

same order. At the depth of 5 fathoms the influence of the diatoms on the oxygen content was much less, and from 10 fathoms downwards hardly any photosynthesis can have taken place.

The variations of the plankton quite clearly depend on the quantity of phosphates and nitrogen compounds available in the surface layers. The diagram of the variations in density ( $\sigma_t$ ) throughout the year shows, that a regular vertical circulation can hardly take place; the authors discuss the possibility, that the surface layers may occasionally be mixed with the bottom layers by the action of winds. I should think that so great fluctuations could hardly be possible, if relatively great quantities of nutritive salts were not also at intervals driven out from the shore.

The paper contains a great wealth of valuable observations condensed into few pages; it is one of the most important papers on plankton published in the last years.

H. H. GRAN.

E. SCHREIBER. Die Reinkultur von Marinem Phytoplankton und deren Bedeutung für die Erforschung der Produktionsfähigkeit des Meerwassers. (The pure culture of marine algae and its importance for the investigation of the fertility of sea water.) — Wiss. Meeresunters., N. F., Abt. Helgoland, XVI, No. 10, 1927.

The Author of this important paper is a young botanist working at the Biologische Anstalt at Helgoland where a new substantial building affords excellent working facilities in many directions.

Mr. SCHREIBER has succeeded in finding a method of work which enables a much more accurate evaluation of the very small quantities of those substances which are essential to plant growth in the sea. To attain such a procedure he had first to master two points of technique, and in both directions his patient labours have been attended with success.

Firstly, the usual method of cultivating marine algae, without considering the bacteria in the water, could not serve his purpose, as the bacteria by reducing or oxidizing part of the soluble contents of the water would frustrate any attempts at accurate determination of the phenomena brought about by the algae themselves. The author accordingly set out to sterilize not only the water used in the experiments but also the algae cultivated. This was achieved by filtering the sea water through special very hard asbestos filters, and the algae were freed from adhering bacteria by placing the mobile cells in a flow of sterilized water with a direction opposite to their phototactic movement, and the immobile ones in a tube with an upward flow of sterile water, the velocity of the flow decreasing upwards as the tube widens. At a certain level the sinking velocity of the diatom cells equals the flow of water and the cells can remain suspended for an indefinite period until completely rinsed.

Secondly, the conditions of light suitable for standard culture experiments had to be found out. The author demonstrated by experiment that common incandescent lamps could be substituted for sunlight, thus making possible a control of the light conditions. By suitable arrangement of trial cultures in different levels under a strong lamp, shaded by a water bath to keep heat out and by oiled paper to diffuse the light evenly, it was found that diatoms thrived best in a light intensity of about 800

metercandles, more or less abnormal growth phenomena setting in under the stronger light tried (up to 3200 meter-candles). The small flagellate *Carteria*, on the other hand, was able to utilize even the last-named strong light nearly as economically as the weaker grades. As the latter organism presented many advantages from a practical point of view, the experiments directed towards the investigation of sea waters of different origin were mainly made with this species.

Having thus settled the influence of light on the growth of diatoms and flagellates, the heat factor was subjected to a similar analysis, and as objects one northern and one southern diatom were used viz. *Biddulphia aurita* and *Biddulphia sinensis*. The former was grown in ten cultures from the 9th March to the end of the month, five in a heated room and five in an unheated one. At the end of the experiment from 79 to 155 cells were counted in 10 cub.-millimetres in the cultures which were kept cool, while in those which were kept in the heated room only 6 to 12 cells were found. *Biddulphia sinensis* on the other hand, which was kept in 12 cultures between the 4th and 30th of March at 9 and 16 degrees centigr. on an average, showed the opposite predilection. In the 6 tubes kept at 9° only 4 to 9 cells of a more or less morbid character were found, while those kept at 16° were found to contain 1460 to 3830 cells of normal form.

Being armed with a method permitting absolutely pure cultures and having demonstrated the extreme importance of keeping the cultures under standard conditions of light and heat, the author could proceed to investigate the relative importance of the nutrient substances in the water. By cultivating the above-named small flagellate *Carteria* in sterile but otherwise natural, sea water from the German Bight, it was shown that the ability of the water to promote growth and division of this alga varied throughout the year. Water was taken every month from August 1926 to July 1927, and a very characteristic curve was obtained when time was taken as abscissa and as ordinates the numbers of *Carteria* counted in each 10 cub.-mm. of the respective cultures when these had been kept sufficiently long to bring multiplication to a standstill. The highest number produced was 302 in January, the lowest only 5 in June, but another minimum of 73 was found at the end of February.

In order to find out which factor was the limiting one, he added either nitrate or phosphate to his cultures, and in this way found that while nitrate addition caused no increase in the production of *Carteria* in March, when added phosphate gave a rise of 35 per cent. above the output from natural water, addition of nitrate in October had a similar effect (50 per cent.) while phosphate made no difference. And when the production after addition of nitrate to October water had reached a maximum, a further addition of phosphate had an immense effect, giving ten times as many cells as addition of nitrate alone.

In this way it is consequently possible, by giving one substance in superfluity, to find out the amount of the other limiting substance expressed in numbers of *Carteria* produced per unit volume of sea water. These numbers can be converted into absolute values of the substance in question present if it be known how many *Carteria* per unit volume can be produced from water of known content of either nitrate or phosphate.

The author found that 1 mg. of sodium nitrate per litre produced 23 cells per cub.mm., 10 mg. gave 254 cells and 100 mg. 2435 cells, on an average corresponding to 100 *Carteria* per cub.mm. when the water contained 680 mg. nitrogen per cub.-m. It was also demonstrated that it did not matter whether the nitrogen was given in the form of nitrate, ammonia, nitrite or glycooll; in every case the amount of cells produced was in close agreement with the quantity of Nitrogen given.

In the same way it was found that a phosphate content of 430 mg. per cub.-m. was necessary to produce 100 *Carteria* per cub. mm.

Using this ingenious and yet very simple method the author was able to show that the nitrogen and the phosphate content of the water at Heligoland in the period in question varied in a similar though not identical way, and that the productivity of the sea water itself closely followed the lowermost of the two curves, phosphate being the limiting factor from March to June and nitrogen from June to December, while the amounts present in January were of equal importance.

These figures were all found by using water taken (from the surface) near Heligoland. By analyzing water nearer to the mouth of the Elbe when a minimum of fertilizing substances occurred near Heligoland, the author demonstrated the comparative richness of the waters from this river, which contained 544 mg. of nitrogen and 271 mg. phosphate at Cuxhaven, 86 and 38 mg. half-way out, and at Heligoland only 3 and 2 mg. This forms a very interesting and forcible demonstration of the rapid exhaustion in the sea of the fertilizers brought from land.

This result which is analogous to although much more extreme than those published by BRANDT in his last paper, is of great importance for the question of the source from which the fertility of the sea is recuperated after its exhaustion in the spring.

The reviewer believes that the rather detailed account given above of this able paper is justified by the importance of this biological analysis as a corrective to any form of purely chemical investigation of the fertilizers in the sea. The biological analysis possesses the inestimable advantage of giving the amounts of fertilizers actually utilised by the algae without disturbance by other substances which might possibly give similar chemical reactions.

OSCAR SUND.

L. FAGE et R. LEGENDRE. Pêches planctoniques à la lumière, effectuées à Banyuls-sur-Mer et à Concarneau. I. Annélides Polychètes. — Archives de Zoologie Expérimentale et Générale. Tome 67. Fasc. 2. 1927. pp. 23—222.

The use of artificial light to attract fish is common to the fishermen of many parts of the world, and has been made use of from time to time by marine biologists for the capture of smaller marine organisms. Systematic collecting in this manner was started by M. RACOVITZA at Banyuls-sur-Mer in 1909, using a 100 c. p. electric lamp and working from a steamship. From 1909 until 1914, together with Prof. L. FAGE he collected a mass of material between Argelès-sur-Mer and Cape Creus. In 1922 MM. FAGE and LEGENDRE started systematic collections in a similar but more simple manner. A floating acetylene lamp with a self-contained