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Zooplankton and Hydrography in the Southern Part of the Norwegian Sea.

by

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Gran (1902) has divided the Norwegian Sea in regions each having its characteristic plankton community. Damas (1905) studied the copepods in the central part of the Norwegian Sea and found 5 plankton elements, the distribution of which he put in relation to the circulation of currents, a hypothesis which was supported by Helland-Hansen and Nansen (1909).

From the laboratories in Aberdeen and Edin burgh extensive investigations are done on the problem of the plankton indicators of hydrographical conditions in the area north and east of Scotland, Fraser (1952), in the sea around the British Islands, published especially in Hull Bulletins of Marine Ecology and in the yearly reports in Annales Biologiques (1949-54) (The continuous plankton recorder survey).and from Plymouth Russell's important works.

Last year Wiborg gave a lecture at the plankton meeting: Plankton and Hydrography in the Norwegian Sea, in which he demonstrated the quantitative distribution of the most important plankton animals.

The material I have dealt with is smaller than Wiborg's. It is from the cruise of the "Dana" in the southern part of the Norwegian Sea (from the Faroes to maximale 65°30' N) in June and November-December 1951 and June 1953.

The quantitative distribution of the zooplankton in June (caculated as dry weight in mg per haul of Hensen Net in 50 - 0 m) shows that the maximum populations 1000 - 6000 mg are found in eddies and border areas between atlantic water and the East Icelandic Current and partly in the Faroe-Shetland Channel. The smallest stocks (100 - 500 mg) were found in 1) the coldest part of the East Icelandic Current and 2) in the coastal waters of the Faroes.

In November-December the total population of zooplankton was very little in the upper 50 m from <1 to 260 mg dry weight per haul, average 68 mg.

The quantitatively dominating plankton animals Calanus finmarchicus, C. hyperboreus and Pseudocalanus minutus hibernate below 600-1000 m depth in the Norwegian Sea, Østvedt (1955).

Also the stock of other plankton animals is decreased exceedingly in the surface layers in the winter. In June 1951 11.880 indv. of chætognaths were caught in 34 hauls, in November-December only 16 indv. in 14 hauls.

The complicated hydrographical conditions in the area investigated give rich opportunity to the study of biological indicators of the hydrographical conditions.

In general three patterns of distribution of the species of zooplankton are met with in the area investigated, where we have neritic, atlantic and subarctic watermasses.

A. The neritic species have two patterns of distribution.

1. In June 1951 the copepods Acartia longiremis (slide) and Centropages hamatus were only found around the Faroes inside the 200 m curve and off the Shetland Islands. These species were exclusively bound to coastal waters.

2. Wiborg (1954) has shown that the neritic species Temora longicornis (Copepoda) and Evadne nordmanni and Podon sp. (Cladocera) are distributed from the Faroes to 65° N and Evadne further from Jan Mayen to Norway. These three species had a characteristic distribution in June 1951. Only a few numbers of Evadne (slide) were found at 4 stations in the Faroe-Shetland Channel. But north of the Faroes this species was found at 14 stations with maximum populations in the mixing area of warm and cold water (up to 1200 indv. per haul). Podon sp. was found exclusively in this area (100-1600 indv. per haul). The quantitave distribution of Temora longicornis was of a similar pattern as that of Evadne. It was found in numbers up to 30 % (37.000 indv. per haul) of the copepods in the border area.

The decapod larvæ had a distribution somewhere between the pattern 1 and 2. They were found in majority around the Faroes and partly in the eastern part of the Faroe-Shetland Channel. A few numbers were found regulary at the stations between the Faroes and the East-Icelandic Current. In November-December 1951 Podon and Evadne were not found at all hibernating as wintereggs.

Temora was found only at the plateau of the Faroes and at two stations north-east of these islands. This indicates that in the spring these 3 species are carried from the Faroes to the productive border area, where they establish great populations during the summer, every spring being dependant on new recruitment from the Faroes.

In the atlantic and subarctic waters Calanus finmarchicus and Pseudocalanus minutus are the dominating plankton animals constituting more than 90 % of the number of copepods.

Both have maximum populations in the border areas between warm and cold water as also Wiborg (1954) has shown. This is a result of 1) the favourable food conditions and 2) introduction of new populations by both the cold and the warm watermasses. In the Norwegian Sea the distribution and course of the currents and watermasses are very variable and complicated and therefore it is often difficult to judge by the number - eo ipso - of Calanus finmarchicus and/or Pseudocalanus what sort of watermasses you have.

But an examination of the percentages, which Calanus finmarchicus and Pseudocalanus make up of the total populations of copepods, will indicate the type of water. As mentioned these two species are the dominating plankton elements. The maps showing the percentages they make up of the total number of the copepods will consequently be reflected images of each other.

B. The atlantic water is characterized by a very high Calanus %, 90 % - 100 % of the copepods in June 1951 (slide). This was the case in the Faroe-Shetland Channel and in the area north and west of the Faroes. In the water of the East-Icelandic Current carrying subarctic water the Calanus % was low (32 % - 70 %). The presence of this water always causes decrease in the percentage of Calanus as seen in the border areas and in the Faroe-Shetland Channel into which a tongue of cold water is stretching. Also the coastal water are characterized by a low percentage of Calanus (18,5 % - 68 % of the copepods).

During the cruise from 4. - 26. June 1953 plankton indicators were used between the stations (fishing at a depth of about 35 m, where the herring shoals are found) (slide). As will be seen later the populations of Calanus decrease with increasing depth. This is the reason why the percentages of Calanus are so extremly low in the subarctic water (often only 14 % - 20 %) compared with the material taken by the Hensen Net (50-0 m) in June 1951. In the atlantic water of 8° - 9° in 20 m we have a Calanus % of the same size as in June 1951, 80 % - 100 %. A percentage of similar size is found in the areas, where tongues of warm water are stretching into the East-Icelandic Current, as in the area ~~west~~ east of Iceland. In the cold water inside the 5° isotherm in 20 m depth we have a Calanus % in 1953 ranging from 14 % - 50 %, most frequently 30 % - 40 %.

Among the species indicating atlantic water are: Rhincalanus nasutus, Euchirella brevis, Centropages typicus, Acartia clausi, Microsetella rosea, Conchoecia obtusata, Tomopteris sp., Physophora hydrostatica.

In an inhomogeneous area such as the Norwegian Sea the populations of plankton animals will be in different stages of development in different zones of temperature.

Tabel I.

Typical populations of Calanus finm. in 3 different zones of temperature.

Date:	Zone of temp. (in 20 m)	The percentage of stages of development. N.	cop.I.	cop.II.	cop.III	cop.IV.	cop.V.		
18/6 1951.	5° C.	2,6	22,8	49,2	22,0	1,7	1,7	+	-
18/6 1951.	6° C.	x	2,7	21,1	42,3	31,7	2,2	-	-
20/6 1951.	7° C.	-	x	1,1	14,6	64,9	19,5	-	-

The populations are about 1 cop. stage older per degree warmer water. During the hibernation which takes place in cop. stage IV & V Østvedt (1955) this difference in development of the stages of the populations in the surface layers is equalized.

Whether you look upon the horizontal or the vertical distribution of the warm and cold watermasses the populations of Calanus are distributed in the same way. Vertically the two watermasses are separated by a discontinuity layer. As a typical example is shown the conditions at station 7635 from eastern border of the East-Icelandic Current. A pronounced discontinuity layer is situated here in 50 m depth (slide). Hauls were taken from 25 - 0 m and below the discontinuity layer from 100 - 50 m. Three features are conspicuos in the populations of Calanus finmarchicus above and below the discontinuity layer.

1) The number of Calanus in 100 - 50 m is only 10 % of the number in 50 - 25 m and only 3 % of the number in 25 - 0 m.

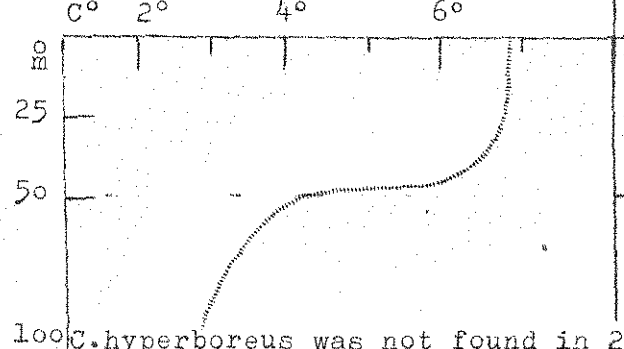
2) In the hauls 25 - 0 m and 50 - 25 m Calanus constitutes resp. 61,6 % and 57,0 % of the copepods, below the discontinuity layer only 36 % (as in the central part of the East-Icelandic Current).

3) The younger stages cop. II - IV are dominating above the discontinuity layer making up > 90 % of the stock. Below the discontinuity layer cop. IV-adults constitutes 96 % of the stock.

C. At station 7635 the vertical distribution of Calanus hyperboreus and Pseudocalanus minutus is reversed that of Calanus finmarchicus.

Table 2.

St. 7635. The vertical distribution of 1. a species preferring atlantic and 2. and 3. species indicating subarctic water.



	Per cent of the copepods.		
	1. Calanus finmar.	2. Calanus hyperbor.	3. Pseudocal. minutus
	61,6	0	35,2
	57,0	3,5	37,0
	36,0	9,5	51,0

C.hyperboreus was not found in 25 - 0 m, in 50 - 25 m it constituted 3,5% (1685 indv.) of the copepods, but below the discontinuity layer 9,5 % (714 indv.) of the copepods.

This species has given name to the arctic plankton in the Norwegian Sea, Damas (1905). The greatest populations are found north and north-east of Jan Mayen, Wiborg (1954). The slide shows its distribution in June 1951 with the close association to the subarctic water, where it occured at most stations, but only in small populations (from a few to 1700 indv. per haul) always making up a few % (maximum 7,5 %) of the copepods. By the East-Icelandic Current it is carried through the Faroe-Shetland Channel, where Fraser (1952) have found it regulary.

Damas (1905) named the plankton of the central part of the Norwegian Sea after Pseudocalanus. Wiborg (1954) found the areas of maximum populations of Pseudocalanus minutus partly in eddies partly in border areas between temperate and cold water. In the material from June 1951 the maximum numbers of Pseudocalanus were also found near the borders of cold and warm water (30.000 - 60.000 indv. per haul, 50 - 0 m). But if you look at the composition of the population of the copepods in the whole area, you will find that Pseudocalanus makes up the greater part of these in colder water.

The material from June 1952, taken by the plankton indicators, shows the same distribution, with association to the subarctic water in the central part of the Norwegian Sea. Here the demonstration of the presence or number - eo ipso - of one of the three predominating plankton elements, Calanus finmarchicus, C. hyperboreus and Pseudocalanus minutus is not sufficient for the indication of the type of watermass . You have to consider the quantitative relation between the three species.

Table 3. Pseudocalanus minutus (1951).

Zone of temperature (2o m.).		Percentage (average) of the copepods.
4° - 5°	north of the Faroes.	35,o
5° - 6°		35,2
6° - 7°		32,7
7° - 8°		32,6
8° - 9°		12,4
The Faroe-Shetland Channel:		
1) Atlantic Water		1,7
2) In the tongue of subarctic water		13,o

Other species indicating subarctic water are Pareuchæta norvegica, Metridia longa and Eukronia hamata. Im November - December 1951 Calanus hyperboreus was not found in the upper 5o m. in the southern part of the Norwegian Sea, and the stocks of Pseudocalanus and Calanus finmarchicus were very small. This is in accordance with Østvedt's (1955) investigations.

Many of the species belonging to the water of the intermediate depths (1oo - 6oo m.), (Østvedt, 1955), submerged during the summer in the southern part of the Norwegian Sea, but were common in November - December in the upper 5o m.(Microcalanus, Scolecithricella minor and Pleuromamma robusta).

This summer it was the intention to make extensive investigations of the fertility of the different watermasses in the southern part of the Norwegian Sea by means of the C^{14} method and compare the result with the distribution of zooplankton as the Norwegians have done in the northern part. Unfortunately this programme had to be reduced, but it is the intention to fullfill the original programme next year.

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