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VARIATIONS IN THE QUANTITY OF ZOOPLANKTON AND THE PROPAGATION OF *CALANUS FINMARCHICUS* AT STATION "M" IN THE NORWEGIAN SEA, 1959—1966

By

ULF LIE

Institute of Marine Research, Bergen

Present address: University of Washington, Dept. of Oceanography, Seattle. Washington 98105, USA.

INTRODUCTION

The weather ship station «M» is located in the core of the North Atlantic Current at 66° N and 02° E. The hydrographic conditions are reviewed in ØSTVEDT (1955). Atlantic water masses extend downwards to 400—600 m; from about 600—1000 m the water masses are of mixed Atlantic and Arctic origin, and below 1 000 m the Norwegian Sea bottom water is found.

Zooplankton has been collected at station «M» since the summer of 1948, and a detailed analysis of the material from October 1948 to November 1949 is presented by ØSTVEDT (1955). Some aspects of the biology of copepods from station «M» were discussed by WIBORG (1955), and the variations in quantity of zooplankton from 1950 to 1958 were presented by WIBORG (1958, 1960).

The present paper reports on the quantities of zooplankton and the propagation of *Calanus finmarchicus* during the period 1959—1966.

MATERIAL AND METHODS

The present paper is based on 805 samples collected from January 1959 to September 1966, but only the 100 to 0 m samples from 1966 are included. The samples were collected in vertical hauls from depths of 25—0 m, 100—0 m, and 600—100 m with a Nansen net (diametre 72 cm, mesh size 0.2 mm) (WIBORG 1954). No samples were available from January to May 1963, and from July to December 1964, when the weatherships were stationed between Iceland and Greenland.

The zooplankton volumes were measured by the displacement method (WIBORG 1954) after removal of large coelenterates and salps, and the stage composition of *Calanus finmarchicus* was determined as described in

LIE (1965). The dominating zooplankton species were identified, but no counting or evaluation of the relative abundance of the species has been performed.

In August 1965 «Polarfront I» and in October 1966 «Polarfront II» changed to Juday nets (diametre of upper ring 40 cm, mesh size 0.2 mm) (BOGOROV 1959). The sampling area of the Nansen net is 3.2 times larger than the Juday net, and the samples obtained with the Juday net were therefore multiplied by 3.2 to make the samples from the two sampling gears comparable.

The samples from the 600 to 0 m layer were assumed to represent the fauna of the Atlantic waters at station «M». However, MOSBY (1950) demonstrated oscillations with an amplitude of 200—300 m in the border layer between the Atlantic water and the underlying mixed water. Samples from 600—0 m may therefore represent zooplankton from different water masses. These conditions emphasize the suggestion by BANSE (1964) that zooplankton sampling should be made in relation to meaningful hydrographic parameters rather than to standard depths. However, that would require the presence of planktologists during the sampling, which was not possible at station «M».

RESULTS AND DISCUSSION

VOLUMES OF ZOOPLANKTON AT STATION «M»

Fig. 1 shows the volumes of zooplankton in the upper 100 m at station «M» as monthly means from January 1959 to September 1966. Considerable differences among the years are demonstrated; particularly 1965 and 1966 were rich and 1961 was poor in zooplankton. Similar differences among the years were demonstrated in Norwegian coastal waters (LIE 1965, 1966), where 1965 was the richest and 1961 was the poorest in zooplankton during the period 1959—1965. The coastal waters in the years 1963 and 1964 had considerably higher zooplankton volumes than in the preceding four years, but a similar pattern could not be demonstrated at station «M».

Comparisons with the earlier investigations (WIBORG 1955, 1958, 1960) indicate that the quantity of zooplankton at station «M» during 1965 and 1966 was considerably higher than in any other year since 1950.

Fig. 1 shows that the zooplankton during the first and last quarter of the year as a rule is extremely scanty in the upper 100 m. WIBORG (1955, 1958, 1960) found a slight second peak on the curves occurring in the period September—November. Similar features are also weakly indicated in Fig. 1.

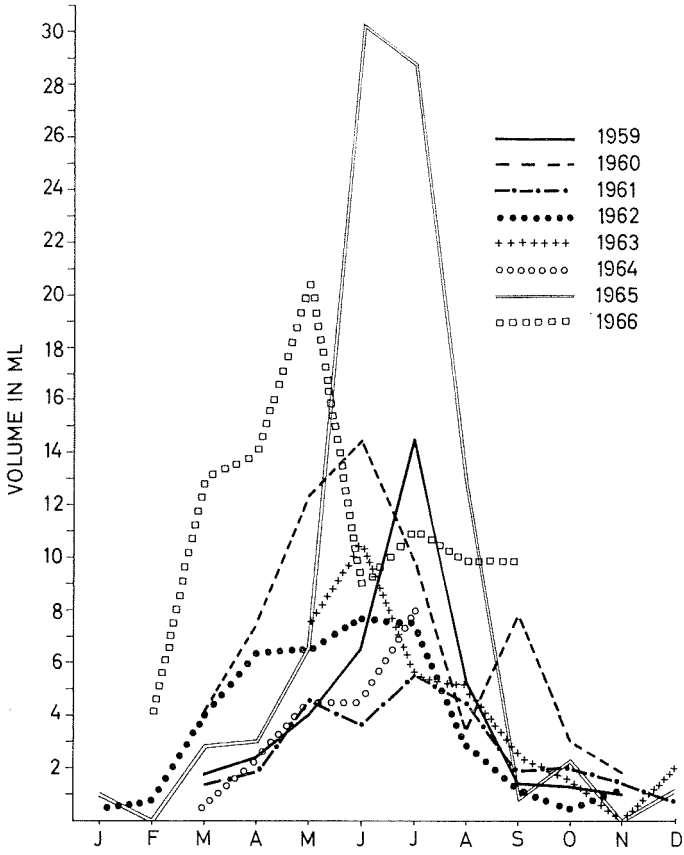

Fig. 1. Monthly mean volumes of zooplankton at station «M» in 100—0 m from 1959 to 1966.

The volumes of zooplankton in the 600 to 100 m layer are shown in Fig. 2. The volumes during December and January are somewhat lower than during the rest of the year, but the curves reveal a remarkably low variability both among monthly means and among years. About 75 % of the monthly mean volumes ranged from 5 to 13 ml.

BARNES (1949) demonstrated that a considerable portion of the plankton in vertically towed nets may be lost during the process of closing the net. The amount of zooplankton from the 600 to 100 m layer may therefore be underestimated and not directly comparable to the samples from the 100 to 0 m layer.

BEYER (1962) discussed the vertical distribution of zooplankton biomass at station «M» during 1950—1951 based on data from WIBORG (1954). He concluded that there were small seasonal variations in the biomass of the water column from 2 000 to 0 m, and he found the con-

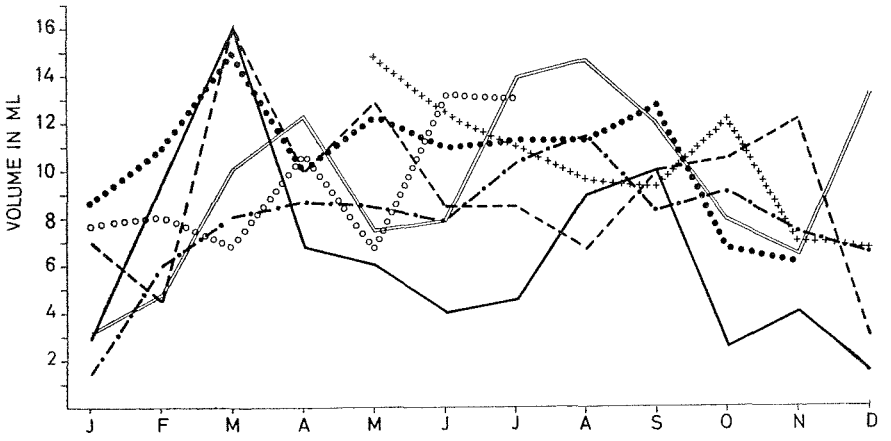

Fig. 2. Monthly mean volumes of zooplankton at station «M» in 600—100 m from 1959 to 1965. Symbols as in Fig. 1.

ditions in this respect at station «M» to be similar to the conditions in the Southern Ocean as reported by FOXTON (1956). The constancy of the total biomass was explained by seasonal vertical migrations as demonstrated in ØSTVEDT (1955), and by absorption of water by the hibernating specimens.

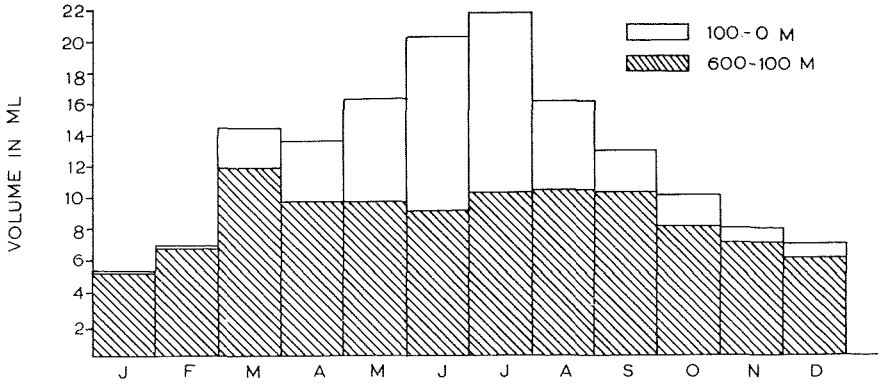

Fig. 3. Average of monthly mean volumes of zooplankton in 100—0 m and 600—100 m from 1959 to 1965.

The zooplankton volumes of the 600 to 100 m layer from 1950 to 1951 (WIBORG 1954) differ significantly from the data from the period 1959—1965. In 1950—1951 there was a maximum/minimum ratio of 6 to 1, while the ratio in 1959—1965 was about 2 to 1. The ratio for the volumes of the 600 to 0 m layer was 8 to 1 in 1950—1951, and about 4 to 1 in 1959—1965 (Fig. 3). However, as indicated in Fig. 1 and 2, the maximum/minimum ratios for individual years could be higher but, as

discussed above, the variability of the 600 to 100 m layer was rather low. WIBORG (1954) found a maximum/minimum ratio in the 2 000 to 600 m layer of about 3 to 1, and during 9 months of the year from 50 % to 80 % of the total biomass was found in this layer. The large volumes and the relatively small variability of the biomass in the 2000 to 600 m and the 600 to 100 m layers tend to subdue the effect on the total biomass of the considerable variations in the upper 100 m. The zooplankton sampling in the layers deeper than 600 m was discontinued in 1959, and therefore a complete comparison with the 1950—1951 data cannot be made.

The trophic significance of zooplankton in the foodweb of marine ecosystems depends on the concentration of the zooplankton. Fig 4. shows the concentration of zooplankton as ml/m^3 for the 25 to 0 m, 100 to 25 m, and the 600 to 100 m layers, and the overwhelming superiority of the uppermost stratum is clearly demonstrated. The data from the 100 to 25 m layer are derived by subtracting the volumes in 25—0 m from the volumes in 100—0 m. Only during January—February and November—December was the concentration of zooplankton highest below 25 m depth. Fig. 4 again demonstrates the relatively small seasonal and annual variability in the density of zooplankton in the 600 to 100 layer.

When calculating the density of zooplankton in Fig. 4 it was tacitly assumed that the biomass was evenly distributed in the 600 to 100 m layer. However, BERNARD (1958) found that the biomass in the deeper water masses might be highly stratified.

PROPAGATION OF calanus finmarchicus

Calanus finmarchicus was in numbers and particularly in biomass a dominating species at station «M» (WIBORG 1954, ØSTVEDT 1955, BEYER 1962). The developmental stage distribution of *C. finmarchicus* was determined from 1962, and the data revealed insignificant differences among years. Fig. 5 shows the average monthly means of the various developmental stages during the period 1962—1966 in the 100 to 0 m samples. The majority of the females occurred in March and April, and the copepodite stages I, II, and III were found from the middle of April to the middle of June. A second peak of females occurred from July to September. The high percentages of copepodite stage V from July throughout the autumn indicate that only a part of the stock reached maturity in July-September, and the majority of the *Calanus* stock at station «M» thus had a life span of one year.

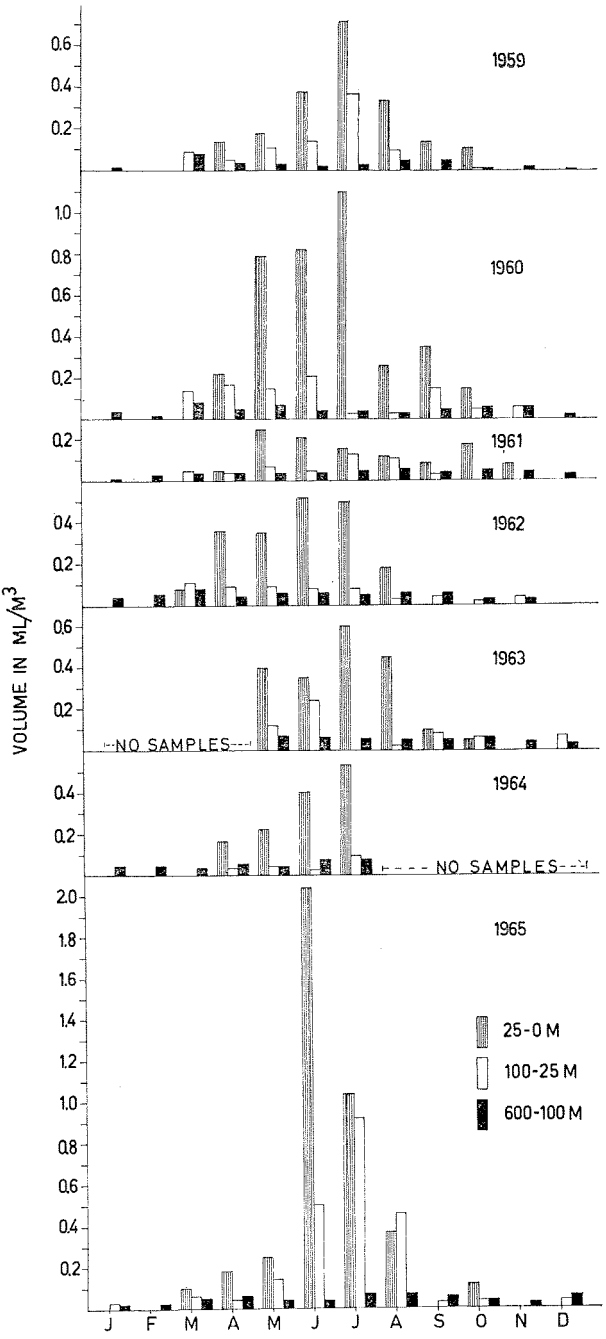

Fig. 4. Density of zooplankton in 25—0 m, 100—25 m, and 600—100 m at station «M» from 1959 to 1965.

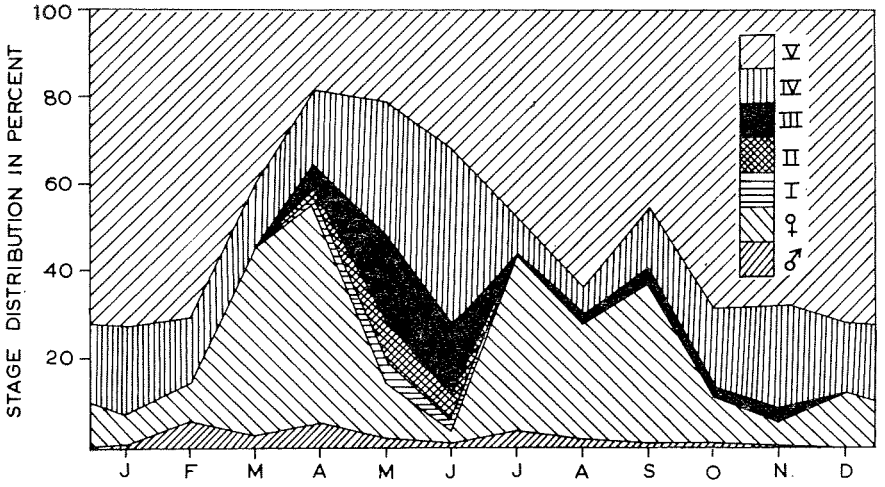

Fig. 5. Percentage distribution of males, females, and copepodite stages I—V of *Calanus finmarchicus* at station «M». Monthly mean figures 1962—1965.

These results strongly support the views on the propagation of *Calanus finmarchicus* at station «M» advocated by ØSTVEDT (1955), who also concluded that the second spawning was of minor importance. The annual variations in the developmental stage composition at station «M» and at Skrova on the northwestern coast of Norway were quite similar (LIE 1965, 1966), although the second spawning seemed to be more important at Skrova.

SUMMARY

1. From January 1959 to September 1966, 805 zooplankton samples were collected in vertical hauls from depths of 25—0 m, 100—0 m, and 600—100 m, at weather ship station «M» in the Norwegian Sea. The displacement volumes were measured, the developmental stage distribution of *Calanus finmarchicus* was determined, and the dominating species were noted.

2. Large seasonal and annual variations occurred in the volumes of zooplankton from the 100 to 0 m layer, while the volumes from the 600 to 100 m layer revealed considerable constancy. In 1965 and 1966 the plankton at station «M» appeared to be much richer and in 1961 somewhat poorer than the average for the period 1950—1966. The density of zooplankton in ml/m/ was very small in the 600 to 100 m layer while the 100 to 25 m and particularly the 25 to 0 m layer showed dense concentrations of zooplankton from April to August.

3. *Calanus finmarchicus* spawned in April and a second spawning of minor importance occurred in July—September.

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