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Zooplankton Surveys in the Northern North Sea with the Gulf III Sampler

By

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Introduction

Zooplankton surveys in the northern North Sea, with the Gulf III sampler, were started by the Aberdeen Laboratory in the autumn of 1960 with the main purpose of obtaining data on the total standing crop of zooplankton, and material for population studies of selected species. During 1961 the samples were also analysed in detail for all specics, and as this is a relatively new method of sampling in this area, the results may be of interest for comparison with those obtained by other workers, during the same period, using other methods of collection.

In this paper the distributions of a number of species will be given.

Detailed results from the same surveys of the standing crop have been submitted to Annales Biologiques, Vol. 18, and the results of a population study of Metridia lucens Boeck are given by Adams (1962).

Methods

The Gulf III sampler used in the present investigations was the modified form with an 8 inch (20.3 cm) aperture (see Bridger, 1958; Gehringer, 1962; and Southward, 1962). The mesh had a mean aperture of 0.231 mm and ended in a detachable silk bag. A Currie and Foxton depth flow meter (Currie and Foxton, 1957) was placed in the tail cone.

All hauls were oblique from near the bottom to surface, the ship steaming at 6 knots. Estimates of most species were based on Stempel pipette subsamples and the flow meter readings were used to calculate densities per m^3.

Steele (1961) - see also Gehringer (1962) - reported that when a metal bucket was used at the end of the net, the collections obtained were extremely small compared with those obtained when a silk bag was used as the cod-end. To test this difference further a number of experimental hauls were carried out and the results are given in Table 1.

Although these data support the suggested difference, they also suggest that the discrepancy is not as great as originally thought. If the results for individual species are grouped or contoured in the method adopted by many workers, i.e. using the intervals

0.1 - 0.3 - 1.0 - 3.0 - 10 - 30 etc.

then in all but two of the examples in Table 1 the two methods would give the same result. The two exceptions are borderline cases. The difference may be more serious in standing crop estimations, as there can be little doubt that the differences that can be expected in dry weight values from year to year will lie between rather narrower limits.

Results and Discussion

The distribution of Calanus.

The distribution and abundance of Calanus are shown in Figure 1. (The two forms of Calanus - finmarchicus (Gunnerus) and helgolandicus (Claus) - were not distinguished.) During March, densities were low throughout the area investigated, but by April the population had greatly increased with a marked centre of abundance towards the north-east of the area. The level of abundance had decreased by June with the main area of abundance to the east of 1°W. The September distribution was completely changed - an area of high densities extending south south-east from the Orkney-Shetland Channel.

Gibbons and Fraser (1937), on the basis of results for the period 6. April to 4. May 1936, discussed the importance of the recruitment of Calanus from the eastern North Sea. Although their observations were further north than the present observations it seems possible that the 1961 April distribution may also be related to additions from the Norwegian Deeps. This possibility is discussed further below.

The September distribution was very suggestive of an inflow from the Orkney-Shetland Channel and thus agreed well with Rees (1948, 1957). As the September distribution corresponds fairly closely with the area where primary production remains at a high level during the June to August period (Steele, 1961, Fig. 2) it is also possible that the changing pattern of primary production was partly responsible for the seasonal change in the centres of abundance.

The distribution of Sagitta elegans Verill.

Similar patterns of changing centres of abundance were shown by Sagitta elegans. Unlike Calanus, the highest densities of S. elegans were recorded in March and September; the high March densities were at two isolated stations surrounded by low values, whilst in September the area of high values (10-30 per m^3) was extensive and covered the same area as the high Calanus densities.

Southward (1962) has suggested that the distribution of S. elegans in a number of areas can be explained on the basis of its being a cold water stenotherm. In Table 2 the different levels of abundance of S. elegans, during September, are compared with the average surface and bottom temperatures, and temperature differences, based on observations made at the same time as the Gulf III hauls. The surface temperature shows little variation and the highest surface temperature is near the meanvalue for the western area of the Irish Sea in autumn (Bowden, 1955, Fig. 3d) where Williamson (1956) reported S. elegans to be the dominant chaetognath, and where Southward (loc. cit.) has correlated its distirubiton with temperature. On the other hand, average bottom temperature ranged from 10.76°C where S. elegans was relatively abundant to 7.35°C where it was absent. Thus, in the present area in September 1961, S. elegans reached highest densities in the area with highest average bottom temperature and greatest thermal homogeneity, but as with Calanus there is no conclusive evidence as to which of the possible factors were controlling its distribution.

Centropages hamatus (Lilljeborg) and Temora longicornis (Müller).

Colebrook et al. (1961) have discussed whether or not the North Sea populations of these species are independent of other populations outside the area. Their distributions in 1961 are shown in Figure 2 a and b. C. hamatus was very restricted in its distribution and it seems almost certain that it was independent of additions from outside, especially from the north-west. T. longicornis on the other hand, had a much more general distribution and there is nothing to suggest that additions from outside the area did not take place.

The distribution of Centropages typicus Krøyer.

This species was recorded during two of the surveys - March and September (Figure 2 d). The September distribution showed two centres of relative abundance, separated by an area where it was not recorded. The two areas may or may not have been connected shoreward of the survey stations, but there was also a slight difference in the modal length of the female cephalothorax - those of the north-west had a modal length of 1.3mm, those of south-east a mode of 1.2 mm.

Thus, as also found by Rae and Rees (1947), the present data suggests the development of C. typicus in the south-east of the area seemingly independently of recruitment from the north-west. That the north-western population was similarly independent is less clear.

The Cladocera

Three species of Cladocera - Evadne nordmanni Lovén, Podon leuckarti Sars and P. intermedius Lilljeborg were recorded in low numbers (see Table 3). The two species of Podon showed a marked seasonal alternation; only P. leuckarti was present in March and it was dominant in April, while only P. intermedius was found in September. Similar results are given by Williamson (1956).

E. nordmanni was present throughout the period of the survey, and was most abundant in September. Its distribution (Fig. 2c) had two main centres, one corresponding with that of C. hamatus and the other on the western edge of the Norwegian Deeps. This latter area corresponds well with the area of mixing suggested by Steele (1957, 1958, 1961) the western boundary of which is indicated on the chart.

It is therefore possible that E. nordmanni may show the extent of the westward transport of water from the Norwegian Deeps area due to lateral mixing. Wiborg (1940, 1944) and Bainbridge (1958) have both shown that E. nordmanni is almost exclusively confined to the upper water layers (upper 50 m in the Oslo Fjord; upper 15 m in Nordåsvatn; upper 30 m in the Firth of Clyde), and if this is true of the present area then it would be well suited to indicate the westward mixing which is confined to the water above the thermocline (approx. 30 m - Steele, 1957). However, E. nordmanni was distributed much further west than expected on the theory by April and it had not extended further west by June. There may have been an early westward mixing bringing with it large numbers of Calanus whose area of abundance is also indicated on Figure 2c, although there does not seem to be any definite hydrographic evidence of this.

It seems that greater attention should be paid to lateral eddy diffusion as an important factor in the seeding of the shelf area of the northern North Sea from the east.

However, unlike Evadne which seems to be confined to waters above the thermocline, in many species, e.g. Calanus different stages will be effected to varying degrees by eddy diffusion, depending on their depth distribution and seasonal changes in this feature.

Summary

Routine Gulf III surveys were recently started from Aberdeen to provide standing crop data, and the samples are also being used in population studies of a number of species. During 1961 the samples were analysed in detail for all species, and it is with this part of the work that the present paper deals. The other aspects of it are described elsewhere.

The report that a Gulf III with a silk bag cod-end caught more than one fitted with a metal bucket cod-end led to further experiments which show that for most purposes the difference, although a real one, is small, but it may be more serious in studies of the standing crop.

The distribution and abundance of Calanus is described. It is suggested that additions from the Norwegian Deeps were responsible for the April distribution, while the September distribution was linked with inflow from the north-west. However, the seasonal changes in primary production must also be considered as a possible cause of changes in distribution.

The general similarity in distribution of Calanus, and Sagitta elegans is noted. Following Southward's suggestions, the temperature associations of S. elegans during September are given, but do not confirm a cold water association.

The distributions of Centropages hamatus and Temora longicornis show that C. hamatus was almost certainly self contained, but T. longicornis may well have received additions from outside.

Centropages typicus was recorded in March and September. Its September distribution shows the presence of a south-east unit which seems to have developed independently of recruitment from the north-west.

The seasonal abundance of the Cladocera is given and the possibility of using Evadne nordmanni to indicate the westward movement of surface waters from the Norwegian Deeps is discussed.

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Table 1

Comparison of catch taken by Gulf III fitted with metal bucket cod-end and silk bag cod-end

Entity 5)	Estimate of abundance per m^3 1)		Factor of difference Bag > Bucket
	Bag 2)	Bucket 3)	
Calanus finmarchicus	63	43	1.46
Pseudo/Paracalanus	17	13	1.31
Temora longicornis	163	114	1.43
Acartia	178	114	1.56
Centropages hamatus	6	4	1.50
C. typicus	5	7	
Oithona	10	6	1.66
Podon intermedius	27	25	1.08
Evadne nordmanni	13	13	
Oilopleura	99	46	2.15
Sagitta elegans	3	1	3.00
Pleurobrachia pileus	0.7	0.5	1.40
Standing crop	2.48 4)	1.38 2)4)	1.80

1) Calculated on basis of flow meter readings.
2) Average of 9 samples.
3) Average of 8 samples.
4) g dry weight/100 m^3.
5) Only those species which were well represented in both sets of samples have been considered.

Table 2

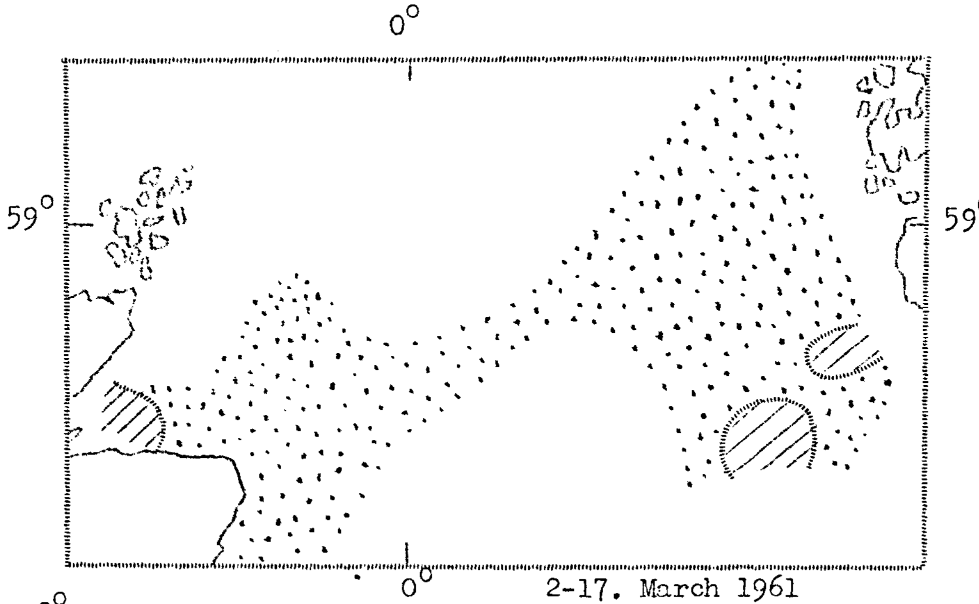
Comparison of density of Sagitta elegans with average surface and bottom temperatures, and surface/bottom temperature differences during September 1961

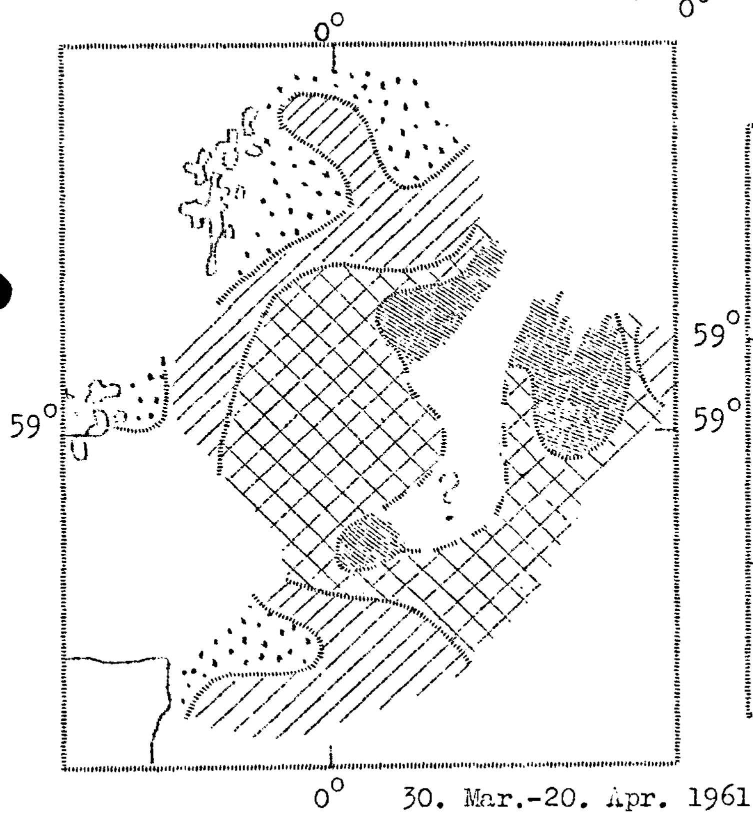
Number of Sagitta elegans per m^3	Average surface temperature °C	Average bottom temperature °C	Average temperature difference °C
10-29	12.47	10.76	1.71
3-9	12.96	9.73	3.23
1-2	12.82	8.50	4.32
Absent	13.63	7.38	6.25

Table 3

Seasonal abundance of the Cladocera in 1961

Number per m^3	2.-17.March	30.March-20.April	14.-25. June	7.-22.Sept.
Evadne nordmanni	1	1	1	4
Podon leuckarti	0.4	2	-	-
P. intermedius	-	0.5	-	5





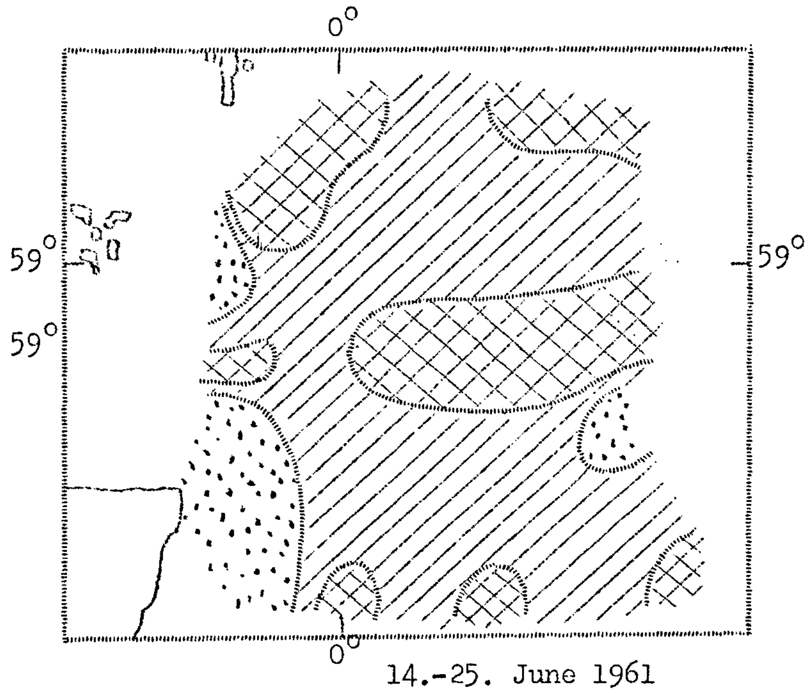
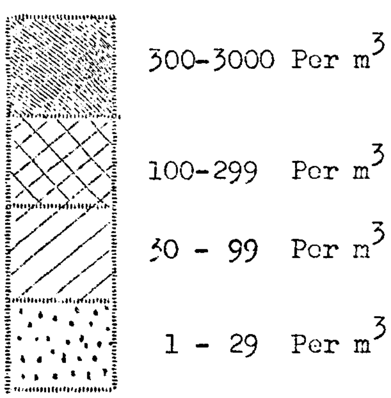
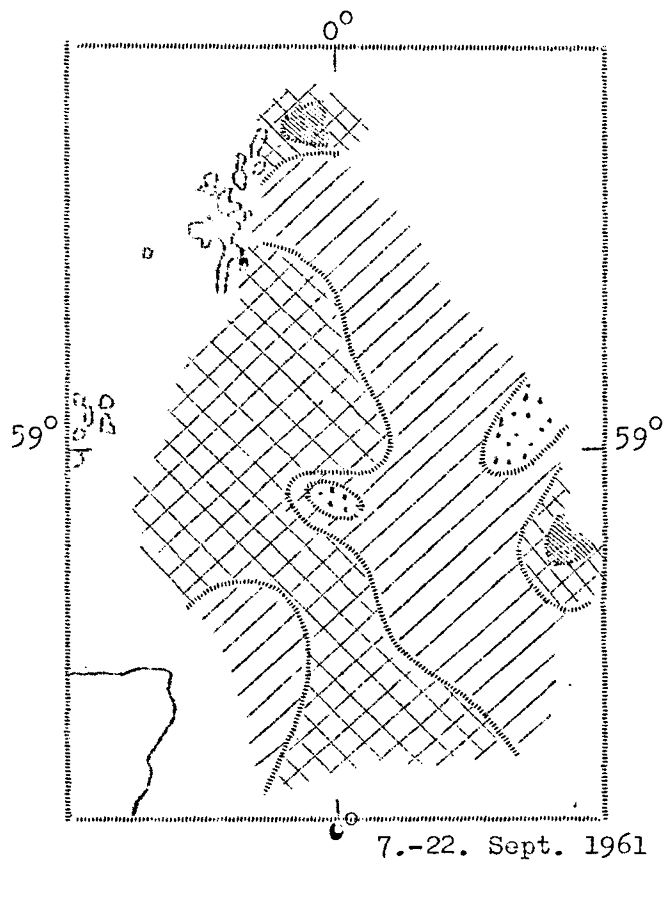
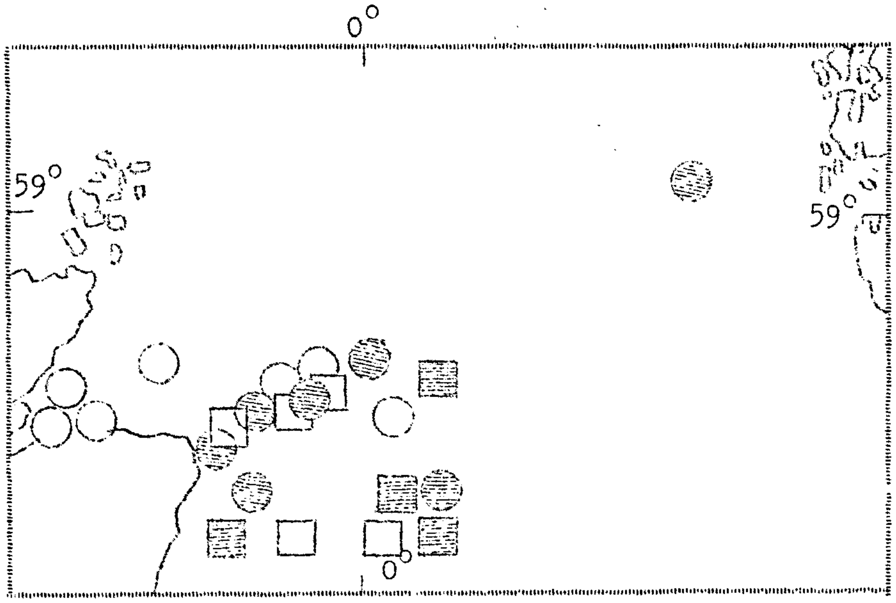


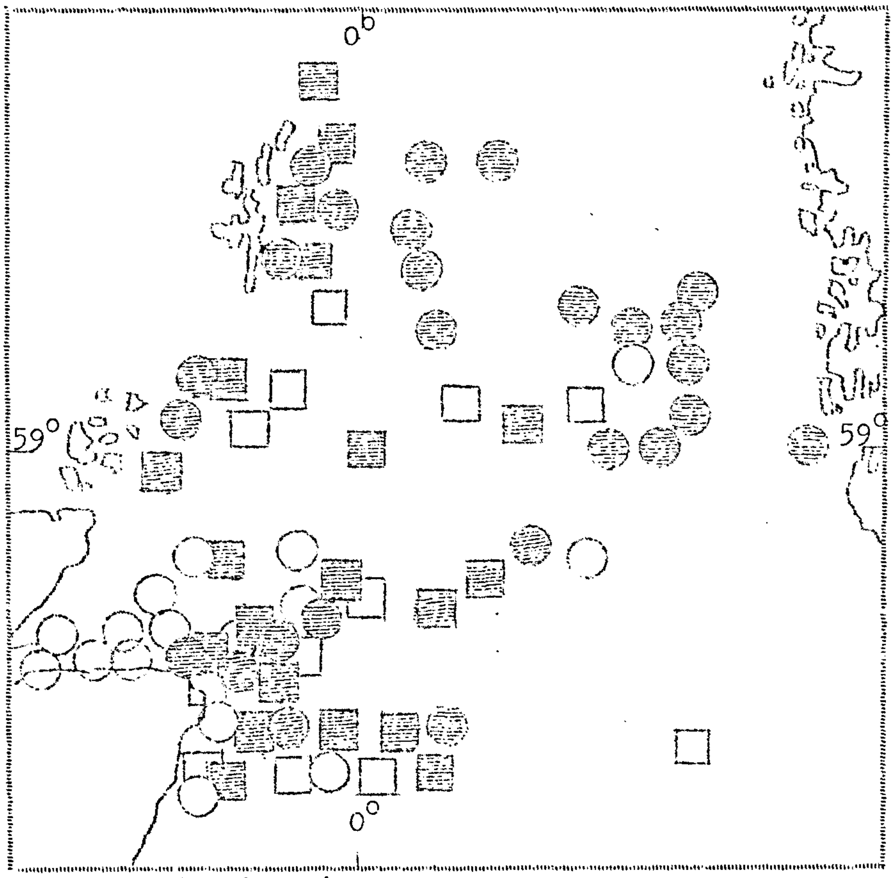
Fig. 1. Zooplankton surveys in the Northern North Sea with the Gulf III sampler.



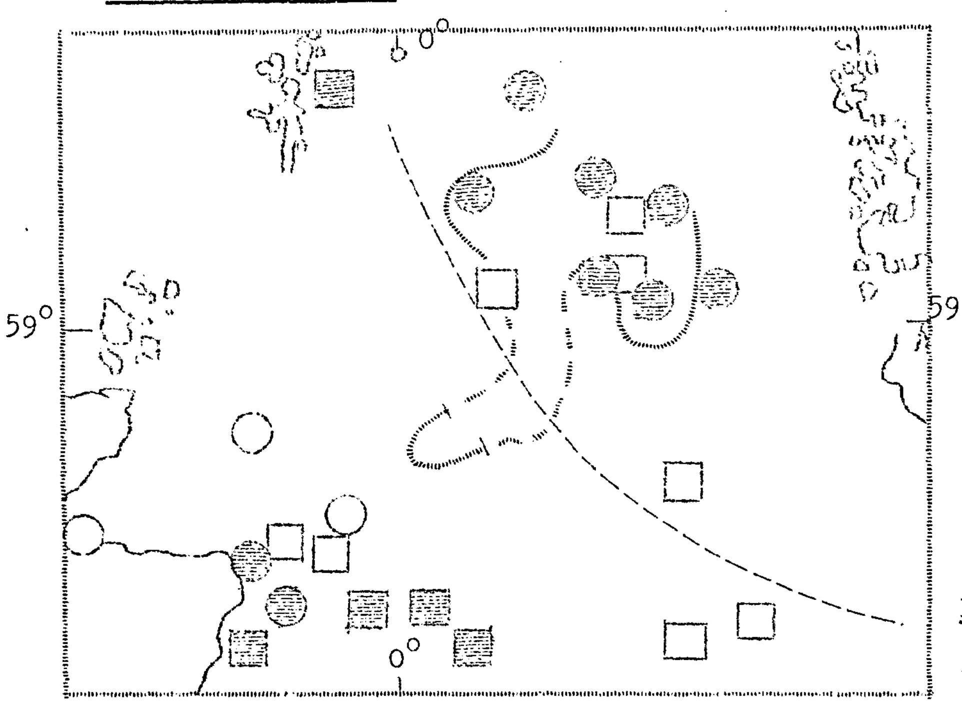




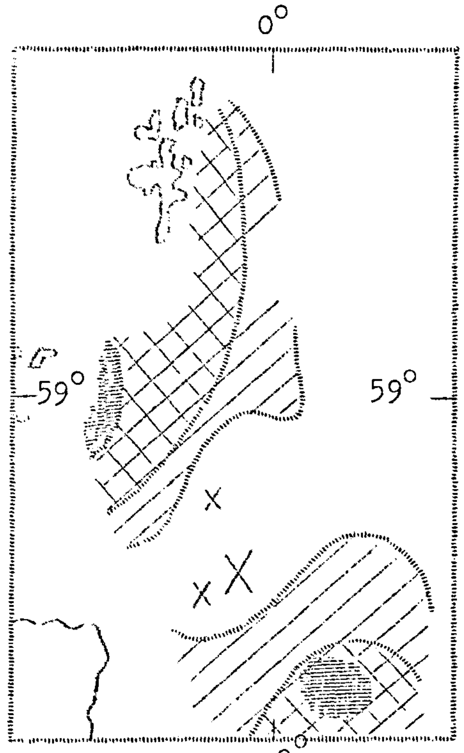
a. Centropages hamatus



b. Temora longicornis



c. Evadne nordmanni



d. Centropages typicus

a.b.c.

- March
- April
- June
- September

Distribution of Calanus > 300/m³ in April

Western edge of area of mixing (after Steele).

d.

- 0.03 per m³, 0.1 per m³: 2.-17. March
- 10-29 per m³, 3- 9 per m³, 0.3-2 per m³: 7.-22. Sept.

Fig. 2. Zooplankton surveys in the northern North Sea with the Gulf III sampler