OCEANOGRAPHY of the SOUTH PACIFIC 1972

NEW ZEALAND NATIONAL COMMISSION FOR UNESCO

OCEANOGRAPHY
OF THE SOUTH PACIFIC 1972

being

Papers presented at an International Symposium
held in Wellington, New Zealand,
9 to 15 February 1972

Compiled by Ronald Fraser

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The contributed papers were edited by a committee consisting of J. W. Brodie (Chairman), D. A. Burns, E. W. Dawson, T. G. L. Shirtcliffe, and B. R. Stanton. Publishing matters, in particular illustrations, were handled by W. S. Edginton.

The volume was compiled for publication by Ronald Fraser.

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FOREWORD

The New Zealand National Commission for UNESCO takes pleasure in publishing the papers which were presented at the International Symposium on the Oceanography of the South Pacific held in Wellington, New Zealand, in February 1972. The chairman of the Organising Committee has acknowledged in his introduction the contribution made by other organisations and individuals both to the symposium and this publication. I wish to endorse this acknowledgment: the National Commission has been ably and generously supported. I wish to thank Mr Brodie in particular for his work as chairman of both the Organising Committee and the Editorial Committee.

Because of this country's geographical position, the New Zealand National Commission for UNESCO is particularly concerned with the South Pacific region. It has therefore taken the initiative in the development within the region of a number of projects coming within UNESCO's fields of activity. This has been the first occasion on which the National Commission has organised an international scientific meeting and it has been greatly helped by the co-operation of the Royal Society of New Zealand with its considerable experience in similar undertakings.

The National Commission was heartened by the response it received to this project. It believes that the papers published in this volume will be of considerable interest to those engaged in the marine sciences and hopes very much that this publication will help to focus attention upon the problems of the South Pacific Ocean. I have conveyed the recommendations adopted by the symposium to UNESCO.

A. N. V. Dobbs, Chairman,
New Zealand National Commission for UNESCO.

INTRODUCTION

UNESCO has always assigned an important place in its scientific programme to the marine sciences. Although much effort both national and international has been devoted to the scientific exploration of the major oceans, comparatively little attention has been given to the South Pacific. In recent years, however, there has been developing in many countries an increasing interest in the oceanography of this area.

It is for this reason that the New Zealand National Commission for UNESCO with the co-operation of the Royal Society of New Zealand and the financial support of the New Zealand Government, UNESCO and SCOR, organised in February 1972 in Wellington an International Symposium on the Oceanography of the South Pacific.

The aim of the symposium was to provide an opportunity for those working in the marine sciences to report on their recent and current research in the South Pacific region. The number and scope of the papers offered indicated that there are many scientists who are currently working on the problems of this region and their solution.

More than 150 scientists from Australia, Canada, Chile, Fiji, France, Indonesia, Japan, New Caledonia, New Hebrides, New Zealand, Papua and New Guinea, Peru, United Kingdom, United States, and U.S.S.R. took part in the symposium. The Director-General of UNESCO was represented by Dr O. I. Mamayev, Assistant Secretary of the International Oceanographic Commission and a member of UNESCO's Office of Oceanography. Other international organisations represented were: WMO, FAO, SCOR, IUGG, IUGS, IUBS, IAPSO, ANZAAS, the Pacific Science Association and the South Pacific Commission.

A total of 83 papers were presented in the 3 sections of Physical Oceanography (Chairman, Dr A. L. Gordon), Marine Geosciences (Chairman, Professor W. W. Hay), and Marine Biology (Chairman, Dr D. R. Stoddart).

At the final plenary session the following recommendations were considered and adopted.

Physical Oceanography

It is recommended that:

1. Research at present being conducted be more closely co-ordinated, especially in the western regions. The ties between scientists made at this meeting are extremely important, and further co-operative work should be encouraged.
2. Studies of upwelling in the eastern regions of the South Pacific be continued, towards a better understanding of the basic dynamics, both physical and biological, of this area, in particular the phenomenon known as El Niño. These studies would extend the work done to date to meet the needs of the fishing industry.
3. The interaction of the "warm" South Pacific with the "Antarctic" South Pacific, at present poorly understood, be more intensively studied.
4. In view of the interest in the central South Pacific and of its unique situation, but of the limited oceanographic and meteorological data available, SCOR be requested to investigate this problem and advise the IOC of its findings.

Marine Geosciences

It is recommended that:

1. A request be made to the organisers of the Deep Sea Drilling Project to encourage a greater degree of discussion and participation by scientists of all nations interested in the South Pacific in the future plans of the project.
2. The suggestion be made to the organisers of the Deep Sea Drilling Project that the strongest efforts be made to obtain cored sequences to basement in the southern South Pacific region and particularly in the Antarctic where the sedimentary history is expected to be most complete.
3. Attention be given to comprehensive geophysical investigations of features important to the understanding of the evolution of the South-west Pacific, particularly the Macquarie Ridge triple junction, Campbell Plateau, Bismarck Sea, and Solomon Sea.

Marine Biology

It is recommended that:

1. The suggestions put forward in 1968 by Professor G. A. Knox be reaffirmed, and that it be noted that work on these is continuing on a national and institutional level (see Knox, G. A. 1970 *in* Scientific Exploration of the South Pacific. (ed.) Warren S. Wooster: National Academy of Sciences, Washington, D.C.).

2. The study of coral reefs and associated communities in the South Pacific be added to the list of suggested topics drawn up in 1968, in view of the growing interest of biologists especially in coral reef studies.

3. In implementation of recommendation (2):

(a) A position paper on South Pacific reef studies be drawn up for circulation to interested workers and national groups by an ad hoc committee consisting of Mr E. W. Dawson, New Zealand Oceanographic Institute (Chairman); Professor J. E. Morton, University of Auckland; Mr P. G. Beveridge, University of the South Pacific; Dr D. R. Stoddart, University of Cambridge; Dr D. M. Devaney, Bernice P. Bishop Museum; Professor F. A. Doumenge, South Pacific Commission; and Mr J. P. Chevalier, Muséum National d'Histoire Naturelle, Paris;

(b) Consideration be given to a small international meeting of South Pacific coral reef workers in 1975 at which specialists would be asked to contribute comprehensive reviews of the present state of knowledge in their fields of study, of reef communities and biogeography;

(c) Efforts be made to encourage international exchange of information on South Pacific reef studies;

(d) Consideration be given to practical problems of financing reef expeditions and of increasing the number of taxonomists working on reef biota.

General

It is recommended that:

1. UNESCO give consideration to the establishment of a Marine Sciences Centre for the South-west Pacific that might act as a focus for work in a range of disciplines. It is suggested that UNESCO might convene a meeting early in 1973 to discuss the feasibility and possible functions of such a centre.

2. UNESCO be asked to provide a framework within which future regional symposia on the oceanography of the South Pacific can be arranged at regular intervals.

It was requested that these recommendations be conveyed to UNESCO for consideration and appropriate action. In doing so, it was recognised that UNESCO itself might not be in a position to implement all the proposals, but participants asked that UNESCO convey them to appropriate organisations, including SCOR, the IOC, and other organisations of the United Nations family.

Acknowledgments are due to UNESCO, the New Zealand Government, and SCOR for substantial financial support; to the Royal Society of New Zealand for its co-operation; also to Victoria University of Wellington and the New Zealand Department of Scientific and Industrial Research for generous provision of facilities and services. Thanks are due also to the members of the Organising Committee and of the Editorial Committee.

J. W. Brodie, Chairman,
Organising Committee.

CONTENTS

PHYSICAL OCEANOGRAPHY

Some Measurements of Oceanic Near Surface Temperature Microstructure

M. J. BOWMAN[1], F. H. SAGAR[2], AND D. E. ASH[2]

Abstract

Measurements have been made of the temperature microstructure in the top few metres of coastal waters off the east coast of the North Island of New Zealand, under a variety of oceanographic and meteorological conditions. The recordings were made with a towed vertically floating buoy in front of the research ship. Measurements were taken at the six depths of 0.66, 0.81, 1.12, 1.73, 2.59, and 5.39 m with thermistor thermometers having the characteristics of 5×10^{-4}°c resolution and 20 mS time constant.

Results show that the records exhibit marked small scale fluctuations, often quite non-stationary and anisotropic.

One-dimensional horizontal spectral densities have been calculated by analogue techniques in order to compare the results with the theories of a passive, conservative contaminant in isotropic turbulent flow.

INTRODUCTION

The temperature structures of the surface layers of the ocean are continually convected by random turbulent water motions, and acquire, if the buoyancy forces are small, statistical properties closely related to those of the turbulence itself.

Since these random velocity and temperature fields scatter acoustic and electromagnetic waves propagated in the medium, and affect the heat transport mechanisms across the air-sea interface, a study of these phenomena is of interest both to the ocean engineer and the geophysicist.

The purpose of this paper is to present preliminary results obtained from measurements of near surface oceanic temperature microstructure in the isothermal layer under a variety of oceanographic conditions, and to compare these results with existing theories, in particular those pertaining to the form of the temperature spectrum in the inertial convective sub-range at large wave numbers.

EXPERIMENTAL APPARATUS AND PROCEDURE

In order to reduce spurious fluctuations introduced by periodic movements of a sea-surface based experimental platform, a freely floating vertical buoy 7.3 m in length carrying six spaced thermistor bead sensors was constructed with aerofoil cross section out of moulded aluminium sheet (see fig. 1). The lower section was flooded and weighted to maintain stability with an additional top float provided to dampen vertical oscillations and add viscous resistance, thus raising the centre of pressure of the complete assembly, allowing the lower towing ropes to be mounted as close to the surface as possible. The lower pair of ropes were secured to the ends of a cross spar, so arranged that the movement of the rope through the water would not disturb the microstructure directly in front of the sensors. These ropes plus a third from the top of the buoy were attached to the end of a long towing boom extending 8.6 m out from the bow of the ship. The thermistor thermometers have been described earlier (Bowman and Sagar, 1971) and had characteristics of 5×10^{-4} °c resolution and 20 mS time constant.

[1]Marine Sciences Center, State University of New York, Stony Brook, New York 11790. U.S.A.
[2]Department of Physics, University of Auckland, Auckland 1, New Zealand.

Oceanography of the South Pacific 1972, comp. R. Fraser. New Zealand National Commission for UNESCO, Wellington: 1973.

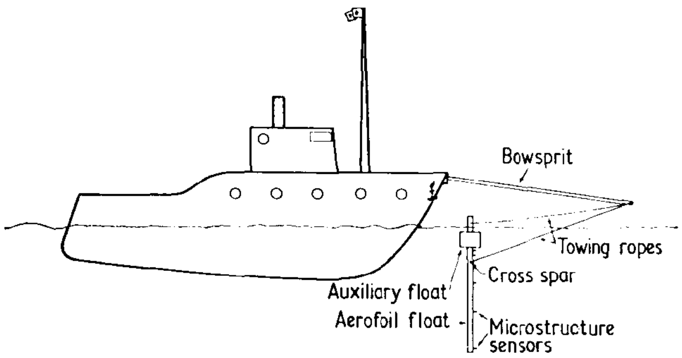

FIG. 1. Sketch of the towing arrangement of the sensing buoy and its attachment to the bowsprit (ship not to scale). (After Bowman and Sagar 1971.)

Table 1 lists the depths and spacings of the mounted sensors when the buoy was in correct towing position.

TABLE 1 Depths and Spacings of the Temperature Probes

Channel	1	2	3	4	5	6
Symbol	×	●	○	□	+	△
Depth (m)	0.66	0.81	1.12	1.73	2.95	5.39
Spacing (m)	0.15	0.31	0.61	1.22	2.44	

A series of experiments was conducted around the east coast of the North Island of New Zealand (~ 36° 20′ S lat., 175° 20′ E long.) under a variety of climatic and oceanographic conditions ranging from sheltered harbour to an open sea environment (small swell). Three runs have been selected as typical of the series, and the relevant details are described in table 2. The minimum ship speed at which steerage could be maintained was around 0.5–1.0 m sec^{-1}, depending somewhat on the local wind and tidal currents.

TABLE 2 Particulars of Runs 1, 2, and 3

Run 1	Run 2	Run 3
18 December 1966 1600 hr	13 April 1967 1135 hr	14 April 1967 0048 hr
Wind velocity = 4.3 m sec^{-1}	Wind velocity = 8.6 m sec^{-1}	Wind velocity = 5.1 m sec^{-1}
South of Wanga-paraoa (north of Auckland ~ 30 km)	Abercrombie harbour (Great Barrier Island)	
Midsummer	Late autumn	Late autumn
Sea slight, no swell	Chop, small white horses, no swell	Flat calm
9/10 cloud	10/10 cloud	10/10 cloud
Bottom depth 14.6 m	Bottom depth 57 m	Bottom depth 42 m
Hours of insolation = 11	Hours of insolation = 5	Hours of insolation = zero

Only occasional problems relating to sensor fouling with plankton were encountered as contrasted to the precautions Grant *et. al* (1968) found necessary to keep their probes clean of marine organisms.

ANALYSIS OF RESULTS

The data were recorded and replayed on IRIG compatible tape recorders (3.75 in. sec^{-1}; Intermediate band FM, carrier frequency 6.75 KHz).

Suitable records, each representing distances of the order of 100 to 300 m, were selected for study on the basis of lack of overloads, gain changes, bridge rebalancing and constant ship speed. The data were sampled for the digital portion of the analysis at a rate equivalent to ~ 6 to 8 cm^{-1} as dictated by the sampling theorem and the thermistor time constants.

A typical short section of microstructure is displayed in fig. 2. The most obvious characteristic is its random nature with patches of all sizes occurring. The microstructure is usually non-stationary with both time varying mean value and mean square value. This lack of stationarity has been a fundamental problem in analysing the records. The data are seen to be non-symmetrical about the mean. Relatively intense, warm spikes frequent the record, and represent localised heating effects before convection breaks down the stronger patches into a more thoroughly mixed structure.

The smallest scale structures are often seen to be correlated in the top four channels, sometimes deeper. The larger trends usually penetrate through all the six channels, although in channel 6 there appears to be a phase shift in the long wavelength periodicity near the right-hand end of the diagram.

RMS FLUCTUATIONS

Fig. 3 displays averaged RMS values of temperature fluctuation for a group of records taken inside Abercrombie Harbour versus hours of insolation. Although the data were obtained at irregular time intervals, the fluctuations increase until late in the day and then decline again after sunset. All the points plotted with the exception of those positioned about 11 hours after sunrise were taken in the late autumn within a period of 35 hours. The other were obtained in midsummer (see table 2) and have been included for comparison. During the night and early morning greater fluctuations are observed nearer the surface than deeper down. During the day, the opposite is true and channel 6 consistently shows the greatest fluctuations.

Solar radiation is absorbed at all depths in the photo zone, dropping off exponentially in the absence of spurious concentrations of organic material. However, cooling by evaporation and conduction occurs only at the air-sea interface. Hence during periods of insolation the instability set up and the resultant mixing maintains the isothermal layer.

All night cooling of the sea surface creates a shallow region of turbulence continually stirred by wave action and presumably in calm conditions molecular dissipation erases any strong microstructures at greater depths.

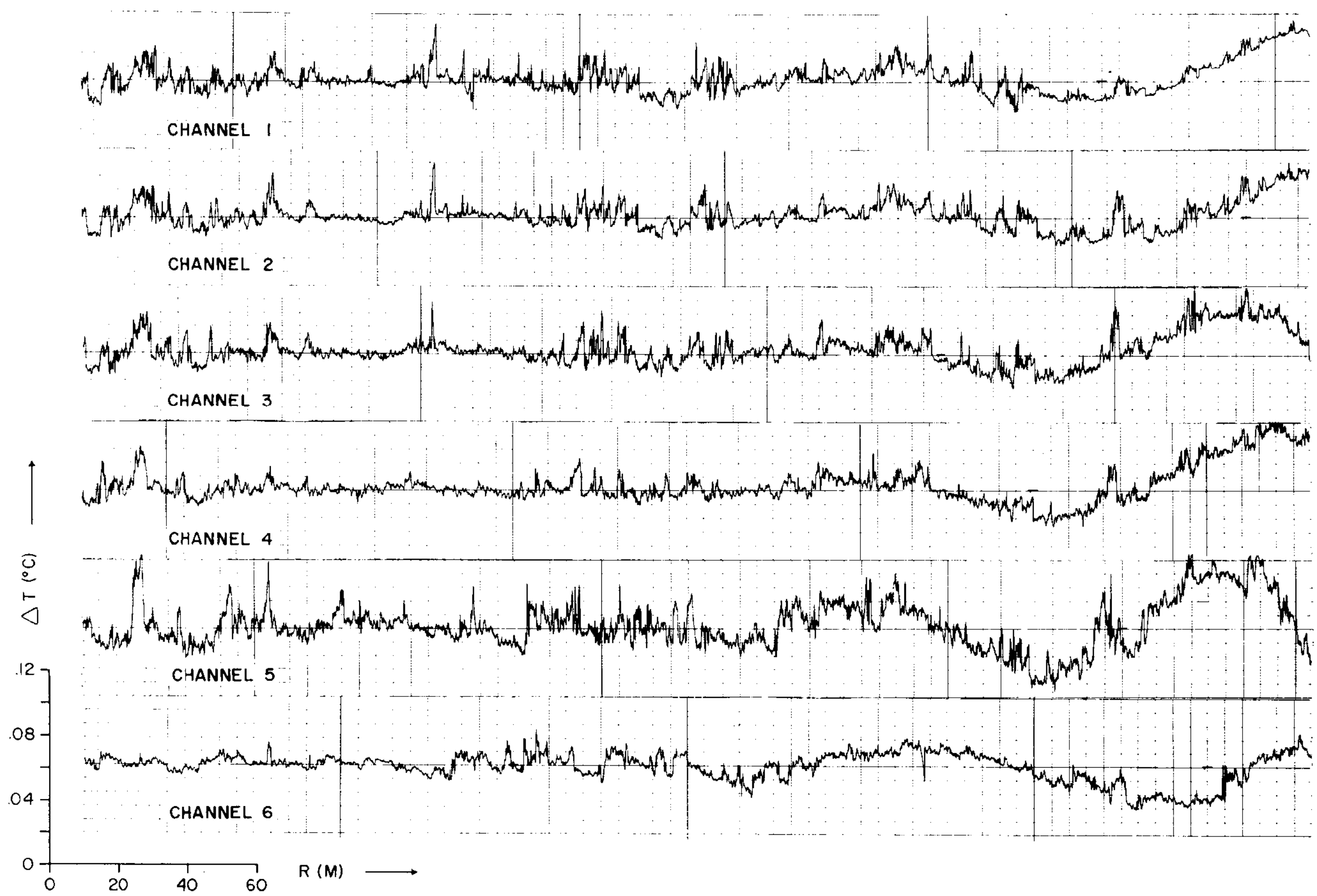

FIG. 2. Section of microstructure record displaying several features of interest as discussed in the text.

A graph of RMS fluctuation versus wind velocity produced no significant correlation for the wind speeds encountered (0 to 15 m sec^{-1}). Unfortunately, in higher winds it becomes increasingly difficult to maintain a stable experimental platform and accordingly it was not possible to produce any results for rough sea conditions.

The Horizontal and Vertical Structure Functions

Berends (1971) has completed extensive data analysis of much of the present data and found most structure functions taken along a horizontal plane possessed gradients significantly above the Obukhov (1949)—Corrsin (1951) "2/3 law". He attributed this to the effects of spatial-temporal sampling and step-type discontinuities, both of which were shown to increase the slopes. The vertical structure functions showed considerable spread and this is doubtless due to the anisotropic nature of the microstructure which is even more obvious in a vertical plane than in the horizontal.

The structure function was introduced by the Russian school as an alternative to the autocorrelation function as a means of eliminating the effect of slow drifts in the data. However, from our observations of the non-stationary nature of the microstructure we conclude that the structure function (and autocorrelation) approach to characterising the medium is unsatisfactory. The most fruitful approach has been through treating the power spectrum as time (distance) varying, and studying the changes in relative magnitude between different wave number bands with time (distance).

One Dimensional Spectra

One dimensional spectra taken in a horizontal direction have been calculated by analogue means. Experimentation with different methods showed that the use of octave filters provided a suitable compromise between resolution bias, and variance errors, the ability to follow time (distance) trends, and labour involved. If too narrow bandwidth filters are used the inevitable fluctuations between adjacent high wave numbers will swamp the average power in that region of the spectrum. Also, harmonic peaks are often cascaded across the spectrum due to step-like structures in the data and add to the variability of the estimates, making comparison with theory difficult.

The rise time τ for an ideal rectangular bandpass filter with a bandwidth of B H_z is given by $\tau \sim B^{-1}$. Hence, if the estimate of the power in the band covered by the filter is properly to describe the time trends in the non-stationary data, the narrow band-pass filter must have a rise time τ which is very short compared to such time trends (Bendat and Piersol, 1966).

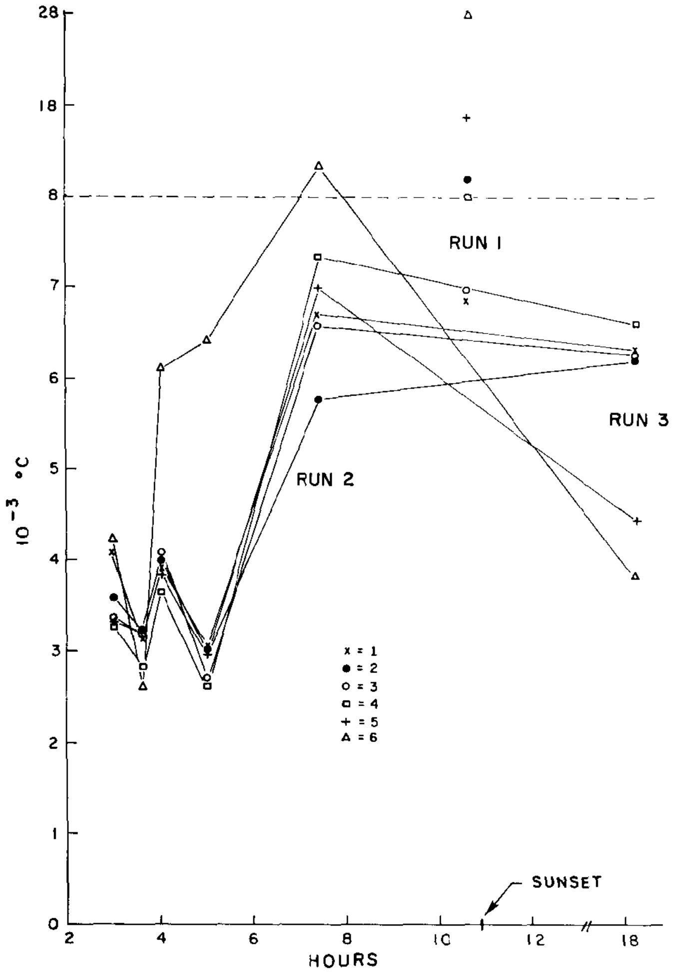

FIG. 3. Variation of RMS fluctuations with depth and hours of insolation within a 35 hr period.

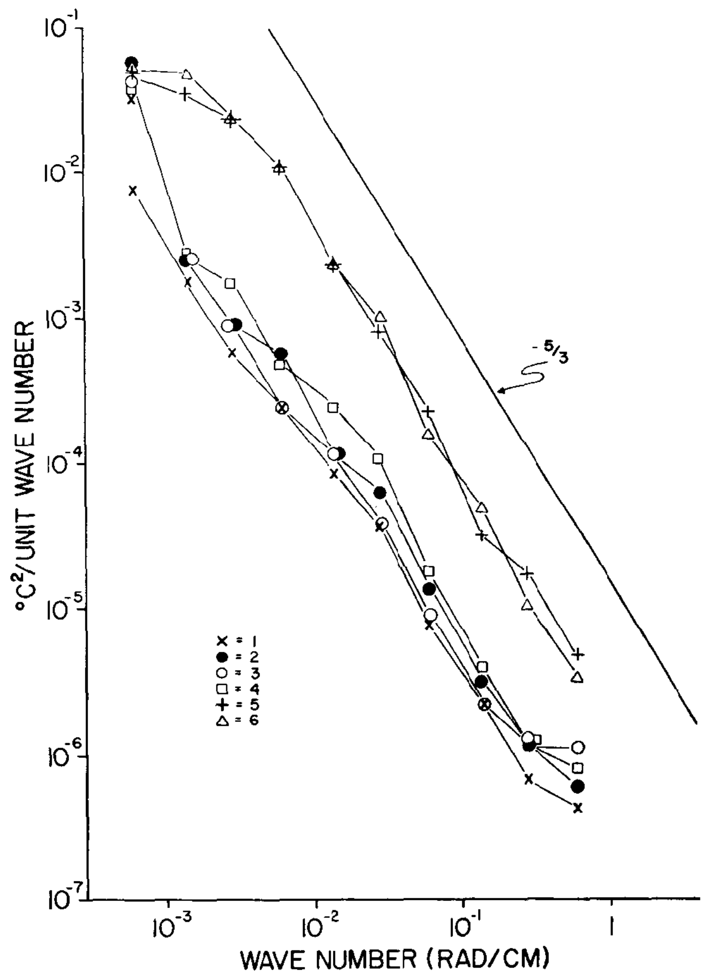

FIG. 4. Horizontal spectral densities for Run 1.

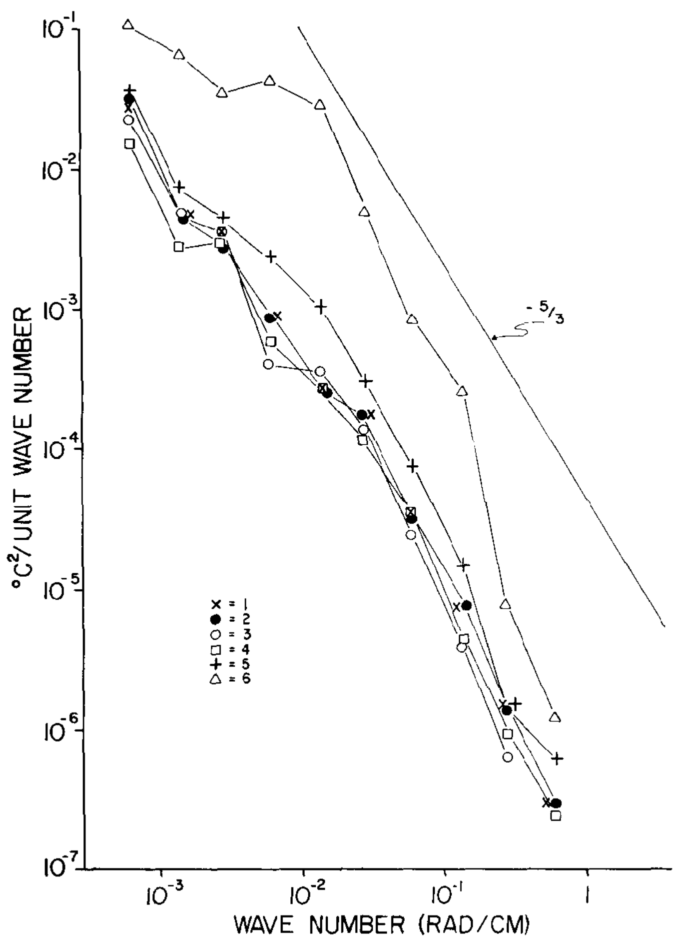

FIG 5. Horizontal spectral densities for Run 2.

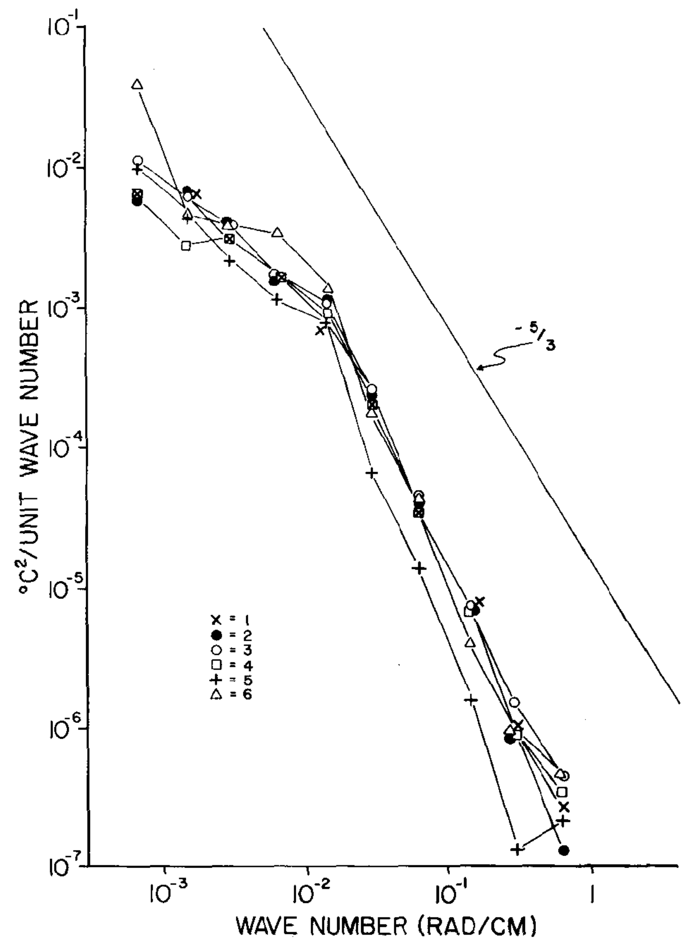

FIG. 6. Horizontal spectral densities for Run 3.