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Departmental Report

LABRADOR WIND AND WAVE ENVIRONMENTS

by

Wah T. Lee

DTNSRDC/SPD-1214-01 Labrador Wind and Wave Environments

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The Labrador Extreme Waves Experiment (LEWEX) is designed to evaluate the in situ and remote sensors of the sea surface. This report is a source document for specifying climatological wind and wave data for the Labrador Sea. This report also provides atmospheric qualities such as temperature and sea ice which are known to affect the operation of certain ship systems as well as tactical decision making.

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ABSTRACT

The Labrador Extreme Waves Experiment (LEWEX) is designed to evaluate the in situ and remote sensors of the sea surface. This report is a source document for specifying climatological wind and wave data for the Labrador Sea. This report also provides atmospheric qualities such as temperature and sea ice which are known to affect the operation of certain ship systems as well as tactical decision making.

ADMINISTRATIVE INFORMATION

This report was prepared under the sponsorship of the Naval Ocean R&D Activity (NORDA) Code P10 Surface Wave Spectra for Ship Design (SWSSD) Program Element 62759N and Project Number SF 59557695, the Naval Ocean Systems Center (NOSC), Code 54 Battle Group Environmental Enhancement Program Element 62435N and Project Number WF 59551001, and the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) Independent Exploratory Development Program, sponsored by the Office of Chief of Naval Research, Director of Navy Laboratories OCNR 300, and administered by the Research Coordinator, DTNSRDC 012.3 under Program Element 62936N, Task Area ZF-66-412-001. It is identified by Work Unit Numbers 1500-386, 1561-045, and 1561-128 at DTNSRDC.

BACKGROUND

The successful operability and survivability of marine vehicles and structures are directly related to the prevailing sea environment. However, there remains no universal standard for incorporating environmental effects into design decisions. While a standard may not be feasible, it is possible to substantially upgrade the quality of the various data now used throughout the naval architectural community. The Labrador Extreme Waves Experiment (LEWEX) of March 1987 is designed to establish reliable directional wave measurements and analyses and to expand the capability for providing reliable, routine measurements during full-scale ship trials and operations. It also facilitates intercomparison and evaluation of the first generation (Global Spectral Wave Model (GSOWM)), second generation (British Meteorological Office), and third generation (WAM) wave models. LEWEX 87 will occur in the southern Labrador Sea from approximately 9 March to 27 March 1987, see Fig. 1. The experiment location is chosen to maximize the probability of encountering high, directional waves systems. Two oceanographic research ships will be involved in this experiment, the Canadian ship CFAV QUEST with at least five conventional wave buoys, and the Dutch ship HNLMS TYDEMAN with at least seven additional wave buoys and two deck-mounted instruments. Additionally, a Synthetic Aperture Radar (SAR) will be flown by Canada (RADARSAT) in a CV-580 aircraft and various other surface imaging systems will be flown in a U.S.A. (NASA) P-3 aircraft. The TYDEMAN is capable of launching buoys in 25 foot (7.6 meters) seas and recovering them in 15 foot (4.6 meters) seas, while the QUEST is limited to 15 feet (4.6 meters) in launch and 12 feet (3.7 meters) in recovery. This atlas provides wind and wave conditions for the Labrador Sea to allow experimenters to plan buoy deployment scenarios for LEWEX. The primary data source is the hindcast data base developed by the U.S. Navy, see References 1 and 2. Briefly, archived wind data are used by Fleet Numerical Oceanography Center to hindcast the wave fields for approximately 1500 locations (grid points) throughout the Northern Hemisphere, see Reference 3, using the Spectral Ocean Wave Model (SOWM). The SOWM was the GSOWM predecessor. The wind fields are updated at 6-hour intervals over a period of 17 years. Thus, the resulting wave directional spectra are a hindcast time history of wave conditions throughout the Northern Hemisphere over a period of 17 years.

DATA PRESENTATION

The darkened circles on Fig. 1 indicates the SOWM grid points included in this work for the Labrador Sea. Table 1 provides a summary of the points currently included on Fig. 1. The parameter sets developed are

1. Significant wave height versus modal wave period
2. Significant wave height versus wind speed
3. Significant wave height versus primary wave direction
4. Air temperature
5. Sea temperature
6. Persistence of wave height
7. Persistence of wind speed

Appendix A provides the data base of open ocean wind and wave conditions derived from the hindcast climatology for the Labrador Sea. March and April wind and wave statistics are provided for areas identified in Table 1.

Each figure in Appendix A is identified by a code as detailed in Fig. 2. A "standard" format has been adhered to for each figure at each grid point.

Data sets 1 through 3 present the percentage frequency of occurrences for various combinations of atmospheric and oceanographic parameters. The number in each square is the percentage frequency of occurrences for that particular combination of parameters indicated at that intersection of the ordinate and abscissa. The number of samples is given at the upper right hand corner and the number at the middle is the grid point number for each graph. The right hand column and bottom row of each graph present the cumulative totals for each respective row and column. As an example, in Figure A-171-3-3 the following information can be obtained: (1) 2 percent of all waves were from the north with significant wave heights between 9 and 12 feet, (2) 6 percent of significant wave heights were from the north, (3) 19 percent of all significant wave heights were between 9 and 12 feet, (4) 12 percent of the primary wave directions were undefined (U), and (5) these events were out of a total of 2474 samples.

Data sets 4 and 5 present the cumulative distributions of observed air and sea temperatures, respectively.

Data sets 6 and 7 present the persistence of wave height and wind speed for various locations. Persistence data are provided for April only.

LABRADOR SEA CLIMATOLOGY

A general climatology for the Labrador Sea has been developed. The ocean currents and the polar front are the major factors whose interaction help determine the climatic pattern for the northern Atlantic Ocean. Ocean currents can provide significant influences on the climate of the surrounding area in the form of temperature, concentration and migration of ice, and the general habitability of the region. In the Labrador Sea, which is the area of greater concern to this climatology, the circulation of the currents is counterclockwise, is centered on the polar front zone, and is influenced by the polar easterlies to the north and the westerlies to the south.

The Icelandic Low is the dominating pressure system influencing weather from eastern Canada across the northern Atlantic to Western Europe. It is apparent that this low pressure system maintains its identity and strong influence throughout the year. The southward migration in winter brings an increase in frontal activity across the area.

Gale force winds of 34 knots or greater occur in conjunction with the intense low pressure systems and hence become more frequent as the systems become more numerous and intense. Gales may occur with frequencies ranging from 14 percent at grid points 171, 277, and 279 to 18 percent at grid point 304 in March. In April, the Labrador Sea experiences much lower frequency of gale force winds. For grid points 277 and 304, 9 percent of reported winds are 34 knots or greater, and only 7 percent for grid points 171 and 279.

In March for grid points 171, 279, and 304, 70 percent of all significant wave heights are greater than 12 feet (3.7 meters), 47 percent are greater than 15 feet (4.6 meters), and 13 percent are more than 25 feet (7.6 meters) in height. In April, the percent frequency of occurrences for significant wave heights are 48, 29, and 5 for greater than 12, 15, and 25 feet (3.7, 4.6, and 7.6 meters), respectively. Modal wave periods of 10 seconds or more occur with a frequency of 79 percent in March and 60 percent in April for grid points 171, 279, and 304. The waves are usually traveling from the northwest to southeast 22 percent of the time in March and 17 percent of the time in April. Persistence data are not available for March. In April, the occurrence of gale force winds should not persist more than 3.5 days. The typical gale force wind persists about a day. In general, significant wave heights which exceed 25 feet (7.6 meters) should not persist more than 3 days.

The southern portion of this region experiences calmer wave conditions in contrast to the northern region during the spring season. In March for grid point 277, 52 percent of all significant wave heights exceed 12 feet (3.7 meters), 32 percent are greater than 15 feet (4.6 meters), and only 6 percent are more than 25 feet (7.6 meters). In April, the significant wave height percent frequency of occurrences are 40, 22, and 2 for greater than 12, 15, and 25 feet (3.7, 4.6, and 7.6 meters), respectively. Modal wave periods of 10 seconds or more occur with a frequency of 66 percent in March and 52 percent in April for grid point 277. Spring waves vary in direction at grid point 277 with the following frequency of occurrences in March: 15 percent from the north, northeast, and northwest, 11 percent from the south and southwest, and 4 percent calm. In April, 16 percent of the waves are from the southwest and west, 12 percent from the south, 10 percent from the north and northeast, and 11 percent calm. Persistence data are not available for March. In April, the occurrence of gale force winds should not persist more than 3 days. The typical gale persists about a day. On the other hand, significant wave heights which exceed 25 feet (7.6 meters) should not persist more than 3 days.

Figures 3 and 4 present the comparison of significant wave height occurrences for the four grid points during March and April. As might be expected, these figures show good agreement of significant wave height exceedances for the open ocean grid points 171, 279, and 304. Figures 5 through 7 provide the significant wave height time histories for the heavy, moderate, and calm spring seasons at grid point 279 for the period of 1959 through 1969. Due to the laborious and time consuming task of computing time history data, only the significant wave height time history of grid point 279 has been processed. However, since the distribution of wave heights are similar for grid points 171, 279, and 304, the time history of grid point 279 may also be used for representing grid points 171 and 304. For March and April of the heavy weather year, 75 percent of all significant wave heights exceed 12 feet (3.7 meters), 55 percent exceed 15 feet (4.6 meters), and 15 percent of all waves are greater than 25 feet (7.6 meters). On the other hand, for the calm March and April, 50 percent of all waves exceed 12 feet (3.7 meters), 30 percent exceed 15 feet (4.6 meters), and only 2 percent are more than 25 feet (7.6 meters). For the moderate March and April, the percent frequency of occurrences for all waves are 8, 40, and 50 for greater than 25, 15, and 12 feet (7.6, 4.6, and 3.7 meters), respectively.

Air temperatures vary significantly between grid points of the Labrador Sea. At grid point 304, the observed maximum, median, and minimum temperatures are 6, -1.5, and -13° C in March, and 6, 0.5, and -7° C in April. For grid point 171, the maximum, median, and minimum temperatures are 16, 8, and -3° C in March, and 16, 9, and 2° C in April. At grid point 279, the maximum, median, and minimum temperatures are 18, 11, and 2° C in March, and 18, 12.5, and 4° C in April. At the most southern grid point 277, the observed maximum, median, and minimum temperatures are 16, 5, and -4° C in March, and 18, 6, and -2° C in April.

The sea surface temperatures in the Labrador Sea have a median value of -0.5, 11, 14, and 5° C in March and 0, 12, 14, and 6° C in April for grid points 304, 171, 279, and 277, respectively.

SEA ICE

Ice is the most unique environmental feature affecting surface ship operations in northern latitudes. The sea ice found may vary from multi-year ice to ice of minimal or moderate thickness which is present only during infrequent cold winters.

Floating ice, which extends well below 50° N in the North Atlantic Ocean as shown in Fig. 1, is driven by the wind, waves, or currents. The ice pack reaches its maximum southern extent during March; however, its eastward coverage is less extensive than in February. Impact from floating ice can be as hazardous to structures as thick land-fast ice, see Reference 4. Icebergs, though rare below 60° N, are massive irregularly shaped pieces of ice broken from a glacier. Ice floats with most of its volume below the sea surface. Depending upon the relative density of the ice and water, ice floes are generally only between 1/5 to 1/7 visible at the surface, and recent experience indicates that even large ice pieces can be difficult to detect by radar.

Ice accretion on the ship structure is caused by salt water spray, precipitation, and fog. Ice accretes with winds ≥ 17 knots, sea temperatures ≤ 6° C, and air temperatures between -2.2° and -18° C. Heavy icing can be expected with winds ≥ 34 knots under the same temperature conditions.* In general, ice accretes about twice as fast on horizontal deck areas as vertical surfaces. Figures 8 and 9 show probabilities of moderate and heavy icing for the Atlantic Ocean based on the above parameters.

Appendix B provides a brief preliminary comparison of GSOWM forecasts with the U.S.A. ENDECO measurements actually made during LEWEX. In general, the forecast wave heights were slightly higher than those derived from the buoy. A more comprehensive comparison of all wave characteristics will be conducted in the future. Additionally, it is noted that the GSOWM forecasts for March 1987 were similar to 1968, a calm year in the South Labrador Sea.

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* Bales, S.L., CDR Larry R. Elliott, USN, and William L. Thomas III, "Degradation of Surface Ship Operations in Arctic/Cold Weather Environments," U.S. Navy Symposium on Arctic/Cold Weather Operations of Surface Ships (Dec 1985).
Lee, W.T., "Wind and Wave Environments for Five Ocean Locations," Report DTNSRDC/SPD-1201-01 (Sep 1986).
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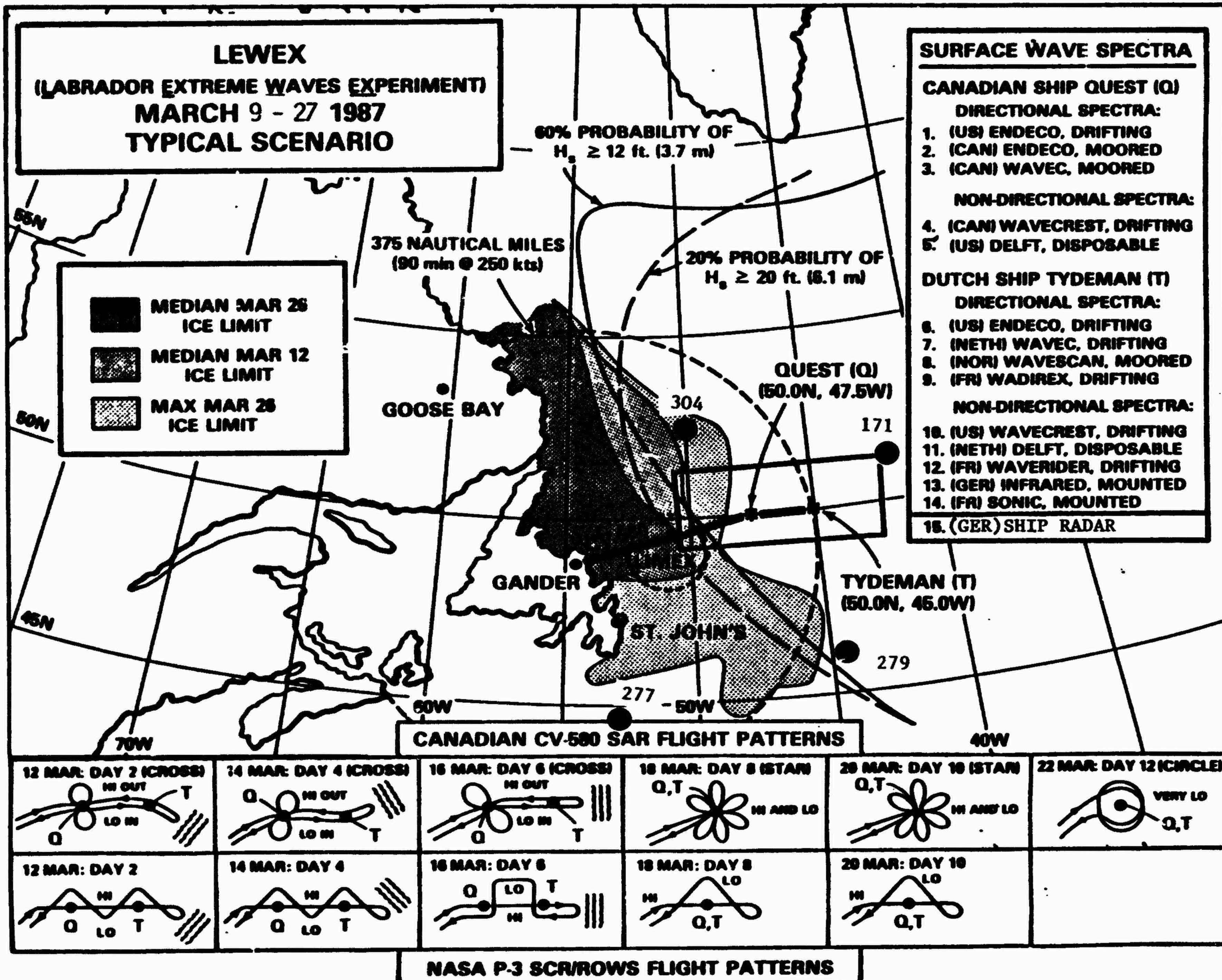


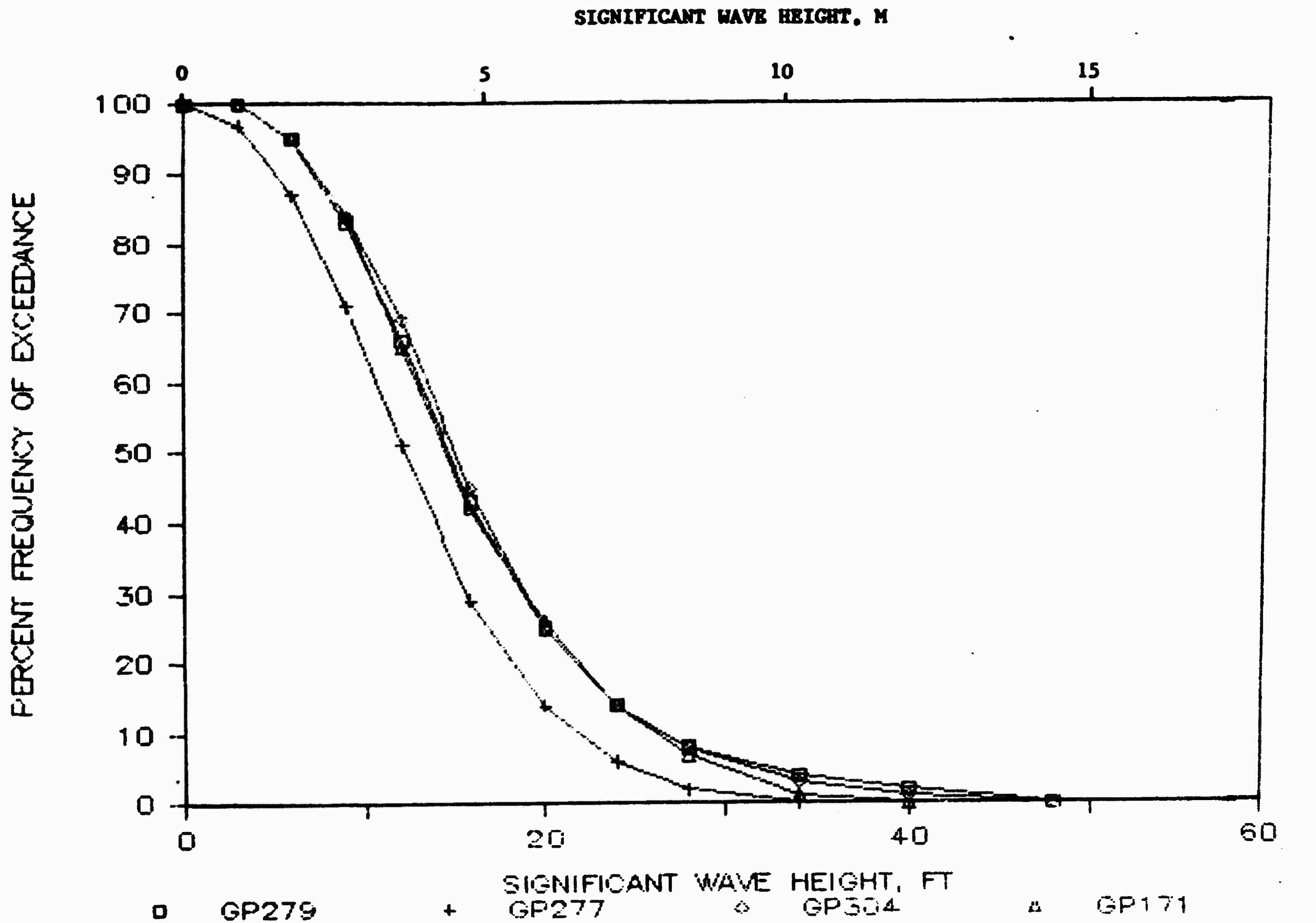
Figure 1 - The Labrador Extreme Waves Experiment

SAMPLE FIGURE NUMBER FIGURE A - 171 - 3 - 1

GRID POINT — MONTH — DATA SET NUMBER

OCEAN	GRID POINT	MONTH	DATA SET NUMBER
A - LABRADOR	171 277 279 304	3-March 4-April	1. Sig wv height vs Modal wv period 2. Sig wv height vs wind speed 3. Sig wv height vs primary wv dir 4. Air temperature 5. Sea temperature 6. Persistence of wave height 7. Persistence of wind speed

Figure 2 - Data Graphs Coding System



Note:, 1 foot = 0.3048 meter

Fig.re 3 - Comparison of March Significant Wave Height Exceedances of All Locations

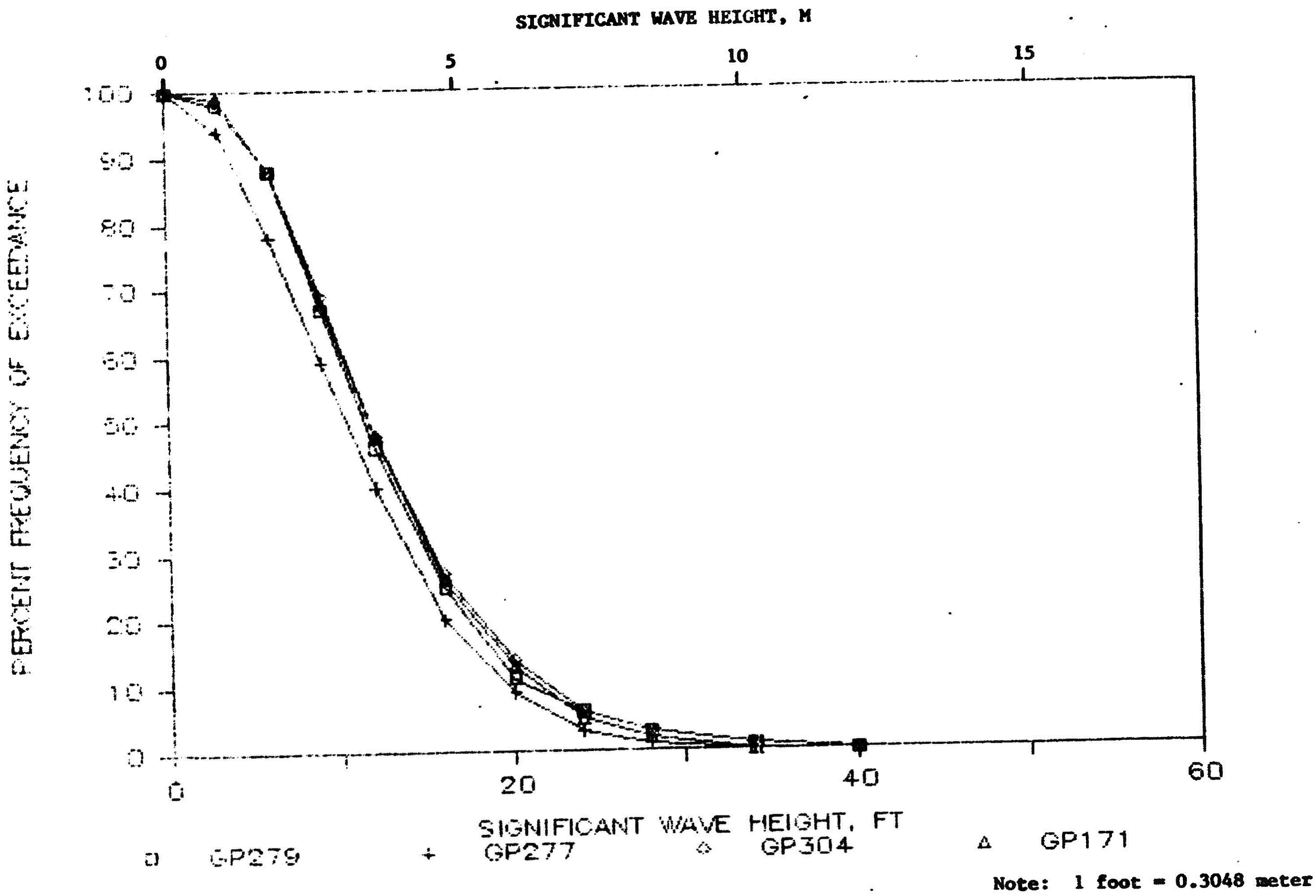


Figure 4 - Comparison of April Significant Wave Height Exceedances of All Locations

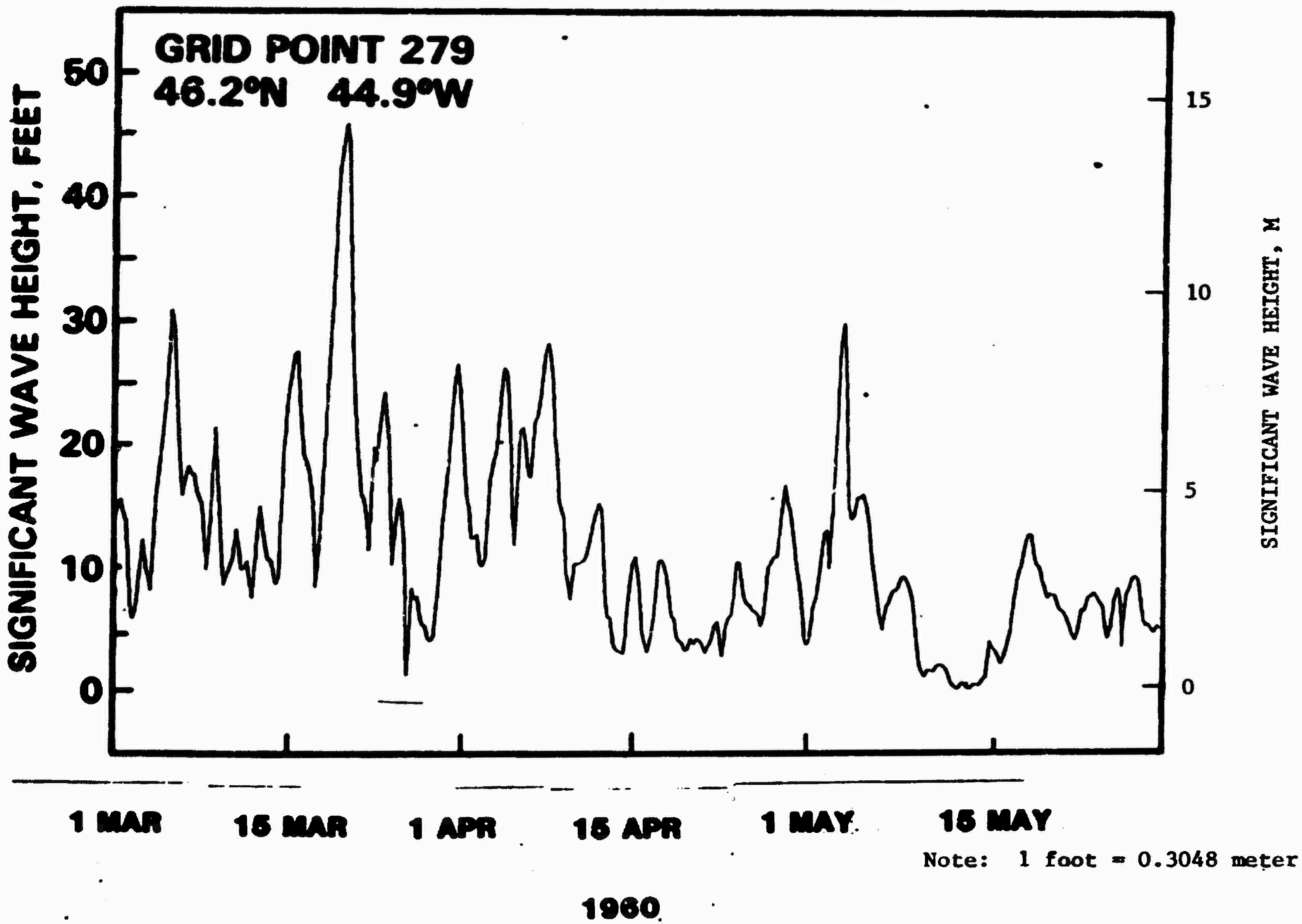


Figure 5 - Time History of Significant Wave Height for Heavy Weather Year.

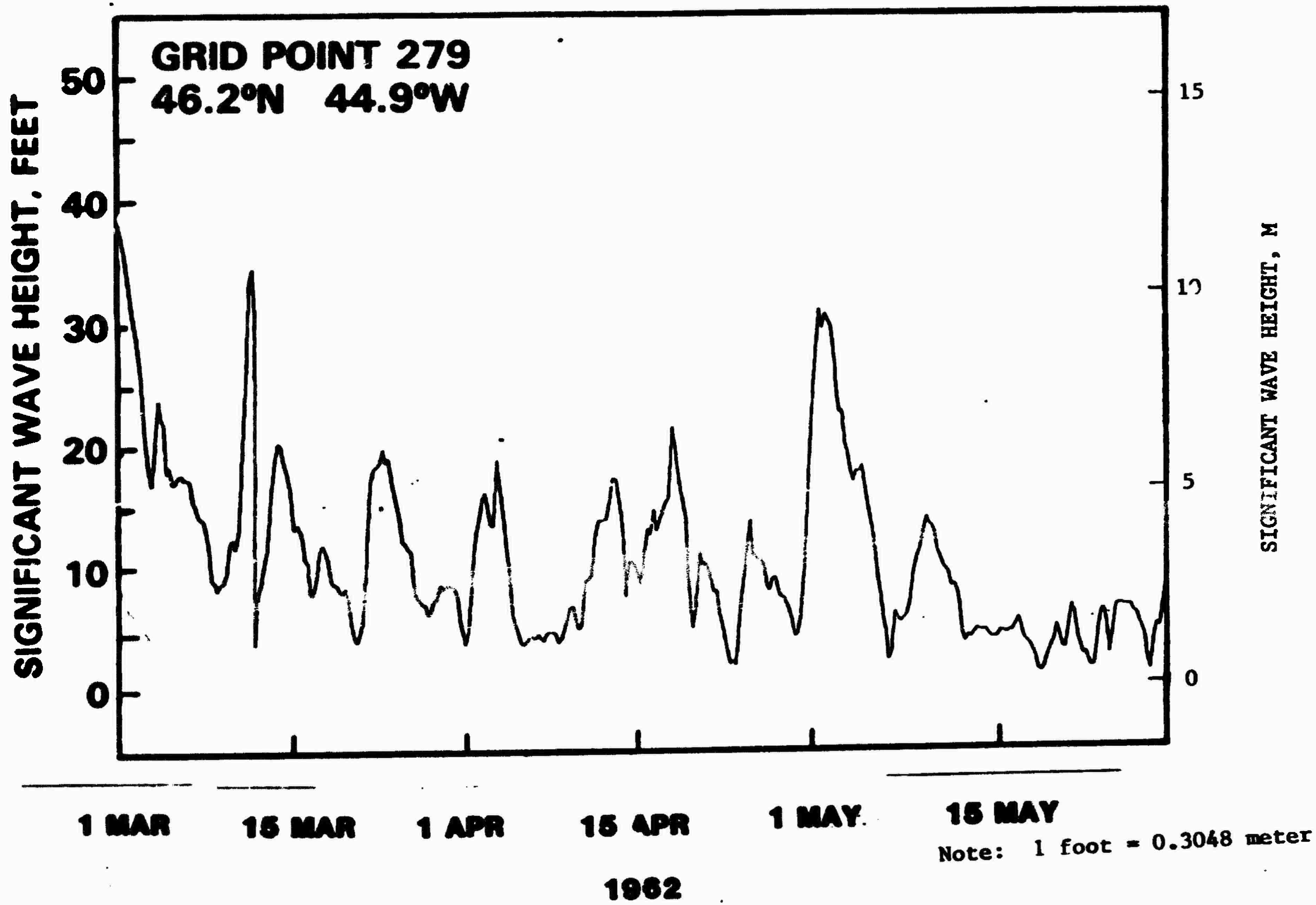
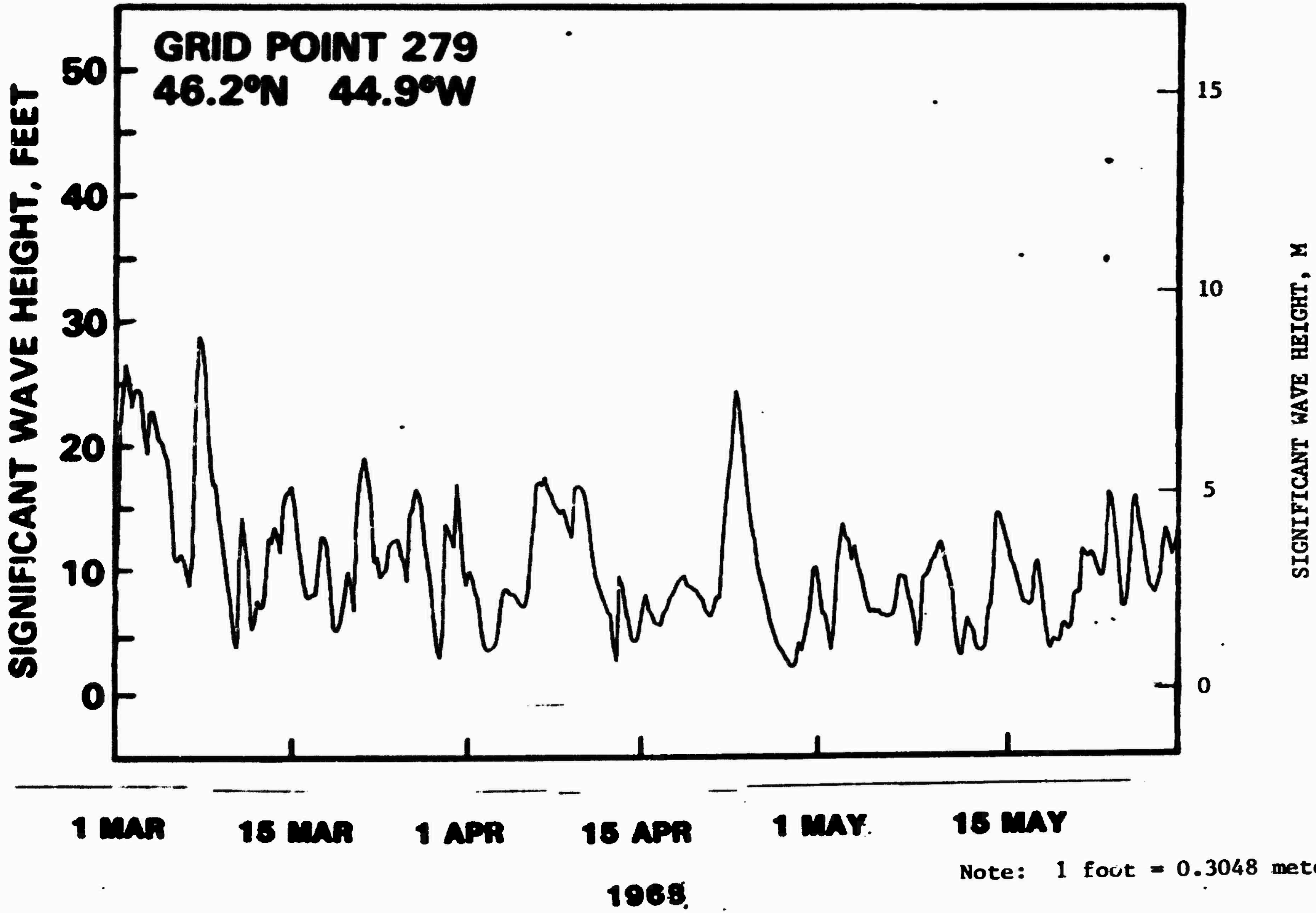


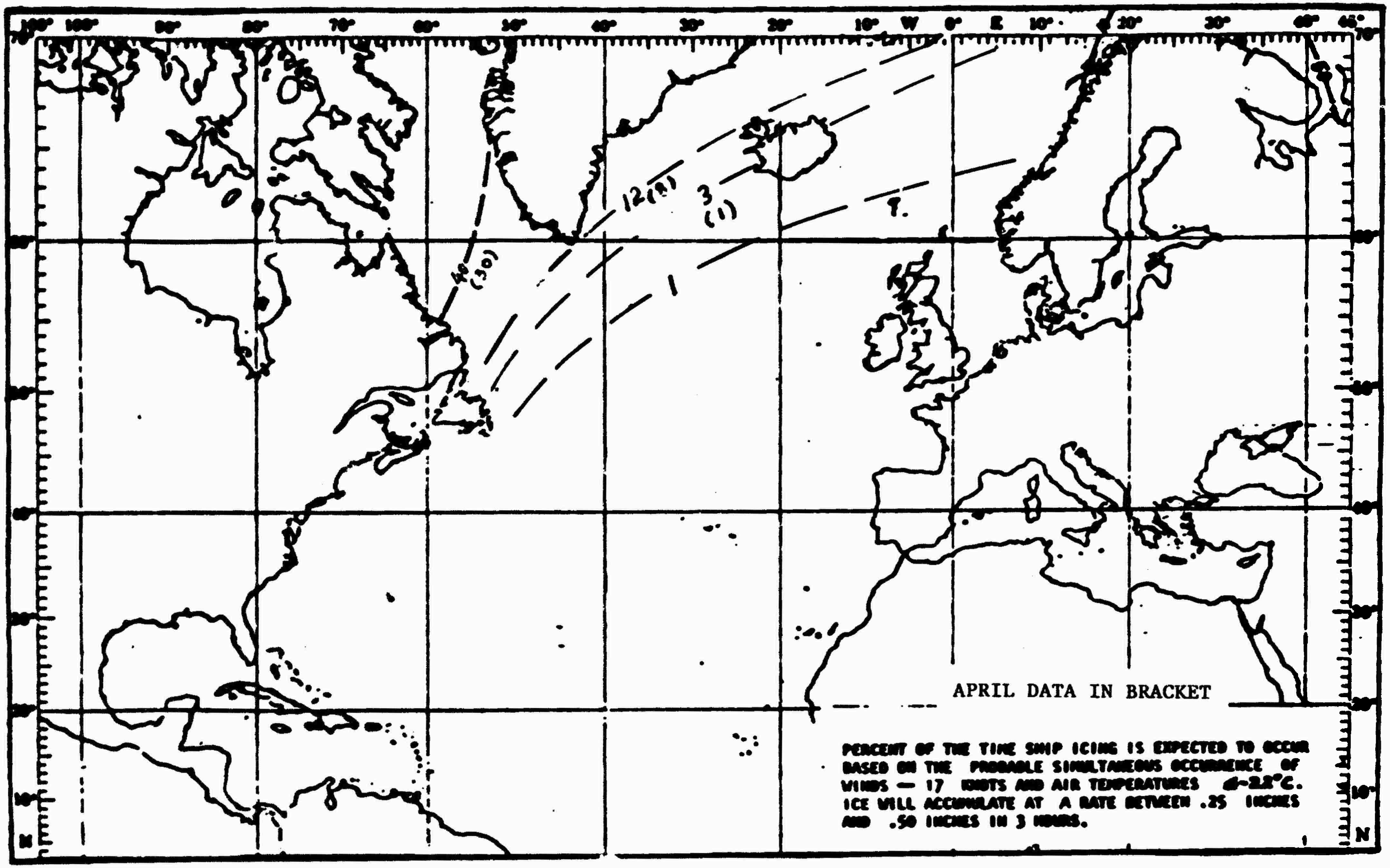
Figure 6 - Time History of Significant Wave Height for Moderate Weather Year.



Note: 1 foot = 0.3048 meter

Figure 7 - Time History of Significant Wave Height for Calm Weather Year.

PROBABILITY OF MODERATE SUPERSTRUCTURE ICING — ATLANTIC



NOTE: 1 inch = 2.54 cm

Figure 8 - Probability of Moderate Superstructure Icing for Spring Atlantic Ocean

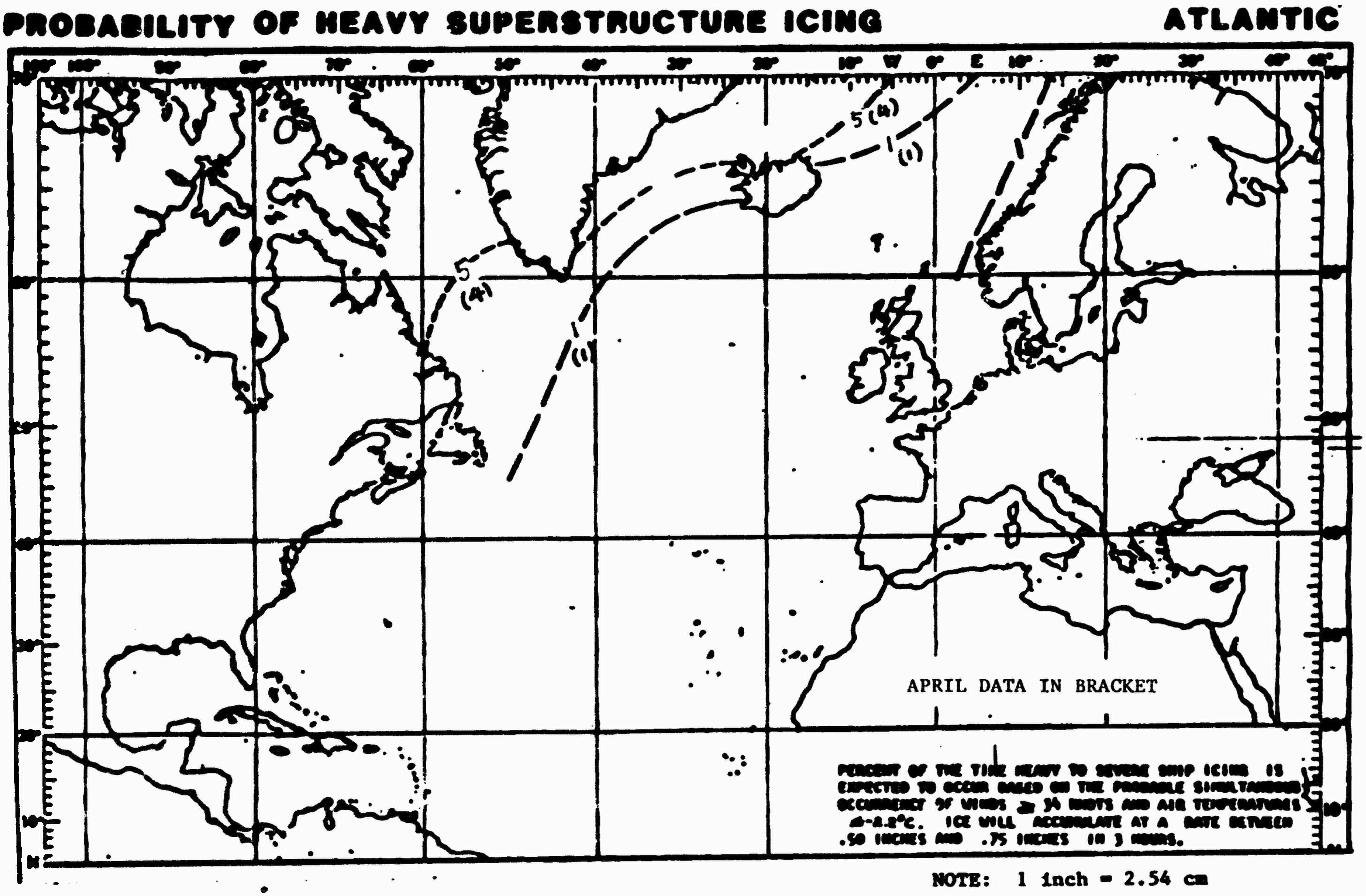


Figure 9 - Probability of Heavy Superstructure Icing for Spring Atlantic Ocean

TABLE 1 LOCATIONS DEFINING LABRADOR SEA AREAS

SUBPROJECTION	GRID POINT	LATITUDE, °N	LONGITUDE, °W
2	277	44.8	53.1
2	279	46.2	44.9
2	304	52.6	49.9
3	171	51.5	42.7

REFERENCES

1. "U.S. Navy Marine Climatic Atlas of the World, Vol. 1, North Atlantic Ocean," Naval Weather Service Detachment Publication NAVAIR-50-1C-528 (1974).

2. "U.S. Navy Hindcast Spectral Ocean Wave Model Climatic Atlas: North Atlantic Ocean," Publication NAVAIR 50-1C-538, Naval Oceanography Command Detachment, Asheville, N.C. (Mar 1983).

3. Lazanoff, S.M. and N.M. Stevenson, "An Evaluation of a Hemispheric Operational Wave Spectral Model," Fleet Numerical Oceanography Center Technical Note 75-3 (Jun 1975).

4. Gaythwaite, J., "The Marine Environment and Structural Design," Van Nostrand Reinhold Co. (1981).

APPENDIX A

WIND AND WAVE CLIMATOLOGY

MARCH 277/2 2478

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56+																
48–56																
40–48																
34–40									+	+	+	+				1
28–34								+	+	1	1	+				2
24–28								1	2	1	1	+				4
20–24						+	+	4	1	1	1	+				8
16–20						1	5	6	1	1	1	+	+			14
12–16					+	6	7	5	1	1	1	+				22
9–12				+	2	7	3	3	1	2	1	+				20
6–9			1	2	2	4	2	2	1	1	1	+	+			16
3–6		+	1	1	1	3	1	1	1	1	1		+			10
0–3	+		+	+	+	1	+	+	+	+	1	+	+			3
TOTALS	+	+	2	3	6	22	18	23	9	8	8	1	+			100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 3 - 1 Significant Wave Height
vs Modal Wave Period

MARCH 277/2 2478

SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56												
40–48												
34–40										+	+	1
28–34	+		+	+	+	+	+	+	1	1	+	2
24–28			+	+	+	+	1	1	2	1		4
20–24			+	+	1	1	1	3	1	+		8
16–20	+	+	+	1	2	3	5	3	+			14
12–16	+	+	1	3	4	8	5	1	+			22
9–12	+	+	2	5	6	6	1					20
6–9	+	1	3	6	5	1	+	+				16
3–6	1	1	3	4	1	+						10
0–3	+	1	1	+	+							3
TOTALS	2	3	11	19	19	19	13	8	4	2	+	100

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 3 - 2 Significant Wave Height vs Wind Speed

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56										
40–48										
34–40	+	+	+			+	+		+	1
28–34	+	+	+	+	+	+	1	+	+	2
24–28	+	1	+	+	+	+	1	+	+	4
20–24	1	1	1	+	2	1	1	+	1	8
16–20	2	2	1	1	3	2	2	+	1	14
12–16	3	4	2	1	3	3	3	1	3	22
9–12	3	3	1	1	2	2	3	1	3	20
6–9	3	3	1	+	1	2	3	1	3	16
3–6	2	2	1	+	+	1	1	1	2	10
0–3	+	+	+	+	+	+	+	+	1	3
TOTALS	15	16	8	4	11	12	15	5	14	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 3 - 3 Significant Wave Height vs Primary Wave Direction

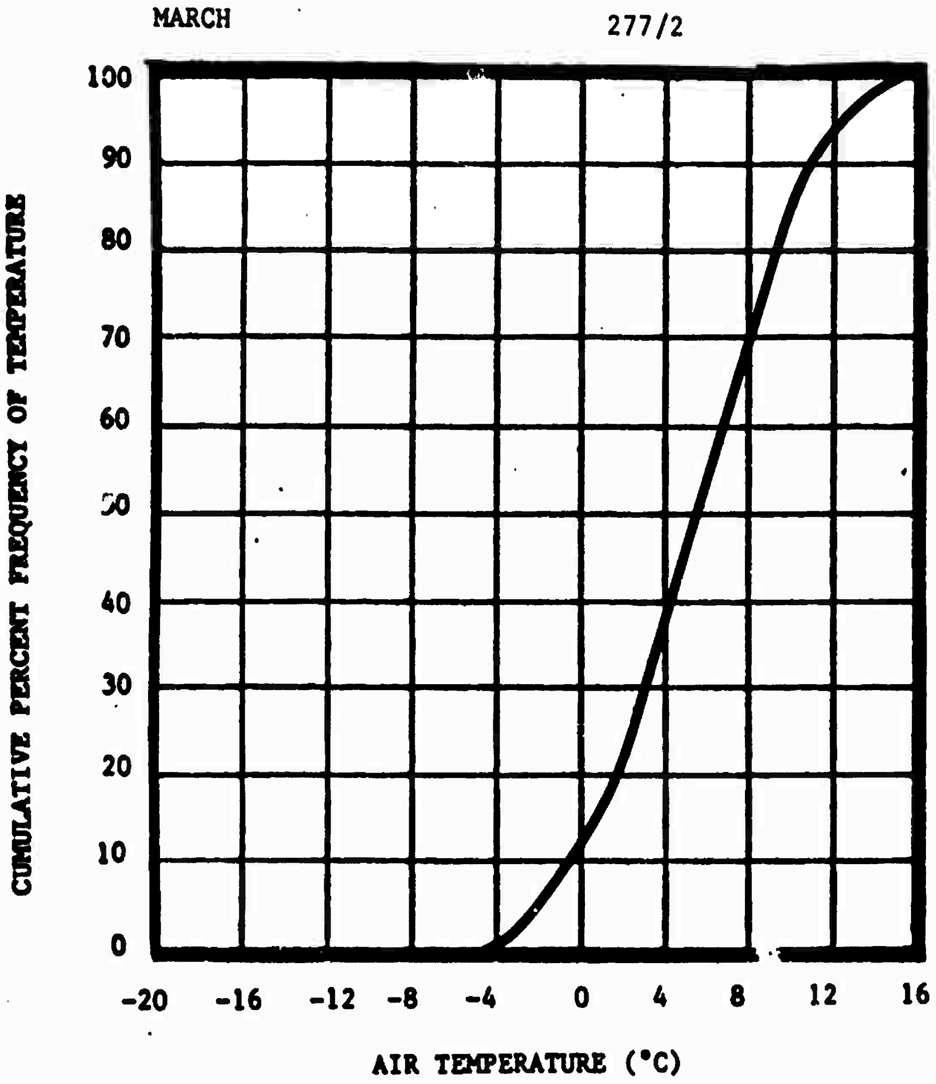


Figure A - 277 - 3 - 4 Air temperature

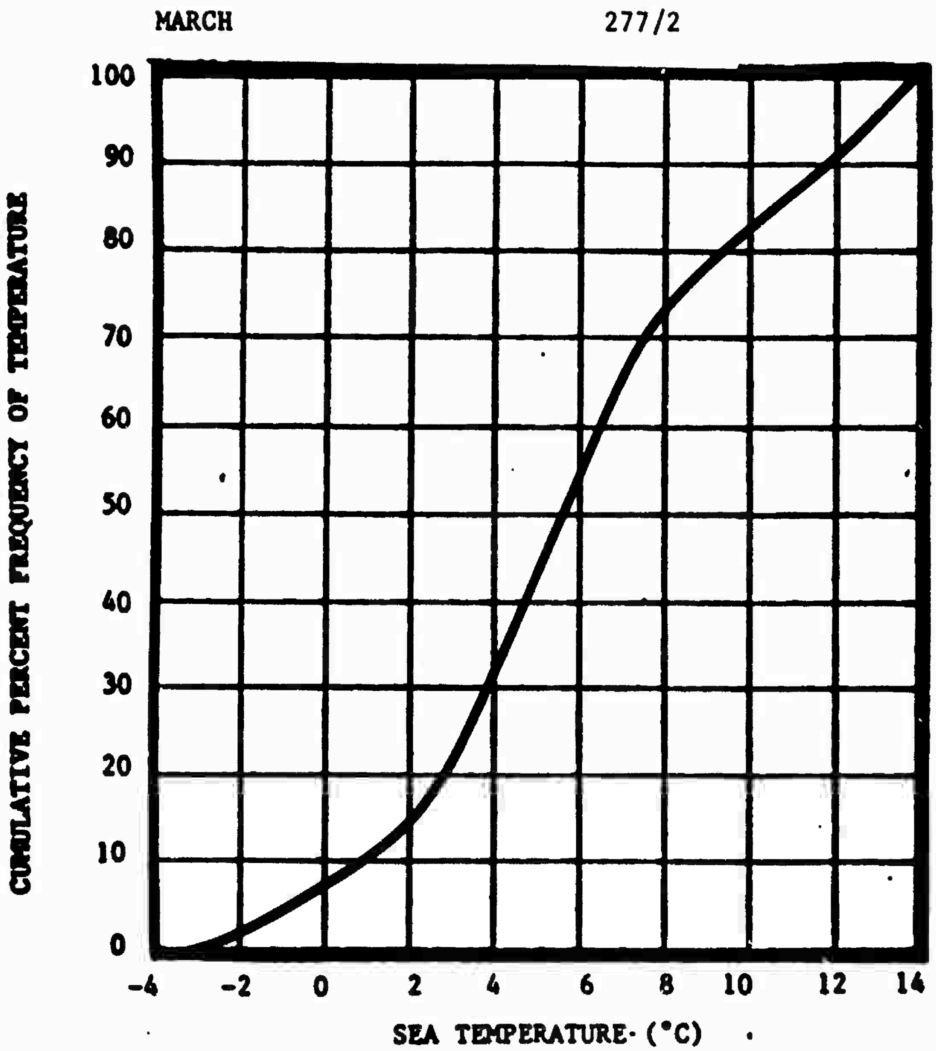


Figure A - 277 - 3 - 5 Sea temperature

APRIL 277/2 2397

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56*																
48–56																
40–48																
34–40									+	+	+					+
28–34								+	+	+	+					1
24–28								+	1	+	+					2
20–24							+	3	1	+	+					6
16–20						1	4	5	1	1	+					11
12–16					+	7	7	3	1	1	1					20
9–12				1	4	8	3	1	1	+	1					19
6–9			+	4	4	6	3	1	1	1	1					19
3–6		+	2	2	2	4	2	2	1	+	1					16
0–3		+	1	1	1	1	1	1	1	+	+					6
TOTALS		+	3	8	11	26	19	18	7	4	4					100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 4 - 1 Significant Wave Height vs Modal Wave Period

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SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56												
40–48												
34–40										+		+
28–34					+	+		+	+	+		1
24–28					+	+	+	1	1	+		2
20–24		+	+	+	+	1	1	2	1	+		6
16–20		+	+	1	1	2	4	2	1	+		11
12–16	+	+	1	3	4	6	5	+	+			20
9–12	+	1	2	4	4	7	+	+				19
6–9	1	1	3	7	6	1	+	+				19
3–6	1	2	5	7	2	+						16
0–3	1	2	2	1	+							6
TOTALS	3	6	13	23	18	17	10	6	3	1		100

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 4 - 2 Significant Wave Height vs Wind Speed

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SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56										
40–48										
34–40	+	+							+	+
28–34	+	+		+	+	+	+		+	1
24–28	+	+	+	+	+	+	+		+	2
20–24	+	1	+	1	1	1	1	+	+	6
16–20	1	1	1	1	2	2	2	+	1	11
12–16	2	3	1	2	3	3	3	+	2	20
9–12	2	2	1	2	3	3	3	1	2	19
6–9	3	2	1	2	2	3	3	1	3	19
3–6	2	1	1	1	1	3	3	1	2	16
0–3	+	+	+	+	+	1	1	+	1	6
TOTALS	11	11	6	10	13	17	17	4	11	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 4 - 3 Significant Wave Height vs Primary Wave Direction

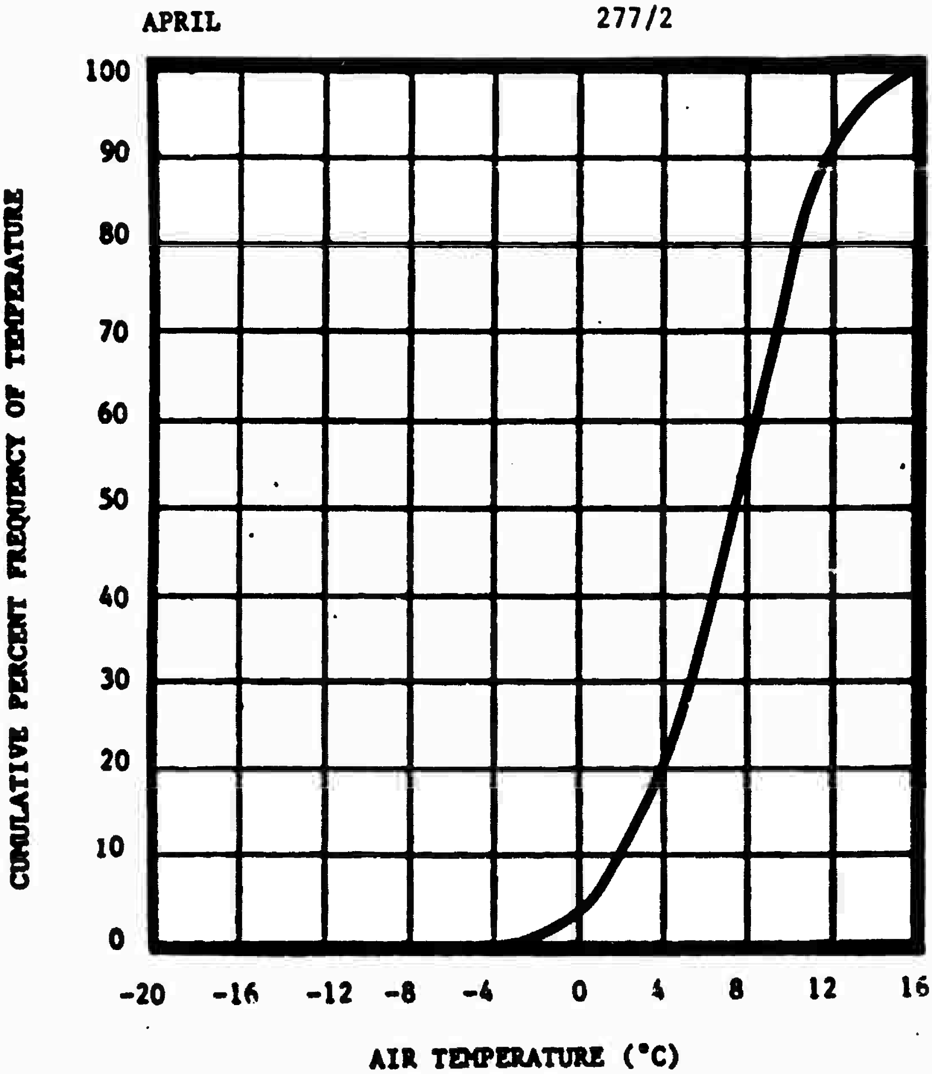


Figure A - 277 - 4 - 4 Air temperature

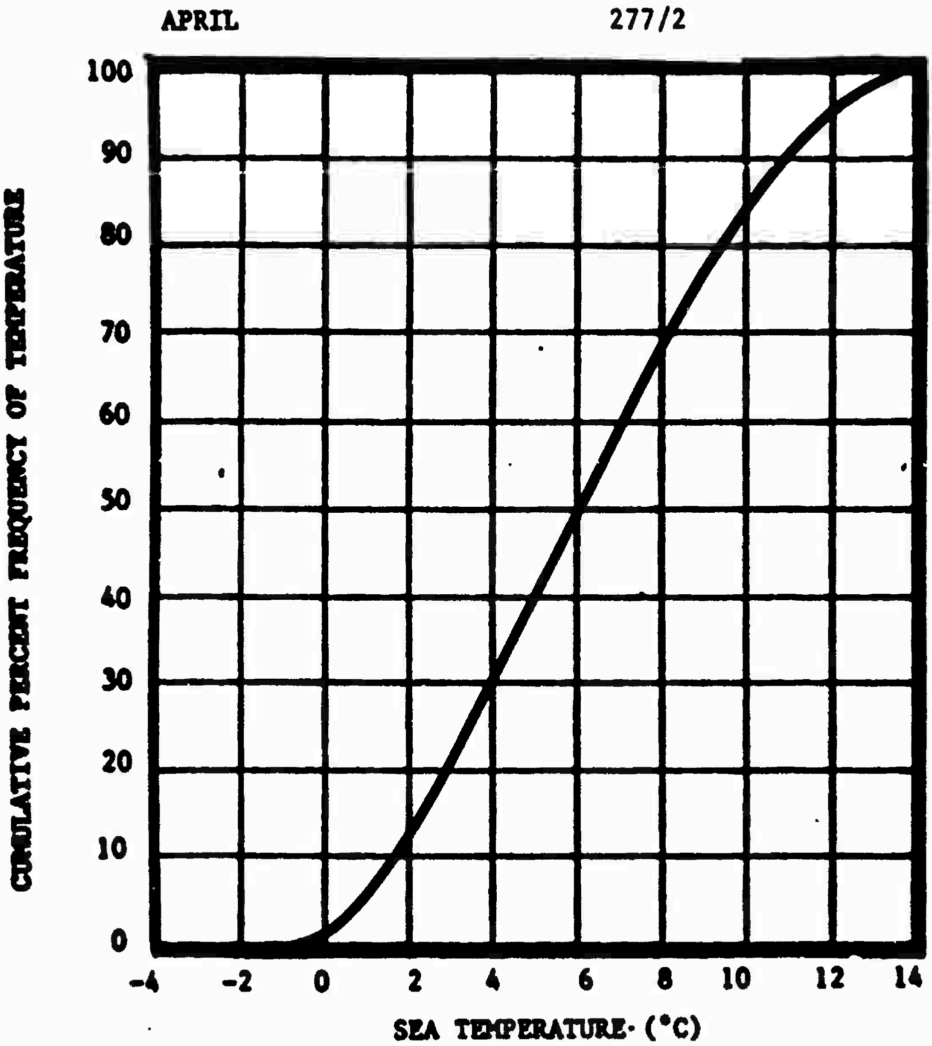


Figure A - 277 - 4 - 5 Sea temperature

APRIL

277/2

SIG. WAVE HEIGHT (FT)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96*	TOTALS
56* –																	
48 – 56																	
40 – 48																	
34 – 40																	
28 – 34	1	1			1												3
24 – 28	4		1	3		2											10
20 – 24	11	6	3	2	2		1	2									27
16 – 20	18	7	10	10	6	5	2		4								62
12 – 16	10	18	17	10	12	5	7	7	3	8	2	1					100
9 – 12	13	13	14	10	12	12	9	8	3	5	8	8	5	3	2	8	133
6 – 9	14	7	6	9	8	8	11	11	6	6	5	3	4	2	4	31	135
3 – 6	7	3	5	7	4	3	6	3	1	6	1	2	5	5	3	47	108
0 – 3	4	2	2	1				2		1	2				1	39	54
TOTALS	82	57	58	52	45	35	36	33	17	26	18	14	14	10	10	125	632

HOURS DURATION OF EVENTS

NOTE: 1 foot = 0.3048 meter

Figure A - 277 - 4 - 6 Persistence of Wave Height

APRIL 277/2

WIND SPEED (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96*	TOTALS
64*																	
48–64																	
41–48	2	2	1	1	1												7
34–41	20	5	3		1	2	1										32
28–34	33	23	7	6	3	1	1	1	2								77
22–28	41	37	28	12	11	3	3	2	4	4	2						147
17–22	42	37	30	16	18	8	15	8	8	5	4	5	3	1		2	202
11–17	29	28	28	20	17	13	12	4	15	6	9	5	7	5	5	12	215
7–11	18	11	16	20	12	11	11	12	12	5	5	5	9	8	4	39	198
4–7	11	3	8	4	7	9	1	8	7	1	2	2	7	2	6	62	140
0–4	2	2	2	2	1	3	2	1		2	1		1	1		59	79
TOTALS	198	148	123	81	71	50	46	36	48	23	23	17	27	17	15	174	1097

HOURS DURATION OF EVENTS

Figure A - 277 - 4 - 7 Persistence of Wind Speed

MARCH 279/2 2478

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56*																
48												+				+
40											+	+	+			1
34										+	1	+	+			2
28								+	+	2	1	+	+			4
24								1	2	2	1	+	+			6
20							+	6	2	1	1	+				11
16						+	5	8	2	1	1	1				18
12					1	5	7	5	2	2	1	1				23
9				+	4	4	4	2	1	1	+	1				18
6			+	1	2	2	2	2	1	+	+	+				12
3		+	+	1	1	1	1	1	+	+	+	+				5
0						+		+								+
TOTALS		+	+	2	7	13	19	26	12	10	7	4	+			100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 3 - 1 Significant Wave Height vs Modal Wave Period

MARCH 279/2 2478

SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56										+	+	+
40–48									+	1	+	1
34–40						+	+	+	+	1		2
28–34		+		+	+	+	+	1	2	+		4
24–28			+	+	1	1	1	2	1	+		6
20–24	+	+	+	1	1	2	3	3	+			11
16–20	+	+	1	3	3	4	6	1	+			18
12–16	+	1	1	5	6	7	3	+	+			23
9–12	+	1	2	5	5	4	+	+				18
6–9	+	1	3	5	3	+						12
3–6	+	1	2	2	+	+	+					5
0–3	+		+	+								+
TOTALS	1	5	9	21	19	19	13	7	4	2	+	100

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 3 - 2 Significant Wave Height vs Wind Speed

MARCH 279/2 2478

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56						+	+	+		+
40–48	+					+	+	+	+	1
34–40	+	+	+			+	+	1	+	2
28–34	+	+	+	+	+	1	1	1	+	4
24–28	1	+	+	+	1	1	1	2	1	6
20–24	2	+	1	+	1	1	1	3	1	11
16–20	3	1	1	1	2	2	2	3	2	18
12–16	4	1	3	2	3	2	2	4	3	23
9–12	2	1	2	1	2	2	2	3	3	18
6–9	2	1	1	1	1	1	1	2	2	12
3–6	1	+	1	1	+	1	1	1	1	5
0–3	+	+		+			+		+	+
TOTALS	15	5	9	6	10	11	11	20	13	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 3 - 3 Significant Wave Height vs Primary Wave Direction

MARCH 279/2

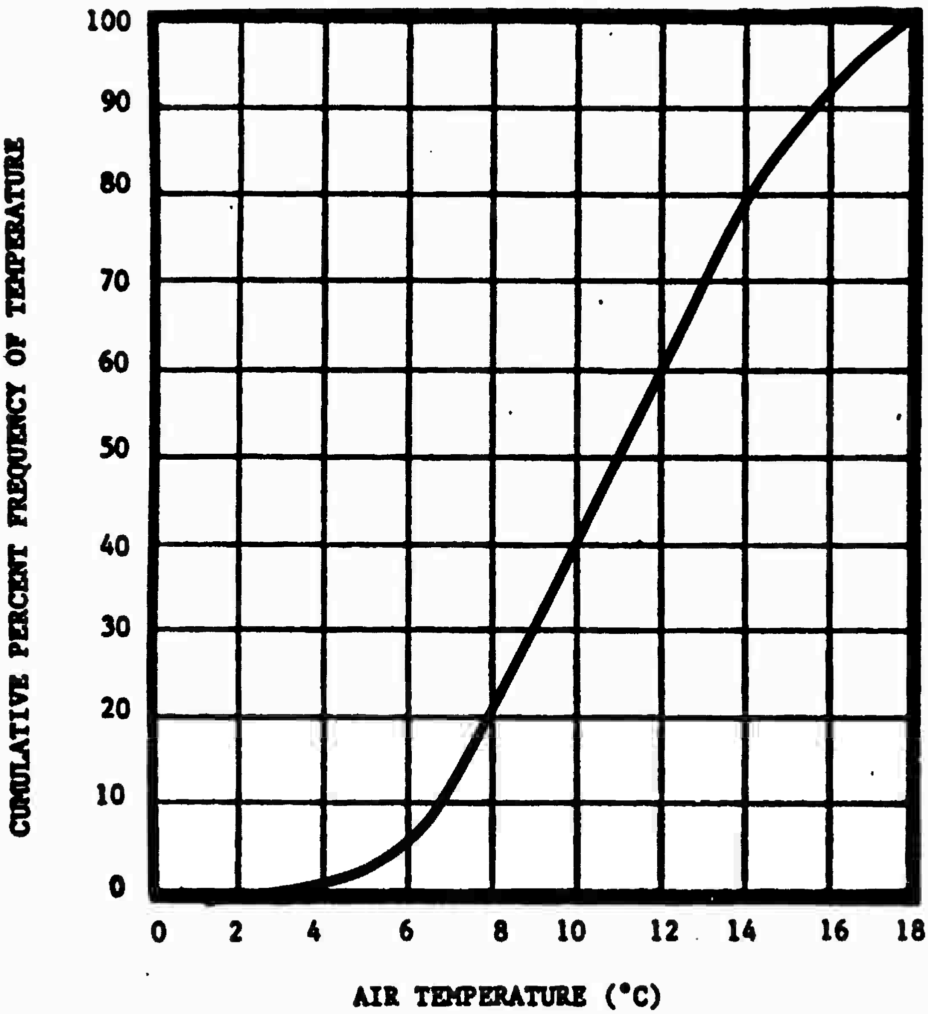


Figure A - 279 - 3 - 4 Air temperature

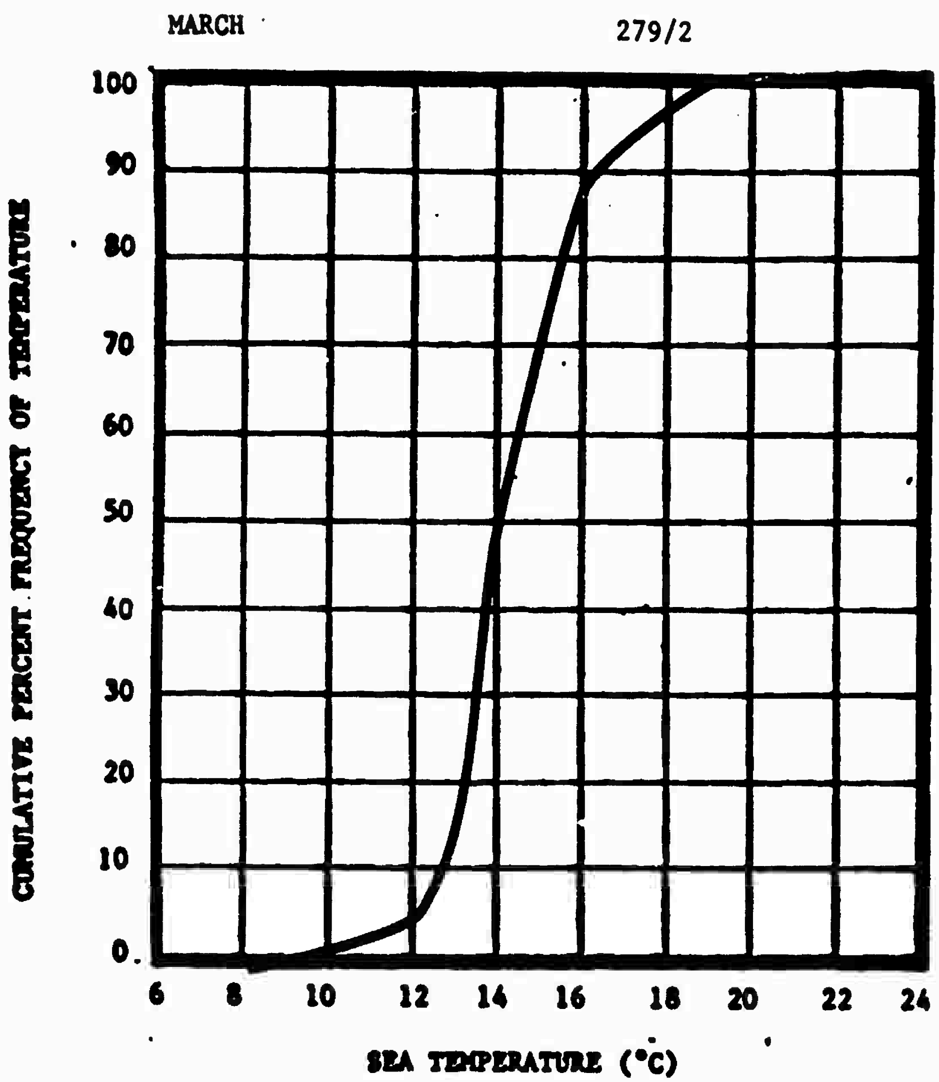


Figure A - 279 - 3 - 5 Sea temperature

APRIL 279/2 2397

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56+																
48–56																
40–48																
34–40									+		1	+				1
28–34									+	1	+	+				2
24–28								1	1	+	1	+				3
20–24							+	3	1	1	1	+				6
16–20						+	4	7	2	1	+	+				13
12–16					+	6	8	5	2	1	+	+				21
9–12				+	4	8	4	2	1	1	+	+				21
6–9			1	4	4	4	3	2	1	1	+	+				21
3–6		+	1	2	2	2	1	+	+	+		+				10
0–3	+		+	+	1	+	+	+	+							2
TOTALS	+	+	2	6	12	21	20	20	9	6	3	1				100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 4 - 1 Significant Wave Height vs Modal Wave Period

APRIL 279/2 2397

SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0	4	7	11	17	22	28	34	41	48	64+	TOTALS
56+												
48												
40												
34			+			+	+		+	+		1
28				+	+	+	+	+	1	+		2
24				+	+	+	1	1	+	+		3
20		+	+	+	+	1	2	2	+			6
16	+	+	+	1	2	4	5	1	+			13
	+	1	1	5	5	7	2	+	+			21
9	1	1	2	6	6	5	+	+				21
6	1	2	4	8	5	1	+					21
3	1	1	3	4	+	+						10
0	+	+	1	+								2
TOTALS	3	6	11	25	19	19	11	4	2	+		100

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 4 - 2 Significant Wave Height vs Wind Speed

APRIL 279/2 2397

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56										
40–48										
34–40	+			+	+		+	+	+	1
28–34	+	+		+	+	+	+	+	+	2
24–28	+	+	+	+	+	+	1	+	+	3
20–24	1	+	+	1	1	1	2	1	1	6
16–20	1	1	1	1	2	3	3	2	1	13
12–16	2	1	1	2	3	4	4	3	2	21
9–12	3	1	1	2	3	4	3	3	2	21
6–9	2	1	1	2	3	3	3	3	2	21
3–6	1	+	1	1		1	2	2	2	10
0–3	+	+	+	+	+	+	+	+	+	2
TOTALS	10	5	5	9	13	16	18	14	10	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 4 - 3 Significant Wave Height vs Primary Wave Direction

APRIL 279/2

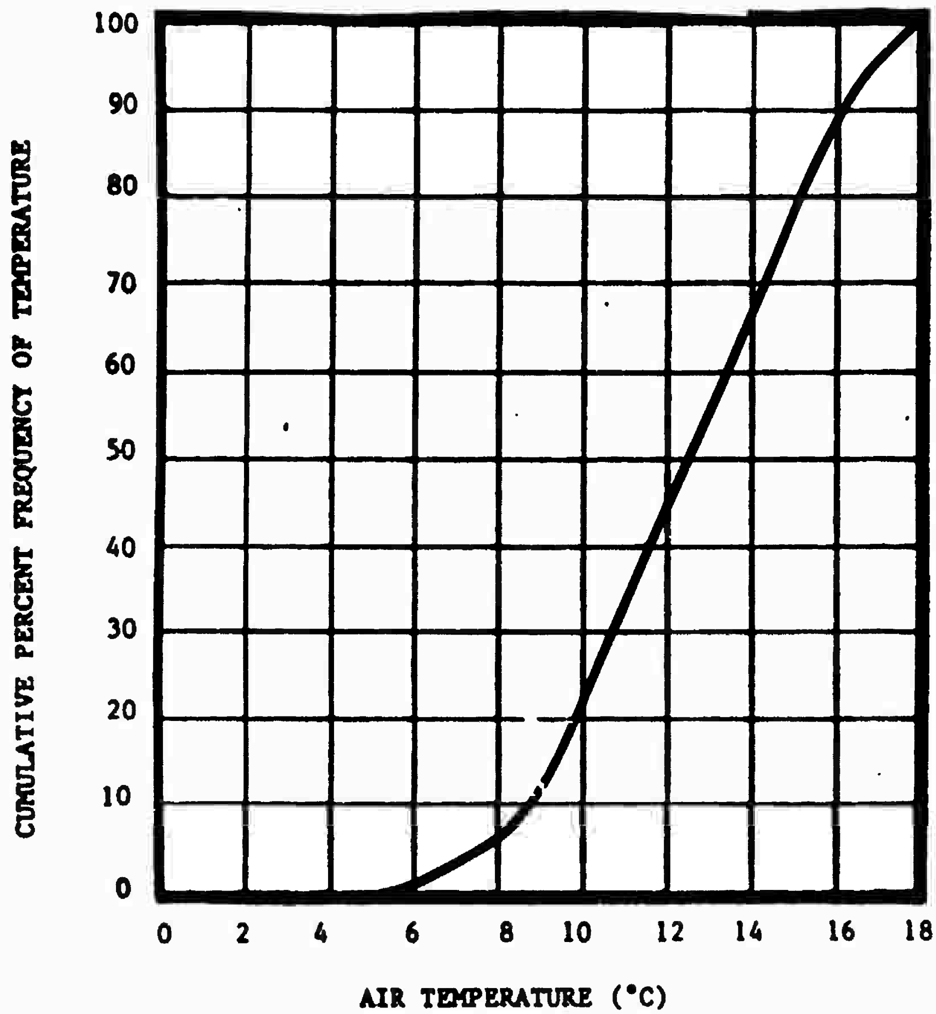


Figure A - 279 - 4 - 4 Air temperature

APRIL 279/2

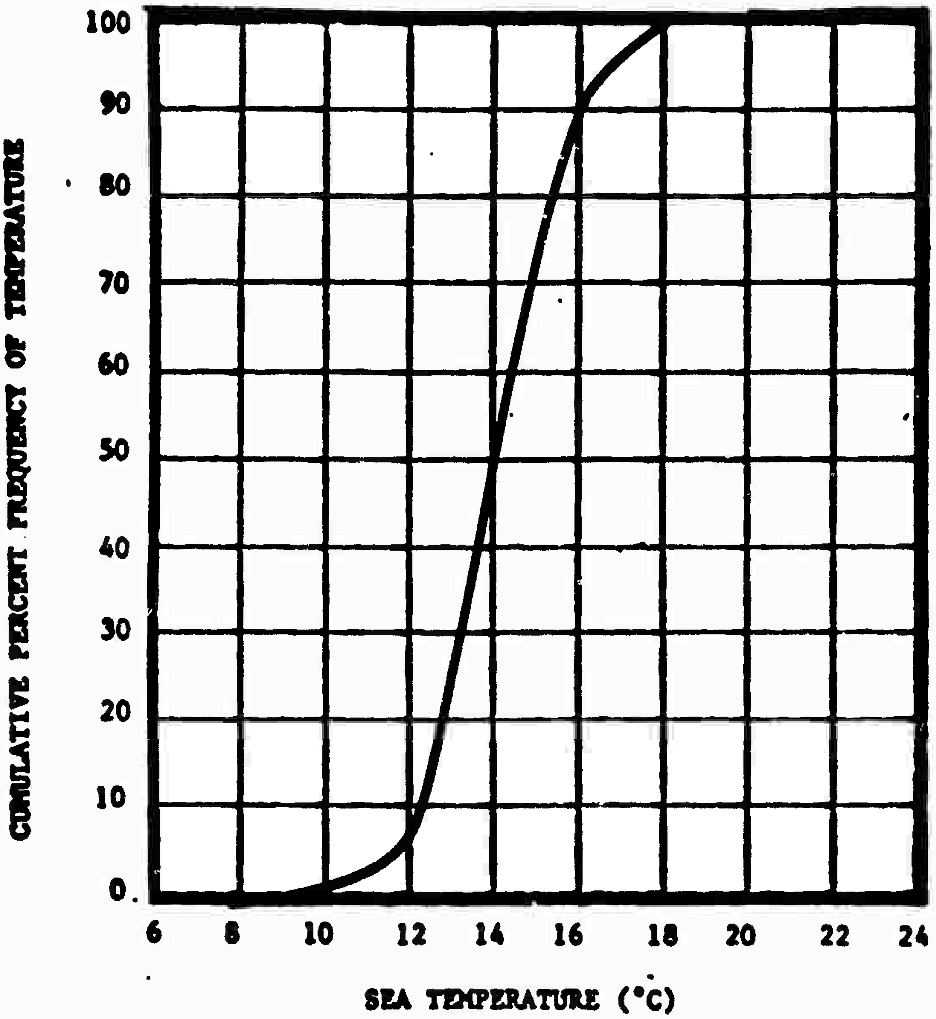


Figure A - 279 - 4 - 5 Sea temperature

APRIL 279/2

SIG. WAVE HEIGHT (FT)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	TOTALS
56+																	
48–56																	
40–48																	
34–40																	
28–34	1	3	3														7
24–28	3	3	5	2	2		1			1							17
20–24	5	4	5	2	8	2	1		1						1		29
16–20	16	8	11	9	3	5	2	2	3		3		1			1	64
12–16	7	14	11	13	9	6	6	9	2	6	5	3	2		2	4	99
9–12	11	8	7	8	9	8	4	8	3	4	5	5	6	5		25	116
6–9	12	9	12	9	6	8	4	5	1	3	4	3	3	7	1	43	130
3–6	2	5	6	3	3	1	3	4	1	1	1	3		1	1	52	87
0–3	1				1									1	1	23	27
TOTALS	58	54	60	46	41	30	21		11	15	18	14	12	14	6	148	576

HOURS DURATION OF EVENTS

NOTE: 1 foot = 0.3048 meter

Figure A - 279 - 4 - 6 Persistence of Wave Height

APRIL 279/2

WIND SPEED (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	TOTALS
64+																	
48–64																17	17
41–48								1								20	21
34–41	2	1		2			1			1					1	27	35
28–34	11	1	1	4	2	4			1	4	1	1	1		1	41	73
22–28	12	8	8	10	6	2	5	4	5	3	1	2	4	3	2	48	123
17–22	28	28	18	16	15	12	8	7	9	6	4	5	5	1	2	35	199
11–17	46	32	32	35	13	14	7	3	12	4	5	2	4	2	3	11	225
7–11	66	56	15	13	8	9	4	3	3	1	4		2				184
4–7	67	32	20	5	3		2										129
0–4	35	13	6	1													55
TOTALS	267	171	100	86	47	41	27	18	30	19	15	10	16	6	9	199	1061

HOURS DURATION OF EVENTS

Figure A - 279 - 4 - 7 Persistence of Wind Speed

MARCH 304/2 2477

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56+																
48–56												+	+			1
40–48											+	1	+			1
34–40										1	1	+				2
28–34								+	1	3	1	+				5
24–28								1	2	2	+	+				5
20–24							1	7	2	1	1					11
16–20						1	6	9	2	1	1					20
12–16					1	5	8	6	2	1	1	+				24
9–12				+	3	4	3	2	1	1	1	+	+	+		15
6–9			+	1	3	2	2	1	1	+	+	+				11
3–6			+	+	1	1	1	1	1	+	+					5
0–3	+		+			+	+									+
TOTALS	+		1	2	8	12	21	26	12	9	7	2	+	+		100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 3 - 1 Significant Wave Height vs Modal Wave Period

MARCH — 304/2 — 2477

Sig. Wave Height (ft) \ Wind Speed (knots)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56							+			+	+	1
40–48						+			+	1	+	1
34–40							+	+	1	1	+	2
28–34			+	+	+	+	+	1	2	1	+	5
24–28				+	+	+	1	3	1			5
20–24		+	+	+	1	2	3	4	+	+		11
16–20	+	+	+	2	3	5	8	2				20
12–16	+	+	1	4	6	9	3	+				24
9–12	+	1	2	4	5	3	+					15
6–9	1	1	2	4	3	+	+					11
3–6	+	1	2	2	+							5
0–3	+	+	+	+	+							+
TOTALS	2	4	7	17	18	19	16	10	4	3	+	100

WIND SPEED (KNOTS)

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 3 - 2 Significant Wave Height vs Wind Speed

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56	+	+	+					+		1
40–48	+	+	+					+		1
34–40	+	+	1	+	+		+	+	+	2
28–34	+	+	1	+	+	+	+	2	1	5
24–28	1	+	1	+	1	+	+	2	1	5
20–24	1	1	2	1	1	1	1	3	1	11
16–20	2	2	4	1	2	1	1	4	2	20
12–16	2	3	4	2	2	2	1	4	4	24
9–12	2	2	2	1	1	1	+	3	3	15
6–9	1	1	1	1	1	1	1	2	2	11
3–6	1	1	1	1	+	+	+	+	1	5
0–3	+		+	+			+	+		+
TOTALS	10	11	17	7	8	6	5	21	15	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 3 - 3 Significant Wave Height vs Primary Wave Direction

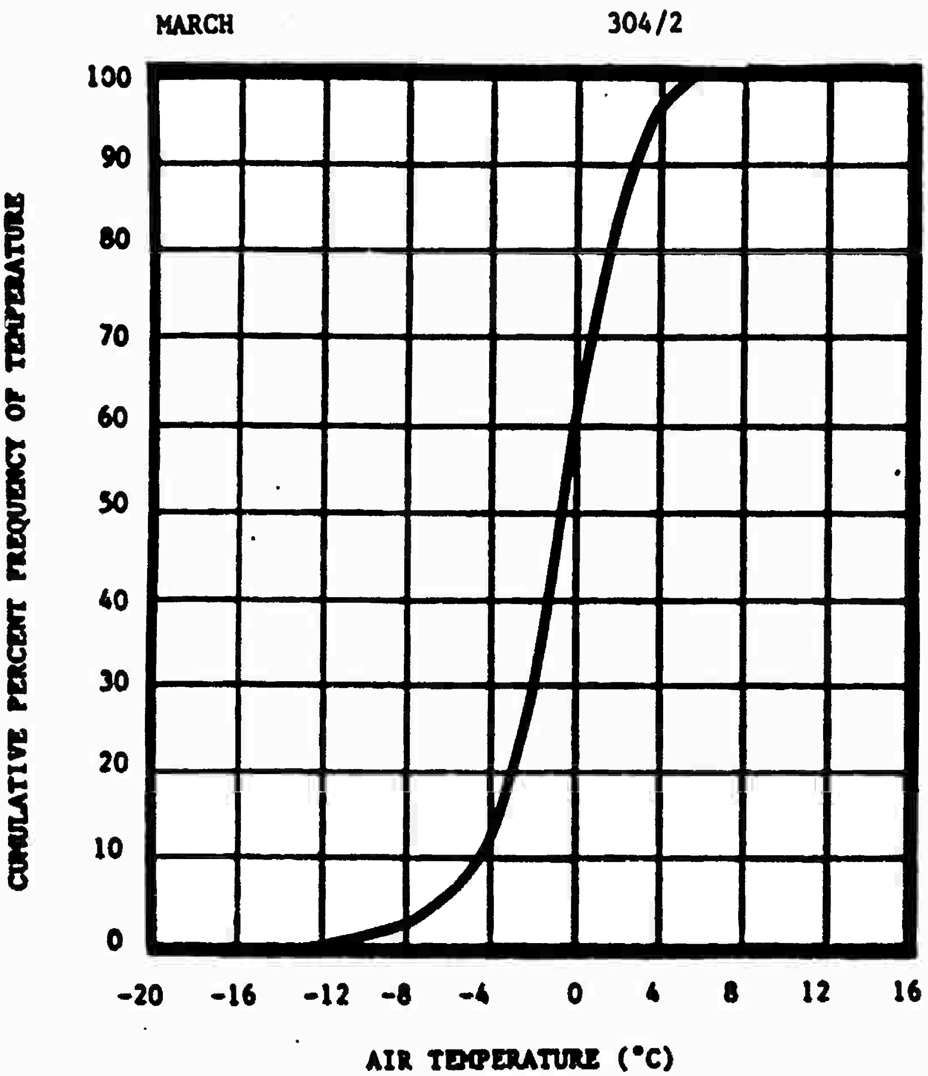


Figure A - 304 - 3 - 4 Air temperature

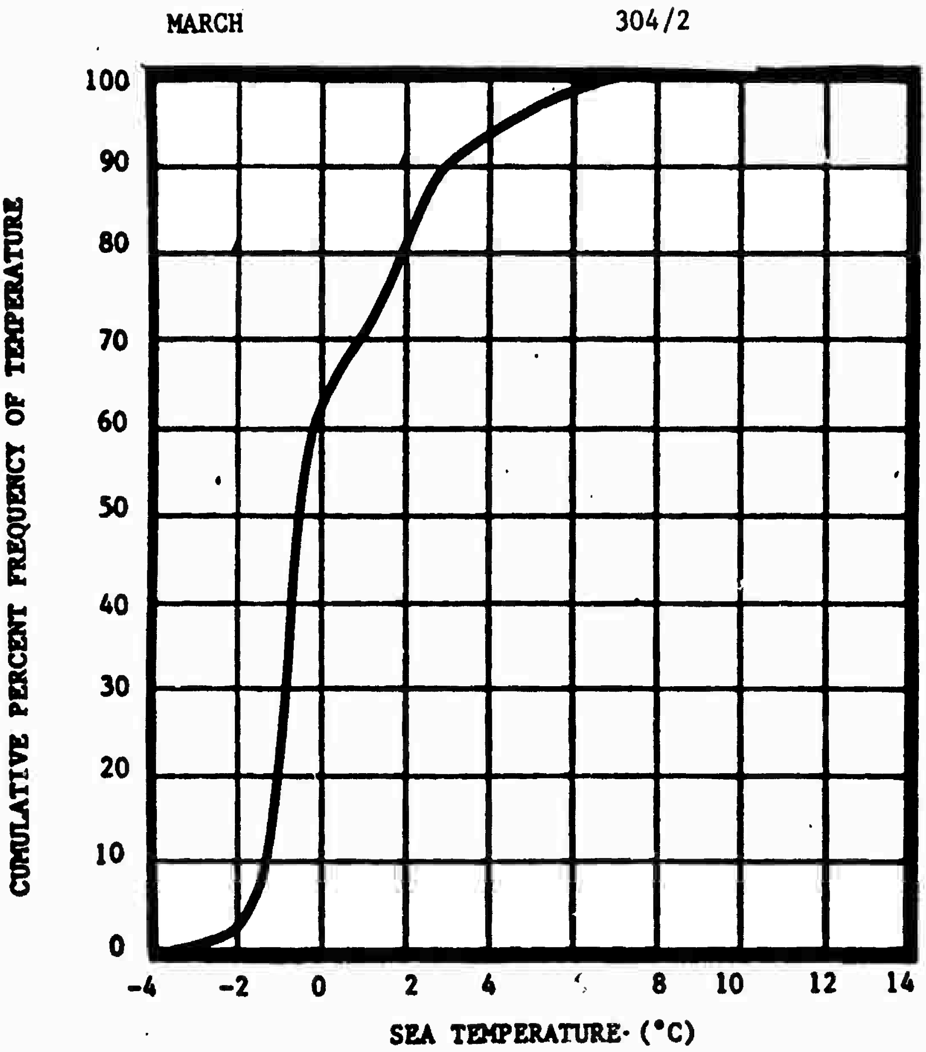


Figure A - 304 - 3 - 5 Sea temperature

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56+																
48–56																
40–48																
34–40										+	+					1
28–34								+	+	1	1	+				2
24–28							+	1	1	1	+	+				3
20–24							+	5	1	1	+	+				8
16–20						+	4	6	2	1	+					13
12–16					1	5	8	5	1	+	1					21
9–12				1	6	7	3	3	1	+	+					21
6–9			+	3	6	4	2	2	1	+	1					19
3–6			1	2	2	2	1	1	+	+	+					11
0–3			+	+	+	+	+	+	+							1
TOTALS			2	6	15	19	19	23	7	5	4	+				100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 4 - 1 Significant Wave Height vs Modal Wave Period

APRIL						304/2					2397

SIG. WAVE HEIGHT (FT) vs **WIND SPEED (KNOTS)**

Sig. Wave Height (ft)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56												
40–48												
34–40								+	+	+		1
28–34				+	+	+	+	1	1	+		2
24–28					+	+	+	1	1	+		3
20–24				+	1	1	3	3	+	+		8
16–20		+	+	1	2	4	5	1	+			13
12–16	+	+	1	3	5	8	3	+	+			21
9–12	+	+	2	5	7	6	+	+				21
6–9	1	1	3	9	6	+	+					19
3–6	1	2	4	4	+							11
0–3	+	+	1	+								1
TOTALS	2	4	11	22	21	19	12	6	3	+		100

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 4 - 2 Significant Wave Height vs Wind Speed

APRIL 304/2 2397

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56										
40–48										
34–40		+	+	+	+				+	1
28–34		+	1	+	+			+	+	2
24–28	+	+	1	+	+	+	+	+	+	3
20–24	+	1	2	1	1	+	+	1	1	8
16–20	1	1	4	1	2	1	1	2	1	13
12–16	2	2	4	2	2	2	2	3	2	21
9–12	2	2	3	2	3	1	1	4	3	21
6–9	1	2	1	1	3	2	2	4	3	19
3–6	2	1	1	1	2	1	1	1	2	11
0–3	+	+	+	+	+	+		+	+	1
TOTALS	8	10	17	9	14	7	7	15	13	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 4 - 3 Significant Wave Height vs Primary Wave Direction

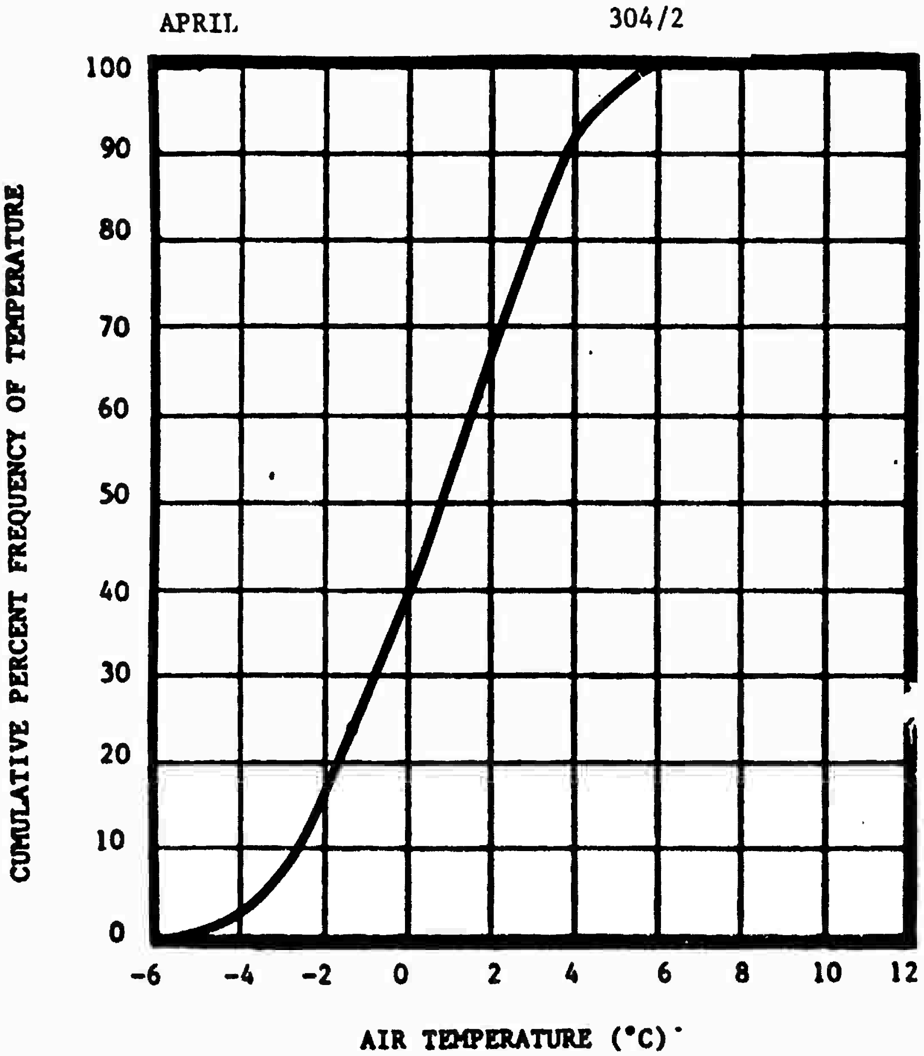


Figure A 304 - 4 - 4 Air temperature

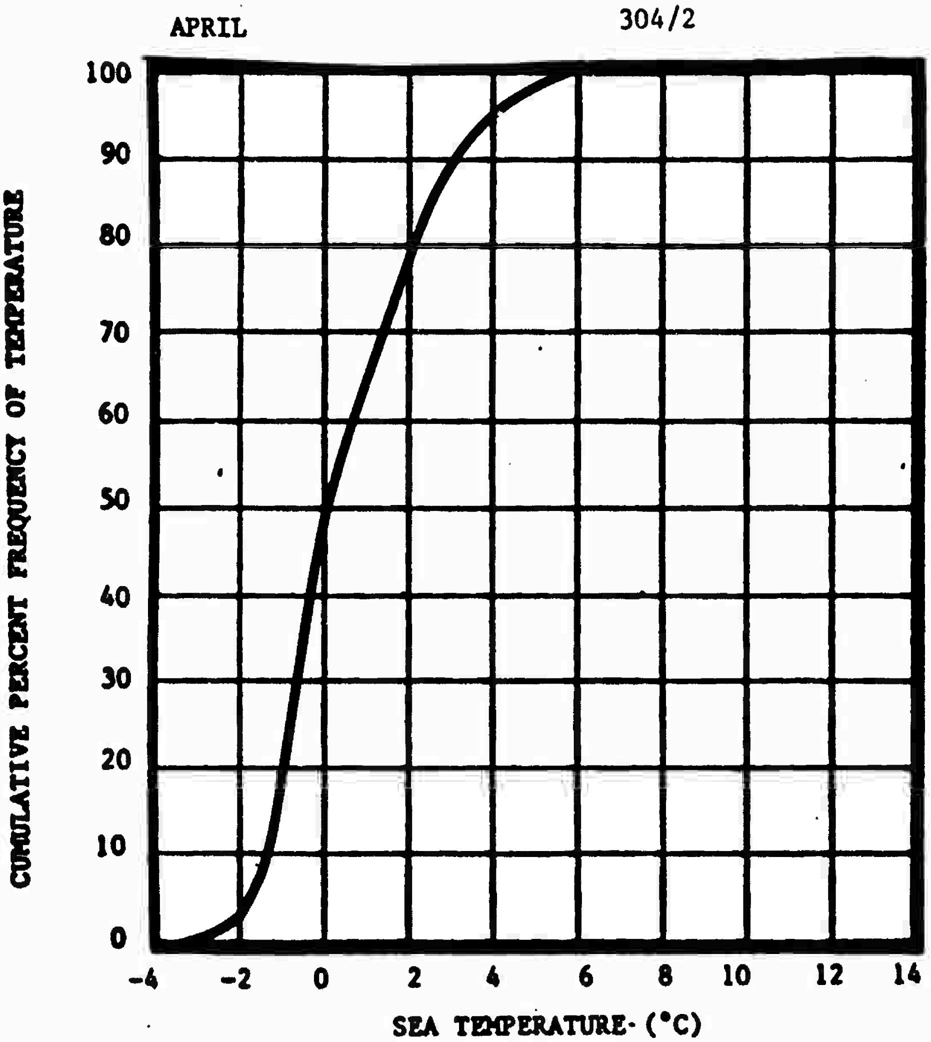


Figure A - 304 - 4 - 5 Sea temperature

APRIL

304/2

SIG. WAVE HEIGHT (FT)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	TOTALS
56+																	
48																	
40																	
34																	
28		3	1		1												5
24	4	4	2		1	1	3			1							16
20	10	6	4	4	4	1	1	1		1		1	1				34
16	9	14	9	12	9	5	1	3	1	2	2		1	2			70
12	10	11	10	15	9	8	11	11	3		3	1	1	3	1	6	103
9	16	7	11	11	12	12	8	5	3	8	3	6	6	1	3	20	132
6	12	8	9	7	4	5	3	6	6	2	7	1	5	6	3	45	129
3	9	3	4	2	4	3		3	2	4	1		3	1	2	49	90
	1							1					1			26	29
TOTALS	71	56	50	51	44	35	27	30	15	18	16	9	18	13	9	146	608

HOURS DURATION OF EVENTS

NOTE: 1 foot = 0.3048 meter

Figure A - 304 - 4 - 6 Persistence of Wave Height

APRIL 304/2

Wind Speed (Knots)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	Totals
64+																	
48–64																	
41–48	2	1			1		1										5
34–41	9	3	6	1	2				1								22
28–34	20	21	9	10	3	1	1		2	1							68
22–28	34	12	21	18	10	13	2	1	4	1	3	1		1		1	122
17–22	52	22	32	19	21	16	5	9	5	2	3	1	3	2	5	5	202
11–17	25	25	27	18	23	14	11	9	12	2	1	4	7	4	1	25	208
7–11	19	11	10	11	11	5	10	10	5	5	1	4	4	1	2	54	163
4–7	4	8	3	6	5	6	5	2	4	2	2	3	1	1	2	55	109
0–4		2	1			1	1	1	3	1						42	52
TOTALS	165	105	109	83	76	56	36	32	36	14	10	13	15	9	10	182	951

HOURS DURATION OF EVENTS

Figure A - 304 - 4 - 7 Persistence of Wind Speed

MARCH 171/3 2474

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
56+												+				+
48–56												+				+
40–48											+	+	+			1
34–40										+	1	+	+			2
28–34								+	+	3	2	+				6
24–28								1	3	2	1	+				7
20–24							+	6	3	1	1	+				11
16–20						+	4	8	2	1	1					15
12–16					+	4	9	6	2	1	1					23
9–12				+	3	4	4	4	2	1	+	+				19
6–9				1	2	3	2	2	+	+	+					11
3–6			+	1	1	1	1	1	1	+						5
0–3						+		+								+
TOTALS			+	2	6	12	20	29	14	9	7	1	+			100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 3 - 1 Significant Wave Height vs Modal Wave Period

APRIL 171/3 2474

SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+											+	+
48–56								+		+		+
40–48							+		+	1	+	1
34–40				+	+		+	+	+	1		2
28–34			+	+	+	+	1	2	2	1		6
24–28			+	+	+	1	2	3	1	+		7
20–24		+	+	1	1	2	4	3	+			11
16–20	+	+	+	2	3	4	6	+	+			15
12–16	+	+	2	5	5	3	2	+	+			23
9–12	+	1	2	7	5	3	+					13
6–9	1	1	3	5	2	+						11
3–6	+	1	2	2	+							5
0–3			+	+								+
TOTALS	1	3	10	22	16	18	15	8	4	3		100

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 3 - 2 Significant Wave Height vs Wind Speed

MARCH	171/3	2474

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+									+	+
48									+	+
40	+	+	+		+	+	+	+	+	1
34	+	+	+	+	+	+	+	1	+	2
28	+	1	1	1	+	+	1	2	+	6
24	+	+	1	1	1	1	1	3	+	7
20	1	1	1	1	1	1	1	3	1	11
16	1	1	1	2	2	1	1	4	1	15
12	1	2	2	4	3	2	2	4	3	23
9	2	2	1	2	2	2	1	4	3	19
6	1	1	1	2	1	1	1	2	2	11
3	+	+	1	1	+	+	1	1	1	5
0							+	+		+
TOTALS	6	8	9	14	10	8	9	24	12	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 3 - 3 Significant Wave Height vs Primary Wave Direction

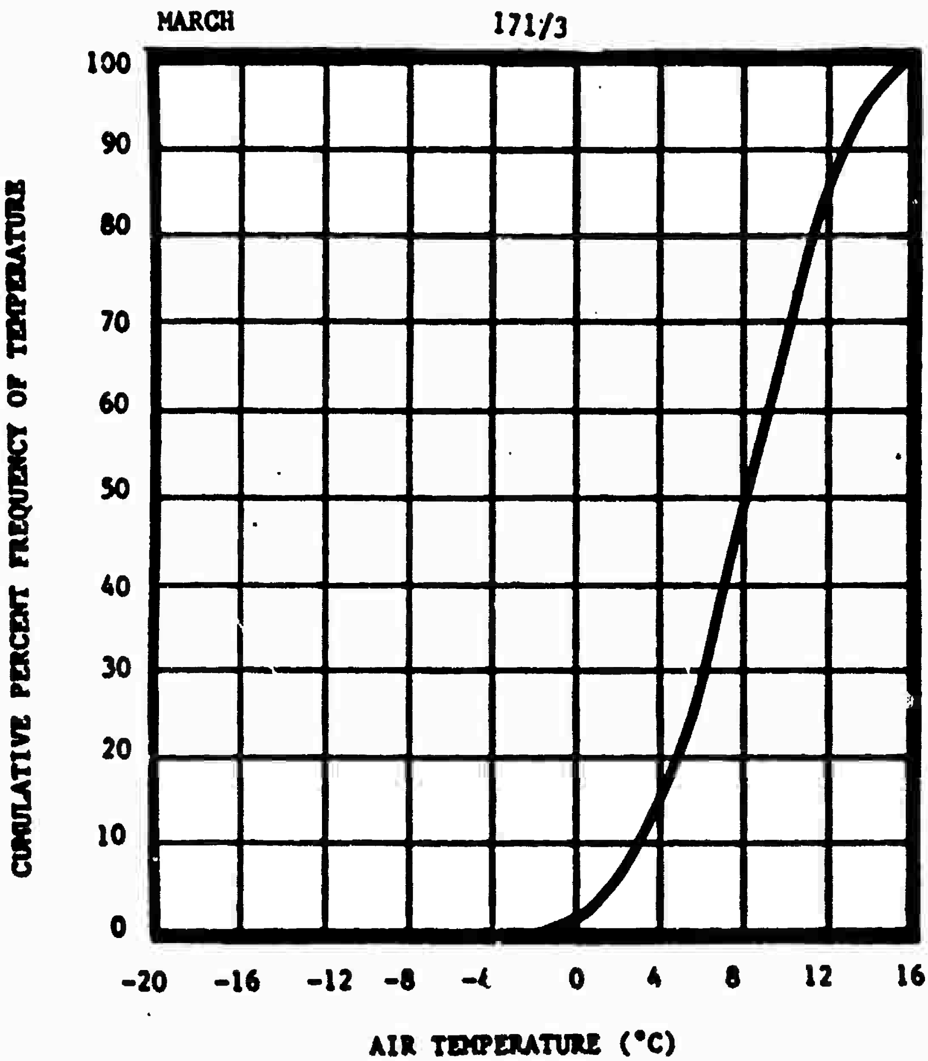


Figure A 171-3 - Air temperature

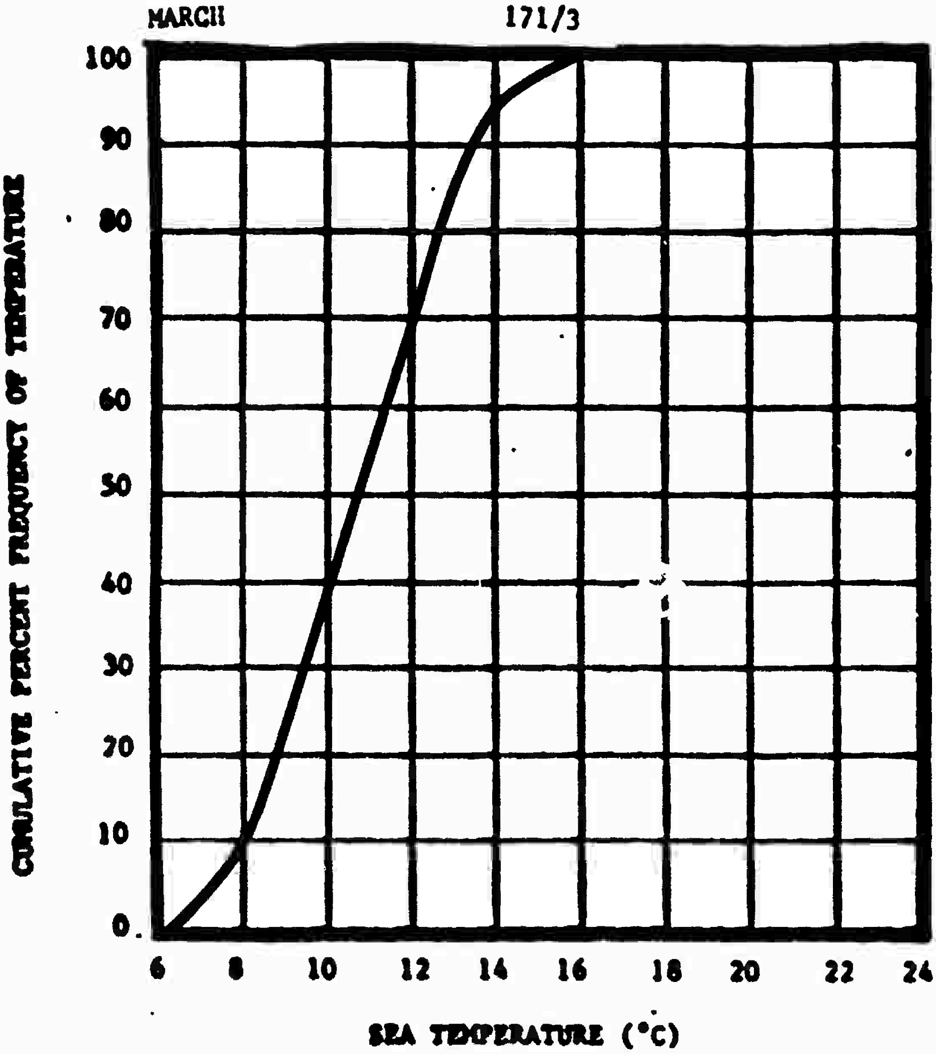


Figure A - 171 [illegible] 5 Sea Temperature

SIG. WAVE HEIGHT (FT)	3.2	4.8	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
>56																
48–56																
40–48																
34–40										+	+	+				+
28–34								+	1	1	1					2
24–28								1	1	+	+					3
20–24							+	3	1	1	+					6
16–20						+	5	7	2	1	+					16
12–16					1	5	8	5	2	1	+					21
9–12				+	4	6	4	3	1	1	+					20
6–9			+	4	5	4	3	2	1	1	+	+				20
3–6		+	1	1	2	3	1	1	+	+	+	+				11
0–3				+	+	1	+	+	+	+						1
TOTALS		+	1	5	12	19	22	23	9	6	3	+				100

MODAL WAVE PERIOD (SEC)

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 4 - 1 Significant Wave Height vs Modal Wave Period

APRIL 171/3 2397

SIG. WAVE HEIGHT (FT) \ WIND SPEED (KNOTS)	0–4	4–7	7–11	11–17	17–22	22–28	28–34	34–41	41–48	48–64	64+	TOTALS
56+												
48–56												
40–48												
34–40									+	+		+
28–34						+	+	1	+	+		2
24–28		+		+	+	+	+	1	+			3
20–24	+		+	+	+	1	1	2	+			6
16–20		+	+	2	3	5	5	1		+		16
12–16	+	1	1	4	5	8	2	+				21
9–12	+	1	2	5	7	5	+					20
6–9	1	1	4	8	5	+	+					20
3–6	1	2	4	4	+							11
0–3	+	1	+									1
TOTALS	3	6	12	23	21	20	9	5	1	+		100

WIND SPEED (KNOTS)

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 4 - 2 Significant Wave Height vs Wind Speed

SIG WAVE HEIGHT (FT)	N	NE	E	SE	S	SW	W	NW	U	TOTALS
56+										
48–56										
40–48										
34–40			+	+	+		+	+		+
28–34	+	+	1	+	+	+	+	+	+	2
24–28	+	+	+	+	+	+	+	+	+	3
20–24	+	+	1	1	1	1	1	1	1	6
16–20	1	1	1	2	2	2	1	3	1	16
12–16	2	2	2	3	3	3	1	4	2	21
9–12	2	1	1	2	3	3	1	4	2	20
6–9	2	1	1	2	3	3	2	3	3	20
3–6	1	1	+	2	1	1	1	2	2	11
0–3	+	+	+	+	+	+	+	+	+	1
TOTALS	8	7	8	13	14	13	8	18	11	100

PRIMARY WAVE DIRECTION

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 4 - 3 Significant Wave Height vs Primary Wave Direction

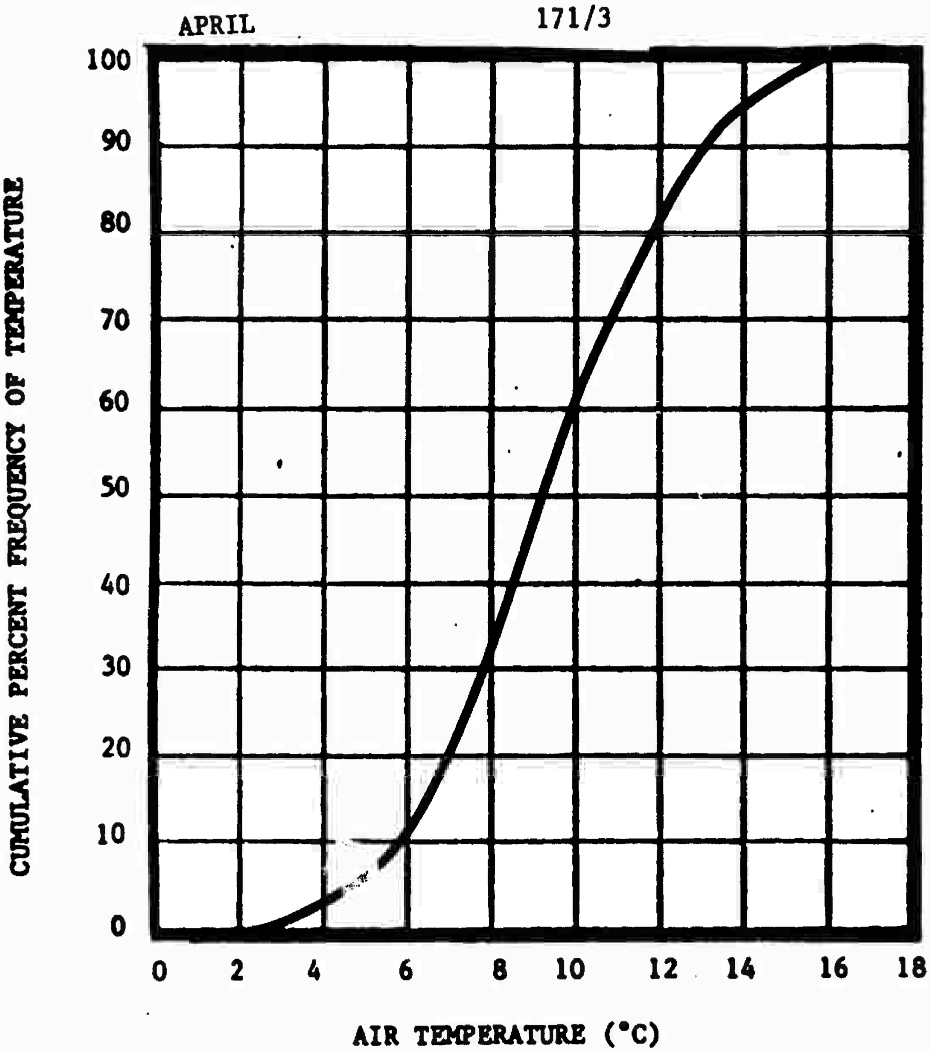


Figure A - 171 - 4 - 4 Air temperature

APRIL 171/3

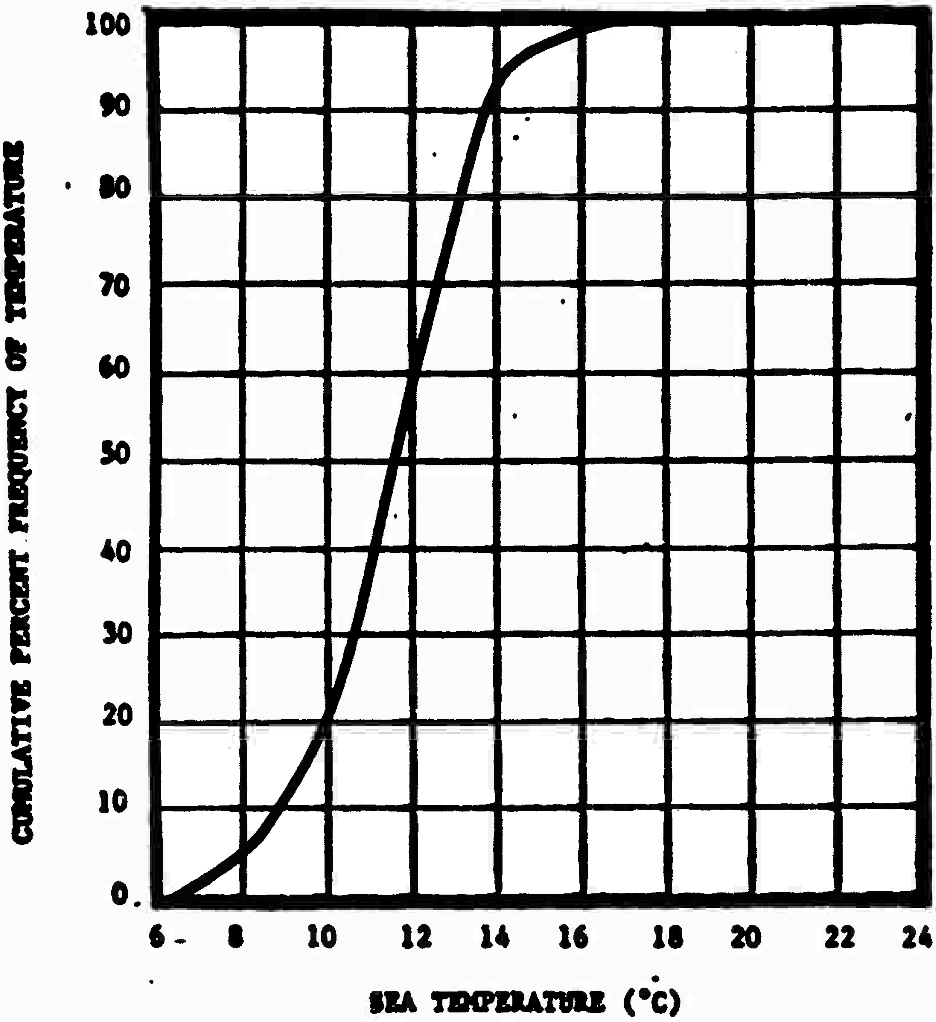


Figure A - 171 - 4 - 5 Sea temperature

APRIL 171/3

SIG. WAVE HEIGHT (FT)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	TOTALS
56+																	
48–56																	
40–48																	
34–40																	
28–34	1	1				1											3
24–28	4	4	3	1	2		1			1							16
20–24	6	3	5	3	4	3		2	1			1					28
16–20	12	8	7	10	10	2	2	2	2	1	1		1	1	1		60
12–16	18	10	10	11	7	13	13	4	5	1	3	1	2		1	7	106
9–12	15	9	8	5	7	8	9	6	5	11	3	3	4	6	3	20	122
6–9	11	5	10	8	5	6	5	3	4	3	4	3	5	1	5	43	121
3–6	4	5	6	6	3	2		3		4		1	1		2	53	90
<3				1												24	25
TOTALS	71	45	49	45	38	35	30	20	17	21	11	9	13	8	12	147	571

HOURS DURATION OF EVENTS

NOTE: 1 foot = 0.3048 meter

Figure A - 171 - 4 - 6 Persistence of Wave Height

APRIL 171/3

WIND SPEED (KNOTS)	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96+	TOTALS
Above 64+																	
48–64+																	
41–48	5	1															6
34–41	10	3	3						1								17
28–34	18	9	12	4	3		2	1					1				50
22–28	29	22	17	11	15	5	3	2	1	1	1			1		1	109
17–22	32	35	25	16	23	5	8	10	6	3	4	1	1	2	1	5	177
11–17	26	32	21	16	13	12	16	10	9	7	4	7	3	3	4	16	199
7–11	15	6	6	9	6	10	10	6	9	10	7	4	3	9	2	46	158
4–7	14	5	5	2	1	1	8	3	3	5	6	5	3	4	4	56	125
0–4	1	4	1	1	1		1		1	2		1		1	1	50	65
TOTALS	150	117	90	59	62	33	48	32	30	28	22	18	11	20	12	174	906

HOURS DURATION OF EVENTS

Figure A - 171 - 4 - 7 Persistence of Wind Speed

APPENDIX B

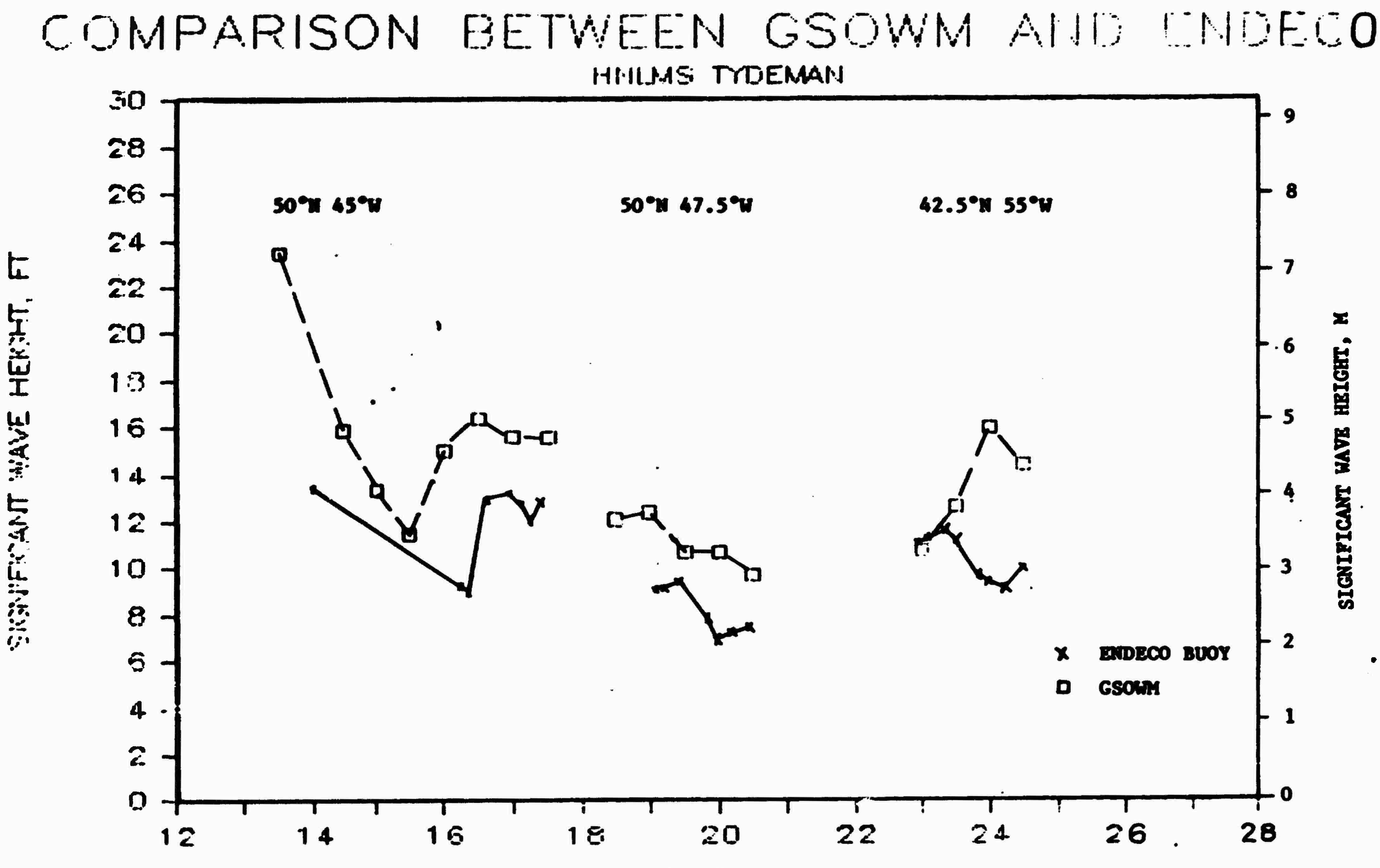
VALIDATION OF GSOWM

APPENDIX B

VALIDATION OF GSOWM

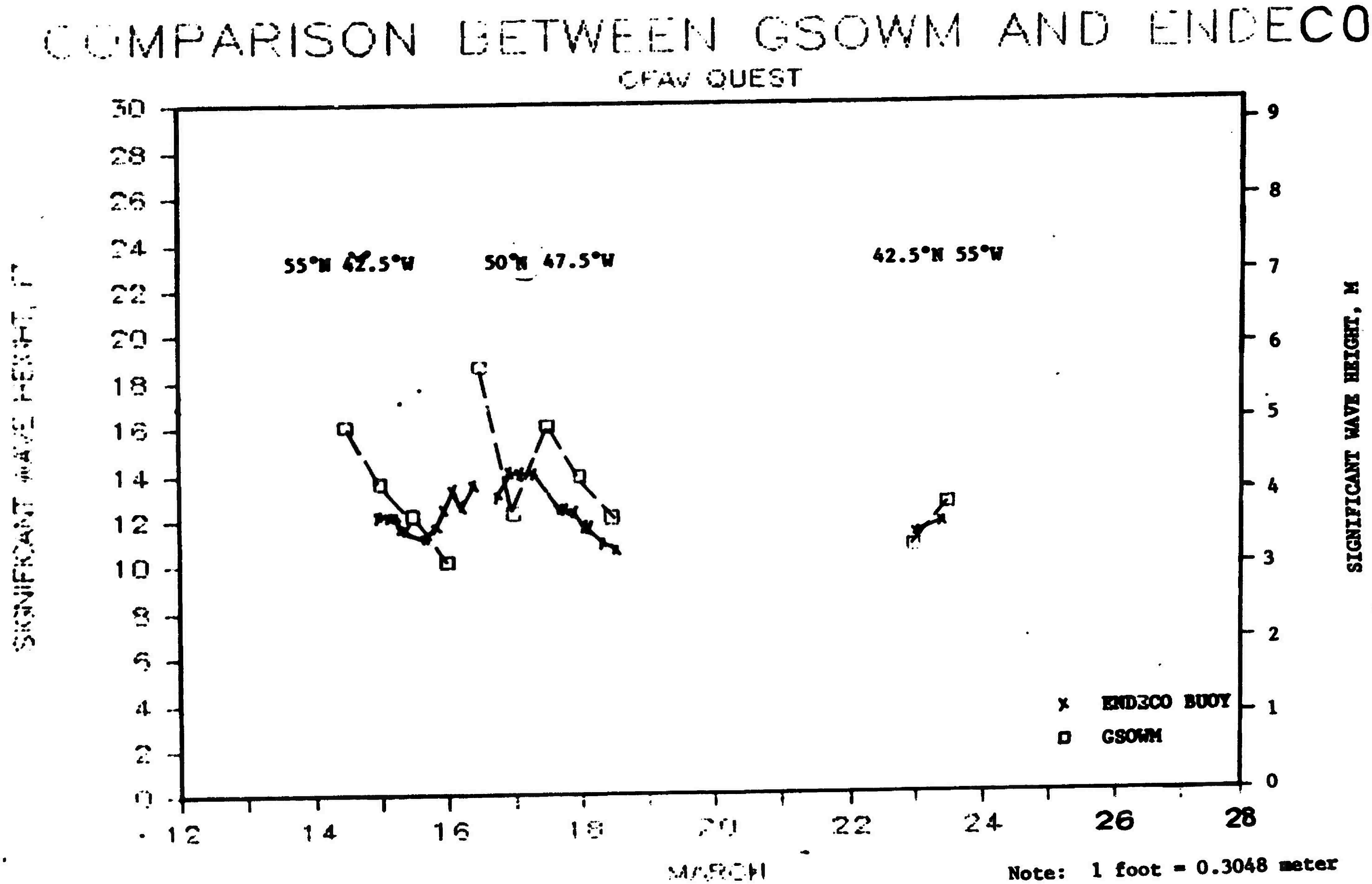
Wave forecasting on the ocean is a problem of great practical interest since sea state impacts virtually all aspects of naval operations. Thus, the operational objectives of LEWEX include the validation of directional wave forecasts now in routine use around the world.

Preliminary directional measurements from LEWEX aboard HNLMS TYDEMAN and CFAV QUEST during March 1987 have been analyzed and compared with GSOWM wave forecasts. Some comparisons are presented in Figures B-1 and B-2. The closest GSOWM location to the deployed U.S.A. ENDECO directional wave buoy, in time and space, is used. Generally, the GSOWM wave heights are higher than those measured. Figure B-3 provides the SOWM and GSOWM significant wave height time histories in the LEWEX region. The distribution of the GSOWM significant wave heights for 1987 is similar to the SOWM calm weather wave heights year of 1968.



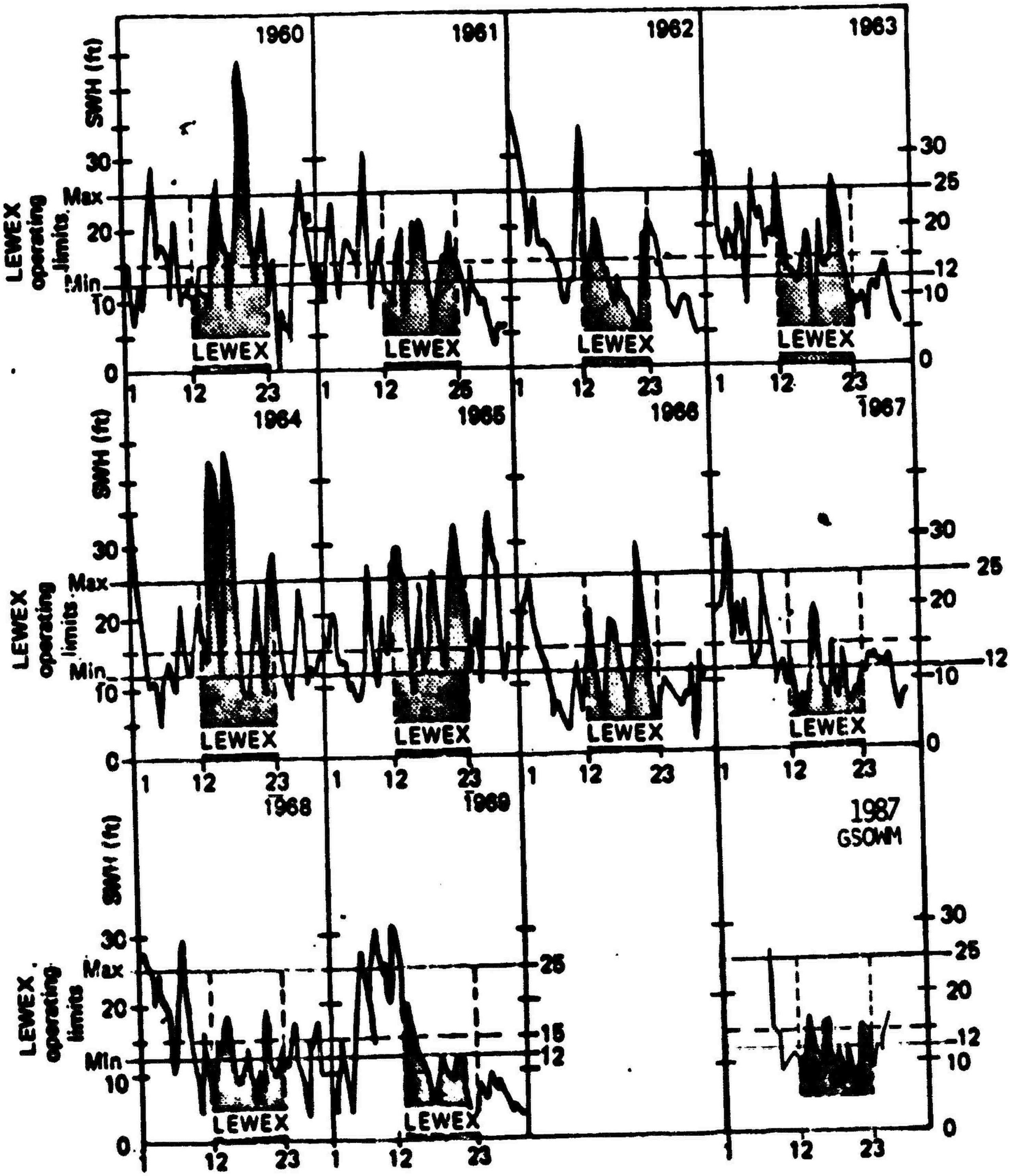
Note: 1 foot = 0.3048 meter

Figure B-1 - Comparison Between GSOWM and ENDECO Wave Heights



Note: 1 foot = 0.3048 meter

Figure B-2 - Comparison Between GSOWM and ENDECO Wave Heights



Note: 1 foot = 0.3048 meter

Figure B-3 - Comparison Between SOWM Hindcasts (46.2°N, 44.9°W) for March 1960-69 and GSOWM (45°N, 45°W) in LEWEX region

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