THE 'TURBULOMETER'—AN APPARATUS FOR MEASURING RELATIVE EXPOSURE TO WAVE ACTION ON SHORES

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INTRODUCTION

Wave action is a very important factor controlling the distribution of shore life and its measurement is a difficult problem confronting biologists wishing to study its effect. The instrument described here was developed in an attempt to improve on subjective descriptions of shores as 'exposed', 'fairly exposed', 'sheltered', etc.

It is not claimed that the instrument can give a measurement of the critical force of breaking waves which may limit the distribution of marine organisms; it can only give an averaged reading of the amount of water flowing over a surface during the period of measurement but this may be helpful in getting a more objective comparison of the degree of exposure between different locations on the shore.

DESCRIPTION

The instrument is basically a Savonius-type currentmeter. The rotor consists of two 1″-high S-shaped lengths of plastic set at right angles to one another, one being above the other. The S-shaped lengths are sandwiched between three plastic discs 6″ in diameter to which they are cemented so that the rotor has four cups. This can be understood by looking at Figures 1 and 2. The rotor revolves about an axle through the centre of the discs and the arrangement of the cups is such that whatever the direction of flow in the plane of the discs past the rotor, the rotor rotates in the same anti-clockwise direction as can be seen from the plan view (Fig. 2). The rotor is mounted within a supporting frame.

The recording mechanism consists of a magnet attached near the circumference of the upper disc of the rotor operating a dry reed switch (obtainable from most electronics suppliers) located on the supporting frame opposite the magnet. The reed switch is triggered once every revolution as the magnet passes it and it is connected in circuit with a battery, a button switch and a counter which records the number of revolutions through which the rotor has been turned. The magnet is counter-balanced by a weight on the opposite side of the disc.

The instrument is held in position manually at the end of an aluminium pipe, eight feet long; the battery and counter are housed in a waterproof plastic food container (with a transparent lid) which can be held out of harms way at some distance from the rotor to which it is connected by insulated wires.

The rotor and the protecting discs of the supporting frame are made of ¼″ poly-vinyl chloride sheeting held together with an adhesive cement which was also used to attach the magnet, weight and reed switch and served to insulate the reed switch terminals. The axle and frame supporting rods are of ¼″ diameter brass rod.

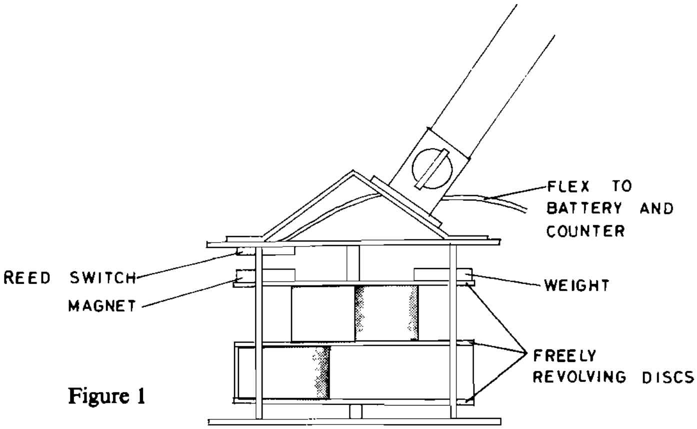

Figure 1

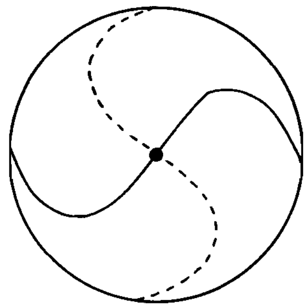

Figure 2

Figure 1. Diagram of the turbulometer in side view showing the main components of the rotor, its central axle and the supporting frame. The rotor is operated by currents from any direction in the plane perpendicular to the page.

Figure 2. Diagrammatic plan view of the rotor with its central axle perpendicular to the page. The solid S-shaped line represents the upper two cups and the broken line the two cups at a lower level.

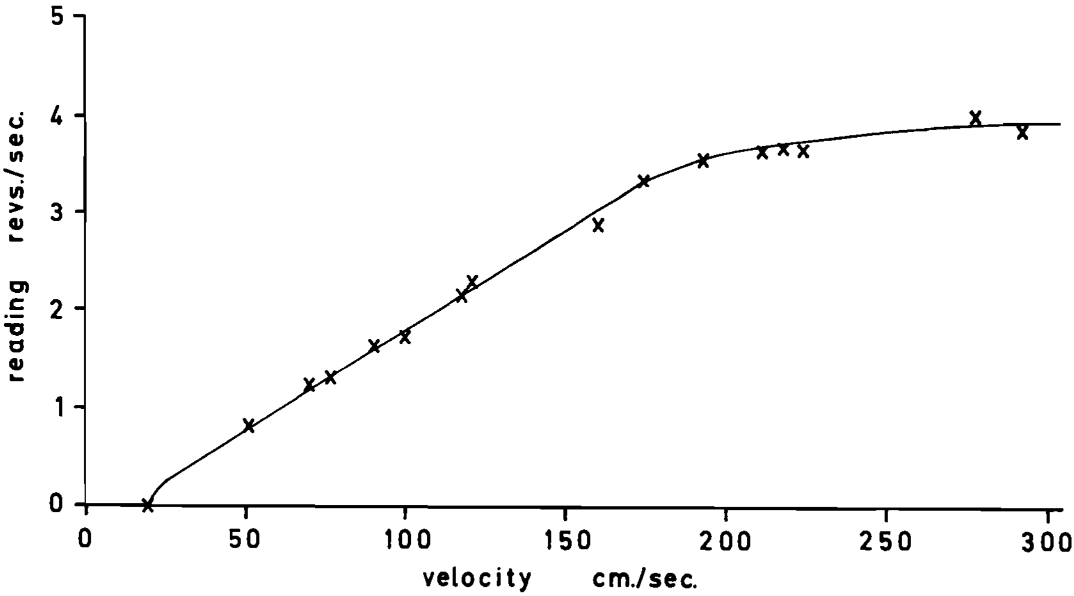

Figure 3. Calibration curve of the turbulometer obtained by measuring the time taken to tow the instrument through water over a fixed distance at different speeds and noting the number of revolutions recorded in that time.

OPERATION

The turbulometer described has been tested on rocky shores (see Field & McFarlane 1968 for results). Merely recording the total flow of water over several minutes did not give a satisfactory measure of the extent of exposure of the site. This is illustrated by observations that at exposed sites, although the rotor rotated very rapidly while a wave was flowing over it and the person holding the instrument was in danger of being swept off the rocks, it did not rotate at all while the instrument was left high and dry in the troughs of the waves which was for well over half the time of observation. The total water flow recorded over five minutes at such exposed sites often did not differ much from the obviously more sheltered areas where the instrument was constantly submerged and subjected to gentle water movements.

The measurement required is therefore not the total water-flow over the site but the rate of flow when the waves are at their strongest. This was done as follows: as a wave surges against the rotor, the counter and a stop-watch are simultaneously switched on; after three seconds both are switched off and the counter reading noted. Ideally the duration of the measurement should be very short but periods shorter than three seconds gave such low readings at sheltered areas that the results would not be reliable. In many instances the 3-second measurement included some of the backwash in addition to the oncoming wave. The readings obtained are thus measurements of the amount of water flowing over the site at the time when the waves are likely to have their greatest biological effect.

As many waves as possible are recorded in this way over a fixed time period. Five minutes was found to be a suitable length of time. According to Shipley (1964) the swells in the Cape area have periods between 10 and 14 seconds so that over a five minute time interval at least 20 waves should break against the shore. This is supported by the wave recording figured in Darbyshire and Darbyshire (1964) which showed 24 wave crests in the five minute record. The ten highest readings obtained during the five-minute period are then selected as representing the greatest degree of exposure at the site at the time of measurement. The mean of the ten readings can be used as a comparative index of exposure or the readings themselves can be used in chi-square or other statistical tests of significance as has been done by Field and McFarlane (1968). The process is repeated at the other sites being compared within as short a time as possible so that there is a minimum change in wave action caused by varying tidal and weather conditions.

CALIBRATION

Calibration is not necessary if only one instrument is used because only comparative values have any meaning when exposure conditions vary so much with changing weather and tide at the same site. However the turbulometer has been calibrated to determine its sensitivity; the calibration curve is shown in Figure 3. From this it can be seen that its sensitivity starts to fall off at water velocities greater than 170 cm./sec. owing to the effects of turbulence and friction. The minimum velocity which will rotate the rotor is 20 cm./sec.

DISCUSSION

It should be noted that this method can only give comparisons of exposure to wave action at one particular time and this might not be when conditions are typical or limiting. A better method would be to use a number of calibrated instruments, one firmly anchored in a position at each site and left to record the maximum rates of flow over a tidal cycle. It is difficult to anchor an instrument firmly enough to withstand strong wave action and for many purposes the easier method described above and tested will be adequate.

ACKNOWLEDGEMENTS

I thank the following members of the Zoology Department, University of Cape Town: Professor J. H. Day for his encouragement and help, Mr. A. Savage for constructing the instrument so ably, Miss G. McFarlane for drawing Figure 1, and the staff members and students who froze patiently while helping to test the instrument. I also thank Mr. G. R. Atkins of the Marine Effluent Research Unit for his advice and for the idea of using a Savonius-type rotor for this purpose.

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