in France. In 1892 a 36-inch glass was made for the Lick Observatory by Alvan Clark, and a 40-inch for the Yerkes Observatory in 1897. These large telescopes led to the discovery of new satellites, the accurate determination of the sizes of planets and satellites, but their main work—used visually—was the discovery and measurement of large numbers of double stars, leading to a very satisfactory knowledge of the masses of stars. Used with the spectroscope, they gave the velocities of stars to and from the earth, and enabled the velocity of the sun among the stars to be determined as 19 kilometres per second. This result, in combination with measurements of angular motions of stars, served to give the mean distances of stars. Large photographic refractors have made possible the measurement of the actual distances of thousands of stars, leading to a much more complete view of the stellar system.

The discoveries made by the large 60-inch and 100-inch reflectors of Mt. Wilson and the 72-inch of British Columbia were also detailed, culminating with the measurement of the size of the disc of Betelgeuse and of several other stars by the interferometer as applied by Michelson.

Irish Sea Plankton.[1]

SIR WILLIAM HERDMAN, in an interesting paper recently issued, gives a summary of plankton researches in a single area extending over a period of fifteen years, and compares the results in each year in such a way that certain general facts are at once apparent.

The object of the investigations was twofold: "(1) To study the distribution of the plankton as a whole, and of its various constituents during the year; and (2) to arrive at some estimate of the representative value of the samples collected in the plankton nets."

The results show very clearly that the distribution of life in the sea is not uniform, but that the organisms appear in patches. Although this applies to a certain extent to all the plankton, it is especially the case with the copepods, which are frequently present in large swarms in one place, while possibly only a short distance away few or none occur. This naturally affects the distribution of other organisms feeding on the copepods, especially fishes, and is of fundamental importance. The diatoms were found to be more evenly distributed both vertically and horizontally during their maximum in the spring than at any other time. Comparing the records for the fifteen years (1907–21), there is always this spring maximum of phytoplankton (chiefly diatoms), which may range from March to June and reach to hundreds of millions in one haul, a dinoflagellate maximum, in much smaller numbers, coming on about a month later; and later still, a copepod maximum ranges from June to October. In late summer or autumn each group may have a second smaller maximum in the same order.

That the bulk of the plankton consists of a small number of genera, chiefly diatoms and copepods (and only a few species of copepods), is well established, and these few form the chief food of most of the marine animals. So far as fishes are concerned, copepods are by far the most important food of the young stages, and also of the plankton-eating adults; but as most copepods are predominantly diatom feeders the presence of diatoms is quite as important to the fish as to the copepod. With regard to the phytoplankton, however, Sir William Herdman apparently regards it as the direct food of many larval fishes, at any rate of the plaice in its infancy, which he has seen with its stomach full of diatoms.

The diatom maximum occurs usually just before the time when most of the fish larvæ begin to be abundant, and the copepods follow. These plankton investigations are thus of great importance relative to the food of fishes.

Dr. Johan Hjort suggests that large mortality among the fish larvæ may occur because of the lack of suitable food at the time when they begin to feed. In the present plankton investigations, together with data gathered from experiments in the plaice hatching at the Port Erin Biological Station, it is shown that diatoms are abundant usually a short time before the very young plaice are set free; but in four out of thirteen years the diatoms were late, and in these years it is possible that the young fishes may not have found enough to eat. "The evidence so far seems to show that larvæ set free as late as March 20 are fairly sure of finding suitable food: but if they are hatched as early as February they run some chance of being starved."

While discussing fully the phytoplankton in relation to fish larvæ very little is said of the zooplankton other than copepods, and one would infer from the conclusions that it is only the diatoms which are of importance as young fish food in the spring. It is, however, probable that in spite of the fact that more diatoms than anything else are present, yet the zooplankton is really of more direct value as food for the larval and post-larval fishes: for example, cirripede nauplii and mollusc larvæ besides copepods, the latter, although not at their height in the spring, yet occurring in large numbers.

Sunlight is shown to play a very important part in the growth of the plankton. In the daytime, however, the largest hauls are usually not at the surface but at about five or ten fathoms, the depth varying with the meteorological conditions. It is regarded as probable that the spring phytoplankton maximum is due chiefly to the great increase of sunlight aided by the winter increase of carbon dioxide and other food matters. The rapid disappearance of the diatoms after the spring maximum is accompanied by a greater alkalinity of the water, and it is suggested that it may be due to the injurious effect of their own metabolism. May not the explanation lie partly in the fact that the diatoms are eaten by an enormous number of pelagic animals coming on just after the diatom maximum?

As to the representative value of the samples collected in the plankton nets, it is shown that variation in the composition of similar hauls is great. These differences show clearly that the life in the sea is not spread evenly either horizontally or vertically, but everywhere occurs irregularly. Simultaneous hauls of similar nets were usually different in quality even if alike in quantity, and the same applied to successive vertical hauls in which the amount of organisms was much the same in each haul but different in kind.

In plankton investigations in which tow-nets are used, however carefully the experiments may be carried out, there is necessarily a great deal of inaccuracy, which is freely admitted and discussed. None of the numerical results can be absolutely exact, but when, by examining and recording these, certain phenomena are seen to repeat themselves year after year, we can at least feel sure that by making these careful quantitative experiments in connexion with numbers of hauls all carried out in an exactly similar way, we are approaching the solution of the general problems relative to the distribution of life in the sea.

M. V. L.

[1] "Spolia Runiana. V. Some Results of Plankton Investigations in the Irish Sea," by Sir William Herdman. Extracted from the Linnean Society's Journal—Botany, vol. xlvi., July 1922.