A distinct correlation is found to exist, however, between the temperature of the bottom waters in March–April–May and the quantity of larvæ which can be caught by standard methods in these months, a relatively high temperature being coincident with a good larval yield and vice versa. The reason for this correlation is claimed to be that temperature conditions are directly responsible for the abundance or otherwise of the planktonic food organisms upon which the fry depend for their survival. The radius of action of a tiny cod larva is very small. If it does not find abundant and easily available food as soon as its yolk is used up it dies.

Dr. Poulsen has also found an apparently significant relation between the temperature of the surface water in January and February and the number of larvæ obtainable in the spring months following. The reason for this, he believes, undoubtedly is that when the surface water in mild winters is comparatively warm the winter minimum of planktonic organisms does not sink so far as in more severe winters. (In this connexion it is interesting to recall that in 1927 Johansen found that the number of plaice fry in the Belt Sea was correlated with the number of days in which the water was covered with ice, and the temperature of the surface water in January and February.)

A definite relation is also established between the salinity of the bottom waters in November and December and the number of fry present in the following spring both in the Belt Sea and to a lesser extent in the Kattegat. This correlation, it is pointed out, cannot be due to any direct influence. Spawning does not begin until January at the earliest and larvæ do not appear until about the end of February. The following tentative explanation is therefore put forward. In the autumn an annual migration of large and sexually mature cod is known to take place from outside into the Belt Sea. This migration is dependent upon an autumn inflow of salt water from the North Sea. The larger the inflow, the greater the number of cod which come in with it. Particularly large numbers of eggs are then spawned and a large brood of larvæ results. At the same time, a large inflow of North Sea water produces a condition of high salinity in the Belt Sea and in the Kattegat.

This explanation implies that fluctuations in the numbers of eggs laid produce corresponding fluctuations in the resulting larval broods. This hypothesis may hold good in the Belt Sea but the author himself, in another part of his report, points out that it does not appear to be true as a general rule. It is to be hoped, therefore, that Dr. Poulsen will continue these researches and that this report will in due course be followed by another containing new and illuminating information on these interesting and important points in the life history of the cod in Danish waters.

G. A. S.

Low Altitude Auroræ

AN unusually low aurora was witnessed on March 8 of this year at the Auroral Observatory, Tromsø, Norway. The height was determined photographically by the Director, L. Harang, working with Dr. W. Bauer (of the Photophysical Laboratory, the Danzig Technical High School), who have made a brief joint report of their work in *Gerlands Beiträge zur Geophysik* (Bd. 37, pp. 109–115, 1932). At the suggestion of E. Brüche, Berlin, two film cameras were in use at the two base stations (43 km. apart) from which simultaneous parallactic photographs were made; this was in order that, by taking short exposures of a few seconds, a continuous record of the development and changes of auroræ might be obtained. On the two evenings of March 8 and 9, 1932, about 500 pairs of photographs of bows, bands, draperies and rays were taken, during intense displays of the northern lights. A series of 20 pairs of these pictures, covering a period of only 75 seconds, on the night of March 8, disclosed a particularly interesting phenomenon.

At 20.45 G.M.T. an intense yellow-green auroral bow with a deep-red lower edge appeared in the north, at an elevation above the horizon of about 13°; it was found to be 290 km. distant, at an altitude of 77 km. Within 40 seconds it drew southwards by 20 km., and penetrated the atmosphere further, to 75 km., while its eastern portion dissolved, so that the bow ceased to be in the field of the camera. Suddenly, during a few seconds, another bow developed, 20 km. behind the first, that is, at the distance where the latter originally appeared; the second bow, however, was lower, its measured height being only 65 km. After 15 seconds its height quickly increased to 80 km., and it receded to 350 km. distance, while the red colour vanished from the lower edge. This bow also then drew slowly southwards, while its right end rose to 100 km.; this disclosed a third faint bow, lying at 90 km. height and 70 km. behind the second one, the gradual southward motion of which it followed. The time during which the second bow was below 75 km. was less than 20 seconds.

The outstanding character of this observation is well illustrated by the diagram here reproduced (Fig. 1), from the paper referred to. In column *A* are shown all the measured heights of the yellow-green auroral bows observed at Tromsø during the period February to October 1929. In the middle column *B* are shown the heights of the red-edged yellow-green bows observed there on March 8, and in column *C* the heights of other yellow-green bows observed on the same evening. The diagram shows that the heights usually exceed 90 km., but, rather rarely, come down nearly to 80 km., as Prof. C. Størmer found. The quite exceptional nature of the lower red-edged

bow of March 8, extending down to 65 km. (or possibly even less) is evident.

We are still ignorant of the precise mode in which the auroral light is produced, but it seems likely to be due to the entry into the atmosphere of charged particles from outside; the sign of the charge, and the speed of the particles, are unknown. Their penetrating power can be conveniently stated (as for α- and β-particles in the laboratory) in terms of the equivalent thickness of air at normal density which they traverse. This cannot be accurately inferred from the measured heights of the lowermost edges of auroræ, because of uncertainties as to the composition and temperature of the air at great heights; but there can be little doubt that particles which come down to 65 km. traverse at least five times as much air as those that come down to 80 km. Thus the newly observed aurora suggests that, at times, particles enter the atmosphere with a penetrating power five times as great as that of those (themselves unusually penetrating) that come down to 80 km. If this interpretation be correct, the extension in the range of our knowledge of these particles is no small one.

Another reflection is prompted by the extremely fleeting nature of this low aurora. Throughout their many years of auroral photography, Størmer, Vegard and Krogness have never measured so low an aurora; of course a great many auroræ the heights of which have not been determined have appeared during this period, and much of their work has been done at stations south of Tromsø. Apart from the red edge, which is not unique, the low bows now measured were not specially outstanding, and there was no obvious indication of their unusually low altitude. May not many such low bows, perhaps equally fleeting, have passed without recognition of their exceptional character? And may there not occasionally be still lower ones to be discovered by some fortunate or patient observer? The answer seems likely to be 'yes'.

Further, every reduction in the auroral heights substantiated by parallactic measurements increases the credibility of the reports of auroræ extending down to the ground. The gap between a height of 65 km. and the ground is a very large one, it is true, but already we have seen the lowermost measured height reduced from 100 km. or 95 km., as in Størmer's early work, to 80 km. in his later work, and, by McLennan's Canadian observations, to 75 km.; and now, by Harang and Bauer, this is brought down to 65 km.—a total reduction of 30 km. The capacity of auroræ to produce low height records—like that of the weather to surpass its own records of long standing—may be much greater than has been supposed.

In this connexion it may be appropriate, finally, to mention that a new collection of reports bearing on the audibility of auroræ, and on low altitude (ground level) auroræ, has been made by Dr. C. S. Beals, of the Dominion Astrophysical Observatory, Victoria, B.C. The reports come from the northern Canadian auroral belt, and are closely similar in tenor to those collected by Mr. J. Halvor Johnson, which I described in an article in NATURE of March 7, 1931. Dr. C. A. Chant, editor of the *Journal of the Royal Astronomical Society of Canada*, had also collected such evidence, during the years 1907–29. Dr. Beals, after discussing the evidence in his paper (which is to appear in January in the *Quarterly Journal of the Royal Meteorological Society*), regards it as reasonably establishing the occurrence, on very rare occasions, both of auroral sounds and of ground-level auroræ.

S. CHAPMAN.

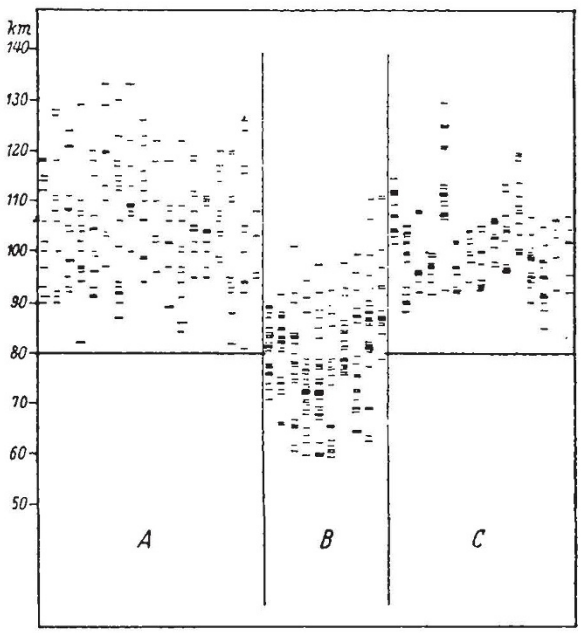

Fig. 1. Heights of auroral bows: *A*, February-October, 1929: *B* and *C*, March 8, 1932. From *Gerlands Beiträge zur Geophysik*, Bd. 37, Heft 1, 1932.

Obituary

PROF. T. GRAY

IT was with profound regret that the many friends of Prof. Thomas Gray learned of his death at Elie, Fife, on September 26. With his passing the Royal Technical College, Glasgow, has lost one of its most distinguished members.

Born at Mid-Calder in 1869, Prof. Gray received his early education at George Watson's College, Edinburgh, and entered the Andersonian College at Glasgow as a student of Prof. Dittmar in 1885. At nineteen years of age, he proceeded to the University of Jena, returning a year later to become assistant to Prof. Dittmar and afterwards to Prof. Henderson. Graduating B.Sc. in the University of London in 1890, his career as a lecturer commenced three years later at the Royal Tech-