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Technical Report on Seismology No. 28

The Relationship Between Microseism Period and Storm Position

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The Relationship Between Microseism Period and Storm Position

by

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ABSTRACT

Microseism periods associated with fourteen hurricanes in the western North Atlantic, Caribbean Sea and Gulf of Mexico over a number of years have been plotted at the appropriate storm positions. Records from fifteen stations were used although only a few may have recorded a particular microseism storm. The results show a definite period "flow" over the Gulf of Mexico, with "highs" generally southeast of Bermuda, and south of the continental shelf to the south of Newfoundland. A less prominent "high" occurs to the north of the West Indies arc. Intermediate periods exist between Bermuda and the east coast. Period seems to show a correlation with water depth. The variation with position seems to negate any significant ocean wave relationship.

INTRODUCTION

In the course of several years of microseism study, a wealth of data on the relationship of microseism period to the position of the generating storm has been accumulated. Since the work was performed by many different record readers, including the writer, over many years, and before this presentation was anticipated, the results are considered to be quite objective.

Although period data was originally obtained for every two hours of a microseism storm, only six-hourly values were used in this study in order to correspond to the times of the six-hourly weather charts from which hurricane positions were taken. Hurricanes were used for the correlations in this study since they present a fairly limited generating area and are the only storms of significant intensity occurring in lower latitudes. A similar study using fronts and extra-tropical cyclones will be published separately. The seismograph stations used in this study are listed below together with their symbols used on the charts and the type and peak response of the instruments available.

Station and symbol	Instrument	Peak Response
Antigua - A	Sprengnether	7 sec
Bermuda - B	Sprengnether (U.S. Navy)	7
	Milne-Shaw (USC&GS)	10
Cherry Point - CP	Sprengnether	7
Fordham - F	Galitzin	12
Guantanamo - G	Sprengnether	7
Halifax - H	Milne-Shaw	10
Miami - M	Sprengnether	7
Palisades - P	Columbia (Galitzin-type)	12
Richmond - R	Sprengnether	7
Roosevelt Roads - RR	Sprengnether	7
San Juan - J	Wenner	10
Swan Island - S	Sprengnether	7
Trinidad - T	Sprengnether	7
Weston - W	Long-period Benioff	1*
Whiting - Wh	Sprengnether	7

* Has 60 sec galvanometer

THE DATA

The times and center tracks of the fourteen hurricanes whose associated microseism storms were used in this work are shown in the chart in Fig. 1. The dotted line is the 1,000 fm contour. Although microseisms were measured for at least twice the number of storms shown, those used here present no ambiguity from the simultaneous presence of two or more storms.

The values for microseism period for each station and for each storm are actually averages of the wave period of at least five microseism groups at the times measured. These values were plotted along each hurricane track at six-hour intervals for each station that recorded microseisms that could be attributed to the hurricane. A total of 345 observations of such six-hourly period-averages were entered. Then each five-degree square crossed by one or more tracks was quartered. The number of observations in any quarter depended on the number of tracks crossing it and the number of stations within range. Hence the frequency of period observations in any quarter varied from 1 to 19, the average frequency being 6.

The circled numbers in Fig. 2 show the average microseism period for each quarter of a five-degree square for which any observations were available. In Fig. 3, the maximum period in each quarter is shown. It is evident from Fig. 2 that a distinct short-period zone of 2.5 to 3.5 sec occurs in the Gulf of Mexico. The elongated zone between Bermuda and the 1,000 fm contour off the east coast seems to be characterized by 4.5 to 5.0 sec. The ocean area generally southeast of Bermuda is characterized by 5.5 to 6.0 sec. Fig. 3 showing maximum periods, indicates two other zones of long-period in the region south-southwest of Newfoundland, just beyond the 1,000 fm contour, and a more restricted area just north of the eastern West Indies arc. This figure also emphasizes more strongly the region of long-periods southeast of Bermuda. In Fig. 4, the number of observations in each quarter are shown to the left of the slant within each circle. The average deviation of period is shown to the right of the slant.

DISCUSSION

Although the period observations are plotted in the quarter in which the storm center lay at a particular time, it should be realized that the generating area, or area of high wind intensity of a hurricane, usually covers an area of about five degrees square in lower latitudes, with this area about doubling as the storm moves through middle latitudes. Hence for many of the values shown in Figs. 2 and 3, part of the generating areas associated may have been over land, or part may have been over deep water and part over shallow. Some ambiguity is thus introduced for these cases if a real depth-period relationship exists. This problem is of less importance over the broad open ocean areas, remote from land. Since it has already been shown (1) that coastal stations record a rather broad spectrum in the former situation and a narrow spectrum in the latter, it must be realized that values near the continental margins may be averages of fairly broad period spectra, with the amphasis on the longer periods owing to the instruments used.

Fig. 3, showing maximum periods, was plotted since a comparison of many records from several stations for distant storms has shown that the maximum period recorded may be more reliable for a position-period relationship. The signal to noise ratio for many of the stations, especially Bermuda, is sufficiently low at long periods that such microseisms, when of distant origin, require generation by very intense storms in order to show above high short-period microseisms of closer or more local origin. This has been verified by comparison of many instruments of different sensitivities at Palisades and Bermuda for the same ocean storms. Further, the literature is replete with observations that period tends to vary directly with amplitude. Often more distant stations show lower periods for the same storm.

Although the general trends are the same in Figs. 2 and 3, more definite period "highs" are seen to exist in the regions south of Newfoundland and southeast of Bermuda in Fig. 3.

Bathymetric charts show that a small major deep area of 2,900 fm coincides with the period high south of Newfoundland, and that a major basin area of over 3,000 fm lies to the southeast of Bermuda, coinciding with the period high there. A narrow trench of great depth (over 3,000 fm) also coincides with the area of the less definite high just north of the West

Indies. Here the trench is sufficiently restricted so that only part of a hurricane could overly it at any time, introducing some ambiguity in any period-depth relationship.

The short-period values in the Gulf of Mexico are not significantly changed by consideration of maximum periods. It may be significant that the only areas of 4.0 sec microseisms recorded for the Gulf in this study are in the central deeper region (near the 90th meridian), and in the deep region south of Cuba. Since the Gulf and Caribbean stations used similar Sprengnether instruments with peak response at 7 sec, it appears that the low values for this region are not a function of the instrumentation.

Further, since hurricane winds and resulting swell in the Gulf reach measured velocities and wave-lengths respectively, not significantly different from those in the Caribbean and Atlantic, it is difficult to explain the observed period discrepancies on the basis of wave or swell generation, either in the storm area, or at the coast. The only obvious correlation seems to be one of depth of water, or possibly depth of water and sediments. The latter would explain period variations where water depths appear to be the same. Owing to the broad area of generation the exact relationship is difficult to ascertain at present.

The use of instruments with increased sensitivity at long-periods, and in particular the use of resonant seismographs, have indicated even longer periods for the deep area south of Newfoundland, than the values given here. Similar instruments will be placed on Bermuda and the results of these studies published separately. It now seems well established that restricted storms or cold fronts over relatively shallow continental shelf waters generate periods from 2 to 4 sec.

The effect of microseism path on recorded period seems to be unimportant in view of the generally small average deviations shown in Fig. 4. Since the precision of period measurements was 0.2 sec for most of the stations and as much as 0.4 to 0.8 for the rest, it is evident that most of the deviations lie within this reading error. Further, studies of numerous individual case histories (1) has shown apparently insignificant period differences at different stations from the same ocean storms.

CONCLUSIONS

A study of the distribution of microseism periods in the Gulf of Mexico, the Caribbean Sea and the western North Atlantic Ocean recorded variously at 15 stations from 14 hurricanes shows a definite relationship exists between microseism period and storm position. The only obvious correlation appears to be with water or water and sediment depth. The short-periods characteristic of the Gulf of Mexico tend to negate ocean waves or swell as the generating mechanism.

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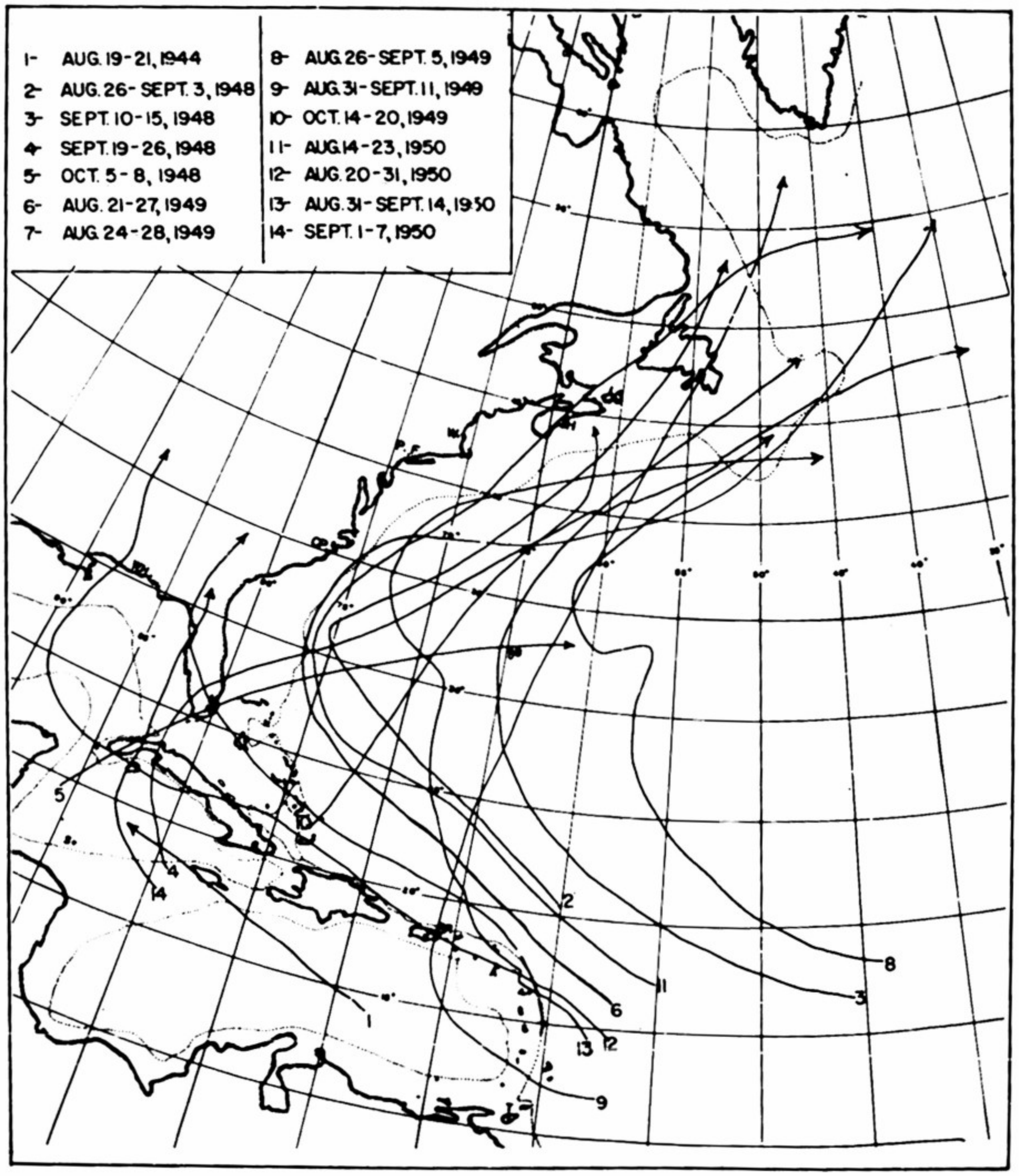
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2- AUG. 26- SEPT. 3, 1948
3- SEPT. 10-15, 1948
4- SEPT. 19-26, 1948
5- OCT. 5-8, 1948
6- AUG. 21-27, 1949
7- AUG. 24-28, 1949
8- AUG. 26- SEPT. 5, 1949
9- AUG. 31- SEPT. 11, 1949
10- OCT. 14-20, 1949
11- AUG. 14-23, 1950
12- AUG. 20-31, 1950
13- AUG. 31- SEPT. 14, 1950
14- SEPT. 1-7, 1950

Figure 1

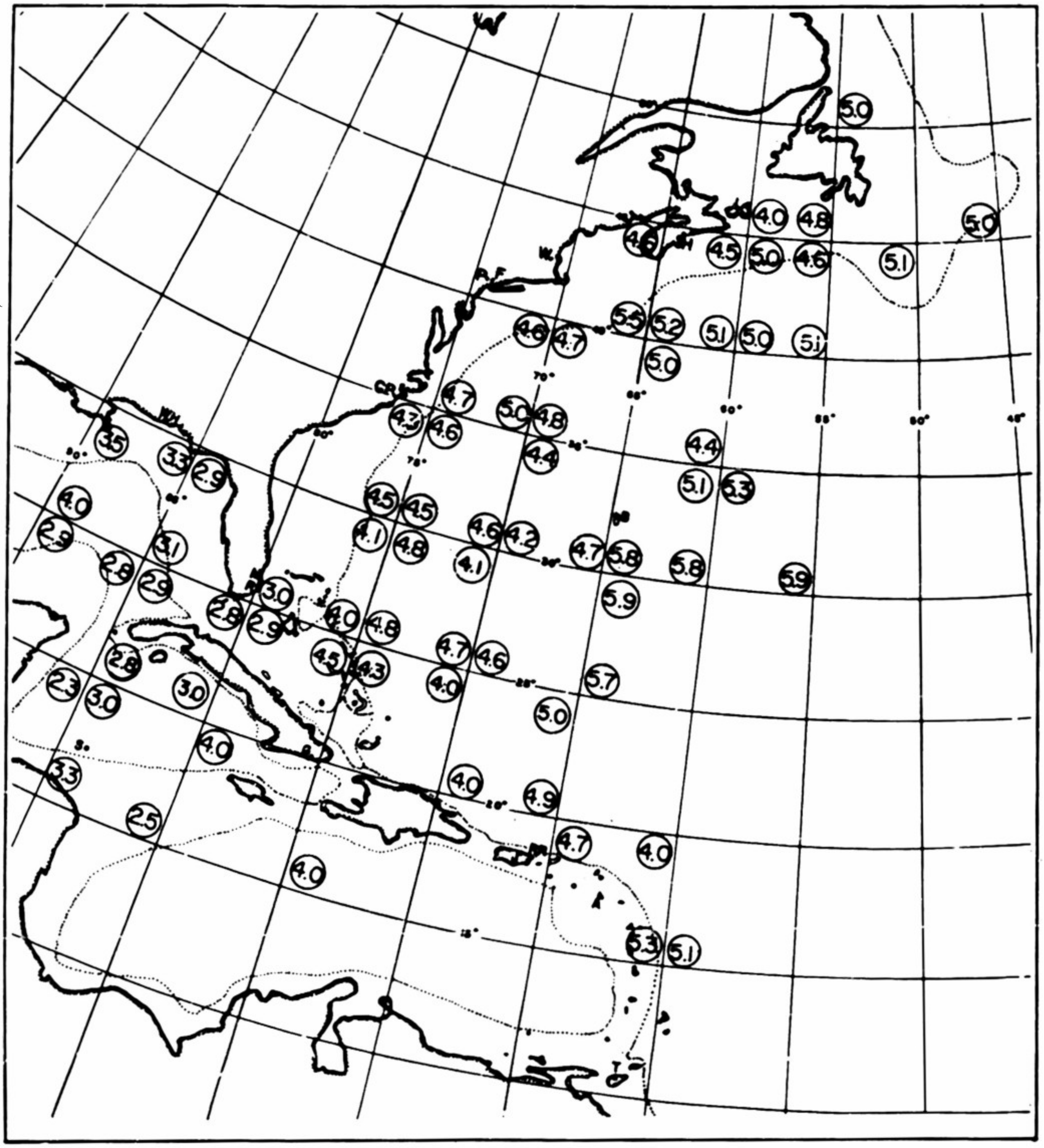
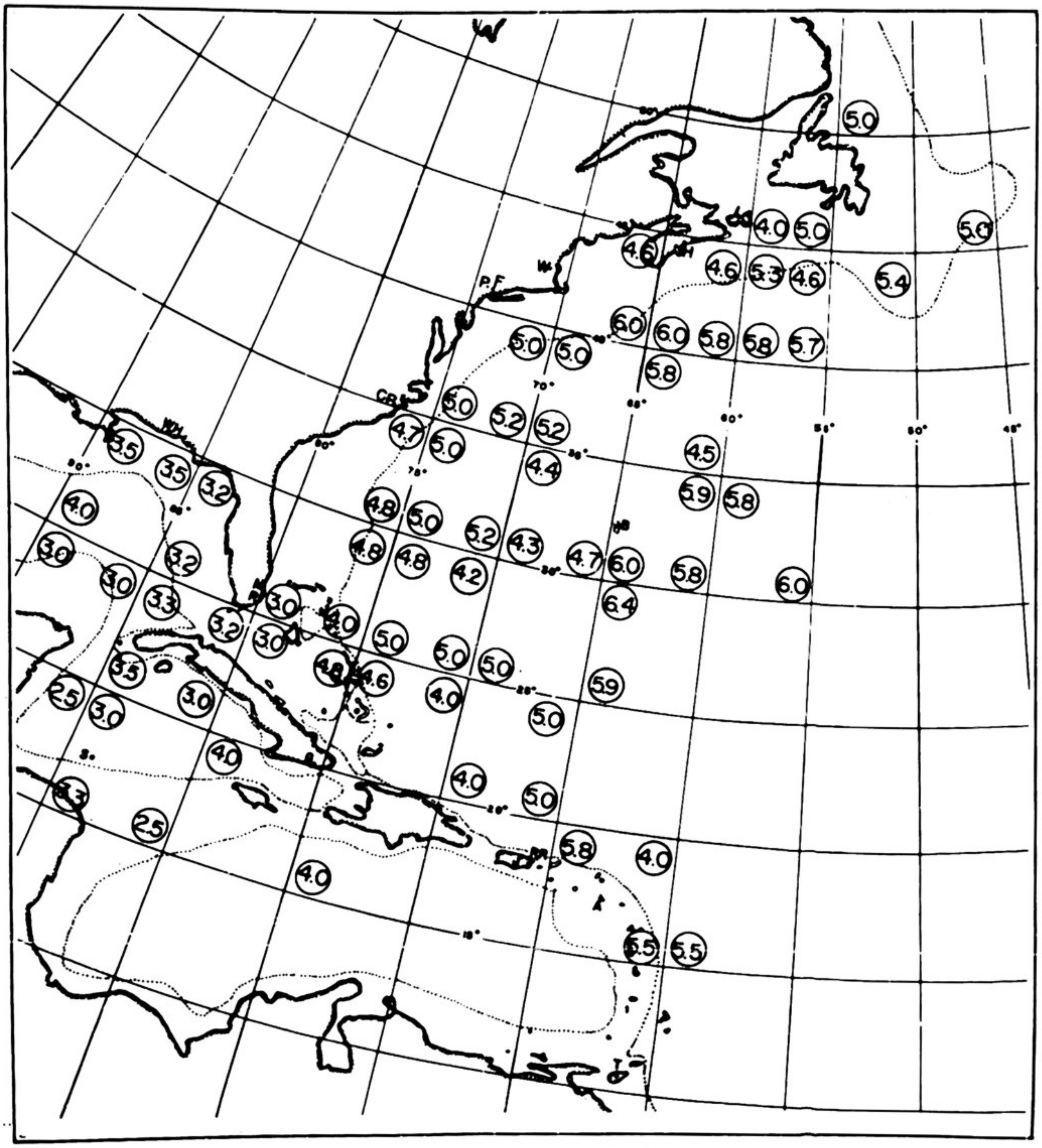


Figure 2



5.0
4.0
5.0
5.0
4.6
4.6
5.3
4.6
5.4
P.F.
6.0
6.0
5.8
5.8
5.7
5.0
5.0
5.8
C.B.
5.0
5.2
5.2
4.7
5.0
70°
65°
60°
55°
50°
45°
3.5
4.5
3.5
3.2
4.4
75°
35°
5.9
5.8
4.0
4.8
5.0
5.2
4.3
3.0
3.2
4.8
4.8
4.7
6.0
5.8
30°
3.0
4.2
6.0
3.3
3.0
6.4
4.0
3.2
3.0
5.0
5.0
5.0
3.5
4.8
4.6
2.5
3.0
3.0
4.0
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25°
5.0
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15°
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5.5

Figure 3

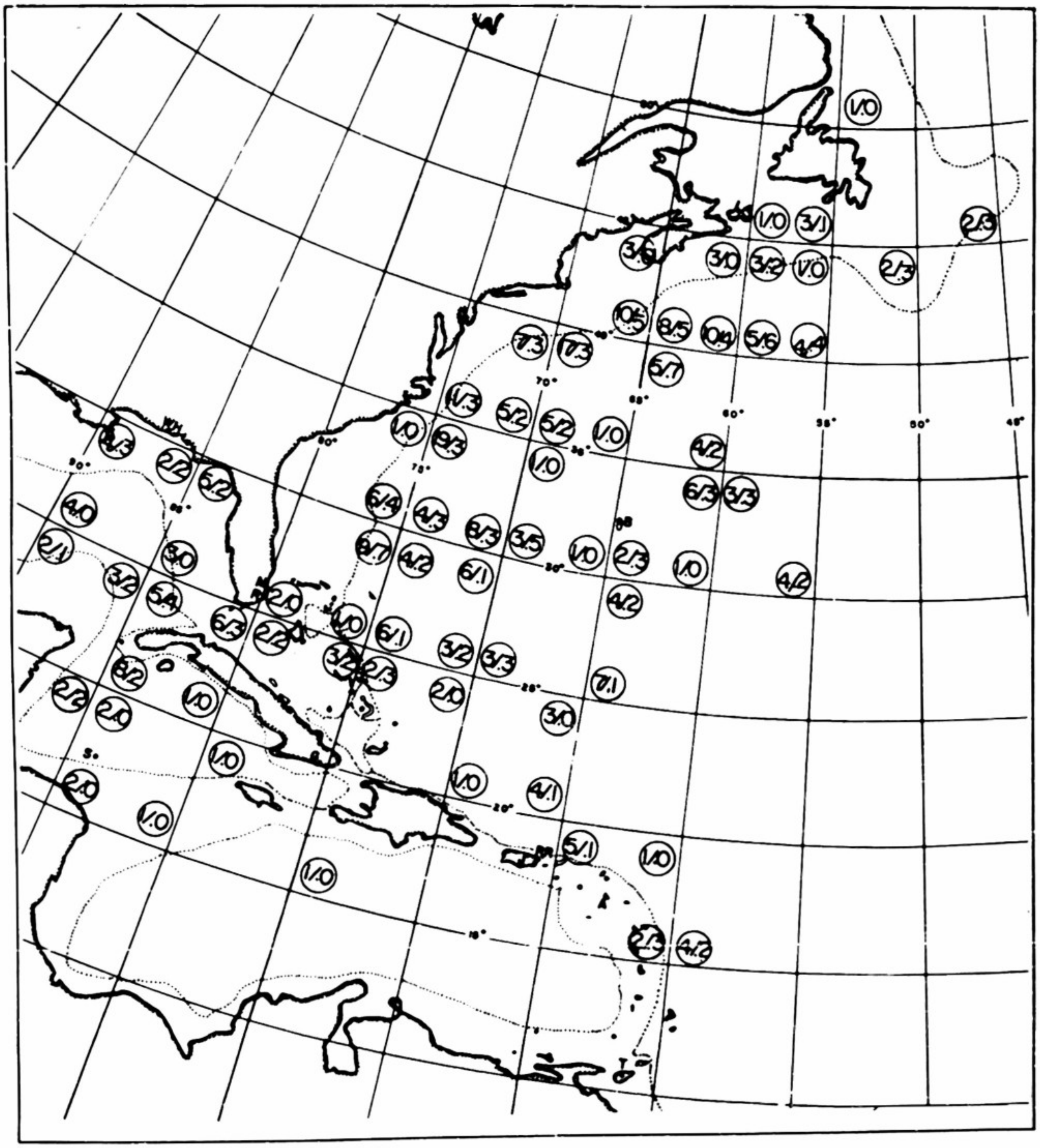

Figure 4