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# Continuous Plankton Records:

## The distribution of plankton off Newfoundland

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In a previous paper presented to the environmental working party of ICNAF at Aberdeen in 1961, Bainbridge and Robinson (1961) gave a preliminary account of the plankton along the Plankton Recorder route ('Z') between Iceland and Newfoundland, up to October 1960. Sampling along this route has been continued and a further route across the Atlantic, from Liverpool to St. John's ('D') was started in June 1961. It is now possible to give a more detailed account of the distribution of plankton in that part of the ICNAF area covered by these two Recorder routes. In this region the cold Labrador Current meets the warm waters of the Gulf Stream System and wide differences in sea temperature over short distances are well known. Consequently, marked differences may be expected in the plankton of this area. The Plankton Recorder, which is towed by commercial ships, obtains a continuous sample of plankton from a depth of 10 metres. It has proved useful in the detection of the sharp boundaries between plankton communities in the area and a number of examples are presented in this paper.

### Phytoplankton and Calanus

Some obvious differences between the plankton of the cold waters of the Labrador Current and the warmer waters further offshore can be seen in the distribution of phytoplankton and in the population structure of *Calanus finmarchicus*, the dominant copepod. This is illustrated by Figs. 1a - d in which the western parts of the Recorder Routes from Iceland have been arranged in order of months regardless of the year of sampling. (Results from the new route from Liverpool are omitted because this route has been in operation for only six months.) The numbers of the early stages of *Calanus* (copepodites I - IV) and the later stages (V & VI) are plotted along the routes. The intensity of any green colour is also shown; this provides a rough measure of the amount of phytoplankton present. The colour is estimated visually in four categories which are transferred to a numerical scale based on acetone extractions of standard Recorder samples. Temperature data have been extracted from the charts showing mean sea surface temperatures which are published each month by the U.S. Navy Hydrographic Office. When available, temperatures in °F are given along the Recorder routes and indicate the approximate positions where the isotherms on the chart for the month cross the route.

It is convenient to consider first the plankton along the route running towards the Straits of Belle Isle. This is generally ice-free from July to December and Records are now available covering all six months (Figs. 1c and d). The effect of the Labrador Current can be seen in the temperature minimum over the shelf and the temperature gradient further offshore. During July, August, September and October phytoplankton was clearly most abundant in the cold water over the Continental shelf and slope. There were also distinct differences in the population structure of *Calanus* along the routes. During July, August and September *Calanus* copepodites I - IV were found, usually, in the cold water of the Labrador Current, whereas stages V and VI were most abundant in the warmer water offshore. In later months, from October to December, highest numbers of Calanus stages V and VI were found in the region directly influenced by the Labrador Current.

The drift of pack ice generally reaches the northern part of the Grand Banks by January and from this month until June the ship's track from Iceland runs south of Cape Race. The western portions of four Recorder routes taken during this period are shown in Figs. 1a and b. Phytoplankton was detectable by colour estimation on the records of February, April and May and was again most abundant in the colder water. Calanus stages V and VI were also more numerous in the colder water during February and March while the converse was true during May. The fluctuations along routes in the vicinity of the Grand Banks do appear to follow surface temperature but might also be related to other factors such as depth.

Warm and Cold Water Species.

The distribution of several zooplankton species shows an interesting pattern which appears to be related to the two major current systems. Species normally associated with warm and cold water conditions on the 'D' and 'Z' routes have been listed in Table I, with the months of occurrence; and the distribution of members of these two groups is shown in Fig. 2. The grouping of the Copepoda in Table I is similar to that given by Kusmorskaya et al. (1960) with the exception of Metridia longa which they consider a boreal species. The euphausiids Thysanoessa gregaria, Nematoscelis megalops and Euphausia krohnii are associated with warm water in other regions of the Recorder survey, though E. krohnii is considered to be a boreal species by some authors. Bainbridge (1961), and Bainbridge and Robinson (1961) noted the presence of warm-water species off the north-eastern slope of the Grand Banks. The introduction of the new route from Liverpool to St. John's has augmented our knowledge of distributions. As shown in Fig. 2, extensive patches of warm-water species have now been found north-east of the Banks during August and September and during December, January, February and March. The presence of these species may be associated with a current filament of the Gulf Stream System. One such filament is indicated north-east of the Grand Banks on the chart given by Fuglister (1951).

The distribution of species of the warm-water group and of Calanus glacialis, the most prominent member of the cold-water group, have also been plotted on the Recorder routes from Iceland shown in Figs. 1a - d. A good correlation with surface temperatures is evident.

The size distribution of furcilia larvae of Thysanoessa longicaudata.

The furcilias of the dominant euphausiid, T. longicaudata, were numerous in August and September 1961. For the purpose of the present work six furcilia stages are recognised. The first has no pleopods, the second has five-non-setose pleopods and the third five setose pleopods. Following this stage the seven spines on the end of the telson are reduced in number in successive moults, so that the fourth stage has five spines, the fifth has three spines and the sixth has one terminal spine, but still has the long lateral spines on the telson common to all the furcilia stages. These lateral spines are then lost, after which it is not possible to recognize definite stages.

Measurements of the overall length of the furcilias, from the rostrum of the carapace to the end of the telson, showed that the furcilias from the oceanic part of the 'D' route were smaller, stage for stage, than those from the continental slope part of the same route. In August there was a particularly sharp boundary between the small and large furcilias and in September there were two populations of quite distinct sizes. The larger furcilias in both months had the same size characteristics as those from the 'Z' route, further north, in August (Figs. 3 and 4; Table II). There was no 'Z' Record in September. Although temperature data are not available for August and September, the different size distributions suggest that the environmental conditions in the vicinity of the Grand Banks in these months were comparable to the conditions in part of the Labrador Current further north. The distribution of warm-water species of plankton overlapped that of the small furcilias but no warm-water species were found in the parts of the Records bearing the large furcilias (Fig. 3).

Concluding Remarks.

There are, therefore, easily distinguishable differences between the plankton of the two main current systems. Waters of the Labrador Current appear to support a much higher standing crop of phytoplankton than do the warmer waters more offshore. Also, the seasonal cycle of *Calanus* shows a considerable time lag in this current compared with adjacent regions. Certain species are restricted to either the Labrador Current or the Gulf Stream System. One widespread species, *Thysanoessa longicaudata*, has been shown to have populations with distinct size differences which appear to be related to these two major currents.

Spatial and temporal variations are known to occur in the Labrador Current (e.g. Soule and Murray, 1957) and in the Gulf Stream System (e.g. Stommel, 1958). We hope to be able to study long and short term variations in the plankton of this area and possible relationships with hydrography and the fisheries. The new Recorder route from Liverpool to St. John's is likely to be most useful in these studies and it will be interesting to compare the results from this area with those obtained from the route between Newfoundland and Boston which was also started in July 1961 under a contract from the United States office of Naval Research (62558-2834, NR 104-601).

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TABLE I.

Warm and Cold Water species found on the 'Z' and 'D' Recorder routes, December '59 to January '62.

The distribution of the two groups is shown in Fig. 2.

| Date | Dec. 59 | Feb. 60 | Mar. 60 | Apr. 60 | Sept.60 | Oct. 60 | Mar. 61 | May 61 | Aug. 61 | Sept.61 | Nov. 61 | Dec. 61 | Jan. 62 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Route | Z | Z | Z | Z | Z | Z | Z | Z | D | D | Z | D | Z |
| Warm-water species | | | | | | | | | | | | | |
| Calanus helgolandicus | | | | | | | | | + | + | | | |
| Nannocalanus minor | | + | | | | | | | + | + | | | |
| Clausocalanus arcuicornis | | + | | | | | | | | | | | |
| Lucicutia flavicornis | | + | | | | | | | | | | | |
| Pleuromamma borealis | | + | | | | | + | | + | + | | | + |
| P. gracilis | | + | | | | | + | | + | + | | | |
| P. abdominalis | | | | | | | + | | + | + | | | |
| Heterorhabdus spinifrons | | + | | | | | | | | | | | |
| H. papilliger | | | | | | | + | | | | | | |
| Nematoscelis megalops | | | | | | | | | + | | | + | + |
| Thysanoessa gregaria | | + | | | | | + | | + | + | | + | + |
| Euphausia krohnii | | + | | | | | + | | + | + | + | | + |
| Cold-water species | | | | | | | | | | | | | |
| Calanus glacialis | + | | | | + | + | + | | | | + | | + |
| C. hyperboreus | | | | + | | | | + | | | | | |
| Metridia longa | | + | + | + | | | | | | | + | | + |
| Sagitta maxima | | | + | | | | | | | | | | |

TABLE II. The size distribution of stages of furcilia *Thysanoessa longicaudata*

From the oceanic parts of the 'D' route in August and September.
(stippled in Fig. 3).

| Size mm | 2.0-2.4 | 2.5-2.9 | 3.0-3.4 | 3.5-3.9 | 4.0-4.4 | 4.5-4.9 | 5.0-5.4 | 5.5-5.9 | 6.0-6.4 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Stages | | | | | | | | | | |
| I | 2 | 2 | | | | | | | | 2.45 |
| II | | 2 | | | | | | | | 2.70 |
| III | | 2 | | 3 | | | | | | 3.30 |
| IV | | | 2 | 8 | 2 | | | | | 3.70 |
| V | | | 1 | 7 | 12 | 4 | | | | 4.06 |
| VI | | | | 1 | 42 | 50 | 8 | | | 4.52 |

From the continental slope parts of the 'D' route in August and September.
(hatched in Fig. 3)

| Size mm | 2.0-2.4 | 2.5-2.9 | 3.0-3.4 | 3.5-3.9 | 4.0-4.4 | 4.5-4.9 | 5.0-5.4 | 5.5-5.9 | 6.0-6.4 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Stages | | | | | | | | | | |
| I | | 1 | 1 | | | | | | | 2.95 |
| II | | | 1 | | | | | | | 3.20 |
| III | | | | 4 | 16 | 2 | | | | 4.15 |
| IV | | | | | 4 | 9 | 6 | 1 | | 4.80 |
| V | | | | | 1 | 4 | 5 | | | 4.90 |
| VI | | | | | | 2 | 10 | 14 | 1 | 5.46 |

From the 'Z' route in August (hatched in Fig. 3)

| Size mm | 2.0-2.4 | 2.5-2.9 | 3.0-3.4 | 3.5-3.9 | 4.0-4.4 | 4.5-4.9 | 5.0-5.4 | 5.5-5.9 | 6.0-6.5 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|
| Stages | | | | | | | | | | |
| I | | | 1 | | | | | | | 3.20 |
| II | | | | | | | | | | - |
| III | | | | | 2 | 1 | | | | 4.37 |
| IV | | | | | 3 | 6 | | 2 | | 4.74 |
| V | | | | | 1 | 3 | 7 | 1 | | 5.03 |
| VI | | | | | | 3 | 8 | 13 | 3 | 5.49 |

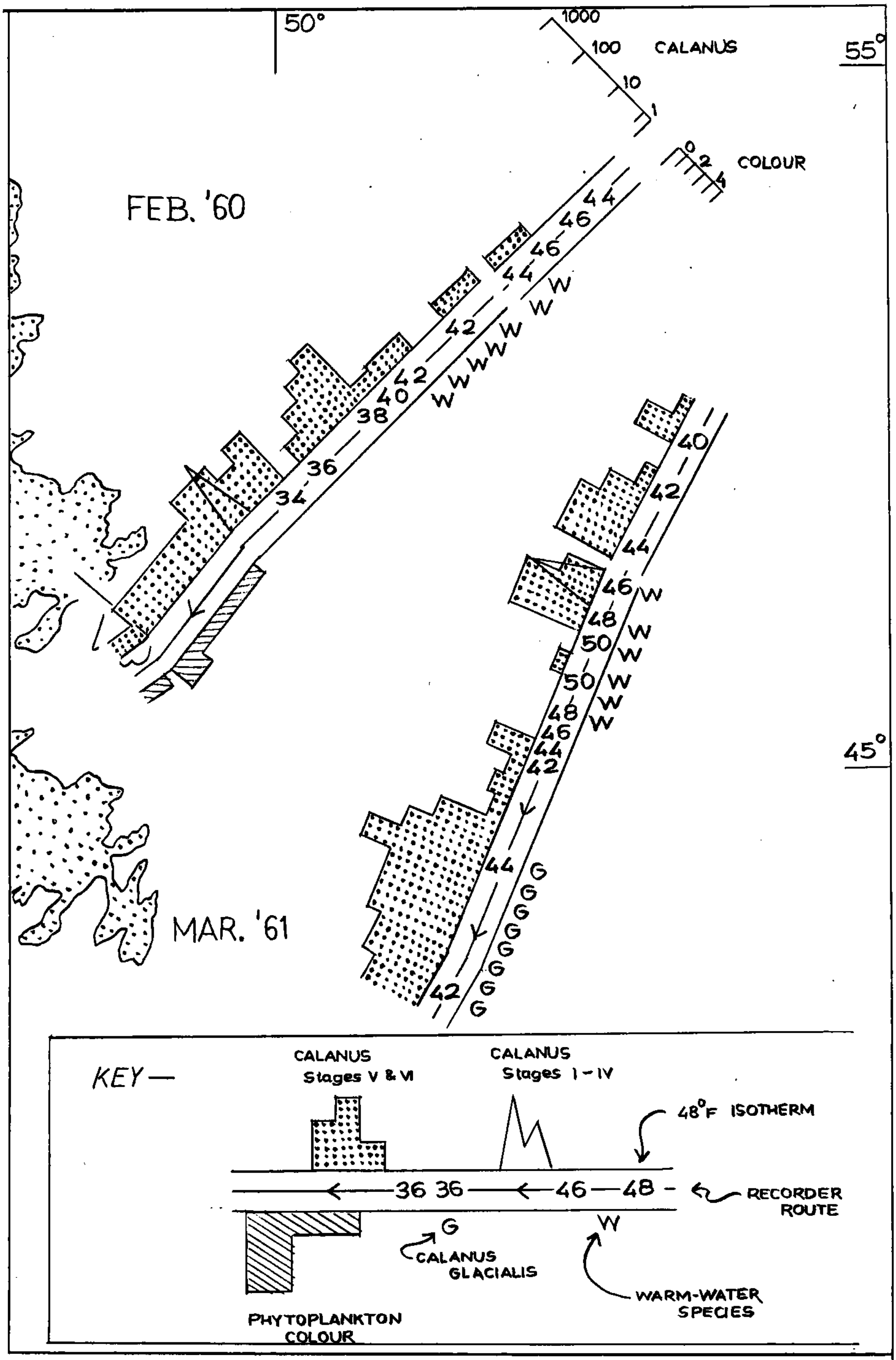


Fig. 1 a.

Fig. 1. Calanus, phytoplankton colour, and surface temperature along Recorder routes ('Z') off Newfoundland. Numbers of Calanus per sample are shown on a logarithmic

cont'd.

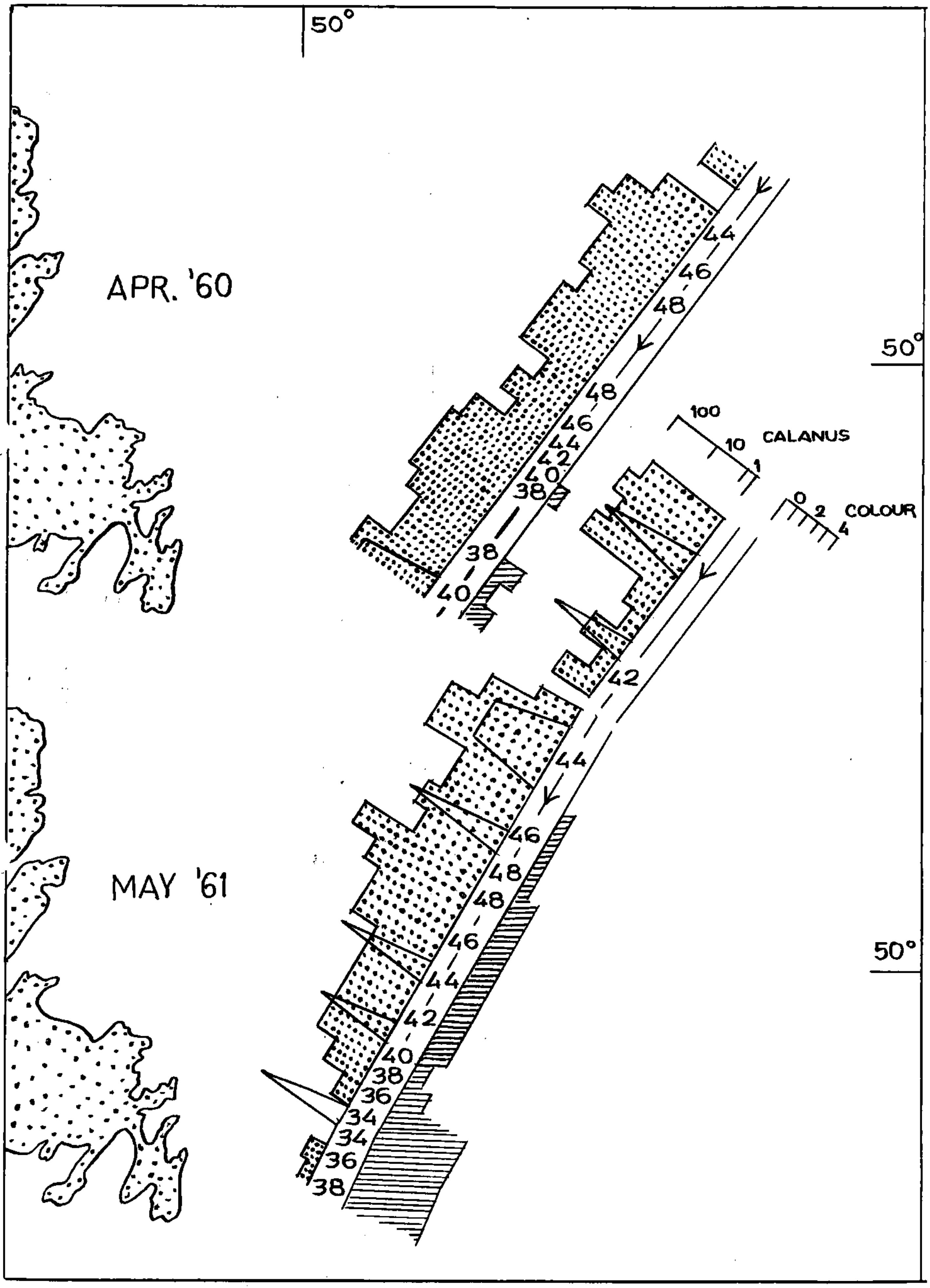


Fig. 1 b.

Fig. 1 cont'd. scale above the route. Stages V- VI are given as histograms and stages I - IV as a line graph. Estimates of phytoplankton colour using an arbitrary scale

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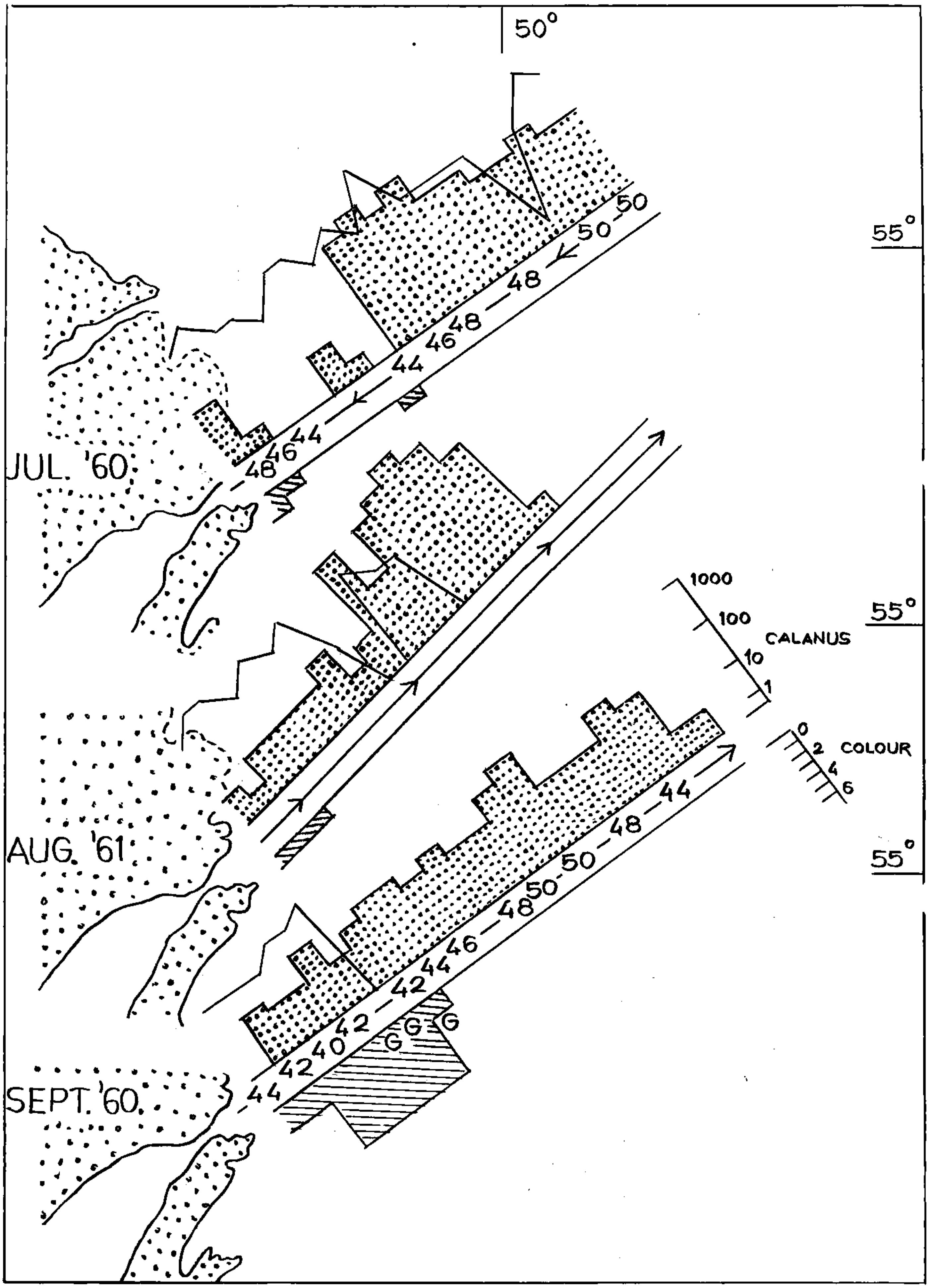


Fig. 1 c.

Fig. 1 cont'd. are shown by histograms below the route. Temperatures in °F are taken from the charts published monthly by the U.S. Hydrographic Office and indicate the positions at which isotherms cross the Recorder route. G. indicates the presence of *Calanus glacialis*

cont'd.

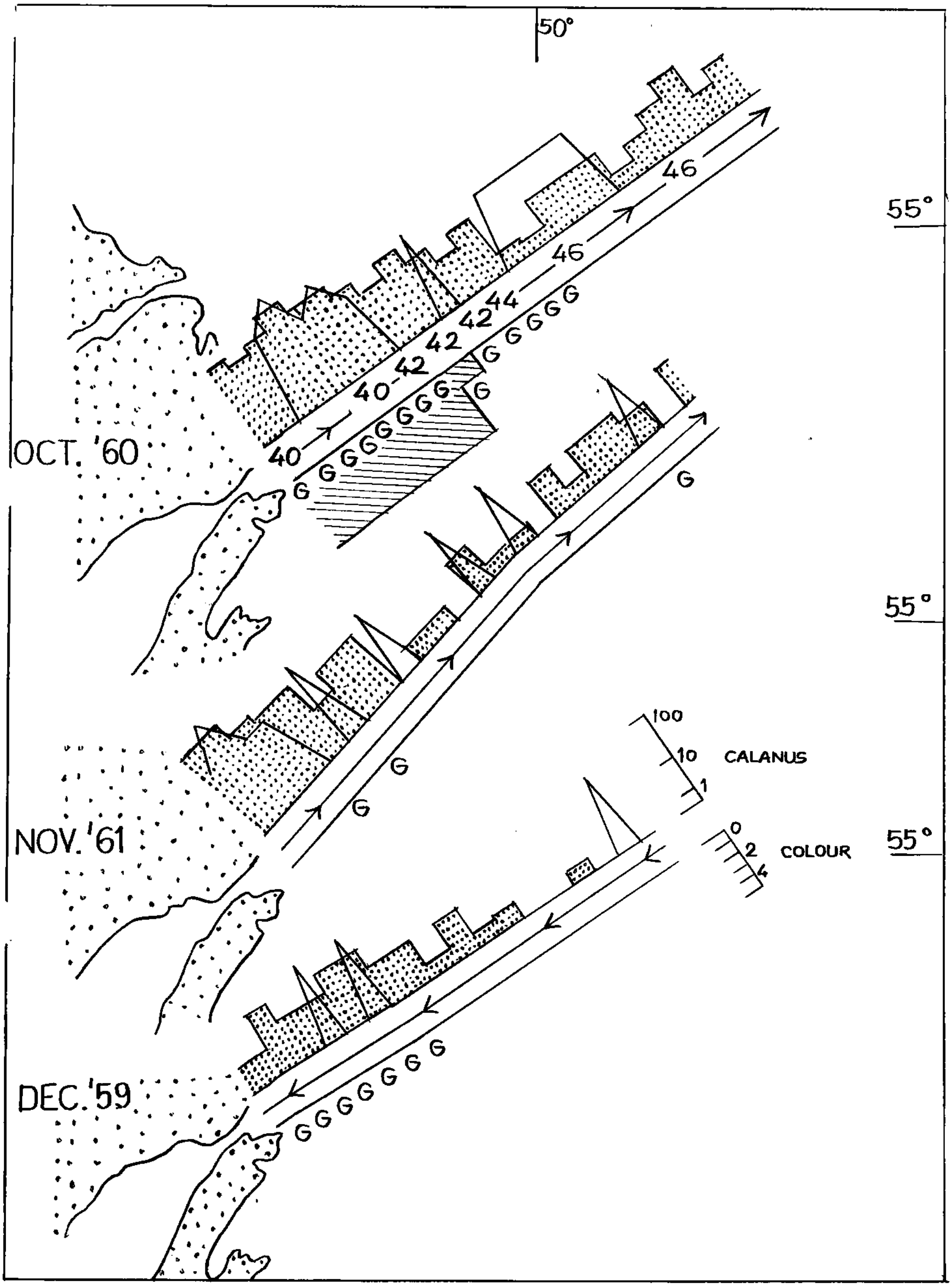


Fig. 1 d.
Fig. 1 cont'd.
and W the presence of warm-water species (See Table I).

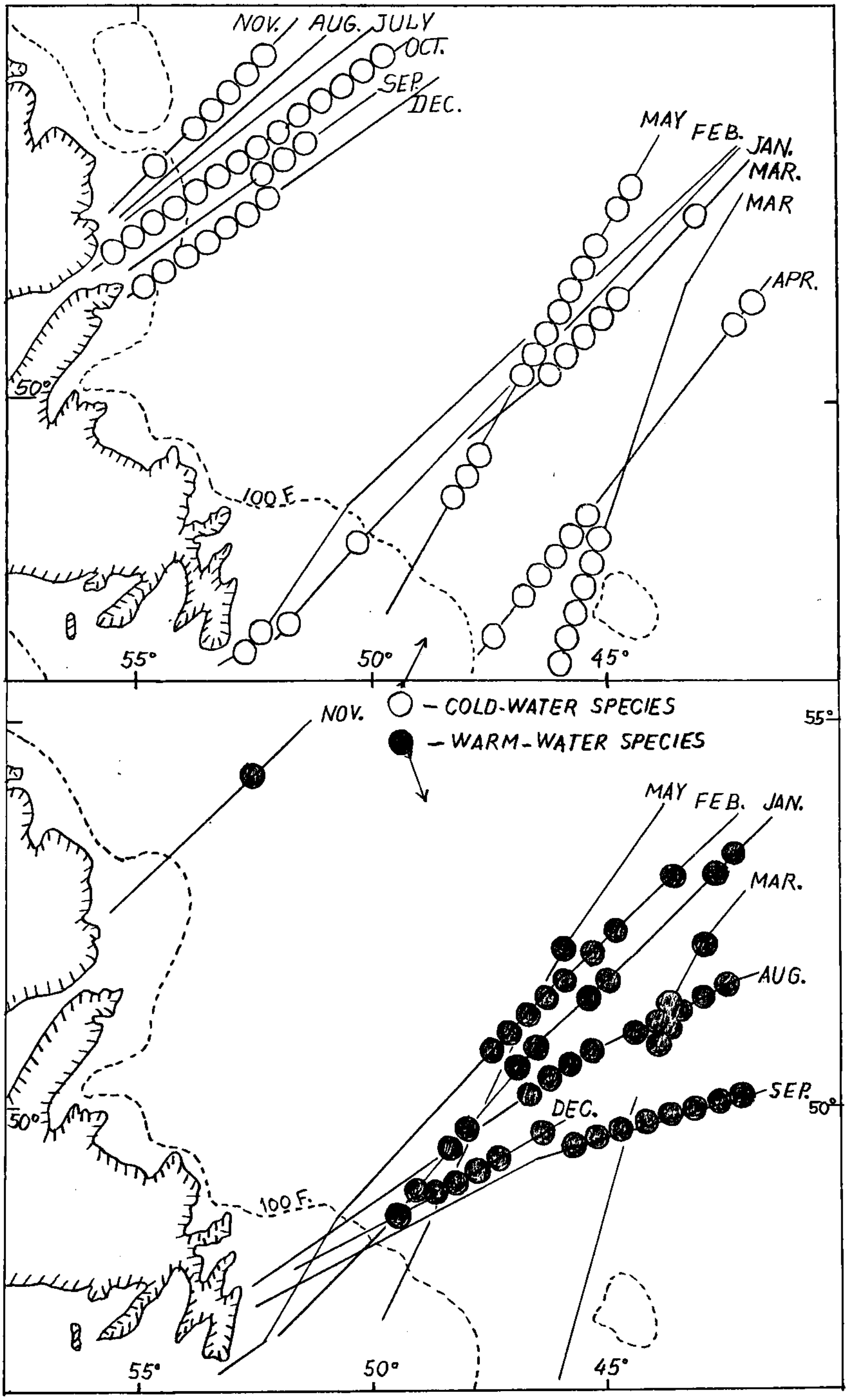


Fig. 2. Distribution of warm-and cold-water species on Recorder routes 'D' and 'Z' off Newfoundland, December 1959 to January 1962 (See Table I).

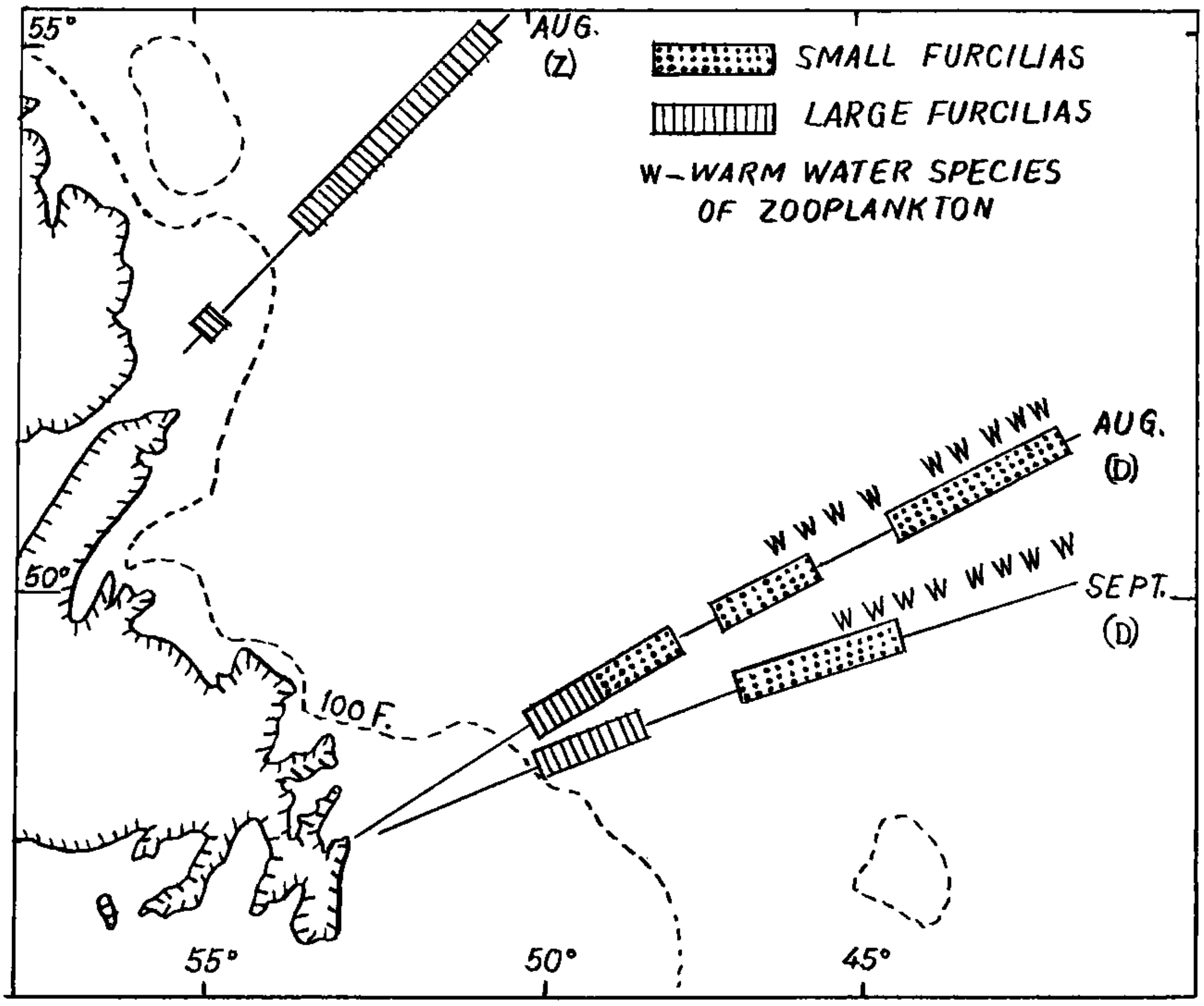


Fig. 3. Distribution of furcilia larvae of Thysanoessa longicaudata on Recorder routes 'D' and 'Z' in August and September 1961 (See Table II).

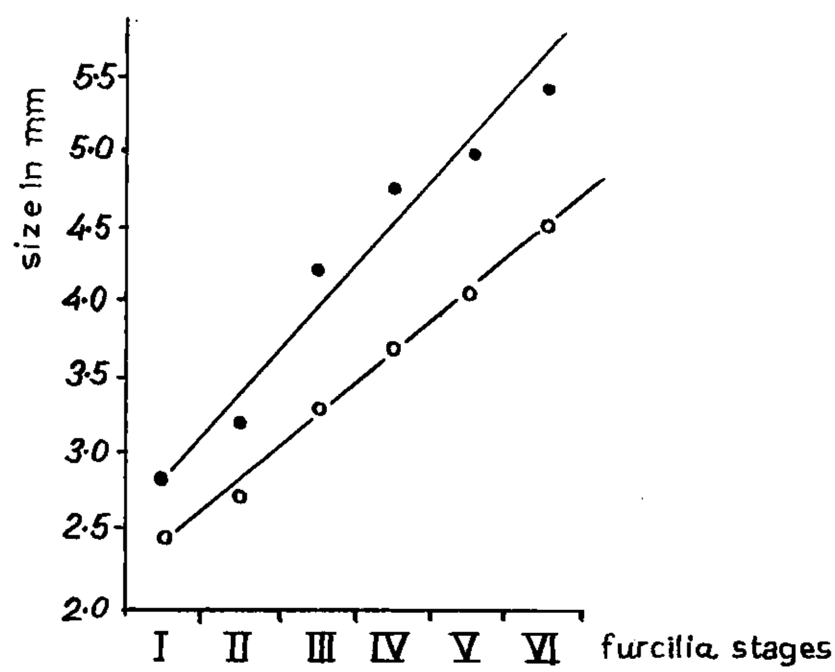


Fig. 4. Mean sizes of Thysanoessa longicaudata furcilia stages. Dots represent furcilias from the hatched areas in Fig. 3. Open circles represent furcilias from the stippled areas in Fig. 3.