and in certain German publications referred to therein. In general terms one may say that, provided the records are used with carefully designed apparatus, they are capable of forming an inexpensive standard source of either acoustical or electrical vibrations over the very wide frequency range of some eight and a half octaves.

In conclusion, it may be noted that in the ordinary commercial electrical record now made to be played upon a mechanical gramophone, the grooves represent fairly accurately the original sound over a frequency range from 60 to 6000 vibrations per second, and especially so over the range from 200 to 4000 vibrations per second. This achievement is largely due to the comprehensive acoustical researches carried out in the Bell Telephone Laboratories, New York, and details will be found in the important paper by Maxfield and Harrison, "Methods of High Quality Recording and Reproduction of Music and Speech based on Telephone Research" (*Jour. Am. Inst. El. Engineers*, **45**, pp. 243-253; 1926).

W. H. GEORGE.

Marine Biology in Ceylon.

THE Administrative Report of the Marine Biologist for 1927, Part IV. Education, Science, and Art (F.), by Dr. Joseph Pearson, November 1928, Ceylon, includes reports by the assistant marine biologist on the pearl fishery, Gulf of Mannar; window pane oyster fishery; chank fishery and trawling survey with statistics, and by the second assistant marine biologist on field and laboratory work with notes on fishes and fishery problems. The work was done under the supervision of the marine biologist, Dr. Joseph Pearson, who contributes the introduction and reports on the research vessels *Nautilus* and *Violet*, with suggestions for suitable fishery vessels and a fishery base.

The report on the pearl fishery is very interesting, showing how quickly conditions change, and that whereas in 1926 in Donnan's Muttuwarattu Paar, which was specially investigated, the oysters were much on the decrease, in the spring of 1927, owing to supplementing of the original stock by drift oysters, they were in much greater numbers, again decreasing in the autumn. A discussion relative to the age of these oysters shows that they seldom live so long as five years, and that they should be fished at three and a half years on this particular paar, and probably on others. This is a very low age estimate compared with that of previous workers.

The chank fishery is apparently peculiar in that there is no substantial diminution in the yearly yield however much it is fished. No details are known with regard to the rate of growth and habits of this animal, and more research is needed.

The important and valuable fishing banks known as the Pedro and Wadge Banks up to 1927 had no charts of any kind. The trawling survey was begun in August 1927, and a Petersen grab is on order for bottom sampling. The figures for the analysis of the trawls are not quite correct, but an average of 207 fish per hour is taken as a low estimate, only fish of first-class edible quality being included. Assuming 20 hours trawling per day, this would give a daily catch of 4140 lb., or approximately 36 cwt. A much larger average is probably possible. Two important features are (1) that the catches are made up of a restricted number of species, which are of a convenient size both for storage and for market, and are equal in edible qualities to any tropical fish now marketed, and (2) there is very little waste. *Lethurus* (sea bream) comes first in numbers, 29 per cent, and *Lutianus* (snapper) second, 23 per cent.

The trawling investigations made by the Department in the seas around Ceylon are promising, particularly on these two banks described. These are the only trawling grounds so far discovered in Indian waters which show promise of successful exploitation. A fish-trawling company was floated in 1926, and during the year under review the company laid down one trawler which was expected to arrive in Ceylon about the middle of 1928. Twenty-seven per cent of the capital of this company has been subscribed by the Sinhalese.

It is a difficult matter to devise suitable boats for the inshore fishermen. This problem is now under consideration.

Much more research is needed into the economic problems, especially on the habits and life-histories of the principal food fishes, and there is abundant room for many more workers.

Theoretical Investigations of Ocean Currents.

THE mathematical investigations of Prof. V. W. Ekman into the dynamics of ocean currents have been directed chiefly to the study of 'type problems'; in these, friction is taken into account, but simplifying assumptions are made as to differences of density, the extent of the field, etc., so that his methods do not lead to quantitative results. He has now given us a non-mathematical account of his later work ("A Survey of Some Theoretical Investigations of Ocean Currents." *J. du Cons. Perm. Internat. pour l'Exploration de la Mer*, **3**, No. 3, p. 295, 1928), in which he shows what modification of his earlier results is necessary.

Starting from the well-known pseudo-force due to the rotation of the earth, which acts on a moving particle directly as its mass and velocity if the latitude is constant, he shows that, conversely, a particle which is acted upon by a constant force and is not otherwise constrained, will move at right angles to the force *cum sole*; its velocity, the 'normal velocity', and not the acceleration, will vary directly as the force. The original theory of the 'pure drift current' is modified by no longer assuming that the 'coefficient of virtual viscosity' is invariable, but no important change results; the spiral is still developed, but it is no longer equiangular, and the angle of surface deflection is not exactly 45°. Unlike the drift current, a slope current extends to the bottom, so that it is necessary to assume a layer in which bottom friction is effective; its thickness is the 'lower depth of frictional influence', corresponding with, but not equal to, the 'upper' depth. It is only in this lower layer that any transport of water in the direction of the slope takes place.

Out of this arise Prof. Ekman's recent investigations into the 'deep current' which lies above the bottom layer, and the effect on it of the topography of the bottom. A deep current running in the direction of increasing depth will experience a rotation *contra solem*. Further, since the velocity of the deep current increases from the pole to the equator, it will experience a rotation *cum sole* when directed towards increasing latitude.

These conclusions require some modification, the