TECHNISCHE HOGESCHOOL DELFT
AFDELING DER SCHEEPSBOUW- EN SCHEEPVAARTKUNDE
LABORATORIUM VOOR SCHEEPSHYDROMECHANICA

FULL SCALE TRIALS WITH m.v.HOLLANDIA
PART I: WAVE AND WIND MEASUREMENTS

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Contents.

1. Introduction.

In the beginning of 1979 and 1980 full scale seakeeping trials have been carried out with m.v. Hollandia, a Dutch container vessel owned by the Royal Netherlands Steamship Company at Amsterdam. The experiments have been carried out by a staff of the Shiphydromechanics Laboratory of the Delft University of Technology in co-operation with Lloyds Register of Shipping on two normal service voyages of the ship from Northern Europe to the Caribbean.
During these trials Lloyds Register of Shipping has tested an operational performance system, installed on the ship. This project is an investigation, financed jointly by the Netherlands Maritime Institute , Lloyds Register of Shipping and Applied Dynamics Europe. The aim of the project is to investigate the feasibility of a computer based shipboard monitoring and prediction system to ensure safe and economic ship operation.
The Delft Shiphydromechanics Laboratory assisted this project by delivering a speed-r.p.m.-power-sea state data base of m.v. Hollandia and measuring the required information of the sea and wind conditions during the experiments. At the same time the Delft Shiphydromechanics Laboratory has also carried out their project to get experimental data on ship motions, speed - loss, power and fuel consumption of a large container ship in different seastates with known energy spectra.

On the first voyage, a double trip during January and the beginning of February 1979, the David Taylor Naval Ship Research and Development Centre has offered a valuable assistance with regard to the choice of suitable wave conditions for the seakeeping trials. For this purpose wave and wind fore casts have been provided on the intended route of the ship. These fore casts, made by the Fleet Numerical Weather Central at Monterey, California, have been transmitted to the ship through the Royal Netherlands Navy.
On the outward voyage only small head waves and acceptable high following waves have been met. This was mainly caused by the followed least time route, adviced by the routeing office of the Royal Netherlands Meterorological Institute (K.N.M.I.). Because the ship was on a normal service trip, it was not permitted to make considerable deviations from the intended route. On the return trip from the Caribbean, high following seas have been met

with heights of over 11 meter.
Because of the lack of experimental data in head waves a new attempt has been made in February 1979, but again without suitable head waves. No experiments have been carried on this voyage.
In January 1980 new experiments have been carried out to get the missing experimental data in head waves. Thanks to the co-operation of the ship's owner it was possible to choose a route with suitable head waves. The decision to go or not to go with regard to the expected weather has been made in deliberation with the routeing office of K.N.M.I. They also have provided advices for the ship's route in such a way that waves between 5 and 7 meter height could be expected. This co-operation has been very succesful, the required waves have been met.

The sea and wind conditions, measured on both voyages, are described in this report.

2. Instrumentation.

The experiments require accurate information about the sea- and windconditions. The seaconditions have been measured by means of disposable wave buoys, developed at the Delft Shiphydromechanics Laboratory [1]. A scheme of the buoy is showed in figure 16.
The disposable wave buoys are equiped with a linear vertical accelerometer of an inductive type with a natural frequency of 35 Hz. The required stabilization, to keep the buoy in a vertical position, has been achieved by means of a simple mechanic stabilizer, consisting of a tail under the buoy connected with a stabilization weight by means of a 40 meter long wire. During the transport and the launching procedure of the buoy the wire is fitted around a cardboard cilinder. The spherical buoy is half immersed when floating and follows the wave surface with sufficient accuracy.
The voltage output of accelerometer, so in fact the acceleration signal, has been put into a voltage to frequency converter. This results into a signal which is independent of variations in the power supply, see figure 17. The frequency modulated signals, of which amplitudes and frequencies vary with the time, have been transmitted continuously to the ship by means of a wireless transmitter and an antenna fitted on top of the wave buoy.
To receive these signals on the ship, which could be done upto

a distance of over 40 miles in 5 meter waves, a 12 meter high antenna has been installed on the aft deck. The frequency modulated signals have been recorded by an instrumentation tape recorder, together with a reference signal from a crystal oscillator to get a real time base independent of variations in the tape speed.
A digital data reduction method has been used to derive the power spectra of the vertical wave displacement, see figure 18. The demodulation of the frequency modulated signals has been derived by counting the number of zero-crossings during fixed time intervals (1.4. seconds). This digital information of the counter, transformed into punch tape data, is input to the digital I.B.M. 370/158 computer of the Delft University of Technology Computation Centre for the calculation of the autocovariance functions and the power spectra. A band-pass filter function has been used to cut of undesirable frequencies [3] . The tranfer function of this band-pass filter is showed in figure 19. The vertical displacement of the waves has been derived by a double numerical integration of the acceleration data by means of the rectangular rule.

The Delft wave buoy measures only the vertical accelerations of the wave surface at the location of the buoy. No information can be obtained with this buoy about the dominant wave directions and the directional spreading of the wave energy of one or more wave systems.
The dominant wave directions have to be estimated visually. Independent observations, carried out by different ship's officers, shows only small relative differences of 10 degrees or less. This doesn't mean that all dominant wave directions can always be distinguished visually. Hardly or not visual wave systems in bi-modal seas can have an important effect on the ship's responses. This is discussed by Gerritsma in [2] with respect to the Tydeman-trials.
The directional spreading of the energy of wave systems cannot be estimated visually. Sometimes a cosine-squared dividing is assumed, but this is only an assumption, which is certainly not valid for each particular seastate.

The relative wind speeds and directions have been measured by a cup anemometer and a windvane, fitted in the fore mast of the ship. This anemometer has been calibrated in a wind-tunnel. The measured signals have been recorded by a pen recorder. With the from the recordings derived mean values and the measured ship's speed and heading the true wind speed and direction can be calculated easily.

3. Experimental results.

A review of the wave and wind measurements, with respect to location, time and measured values, is given in table I. The true windspeed V_w and the true winddirection α_w are mean values during approximately half an hour.

Two expressions for the significant wave height are given:

$$\overline{H}_{1/3} = 4\sqrt{m_o}$$

$$\overline{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_o + \frac{m_2^{2}}{m_4}\right)}$$

in which:

$$m_n = \int_0^{\infty} \omega^n S_\zeta(\omega)\, d\omega \qquad \text{(spectral moments)}$$

where:

ω	circular wave frequency
S_ζ	sprectral value

Normally $\overline{H}_{1/3}$ will be used for the significant wave height. $\overline{H}_{1/3}^{*}$ includes a correction for the breadth of the spectrum and has been used by Lloyds Register of Shipping in the operational performance system, reason why this value is given here too.

The average zero-crossing period of the waves is defined by:

$$\overline{T}_2 = 2\pi\sqrt{\frac{m_o}{m_2}}$$

Figures 1-1, 1-2, 1-3 and 1-4 show the results of the analyses of the 1979 and 1980 wave and wind measurements. The results will be discussed here day by day.

1-1-1979. ($45^{O}N$ $23^{O}W$)

Between 16.20 and 19.00 G.M.T. seakeeping trials have been carried out at normal operating power. Two wave systems have been observed: a head swell from 250 degrees with a height of 3-4 meters and a low following sea from 070 degrees with an observed height of 1 meter or less.
At 17.15 G.M.T. wave buoy 18 has been launched. Two analyses are given here, one at 18.00 G.M.T. and the other at 19.00 G.M.T. The significant wave height decreased from 4.0 to 3.7 meter by a decrease of long period waves. The wave spectra are given in figure 2 and table II-1 and II-2.
During the experiments there was a variable wind, coming from directions between north and east, with a speed of about 11 knots.

4-1-1979. ($30^{O}N$ $46^{O}W$).

Seakeeping trials at 100 and 75 percent of the normal engine speed have been carried out between 10.30 and 16.10 G.M.T. A somewhat confused following sea and swell has been observed. The sea, coming from 080 degrees, had a visual height of about 2 meters and the swell was estimated on 5-6 meters, coming from 090 degrees. It may be noted that sea and swell were certainly not uni-directional. The estimated dominant wave direction was 085 degrees.
Two wave buoys have been launched; buoy 22 at 17.35 G.M.T. and buoy 16 at 20.25 G.M.T. The analyses are given here at 18.10 G.M.T. and at 21.00 G.M.T. and show a significant wave height of 5.2 and 5.7 meter. The signal of the second wave buoy has not the quality that it should have, the energy in the low frequency part is somewhat doubtful. The wave spectra are given in figures 3 and 4 and in the tables III and IV.
The measured true wind was reasonable constant, 31 knots coming from 095 degrees.

2-2-1979. ($30^{O}N$, $53^{O}W$)

The seakeeping trials have been carried out at 100 and 75 percent of the normal engine speed between 14.40 and 20.30 G.M.T. in very high following seas. At about 14.00 the seastate was suddenly increasing up to extreme observed wave heights of 11-12 meter.

The first wave buoy, buoy 8 launched at 14.30 G.M.T., gives at 15.15 G.M.T. a significant wave height of 11.1 meter. However an analysis 35 minutes later, shows a decreased wave height of 9.8 meter. Another wave buoy, buoy 9 launched at 18.00 G.M.T., shows also a wave height of 9.8 meter.
The visual observed sea came from 260 to 270 degrees with wave height of 4 up to even 8 meter. The swell came from 275 to 285 degrees with visual observed wave heights of 8 to 10 meters. The dominant wave direction has been estimated on 275 degrees and the waves were somewhat short-crested. The analysed wave spectra are given in figures 5 and 6 and in the tables V-1, V-2 and VI.
The true winddirection was varying between 270 and 280 degrees with a true speed of 37 to 41 knots.

<u>5-1-1980.</u> (50^{O}N, 11^{O}W).

The seakeeping trials at normal operating power are carried out between 10.00 and 13.35 G.M.T. in head seas. The seastate was strongly decreasing during the experiments. At 10.00 G.M.T. 6 to 7 meter waves have been observed, coming from 300 degrees. At the end of the experiments the visual observed wave height was about 4 meter and the seadirection started to shift to 285 degrees. During the main part of the experiments the dominant wave direction was 300 degrees and no other wave systems could be observed.
Two wave buoys have been launched:
buoy 29 at 10.55 G.M.T. and buoy 15 at 12.10 G.M.T.
The analyses of the wave buoy signals confirm the visual observations. The first wave buoy gives at 11.15 G.M.T. a significant wave height of 6.7 meter and the second one gives at 12.30 G.M.T. a significant wave height of 4.2 meters. The higher long period waves have been decreased considerably in a little more than one hour. The results of the wave analyses are showed in figures 7 and 8 and in the tables VII and VIII.
The measured true wind was varying between 295 and 300 degrees with a speed of 22 to 24 knots.

<u>6-1-1980.</u> (45^{O}N, 22^{O}W).

During this day many seakeeping trials in head waves have been carried out: at 75 and 50 percent of the normal operating engine

speed during daylight between 16.25 and 19.10 G.M.T. and at the normal operating engine speed at night between 21.35 and 23.45 G.M.T. The waves have been classified by the ship's officers as "constant", "unusual unidirectional" and even "off and on long crested". During daylight the visually observed wave height varied from "not more than 5 meter" to "5 meter, sometimes 6 meter" and the wave direction was estimated on 270-275 degrees.
The estimated dominant wave direction during daylight was 275 degrees. At night the dominant wave direction was estimated from the seaclutter on the ship's radar: 270 degrees.
Four wave buoys have been launched: buoy 20 at 16.20 G.M.T., buoy 10 at 18.00 G.M.T., buoy 17 at 21.25 G.M.T. and buoy 11 at 22.45 G.M.T. The analysed signals show significant wave heights varying between 4.6 and 5.4 meter. All spectral forms are less or more equal. This is showed in the figures 9, 10, 11 and 12 and in the tables IX-1, IX-2, X-1, X-2, XI, XII-1 and XII-2.
During daylight the measured true windspeed was about 26 knots with a true wind direction increasing from 280 to 300 degrees. At night the windspeed was decreasing until 18 knots at a winddirection between 310 and 330 degrees.

8-1-1980. (37°N, 36°W).

At normal operating power a few sea keeping trials in beam to quartering seas have been carried out between 12.00 and 13.45 G.M.T. According to the visual observations during the trials the sea consists of three wave systems:

- a swell, coming from 270 degrees, decreasing from 4-5 meter to 3 meter.
- a swell, coming from 330 degrees, decreasing from 4-5 meter to 4 meter.
- a coming on sea from 030 degrees.

The dominant wave direction should have been 330 degrees, but this was difficult to estimate.
Two wave buoys have been launched: buoy 13 at 12.20 G.M.T. and buoy 14 at 13.10 G.M.T. During the reception of buoy 13 there was a lot of radio interference. Two analyses with a time shift of 5 minutes show significant wave heights of 5.1 and 4.1 meter respectively. Considering the results of buoy 14 (5.0 meter) the first analysis seems to be the best, but certainty can't be given. The results are showed in the figures 13 and 14 and the tables XIII and XIV.

The measured true wind varied between 025 and 035 degrees, with a speed of 30 to 32 knots.

9-1-1980. (32^{O}N, 43^{O}W).

One experiment in quartering seas at normal operating power has been carried out between 14.15 and 14.45 G.M.T. According to visual observations a 4-4½ meter swell was coming from 340-350 degrees and a 2-3 meter sea came from 350-355 degrees. There was also a very small swell from 270 degrees. For the dominant wave direction 350 degrees has been estimated.
Wave buoy 7 has been launched at 14.10 G.M.T. The measured significant wave height was 4.7 meter. Also the spectral form suggests that more than one wave system was present. The results are given in figure 15 and table XV.
The measured true wind came from 353 degrees with a speed 26 knots.

In total 16 wave buoys have been used for these experiments.
In spite of some radio interference, 14 wave buoys have worked very well, but the results of the analyses of buoy 13 and 16 are somewhat doubtfull.
One wave buoy was damaged when hitting the water surface and another was lost by a misunderstanding during the launching procedure.

4. Acknowledgement.

The authors wish to express their appreciation to the owner, officers and crew of m.v. Hollandia for their co-operation and interest during the trials. Moreover they are greatful to D.T.N.S.R.D.C. who offered the detailed weather-predictions during the 1979 voyage. Last but not least the authors wish to thank the routeing office of K.N.M.I. for giving excellent routeing advices during the 1980 voyage.

5. References.

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[2] J. Gerritsma and W. Beukelman,
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Shiphydromechanics Laboratory of the Delft University of Technology.
Report no. 494, March 1980.

[3] F.J. Pasveer,
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Delft University of Technology Computation Centre.
Proceedings of 7th A.I.C.A. Congress, Praag 1973.

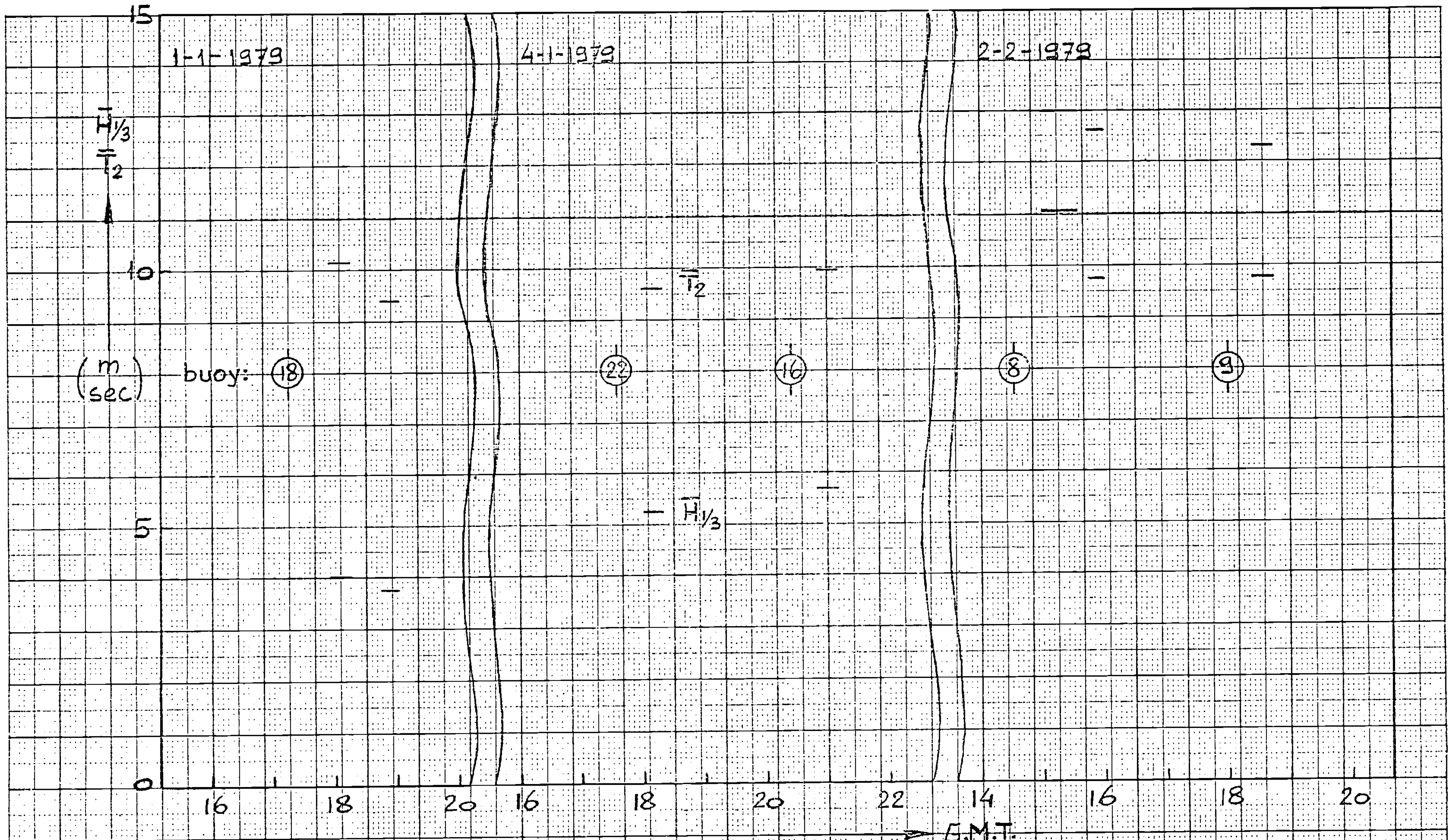


Figure 1-1. Results of the 1979 wave experiments.

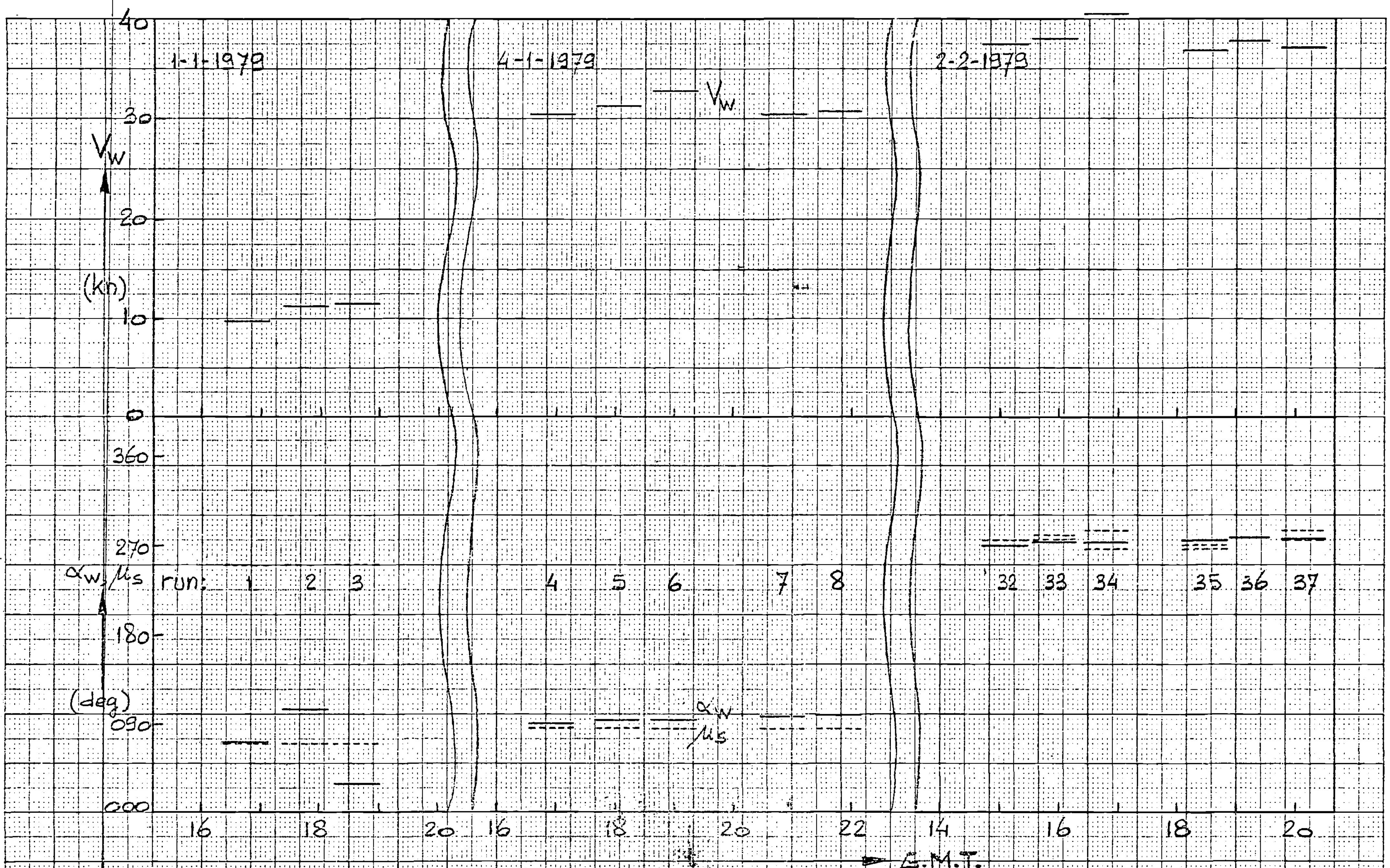


Figure 1-2. Results of the 1979 wind measurements.

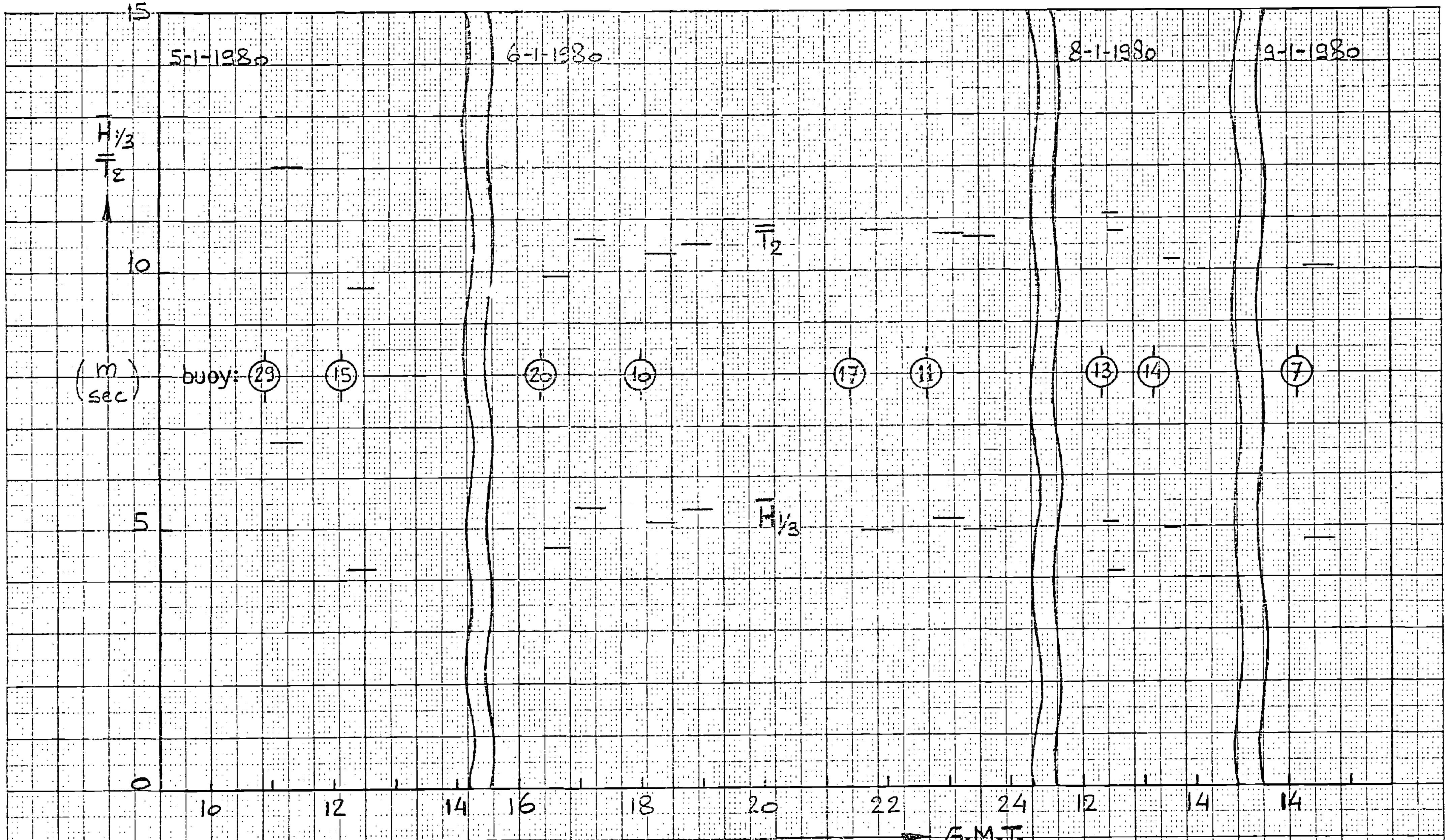


Figure 1-3. Results of the 1980 wave experiments.

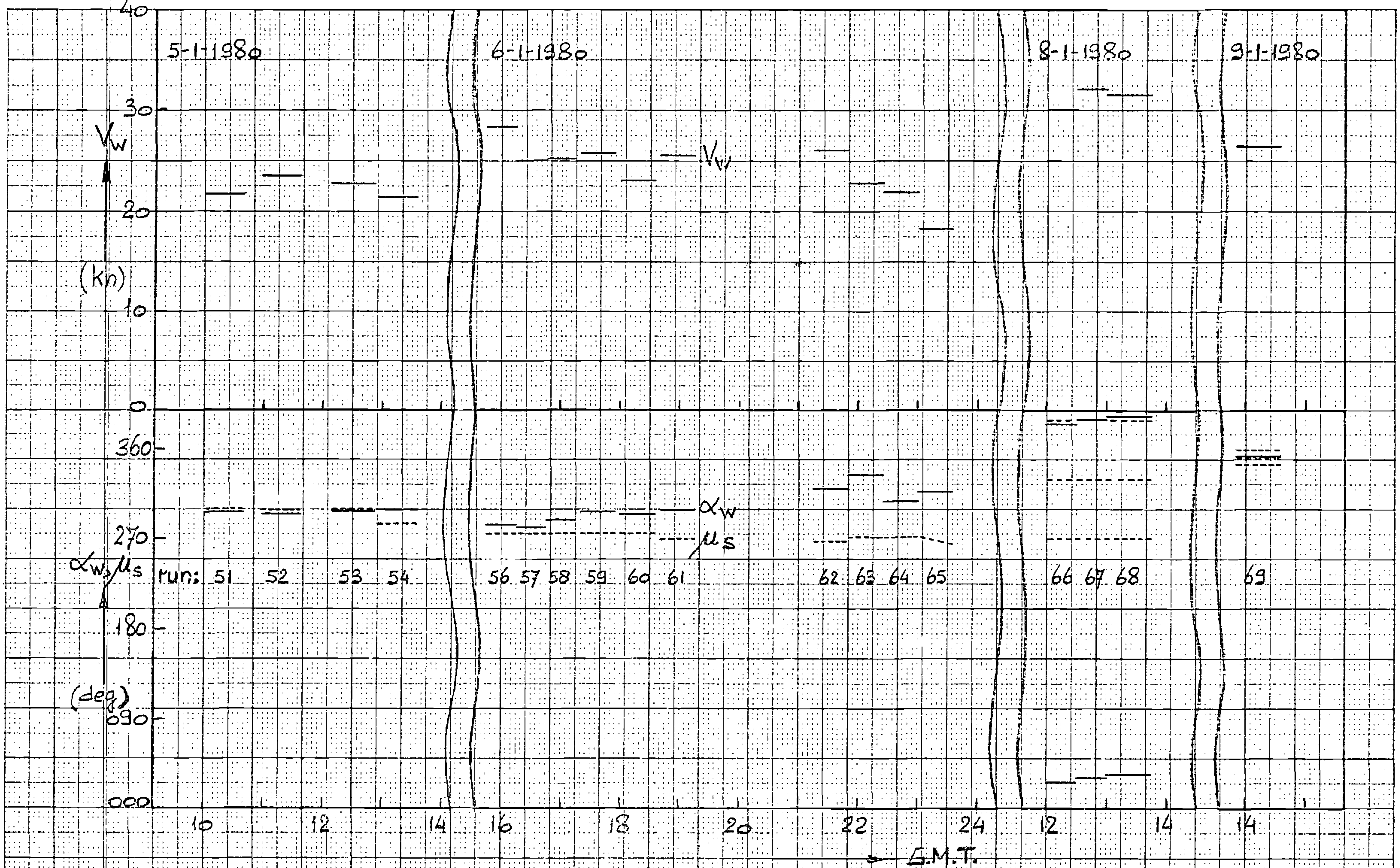


Figure 1-4. Results of the 1980 wind measurements.

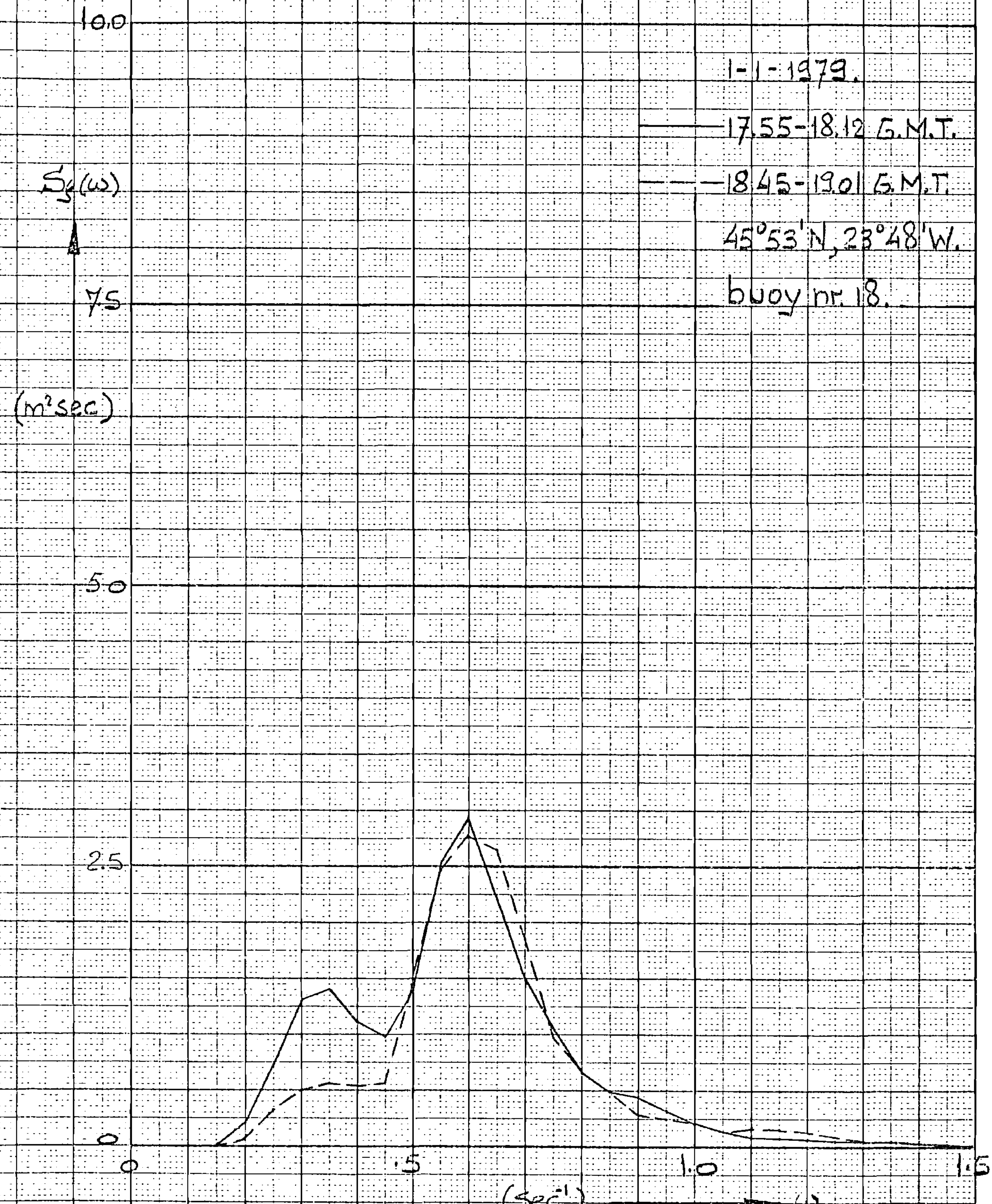


Figure 2. Wave spectra buoy 18.

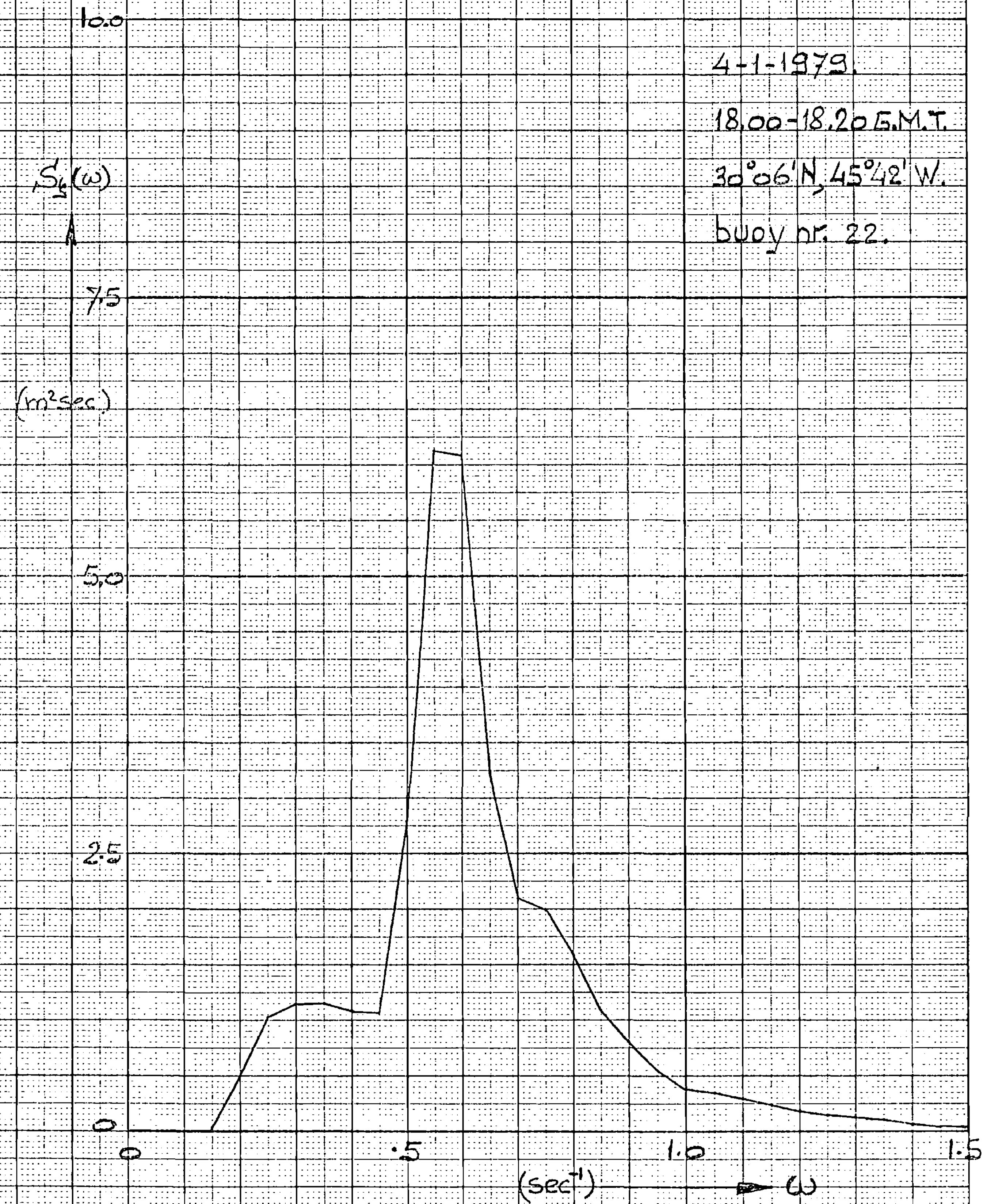


Figure 3. Wave spectrum buoy 22.

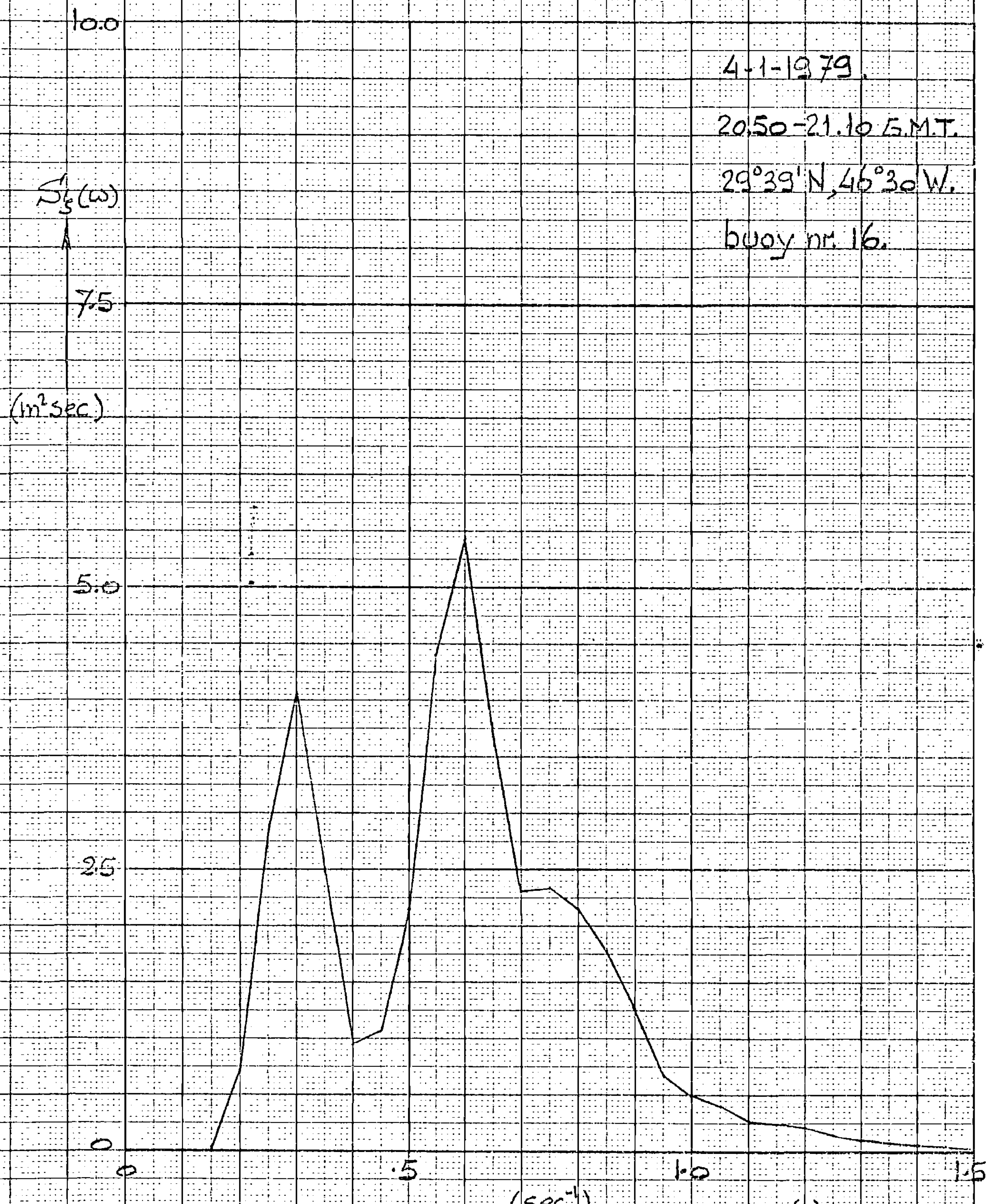


Figure 4. Wave spectrum buoy 16.

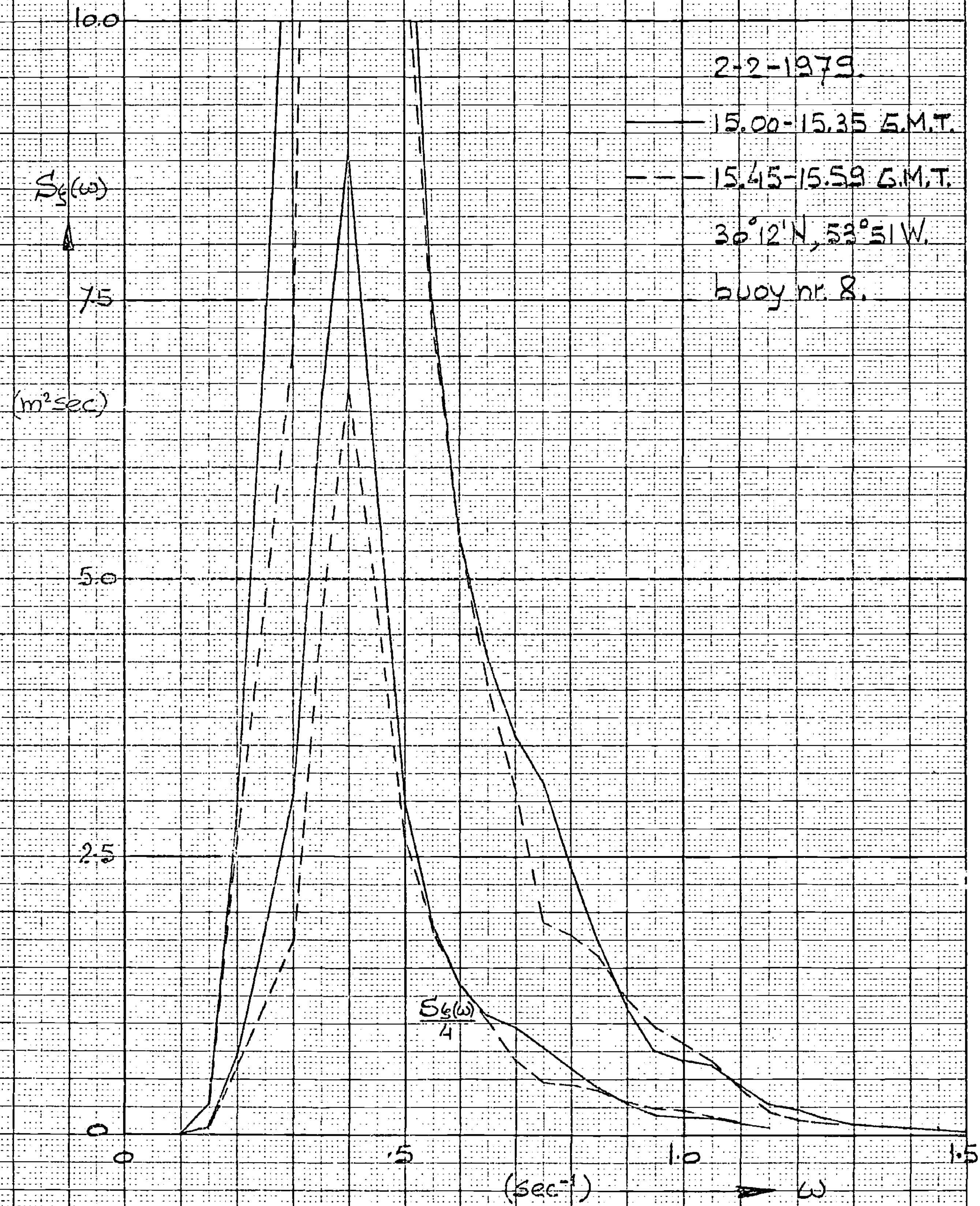


Figure 5. Wave spectra buoy 8.

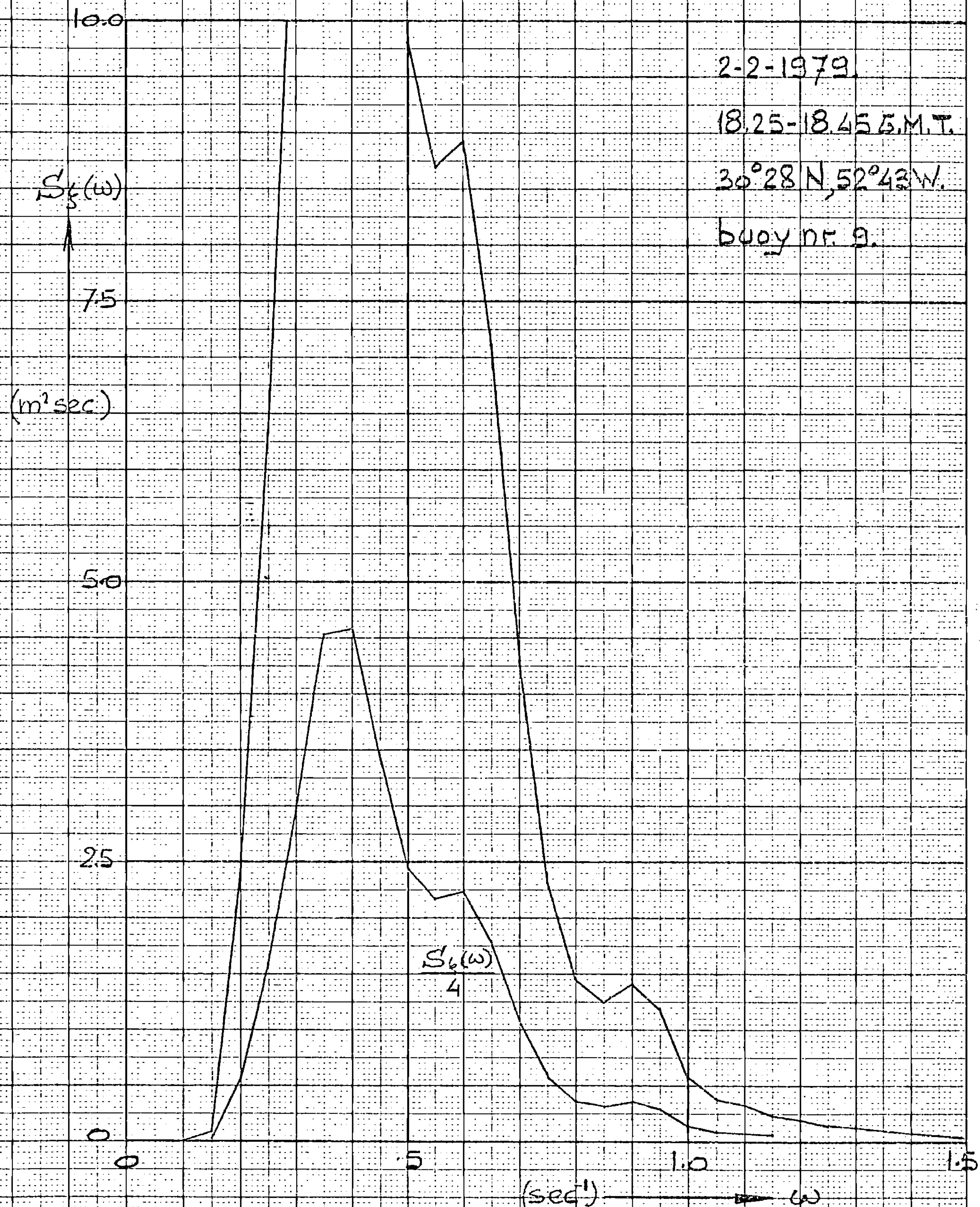


Figure 6. Wave spectrum buoy 9.

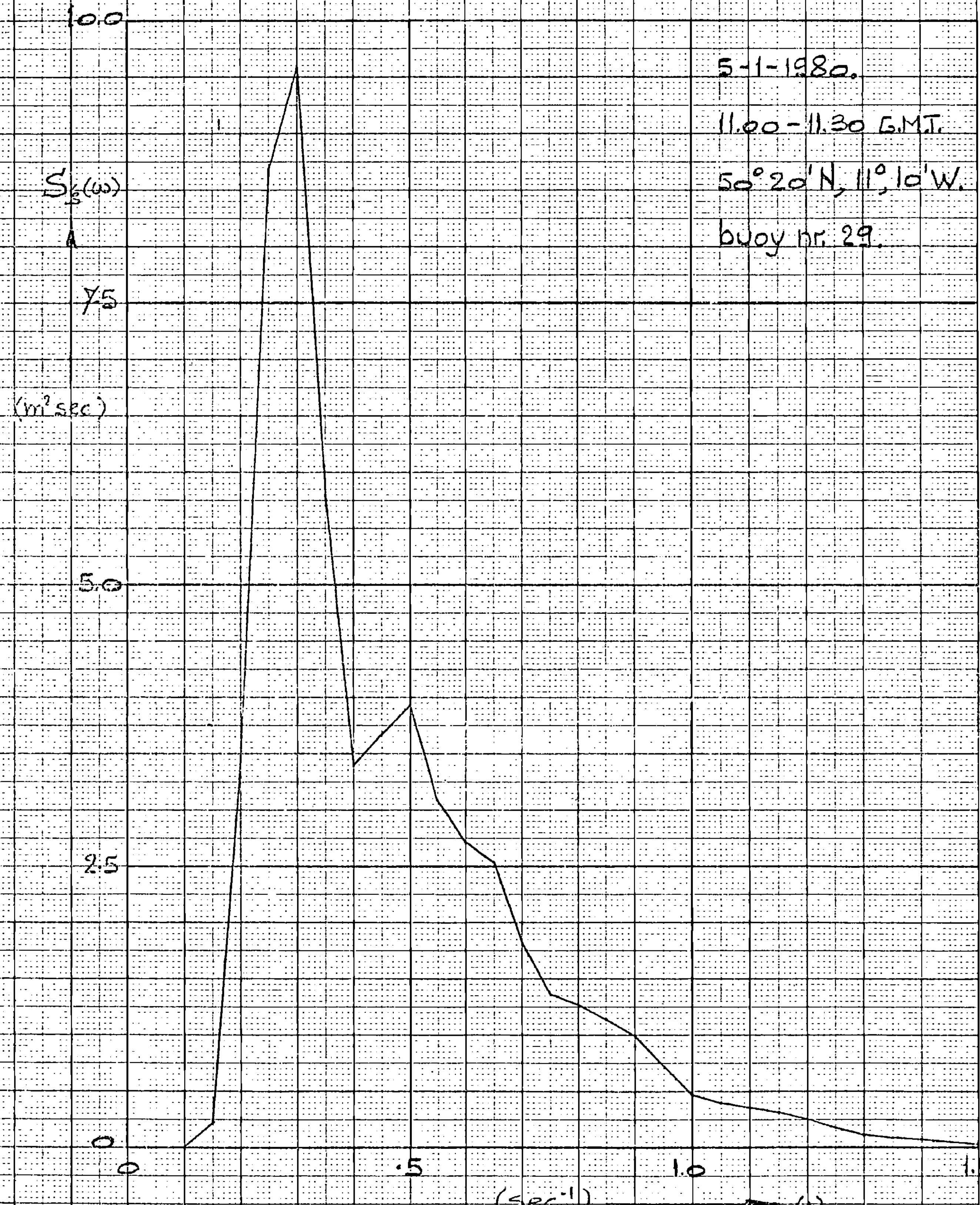


Figure 7. Wave spectrum buoy 29.

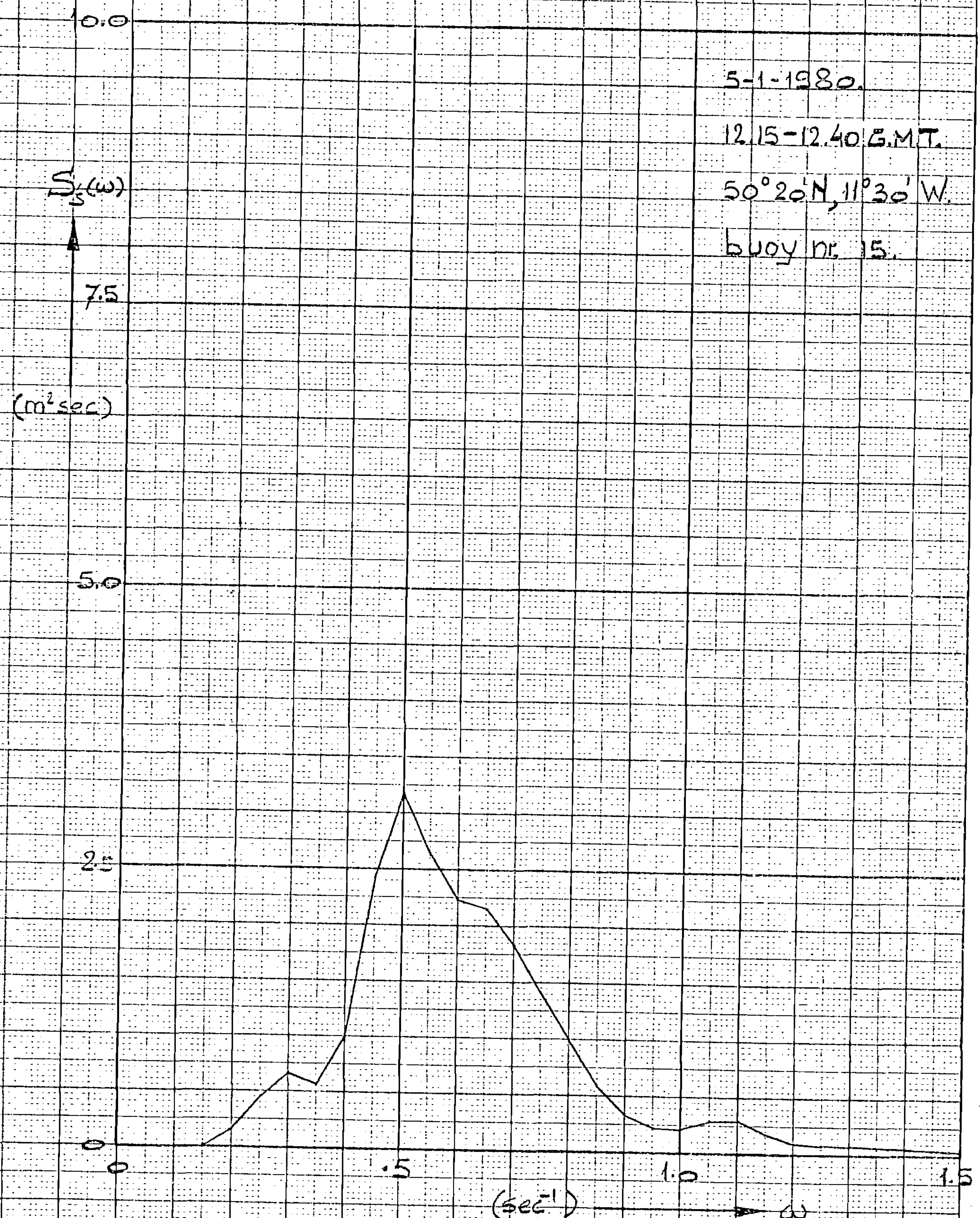


Figure 8. Wave spectrum buoy 15.

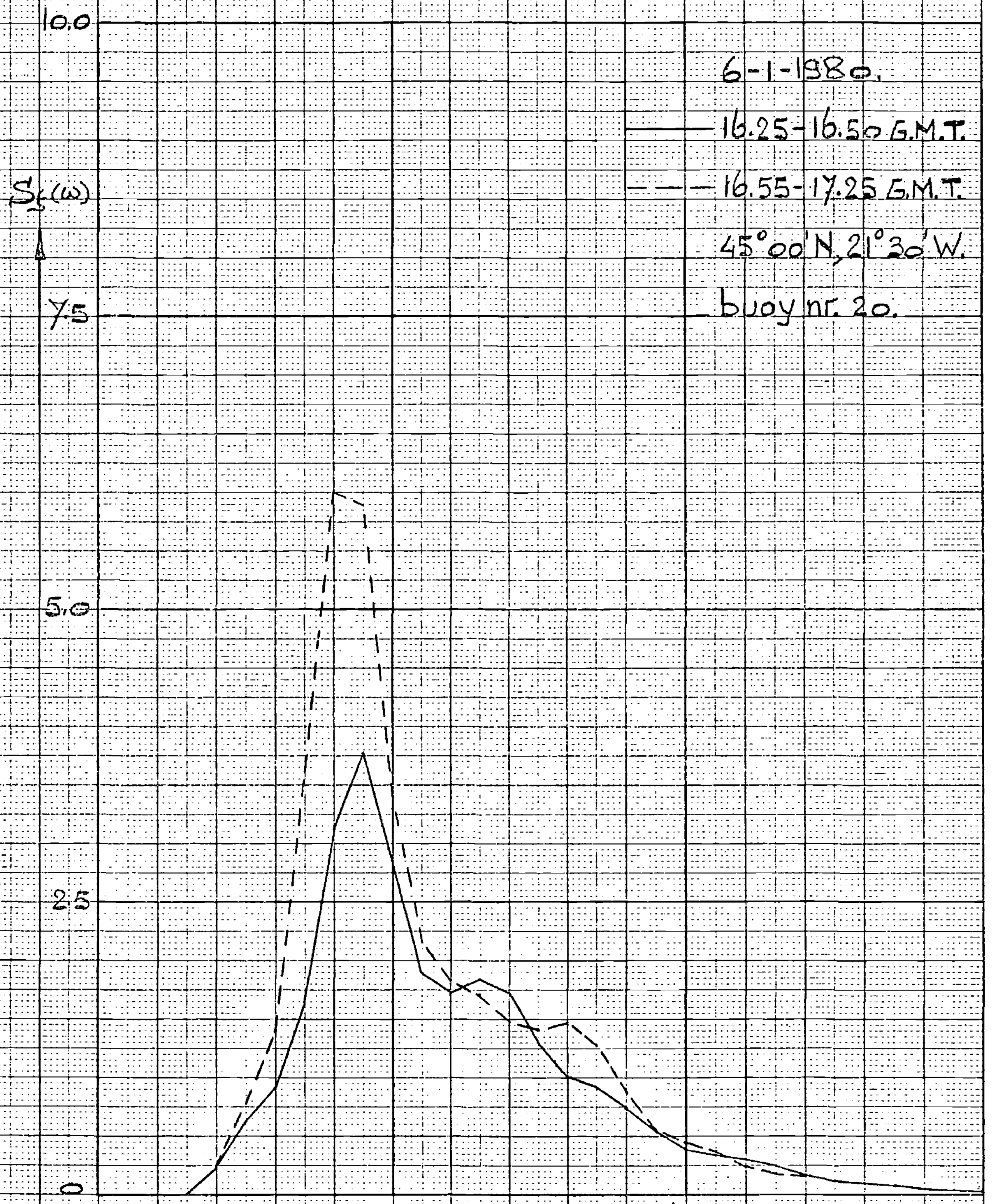


Figure 9. Wave spectra buoy 20.

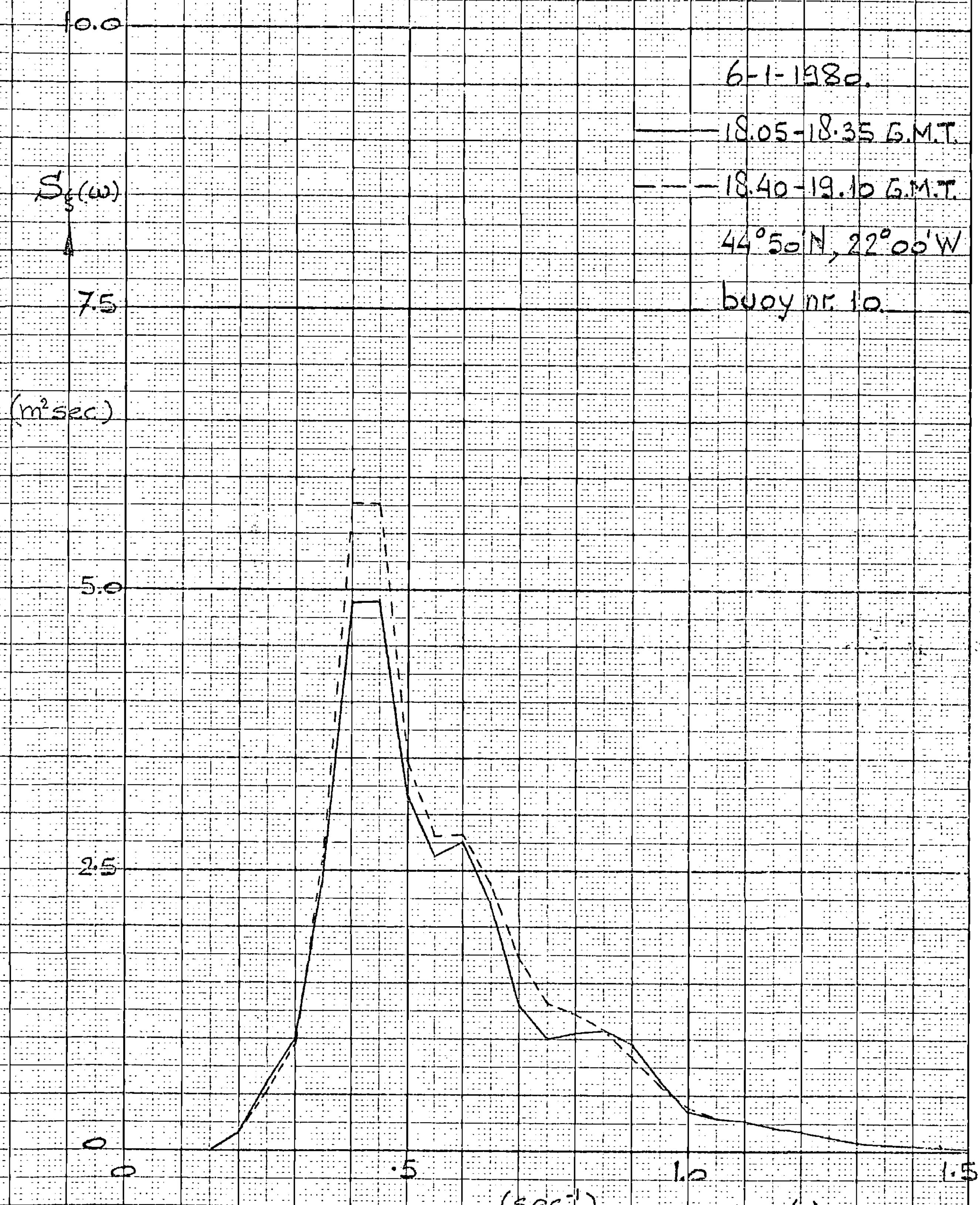


Figure 10. Wave spectra buoy 10.

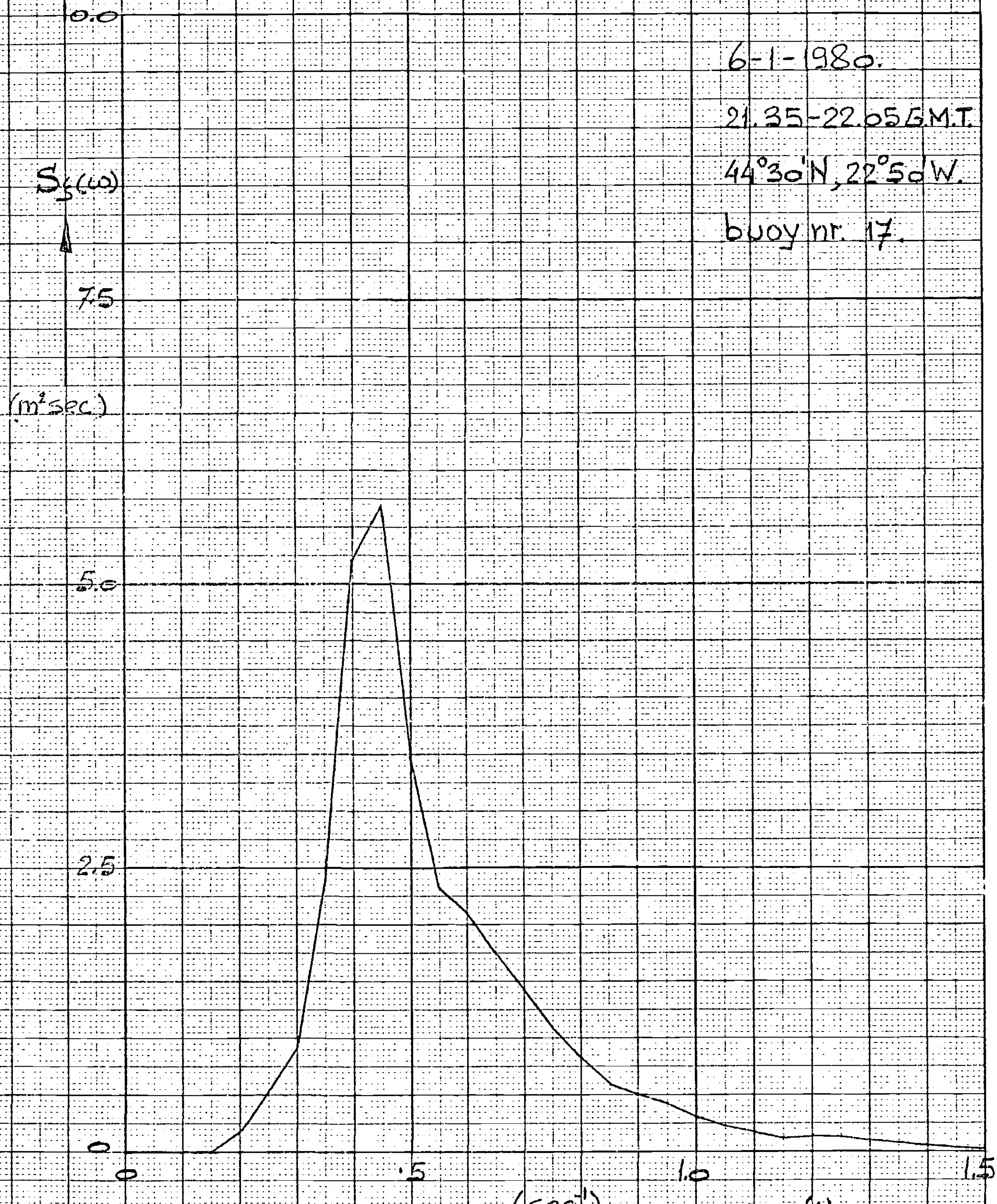


Figure 11. Wave spectrum buoy 17.

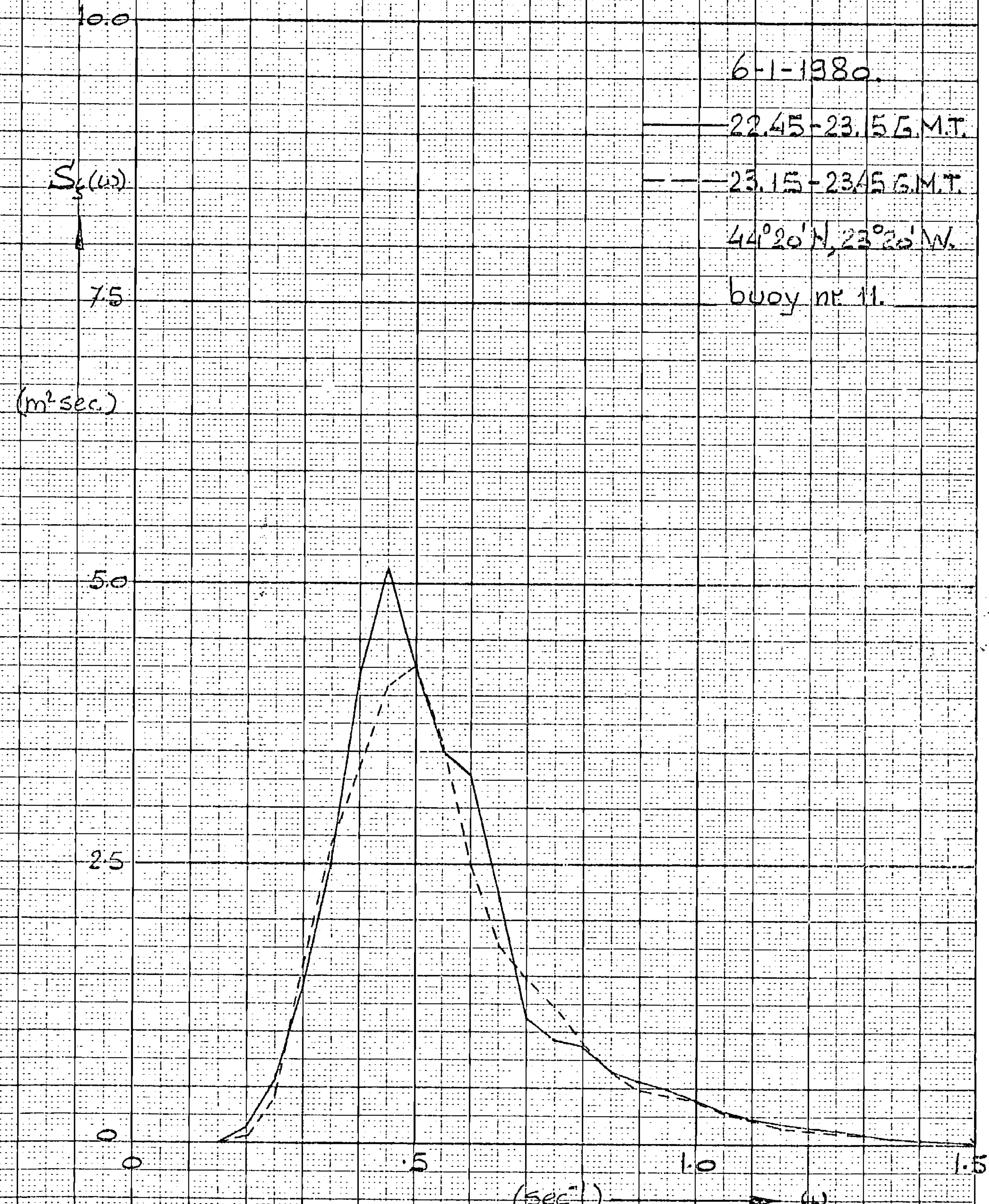


Figure 12. Wave spectra buoy 11.

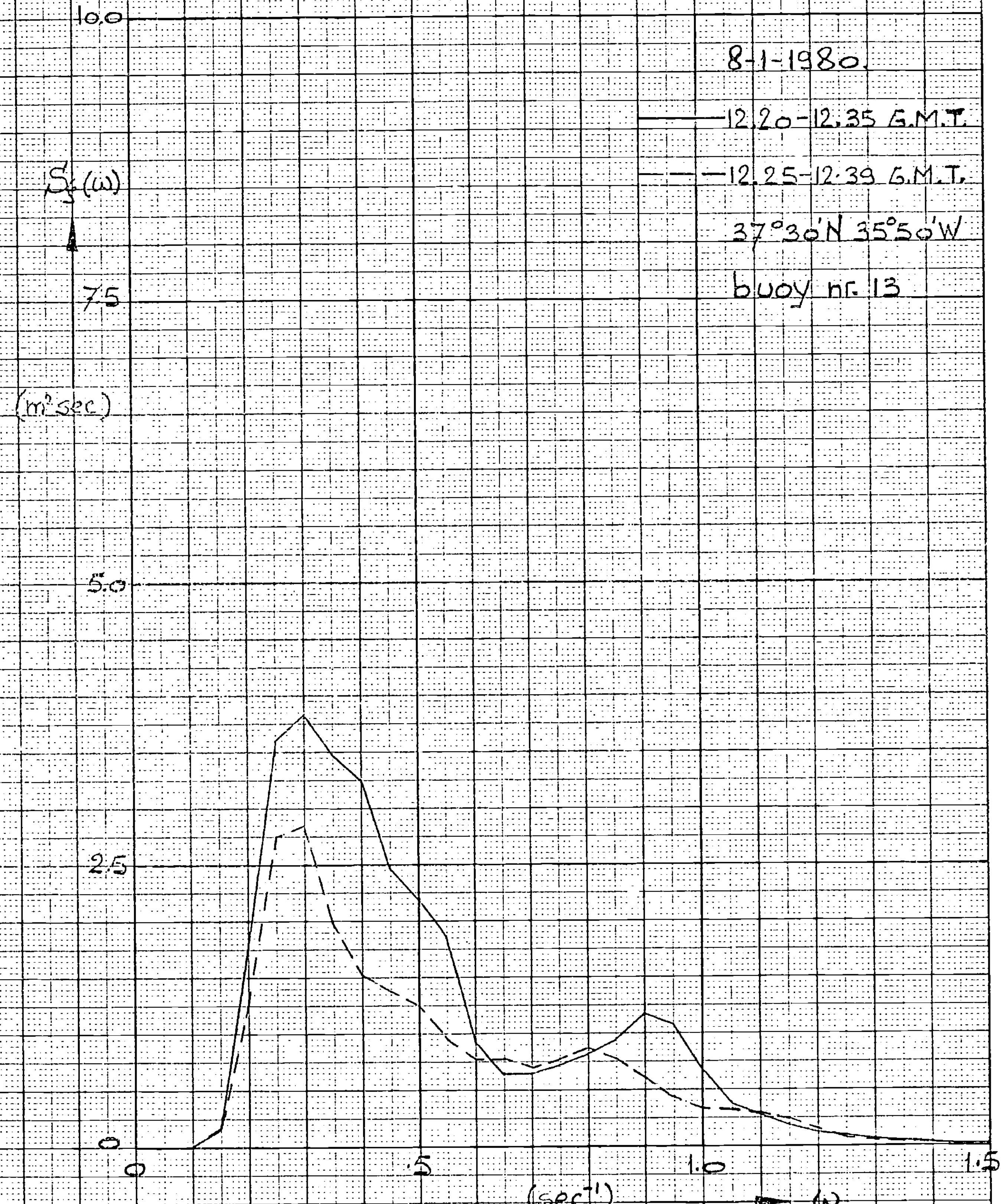


Figure 13. Wave spectrum buoy 13.

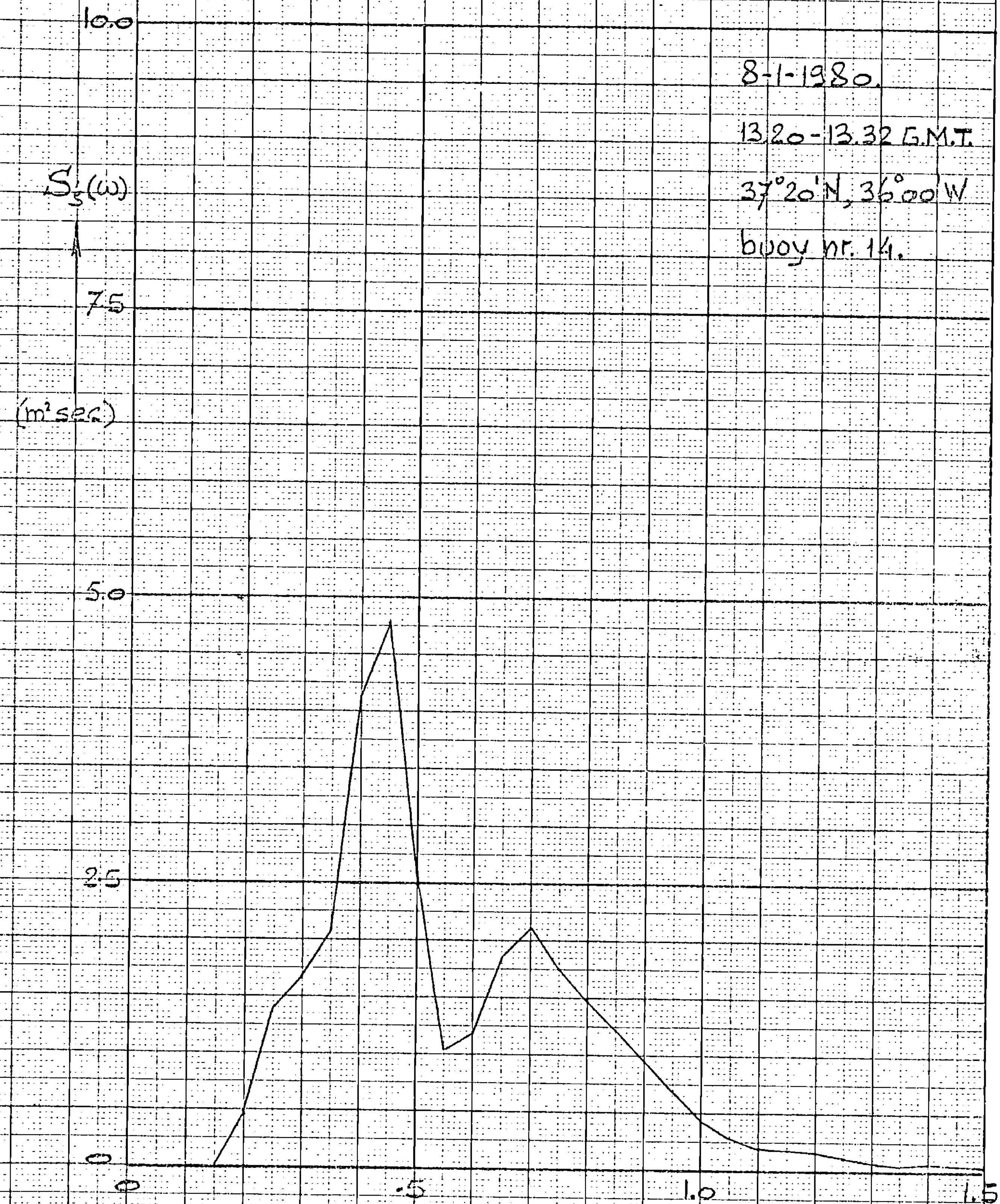


Figure 14. Wave spectrum buoy 14.

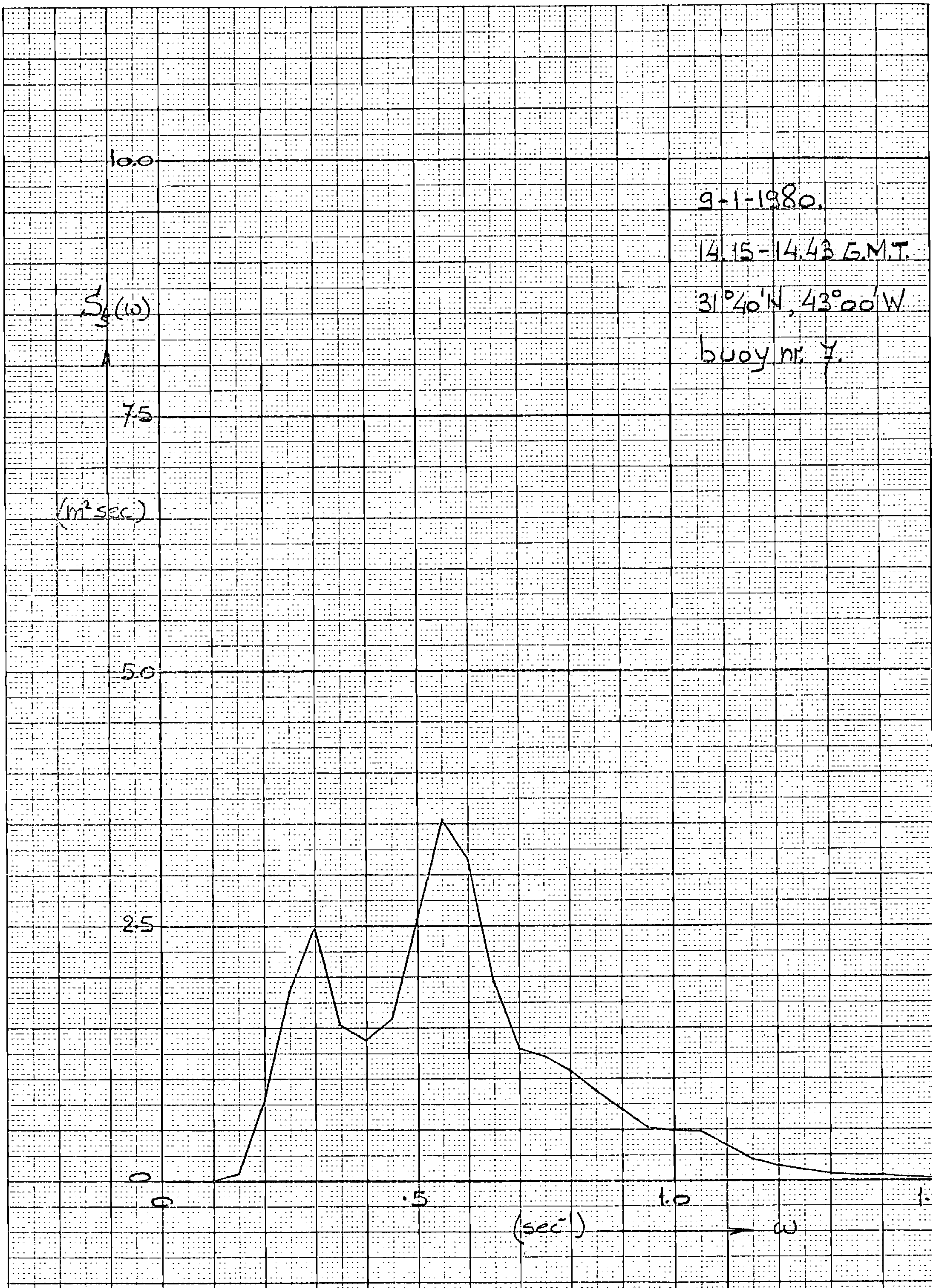
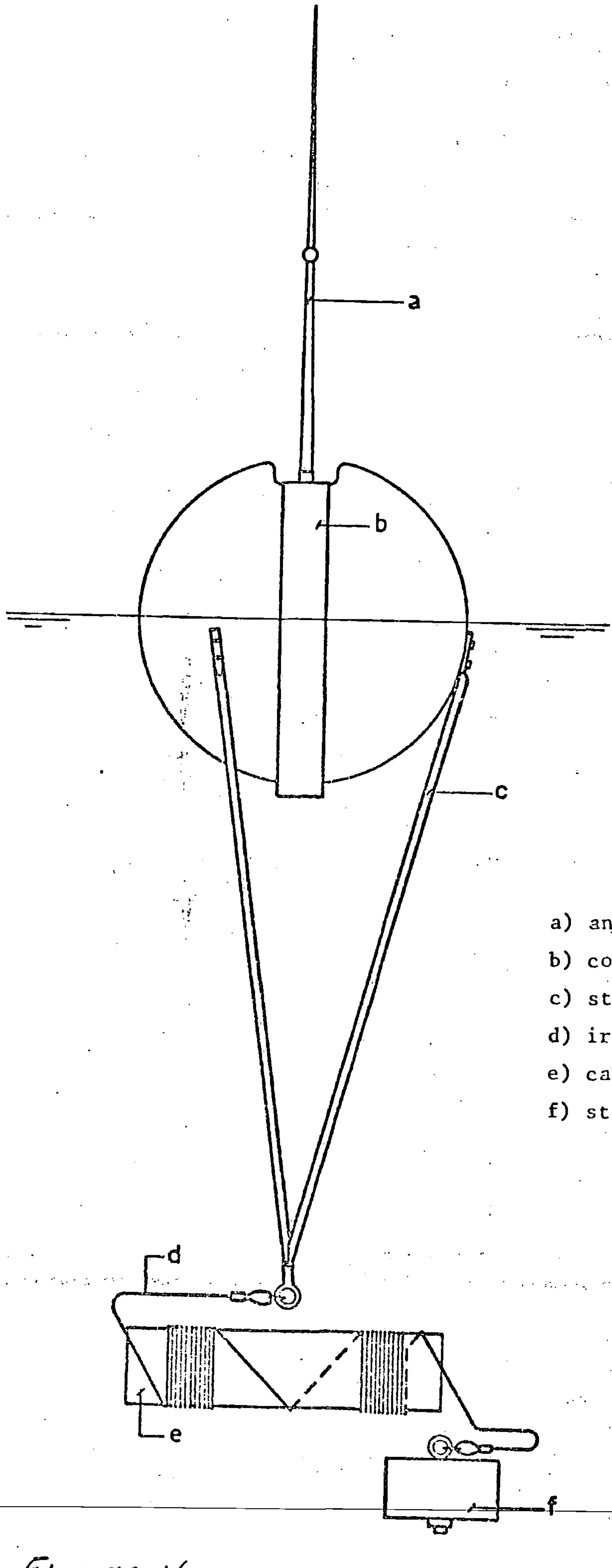


Figure 15. Wave spectrum buoy 7.



a) antenna
b) copper earthstring
c) stiff 3-legg tail
d) iron wire with length of 40 m
e) cardboard case
f) stabilisation weight

Figure 16.. DELFT WAVE BUOY

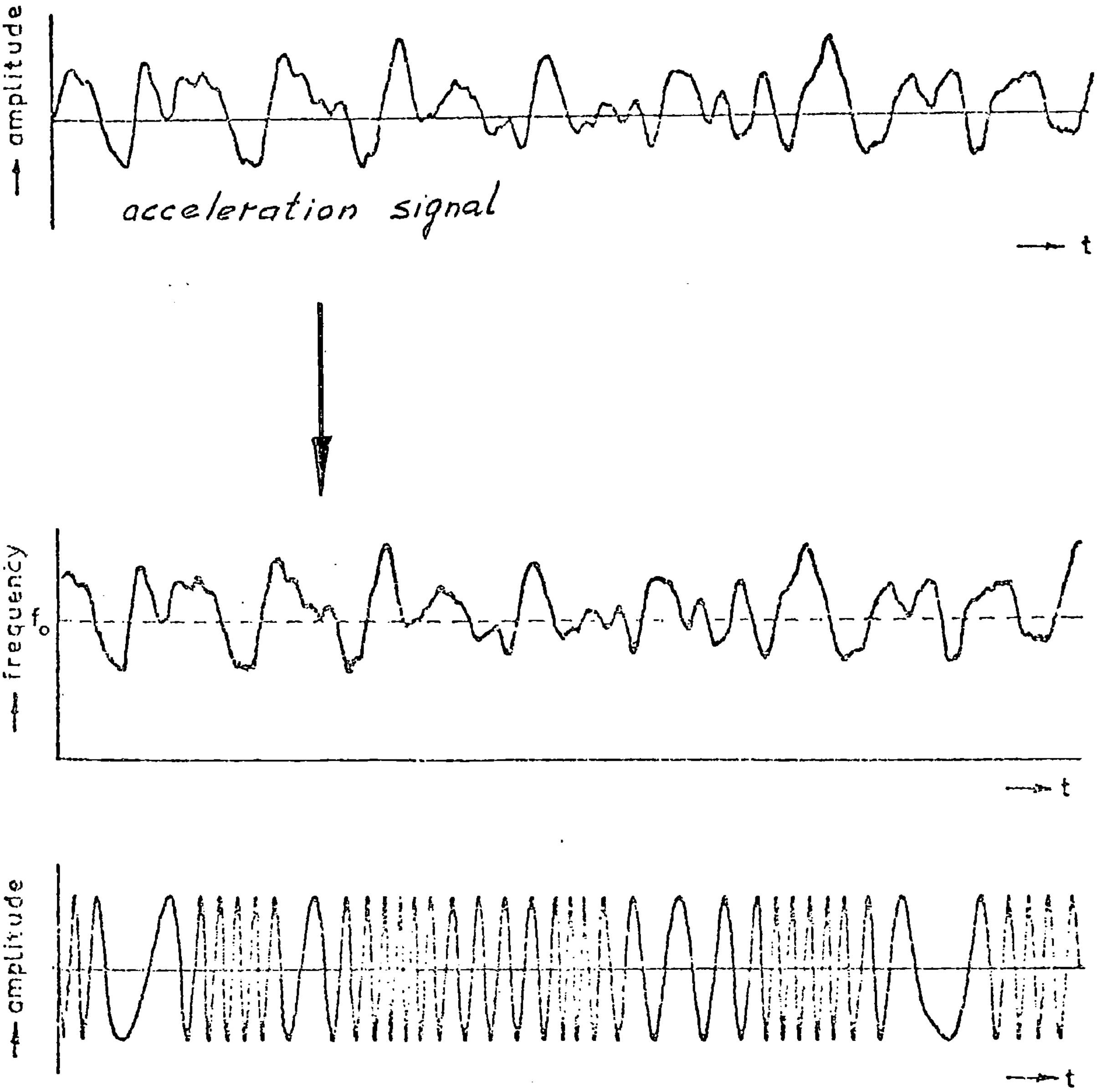


Figure 17. Frequency modulated signal.

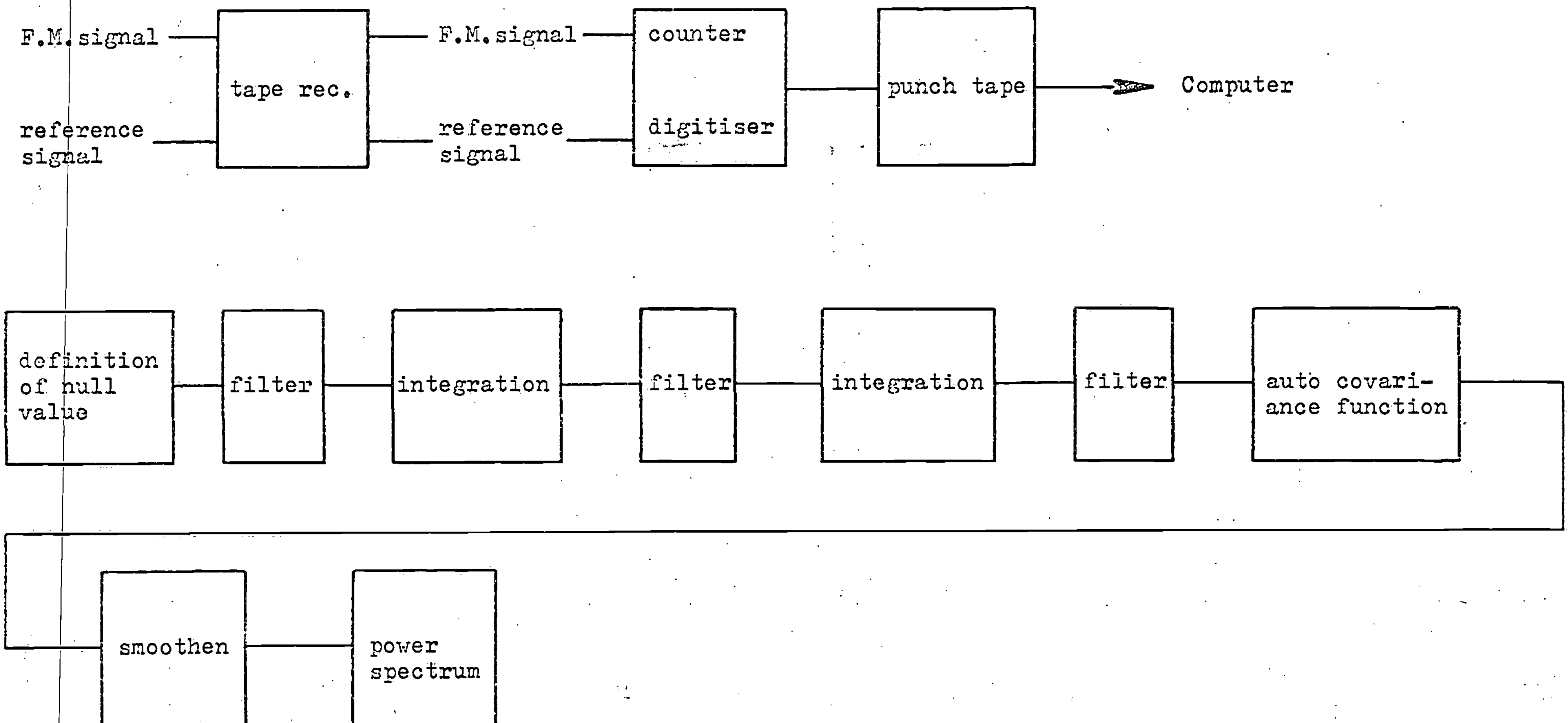


Figure 18. Block diagram of data processing.

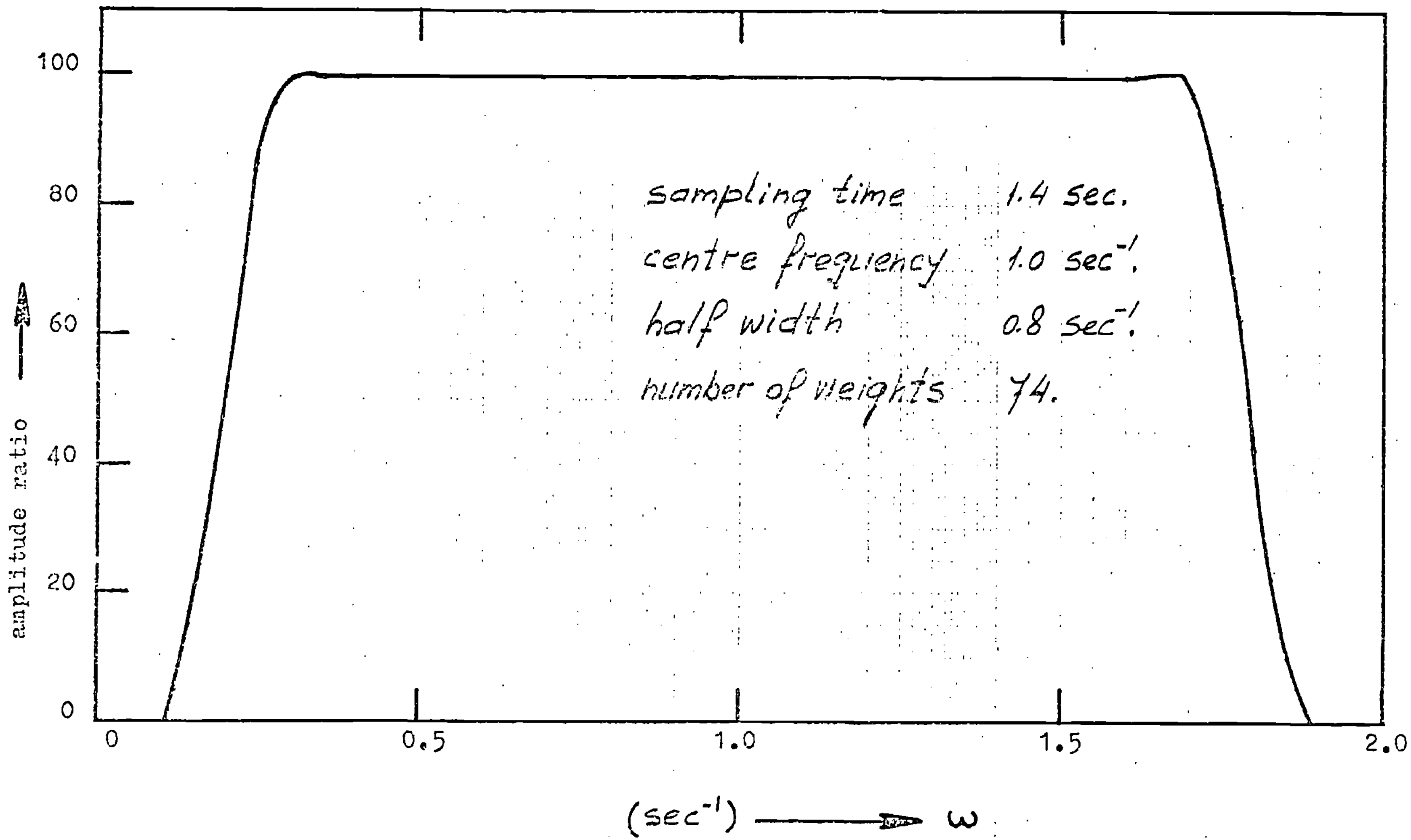


Figure 19. Transfer function of band-pass filter.

date	time G.M.T.		location N	location W	buoy nr	wind dir. deg.	wind speed kn.	sea dir. deg	sea $\bar{H}_{1/3}$ m	sea $\bar{H}^{*}_{1/3}$ m	sea $\bar{T}_2$ sec
1-1-'79	17.55	18.12	45°53'	23°28'	18	–	11	250	4.01	3.61	10.15
	18.45	19.01	45°53'	23°28'	18	–	11	250	3.74	3.41	9.40
4-1-'79	18.00	18.20	30°06'	45°42'	22	094	31	085	5.24	4.76	9.61
	20.50	21.10	29°39'	46°30'	16	098	30	085	5.69	5.11	9.94
2-2-'79	15.00	15.35	30°12'	53°51'	8	269	38	275	11.05	9.72	13.00
	15.45	15.59	30°12'	53°51'	8	273	38	275	9.75	8.61	12.60
	18.25	18.45	30°28'	52°43'	9	274	37	275	9.77	8.63	12.30
5-1-'80	11.00	11.30	50°20'	11°10'	29	295	24	300	6.72	5.40	12.03
	12.15	12.40	50°20'	11°30'	15	298	23	300	4.21	3.80	9.71
6-1-'80	16.25	16.50	45°00'	21°30'	20	282	25	275	4.63	4.11	9.89
	16.55	17.25	45°00'	21°30'	20	290	25	275	5.39	4.76	10.63
	18.05	18.35	44°50'	22°00'	10	295	23	275	5.10	4.52	10.32
	18.40	19.10	44°50'	22°00'	10	299	26	275	5.34	4.76	10.51
	21.35	22.05	44°30'	22°50'	17	328	24	267	4.96	4.38	10.78
	22.45	23.15	44°20'	23°20'	11	313	20	272	5.17	4.59	10.71
	23.15	23.45	44°20'	23°20	11	318	18	268	4.96	4.42	10.65
8-1-'80	12.25	12.39	37°30'	35°50'	13	029	31	330	5.10 4.13	4.36 3.54	11.11 10.75
	13.20	13.32	37°20'	36°00'	14	034	32	330	4.98	4.39	10.19
9-1-'80	14.15	14.43	31°40'	43°00'	7	353	26	350	4.74	4.21	10.06

Table I. Review of wave and wind measurements.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ m^{2}sec	ω sec^{-1}	$S_\zeta(\omega)$ m^{2}sec
·000		1.147	·075
·050		1.197	·065
·100	·000	1.247	·051
·150	·016	1.297	·051
·199	·212	1.346	·055
·249	·731	1.396	·037
·299	1.310	1.446	·018
·349	1.405	1.496	·015
·399	1.130	1.546	·018
·449	·978	1.596	·016
·499	1.373	1.646	·010
·549	2.506	1.695	·005
·598	2.978	1.745	·003
·648	2.208	1.795	·001
·698	1.489	1.845	·000
·748	1.064	1.895	
·798	·660	1.945	
·848	·488	1.995	
·898	·445	2.045	
·947	·318	2.094	
·997	·205	2.144	
1.047	·126	2.194	
1.097	·081	2.244	

DATE: 1 - 1 - 1979.

TIME: 17.55-18.12 GMT.

POSITION: 45°53'N, 23°48'W.

BUOY NR.: 18.

$m_{-1} = 1.984860$ m^2 sec.

$m_0 = 1.004736$ m^2.

$m_1 = \cdot 584780$ m^2 sec^{-1}.

$m_2 = \cdot 385075$ m^2 sec^{-2}.

$m_4 = \cdot 238089$ m^2 sec^{-4}.

$\overline{H}_{1/3} = 4\sqrt{m_0} = 4.01$ m.

$\overline{H}_{1/3}^{*} = 4\sqrt{\frac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 3.61$ m.

$\overline{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.15$ sec.

VISUAL OBSERVATIONS:

sea: 070 deg/ ·5 - 1 m/ 5 sec.
(250)

swell: 250 deg/ 3-4 m/ 8-9 sec.

MEASURED LOCAL WIND:

confused / 11 knots.

(15 miles west of buoy)

Table II-1. Wave spectrum buoy 18.

WAVE SPECTRUM

ω (sec^{-1})	$S_\zeta(\omega)$ (m^{2}sec)		ω (sec^{-1})	$S_\zeta(\omega)$ (m^{2}sec)
·000			1.147	·159
·050			1.197	·137
·100			1.247	·091
·150	·000		1.297	·039
·199	·086		1.346	·035
·249	·323		1.396	·041
·299	·496		1.446	·035
·349	·564		1.496	·030
·399	·528		1.546	·023
·449	·561		1.596	·014
·499	1.437		1.646	·009
·549	2.453		1.695	·006
·598	2.754		1.745	·003
·648	2.658		1.795	·001
·698	1.851		1.845	·000
·748	·963		1.895	
·798	·680		1.945	
·848	·486		1.995	
·898	·291		2.045	
·947	·249		2.094	
·997	·206		2.144	
1.047	·154		2.194	
1.097	·169		2.244	

DATE: 1 - 1 - 1979.

TIME: 18.45-19.01 GMT.

POSITION: 45°53'N, 23°48'W.

BUOY NR.: 18.

$m_{-1} = 1.524894$ m^2 sec.

$m_0 = \cdot 874260$ m^2.

$m_1 = \cdot 556264$ m^2 sec^{-1}.

$m_2 = \cdot 390514$ m^2 sec^{-2}.

$m_4 = \cdot 264828$ m^2 sec^{-4}.

$$\overline{H}_{1/3} = 4\sqrt{m_0} = 3.74 \text{ m.}$$

$$\overline{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 3.41 \text{ m}$$

$$\overline{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 9.40 \text{ sec.}$$

VISUAL OBSERVATIONS:

sea: 070 deg / 5-1 m / 5 sec.
(250)

swell: 250 deg / 3-4 m / 8-9 sec.

MEASURED LOCAL WIND:

confused / 11 knots.

(30 miles west of buoy)

Table II-2. Wave spectrum buoy 18.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$	ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$	sec^{-1}	$m^2 sec$
.000		1.147	.242
.050		1.197	.178
.100	.000	1.247	.148
.150	.037	1.297	.137
.199	.485	1.346	.106
.249	1.013	1.396	.065
.299	1.150	1.446	.043
.349	1.154	1.496	.035
.399	1.080	1.546	.028
.449	1.066	1.596	.019
.499	2.792	1.646	.012
.549	6.133	1.695	.007
.598	6.090	1.745	.003
.648	3.227	1.795	.000
.698	2.107	1.845	
.748	1.999	1.895	
.798	1.593	1.945	
.848	1.092	1.995	
.898	.802	2.045	
.947	.564	2.094	
.997	.389	2.144	
1.047	.354	2.194	
1.097	.303	2.244	

DATE: 4 - 1 - 1979.

TIME: 18.00 - 18.20 GMT.

POSITION: 30°06'N, 45°42'W.

BUOY NR.: 22.

$m_{-1} = 3.155831 \ m^2 sec.$

$m_0 = 1.718252 \ m^2.$

$m_1 = 1.063174 \ m^2 sec^{-1}.$

$m_2 = .734117 \ m^2 sec^{-2}.$

$m_4 = .482887 \ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 5.24 \ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\frac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.76 \ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 9.61 \ sec.$$

VISUAL OBSERVATIONS:

sea: 080 deg/ 2 m/5-7 sec.
(085)

swell: 090 deg/5-6 m/8-12 sec.

MEASURED LOCAL WIND:

094 deg/ 31 knots.
(11 miles west of buoy.)

Table III. Wave spectrum buoy 22.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
·000		1.147	·257
·050		1.197	·218
·100	·000	1.247	·154
·150	·032	1.297	·110
·199	·730	1.346	·079
·249	2.856	1.396	·057
·299	4.090	1.446	·044
·349	2.489	1.496	·029
·399	·954	1.546	·019
·449	1.078	1.596	·014
·499	2.149	1.646	·012
·549	4.405	1.695	·006
·598	5.438	1.745	·002
·648	3.683	1.795	·000
·698	2.314	1.845	
·748	2.346	1.895	
·798	2.163	1.945	
·848	1.785	1.995	
·898	1.259	2.045	
·947	·670	2.094	
·997	·498	2.144	
1.047	·408	2.194	
1.097	·286	2.244	

DATE: 4 - 1 - 1979.

TIME: 20.50 - 21.10 GMT.

POSITION: 29°39'N, 46°30'W.

BUOY NR.: 16.

$m_{-1} = 4.162612 \; m^2 sec.$

$m_0 = 2.026676 \; m^2.$

$m_1 = 1.188309 \; m^2 sec^{-1}.$

$m_2 = .809143 \; m^2 sec^{-2}.$

$m_4 = .529116 \; m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 5.69 \; m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 5.11 \; m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 9.94 \; sec.$$

VISUAL OBSERVATIONS:

sea: 080 deg/ 2 m/ 5-7 sec.
(085)

swell: 090 deg/ 5-6 m/ 8-12 sec.

MEASURED LOCAL WIND:

098 deg/ 30 knots.
(9 miles west of buoy.)

Table IV. Wave spectrum buoy 16.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$		ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000			1.147	.274
.050			1.197	.223
.100	.000		1.247	.152
.150	.271		1.297	.091
.199	2.926		1.346	.068
.249	7.292		1.396	.059
.299	12.230		1.446	.049
.349	26.313		1.496	.030
.399	35.320		1.546	.023
.449	23.858		1.596	.020
.499	11.958		1.646	.014
.549	7.631		1.695	.009
.599	5.430		1.745	.004
.648	4.307		1.795	.001
.698	3.585		1.845	.000
.748	3.179		1.895	
.798	2.405		1.945	
.848	1.733		1.995	
.898	1.157		2.045	
.947	.751		2.094	
.997	.655		2.144	
1.047	.626		2.194	
1.097	.436		2.244	

DATE: 2 - 2 - 1979.

TIME: 15.00 - 15.35 GMT.

POSITION: 30°12' N, 53°51' W.

BUOY NR.: 8.

$m_{-1} = 18.763380\ m^2 sec.$

$m_0 = 7.633567\ m^2.$

$m_1 = 3.459480\ m^2 sec^{-1}.$

$m_2 = 1.783464\ m^2 sec^{-2}.$

$m_4 = .760353\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 11.05\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 9.72\ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 13.00\ sec.$$

VISUAL OBSERVATIONS:

sea: 260 deg/ 4-8 m/ 9-10 sec.
(275)

swell: 285 deg/ 8-10 m/ 12-14 sec.

MEASURED LOCAL WIND:

269 deg/ 38 knots.
(15 miles west of buoy.)

Table V-1. Wave spectrum buoy 8.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$	ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$	sec^{-1}	$m^2 sec$
.000		1.147	.199
.050		1.197	.135
.100	.000	1.247	.105
.150	.273	1.297	.094
.199	2.586	1.346	.085
.249	4.764	1.396	.057
.299	7.007	1.446	.026
.349	18.422	1.496	.015
.399	26.704	1.546	.019
.449	19.206	1.596	.017
.499	10.749	1.646	.008
.549	7.276	1.695	.000
.598	5.355	1.745	
.648	4.041	1.795	
.698	2.618	1.845	
.748	1.910	1.895	
.798	1.798	1.945	
.848	1.601	1.995	
.898	1.212	2.045	
.947	.961	2.094	
.997	.817	2.144	
1.047	.662	2.194	
1.097	.401	2.244	

DATE: 2 - 2 - 1979.

TIME: 15.45 - 15.59 GMT.

POSITION: 30°12'N, 53°51'W.

BUOY NR.: 8.

$m_{-1} = 14.251756\ m^2 sec.$

$m_0 = 5.942996\ m^2.$

$m_1 = 2.776815\ m^2 sec^{-1}.$

$m_2 = 1.476737\ m^2 sec^{-2}.$

$m_4 = .656045\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 9.75\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 8.61\ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 12.60\ sec.$$

VISUAL OBSERVATIONS:

sea: 260 deg / 4-8 m / 9-10 sec.
(275)

swell: 285 deg / 8-10 m / 12-14 sec.

MEASURED LOCAL WIND:

273 deg / 38 knots.
(26 miles west of buoy.)

Table V-2. Wave spectrum buoy 8.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.236
.050		1.197	.201
.100	.000	1.247	.158
.150	.077	1.297	.121
.199	2.325	1.346	.107
.249	6.338	1.396	.082
.299	11.790	1.446	.054
.349	18.165	1.496	.036
.399	18.388	1.546	.020
.449	13.673	1.596	.013
.499	9.806	1.646	.009
.549	8.696	1.695	.003
.598	8.936	1.745	.000
.648	7.117	1.795	
.698	4.284	1.845	
.748	2.309	1.895	
.798	1.452	1.945	
.848	1.255	1.995	
.898	1.417	2.045	
.947	1.171	2.094	
.997	.573	2.144	
1.047	.384	2.194	
1.097	.330	2.244	

DATE: 2 - 2 - 1979.

TIME: 18.25 – 18.45 GMT.

POSITION: 30°28'N, 52°43'W.

BUOY NR.: 9.

$m_{-1} = 14.200285\ m^2 sec.$

$m_0 = 5.961421\ m^2.$

$m_1 = 2.842534\ m^2 sec^{-1}.$

$m_2 = 1.554785\ m^2 sec^{-2}.$

$m_4 = .721555\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 9.77\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 8.63\ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 12.30\ sec.$$

VISUAL OBSERVATIONS:

sea: 270 deg / 3-4 m / - sec.
(275)

swell: 275 deg / 8-9 m / 9 sec.

MEASURED LOCAL WIND:

274 deg / 37 knots.

(8 miles west of buoy.)

Table VI. Wave spectrum buoy 9.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$	ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$	sec^{-1}	$m^2 sec$
.000		1.147	.318
.050		1.197	.257
.100	.000	1.247	.172
.150	.214	1.297	.117
.199	3.276	1.346	.093
.249	8.689	1.396	.069
.299	9.567	1.446	.047
.349	5.806	1.496	.036
.399	3.403	1.546	.024
.449	3.672	1.596	.015
.499	3.930	1.646	.014
.549	3.094	1.695	.010
.598	2.712	1.745	.004
.648	2.529	1.795	.000
.698	1.810	1.845	
.748	1.373	1.895	
.798	1.277	1.945	
.848	1.140	1.995	
.898	1.003	2.045	
.947	.721	2.094	
.997	.463	2.144	
1.047	.396	2.194	
1.097	.356	2.244	

DATE: 5 - 1 - 1980.

TIME: 11.00-11.30 GMT.

POSITION: 50°20'N, 11°10'W.

BUOY NR.: 29.

$m_{-1} = 7.547685\ m^2 sec.$

$m_0 = 2.822936\ m^2.$

$m_1 = 1.310676\ m^2 sec^{-1}.$

$m_2 = .769587\ m^2 sec^{-2}.$

$m_4 = .480897\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 6.72\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 5.70\ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 12.03\ sec.$$

VISUAL OBSERVATIONS:

sea: 300 deg/ 6-7 m/ 10-11 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

295 deg/ 24 knots.

(6 miles west of buoy)

Table VII. Wave spectrum buoy 29.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.167
.050		1.197	.097
.100	.000	1.247	.083
.150	.009	1.297	.079
.199	.151	1.346	.073
.249	.460	1.396	.057
.299	.656	1.446	.041
.349	.561	1.496	.030
.399	.991	1.546	.022
.449	2.419	1.596	.015
.499	3.164	1.646	.010
.549	2.633	1.695	.006
.598	2.236	1.745	.003
.648	2.154	1.795	.001
.698	1.821	1.845	.000
.748	1.402	1.895	
.798	.999	1.945	
.848	.585	1.995	
.898	.326	2.045	
.947	.218	2.094	
.997	.210	2.144	
1.047	.289	2.194	
1.097	.279	2.244	

DATE: 5 - 1 - 1980.

TIME: 12.15-12.40 GMT.

POSITION: 50°20'N, 11°30'W.

BUOY NR.: 15.

$m_{-1} = 2.036817$ $m^2 sec$.

$m_0 = 1.109880$ m^2.

$m_1 = .678275$ $m^2 sec^{-1}$.

$m_2 = .464348$ $m^2 sec^{-2}$.

$m_4 = .311806$ $m^2 sec^{-4}$.

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 4.21 \ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 3.80 \ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 9.71 \ sec.$$

VISUAL OBSERVATIONS:

sea: 300 deg/ 4-5 m/ 10 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

298 deg/ 23 knots.
(6 miles west of buoy.)

Table VIII. Wave spectrum buoy 15.

WAVE SPECTRUM

ω (sec^{-1})	$S_\zeta(\omega)$ (m^{2}sec)	ω (sec^{-1})	$S_\zeta(\omega)$ (m^{2}sec)
.000		1.147	.252
.050		1.197	.177
.100	.000	1.247	.128
.150	.014	1.297	.100
.199	.235	1.346	.069
.249	.630	1.396	.047
.299	.911	1.446	.032
.349	1.643	1.496	.025
.399	3.121	1.546	.022
.449	3.765	1.596	.017
.499	2.854	1.646	.013
.549	1.893	1.695	.008
.598	1.717	1.745	.003
.648	1.836	1.795	.000
.698	1.732	1.845	
.748	1.307	1.895	
.798	1.011	1.945	
.848	.926	1.995	
.898	.750	2.045	
.947	.535	2.094	
.997	.398	2.144	
1.047	.342	2.194	
1.097	.310	2.244	

DATE: 6-1-1980.

TIME: 16.25-16.50 GMT.

POSITION: 45°00'N, 21°30'W.

BUOY NR.: 20.

$m_{-1} = 2.610275$ m^2 sec.

$m_0 = 4.337681$ m^2.

$m_1 = .790721$ m^2 sec^{-1}.

$m_2 = .539756$ m^2 sec^{-2}.

$m_4 = .375908$ m^2 sec^{-4}.

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 4.63 \text{ m.}$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.11 \text{ m.}$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 9.89 \text{ sec.}$$

VISUAL OBSERVATIONS:

sea: 275 deg/ 5-6 m/ 10 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

282 deg/ 25 knots.

(3 miles west of buoy)

Table IX-1. Wave spectrum buoy 20.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.176
.050		1.197	.165
.100	.000	1.247	.130
.150	.008	1.297	.087
.199	.230	1.346	.059
.249	.773	1.396	.046
.299	1.396	1.446	.038
.349	3.618	1.496	.029
.399	6.493	1.546	.018
.449	5.899	1.596	.014
.499	3.401	1.646	.013
.549	2.161	1.695	.008
.598	1.839	1.745	.003
.648	1.704	1.795	.000
.698	1.431	1.845	
.748	1.413	1.895	
.798	1.476	1.945	
.848	1.287	1.995	
.898	.875	2.045	
.947	.559	2.094	
.997	.441	2.144	
1.047	.370	2.194	
1.097	.242	2.244	

DATE: 6-1-1980.

TIME: 16.55-17.25 G.M.T.

POSITION: 45°00'N, 21°30'W.

BUOY NR.: 20.

$m_{-1} = 3.780226\ m^2 sec.$

$m_0 = 1.818137\ m^2.$

$m_1 = .998523\ m^2 sec^{-1}.$

$m_2 = .635317\ m^2 sec^{-2}.$

$m_4 = .398094\ m^2 sec^{-4}.$

$\overline{H}_{1/3} = 4\sqrt{m_0} = 5.39\ m.$

$\overline{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.76\ m.$

$\overline{\overline{T}}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.63\ sec.$

VISUAL OBSERVATIONS:

sea: 275 deg/ 5-6 m/ 10 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

290 deg/ 25 knots.
(6 miles west of buoy)

Table IX-2. Wave spectrum buoy 20.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$		ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$		sec^{-1}	$m^2 sec$
.000			1.147	.215
.050			1.197	.171
.100	.000		1.247	.124
.150	.008		1.297	.078
.199	.161		1.346	.062
.249	.604		1.396	.059
.299	.992		1.446	.045
.349	2.443		1.496	.028
.399	4.889		1.546	.023
.449	4.906		1.596	.021
.499	3.187		1.646	.013
.549	2.633		1.695	.006
.598	2.758		1.745	.002
.648	2.205		1.795	.000
.698	1.309		1.845	
.748	1.009		1.895	
.798	1.054		1.945	
.848	1.075		1.995	
.898	.946		2.045	
.947	.617		2.094	
.997	.355		2.144	
1.047	.295		2.194	
1.097	.269		2.244	

DATE: 6 - 1 - 1980.

TIME: 18.05 - 18.35 GMT.

POSITION: 44°50'N, 22°00'W.

BUOY NR.: 10.

$m_{-1} = 3.244186 \; m^2 sec.$

$m_0 = 1.623800 \; m^2.$

$m_1 = .922351 \; m^2 sec^{-1}.$

$m_2 = .601496 \; m^2 sec^{-2}.$

$m_4 = .389240 \; m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 5.10 \; m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.52 \; m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.32 \; sec.$$

VISUAL OBSERVATIONS:

sea: 275 deg/ 5 m/ 10 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

295 deg/ 23 knots.

(2 miles west of buoy.)

Table X-1. Wave spectrum buoy 10.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.175
.050		1.197	.105
.100	.000	1.247	.088
.150	.026	1.297	.093
.199	.157	1.346	.070
.249	.511	1.396	.049
.299	.955	1.446	.038
.349	2.700	1.496	.027
.399	5.768	1.546	.020
.449	5.763	1.596	.017
.499	3.482	1.646	.012
.549	2.811	1.695	.007
.598	2.818	1.745	.003
.648	2.380	1.795	.000
.698	1.722	1.845	
.748	1.330	1.895	
.798	1.222	1.945	
.848	1.091	1.995	
.898	.840	2.045	
.947	.570	2.094	
.997	.376	2.144	
1.047	.300	2.194	
1.097	.261	2.244	

DATE: 6-1-1980.

TIME: 18.40-19.10 GMT.

POSITION: 44°50'N, 22°00'W.

BUOY NR.: 10.

$m_{-1} = 3.579279$ $m^2 sec$.

$m_0 = 1.784587$ m^2.

$m_1 = 1.000434$ $m^2 sec^{-1}$.

$m_2 = .637964$ $m^2 sec^{-2}$.

$m_4 = .388602$ $m^2 sec^{-4}$.

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 5.34\, m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.76\, m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.51\, sec.$$

VISUAL OBSERVATIONS:

sea: 270 deg/ 5 m/ 10 sec.

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

299 deg/ 26 knots.

(6 miles west of buoy)

Table X-2. Wave spectrum buoy 10.

WAVE SPECTRUM

ω (sec^{-1})	$S_\zeta(\omega)$ ($m^2 sec$)	ω (sec^{-1})	$S_\zeta(\omega)$ ($m^2 sec$)
.000		1.147	.129
.050		1.197	.140
.100	.000	1.247	.135
.150	.015	1.297	.103
.199	.157	1.346	.077
.249	.515	1.396	.052
.299	.915	1.446	.029
.349	2.356	1.496	.021
.399	5.206	1.546	.015
.449	5.694	1.596	.011
.499	3.482	1.646	.009
.549	2.335	1.695	.006
.598	2.098	1.745	.002
.648	1.749	1.795	.000
.698	1.430	1.845	
.748	1.098	1.895	
.798	.826	1.945	
.848	.596	1.995	
.898	.502	2.045	
.947	.434	2.094	
.997	.305	2.144	
1.047	.232	2.194	
1.097	.173	2.244	

DATE: 6-1-1980.

TIME: 21.35 - 22.05 G.M.T.

POSITION: 44°30'N, 22°50'W.

BUOY NR.: 17

$m_{-1} = 3.164980\ m^2 sec.$

$m_0 = 1.538089\ m^2.$

$m_1 = .838311\ m^2 sec^{-1}.$

$m_2 = .522083\ m^2 sec^{-2}.$

$m_4 = .315675\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 4.96\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.38\ m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.78\ sec.$$

VISUAL OBSERVATIONS:

sea: 267 deg/ - m/ - sec.
(dark)

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

328 deg/ 24 knots.

(8 miles West of buoy.)

Table XI. Wave spectrum buoy 17.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.175
.050		1.197	.149
.100	.000	1.247	.123
.150	.020	1.297	.080
.199	.136	1.346	.050
.249	.555	1.396	.033
.299	1.391	1.446	.025
.349	2.516	1.496	.024
.399	4.171	1.546	.019
.449	5.121	1.596	.012
.499	4.245	1.646	.009
.549	3.509	1.695	.007
.598	3.309	1.745	.003
.648	2.232	1.795	.000
.698	1.124	1.845	
.748	.946	1.895	
.798	.879	1.945	
.848	.650	1.995	
.898	.552	2.045	
.947	.483	2.094	
.997	.384	2.144	
1.047	.295	2.194	
1.097	.228	2.244	

DATE: 6 - 1 - 1980.

TIME: 22.45 - 23.15 GMT.

POSITION: 44°20'N, 23°20'W.

BUOY NR.: 11.

$m_{-1} = 3.391840 \; m^2 sec.$

$m_0 = 1.668313 \; m^2.$

$m_1 = .919246 \; m^2 sec^{-1}.$

$m_2 = .574616 \; m^2 sec^{-2}.$

$m_4 = .340339 \; m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 5.17 \; m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.59 \; m.$$

$$\bar{\bar{T}}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.71 \; sec.$$

VISUAL OBSERVATIONS:

sea: 272 deg/ - m/ - sec.
(dark)

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

313 deg/ 20 knots.
(6 miles West of buoy)

Table XII-1. Wave spectrum buoy 11.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$		ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$		sec^{-1}	$m^2 sec$
·000			1.147	·138
·050			1.197	·109
·100	·000		1.247	·094
·150	·022		1.297	·076
·199	·065		1.346	·056
·249	·422		1.396	·037
·299	1.575		1.446	·032
·349	2.660		1.496	·023
·399	3.348		1.546	·018
·449	4.088		1.596	·016
·499	4.264		1.646	·011
·549	3.550		1.695	·005
·598	2.493		1.745	·002
·648	1.785		1.795	·000
·698	1.473		1.845	
·748	1.231		1.895	
·798	·897		1.945	
·848	·630		1.995	
·898	·480		2.045	
·947	·423		2.094	
·997	·361		2.144	
1.047	·264		2.194	
1.097	·205		2.244	

DATE: 6 - 1 - 1980.

TIME: 23.15 - 23.45 GMT.

POSITION: 44°20'N, 23°20'W

BUOY NR.: 11.

$m_{-1} = 3.111522\ m^2 sec.$

$m_0 = 1.538756\ m^2.$

$m_1 = \cdot 852750\ m^2 sec^{-1}.$

$m_2 = \cdot 536075\ m^2 sec^{-2}.$

$m_4 = \cdot 319261\ m^2 sec^{-4}.$

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 4.96\ m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.42\ m.$$

$$\bar{\bar{T}}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.65\ sec.$$

VISUAL OBSERVATIONS:

sea: 268 deg/ - m/ - sec.
(dark)

swell: deg/ m/ sec.

MEASURED LOCAL WIND:

318 deg/ 18 knots.
(15 miles West of buoy)

Table XII-2. Wave spectrum buoy 11.

WAVE SPECTRUM

ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$	ω sec^{-1}	$S_\zeta(\omega)$ $m^2 sec$
.000		1.147	.187 / .242
.050		1.197	.121 / .159
.100	.000 / .000	1.247	.097 / .087
.150	.149 / .153	1.297	.064 / .055
.199	1.710 / 1.256	1.346	.052 / .032
.249	3.591 / 2.740	1.396	.037 / .020
.299	3.837 / 2.800	1.446	.024 / .015
.349	3.483 / 1.977	1.496	.023 / .014
.399	3.258 / 1.532	1.546	.024 / .016
.449	2.987 / 1.377	1.596	.019 / .014
.499	2.693 / 1.251	1.646	.014 / .009
.549	1.853 / .945	1.695	.009 / .004
.598	.913 / .773	1.745	.003 / .001
.648	.654 / .769	1.795	.000 / .000
.698	.644 / .706	1.845	
.748	.725 / .776	1.895	
.798	.814 / .862	1.945	
.848	.956 / .786	1.995	
.898	1.173 / .600	2.045	
.947	1.071 / .440	2.094	
.997	.693 / .346	2.144	
1.047	.387 / .320	2.194	
1.097	.271 / .299	2.244	

DATE: 8-1-1980.

TIME: $12.^{20}/_{25}$ - $12.^{35}/_{39}$ GMT.

POSITION: 37°30'N 35°50'W.

BUOY NR.: 13.

$m_{-1} = {}^{4.052035}_{2.673641}$ $m^2 sec.$

$m_0 = {}^{1.623337}_{1.066399}$ $m^2.$

$m_1 = {}^{.816914}_{.550902}$ $m^2 sec^{-1}.$

$m_2 = {}^{.519367}_{.364567}$ $m^2 sec^{-2}.$

$m_4 = {}^{.360545}_{.266975}$ $m^2 sec^{-4}.$

$\overline{H}_{1/3} = 4\sqrt{m_0} = {}^{5.10}_{4.13}$ m.

$\overline{H}_{1/3}^{*} = 4\sqrt{\frac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = {}^{4.36}_{3.54}$ m.

$\overline{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = {}^{11.11}_{10.75}$ sec.

VISUAL OBSERVATIONS:

sea: 030 deg/ - m/ - sec.
(330)

swell: 270 / 330 deg/ 4-5 / 4 m/ - / - sec.

MEASURED LOCAL WIND:

029 deg/ 31 knots.
(5 miles West of buoy)

Table XIII. Wave spectrum buoy 13.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$		ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$		sec^{-1}	$m^2 sec$
.000			1.147	.172
.050			1.197	.167
.100	.000		1.247	.107
.150	.018		1.297	.063
.199	.482		1.346	.050
.249	1.406		1.396	.059
.299	1.686		1.446	.048
.349	2.090		1.496	.035
.399	4.135		1.546	.034
.449	4.785		1.596	.020
.499	2.577		1.646	.009
.549	1.037		1.695	.009
.598	1.188		1.745	.007
.648	1.851		1.795	.003
.698	2.109		1.845	.001
.748	1.748		1.895	.000
.798	1.466		1.945	
.848	1.228		1.995	
.898	.945		2.045	
.947	.693		2.094	
.997	.436		2.144	
1.047	.280		2.194	
1.097	.190		2.244	

DATE: 8-1-1980.

TIME: 13.20-13.32 GMT.

POSITION: 37°20'N, 36°00'W.

BUOY NR.: 14.

$m_{-1} = 3.223935\ m^2 sec.$

$m_0 = 1.553056\ m^2.$

$m_1 = .883267\ m^2 sec^{-1}.$

$m_2 = .590377\ m^2 sec^{-2}.$

$m_4 = .406082\ m^2 sec^{-4}.$

$\overline{H}_{1/3} = 4\sqrt{m_0} = 4.98\ m.$

$\overline{H}_{1/3}^{*} = 4\sqrt{\frac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.39\ m.$

$\overline{\overline{T}}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.19\ sec.$

VISUAL OBSERVATIONS:

sea: 030 deg/ - m/ - sec.
(300)

swell: 270 / 330 deg/ 3 / 4 m/ - / - sec.

MEASURED LOCAL WIND:

034 deg/ 32 knots.
(5 miles West of buoy.)

Table XIV. Wave spectrum buoy 14.

WAVE SPECTRUM

ω	$S_\zeta(\omega)$	ω	$S_\zeta(\omega)$
sec^{-1}	$m^2 sec$	sec^{-1}	$m^2 sec$
.000		1.147	.202
.050		1.197	.145
.100	.000	1.247	.100
.150	.070	1.297	.061
.199	.765	1.346	.056
.249	1.860	1.396	.054
.299	1.982	1.446	.037
.349	1.523	1.496	.022
.399	1.388	1.546	.015
.449	1.594	1.596	.012
.499	2.558	1.646	.008
.549	3.536	1.695	.005
.598	3.150	1.745	.002
.648	1.949	1.795	.000
.698	1.300	1.845	
.748	1.212	1.895	
.798	1.070	1.945	
.848	.887	1.995	
.898	.710	2.045	
.947	.516	2.094	
.997	.480	2.144	
1.047	.486	2.194	
1.097	.346	2.244	

DATE: 9 - 1 - 1980.

TIME: 14.15 - 14.43 GMT.

POSITION: 31°40'N, 43°00'W.

BUOY NR.: 7.

m_{-1} = 2.936297 m^2 sec.

m_0 = 1.402214 m^2.

m_1 = .808571 $m^2 sec^{-1}$.

m_2 = .546936 $m^2 sec^{-2}$.

m_4 = .368966 $m^2 sec^{-4}$.

$$\bar{H}_{1/3} = 4\sqrt{m_0} = 4.74\, m.$$

$$\bar{H}_{1/3}^{*} = 4\sqrt{\tfrac{1}{2}\left(m_0 + \frac{m_2^2}{m_4}\right)} = 4.21\, m.$$

$$\bar{T}_2 = 2\pi\sqrt{\frac{m_0}{m_2}} = 10.06\, sec.$$

VISUAL OBSERVATIONS:

sea: 353 deg / 2-3 m / 6 sec.
(350)

swell: 345 deg / 4-4½ m / 12 sec.

MEASURED LOCAL WIND:

353 deg / 26 knots.
(7 miles west of buoy.)

Table XV. Wave spectrum buoy 7.

Chronological table.

In behalf of Lloyds Register of Shipping, who used the local time during their experiments, the time differences between G.M.T. and the local time on shipboard are given here.

$$\text{Local time} = \text{G.M.T.} - \Delta T$$

date	ΔT (hours)
1-1-1979	1
4-1-1979	3
2-2-1979	4
5-1-1980	½
6-1-1980	1½
8-1-1980	2½
9-1-1980	3