

A further example of the patchiness of plankton distribution

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Summary.—32 consecutive plankton samples were taken by identical tow-nets in a straight line covering a total distance of nearly 11 miles. A marked patchiness was demonstrated for all animals occurring in sufficient numbers. The results are considered in relation to those of some other such samplings already published.

IN JANUARY 1927, when the Royal Research Ships *Discovery* and *William Scoresby* were making a survey of the plankton of the sub-antarctic whaling grounds round the island of South Georgia, two series of consecutive net hauls were taken to find out how patchy in distribution were the main elements in the macroplankton. One series consisted of 23 samples and the other of 48. The results, showing a marked patchiness, particularly in the distribution of *Euphausia superba* and the amphipod *Parathemisto gaudichaudi*, were published by HARDY and GUNTHER (1935, pp. 255–263). A similar series of 32 consecutive samples were taken further to the south in the Bransfield Strait off Graham Land by the *Discovery* in April of the same year. As this series lay far outside the region of the South Georgia survey the results were not included in the former report and have not hitherto been published. Knowing that Professor BIGELOW was much interested in the matter of uneven plankton distribution I have thought that, small as it is, this additional evidence of patchiness might not be an inappropriate contribution to this volume in his honour; I wish it could have been a larger study, but it is the only piece of marine work that I have at the moment ready for immediate publication.

The series of samples now to be described was taken by the *Discovery* on April 7th, 1927, at Station 207 which lay some fifteen miles south of Livingstone Island; the exact positions at the beginning and end of the observations were respectively $62^{\circ} 54' 00''$ S., $59^{\circ} 50' 30''$ W. and $62^{\circ} 49' 30''$ S., $60^{\circ} 10' 30''$ W. The procedure adopted was the same as that on the two earlier occasions except that the nets used were of 70 cm diameter instead of the larger 100 cm diameter nets used formerly; a detailed description of these nets (N70H and N100H) will be found in KEMP and HARDY (1929, pp. 183–185). Two nets, exactly similar to each other in every particular, were used. The first net was lowered away from the starboard quarter and towed just below the surface for exactly 10 minutes at a speed of 2 knots and then hauled in; as this net was coming in, the second net was lowered away from the port quarter and towed for a similar period. Whilst this net was being towed the first net was washed down, the bucket emptied and replaced and the net got ready for reshooting; then as the second net came in at the end of its ten minutes the first net went out again. In this manner the sampling was continued to give a series of 32 consecutive hauls each beginning just as the one before it ended so that a continuous line of observation (except for one four-minute gap) was made over a distance of nearly 11 miles. The sampling began at 0300 hrs and ended at 0824 hrs; there was a loss of 4 minutes between sample 30 and 31 due to one of the nets being torn and having to be replaced by a new one. At the

speed of 2 knots each sample represented a haul covering a distance of one-third of a mile.

It might perhaps be thought that there was little need for further studies of patchiness of the kind here described since the automatic plankton recorder is always taking

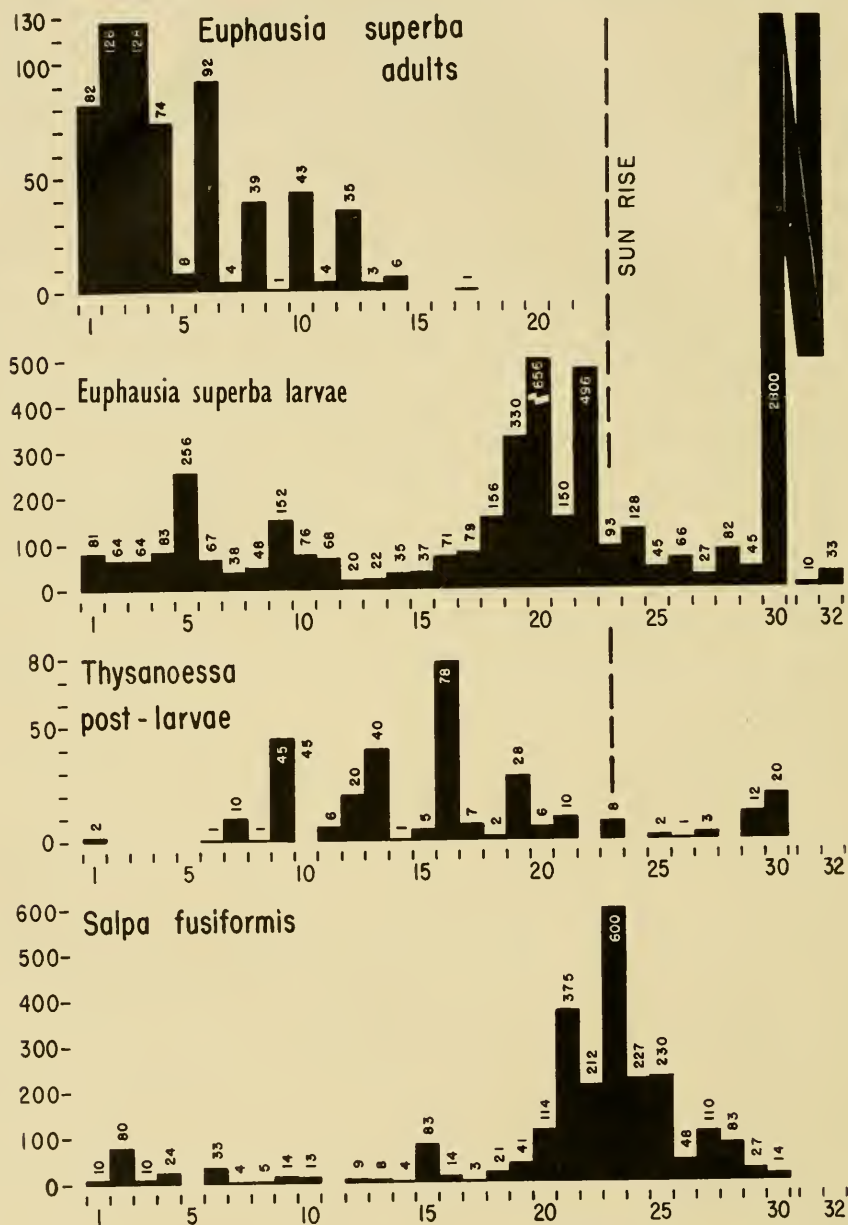


Fig. 1. Histograms showing the varying numbers of some plankton animals in thirty-two consecutive net hauls taken just below the surface at the *Discovery* station 207; each haul was of 10 minutes duration and covered a distance of one-third of a mile. For further details see text.

series of continuous samples and often revealing marked unevenness in distribution. The plankton recorder, however, because it samples continuously on an ever-moving banding, cannot show the real degree of patchiness; each section of the banding

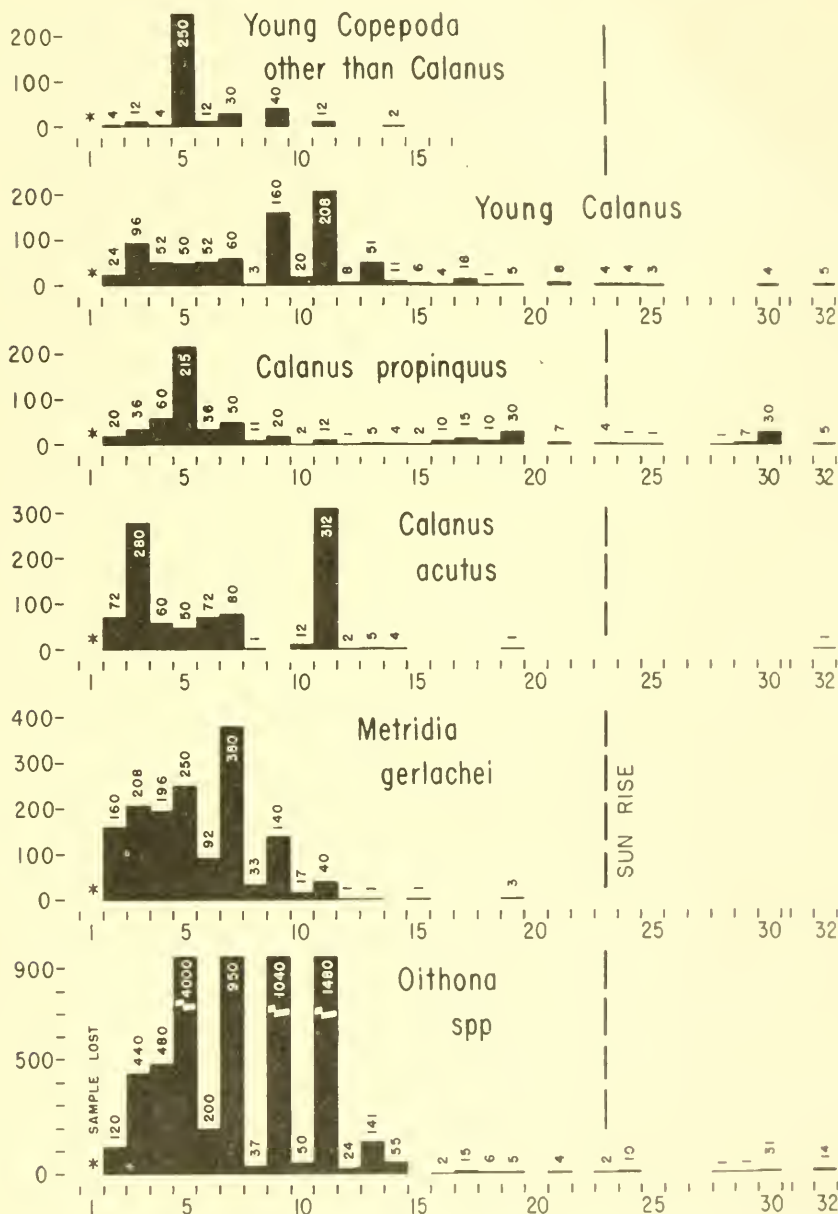


Fig. 2. Histograms showing the varying numbers of the more important copepods in the same series of consecutive net hauls in Fig. 1. The first sample was unfortunately lost by a tube breakage before the analysis had been made.

represents the passage of several miles of sea, so that any marked variation in numbers appearing from the analysis of the records is really showing itself through a considerable "smoothing of results" effected by the very nature of the sampling (HARDY, 1936 A, p. 495). The recorder was, of course, in part designed to overcome the errors due to patchiness which may falsify the results of an ordinary net survey. As far as I am aware no other experiments of the kind here described have been made except those in the South Georgia survey already referred to, and two series taken to test the validity of the plankton recorder method: one in the open South Atlantic midway between Gough Island and Cape Town (HARDY, 1936 B, p. 535) and the other in the North Sea (HARDY and ENNIS, in an appendix to HARDY, 1936 A). I believe more such experiments might be valuable in the understanding of planktonic ecology.

The results of the series here published may be shown most easily in graphical form by the use of histograms and so save much description in the text. They are shown in Figs. 1 and 2, and include only those animals of which over 50 have occurred in a single sample; the remainder, including ctenophores, several kinds of amphipod, other species of copepods, and *Euphausia frigida* were present in only insignificant numbers. Instead of giving the data in tabular form as well as graphically, the actual numbers are inserted against the appropriate histograms. Apart from the marked unevenness of distribution, the effect of vertical migration is clearly seen in the case of the *Euphausia superba* adults and the copepods. The series began in darkness and ended in daylight, sunrise being at 0645, i.e. in the middle of sample 23; we see the animals just mentioned gradually withdrawing from the surface as dawn approaches. It would be valuable, but difficult, to operate such a series of consecutive nets at lower levels, for they would have to be opened and closed at the end of each haul. Regarding the many possible causes of patchiness I still believe that some of the factors suggested in the section on the dynamics of distribution in HARDY and GUNTHER (*loc. cit.*, pp. 343-356) are likely to be important. More observations in the field are required and particularly more experiments specially designed to test the different hypotheses; further discussion must await the results of such work.

Apart from a consideration of causes, not much comment is necessary; the degree of patchiness is obvious. What moral can be drawn from it? Let us suppose we had been carrying out a survey in this region using similar nets towed for 10 minutes at points say 10 miles apart; it is clear that we should arrive at very different conclusions as to the distribution of the macroplankton according to exactly where our stations were placed within a circle having a radius of only half a mile. In the consecutive series here described a mile covers three adjacent samples; we see what a contrast there is within any such three we may select. On the evidence provided by this and the only available similar experiments it appears that much of the quantitative plankton distribution work of the past cannot have the degree of validity often attributed to it. Ecological experiments in the field call for a control just as much as those in the laboratory. Each tow-net survey is really in the nature of an experiment; in the case just imagined the experiment was to sample the water at 10 mile intervals to find out the distribution of the more important plankton animals over the area. Before accepting the results as valid a control experiment is necessary to see, if such samples are repeated at several points near the same place, that they give a reasonably consistent result: to see in fact if one such net towed at one place can be said to give a fair measure of the plankton lying to five miles on either side of it.

I once heard quite a well known planktologist say that it did not do to arrange your stations in a survey too close together because it made it almost impossible to use contour methods when charting the results: I don't think he realized the significance of what he was saying.

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