Wave Height by
Wind Speed (WMO Sea State Chart)
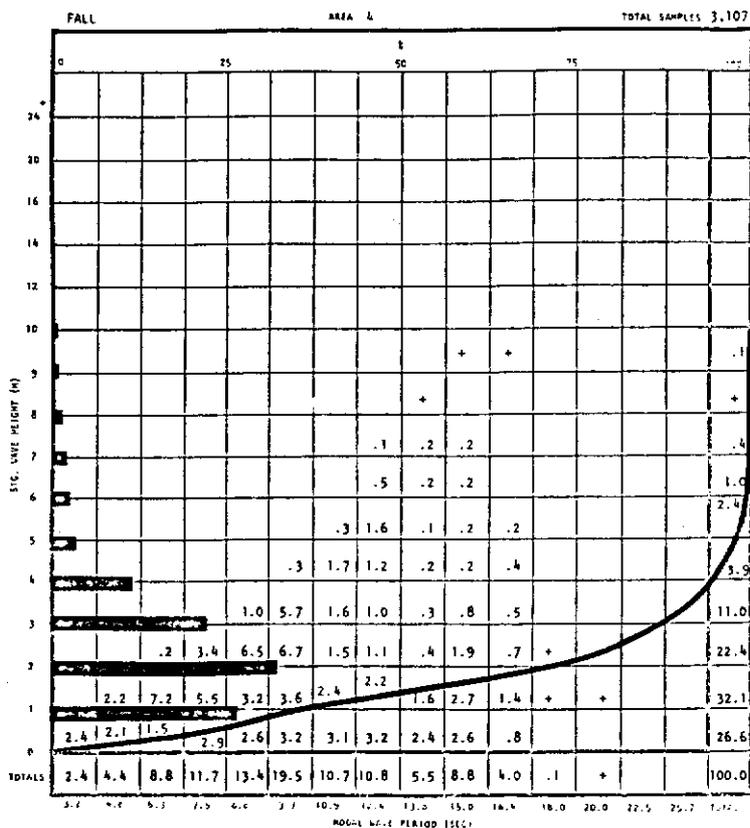
Figure C-4-5-1 Significant Wave
Height by Modal Wave Period
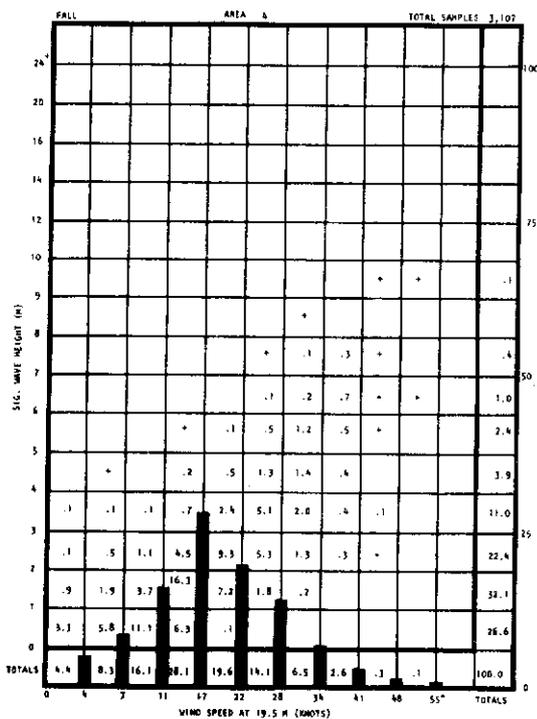
Figure C-4-5-2 Significant Wave
Height by Wind Speed

FALL   AREA 4   TOTAL SAMPLES 3,107

SIG. WAVE HEIGHT (M) — PERCENT

Height	N	NE	E	SE	S	SW	W	NW	TOTALS
9							.1		.1
							+		
8							.3	.1	.4
7	.1				.2		.5	.2	1.0
6	.2				.1	.5	.9	.7	2.4
5	.5			+	.1	.9	1.8	.6	3.9
4	.8	.1	.3	.3	1.4	3.0	3.2	1.9	11.0
3	1.2	.4	1.6	1.4	2.9	4.4	7.4	3.1	22.4
2	3.3	.9	4.4	3.0	4.2	3.5	7.6	5.3	32.1
1	5.0	.5	2.4	1.7	2.3	.6	6.1	7.9	26.6
TOTALS	11.0	1.9	8.8	6.5	11.0	13.1	27.8	19.9	100.0

PRIMARY WAVE DIRECTION
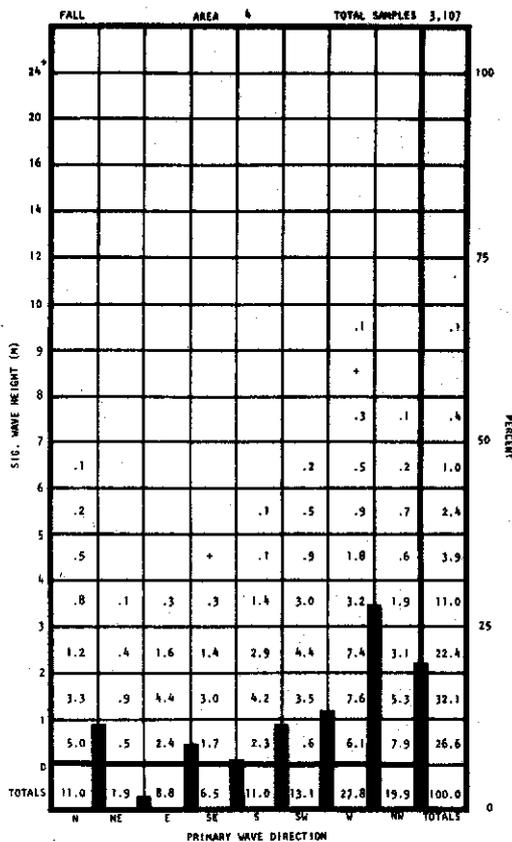
Figure C-4-5-3 Significant Wave
Height by Wave Direction

FALL   AREA 4   TOTAL SAMPLES 3,107

PERCENT: 0 — 50 — 100

WIND SPEED AT 19.5 M (KNOTS) — PERCENT

Wind Speed	N	NE	E	SE	S	SW	W	NW	TOTALS
55+							.1		.1
48				+	.1	.1	.1		.3
41	+			.4	.5	.8	.7	.2	2.6
34	.1	+	.4	1.0	1.5	1.5	1.1	.8	6.4
28	.5	.3	1.0	1.9	3.2	4.0	2.0	1.3	14.1
22	.8	1.0	1.5	2.6	3.0	5.2	3.6	1.9	19.6
17	1.8	1.6	2.5	4.6	4.2	5.9	5.0	2.5	28.1
11	1.2	1.2	1.3	2.3	2.7	3.0	2.8	1.5	16.1
7	.7	.7	.7	.9	1.5	1.1	1.4	1.3	8.3
4	.6	.5	.5	.5	.6	.6	.5	.5	4.4
TOTALS	5.8	5.3	7.7	14.4	17.5	22.2	17.0	10.1	100.0
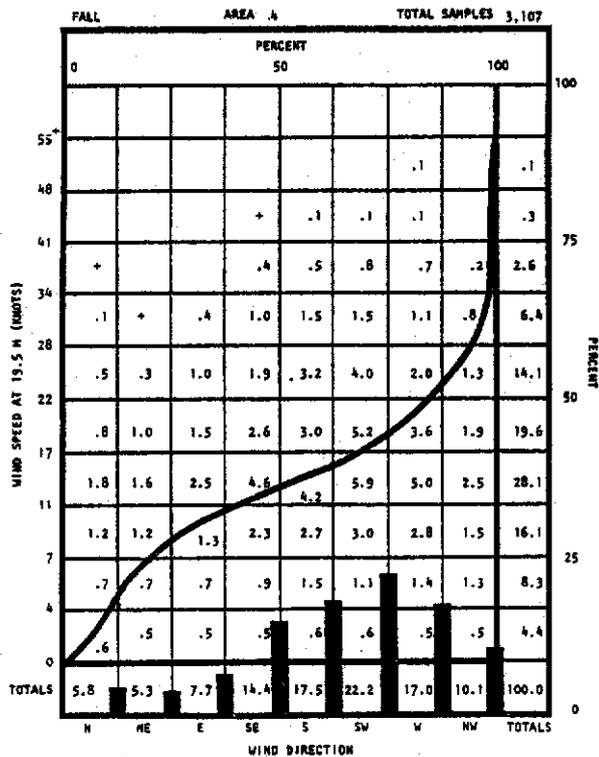
WIND DIRECTION

Figure C-4-5-4 Wind Speed by
Wind Direction

FALL   AREA 4   TOTAL SAMPLES 3,107

SIG. WAVE HEIGHT (M)	0–6	6–10	10–16	16–21	21–27	27–47	47–55	55–63+	63+	TOTALS	SEA STATE NO.
14.0+						•	•			.1	8
9.0				•	1.3	•				1.4	7
6.0	.1	.1	.3	1.0	3.2	5.9				10.6	6
4.0	.1	.3	1.9	3.9	7.3	2.6				16.1	5
2.5	1.6	2.3	11.0	14.0	5.6	1.0				35.5	4
1.25	4.4	6.9	14.7	1.4	•					27.4	3
0.5	3.6	4.9	.5							8.9	2
0.1											1
0											
TOTALS	9.8	14.4	28.3	20.4	16.2	10.9	.1			100.0	

WIND SPEED AT 10 M (KNOTS)
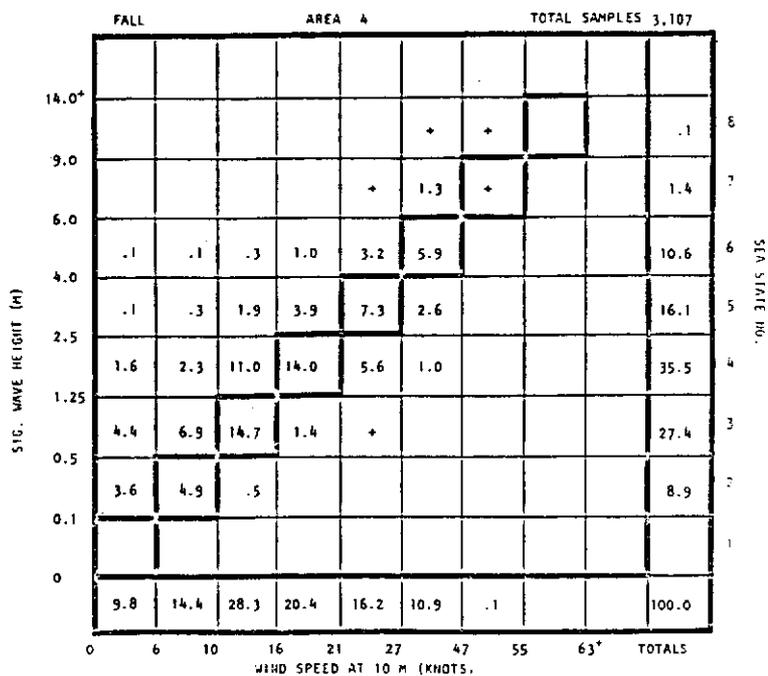
Figure C-4-5-5 Significant Wave Height by Wind Speed (WMO Sea State Chart)

APPENDIX D
SEASONAL CLIMATOLOGY OF THE BALTIC SEA

The following data graphs are derived primarily from Reference 11, 12 and 13.
Figures D-(32,34,36,38)-(1,2,3,4,5)-3 and Tables D-(32,34,36,38)-1-1 are adopted
from Reference 9. All wave data in both References are from the same source, namely,
the U.S. Naval Oceanography Command Detachment, formerly the U.S. Naval Weather
Service Command, in Asheville, North Carolina. However, due to the difficulty of
defining the directionality of low waves, wave data presented in Figures D-(32,34,
36,38)-(1,2,3,4,5)-3 can be misleading because reported observations are only for
the relatively higher waves. Therefore, it is recommended that the wave data in
Figures D-(32,34,36,38)-(1,2,3,4,5)-3 should not be interpreted as the overall per-
centage frequency of occurrence of significant wave heights, rather Figure D-(32,34,
36,38)-(1,2,3,4,5)-1 should be used in this regard.
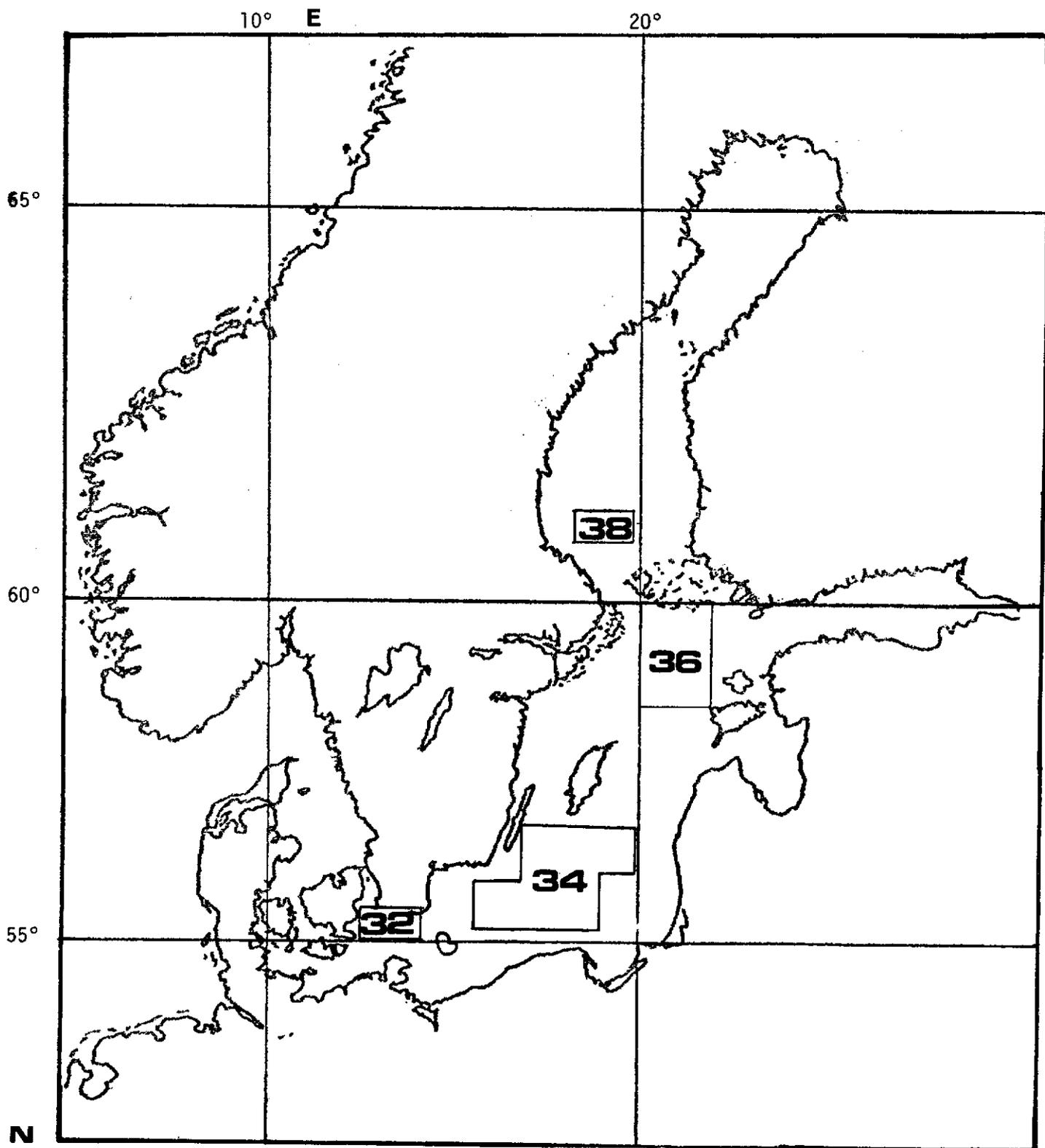
Figure D-1- Definition of Representative Areas in the
Baltic Sea (Including Gulf of Bothnia)

ANNUAL   AREA BALTIC   TOTAL OBS. 14,900

SIG. WAVE HEIGHT (M)	<6 or INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
5	.3	.2	+	+	+		.5
4	2.5	.9	.3	.1	.1		3.9
3	19.0	3.4	.6	.2	.1		23.3
2	23.3	.9	.1	.1	+		24.4
1	47.8	.1	+		+		47.9
TOTALS	92.9	5.5	1.0	.4	.2		100.0

MODAL WAVE PERIOD (SEC)
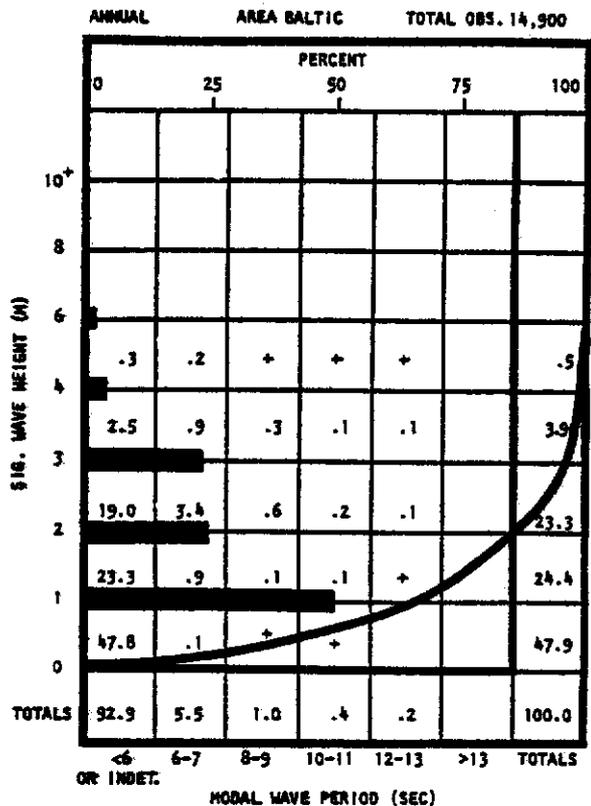
Figure D-2 Significant Wave Height by Modal Wave Period

ANNUAL   AREA BALTIC   TOTAL OBS. 9,956

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6				+		+	
4-5		+	.1	.6	.2		.9
3		.1	.9	1.5	.1	.1	2.7
2		.4	5.9	7.4	.5		14.2
1		1.9	14.6	4.4			20.9
0	5.4	27.5	28.4				61.3
TOTALS	5.4	29.9	49.9	13.9	.8	.1	100.0

WIND SPEED AT 10 M (KNOTS)

Figure D-3 Significant Wave Height by Wind Speed

ANNUAL   AREA BALTIC   TOTAL OBS. 1,448

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
8						.1				.1
5	.4	.3	.3	.2	.6	1.6	1.2	.8		5.4
4	1.1	1.2	1.2	1.0	1.8	5.1	3.1	1.5		16.0
3	4.5	4.6	4.2	2.4	3.5	10.2	7.4	3.9		40.7
2	1.6	2.8	1.8	1.8	2.2	4.4	3.4	1.7		19.7
1	1.1	1.8	1.0	1.2	1.4	2.9	2.3	1.1	5.0	12.8
TOTALS	8.7	10.7	8.5	6.6	9.5	24.2	17.5	9.0	5.0	99.7
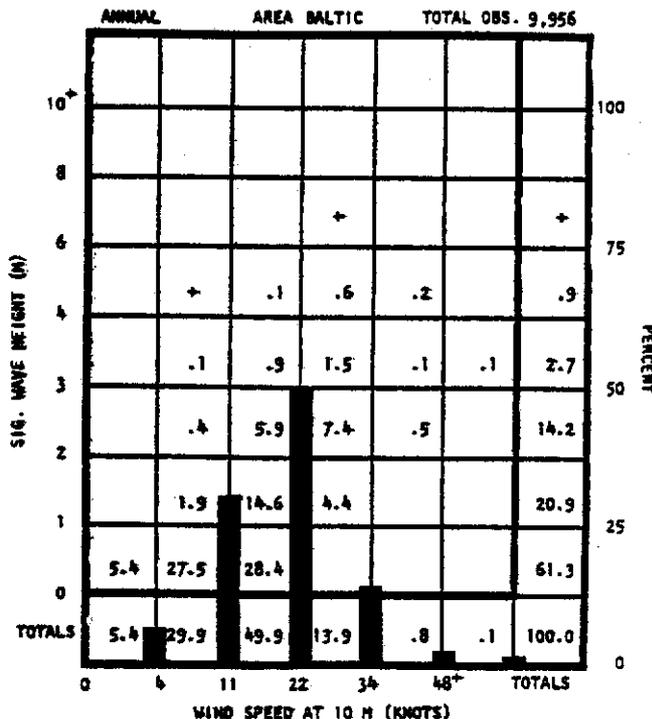
PRIMARY WAVE DIRECTION
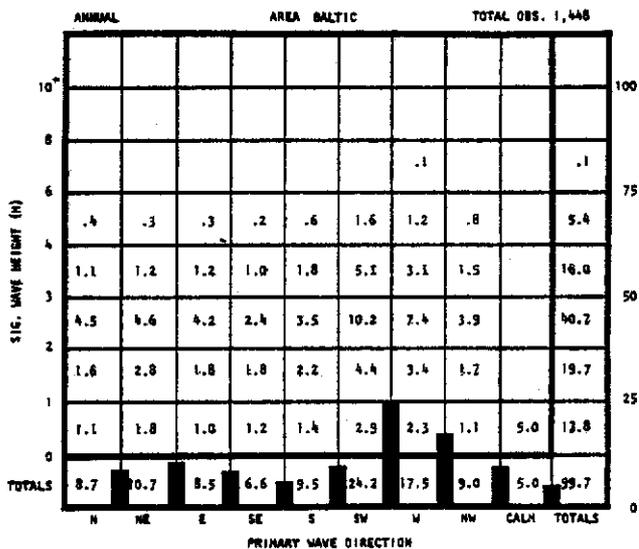
Figure D-4 Significant Wave Height by Wave Direction

ANNUAL   AREA BALTIC   TOTAL OBS. 156,272

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1	+	+	+	+	.1	.1	.1		.4
41	.1	.1	.1	.1	.1	.1	.2	.1		.9
34	.2	.1	.1	.1	.2	.4	.6	.4		2.1
28	.4	.3	.4	.5	.4	.9	.9	.6		4.3
22	.8	.6	.3	.7	.8	1.7	1.9	1.2		8.3
17	1.1	1.2	1.3	1.6	1.5	2.8	2.7	1.7		14.0
11	1.7	1.8	2.1	2.2	2.5	3.7	3.9	2.6		20.6
7	1.9	2.0	2.3	2.3	2.3	3.8	3.2	2.5		21.3
4	1.8	1.7	1.9	2.1	2.4	2.6	2.3	2.0		16.8
0	.9	.9	1.1	.9	1.2	1.1	1.1	.8	3.3	11.3
TOTALS	9.0	8.7	9.8	11.1	12.0	17.2	16.9	12.0	3.3	100.0
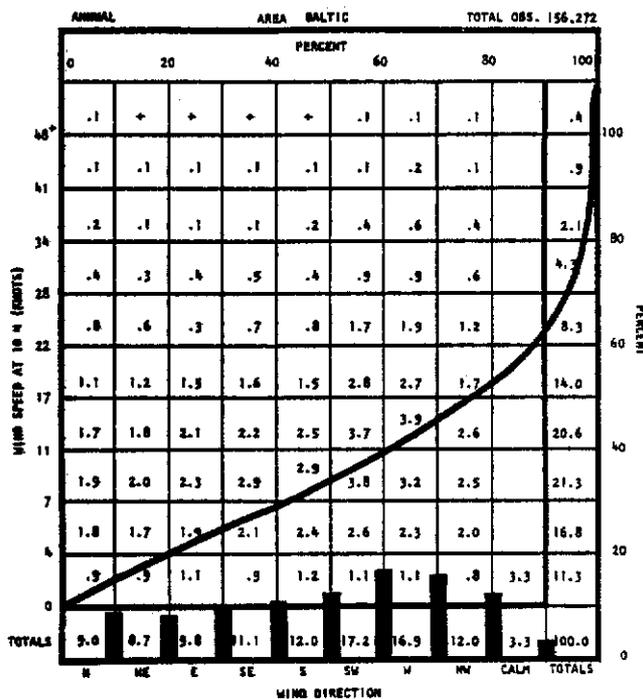
WIND DIRECTION

Figure D-5 Wind Speed by Wind Direction

WINTER   AREA BALTIC   TOTAL OBS. 2,618

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
10+							
8							
6							
4	1.2	.3	.2	.2	+		1.9
3	3.4	1.0	.5				4.9
	28.9	3.4	1.0	.2	.2		33.6
2	21.8	1.2					23.0
1	36.5			.2			36.7
0							
TOTALS	91.8	5.5	1.7	.6	.2		100.2

MODAL WAVE PERIOD (SEC)
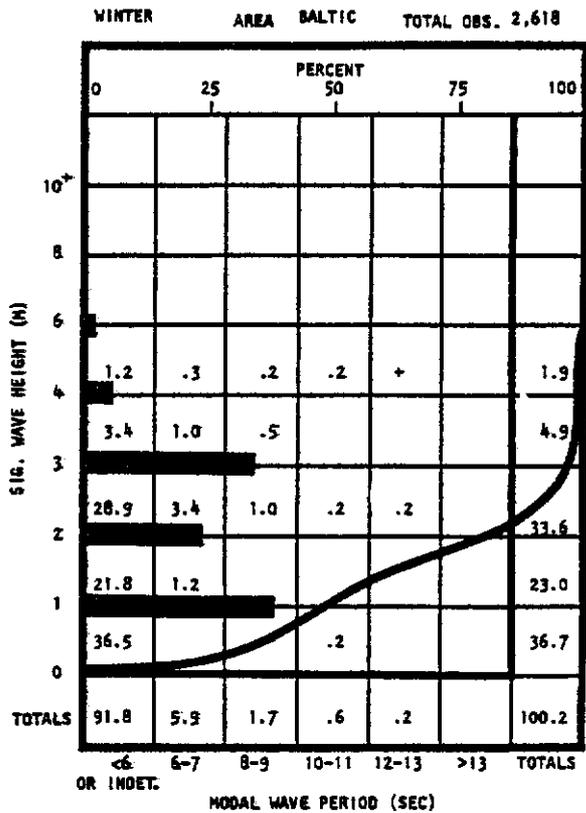
Figure D-6 Significant Wave Height by Modal Wave Period

WINTER   AREA BALTIC   TOTAL OBS. 1,673

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
10+							
8							
6							
4		.1	.1	1.1	.5		1.8
3		.1	1.1	2.1	.7		4.0
2		.2	6.8	13.2	1.0		21.2
1		1.4	6.1	9.0	+		26.5
0	3.6	18.2	24.9				46.7
TOTALS	3.6	20.0	49.0	25.4	2.2		100.2

WIND SPEED AT 10 M (KNOTS)
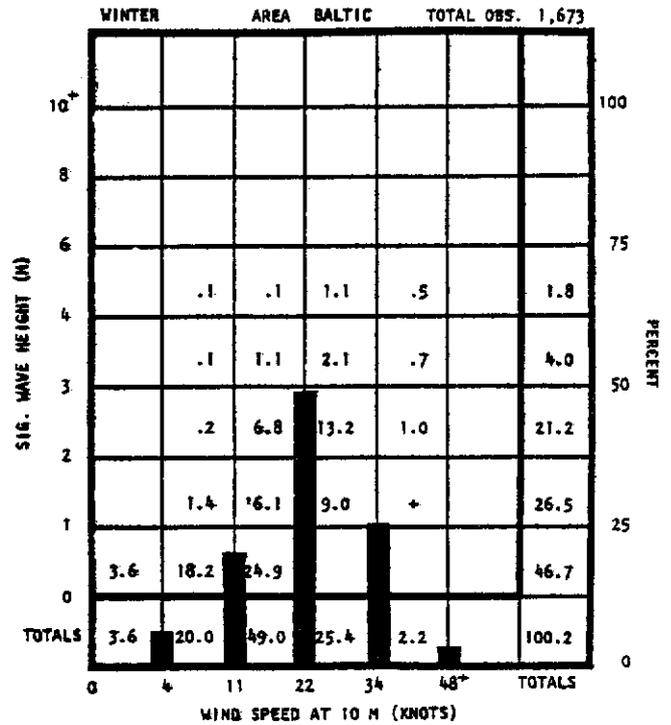
Figure D-7 Significant Wave Height by Wind Speed

WINTER   AREA BALTIC   TOTAL OBS. 364

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
10+										
8										
6										
4	1.0	.6		.3	1.3	2.7	1.7	1.0		8.6
3	1.7	2.0	.6	1.0	3.0	4.3	4.0	4.3		20.9
2	6.0	6.0	3.6	2.7	4.0	9.7	9.7	6.3		48.0
1	1.0	2.0	1.4	.2	1.6	2.4	1.8	2.6		13.0
0	.7	1.3	.9	.1	1.1	1.6	1.2	1.7	1.2	9.8
TOTALS	10.4	11.9	6.5	4.3	11.0	20.7	18.4	15.9	1.2	100.3

PRIMARY WAVE DIRECTION
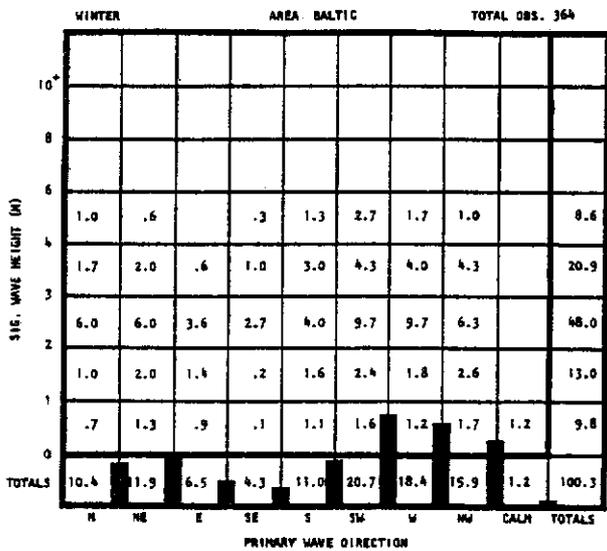
Figure D-8 Significant Wave Height by Wave Direction

WINTER   AREA BALTIC   TOTAL OBS. 28,461

| WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	+	.1	.1	.1	+	.1	.1	.1		.6
41	.1	.1	.1	.2	.1	.3	.3	.1		1.3
34	.4	.2	.4	.7	.5	.8	.7	.5		4.2
28	.5	.5	.4	.9	.8	1.7	1.5	.5		6.8
22	.8	.5	.9	1.8	1.6	3.1	2.9	1.1		12.7
17	.7	.9	1.2	2.3	2.1	4.5	4.1	1.4		17.2
11	1.4	1.5	1.8	2.8	3.1	4.6	5.0	2.4		22.6
7	1.3	1.2	1.7	2.5	2.8	4.0	3.7	1.9		19.1
4	1.2	.9	.8	1.5	1.6	1.9	1.8	1.0		10.7
0	.5	.3	.4	.5	.7	.6	.3	.4	1.4	5.1
TOTALS	6.9	6.2	7.6	13.3	13.3	21.6	20.4	9.4	1.4	100.3
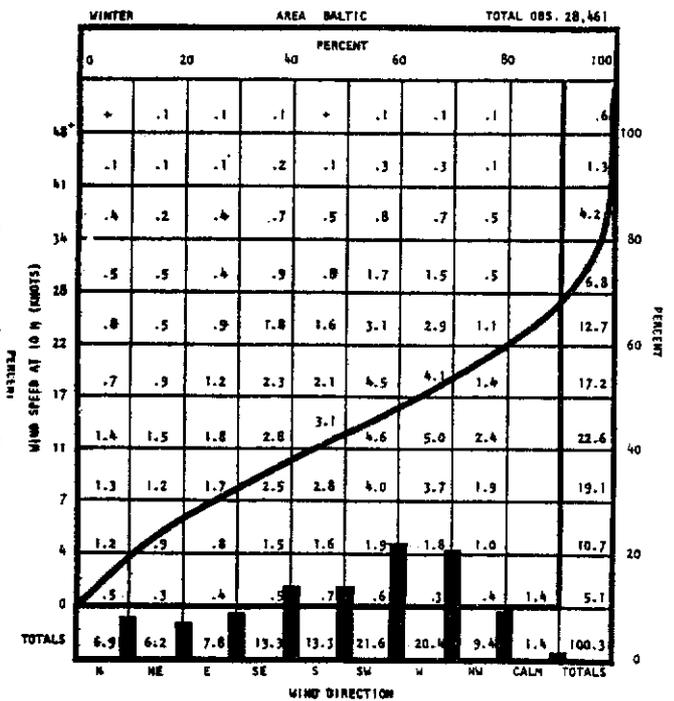
WIND DIRECTION

Figure D-9 Wind Speed by Wind Direction

TABLE D-32-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Western Baltic Sea, 54.7° N, 11.3° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1	2.5	1	1
Wave Period, sec	1.5	3.5	6	3.5	3.5
Direction	-	-	-	-	-
Winds					
Speed, knots	4	14	30	17	16
Corresponding Mean Sig. Wave Height, m.	.5	1	2.5	1.5	1.5
Direction	-	-	-	-	SW - W
Visibility, nautical miles	2	10	25	10	10
Cloud Cover					
Total clouds, in eighths of sky obscured	1	5	8	5	8
Low clouds, in eighths of sky obscured	Nil	3.5	8	4	8
Precipitation (Occurrence)	All precipitation - 11.6% of the time		Snow - 10.5% of the time (Dec - Mar)		
Relative Humidity, %	72	89	97	87	95
Air Temperature, °C	4.5	9	13.5	9.5	-
Surface Water Temperature, °C	1	10	17.5	9	-
Sea Level Pressure, millibars	997	1,016	1,030	1,015	1,014
Ice	Moderate superstructure icing - 4% of the time (Dec - Mar)				
Refractivity					
Mean Surface Refractivity (1 km, Annual)	-	-	-	322	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

ANNUAL   AREA 32   TOTAL OBS. 7,310
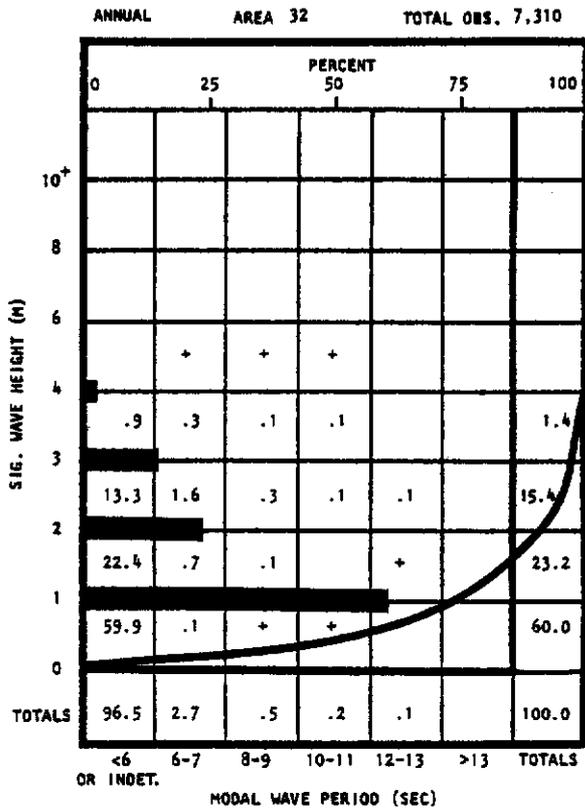
Figure D-32-1-1 Significant Wave
Height by Modal Wave Period

ANNUAL   AREA 32   TOTAL OBS. 5,959
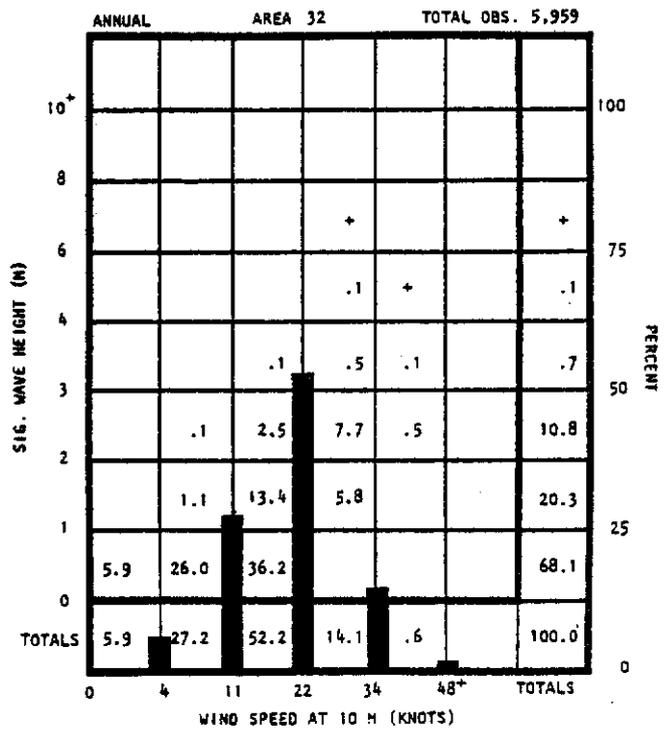
Figure D-32-1-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

ANNUAL   AREA 32   TOTAL OBS. 68,926

Figure D-32-1-3 Significant Wave
Height by Wave Direction

Figure D-32-1-4 Wind Speed by
Wind Direction

WINTER   AREA 32   TOTAL OBS. 1,419
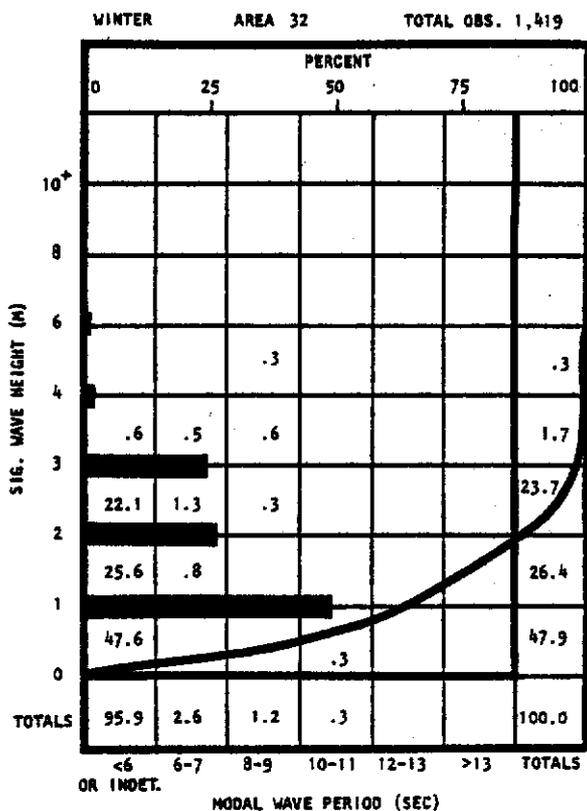
Figure D-32-2-1 Significant Wave
Height by Modal Wave Period

WINTER   AREA 32   TOTAL OBS. 1,133
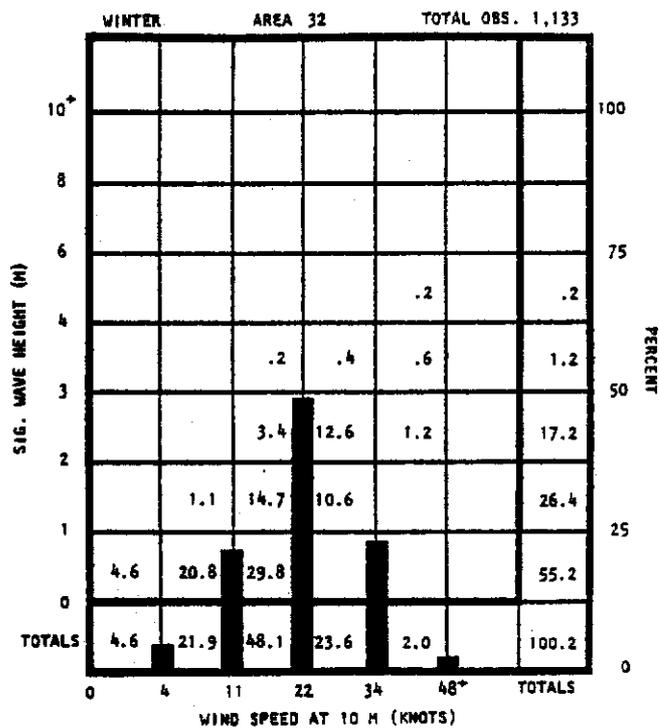
Figure D-32-2-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure D-32-2-3 Significant Wave
Height by Wave Direction

WINTER   AREA 32   TOTAL OBS. 15,048
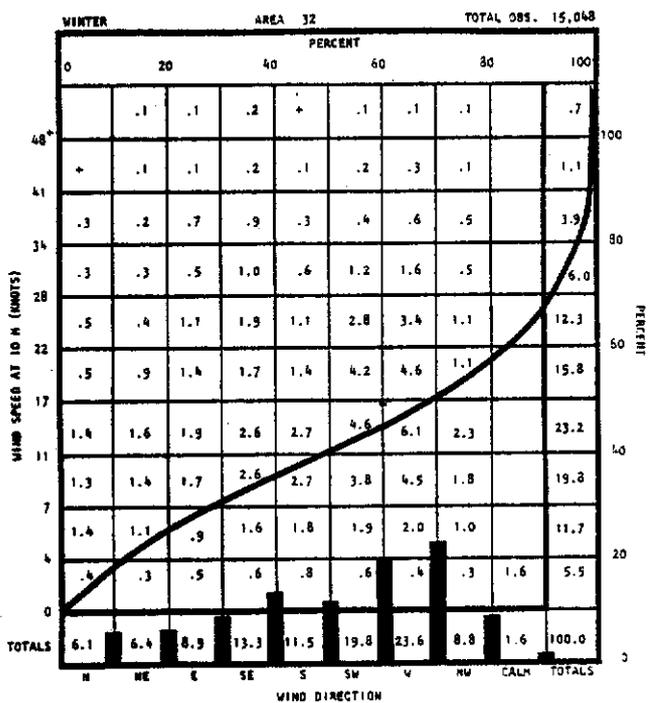
Figure D-32-2-4 Wind Speed by
Wind Direction

SPRING   AREA 32   TOTAL OBS. 1,671
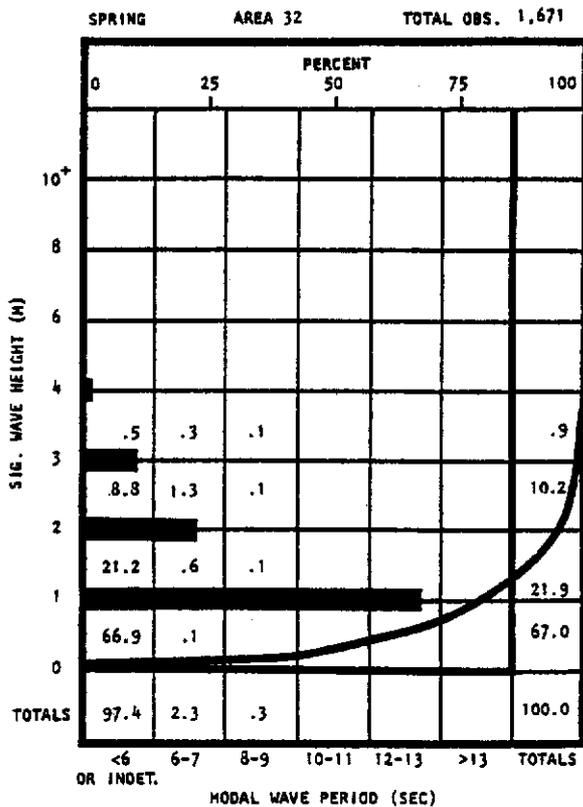
Figure D-32-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 32   TOTAL OBS. 1,404
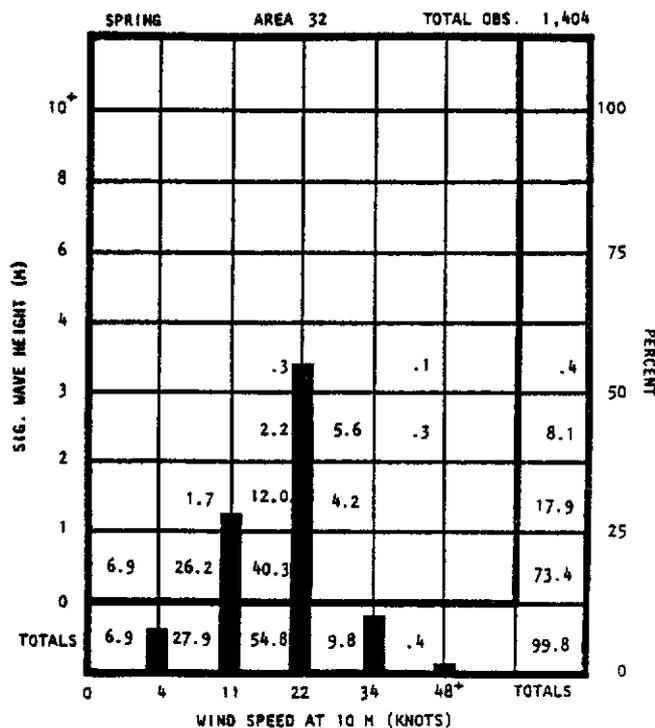
Figure D-32-3-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
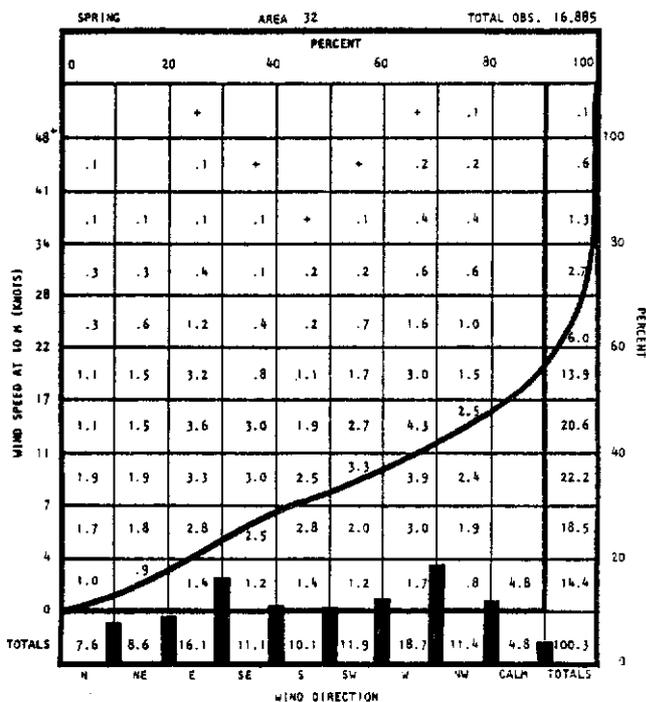
Figure D-32-3-3 Significant Wave
Height by Wave Direction

SPRING   AREA 32   TOTAL OBS. 16,885

Figure D-32-3-4 Wind Speed by
Wind Direction

SUMMER   AREA 32   TOTAL OBS. 1,978

Significant Wave Height (M) by Modal Wave Period (SEC) — PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
3+	.7			.1			.8
2	12.5	.7	.2		.1		13.5
1	21.1	.9	.4				22.4
0	63.0	.1	.1				63.2
TOTALS	97.3	1.7	.7	.1	.1		99.9
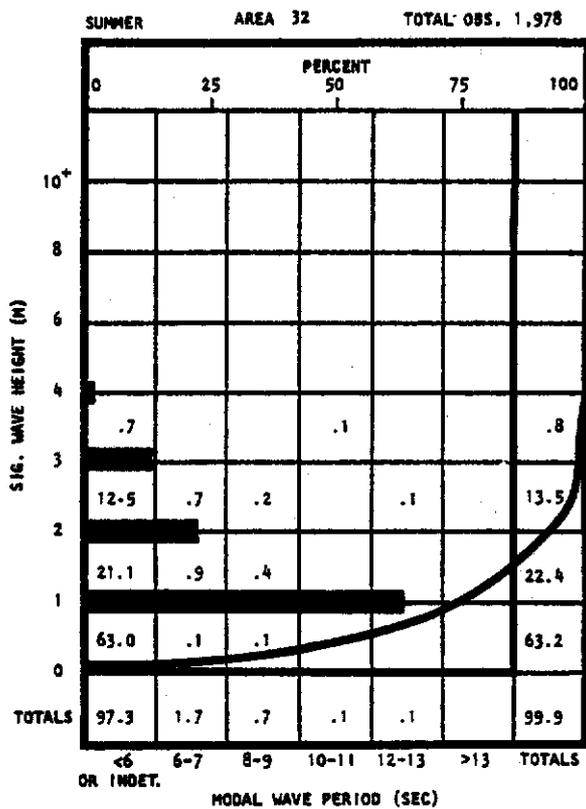
Figure D-32-4-1 Significant Wave Height by Modal Wave Period

SUMMER   AREA 32   TOTAL OBS. 1,978

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS) — PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
3			.2	.4			.6
2			2.9	4.1			7.0
1		.6	12.7	2.6			15.9
0	7.6	33.3	35.6				76.5
TOTALS	7.6	33.9	51.4	7.1			100.0
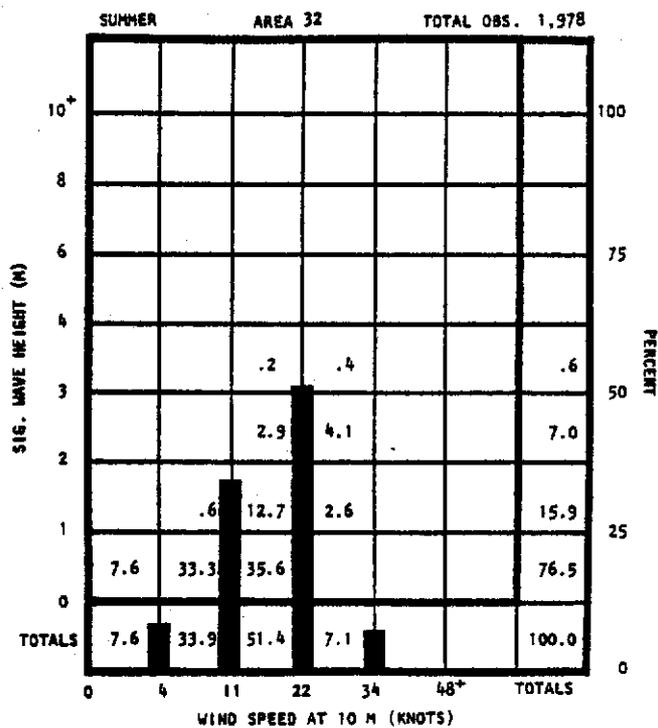
Figure D-32-4-2 Significant Wave Height by Wind Speed

NOT AVAILABLE

Figure D-32-4-3 Significant Wave Height by Wave Direction

SUMMER   AREA 32   TOTAL OBS. 19,179

Wind Speed at 10 M (KNOTS) by Wind Direction — PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+							*			
41							.1	*		.1
34				*		.2	.4	.3		.9
28	.1		*		.1	.3	1.4	.7		2.6
22	.3	*	.1	*	.2	1.2	2.9	1.5		6.2
17	.8	.4	.9	.3	.5	2.1	4.6	2.8		12.4
11	1.4	1.0	1.8	1.2	1.2	3.3	6.4	3.4		19.7
7	1.7	1.5	2.1	1.9	1.9	2.6	3.8	3.8		19.3
4	2.2	1.7	2.4	2.3	2.3	2.7	3.7	3.0		20.3
0	1.4	1.3	1.5	1.5	1.9	1.4	2.2	1.7	5.6	18.5
TOTALS	7.9	5.9	8.8	7.2	8.1	13.8	25.5	17.2	5.6	100.0
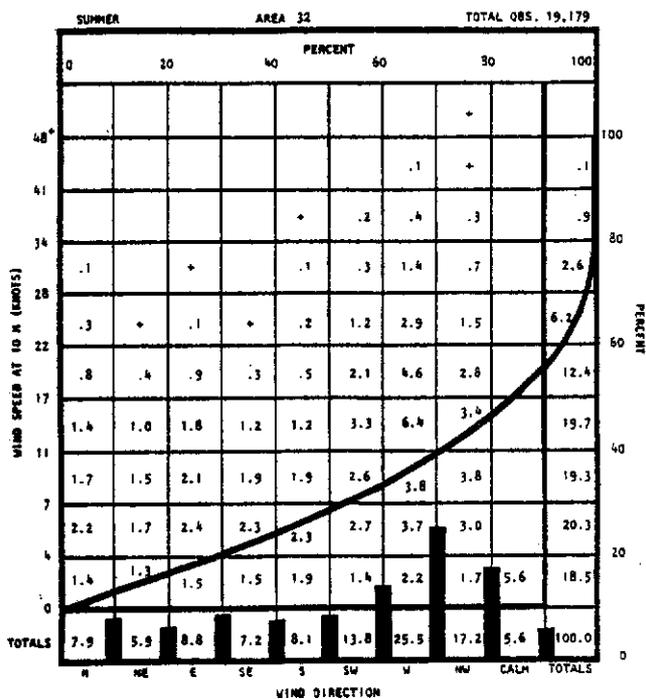
Figure D-32-4-4 Wind Speed by Wind Direction

FALL   AREA 32   TOTAL OBS. 1,810

PERCENT
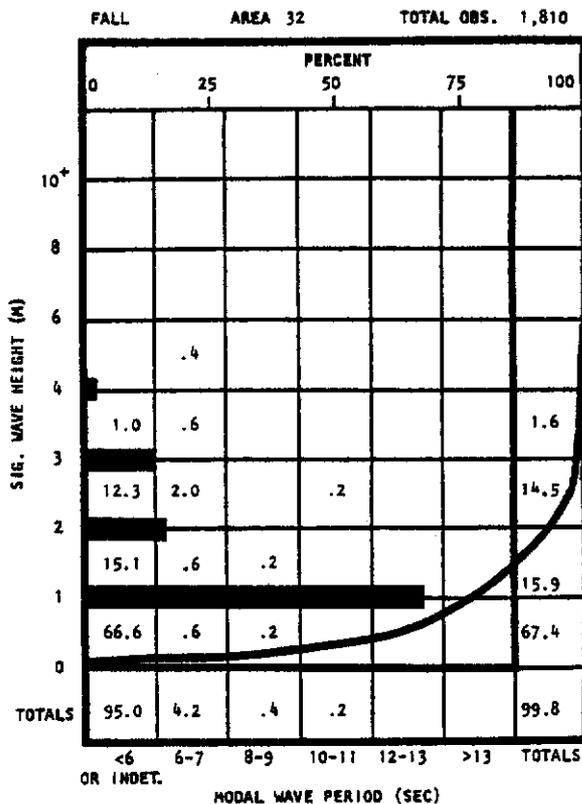
Figure D-32-5-1 Significant Wave
Height by Modal Wave Period

FALL   AREA 32   TOTAL OBS. 1,444
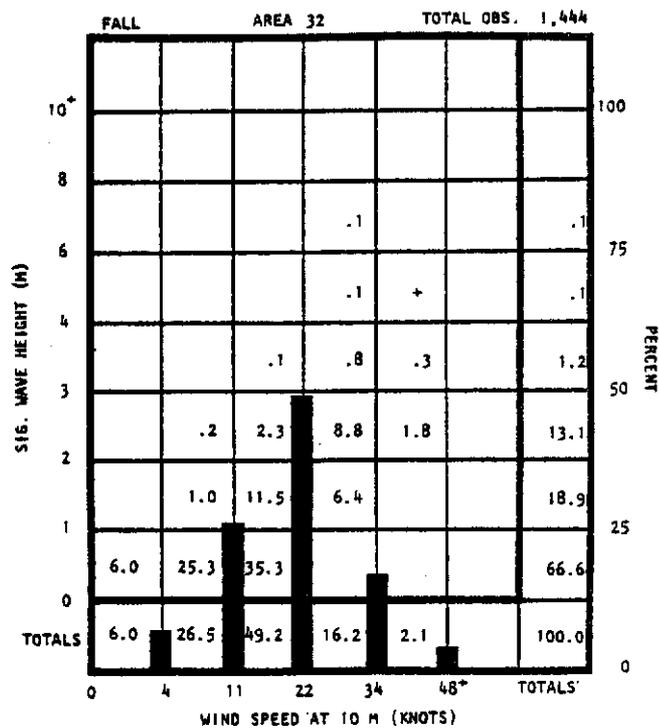
Figure D-32-5-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
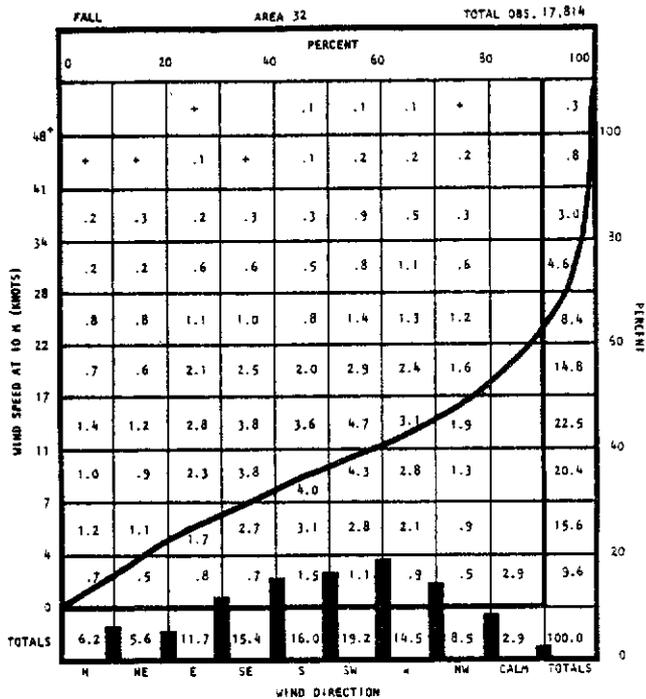
Figure D-32-5-3 Significant Wave
Height by Wave Direction

FALL   AREA 32   TOTAL OBS. 17,814

Figure D-32-5-4 Wind Speed by
Wind Direction

N A T O   U N C L A S S I F I E D

TABLE D-34-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Southern Baltic Sea, 55.3° N, 18.1° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	3.5	1.5	1.5
Wave Period, sec	1.5	4	6.5	4	3.5
Direction	-	-	-	-	SW - W
Winds					
Speed, knots	6	13	30	14	16
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3.5	1.5	1.5
Direction	-	-	-	-	SW - W
Visibility, nautical miles	2	10	25	10	10
Cloud Cover					
Total clouds, in eighths of sky obscured	1	6	8	5	8
Low clouds, in eighths of sky obscured	Nil	5	8	4.5	8
Precipitation (Occurrence)	All precipitation - 7% of the time		Snow - 5.5% of the time (Dec - Mar)		
Relative Humidity, %	70	88	97	86	95
Air Temperature, °C	3.5	8.5	13	9.5	-
Surface Water Temperature, °C	1.5	9	18	8.5	-
Sea Level Pressure, millibars	996	1,014	1,030	1,014	1,014
Ice	Moderate superstructure icing - 6% of the time (Dec - Mar)				
Refractivity					
Mean Surface Refractivity	-	-	-	320	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1.5% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

ANNUAL   AREA 34   TOTAL OBS. 4,528

SIG. WAVE HEIGHT (M) — PERCENT (0, 25, 50, 75, 100)

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.5	.3	.1	+	+		.9
4	4.0	1.5	.5	.2	.1		6.3
3	23.1	4.7	.8	.3	.1		29.0
2	23.5	.8	.2	.1			24.6
1	38.9	.2	+	.1			39.2
TOTALS	90.0	7.5	1.6	.7	.2		100.0

MODAL WAVE PERIOD (SEC)

Figure D-34-1-1 Significant Wave Height by Modal Wave Period

ANNUAL   AREA 34   TOTAL OBS. 2,600

SIG. WAVE HEIGHT (M) — PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
7				.1			.1
6			.4	1.2	.3		1.9
4		.1	2.3	2.5	.4	.1	5.4
3		.8	10.3	6.4	.6		18.1
2		3.0	15.3	2.1			20.4
1	3.9	32.9	17.5				54.3
TOTALS	3.9	36.8	45.8	12.3	1.3	.1	100.2

WIND SPEED AT 10 M (KNOTS)

Figure D-34-1-2 Significant Wave Height by Wind Speed

ANNUAL   AREA 34   TOTAL OBS. 1,448

SIG. WAVE HEIGHT (M) — PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6							.1			.1
4	.4	.3	.3	.2	.6	1.6	1.2	.8		5.4
3	1.1	1.2	1.2	1.0	1.8	5.1	3.1	1.5		16.0
2	4.5	4.6	4.2	2.4	3.5	10.2	7.4	3.9		40.7
1	1.6	2.8	1.8	1.8	2.2	4.4	3.4	1.7		19.7
<1	1.1	1.8	1.0	1.2	1.4	2.9	2.3	1.1	5.0	17.8
TOTALS	8.7	10.7	8.5	6.6	9.5	24.2	17.5	9.0	5.0	99.7

PRIMARY WAVE DIRECTION

Figure D-34-1-3 Significant Wave Height by Wave Direction

ANNUAL   AREA 34   TOTAL OBS. 53,463

WIND SPEED AT 10 M (KNOTS) — PERCENT (0, 20, 40, 60, 80, 100)

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	+	+		+	+	.1	.1	.1		.3
41	.1	.1	+	.1	.1	.2	.2	.1		.9
34	.3	.1	.2	.1	.2	.4	.7	.4		2.4
28	.4	.4	.2	.5	.4	1.1	1.0	.5		4.5
22	1.1	.6	.6	.7	.8	1.7	2.0	1.1		8.6
17	1.2	1.5	1.1	1.5	1.4	2.8	2.6	1.5		13.6
11	2.0	2.1	1.8	2.2	2.4	3.7	3.7	2.5		20.4
7	2.0	2.5	2.1	2.8	2.8	4.0	3.1	2.4		21.7
4	1.8	1.9	2.0	2.1	2.2	2.8	2.2	2.0		17.0
0	.9	1.0	1.1	.9	1.1	1.1	.9	.8	2.8	10.6
TOTALS	9.8	10.2	9.1	10.9	11.4	17.9	16.5	11.4	2.8	100.0

WIND DIRECTION

Figure D-34-1-4 Wind Speed by Wind Direction
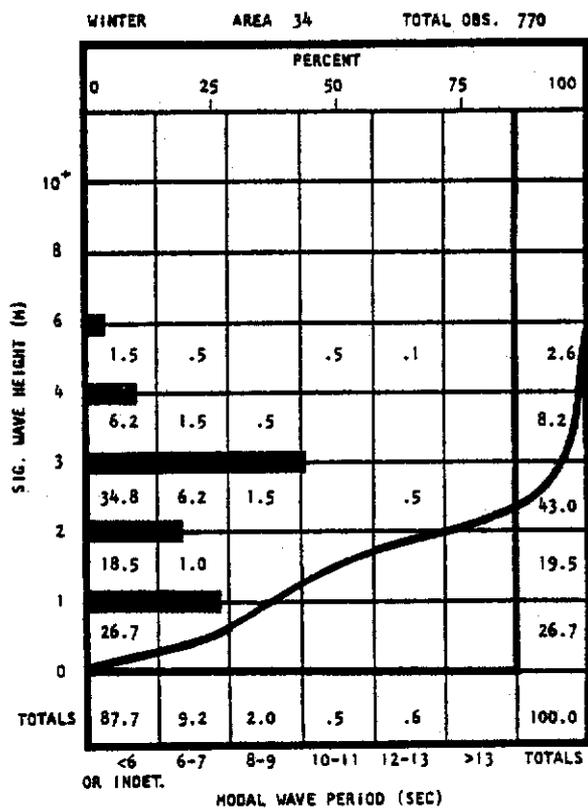
Figure D-34-2-1 Significant Wave Height by Modal Wave Period

WINTER   AREA 34   TOTAL OBS. 770

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6							
5	1.5	.5		.5	.1		2.6
4	6.2	1.5	.5				8.2
3	34.8	6.2	1.5		.5		43.0
2	18.5	1.0					19.5
1	26.7						26.7
0							
TOTALS	87.7	9.2	2.0	.5	.6		100.0

MODAL WAVE PERIOD (SEC)

Figure D-34-2-2 Significant Wave Height by Wind Speed

WINTER   AREA 34   TOTAL OBS. 341

| SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
5			.5	2.3	.7		3.5
4			2.9	5.7	.9		9.5
3		.7	13.6	15.3	1.3		30.9
2		1.9	21.1	4.6	.1		27.7
1	1.2	11.7	15.5				28.4
0							
TOTALS	1.2	14.3	53.6	27.9	3.0		100.0

WIND SPEED AT 10 M (KNOTS)
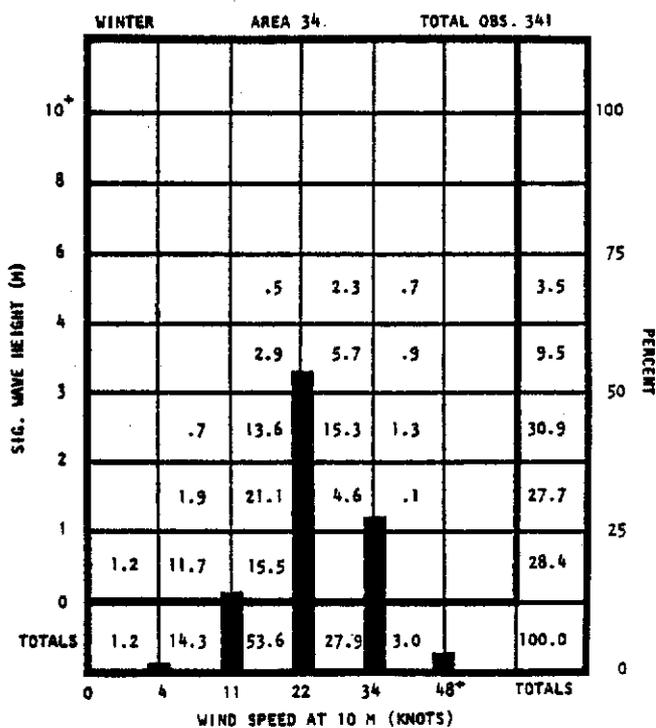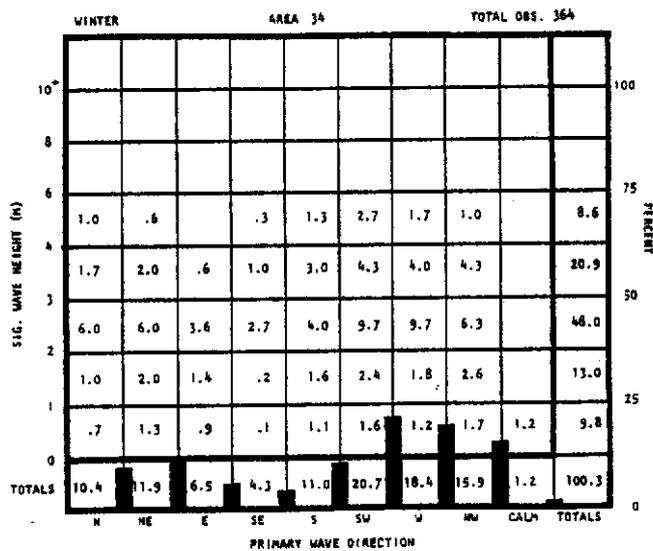
Figure D-34-2-3 Significant Wave Height by Wave Direction

WINTER   AREA 34   TOTAL OBS. 364

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
5	1.0	.6		.3	1.3	2.7	1.7	1.0		8.6
4	1.7	2.0	.6	1.0	3.0	4.3	4.0	4.3		20.9
3	6.0	6.0	3.6	2.7	4.0	9.7	9.7	6.3		48.0
2	1.0	2.0	1.4	.2	1.6	2.4	1.8	2.6		13.0
1	.7	1.3	.9	.1	1.1	1.6	1.2	1.7	1.2	9.8
0										
TOTALS	10.4	11.9	6.5	4.3	11.0	20.7	18.4	15.9	1.2	100.3

PRIMARY WAVE DIRECTION
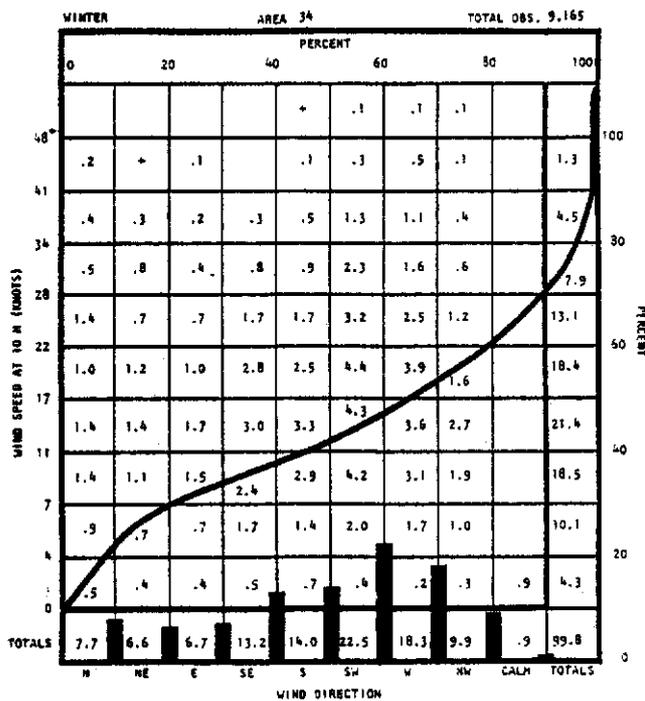
Figure D-34-2-4 Wind Speed by Wind Direction

WINTER   AREA 34   TOTAL OBS. 9,165

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+					+	.1	.1	.1		
41	.2	+	.1		.1	.3	.5	.1		1.3
34	.4	.3	.2	.3	.5	1.3	1.1	.4		4.5
28	.5	.8	.4	.8	.9	2.3	1.6	.6		7.9
22	1.4	.7	.7	1.7	1.7	3.2	2.5	1.2		13.1
17	1.0	1.2	1.0	2.8	2.5	4.4	3.9	1.6		18.4
11	1.4	1.4	1.7	3.0	3.3	4.3	3.6	2.7		21.4
7	1.4	1.1	1.5	2.4	2.9	4.2	3.1	1.9		18.5
4	.9	.7	.7	1.7	1.4	2.0	1.7	1.0		10.1
0	.5	.4	.4	.5	.7	.4	.2	.3	.9	4.3
TOTALS	7.7	6.6	6.7	13.2	14.0	22.5	18.3	9.9	.9	99.8

WIND DIRECTION

Figure D-34-3-1 — SPRING AREA 34 TOTAL OBS. 1,251

SIG. WAVE HEIGHT (M) by MODAL WAVE PERIOD (SEC), PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
3–4	2.6	.5	.2				3.3
2–3	13.0	3.2	.7				16.9
1–2	24.5	.5	.2	.2			25.4
0–1	53.2	.9					54.1
TOTALS	93.3	5.1	1.1	.2			99.7

Figure D-34-3-1 Significant Wave Height by Modal Wave Period

Figure D-34-3-2 — SPRING AREA 34 TOTAL OBS. 965

SIG. WAVE HEIGHT (M) by WIND SPEED AT 10 M (KNOTS), PERCENT

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48⁺	TOTALS
3–4			1.2	.9	.3		2.4
2–3			8.8	1.8	.1		10.7
1–2		3.4	16.8	1.2			21.4
0–1	2.4	38.6	24.5				65.5
TOTALS	2.4	42.0	51.3	3.9	.4		100.0
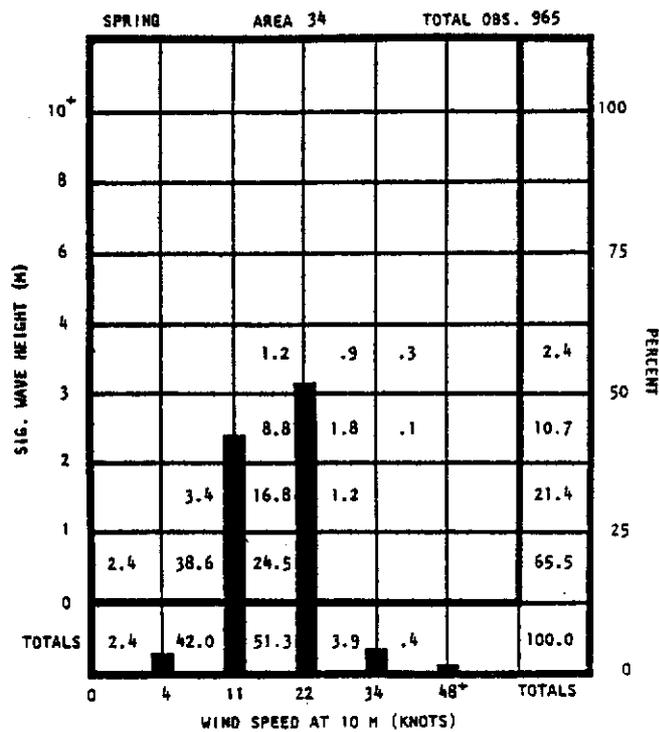
Figure D-34-3-2 Significant Wave Height by Wind Speed

Figure D-34-3-3 — SPRING AREA 34 TOTAL OBS. 473

SIG. WAVE HEIGHT (M) by PRIMARY WAVE DIRECTION, PERCENT

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
4–6	.2	+	1.0	+	.2	.2				1.6
3–4	.7	1.3	1.3	1.0	1.0	1.7	.2			7.2
2–3	4.7	6.3	7.0	5.3	3.0	6.3	3.3	1.3		37.2
1–2	2.8	5.4	2.4	4.2	4.0	5.4	3.4	.8		28.4
0–1	1.9	3.6	1.6	2.8	2.7	3.6	2.3	.5	6.6	25.6
TOTALS	10.3	16.6	13.3	13.3	10.9	17.2	9.2	2.6	6.6	100.0
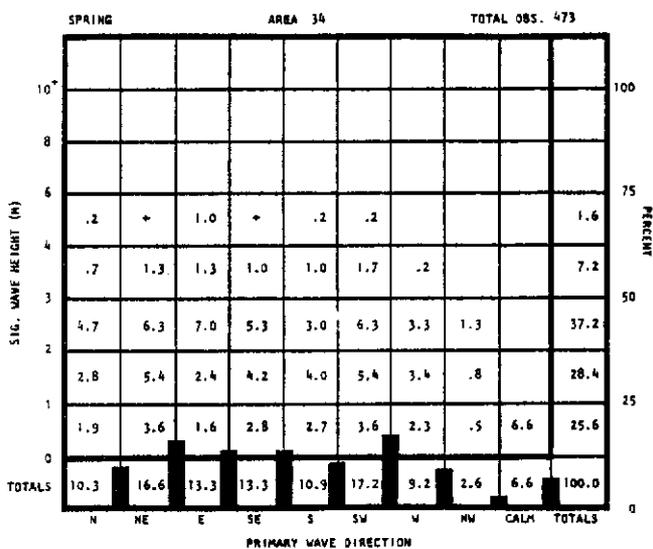
Figure D-34-3-3 Significant Wave Height by Wave Direction

Figure D-34-3-4 — SPRING AREA 34 TOTAL OBS. 11,671

WIND SPEED AT 10 M (KNOTS) by WIND DIRECTION, PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48⁺	+	+					+			
41	.1	.1	+	+		+	.1	.1		.4
34	.2	.1	.1	.1		.1	.3	.3		1.2
28	.4	.4	.1	.2	.2	.3	.8	.3		2.7
22	1.0	.4	.3	.6	.4	.7	.8	.7		4.9
17	1.5	2.1	1.4	1.1	.9	1.6	1.7	.8		11.1
11	2.2	4.0	2.6	2.5	1.7	2.9	3.0	2.3		21.2
7	2.8	2.9	2.6	3.0	2.8	3.1	2.8	1.8		21.8
4	2.2	3.0	2.6	2.3	2.5	2.8	2.8	2.1		20.3
0	1.2	1.5	1.7	1.1	1.5	1.6	1.5	1.2	5.1	16.4
TOTALS	11.6	14.5	11.4	10.9	10.0	13.1	13.8	9.6	5.1	100.0
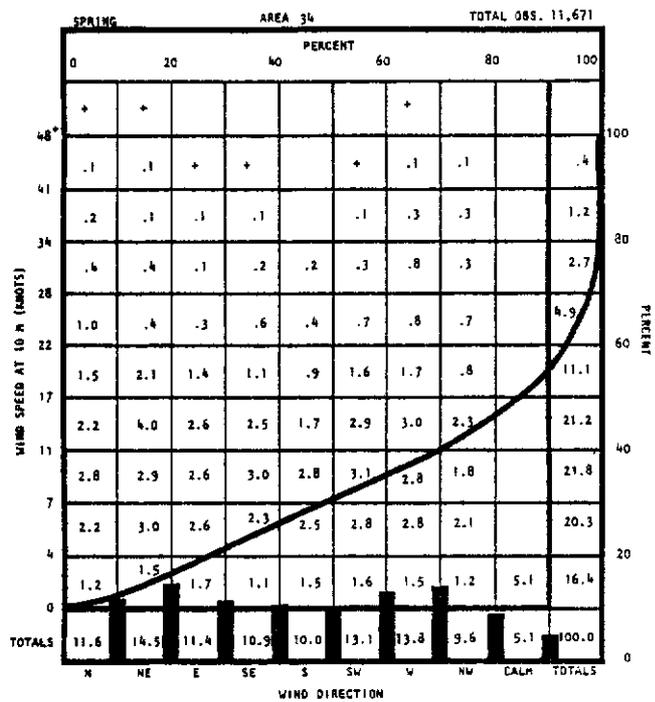
Figure D-34-3-4 Wind Speed by Wind Direction
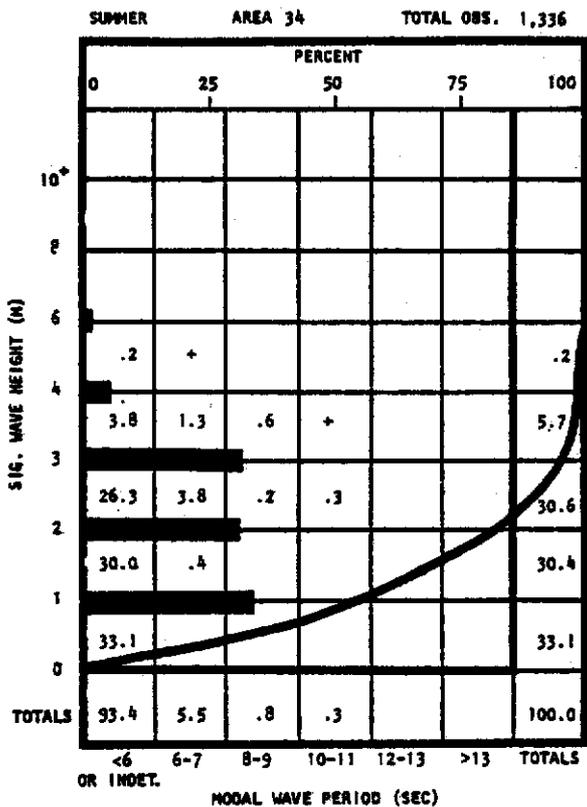
Figure D-34-4-1 Significant Wave
Height by Modal Wave Period
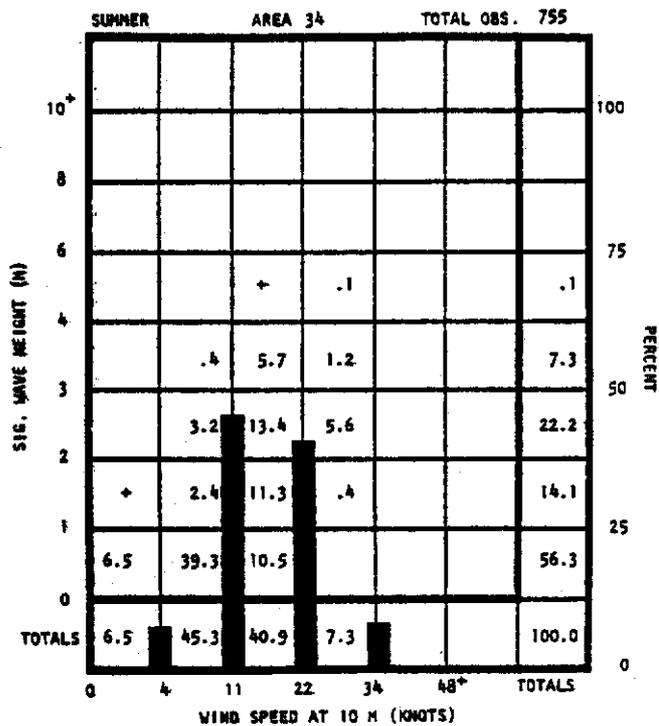
Figure D-34-4-2 Significant Wave
Height by Wind Speed
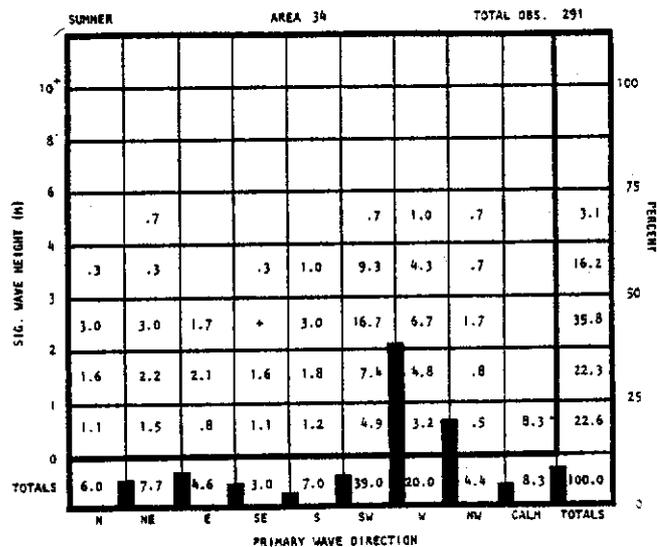
Figure D-34-4-3 Significant Wave
Height by Wave Direction
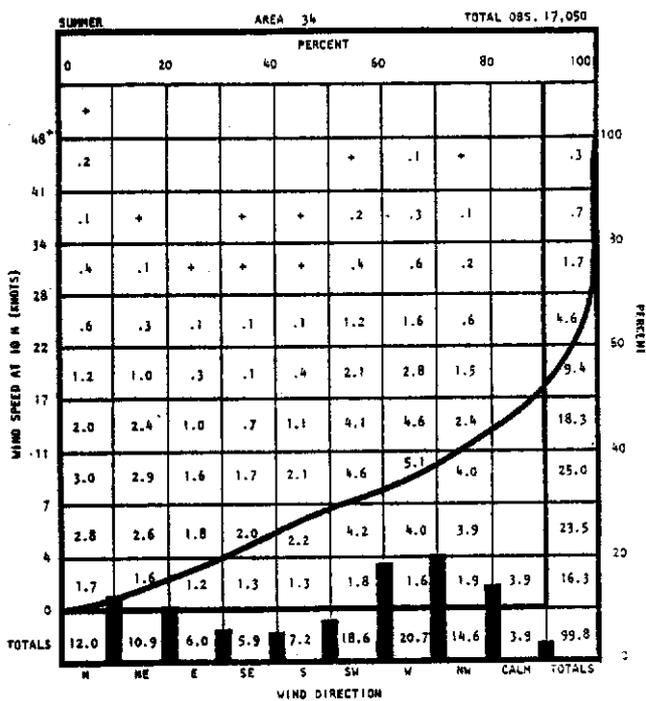
Figure D-34-4-4 Wind Speed by
Wind Direction

FALL   AREA 34   TOTAL OBS. 1,171

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.2	.7		.2			1.1
4	2.3	1.8	1.4	.2			5.7
3	27.4	6.5	.4	.5			34.8
2	19.9	1.4	.7				22.0
1	36.2	.2					36.4
TOTALS	86.0	10.6	2.5	.9			100.0

MODAL WAVE PERIOD (SEC)
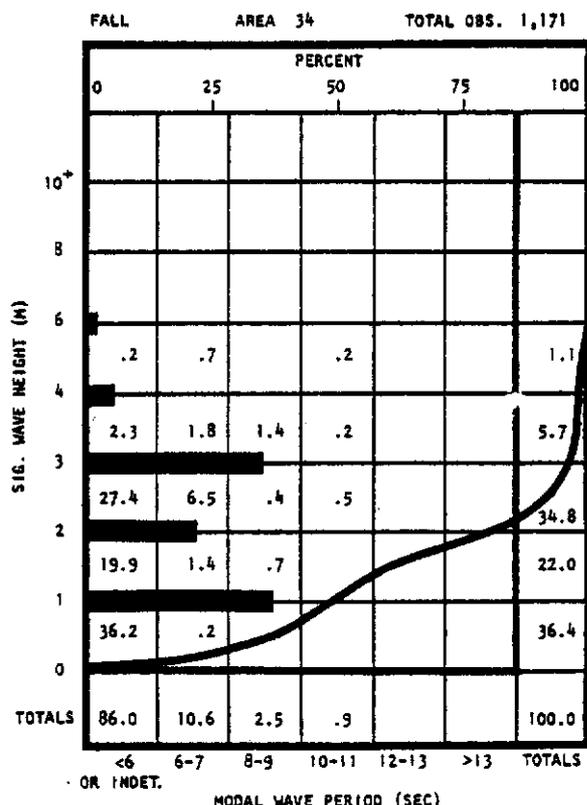
Figure D-34-5-1 Significant Wave Height by Modal Wave Period

FALL   AREA 34   TOTAL OBS. 539

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6				.3			.3
5			.8	2.2	.2		3.2
4		.3	1.6	2.7	.2		4.8
3		.6	12.7	5.8	.5		19.6
2		3.1	15.9	2.0	.3		21.3
1	2.6	30.2	17.7				50.5
TOTALS	2.6	34.2	48.7	13.0	1.2		99.7

WIND SPEED AT 10 M (KNOTS)
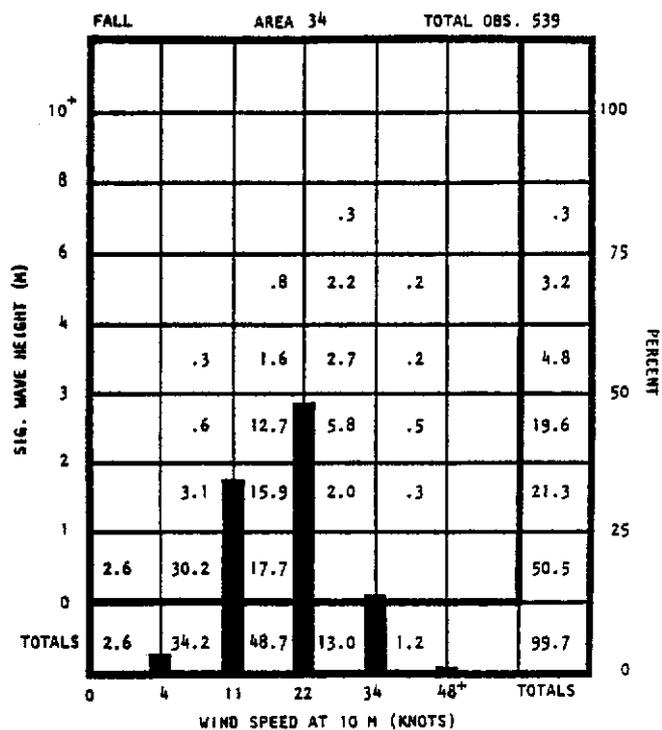
Figure D-34-5-2 Significant Wave Height by Wind Speed

FALL   AREA 34   TOTAL OBS. 320

SIG. WAVE HEIGHT (M)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
6								.3		.3
5	.3		.3	.3	1.0	2.7	2.3	1.7		8.6
4	1.7	1.3	3.0	1.7	2.0	5.0	4.0	1.0		19.7
3	4.3	3.3	4.7	1.7	4.0	8.3	9.7	6.3		42.3
2	1.2	1.4	1.4	1.4	1.2	2.4	3.8	2.6		15.4
1	.8	.9	.9	.9	.8	1.6	2.5	1.7	3.6	13.7
TOTALS	8.3	6.9	10.3	6.0	9.0	20.0	22.6	13.3	3.6	100.0

PRIMARY WAVE DIRECTION
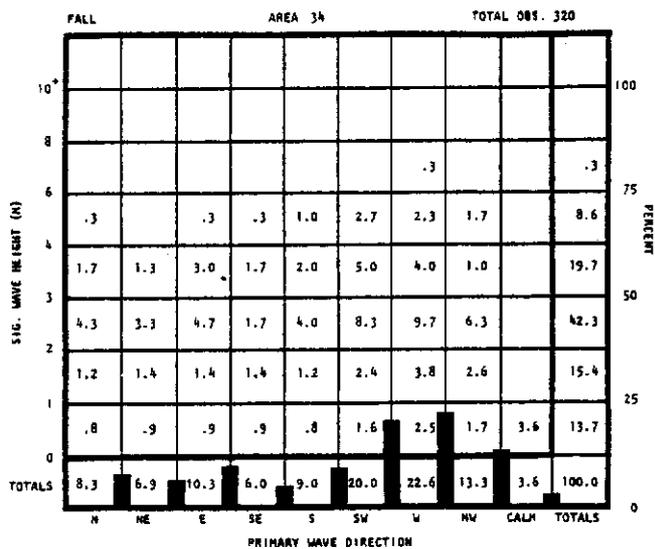
Figure D-34-5-3 Significant Wave Height by Wave Direction

FALL   AREA 34   TOTAL OBS. 15,577

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1	+		.1	.1	.1				.4
41	.2	.1	+	.1	.1	.3	.1	.1		1.0
34	.3	.2	.3	.3	.2	.8	.6	.4		3.1
28	.4	.3	.2	.7	.7	1.3	.9	.6		5.1
22	1.0	.5	.8	1.2	1.2	2.0	1.8	1.3		9.8
17	1.0	.9	1.0	2.1	2.0	3.5	2.7	1.9		15.1
11	1.6	1.4	1.8	3.4	3.1	4.1	4.0	2.9		22.3
7	1.7	1.6	2.2	2.9	3.7	4.2	2.7	2.6		21.6
4	1.2	1.3	1.5	2.2	2.6	2.4	1.7	1.4		14.3
0	.6	.5	.8	.8	.8	.7	.6	.6	1.9	7.3
TOTALS	8.1	6.8	8.6	13.7	14.4	19.4	15.2	11.9	1.9	100.0
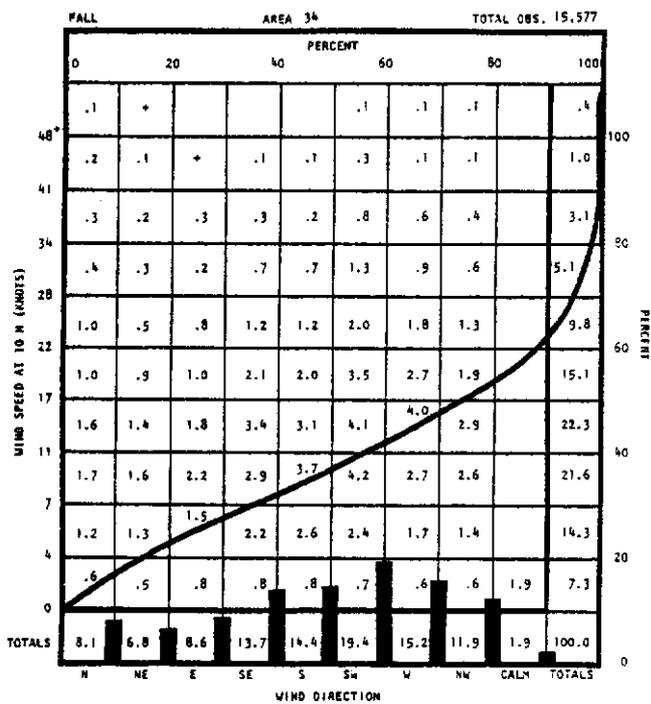
WIND DIRECTION

Figure D-34-5-4 Wind Speed by Wind Direction

TABLE D-36-1-1 – SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Central Baltic Sea, 57.7° N, 21° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1.5	4	1.5	1
Wave Period, sec	1.5	4	6.5	4	3.5
Direction	-	-	-	-	-
Winds					
Speed, knots	4	14	30	15	16
Corresponding Mean Sig. Wave Height, m.	.5	1.5	3.5	1.5	1.5
Direction	-	-	-	-	SW-W-NW
Visibility, nautical miles	2	10	25	10	10
Cloud Cover					
Total clouds, in eighths of sky obscured	1	5.5	8	5	8
Low clouds, in eighths of sky obscured	Nil	5	8	4.5	8
Precipitation (Occurrence)	All precipitation - 8.1% of the time		Snow - 7% of the time (Dec - Mar)		
Relative Humidity, %	64	88	97	87	93
Air Temperature, °C	2	8	12	9.5	-
Surface Water Temperature, °C	1	11	18	7.5	-
Sea Level Pressure, millibars	994	1,014	1,030	1,013	1,013
Ice	Moderate superstructure icing - 6% of the time (Dec - Mar)				
Refractivity					
Mean Surface Refractivity	-	-	-	317	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

ANNUAL   AREA 36   TOTAL OBS. 2,859

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.9	.4		+			1.3
4	4.2	1.4	.6	+	.1		6.3
3	27.2	5.8	1.3	.3			34.6
2	25.7	1.3	.1	+			27.1
1	30.4						30.4
TOTALS	88.4	8.9	2.0	.3	.1		99.7

MODAL WAVE PERIOD (SEC)

Figure D-36-1-1 Significant Wave
Height by Modal Wave Period

ANNUAL   AREA 36   TOTAL OBS. 1,245

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4		.3	.2	1.9	.6		3.0
3		.2	1.6	4.3	.4		6.5
2		.5	12.9	8.2	.1		21.7
1		3.3	18.6	3.3			25.2
	5.3	22.2	16.1				43.6
TOTALS	5.3	26.5	49.4	17.7	1.1		100.0

WIND SPEED AT 10 M (KNOTS)

Figure D-36-1-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure D-36-1-3 Significant Wave
Height by Wave Direction

ANNUAL   AREA 36   TOTAL OBS. 26,632

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1	+	+	+	+	.1	.1	.1		.4
41	.1	.1	.1	.1	.1	.1	.1	.2		.9
34	.4	.1	.1	.3	.3	.6	.4	.3		2.5
28	.5	.4	.3	.5	.7	1.0	.6	.7		4.7
22	1.0	.6	.4	.9	1.2	2.2	1.1	1.1		8.5
17	1.6	1.3	1.0	1.6	2.0	3.2	2.0	1.9		14.6
11	2.3	1.9	1.4	2.2	2.7	4.4	2.8	2.5		20.2
7	2.2	2.2	1.8	2.7	3.0	3.7	2.5	2.8		20.9
4	2.0	2.1	1.9	2.0	2.1	2.6	1.9	2.2		16.8
	1.0	1.1	1.0	.8	.8	1.0	.5	.5	3.0	10.5
TOTALS	11.2	9.8	8.0	11.1	12.9	18.9	12.4	12.7	3.0	100.0

WIND DIRECTION

Figure D-36-1-4 Wind Speed by
Wind Direction

Figure D-36-2-1 Significant Wave
Height by Modal Wave Period

Figure D-36-2-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure D-36-2-3 Significant Wave
Height by Wave Direction
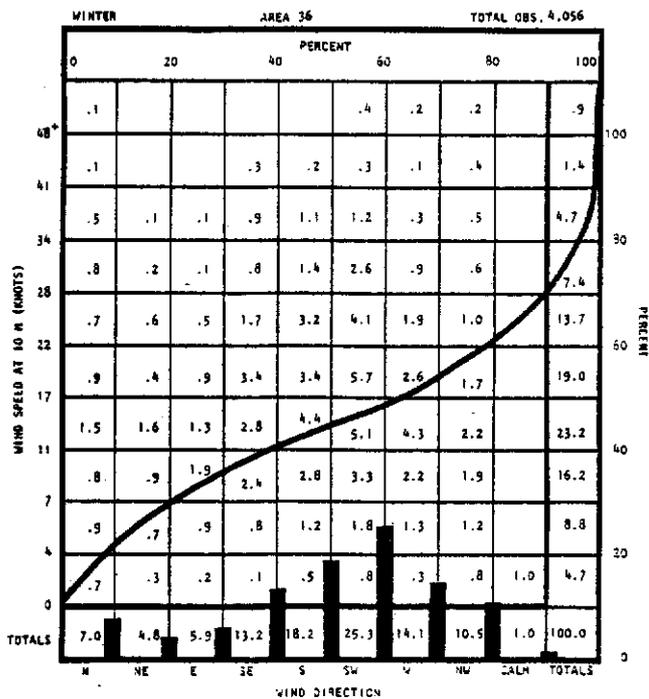
Figure D-36-2-4 Wind Speed by
Wind Direction

SPRING   AREA 36   TOTAL OBS. 579

PERCENT

	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	.6	.2			.4		1.2
4	1.9	.9	.2				3.0
3	15.5	3.0	.6				19.1
2	23.3	1.7		.1			25.1
1	51.6						51.6
TOTALS	92.9	5.8	.8	.1	.4		100.0

SIG. WAVE HEIGHT (M)

MODAL WAVE PERIOD (SEC)
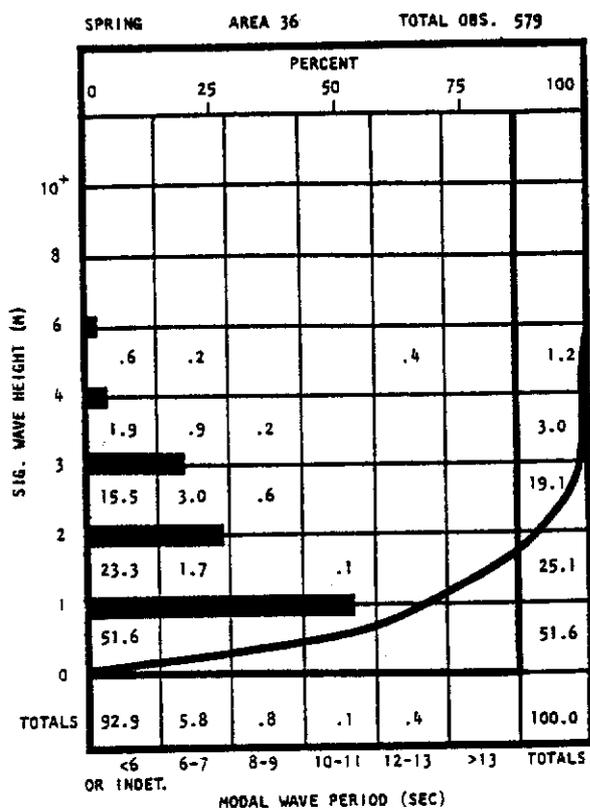
Figure D-36-3-1 Significant Wave
Height by Modal Wave Period

SPRING   AREA 36   TOTAL OBS. 383

	0	4	11	22	34	48+	TOTALS
6		.9	.9				1.8
4				.9			.9
3			10.0	7.2			17.2
2		1.8	18.9	1.8			22.5
1	9.9	19.8	27.9				57.6
TOTALS	9.9	22.5	57.7	9.9			100.0

SIG. WAVE HEIGHT (M)

PERCENT

WIND SPEED AT 10 M (KNOTS)
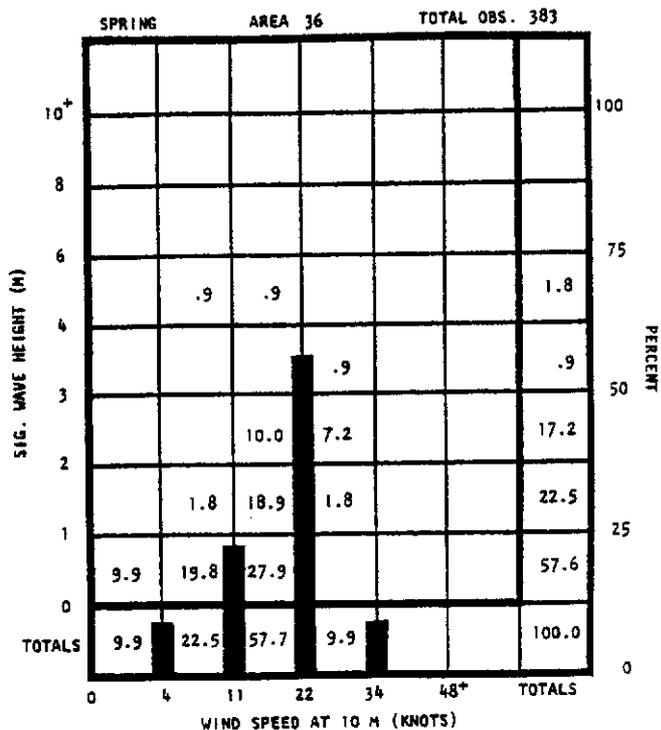
Figure D-36-3-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure D-36-3-3 Significant Wave
Height by Wave Direction

SPRING   AREA 36   TOTAL OBS. 5,111

PERCENT

	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.2	.1		.1		.2				.6
41	.1	.1		.1	+	.1				.4
34	.5	.2		.2	.4	.4	.1	.3		2.1
28	1.5	.1	.3	.6	.8	.9	.2	1.1		5.5
22	1.7	1.7	1.1	.8	2.3	1.9	.9	1.3		11.7
17	2.5	3.0	1.9	2.2	2.1	3.0	1.0	1.5		17.2
11	3.4	3.8	1.6	2.6	3.1	3.0	2.4	3.3		23.2
7	3.5	3.2	2.9	2.2	2.9	2.6	2.1	2.8		22.2
4	1.5	2.4	1.1	1.3	.6	1.6	2.1	1.7	4.6	16.9
TOTALS	14.9	14.6	8.9	9.9	12.4	13.4	8.8	12.3	4.6	99.8

WIND SPEED AT 10 M (KNOTS)

PERCENT
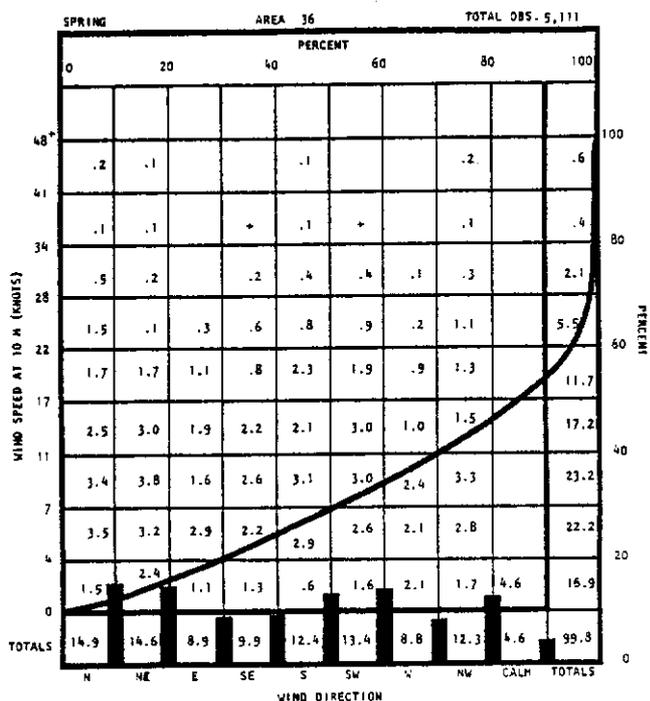
WIND DIRECTION

Figure D-36-3-4 Wind Speed by
Wind Direction
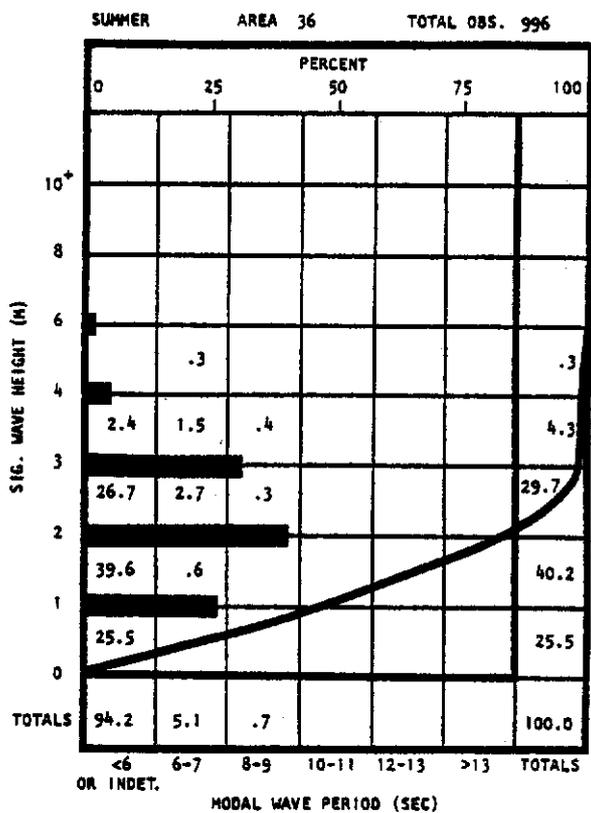
Figure D-36-4-1 Significant Wave
Height by Modal Wave Period
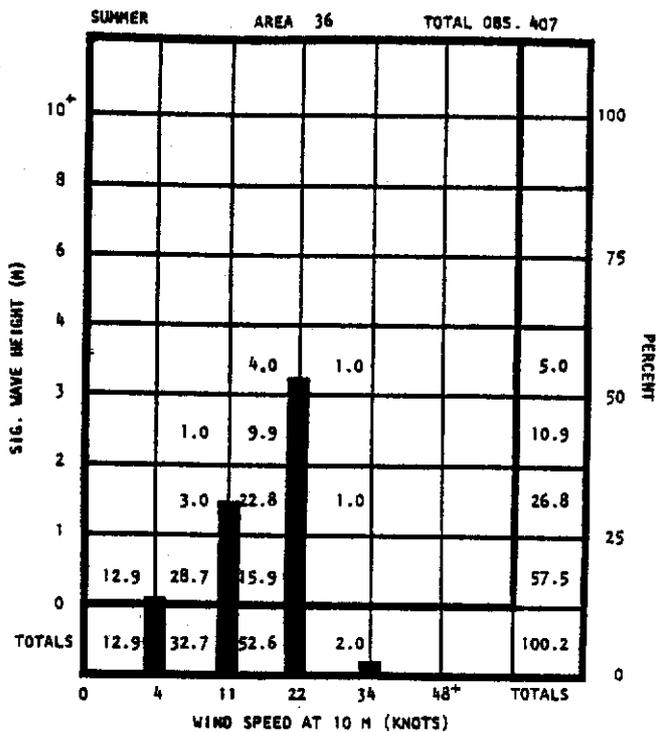
Figure D-36-4-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
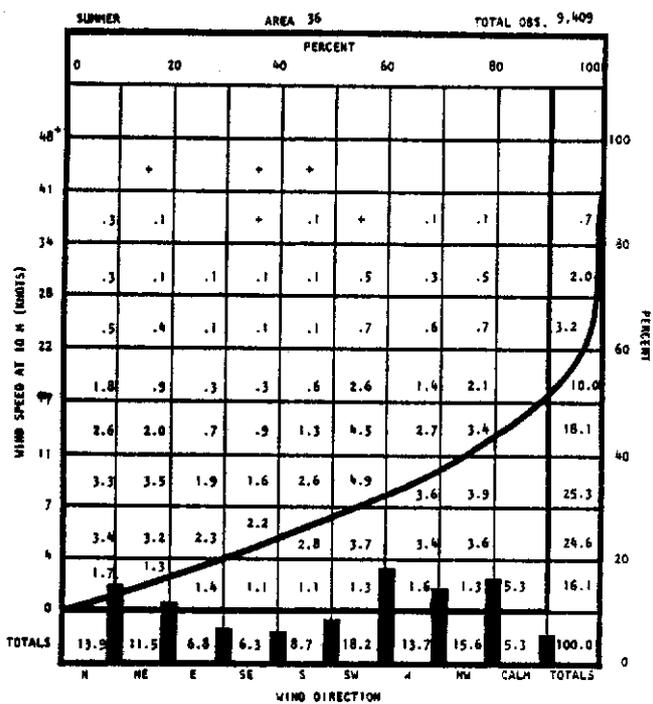
Figure D-36-4-3 Significant Wave
Height by Wave Direction


Figure D-36-4-4 Wind Speed by
Wind Direction

FALL   AREA 36   TOTAL OBS. 893

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	1.1	.4					1.5
4	4.9	3.3	1.1		.4		9.7
3	35.7	8.9	2.9	1.5			49.0
2	21.2	1.5					22.7
1	17.1						17.1
TOTALS	80.0	14.1	4.0	1.5	.4		100.0

MODAL WAVE PERIOD (SEC)
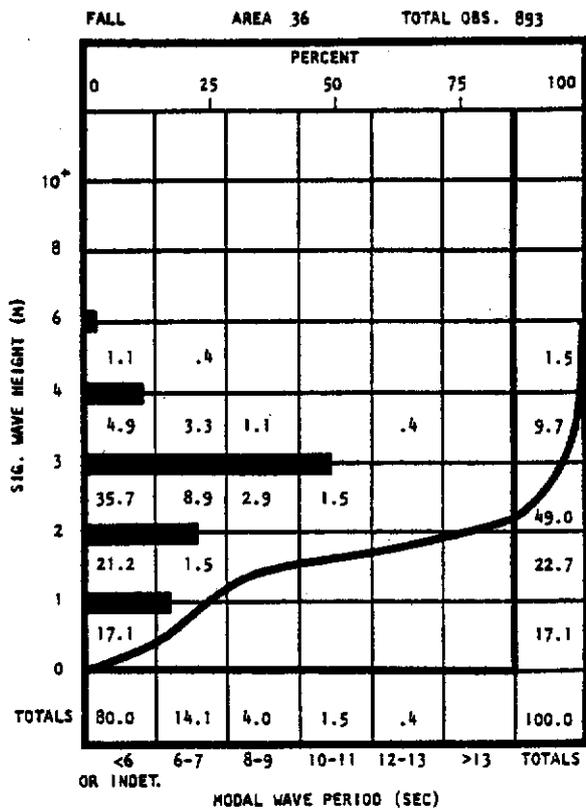
Figure D-36-5-1 Significant Wave
Height by Modal Wave Period

FALL   AREA 36   TOTAL OBS. 289

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6			1.3	2.5			3.8
4			1.2	6.3	2.4		9.9
3			11.3	15.0			26.3
2		3.7	20.0	5.0			28.7
1	2.5	13.8	15.0				31.3
TOTALS	2.5	17.5	48.8	28.8	2.4		100.0

WIND SPEED AT 10 M (KNOTS)
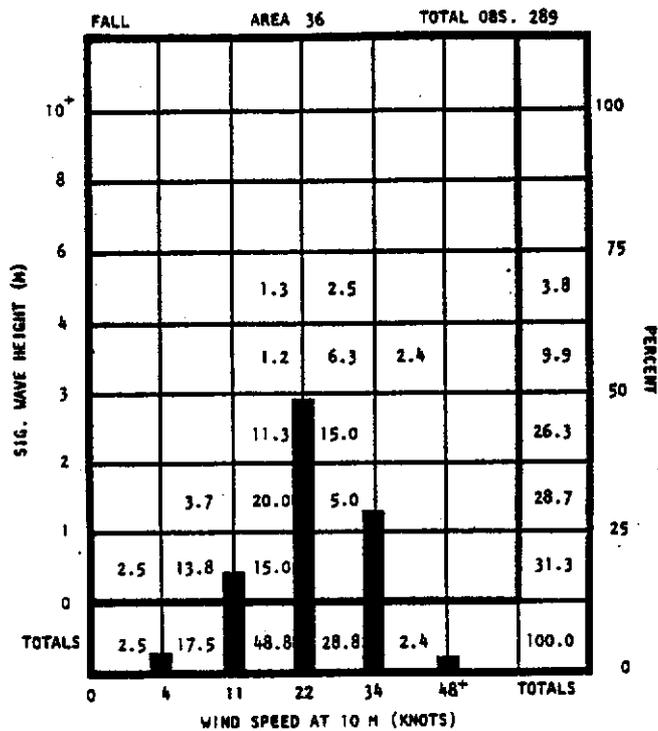
Figure D-36-5-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

FALL   AREA 36   TOTAL OBS. 8,056

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.2	.1	.1	+	+	.2	.1	.1		.8
41	.3	.4	.1	.1	.1	.3	.2	.3		1.8
34	.5	.2	.1	.5	.4	1.4	.6	.5		4.2
28	.4	.5	.2	.8	1.0	2.0	.7	1.1		6.7
22	1.3	.7	.6	1.2	1.5	3.1	1.5	1.8		11.7
17	1.6	1.1	1.0	2.2	2.4	3.7	2.8	2.7		17.5
11	2.0	1.5	1.4	3.1	3.0	3.7	3.6	3.0		21.3
7	1.3	1.4	1.3	2.5	3.0	3.8	2.6	2.0		17.9
4	1.2	.8	1.5	2.1	2.3	2.1	1.5	1.3		12.8
0	.5	.6	.6	.4	.5	.7	.3	.5	1.2	5.3
TOTALS	9.3	7.3	6.9	12.9	14.2	21.0	13.9	13.3	1.2	100.0
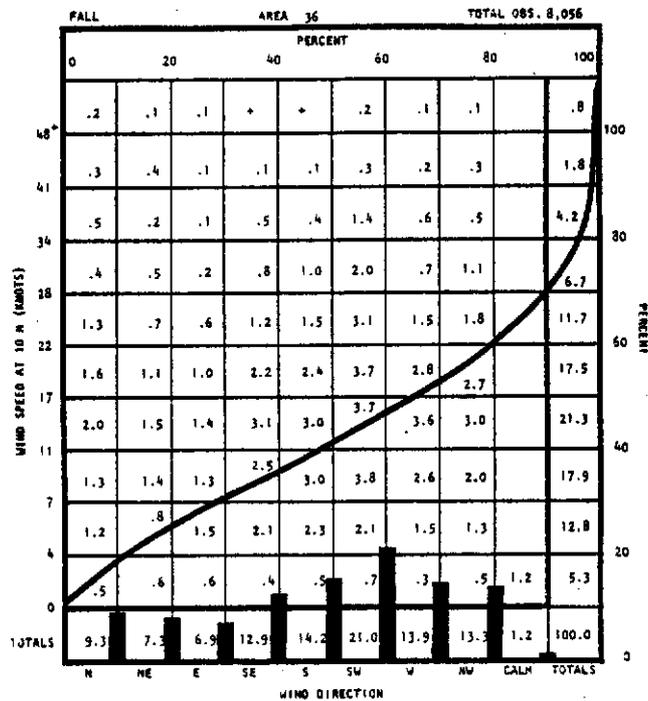
WIND DIRECTION

Figure D-36-5-3 Significant Wave
Height by Wave Direction

Figure D-36-5-4 Wind Speed by
Wind Direction

TABLE D-38-1-1 - SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual*; Location: Northern Baltic Sea, 60.5° N, 18.9° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	1	2.5	1	1
Wave Period, sec	1.5	4	6.5	4	3.5
Direction	-	-	-	-	-
Winds					
Speed, knots	2	10	27	11	11
Corresponding Mean Sig. Wave Height, m.	.5	1	2.5	1	1
Direction	-	-	-	-	N - NW
Visibility, nautical miles	2	10	25	10	10
Cloud Cover					
Total clouds, in eighths of sky obscured	Nil	5	8	4.5	Nil
Low clouds, in eighths of sky obscured	Nil	4.5	8	4	Nil
Precipitation (Occurrence)	All precipitation - 9.3% of the time		Snow - 4% of the time (Nov - Dec)		
Relative Humidity, %	73	90	97	88	95
Air Temperature, °C	4	9	13.5	10.5	-
Surface Water Temperature, °C	3.5	10.5	16.5	8.5	-
Sea Level Pressure, millibars	994	1,013	1,027	1,013	1,013
Ice	Moderate superstructure icing - 20% of the time (December)				
Refractivity					
Mean Surface Refractivity	-	-	-	317	-
Sub-Refraction (1 km, Annual)	-	-	-	-	1% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	1% of the time

*Annual data reported herein is for the period of May through December only.

ANNUAL   AREA 38   TOTAL OBS. 203
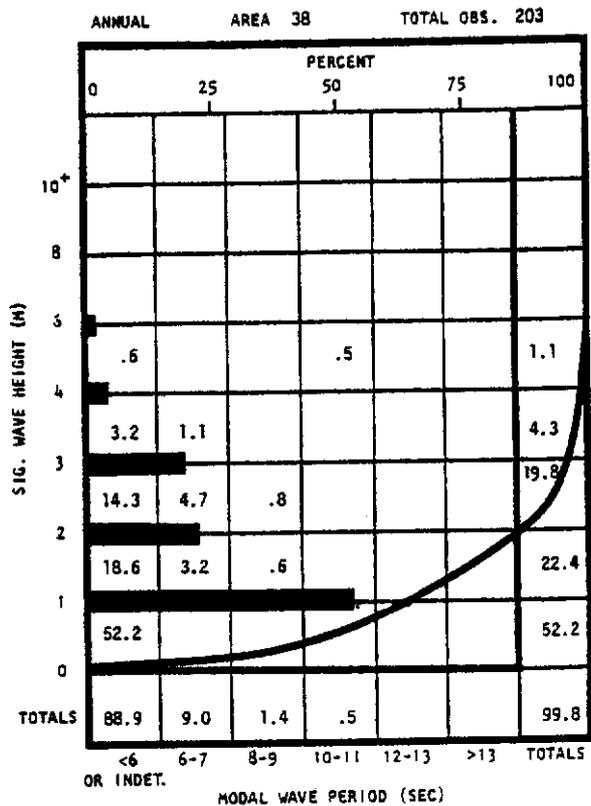
Figure D-38-1-1 Significant Wave Height by Modal Wave Period

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
5	.6		.5				1.1
4	3.2	1.1					4.3
3	14.3	4.7	.8				19.8
2	18.6	3.2	.6				22.4
1	52.2						52.2
TOTALS	88.9	9.0	1.4	.5			99.8

MODAL WAVE PERIOD (SEC)

ANNUAL   AREA 38   TOTAL OBS. 152
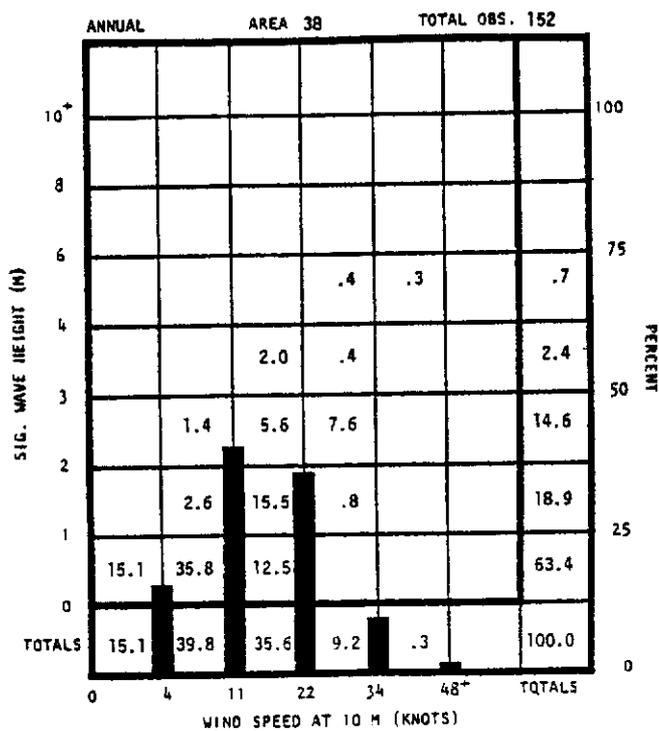
Figure D-38-1-2 Significant Wave Height by Wind Speed

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
6			.4	.3			.7
4			2.0	.4			2.4
3		1.4	5.6	7.6			14.6
2		2.6	15.5	.8			18.9
1	15.1	35.8	12.5				63.4
TOTALS	15.1	39.8	35.6	9.2	.3		100.0

WIND SPEED AT 10 M (KNOTS)

NOT AVAILABLE
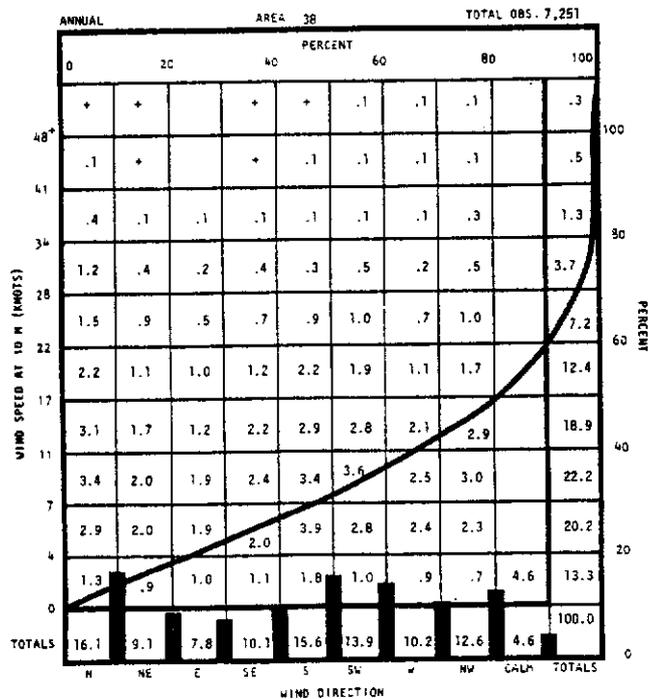
Figure D-38-1-3 Significant Wave Height by Wave Direction

ANNUAL   AREA 38   TOTAL OBS. 7,251

Figure D-38-1-4 Wind Speed by Wind Direction

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	+	+		+	+	.1	.1	.1		.3
41	.1	+		+	.1	.1	.1	.1		.5
34	.4	.1	.1	.1	.1	.1	.1	.3		1.3
28	1.2	.4	.2	.4	.3	.5	.2	.5		3.7
22	1.5	.9	.5	.7	.9	1.0	.7	1.0		7.2
17	2.2	1.1	1.0	1.2	2.2	1.9	1.1	1.7		12.4
11	3.1	1.7	1.2	2.2	2.9	2.8	2.1	2.9		18.9
7	3.4	2.0	1.9	2.4	3.4	3.6	2.5	3.0		22.2
4	2.9	2.0	1.9	2.0	3.9	2.8	2.4	2.3		20.2
0	1.3	.9	1.0	1.1	1.8	1.0	.9	.7	4.6	13.3
TOTALS	16.1	9.1	7.8	10.1	15.6	13.9	10.2	12.6	4.6	100.0

WIND DIRECTION

Figure D-38-2-1 (WINTER AREA 38 TOTAL OBS. 38)

Significant Wave Height (M) by Modal Wave Period (SEC), PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6	5.2						5.2
4	7.9						7.9
3	13.1	5.3	2.6				21.0
2	21.1	7.9					29.0
1	36.9						36.9
TOTALS	84.2	13.2	2.6				100.0

Figure D-38-2-1 Significant Wave
Height by Modal Wave Period

Figure D-38-2-2 (WINTER AREA 38 TOTAL OBS. 33)

Significant Wave Height (M) by Wind Speed at 10 M (KNOTS), PERCENT

| SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4				3.0	3.0		6.0
3				6.1	3.0		9.1
2			3.0	9.1	6.1		18.2
1			3.0	15.2	6.0		24.2
0	9.1	18.2	15.2				42.5
TOTALS	9.1	24.2	45.6	18.1	3.0		100.0
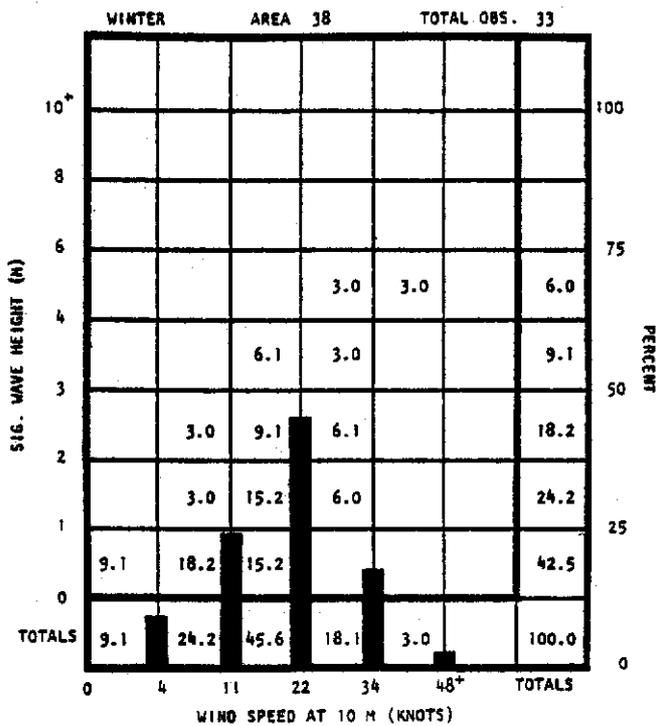
Figure D-38-2-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
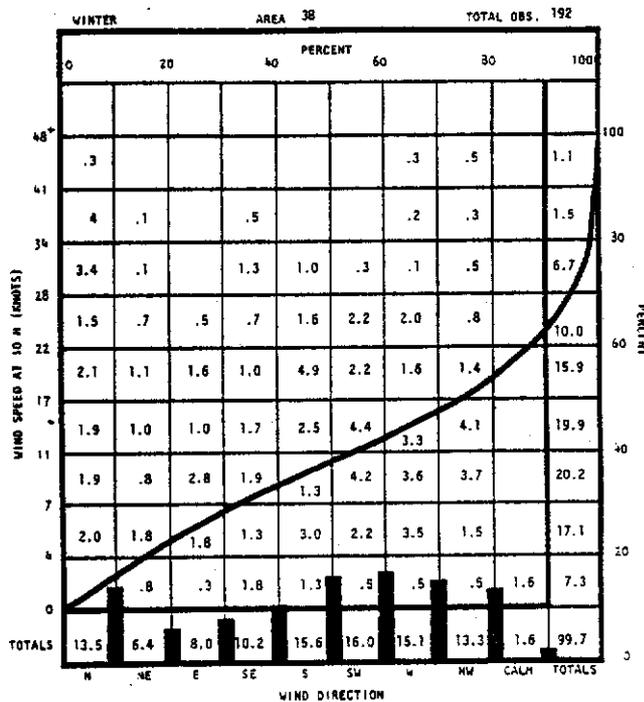
Figure D-38-2-3 Significant Wave
Height by Wave Direction

Figure D-38-2-4 (WINTER AREA 38 TOTAL OBS. 192)

Wind Speed at 10 M (KNOTS) by Wind Direction, PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.3					.3	.5			1.1
41	.4	.1		.5		.2	.3			1.5
34	3.4	.1		1.3	1.0	.3	.1	.5		6.7
28	1.5	.7	.5	.7	1.6	2.2	2.0	.8		10.0
22	2.1	1.1	1.6	1.0	4.9	2.2	1.6	1.4		15.9
17	1.9	1.0	1.0	1.7	2.5	4.4	3.3	4.1		19.9
11	1.9	.8	2.8	1.9	1.3	4.2	3.6	3.7		20.2
7	2.0	1.8	1.8	1.3	3.0	2.2	3.5	1.5		17.1
4		.8	.3	1.8	1.3	.5	.5	.5	1.6	7.3
TOTALS	13.5	6.4	8.0	10.2	15.6	16.0	15.1	13.3	1.6	99.7

Figure D-38-2-4 Wind Speed by
Wind Direction
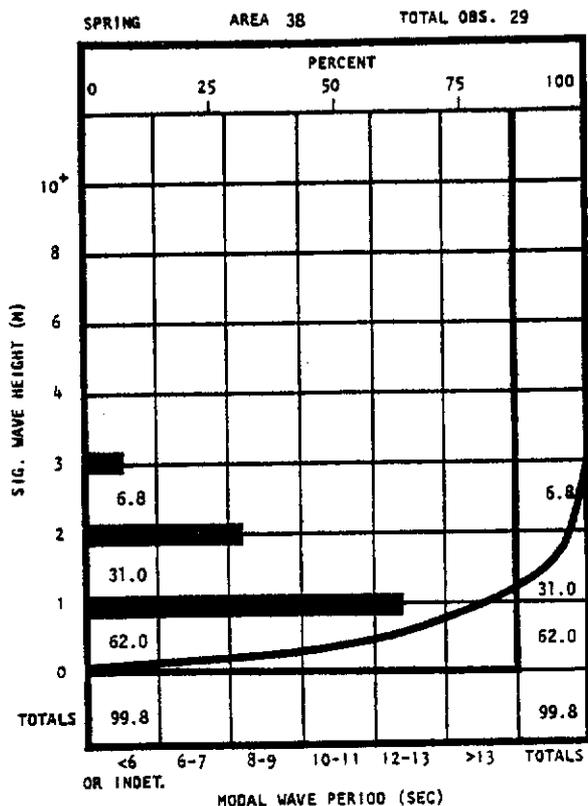
Figure D-38-3-1 Significant Wave
Height by Modal Wave Period
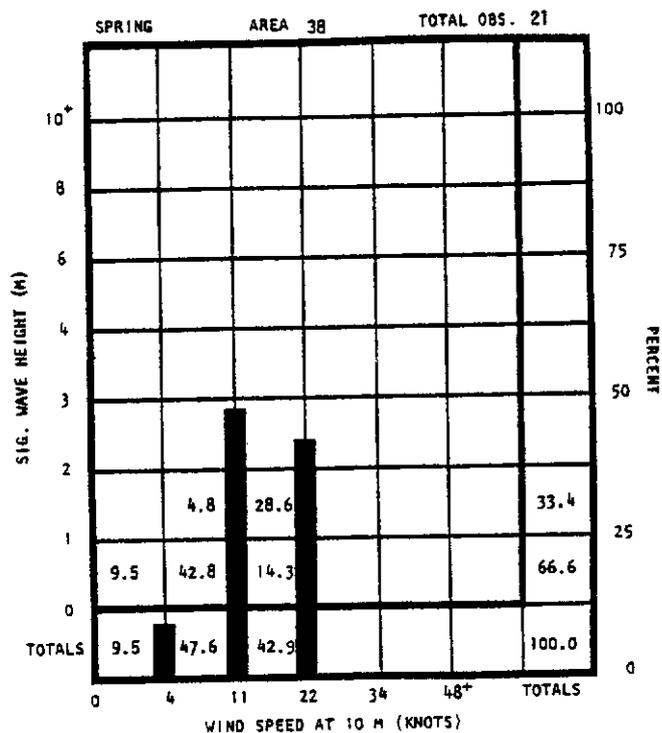
Figure D-38-3-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure D-38-3-3 Significant Wave
Height by Wave Direction
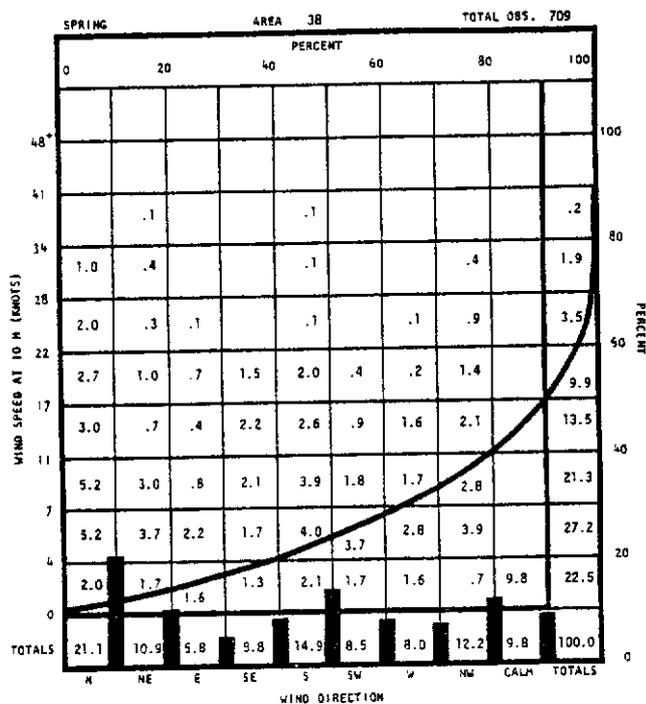
Figure D-38-3-4 Wind Speed by
Wind Direction
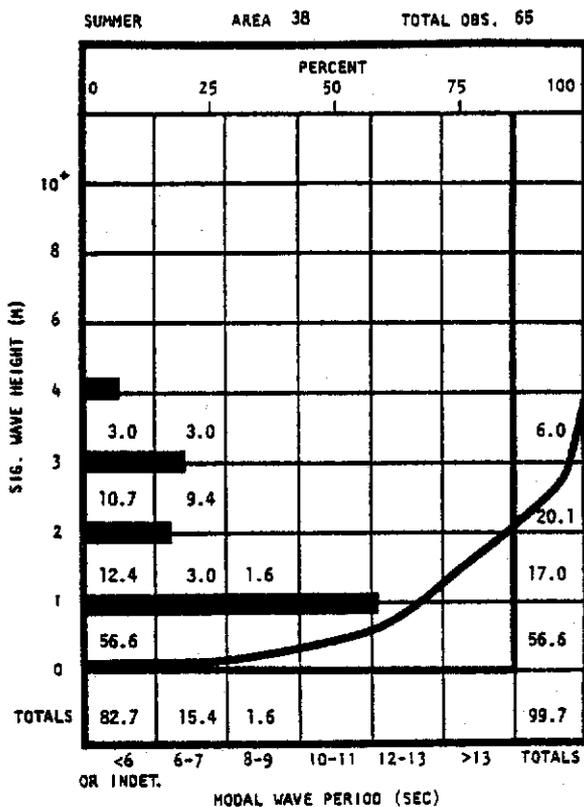
N A T O   U N C L A S S I F I E D

Figure D-38-4-1 Significant Wave
Height by Modal Wave Period
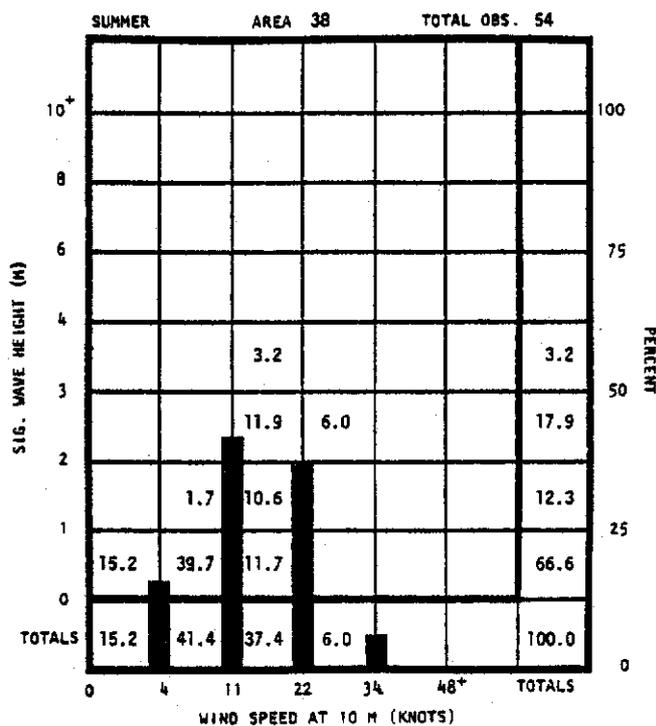
Figure D-38-4-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
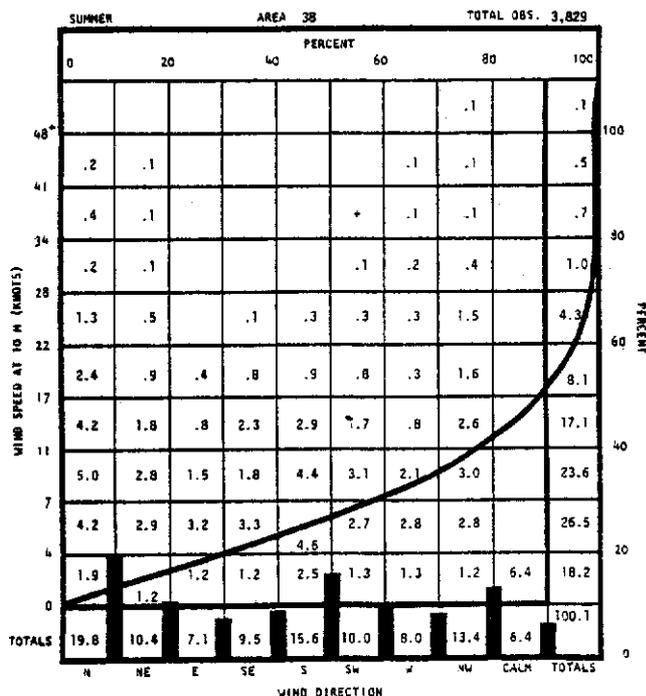
Figure D-38-4-3 Significant Wave
Height by Wave Direction

Figure D-38-4-4 Wind Speed by
Wind Direction

FALL   AREA 38   TOTAL OBS. 71

SIG. WAVE HEIGHT (M) by MODAL WAVE PERIOD (SEC), PERCENT

SIG. WAVE HEIGHT (M)	<6 OR INDET.	6-7	8-9	10-11	12-13	>13	TOTALS
6							
4			1.3				1.3
3	2.8						2.8
2	20.9	1.4	1.4				23.7
1	19.8	2.8					22.6
0	49.6						49.6
TOTALS	93.1	4.2	1.4	1.3			
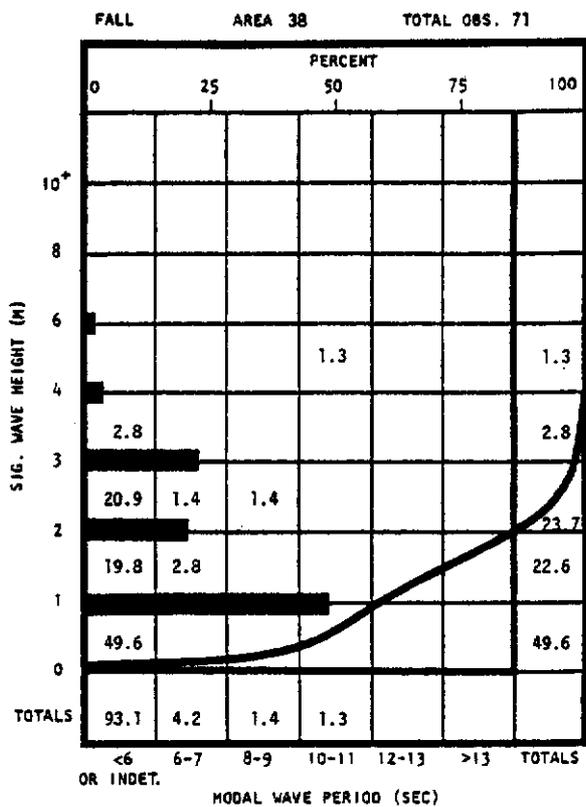
Figure D-38-5-1 Significant Wave Height by Modal Wave Period

FALL   AREA 38   TOTAL OBS. 44

SIG. WAVE HEIGHT (M) by WIND SPEED AT 10 M (KNOTS)

SIG. WAVE HEIGHT (M)	0	4	11	22	34	48+	TOTALS
4				5.5			5.5
3			2.8	6.9			9.7
2		2.8	16.0				18.8
1	18.8	35.4	11.8				66.0
TOTALS	18.8	41.0	27.8	12.4			100.0
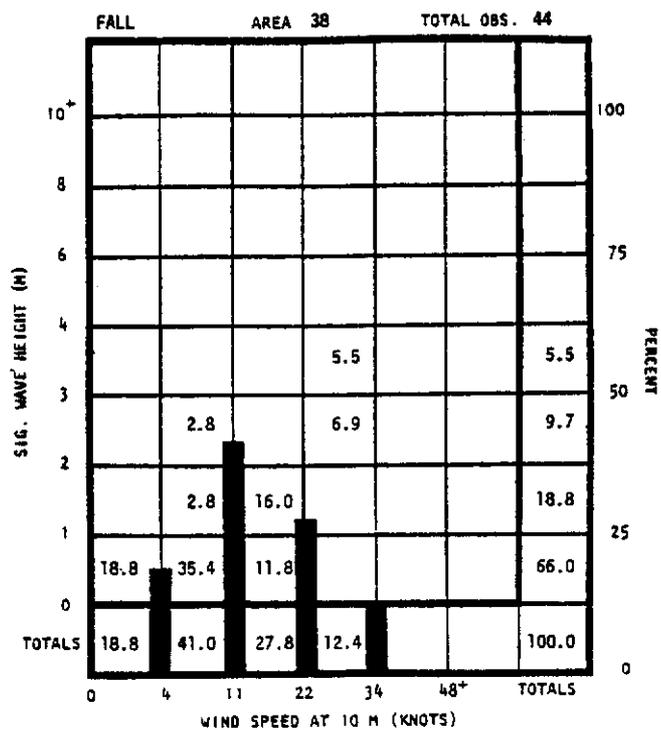
Figure D-38-5-2 Significant Wave Height by Wind Speed

NOT AVAILABLE

FALL   AREA 38   TOTAL OBS. 2,521

WIND SPEED AT 10 M (KNOTS) by WIND DIRECTION, PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	CALM	TOTALS
48+	.1	.1	.		.1	+				.3
41	.1	.1		.1	.1	.1				.5
34	.3	.3	.3	.1	.4	.5	.2	.2		2.3
28	1.2	1.2	.5	.5	.2	2.1	.7	.3		6.7
22	1.1	.8	1.0	1.1	1.9	2.2	.8	.7		9.6
17	1.7	1.9	.7	2.2	3.1	3.2	1.8	1.3		15.3
11	2.4	1.3	1.5	2.8	3.0	4.7	3.5	2.3		21.5
7	3.1	2.2	2.2	3.0	3.2	4.2	2.8	2.5		23.2
4	1.6	1.0	1.5	1.2	2.5	2.9	2.4	1.7		14.8
0	.3	.1	.4	.6	.9	.5	.2	.1	2.1	5.2
TOTALS	11.9	9.0	8.1	11.6	15.4	20.4	12.4	9.1	2.1	100.0
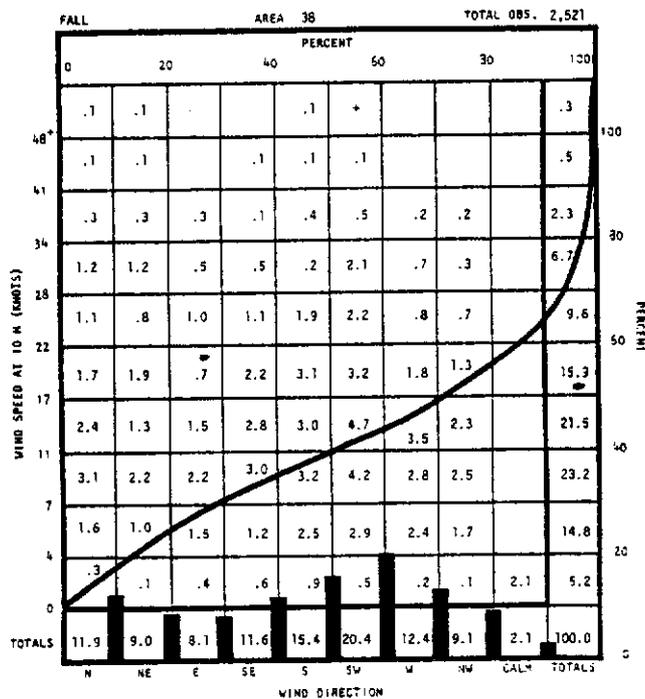
Figure D-38-5-3 Significant Wave Heighy by Wave Direction

Figure D-38-5-4 Wind Speed by Wind Direction

APPENDIX E
SEASONAL CLIMATOLOGY OF THE BLACK SEA

The following data graphs are derived from Reference 14. This Appendix con-
tains the wind and wave data for the more western portion of the basin only because
wind speeds and wave heights are statistically less severe in the more eastern
regions.
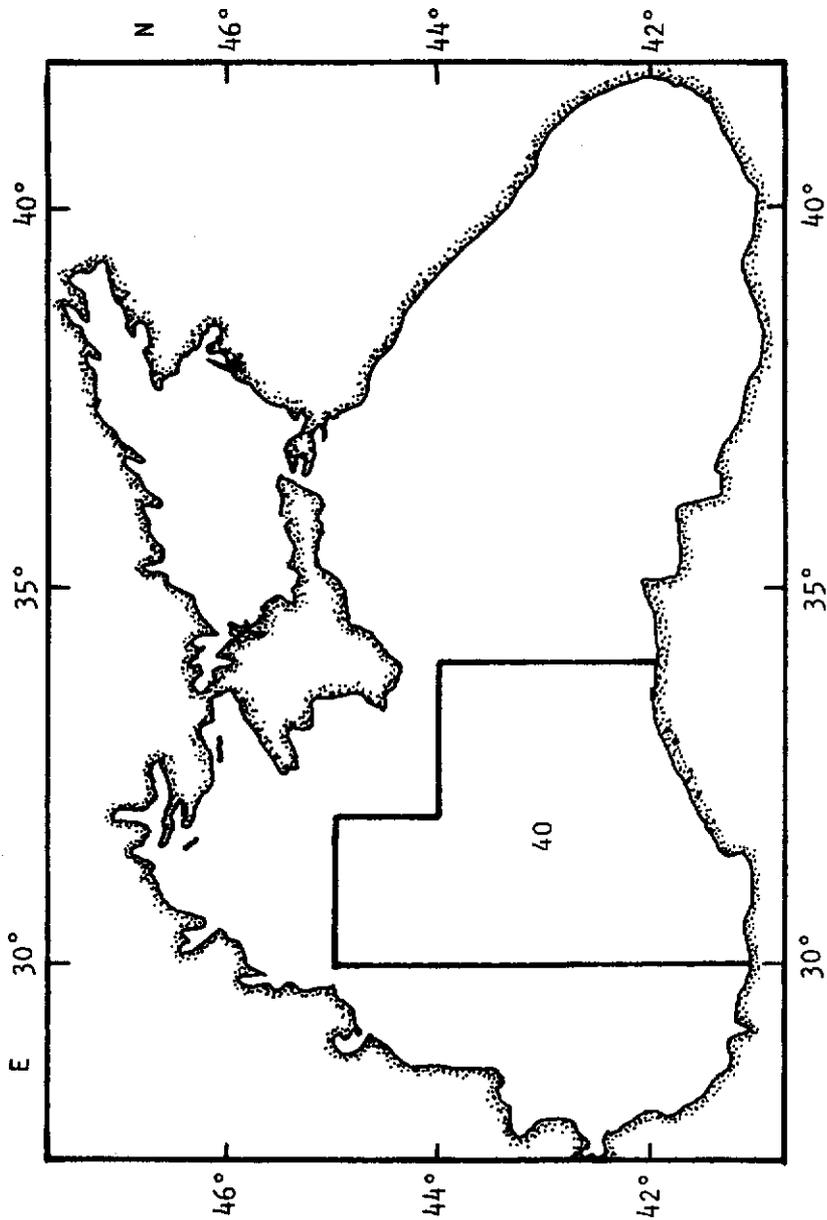
Figure E-1- Definition of Representative Area in the Black Sea

TABLE E-40-1-1 – SURFACE NATURAL ENVIRONMENT SUMMARY

Season: Annual; Location: Black Sea, 43° N, 32° E

Natural Environment	Minimum (5 Percentile)	Median (50 Percentile)	Maximum (95 Percentile)	Mean	Most Probable
Sea Surface					
Sig. Wave Height, m.	.5	2	4	2	1.5
Wave Period, sec	1.5	3	7	3	2.5
Direction	-	-	-	-	-
Winds					
Speed, knots	3	10	25	11	9
Corresponding Mean Sig. Wave Height, m.	.5	2	3.5	2	2
Direction	-	-	-	-	NE - E
Visibility, nautical miles	-	-	-	-	-
Cloud Cover					
Total clouds, in eighths of sky obscured	Data not available				
Low clouds, in eighths of sky obscured					
Precipitation (Occurrence)					
Relative Humidity, %					
Air Temperature, °C					
Surface Water Temperature, °C					
Sea Level Pressure, millibars					
Ice					
Refractivity					
Mean Surface Refractivity	-	-	-	332	-
Sub-Refraction (1 km, Annual)	-	-	-	-	7% of the time
Super-Refraction or Ducting (1 km, Annual)	-	-	-	-	2% of the time

Figure E-40-1-1 Significant Wave
Height by Modal Wave Period

Figure E-40-1-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure E-40-1-3 Significant Wave
Height by Wave Direction
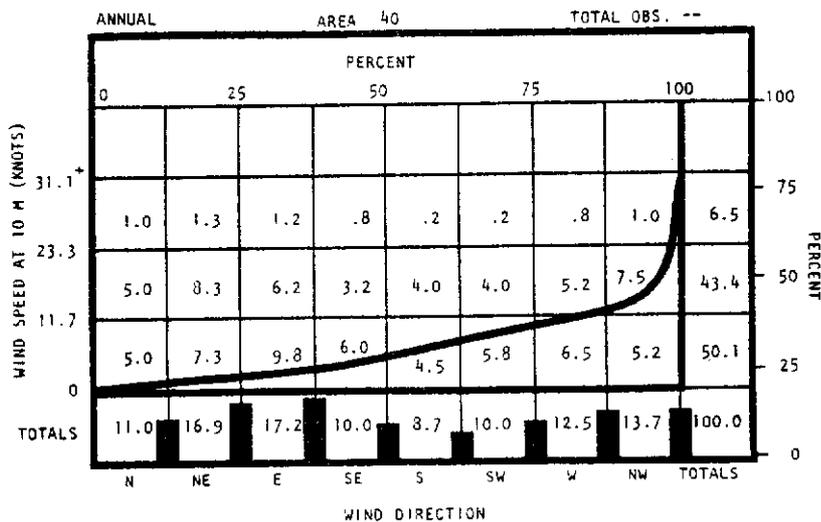
Figure E-40-1-4 Wind Speed by
Wind Direction
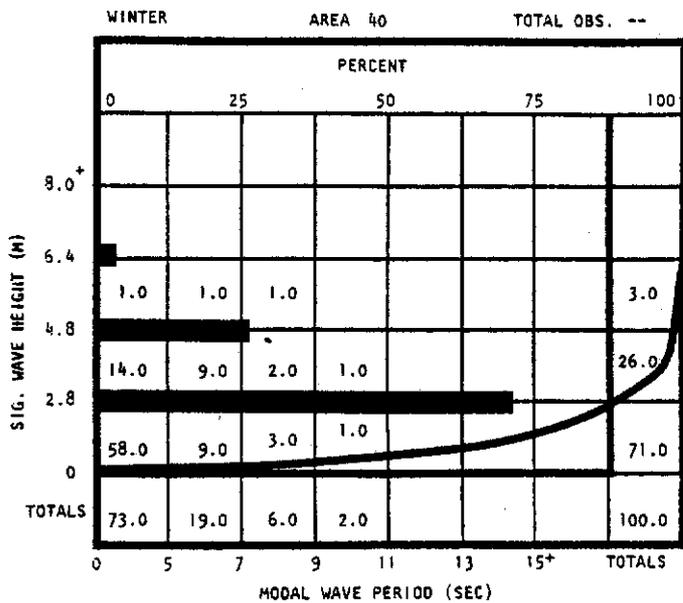
Figure E-40-2-1 Significant Wave
Height by Modal Wave Period
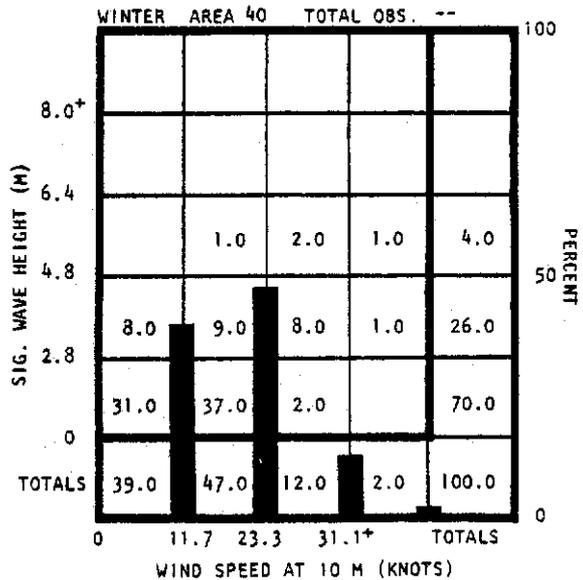
Figure E-40-2-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
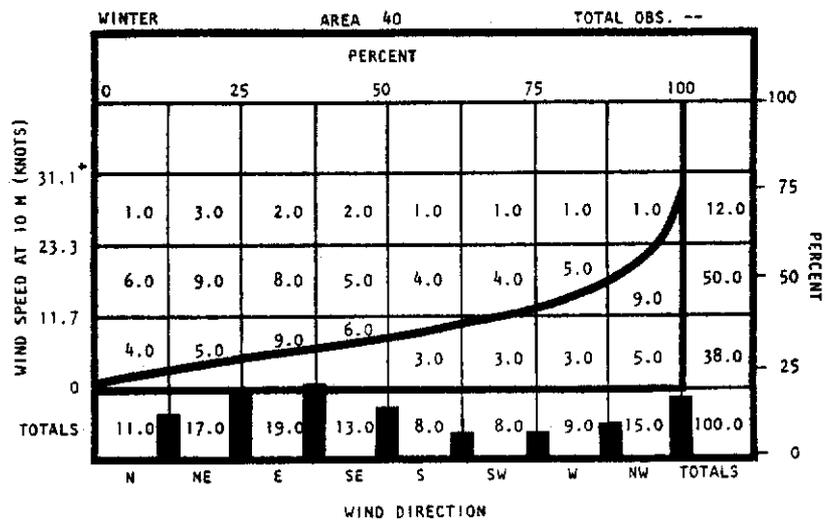
Figure E-40-2-3 Significant Wave
Height by Wave Direction

Figure E-40-2-4 Wind Speed by
Wind Direction
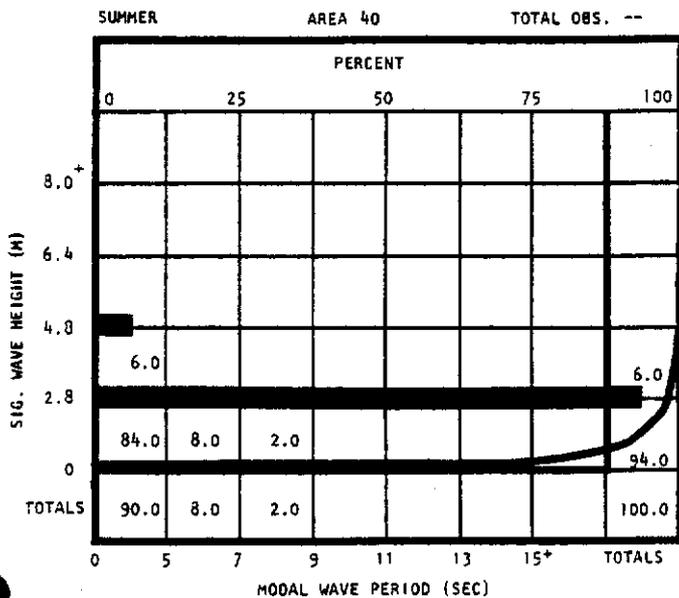
Figure E-40-3-1 Significant Wave
Height by Modal Wave Period
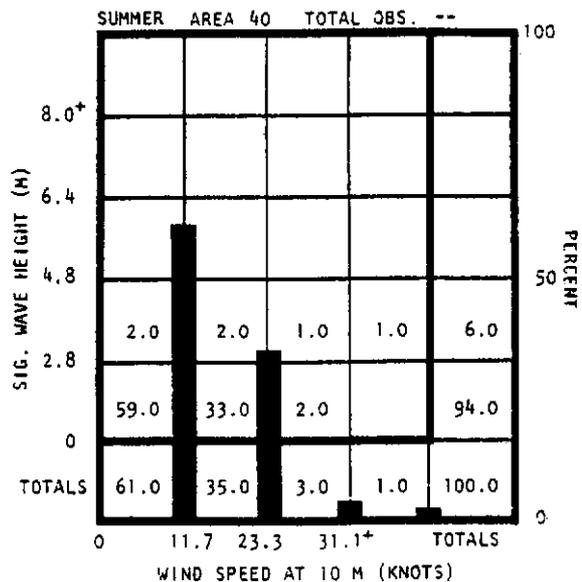
Figure E-40-3-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
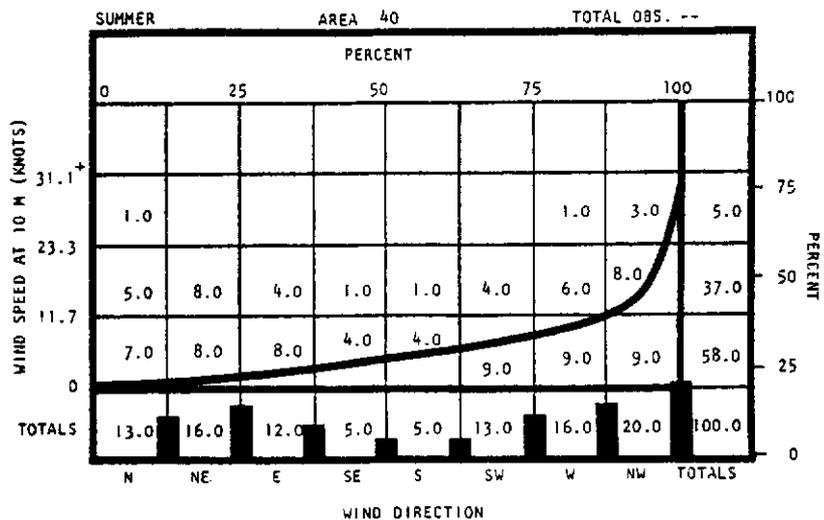
Figure E-40-3-3 Significant Wave
Height by Wave Direction

Figure E-40-3-4 Wind Speed by
Wind Direction
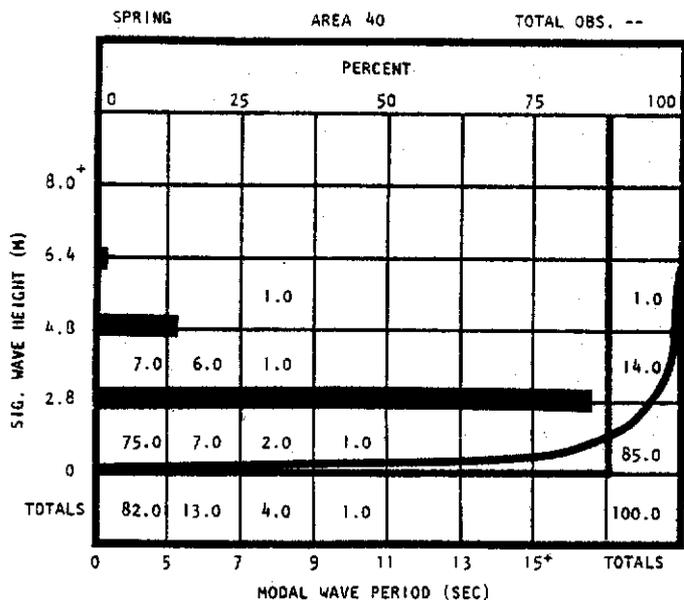
Figure E-40-4-1 Significant Wave
Heighy by Modal Wave Period
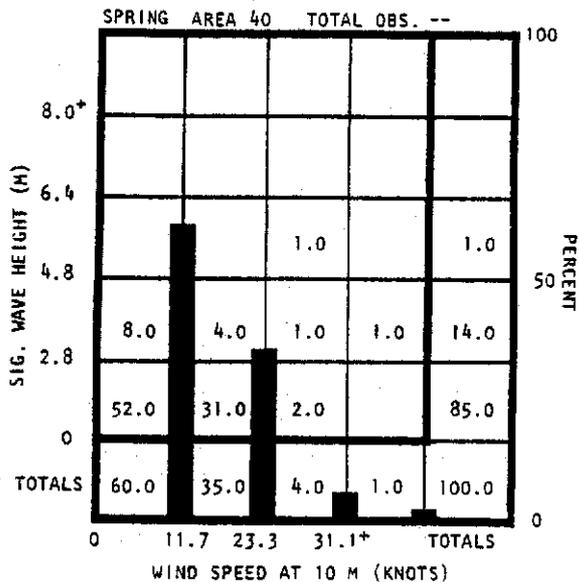
Figure E-40-4-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE
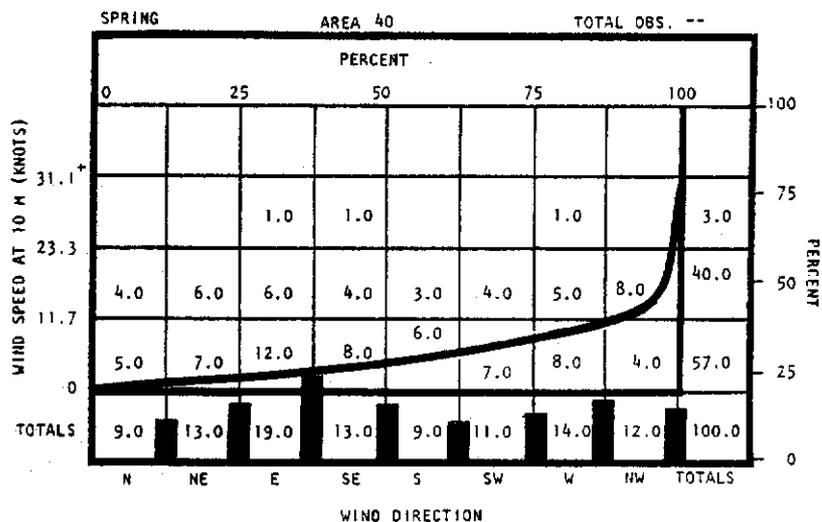
Figure E-40-4-3 Significant Wave
Height by Wave Direction

Figure E-40-4-4 Wind Speed by
Wind Direction

FALL · AREA 40 · TOTAL OBS. --

PERCENT

SIG. WAVE HEIGHT (M)	0	5	7	9	11	13	15+	TOTALS
8.0+								
6.4	1.0	1.0	1.0					3.0
4.8	9.0	4.0	1.0					14.0
2.9	77.0	4.0	2.0					83.0
0								
TOTALS	87.0	9.0	4.0					100.0

MODAL WAVE PERIOD (SEC)
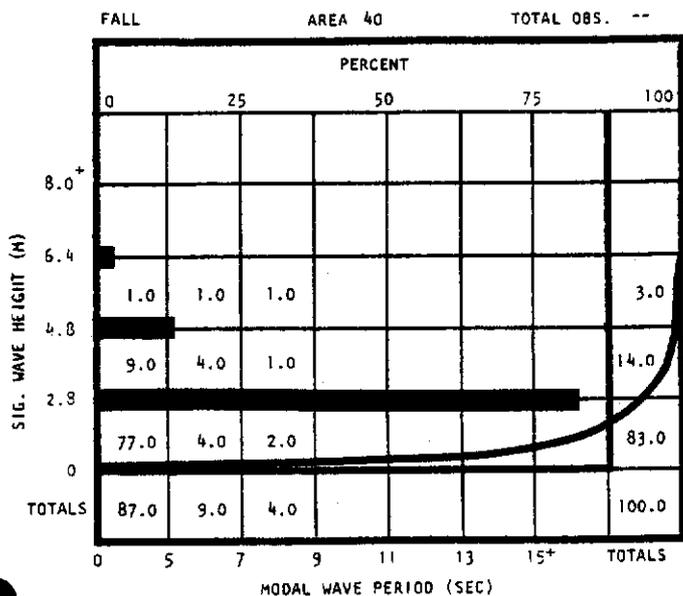
Figure E-40-5-1 Significant Wave
Height by Modal Wave Period

FALL   AREA 40   TOTAL OBS.--

SIG. WAVE HEIGHT (M)	0	11.7	23.3	31.1+	TOTALS
8.0+					
6.4					
4.8			1.0	1.0	2.0
2.8	8.0	4.0	2.0	1.0	15.0
0	42.0	37.0	4.0		83.0
TOTALS	50.0	41.0	7.0	2.0	100.0

WIND SPEED AT 10 M (KNOTS)
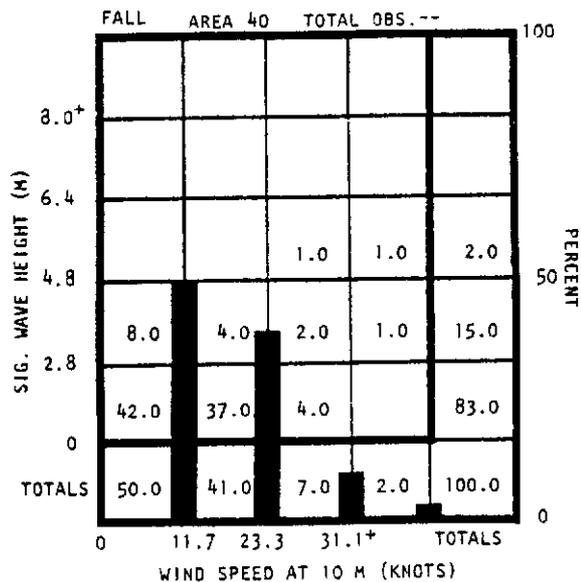
Figure E-40-5-2 Significant Wave
Height by Wind Speed

NOT AVAILABLE

Figure E-40-5-3 Significant Wave
Height by Wave Direction

FALL   AREA 40   TOTAL OBS. --

PERCENT

WIND SPEED AT 10 M (KNOTS)	N	NE	E	SE	S	SW	W	NW	TOTALS
31.1+	2.0	2.0	2.0						6.0
23.3	5.0	10.0	7.0	3.0	8.0	4.0	5.0	5.0	47.0
11.7	4.0	9.0	10.0	6.0					47.0
0					5.0	4.0	6.0	3.0	
TOTALS	11.0	21.0	19.0	9.0	13.0	8.0	11.0	8.0	100.0
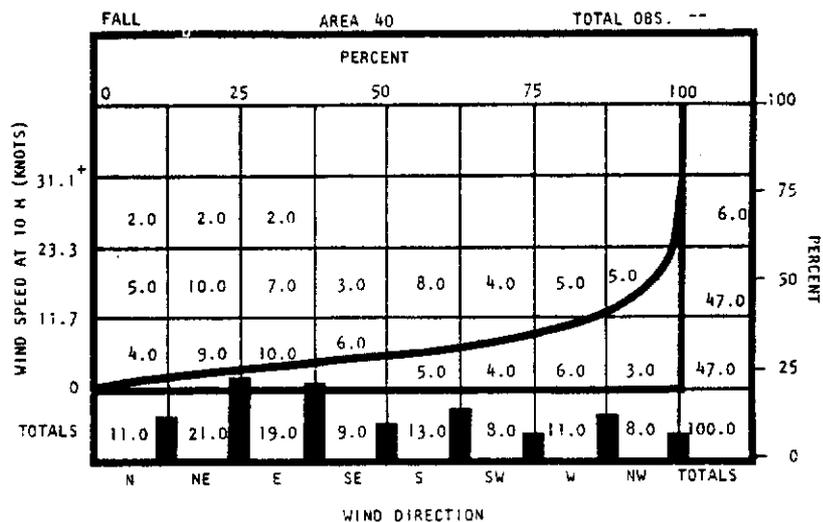
WIND DIRECTION

Figure E-40-5-4 Wind Speed by
Wind Direction

APPENDIX F
DATA FORMAT DESCRIPTION

Appendices A through E contain, where possible, the following natural environment data distributions for their respective oceanographic location:

    I.   Surface Natural Environment Summary

  II.   Waves and Wind

       1.   Significant wave height vs. modal wave period

       2.   Significant wave height vs. wind speed

       3.   Significant wave height vs. primary wave direction

       4.   Wind speed vs wind direction

       5.   Significant wave height vs. wind speed (WMO Standard Sea State Chart)

 III.   Persistence

       6.   Significant wave height vs. duration

       7.   Wind speed vs. duration

A description of each of the standard graph types is now given. These descriptions should be referred to in interpreting the data presented in Appendices A through E. Generally, a "standard" format has been adhered to for each environmental parameter at each ocean location. However, due to the multiplicity of data sources, some exceptions do exist. These are clearly annotated as they occur within each appendix. Each figure is identified by a code as detailed in Figure F-1.

I.   Surface Natural Environment Summary

This table, given for individual ocean or sea areas, summarizes the total natural environment by listing mean, median, most probable, minimum, and maximum values for the various environmental parameters. Ninety-five percent of all natural environment values exceed minimum values, while 5 percent of all natural environment values exceed maximum values. Thus, 90 percent of all values fall within the minimum to maximum value range. The median is the value where above or below lie an equal number of all parameter values. The mean is the average of all values, while the most probable is the one which occurs most often. Together, these parameters provide an idea of the "shape" of the distribution of occurrences. For example, if the most probable value is less than the mean, the distribution of occurrences is skewed to the lower values. If the most probable value is greater than the mean, the distribution of all occurrences is skewed to the higher values. If the most probable and mean values coincide, the distribution of occurrences may be of the normal type. It should be noted that the 5 and 95 percentiles and the median are slightly higher than indicated using the cumulative curves (about one-half of bin width) described below, which were inadvertently plotted to bin mid-points rather than end-points.

II. Waves and Wind

1. Significant wave height by modal wave period* offers three presentations
in one graph:

a. A cumulative distribution of wave heights (plotted to the mid-point of
each height range) is shown via a smooth curve relative to the top and left
scales

b. The typed numbers indicate percentage of data within various period
(bottom scale) and height (left scale) combinations

c. The total percentage frequency in various significant wave height
intervals is indicated by bar graphs with reference to the left and top scales
of the chart

2. Significant wave height by wind speed is presented in this set of graphs:

a. The percentage frequency of wind speed in various significant wave
height intervals is indicated by bar graphs with reference to the bottom and
right scales of the chart

b. The typed numbers indicate percentage of data within various period
(bottom scale) and height (left scale) combinations

Direction (right scale): Bars represent total percentage frequency of
occurrence of significant wave heights measured from each direction.
Height (left scale): Types numbers represent percentage frequency of sig-
nificant wave height measured from each direction.
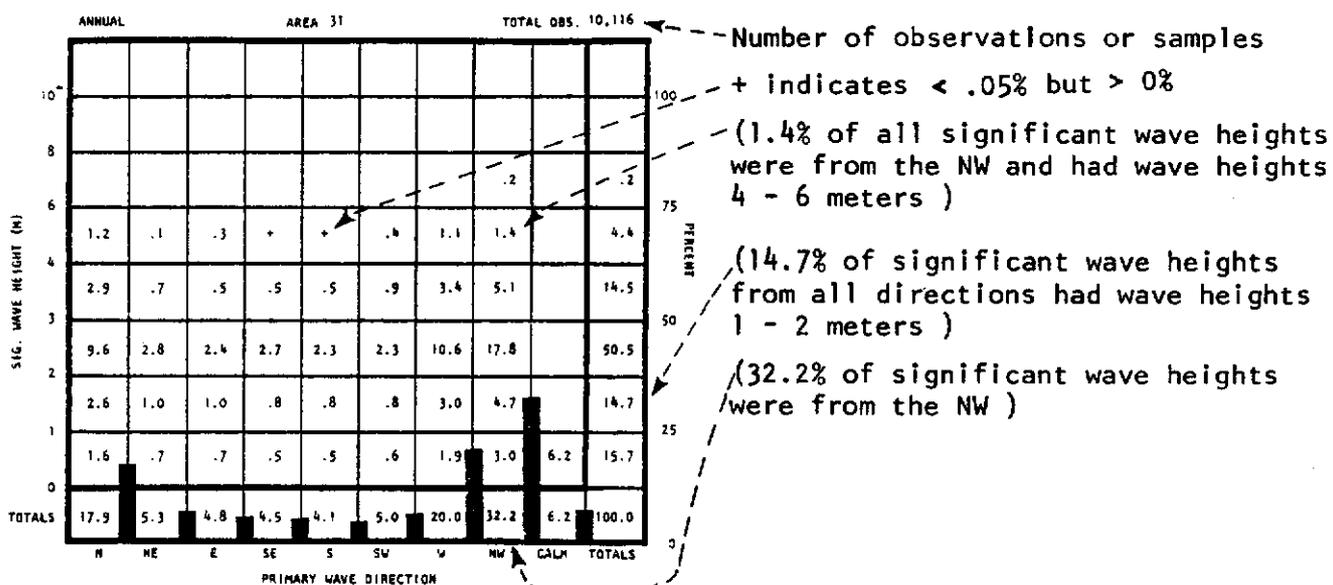
*Periods correspond to the peak of total (density) directional spectrum.

3. Significant wave height by primary wave direction is portrayed by use of a single graph. (The legend on last page illustrates use of the graph.)

4. Wind speed by wind direction is presented in a manner similar to the preceding graph. In addition, a cumulative distribution (plotted to the mid-point of each speed range) of wind speeds is shown via smooth curve relative to the top and left scales.

5. In Appendices A and C, significant wave height by wind speed is displayed in terms of the World Meteorological Organization (WMO) Sea State Numeral definition, defined in the first three columns of Table F-1,* see References 20 to 22. Percentage frequencies of joint occurrence of wind speed and wave heights are presented. The darkly outlined squares indicate the percentage of occurrences in each actual sea state by wave height and wind speed. The data outside of the darkened squares may indicate incoming swell, locally decaying seas, or locally growing seas, and by the scatter are indicative of the inadequacies associated with sea state numerals.

III. Persistence

These tables present the persistence or duration of wave heights (Figure 6) and wind speeds (Figure 7) in terms of occurrences of events within a range of values for a certain number of hours. The parameter values (wave height or wind speed) are shown on the left scale, and the duration in hours is on the bottom scale. The minimum duration is 6 hours which is also the time increment of the data summarized. The figures indicate the number of events of each wave height or wind speed which continued for the number of hours shown in the column. The percentage of events within each time interval is portrayed by the weighted bar graph with reference to the right and bottom scales of the chart.

The persistence tables were derived from the Ten Year Hindcast Climatology. For purposes of computing the events for each combination of time and parameter value, a data record was assumed to be one season; i.e., a winter data record begins in December and ends in February. Therefore any persistence of a parameter value from the end of one season into the next is not accounted for because the data record ended with the end of the season.

---

*Table F-1 provides wave statistics derived from the Ten Year Hindcast Climatology for the annual open ocean North Atlantic for the regions defined in Figure 2 of the main text. The data of Appendix A were used to develop this table. The WMO Sea State Numeral Definition is adopted as the NATO standard herein.

Figure Number   Figure A - 17 - 1 - 1
                                                  └─Figure Number
                                            └─ Season
                                      └─ Area Number
                          └─Appendix
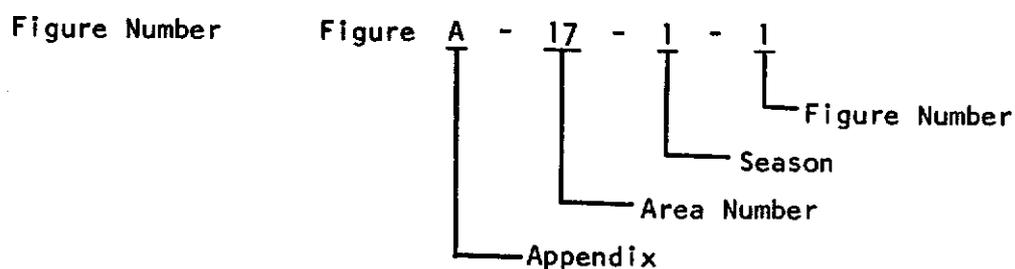
Appendix	Area Number	Season	Figure Number
A - North Atlantic Ocean	0,00,1,2,6,7,10, 11,16,17	1 - Annual	1 through 7
B - Mediterranean Sea	29,30,31	2 - Winter	
C - North Sea	4	3 - Spring	
D - Baltic Sea	32,34,36,38	4 - Summer	
E - Black Sea	40	5 - Fall	

Figure F-1 - Figure Number Coding System

TABLE F-1 – NATO SEA STATE NUMERAL TABLE FOR THE OPEN OCEAN NORTH ATLANTIC

Sea State Number	Significant Wave Height (m)		Sustained Wind Speed (Knots)*		Percentage Probability of Sea State	Modal Wave Period (sec)	
	Range	Mean	Range	Mean		Range**	Most Probable***
0 – 1	0 – 0.1	0.05	0 – 6	0.5	0	—	—
2	0.1 – 0.5	0.3	7 – 10	3.5	7.2	3.3 – 12.8	7.5
3	0.5 – 1.25	0.88	11 – 16	8.5	22.4	5.0 – 14.8	7.5
4	1.25 – 2.5	1.88	17 – 21	19	28.7	6.1 – 15.2	8.8
5	2.5 – 4	3.25	22 – 27	24.5	15.5	8.3 – 15.5	9.7
6	4 – 6	5	28 – 47	37.5	18.7	9.8 – 16.2	12.4
7	6 – 9	7.5	48 – 55	51.5	6.1	11.8 – 18.5	15.0
8	9 – 14	11.5	56 – 63	59.5	1.2	14.2 – 18.6	16.4
> 8	> 14	> 14	> 63	> 63	< 0.05	15.7 – 23.7	20.0

*Ambient wind sustained at 19.5 m above surface to generate fully-developed seas. To convert to another altitude, H_2, apply $V_2 = V_1 (H_2/19.5)^{1/7}$

**Minimum is 5 percentile and maximum is 95 percentile for periods given wave height range.

***Based on periods associated with central frequencies included in Hindcast Climatology.

APPENDIX G

RELATIVE WIND ENVELOPES
FOR
VTOL AIRCRAFT OPERATIONS

For Vertical Takeoff and Landing (VTOL) aircraft, a generic relative wind (over deck) envelope, originally developed in Reference 23 is given in Figure G-1. The wind envelope, derived from References 24 and 25, represents the limits of relative wind speed, with respect to relative heading into which the aircraft can be launched or recovered. Launch or recovery outside of the envelope results in unacceptable crosswind or turbulence for safe efficient operation. By mapping this envelope onto the plane of possible ship speeds and headings for mean sustained ambient winds*, operating envelopes for relative wind are defined for launch and recovery operations, see Figure G-2. The limit lines (identified by tick marks and the arbitrary numerical key of 1.5) define the operating envelopes due to relative wind. The operating area is within the "non-ticked" region.

The effect of applying the relative wind envelope of Figure G-2 is to limit the combination of ship headings and speeds at which operations may continue. One example of this is given in Figure G-3. The shaded region indicates that region in which VTOL aircraft may operate in the prevailing seaway. While this example is somewhat conservative (in reality the aircraft on large flat-top ships can be rotated to virtually eliminate relative wind as a consideration), it serves to illustrate the effect of wind alone on VTOL operations. One would expect the effect for operations off frigates and destroyers to be notable.

---

*The mean sustained ambient winds used here are 18, 22, and 28.5 knots which correspond to about a median Sea State 4, a low Sea State 5, and a low Sea State 6. It is considered unlikely that VTOL operations would be conducted in higher winds than these, nor should there be substantial degradation of operations, e.g., due to ship motions, in lesser sea conditions. However, it is noted that closer to the water surface (e.g., < 19.5 m), the average winds would be lessened.

DIRECTION
OF
SHIP
HEADING

310°

50°

**40 Kt.
RELATIVE WIND**

**20 Kt.
RELATIVE WIND**

GENERIC VTO
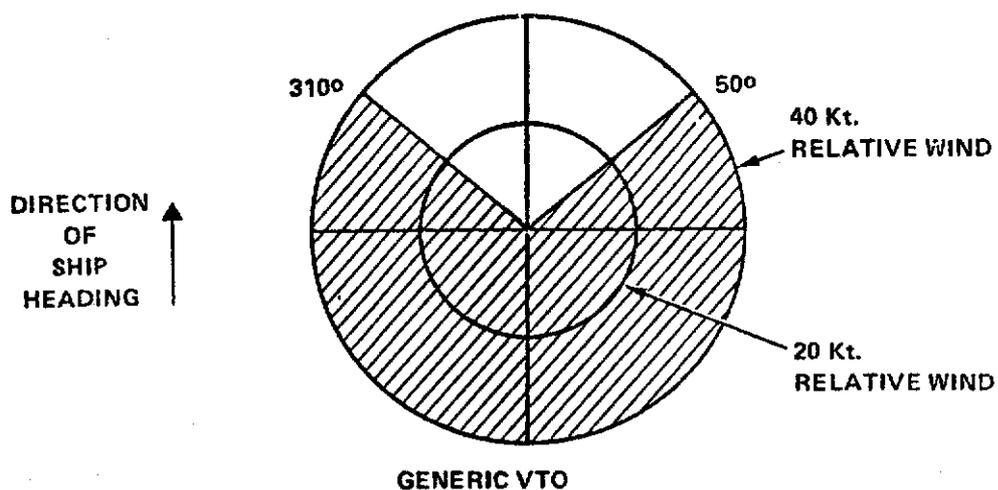
Figure G-1 - Generic Relative Wind Envelope for Vertical Takeoff and
Landing (VTOL) Aircraft Operations
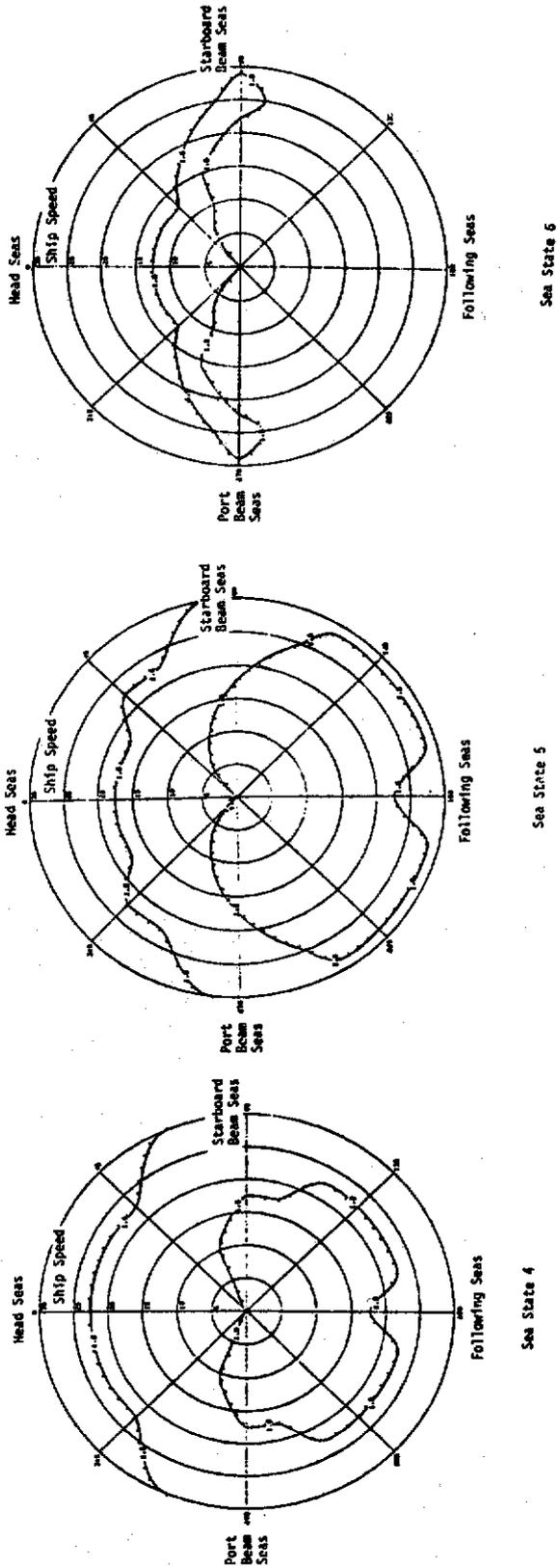
Figure G-2 - VTOL Relative Wind Envelopes for Sea States Median 4, Low 5, and Low 6 in the Ship Speed Plane
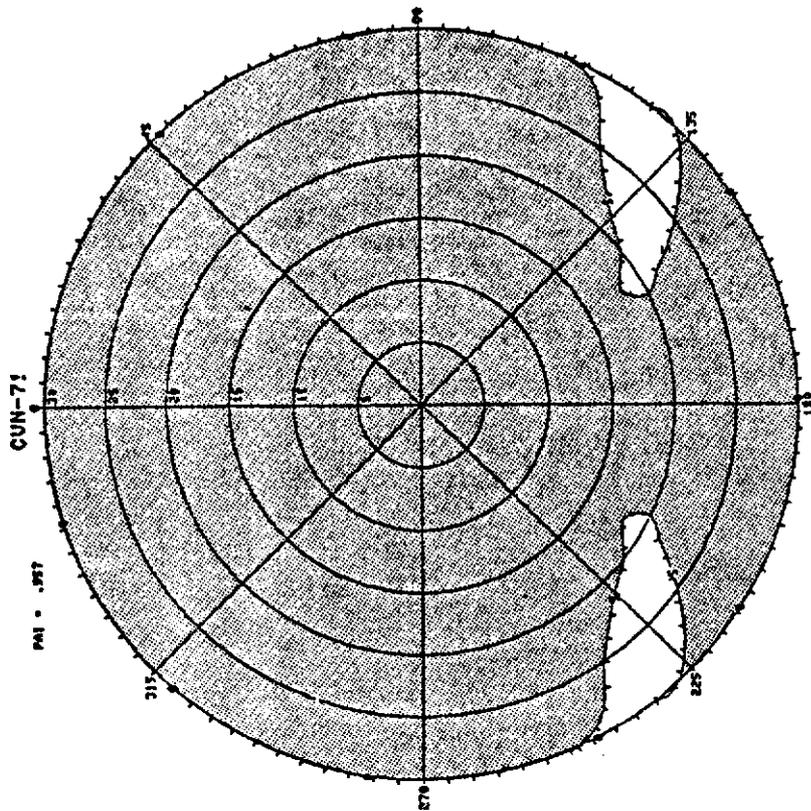
Without Relative Wind
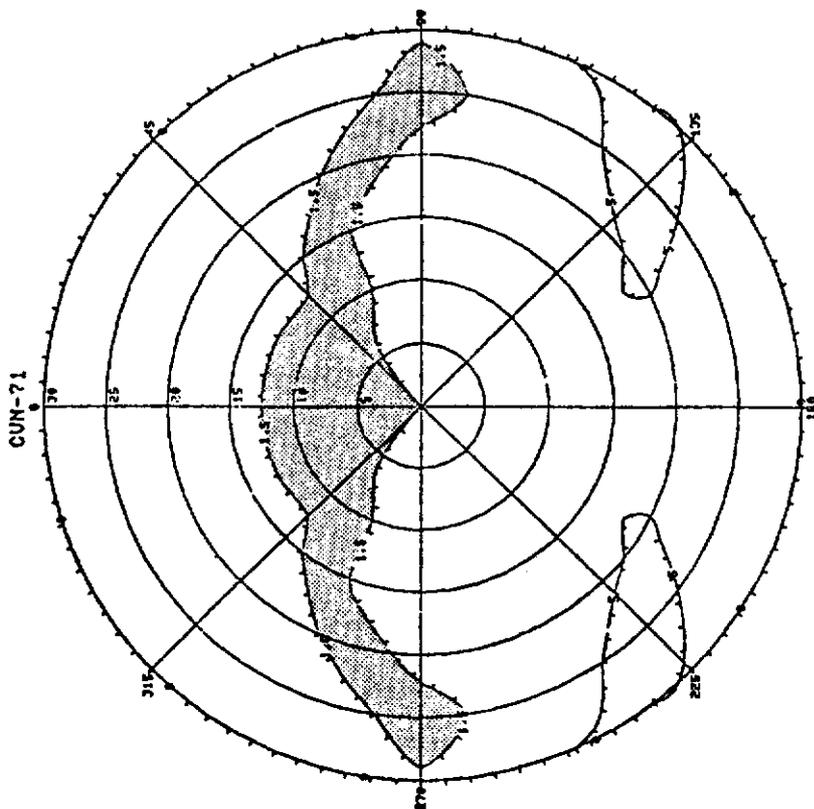
With Relative Wind

Figure G-3 - Comparison of Operating Area (e.g., Headings and Speeds) for VTOL Type Aircraft with and without Relative Wind Considerations for a Large Carrier (Reference 23)

APPENDIX H

FORTRAN SUBROUTINE TO CALCULATE BRETSCHNEIDER SPECTRA

PROGRAM BRET

The Bretschneider spectrum is representative of open ocean data and is defined by the two parameters, significant wave height and modal wave period. Program BRET computes the spectrum and a listing as well as typical output are presented in Tables H-1 and H-2, respectively.

TABLE H-1 - COMPUTER PROGRAM BRET

```
CHWE.CM55000.T150.P3.
CHARGE.CHWE.LCLCU15026.
FTN(T.A;OPT=1.R=3)
SFTCORE(INDEF.ADDR)
LGO.
000000000000000000000000
       PROGRAM BRET      (INPUT.OUTPUT.TAPE5=INPUT.TAPF6=OUTPUT)
C
C    INPUT   (I3)   NCASES
C                   (2F8.2)   WVHT1.PEPIOD
C                   WVHT1 = SIG. WAVE HT. IN METERS
C                   PERIOD= MODAL WAVE PERIOD IN SECONDS
C
       DIMENSION    S(200).FREQ1(200).W(120).S1(200)
       DOUBLE PRECISION FREQ.ALPHA.TERM1.TERM2.TERM3.TERM4
C
       DATA  I.PI/120.3.1415926/
       DATA  G/9.8087/
        DATA W/.05..10..15..20..25..30..35..40..45..50..55..60..65.
      2 .70..75..80..85..90..95.1.00.1.05.1.10.1.15.1.20.1.25.1.30.
      2 1.35.1.40.1.45.1.50.1.55.1.60.1.65.1.70.1.75.1.80.1.85.
      2 1.90.1.95.2.00.2.05.2.10.2.15.2.20.2.25.2.30.2.35.2.40.2.45.2.50.
      2 2.55.2.60.2.65.2.70.2.75.2.80.2.85.2.90.2.95.3.00.3.05.3.10.
      2 3.15.3.20.3.25.3.30.3.35.3.40.3.45.3.50.3.55.3.60.3.65.3.70.
      2 3.75.3.80.3.85.3.90.3.95.4.00.4.05.4.10.4.15.4.20.4.25.4.30.4.35.
      2 4.40.4.45.4.50.4.55.4.60.4.65.4.70.4.75.4.80.4.85.4.90.4.95.5.00.
      2 5.05.5.10.5.15.5.20.5.25.5.30.5.35.5.40.5.45.5.50.5.55.5.60.5.65.
      2 5.70.5.75.5.80.5.85.5.90.5.95.6.00/
       DATA GAMMA.SIGA.SIGB/3.3..07..09/
       DATA E/2.71828/
C
       READ(5.100)NCASES
       DO 200  I=1.NCASES
       READ(5.110)WVHT1.PERIOD
       WRITE(6.210)WVHT1.PERIOD
       WRITE(6.215)
       DO 11j N=1.J
       FREQ1(N)=W(N)/2/PI
       P=PERIOD**4.
       A=(483.5*WVHT1**2.)/P
       B=1944.5/P
       CONST=-B/W(N)**4.
       IF(CONST.LE.-500.)  GO TO 108
       S(N)=A*W(N)**(-5.)*EXP(CONST)
       GO TO 109
  108 S(N)=0.
```

TABLE H-1 - COMPUTER PROGRAM BRET (continued)

```
C
   109 WRITE(5,220) W(N),S(N),FREQ1(N)
C
   111 CONTINUE
       CALL ALGRNG (N,W,S,AREA)
C
       RMS=SQRT(AREA)
       WRITE (6,104) RMS
       SIGM=4.*RMS
       WRITE(6,105) SIGM
   200 CONTINUE
       STOP
   104  FORMAT (* INTEGRATED RMS =*F5.2 * M  *)
   105  FORMAT (* SIG. WAVE HT. =*F5.2 * M  *)
   100 FORMAT(I5)
   110 FORMAT(2F8.2,F10.6)
   210 FORMAT(1H0,5X,12HSIG WAVE HT=,F5.2,16HM  MODAL PERIOD=,F5.2,3HSEC,
      15X,F10.8)
   310 FORMAT(///,15X,19HWIND SPEED (KNOTS)=,F8.2,05X,10HFETCH(NM)=,F8.2)
   215 FORMAT(15X,1HW,18X,4HS(W),15X,1HF)
   220 FORMAT(4F20.9)
       END
       SUBROUTINE ALGRNG ( N,W,S,AREA)
*
*FORTRAN ROUTINE TO PERFORM A LAGRANGIAN INTEGRATION.
*
       DIMENSION W(N),S(N)
       MN=N-2
       AREA=0.
       DO 20 M=1,MN,2
       A=W(M+2)-W(M)
       B=W(M+2)-W(M+1)
       C=W(M+1)-W(M)
   10      AREA=AREA+A*A/6.*(S(M)*(3.*C-A)/(A*C)+S(M+1)*A/(B*C)+
      +  S(M+2)*(2.*A-3.*C)/(A*B))
   20    CONTINUE
       RETURN
       END
0n000000000n0000000000
     1
   4.08     8.
0n000000000n0000000000
0n000000000n0000000000
0n000000000n0000000000
0n000000000n0000000000 END OF FILE
```

TABLE H-2 - OUTPUT FROM PROGRAM BRET

SIG WAVE HT= 4.08M   MODAL PERIOD= 8.00SEC

W	S(W)	F
.050000000	0.000000000	.007957747
.100000000	0.000000000	.015915495
.150000000	0.000000000	.023873242
.200000000	.000000000	.031830989
.250000000	.000000000	.03 788736
.300000000	.000000000	.047746484
.350000000	.000000000	.055704231
.400000000	.000001696	.063661978
.450000000	.000998723	.071619726
.500000000	.031603478	.079577473
.550000000	.217990606	.08 535220
.600000000	.648272574	.09 492967
.650000000	1.185218216	.103450715
.700000000	1.618710750	.111408462
.750000000	1.846891000	.11 366209
.800000000	1.881716823	.127323957
.850000000	1.783606518	.135281704
.900000000	1.614000725	.14 239451
.950000000	1.417790851	.151197199
1.000000000	1.222316318	.159154946
1.050000000	1.041816234	.16 112693
1.100000000	.882214779	.17 070440
1.150000000	.744710422	.183028188
1.200000000	.628091537	.190985935
1.250000000	.530100519	.198943682
1.300000000	.448180658	.206901430
1.350000000	.379853209	.214859177
1.400000000	.322885164	.222816924
1.450000000	.275344659	.230774671
1.500000000	.235599835	.23 732419
1.550000000	.202292068	.246690166
1.600000000	.174300006	.254647913
1.650000000	.150702694	.262605661
1.700000000	.130745591	.270563408
1.750000000	.113810927	.278521155
1.800000000	.099392656	.28 478902
1.850000000	.087075683	.294436650
1.900000000	.076518850	.302394397
1.950000000	.067441100	.310352144
2.000000000	.059610265	.31 309892
2.050000000	.052834016	.325267639
2.100000000	.046952550	.33 225386
2.150000000	.041832676	.34 183133
2.200000000	.037363045	.350140881
2.250000000	.033450276	.358098628
2.300000000	.030015817	.36 056375
2.350000000	.026993383	.374014123
2.400000000	.024326880	.381971870
2.450000000	.021968690	.389929617
2.500000000	.019878279	.397887365
2.550000000	.018021041	.405845112
2.600000000	.016367352	.413802859
2.650000000	.014891786	.421760606
2.700000000	.013572459	.42 718354
2.750000000	.012390488	.43 676101
2.800000000	.011329544	.445633848
2.850000000	.010375464	.453591596
2.900000000	.009515944	.461549343
2.950000000	.008740261	.469507090
3.000000000	.008039059	.477464837
3.050000000	.007404149	.48 422585
3.100000000	.006828352	.493380332
3.150000000	.006305362	.501338079
3.200000000	.005829627	.509295827

TABLE H-2 - OUTPUT FROM PROGRAM BRET (continued)

3.250000000	.005396250	.517253574
3.300000000	.005000906	.525211321
3.350000000	.004639763	.533169068
3.400000000	.004309426	.541126816
3.450000000	.004006878	.549084563
3.500000000	.003729432	.557042310
3.550000000	.003474697	.565000058
3.600000000	.003240536	.572957805
3.650000000	.003025039	.580915552
3.700000000	.002826495	.588873299
3.750000000	.002643370	.596831047
3.800000000	.002474287	.604788794
3.850000000	.002318007	.612746541
3.900000000	.002173415	.620704289
3.950000000	.002039504	.628662036
4.000000000	.001915365	.636619783
4.050000000	.001800178	.644577531
4.100000000	.001693199	.652535278
4.150000000	.001593754	.660493025
4.200000000	.001501232	.668450772
4.250000000	.001415078	.676408520
4.300000000	.001334786	.684366267
4.350000000	.001259496	.692324014
4.400000000	.001189990	.700281762
4.450000000	.001124685	.708239509
4.500000000	.001063632	.716197256
4.550000000	.001006512	.724155003
4.600000000	.000953031	.732112751
4.650000000	.000902924	.740070498
4.700000000	.000855943	.748028245
4.750000000	.000811865	.755985993
4.800000000	.000770482	.763943740
4.850000000	.000731603	.771901487
4.900000000	.000695054	.779859234
4.950000000	.000660674	.787816982
5.000000000	.000628314	.795774729
5.050000000	.000597837	.803732476
5.100000000	.000569117	.811690224
5.150000000	.000542035	.819647971
5.200000000	.000516486	.827605718
5.250000000	.000492367	.835563465
5.300000000	.000469587	.843521213
5.350000000	.000448060	.851478960
5.400000000	.000427706	.859436707
5.450000000	.000408452	.867394455
5.500000000	.000390228	.875352202
5.550000000	.000372971	.883309949
5.600000000	.000356621	.891267697
5.650000000	.000341124	.899225444
5.700000000	.000326428	.907183191
5.750000000	.000312485	.915140938
5.800000000	.000299250	.923098686
5.850000000	.000286683	.931056433
5.900000000	.000274743	.939014180
5.950000000	.000263395	.946971928
6.000000000	.000252605	.954929675

INTEGRATED QMS = 1.02 M
STG. WAVE HT. = 4.06 M

APPENDIX I

FORTRAN SUBROUTINE TO CALCULATE MODIFIED JONSWAP SPECTRA

PROGRAM JONSW2

Program JONSW2 computes the spectrum using the modified JONSWAP formulation. The JONSWAP spectral density equation is currently the most widely used spectrum for representing fetch-limited seas. The user, upon selecting the values for significant wave height and modal wave period, determines β from Figure 17 or 18 and thence the spectrum can be developed. A program listing as well as typical output are presented in Tables 1-1 and 1-2, respectively.

TABLE 1-1 - COMPUTER PROGRAM JONSW2

```
CHWE.CMS500n,T150.P9.
CHARGE,CHWE,LCLCU15026.
FTN(T.A,OPT=1,R=3)
SFTCORE(INDFF,ABDR)
LGO.
0n0un00u8u0n0000000000
      PROGRAM JONSW2   (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C    INPUT     (I5)  NCASES
C               (2F8.2,F10.6)  WVHT1,PERIOD,B
C                     WVHT1 = SIG. WAVE HT. IN METERS
C                     PERIOB= MODAL WAVE PERIOD IN SECONDS
C                     B    = BETA
C
      DIMENSION   S(200),FREQ1(200),W(120),S1(200)
      DOUBLE PRECISION FREQ,ALPHA,TERM1,TERM2,TERM3,TERM4
C
      DATA J,PI/120,3.1415926/
      DATA G/9.8087/
      DATA W/.05,.10,.15,.20,.25,.30,.35,.40,.45,.50,.55,.60,.65,
     2 .70,.75,.80,.85,.90,.95,1.00,1.05,1.10,1.15,1.20,1.25,1.30,
     2 1.35,1.40,1.45,1.50,1.55,1.60,1.65,1.70,1.75,1.80,1.85,
     2 1.90,1.95,2.00,2.05,2.10,2.15,2.20,2.25,2.30,2.35,2.40,2.45,2.50,
     2 2.55,2.60,2.65,2.70,2.75,2.80,2.85,2.90,2.95,3.00,3.05,3.10,
     2 3.15,3.20,3.25,3.30,3.35,3.40,3.45,3.50,3.55,3.60,3.65,3.70,
     2 3.75,3.80,3.85,3.90,3.95,4.00,4.05,4.10,4.15,4.20,4.25,4.30,4.35,
     2 4.40,4.45,4.50,4.55,4.60,4.65,4.70,4.75,4.80,4.85,4.90,4.95,5.00,
     2 5.05,5.10,5.15,5.20,5.25,5.30,5.35,5.40,5.45,5.50,5.55,5.60,5.65,
     2 5.70,5.75,5.80,5.85,5.90,5.95,6.00/
      DATA GAMMA,SIGA,SIGB/3.3,.07,.09/
      DATA E/2.71824/
C
      READ(5,108)NCASES
      DO 200 I=1,NCASES
      READ(5,118)WVHT1,PERIOD,B
      WRITE(6,210)WVHT1,PERIOD,B
      WRITE(6,215)
      DO 111 N=1,J
      FREQ1(N)=W(N)/2/PI
      WAFQ=W(N)**(-5.)
      ALPHA=WAFQ*G*G*B
      TERM1=-1.25*(PERIOD*FREQ1(N))**(-4.)
      IF(TERM1.LE.-50.) GO TO 322
      TERM2=E**TERM1
      GO TO 323
  322 TERM2=0.
  323 FREQ2=1/PERIOD
      IF(FREQ1(N).LE.FREQ2) GO TO 10
      SIG=SIGB
      GO TO 5
   10 SIG=SIGA
    5 TERM3=-.5*SIG**(-2.)
      TERM4=(FREQ1(N)*PERIOD-1)**2.
      ARG=TERM3*TERM4
      IF(ARG.LE.-50.) GO TO 333
      TERM5=E**(TERM3*TERM4)
      GO TO 444
  333 TERM5=0.
  444 TERM6=GAMMA**TERM5
C
      S(N)=ALPHA*TERM2*TERM6
      S1(N)=ALPHA*TERM2*TERM6*3.28*3.28*2*PI
C
```

TABLE I-1 - COMPUTER PROGRAM JONSW2 (continued)

```
      WRITE(5,220) W(N),S(N),FREQ1(N),S1(N)
C
  111 CONTINUE
      FO=1/PERIOD
      XO=(8/.076)**(-4.54546)
      FMO=3.5*XO**(-.33)
      U=FMO*9.807/(FO*.5144)
      X=U*U*XO/(9.807*1893)*.5144*.5144
      WRITE(6,310)U,X
      CALL ALGRNG (N,W,S,AREA)
C
      RMS=SQRT(AREA)
      WRITE (6,104) RMS
      SIGM=4.*RMS
      WRITE(6,105) SIGM
  200 CONTINUE
      STOP
  104  FORMAT (* INTEGRATED RMS =*F5.2 * M  *)
  105  FORMAT (* SIG. WAVE HT. =*F5.2 * M  *)
  100 FORMAT(I5)
  110 FORMAT(2F8.2,F10.6)
  210 FORMAT(1H0,5X,12HSIG WAVE HT=,F5.2,16HM  MODAL PERIOD=,F5.2,3HSEC,
     15X,F10.8)
  310 FORMAT(///,15X,19HWIND SPEED (KNOTS)=,F8.2,05X,10HFETCH(NM)=,F8.2)
  215 FORMAT(15X,1HX,15X,4HS(W),16X,1HF,17X,4HS(F))
  220 FORMAT(4F20.9)
      END
      SUBROUTINE ALGRNG ( N,W,S,AREA)
*
*FORTRAN ROUTINE TO PERFORM A LAGRANGIAN INTEGRATION.
*
      DIMENSION W(N),S(N)
      MN=N-2
      AREA=0.
      DO 20 M=1,MN,2
      A=W(M+2)-W(M)
      B=W(M+2)-W(M+1)
      C=W(M+1)-W(M)
   10    AREA=AREA+A*A/6.*(S(M)*(3.*C-A)/(A*C)+S(M+1)*A/(B*C)+
     + S(M+2)*(2.*A-3.*C)/(A*B))
   20    CONTINUE
      RETURN
      END
0n0000000000n0000000000
    1
  4.08     8.       .7135
0n0000000000n0000000000
0n0000000000n0000000000
0n0000000000n0000000000
0n0000000000n0000000000 END OF FILE
```

TABLE I-2 - OUTPUT FROM PROGRAM JONSW2

SIG WAVE HT= 4.08M   MODAL PERIOD= 8.00SEC   .01350000

W	S(W)	F	S(F)
.050000000	0.000000000	.007957747	0.000000000
.100000000	0.000000000	.015915495	0.000000000
.150000000	0.000000000	.023873242	0.000000000
.200000000	0.000000000	.031830989	0.000000000
.250000000	0.000000000	.03 788736	0.000000000
.300000000	0.000000000	.047746484	0.000000000
.350000000	.000000000	.055704231	.000000000
.400000000	.000001082	.063661978	.000073164
.450000000	.000645845	.071619726	.043657217
.500000000	.020591681	.079577473	1.391936271
.550000000	.142701091	.08?535220	9.646168484
.600000000	.427273440	.09?492967	28.882411137
.650000000	.825654994	.103450715	55.811816877
.700000000	1.523775909	.111408462	103.002710102
.750000000	3.212567437	.11 366209	217.159984168
.800000000	3.993643566	.127323957	269.958402658
.850000000	2.583726847	.135281704	174.652234486
.900000000	1.468306060	.143239451	99.253113590
.950000000	1.013418946	.151197199	68.504100421
1.000000000	.816884072	.159154946	55.218928653
1.050000000	.688873907	.167112693	46.565823039
1.100000000	.582818752	.17 070440	39.396810666
1.150000000	.491999883	.183028188	33.257725781
1.200000000	.414987090	.190985935	28.051890510
1.250000000	.390266182	.198943682	23.676949992
1.300000000	.296153109	.206901430	20.019067553
1.350000000	.251014108	.214859177	16.967805572
1.400000000	.213376372	.222816924	14.423606815
1.450000000	.181965140	.230774671	12.300301133
1.500000000	.155703264	.234732419	10.525076564
1.550000000	.133693737	.246690166	9.037298159
1.600000000	.115196073	.254647913	7.786911206
1.650000000	.099602029	.262605661	6.732800292
1.700000000	.086413211	.270563408	5.841275542
1.750000000	.075221531	.278521155	5.084751307
1.800000000	.065692674	.28 478902	4.440628946
1.850000000	.057552393	.294436650	3.890370271
1.900000000	.050575281	.302394397	3.418738289
1.950000000	.044575628	.310352144	3.013179595
2.000000000	.039400023	.31?309892	2.663324137
2.050000000	.034921376	.326267639	2.360580937
2.100000000	.031034084	.33 225386	2.097811584
2.150000000	.027650131	.34 183133	1.869066457
2.200000000	.024695932	.350140881	1.669371383
2.250000000	.022109774	.358098628	1.494554804
2.300000000	.019839743	.36?056375	1.341107471
2.350000000	.017842033	.374014123	1.206068274
2.400000000	.016079572	.381971870	1.086931112
2.450000000	.014520887	.389929617	.981568704
2.500000000	.013139190	.397887365	.888170107
2.550000000	.011911610	.405845112	.805189310
2.600000000	.010818566	.413802859	.731302831
2.650000000	.009843254	.421760606	.665374633
2.700000000	.008971209	.42 718354	.606427020
2.750000000	.008189953	.43 676101	.553616416
2.800000000	.007488690	.445633848	.506213157
2.850000000	.006858062	.453591596	.463584584
2.900000000	.006289935	.461549343	.425180856
2.950000000	.005777222	.469507090	.390523017
3.000000000	.005313739	.477464837	.359192931
3.050000000	.004894073	.48 422585	.330824766
3.100000000	.004513480	.493380032	.305097786
3.150000000	.004167790	.501338079	.281730213

TABLE I-2 - OUTPUT FROM PROGRAM JONSW2 (continued)

3.200000000	.003853336	.509295827	.260474004
3.250000000	.003556879	.517253574	.241110393
3.300000000	.003305561	.525211321	.223446071
3.350000000	.003066850	.533169068	.207309913
3.400000000	.002848501	.541126816	.192550163
3.450000000	.002648519	.549084563	.179032007
3.500000000	.002465131	.557042310	.166635482
3.550000000	.002296753	.565000058	.155253667
3.600000000	.002141975	.572957805	.144791108
3.650000000	.001999533	.580915552	.135162460
3.700000000	.001868297	.588873299	.126291300
3.750000000	.001747253	.596831047	.118109093
3.800000000	.001635491	.604788794	.110554287
3.850000000	.001532191	.612746541	.103571530
3.900000000	.001436616	.620704289	.097110972
3.950000000	.001348102	.628662036	.091127660
4.000000000	.001266047	.636619783	.085581004
4.050000000	.001189909	.644577531	.080434308
4.100000000	.001119197	.652535278	.075654355
4.150000000	.001053464	.660493025	.071211041
4.200000000	.000992308	.668450772	.067077048
4.250000000	.000935360	.676408520	.063227562
4.300000000	.000882288	.684366267	.059640015
4.350000000	.000832786	.692324014	.056293862
4.400000000	.000786579	.700281762	.053170375
4.450000000	.000743412	.708239509	.050252469
4.500000000	.000703057	.716197256	.047524539
4.550000000	.000665300	.724155003	.044972319
4.600000000	.000629950	.732112751	.042582752
4.650000000	.000596829	.740070498	.040343878
4.700000000	.000565775	.748028245	.038244732
4.750000000	.000536640	.755985993	.036275249
4.800000000	.000509286	.763943740	.034426186
4.850000000	.000483587	.771901487	.032689043
4.900000000	.000459429	.779859234	.031055999
4.950000000	.000436703	.787816982	.029951851
5.000000000	.000415314	.795774729	.028073961
5.050000000	.000395168	.803732476	.026712204
5.100000000	.000376184	.811690224	.025428925
5.150000000	.000358284	.819647971	.024218901
5.200000000	.000341395	.827605718	.023077300
5.250000000	.000325453	.835563465	.021999651
5.300000000	.000310396	.843521213	.020981816
5.350000000	.000296166	.851478960	.020019958
5.400000000	.000282712	.859436707	.019110519
5.450000000	.000269985	.867394455	.018250198
5.500000000	.000257939	.875352202	.017435927
5.550000000	.000246532	.883309949	.016664857
5.600000000	.000235725	.891267697	.015934339
5.650000000	.000225482	.899225444	.015241906
5.700000000	.000215768	.907183191	.014585263
5.750000000	.000206552	.915140938	.013962270
5.800000000	.000197804	.923098686	.013370933
5.850000000	.000189496	.931056433	.012809392
5.900000000	.000181604	.939014180	.012275910
5.950000000	.000174103	.946971928	.011768865
6.000000000	.000166971	.954929675	.011286742

WIND SPEED (KNOTS)= 39.96   FETCH(NM)= 59.95

INTEGRATED RMS = 1.02 M

SIG. WAVE HT. = 4.08 M