regarded in the same light, i.e., that of being incidental rather than indigenous. Laboratory experiments indicate the possibility that ammonia and nitrate, as such, present in lake water, are used as nitrogen sources for bacteria. In this connection C. H. Mortimer has shown that the seat of nitrification is on the mud surface.

Nitrate-reduction plays a much more important part in the nitrogen cycle in lakes. Relatively large numbers of bacteria capable of reducing nitrates were found in the epilimnion in summer, but fewer in the hypolimnion, which conforms to the general distribution of bacteria in the water. After the overturn numbers were equally distributed throughout the lake, and increased from an average of 50 per millilitre to 100 per millilitre ; this increase corresponded with a period when greater quantities of nitrate were washed into the lake.

It would appear that the mud and the water above may have a joint nitrogen cycle, and that the particular part played by the water bacteria is largely one of reduction.

LAKE DEPOSITS

by C. H. Mortimer.

An article on bathymetric surveys and lake deposits appeared in last year's report (page 33), and described the early stages of work on this subject. During the past year these studies have been extended in three directions: firstly, attempts have been made to discover how far the layering shown by records obtained with the echo-sounding machine represent a similar layering in the actual lake deposits, and in this connection special apparatus has been designed for direct measurement of the depth of deposits and for obtaining cores from these: secondly, bathymetric surveys with echo-sounding apparatus have been extended to all the larger lakes of the district; and thirdly diatom shells and other plant remains contained in cores raised from the deposits have been examined qualitatively and quantitatively. This work has been a communal effort to which the chief contributors have been Mr. B. M. Jenkin, Dr. J. A. Ramsay, Miss W. Pennington, the laboratory staff at Wray Castle and myself. Much of the work was made possible by the generous loan by Messrs. Henry Hughes & Co. of one of their new phasing echo-recorders.

Circumstantial evidence that the echo-records gave a true picture of the depth of bottom deposits overlying rock or other hard material, in addition to the depth of the water, was adduced in last year's report. Final proof however can only be obtained by direct measurements on the deposits themselves. A start in this direction was reported last year: cores of deposits from Windermere were described which were obtained by a simple steel tube borer fitted with a ramming weight. The friction involved in pushing such a tube several feet into the deposits causes compression of the core, which is a serious drawback in stratigraphical work. Accordingly Mr. B. M. Jenkin, an experienced engineer and an old friend of the Association, has given much time and skill to solving the problem of obtaining cores from below a considerable depth of water, without distorting their contents in any way. He has constructed a deposit-sampler which is ideal for accurate stratigraphical work on lake deposits.

The constructional details and mode of working are described by Jenkin and Mortimer in *Nature* **142**, page 835, November 1938. Quoting from this letter: the sampler "consists of an outer tube, of $2\frac{1}{2}$ inch bore, of which one-third of the circumference is cut away, and an inner half tube. The cut side of the outer tube is closed, except for a small longitudinal opening, by a face plate. The inner half-tube is carried by radial arms on a shaft, which passes upwards to the closing gear, so that, when the shaft is rotated, the inner half-tube projects through the longitudinal opening, passes through the arc of a circle, and closes against the face-plate." The whole apparatus is lowered by a single cable from a pontoon; while in the open position the tube is driven into the layer of the deposit from which it is required to take a sample, and it is then closed as described above. In this way "there is no compression or appreciable distortion of the core, ... because the inner half-tube cuts laterally along the arc of a circle into undisturbed deposit." The top and bottom of the inner half-tube are closed by diaphragms so that none of the deposit, whatever its consistency, is lost. The sampler itself is 4 feet long. For use in deep deposits extension tubes are fitted in order to connect the sampler with the driving and closing gear, which must be above the mud surface. Other advantages of this apparatus over those previously used for similar purposes are that it can be operated by one cable in almost any depth of water; that there are no connecting rods or pipes to the surface of the water; that there is no need for devices

to ensure the sampler's entering the same hole again when obtaining cores at successive depths in deposits. Work with the Jenkin sampler was this year confined to testing. Mr. Jenkin is now developing certain accessory gear, including portable pontoons, in order that the sampler may be used on other lakes.

Another most useful apparatus was designed and constructed during the summer by Dr. J. A. Ramsay. This is a mud-probe, whereby the total depth of soft deposit under water can be measured. It consists of a steel rod (actually thick-walled tubing) 1 inch external diameter and 30 feet long, in sections, pointed at the bottom and fitted with a ramming weight at the top. Annular grooves of ratchet form are cut at 3 inch intervals along its length. A light disc, 3 feet in diameter, fitted with ratchets engaging with the grooves, is so arranged that it can slide easily up, but not down, the probe. With this disc at the bottom, the probe is lowered and driven vertically into the deposit until a hard layer, gravel or rock, is encountered. It is then withdrawn and the height to which the deposit has pushed the disc up the probe is taken to be the depth of the deposit.

In order to compare the depth of soft deposit as measured by this instrument with that recorded by the echo-sounding machine, the mud-probe was brought into action at ten-foot intervals along a rope stretched from the shore to a boat securely anchored in the lake. The same line was surveyed with the echo-sounder. The depths of deposit at each point were measured, to the nearest 0.1 metre from the echo-record, and directly to the nearest 3 inches by the probe. Twenty-six tests in deposit varying from 0 to 4 metres in thickness were made, and the difference between the depth of deposit as measured by the two methods was less than 9 cm. in 9 tests, between 10 and 30 cm. in 12 tests and more than 30 cm. in only 5 tests. The last group of tests were all made in very shallow water in which it is extremely difficult to obtain an adequate record of the deposit. On the record obtained by echo-sounding the total deposit was divided into two layers, which probably result from differences in consistency, recorded as differences in the ratio of reflected to transmitted sound, in successive layers. It was suggested in last year's report that such a record might be obtained from soft mud overlying glacial clay on top of gravel or rock. It is interesting to note that, in the region of this double layer, the probe, although smeared on extraction with

soft mud, in many cases showed traces of red glacial clay adhering to the lower end.

As a result of this work with the mud-probe, it can be said with a fair degree of certainty that the echo-sounding apparatus can record the presence or absence of soft deposit and that, under favourable conditions, the depth of this deposit as shown by the record is its depth on the floor of the lake. The final proof of the correctness of this conclusion and of the qualitative interpretation of the records now available from all the larger and some smaller lakes in the district, can only be given by undistorted cores of the deposits themselves. It is, for instance, not yet possible to say conclusively how much of the total deposit is post-glacial. Records from Windermere and other lakes, however, indicate the presence of pockets of glacial clay in depressions of the rock basin, the whole being covered with post-glacial deposit. No interpretation of the multiple layering often noted in records from some parts of Windermere, Wastwater, Thirlmere and Ullswater can yet be attempted. In view of the possible practical and scientific applications of the echo-sounding method in determining the kind and amount of sub-aqueous deposit, it is clear that Mr. Jenkin's development of an accurate deposit-sampler represents a real step forward.

The echo-sounding machine used in the past year's work differs from the model employed during 1937, in regard to the method of recording in deep water. In the model used in 1937 deep water records were obtained by slow gearing of the pen-speed with a consequent diminution in the size and detail of the record of bottom deposits, whereas in the newer " phasing " type of machine when used in deep water the signal is sent out at a definite time before the pen reaches the paper. In this way the echo from the bottom is recorded in undiminished detail at full pen-speed. Survey lines on Windermere which, during the 1937 survey, showed definite characteristics in the record, such as the presence or absence of single, double or multiple layering, were re-surveyed in 1938 with the phasing apparatus. The new records show in all cases, in much more detail, the same configuration and identical positions and depths of deposit as were found the previous year with the different type of recorder. The phasing recorder has been used in this way to check the detailed map of the deposits which was drawn from data obtained by the Admiralty's survey of Windermere in 1937.

A good general idea of the type and extent of the deposits as shown by echo-records, subject to the same limitations of interpretation as those of Windermere, has been obtained from surveys on all the larger lakes in the district, with the exception of Crummock Water. Surveys on Haweswater and Thirlmere (where the work was carried out with the permission and co-operation of the Manchester Corporation Waterworks), Loweswater, Esthwaite Water, Grasmere and Blelham Tarn have been completed. Of these only Haweswater had previously been surveyed in detail from a bathymetric point of view. Buttermere, Coniston Water, Rydal Water and Ullswater were examined in somewhat less detail. Added to these, surveys on Wastwater, Ennerdale Water, Bassenthwaite Lake and Derwentwater were reported on last year. The field work has involved arduous days on the part of the scientists and laboratory staff, and has necessitated a long period of plotting the results. A set of detailed maps showing depth of water and deposits on the 6 inch to a mile scale is now available and will form the foundation for future limnological studies on all these lakes. The results obtained from calculation of total volumes of soft deposits show that the lakes can be divided into two general groups; one, with drainage areas on igneous rocks has had a slow rate of silting since the Ice Age; the other, receiving drainage from sedimentary rocks and agricultural lowland, has silted more rapidly. An account of these surveys is to be presented to the Royal Geographical Society in the near future.

The study of plant remains in the deposits of Windermere, mentioned at the beginning of this article has been undertaken by Miss Winifred Pennington of the Botanical Department at Reading University. She has examined a number of cores, but most of the work has been done on one core, representing 9 feet vertical thickness of deposit; it was obtained with the Jenkin core sampler. All these cores were taken in relatively shallow water in the same region as the core figured on page 36 of last year's report. They all show a similar zonation namely—from the bottom upwards—gravel, lower laminated clay, lower diatomaceous earth, upper laminated clay and upper diatomaceous earth, apparently continuous with surface mud. Miss Pennington records sixty-two species and six distinct varieties of diatoms, the silicious shells of which are preserved in the deposits. Quoting from her report: "The greater part of the diatomaceous deposits is made up of small forms, occurring in similar proportions

throughout the core. They are therefore of no use for zonation purposes." Focussing attention on the larger species, she was able to establish eight zones distinguished chiefly on the abundance of five species. Apart from one case where the lower diatomaceous earth contained roots, moss leaves and fruits, catkin scales and birch pollen, very little pollen was found. Occasional grains of *Pinus* were noted. With the exception of the lower part of the upper laminated clay, both clay layers contained no diatoms in appreciable numbers.

Of the species found, all are known as living forms except *Melosira arenaria var. hungarica*, which is confined to the lower parts of the core, and is recorded from fossil deposits in Hungary. " Most of the species, including all the abundant species are littoral forms . . . . . not altogether surprising, since the core was obtained from relatively shallow water." (Note: This might be adduced as evidence for no considerable change in lake level since glacial times.) Of the sixty-two species and six varieties, four have been recorded from the present Windermere plankton but not the littoral region, ten from Windermere littoral but not plankton, ten from both littoral and plankton. Thus most of the species from the cores have not been recorded for the lake. A noteworthy feature is the fact that *Asterionella gracillima*, so abundant in the plankton at present, has not been recorded from the cores. Fourteen species have been designated by Mr. Ross of the British Museum as having arctic, arctic-alpine or northern distribution.

It is to be hoped that Miss Pennington will be able to continue this very interesting work, especially on cores which we hope to obtain from deeper water. In this way it should be possible to throw valuable light on the past climatic and biological history of Windermere and other lakes.

FAUNISTIC STUDIES

by T. T. Macan and H. B. N. Hynes.

Faunistic Work on Adult Animals. Macan's work on the ecology of corixid water bugs was published in June, 1938, but during the year additional field data, extending and corroborating the conclusions drawn, have been obtained. In addition comparison