FISHERIES SIGNIFICANCE OF THE ACOUSTIC ATTENUATION DUE TO FISH

It is the purpose of this note to call attention to a major new acoustic effect due to fish, and to discuss its significance for fisheries. It is found that the attenuation of low-frequency sound in shallow coastal water may increase greatly at night. The observations are described by WESTON *et al.* (1969) and CHING and WESTON (1971), and the latter in particular should be consulted for many further details. Sample plots of sound level received over a 23 km path from a pulsed CW source are shown in Figure 1 and show the low level at night.

The effect is due basically to the high acoustic target strength of pelagic fish having swimbladders, provided the frequency is in the neighbourhood of the resonance frequency. The acoustic cross-section can then be greater than the geometric cross-section. At night the fish are dispersed and their scattering and absorption can produce a high attenuation. The acoustic propagation may be likened to the transmission of light through a mist. During the day the fish are congregated into shoals, and in these conditions the fish in the back rows of a shoal are shielded from the sound and can play little part in the attenuation. Even for the fish in the front row there is an acoustic jostling or mutual interference effect which limits their scattering. Broadly speaking the fish when shoaled cannot scatter and absorb more sound energy than is directly incident on the shoal, and the acoustic cross-section of a shoal cannot exceed its geometric cross-section. In shoal conditions the overall attenuation rate is considerably reduced, and in our light analogy the mist droplets have coalesced into raindrops and one can see much further.

The major importance of this effect lies in the field of shallow-water acoustics in general and sonar in particular. But of course sonar is important in fisheries; for research, for commercial fisheries, and as used by porpoise and other cetaceans.

The timing and shape of the attenuation patterns can be useful in behavioural studies on fish, since they depend on the aggregation and depth changes. But it is also possible to obtain quantitative information. Multiple-frequency studies at the time of Figure 1(a) suggested that the peak effect was at 700 Hz. With certain assumptions about the depth and physiology of the fish this translates into a fish length of 24 cm, which is almost certainly pilchard (*Pilchardus sardinus*) since the observations were in the Bristol Channel. From the measured attenuation in Figure 1(a) and the measured frequency spread the mean numbers of fish on this occasion were estimated as at least 0·11 per m^2 of sea surface, with mass about 11 g/m^2. Similarly the Figure 1(b) data correspond to fish of length 5 cm, numbers 1·0 per m^2, and mass 1 g/m^2. Thus we have a crude method of estimating fish populations, which can assess the total numbers along the whole acoustic path length with one measurement.

For completeness some supporting sonar observations should be mentioned (WESTON and REVIE, 1971), of great importance in their own right. There is also a second acoustic propagation effect which may be due to fish, though any application to fisheries is doubtful. This is the signal level fluctuation with a

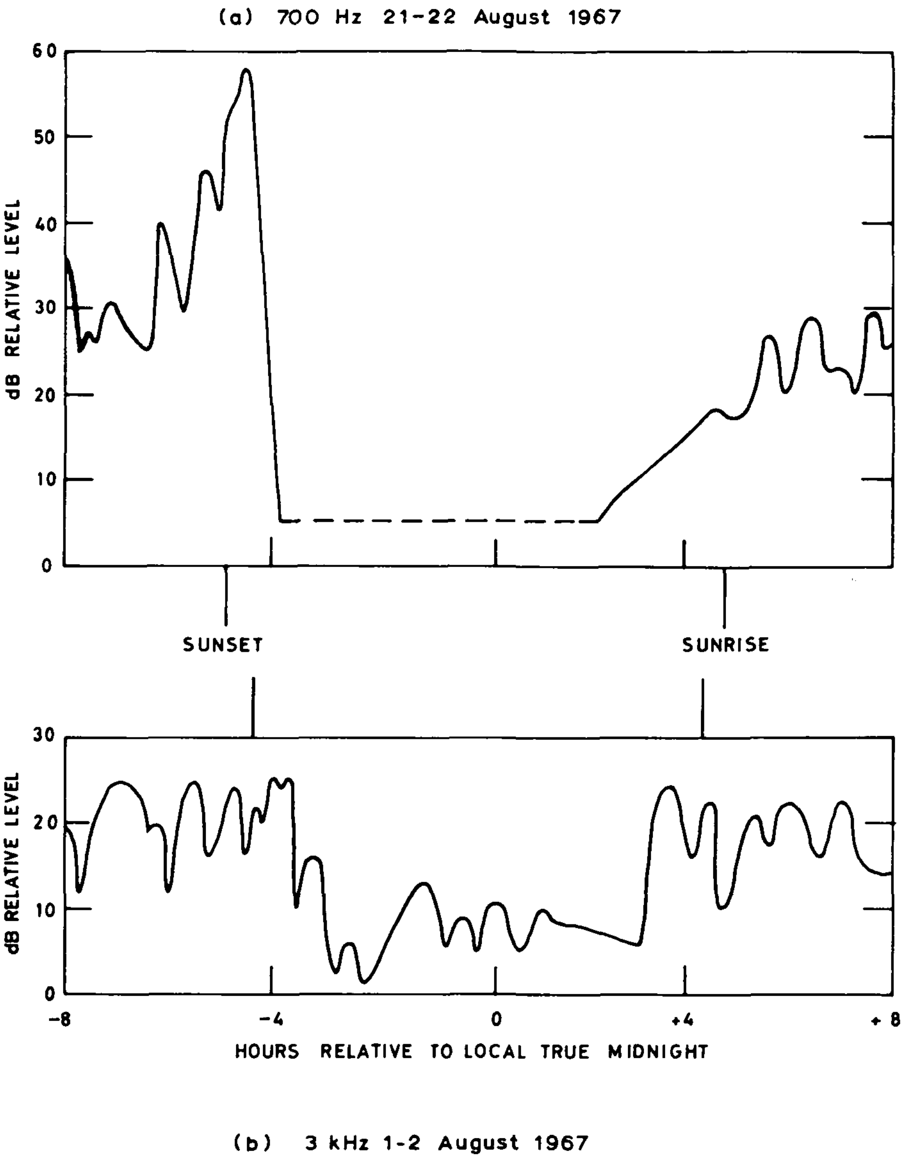

Figure 1. Examples of fish attenuation changes illustrated by pulse envelope curves at 23 km.

period of a few minutes which occurs only in the summer daytime (see WESTON *et al.*, 1969). This effect is not well understood.

So far the many difficulties and exceptions have not been discussed, but an account of these is necessary to balance the picture. To carry out the experiments at all acoustic projectors and receivers are needed, preferably mounted on the sea-bed and covering a wide frequency range. Monitoring equipment and staff must be available for long periods at a time. If fish attenuation effects do occur they are certain to arrive well mixed up with a variety of other fluctuations, and separation is rarely easy and usually possible only after long studies of all the fluctuations. The variations in the fish attenuation can be due to changes in both aggregation and depth, and the description of the aggregation mechanism above is much simplified. Lastly it should be noted that the major diurnal changes in attenuation are due to those fish which possess swimbladders and change their state of aggregation near sunrise and sunset; there will be many other fish which do not satisfy both these conditions.

All these complications mean that a measurement programme on fish populations cannot be casually set up with any chance of success. Success may come if the work is integrated with more general acoustic studies, as in the present experiments. Another worthwhile idea is to use the attenuation approach in special applications, for areas and times where there are large numbers of fish of known type. This would also ease the problem of "calibrating" the attenuation method against other techniques of population assessment. In defence of the attenuation method and its admitted difficulties it is worth pointing out that all these other techniques have grave drawbacks too!

D. E. Weston
Admiralty Research Laboratory,
Teddington, Middlesex, England

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A TECHNIQUE FOR RECORDING THE FILTERING ACTIVITY OF MARINE INVERTEBRATES

INTRODUCTION

The problem of detecting filtering activity in invertebrate filter feeding organisms has been of interest to biologists for many years. A number of techniques have been used (Coughlan and Ansell, 1964; Heusner and Enright, 1966; Hogarth and Trueman, 1967; Morton, 1969), but they nearly all suffer from the disadvantages of either requiring apparatus to be attached to the specimen, they are not sensitive enough to detect the small currents set up, or suffer from thermal gradient problems. The technique described below is not subject to these difficulties, no attachment is required to the specimen under test and the apparatus can be made extremely sensitive and does not require strict temperature control.