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Investigations on Zooplankton in Coastal and Offshore Waters of Western and Northwestern Norway

With Special Reference to the Copepods

by
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PREFACE

In the autumn of 1948 the Directorate of Fisheries, Institute of Marine Research, Bergen, at the initiative of the present author started investigations on zooplankton in Norwegian coast waters in order to study variations in the composition and quantity of the plankton throughout the year, and from one year to another. The plankton was collected by the personnel at the permanent hydrographical stations at Ona and Sognesjøen between 61°—63° N on the west coast of Norway, and at Skrova and Eggum in the Lofoten area in Northern Norway. The sampling has been carried on from the autumn of 1948 up to the present date.

Selected samples from plankton material collected by the staff of the Institute in Norwegian coastal and offshore waters and in the Norwegian Sea and adjacent areas during the years 1927—39 and 1947—51 have also been used, mainly for a study of variations in the quantity of plankton and of length variations of copepods. In addition, I have analysed a material of zooplankton taken by the meteorologists on board the Norwegian weather ships «Polarfront I» and «Polarfront II» in the centre of the Norwegian Sea during 1950, 1951, and 1952.

All the plankton samples above have been collected in vertical hauls with a Nansen net.

I have also investigated samples collected in oblique hauls with the Clarke-Bumpus plankton sampler in the Lofoten area during April—June in the years 1949, 1950, and 1951.

On this occasion I would like to express my sincere gratitude to the director of the Institute, Mr. G. Rollefsen, who made it possible for me to undertake this investigation, to the leader of the hydrographical section of the Institute, Dr. J. Eggvin, who gave me the opportunity of having plankton sampled at the permanent hydrographical stations and supplied me with the necessary hydrographical data for the period of the investigations. I would also like to thank the members of the staff at the Institute for their cooperation and assistance, especially Mr. Kaare Gundersen and Mr. Philip Tallantire, and also Miss Herdis Aadland, who has prepared most of the drawings.

Finally, I want to thank Dr. J. EGGVIN, Professor JOHAN T. RUUD, and Professor H. MOSBY, who took the initiative in the sampling of plankton from the Norwegian weatherships, and have entrusted me with the material collected since the spring of 1950, and have also supplied me with the necessary hydrographical data. To the chief meteorologists M. E. MADSEN, J. SKAAR, and J. TØNNESSEN, who have been in charge of the plankton sampling, their assistants and to the officers and crew on board I convey my warmest thanks for the very valuable material which they have collected at all times of the year, sometimes in spite of very rough weather.

The investigations have been partly financed by a grant from Fiskeribedriftens Forskningsfond.

Bergen, June 1953.

Kristian Fredrik Wiborg.

GENERAL PART

Introduction.

Previous Investigations.

During the last 50 years a considerable amount of work has been devoted to investigations on zooplankton in the coastal waters of Norway and in the open ocean outside. NORDGAARD (1898, 1899, 1900, 1901, '05, '10, '12) investigated the plankton at different parts of the coast during all the year, but his work was only partly quantitative. GRAN (1900) gives a great deal of information both on the quantitative variation of the plankton as a whole (the weights of combined phyto- and zooplankton from hauls with fine nets) and on the numerical variations of some copepods off the coast of Nordland (Northwestern coast of Norway). In the very comprehensive survey of the phyto- and zooplankton of the Norwegian Sea (GRAN 1902) there are also some observations from the coast of Norway. DAMAS (1905 and 1909) and DAMAS & KOEFOED (1907) also studied the copepods of the Norwegian Sea.

The papers mentioned deal mainly with the seasonal and local variations in the quantitative distribution, partly with the biology of the organisms. But we must also mention the important taxonomic works of SARS (1903—18).

The first more comprehensive investigation on zooplankton in coastal and offshore waters during a longer period was made by RUUD (1929) on the west coast of Norway. Later RUNNSTRÖM (1932) and the present author (1944), studied the zooplankton in some fjords near Bergen all the year round. In the Lofoten area SØMME (1934) made a thorough study of the copepods *Calanus finmarchicus* and *C. hyperboreus* during winter and spring.

Material and Methods.

The present paper is based on plankton material collected in Norwegian coastal and offshore waters for many years, since 1927 up to the present date. For special purposes plankton samples from the weather-ship «M» have also been utilized. The main part of the material (A) derives from 4 permanent hydrographical stations along the Norwegian coast, namely:

1. *Sognesjøen,* located at the mouth of the Sognefjord, lat. 61°04.1' N, long. 04°50.5' E, depth 300 m.

2. *Ona,* at Møre, 62°54.0' N, 06°30.5' E, depth 200 m.

3. *Skrova,* in the Vestfjord, North Norway, 68°07.5' N, 14°39.4' E, depth 300 m.

4. *Eggum,* on the ocean side of the Lofoten Islands, 68°22.8' N, 13°38.7' E, depth 200 m.

The stations are indicated on fig. 1.

The sampling of zooplankton started in the autumn of 1948 and has continued ever since. The intervals between observations have been from a few days to a month or more, when the weather was bad. The average interval was usually a fortnight. The present study is mainly based on the plankton material collected during the years 1949, 1950 and 1951. For some of the species I have also included the material taken in the autumn of 1948. All the samples have been taken in vertical hauls with the Nansen net, diameter 70 cm, silk No. 0 (mesh width 0,4—0,6 mm) in the cylindrical part, and silk No. 8, (mesh width 0.2 mm) in the conical part. During 1949 the hauls were divided, one haul being taken from the bottom to 50 m and closed, one from 50 m to the surface. As, according to BARNES (1949) part of the plankton sampled may be lost during the closing of the net, the closing was abandoned from the beginning of 1950, and later all the hauls were taken from the bottom or from 50 m to the surface.

The plankton collected during 1948—50 has been used for a detailed study of the quantitative and qualitative composition of the zooplankton, whereas the samples from 1951 have only been measured as to volume.

(B) From the large amount of plankton material collected during fisheries research cruises in Norwegian coastal and offshore waters during the years 1927—39 a number of samples taken in vertical hauls with the Nansen net at or near the position of the permanent stations has been used for a comparative study of variations in the volumes of the plankton. Plankton sampled in the Vestfjord during the spring of the years 1930, 1939, 1946 and 1947 has also been used for a study of the propagation of *Calanus finmarchicus* and *C. hyperboreus.*

(C) In the years 1949—51 a number of oblique hauls were made with Clarke-Bumpus plankton samplers during April—June in the Vestfjord and on the coastal banks outside (see fig.s 14—19) mainly for a study of the occurrence of fish eggs and larvae (WIBORG 1950 and 1952). Three samplers, equipped with nets made of silk No. 2 (size of mesh aperture 0.366 mm) were towed simultaneously at different depths and raised in steps of 5 m. The depth intervals fished were usually 75—55 m, 50—30 m and 25—5 m, the towing lasting for 20 minutes in all. At

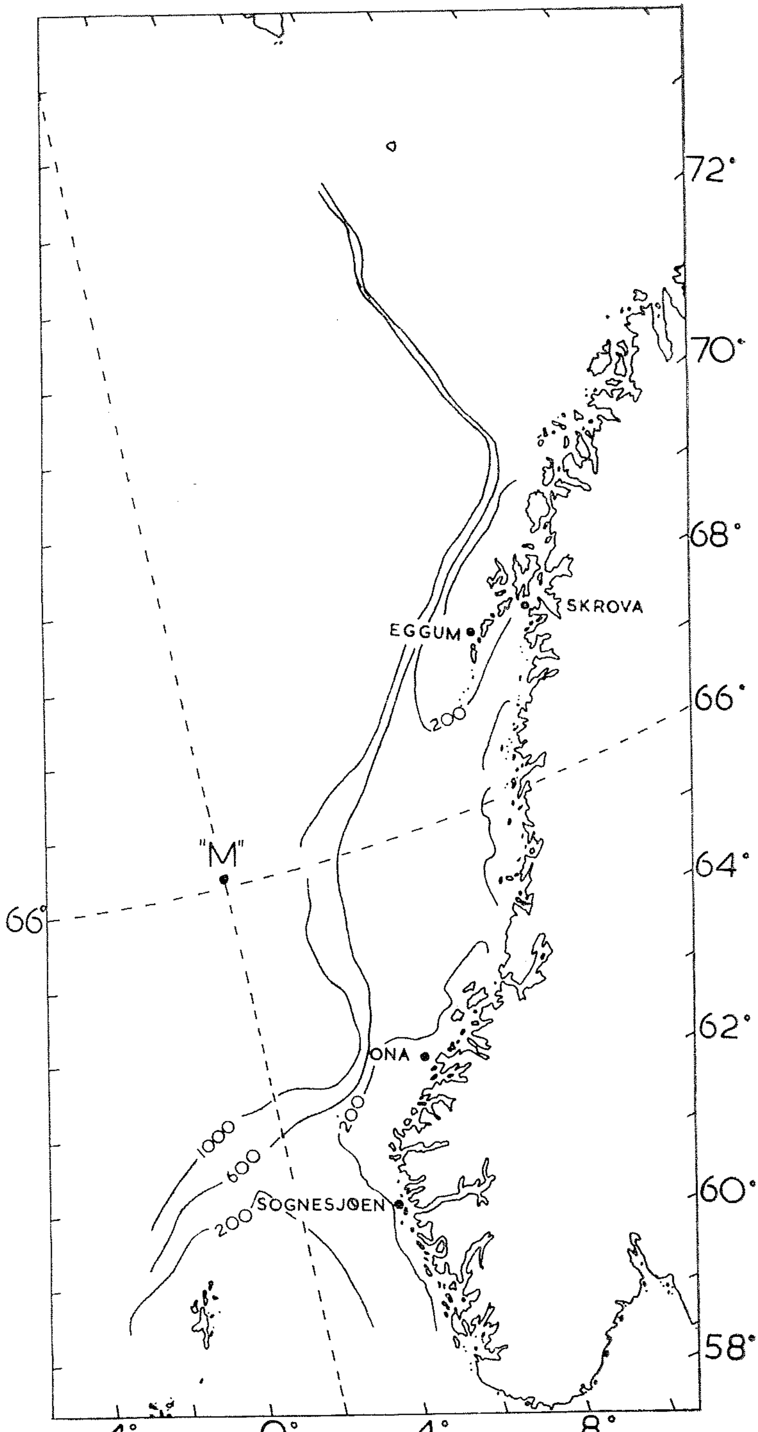


Fig. 1. Zooplankton stations in 1948–51.

the end of the 3 mm wire was attached a weight of 28 kg and the wire was kept at an angle of 40 degrees to the vertical, the vessel running at a speed of 1½—2 knots. The volume of water filtered by each sampler usually varied between 6 and 12 m^3. Most of the stations worked were visited twice, at the end of April/beginning of May, and at the end of May/beginning of June. In the Vestfjord the hauls during the last cruise were as a rule taken between 50 m and the surface, as most of the plankton, fish eggs and larvae included, was found to keep mainly in this layer.

(D) For studies on the variations in the quantitative distribution of the plankton and on the length variations of the copepods I have also used plankton samples collected in vertical hauls with the Nansen net during the fisheries research cruises in the Norwegian Sea and adjacent areas in 1948—1951 and from the Norwegian weather-ships «Polarfront I» and «Polarfront II» at station «M», 66° N, 2° E, during 1950—1951. Plankton material collected by the weather ships during 1949 has been worked up by ØSTVEDT (in press) at the Biological laboratory in Oslo.

All plankton samples have been preserved in 5—10 % formalin.

The volumes of the samples were measured by displacement or draining. The sample was poured into a measuring cylinder and water added, until the total volume amounted to 10 ml, 50 ml, or 100 ml, according to the size of the sample. Afterwards the liquid was drained off through a sieve of plankton silk, the plankton being squeezed gently with a spattle to get out most of the liquid. Then the liquid was measured separately, the difference giving the volume of «dry» plankton. Larger organisms, e.g. krill, chaetognaths and larger medusae, were removed before the volume measurement and their volumes in some cases measured separately.

An experiment was carried out in which the volume of some plankton samples was first measured by settling in measuring cylinders, and afterwards by displacement. The former values where from 1.6 to 6.6 times, on the average 4 times larger than the latter.

The improved Lea's plankton divider (WIBORG 1951) has been used for the fractioning of the samples when this was necessary for computing the total number of organisms present. According to the size and nature of the sample a subsample of 1/10 or 1/100 was taken out and the organisms present counted. Another fraction was always kept as a control and analysed if necessary. Finally, the entire sample was given a cursory inspection (for further details see WIBORG 1940).

Several workers have investigated the validity of single plankton hauls. It has been shown that in a series of vertical hauls taken from a restricted area at short intervals of time, the size of the catch may vary considerably, as much as 90—120 % from the mean (GARDINER

1931, WINSOR and WALFORD 1936 and others). GARDINER found that deviations from the mean of 33% must be considered as fairly good, and the same (35 %) was also shown by BARNES (1949) to be the coefficient of variation of a single observation for a haul of moderate length. BARNES showed further, that there might be a loss of material when the net in a divided haul was closed on the Nansen principle. As mentioned above, the closing of the net was for this reason abandoned at the permanent stations from the autumn of 1949.

In a long series of observations extending over more than one year, it is to be expected that the errors involved in the single observations will to some extent be equalized, but it is necessary to have the errors mentioned in mind when we draw our conclusions from the material.

The errors envolved in the subsampling have been discussed in a previous paper (WIBORG 1951).

The papers and handbooks used for the determination of species were partly the same as used before (WIBORG 1940, 1944). In addition, the Plankton Sheets issued by the International Council (No.s 7, 13, 37, 38, 42) have also been used.

Length Measurements. The cephalothorax lengths of the copepods were measured in a Spencer binocular microscope with a built-in micrometer. *Calanus finmarchicus, C. hyperboreus* and *Pareuchaeta norvegica* were measured with oculars No. 9 and objectives No. 1, the divisions of the micrometer equalling 0.097 mm. For *Pseudocalanus elongatus* and *P. minutus, Metridia longa* and *M. lucens* were used oc. No. 9 and obj. No. 2, divisions equalling 0.0513 mm, and for *Microcalanus pusillus* and *M. pygmaeus* oc. No. 9 and obj. No. 8, — 0.0125 mm. *Pseudocalanus* was also measured in a Leitz binocular microscope, oculars No. 12.5, objectives No. 2, the micrometer divisions equalling 0.0509 mm.

All figures exceeding one value were raised to the next higher. In order to compare the cephalothorax lengths with the total lengths given by other workers, I have calculated the relation cephalothorax length: total length for a number of species from the drawings of SARS (1903) and got the following values:

Calanus finmarchicus ♀	0.79
C. hyperboreus ♀	0.82
Ps. elongatus ♀	0.66
Metridia longa ♀	0.62
M. lucens ♀	0.64
Pareuchaeta norvegica ♀	0.67
Microcalanus pusillus ♀	0.75
M. pygmaeus ♀	0.75

The total length may thus be converted into cephalothorax length and vice versa in multiplying or dividing by these factors.

Hydrography.

Previous Investigations.

According to HELLAND-HANSEN and NANSEN (1909) the water along the western and north-western coast of Norway is characterized by a salinity less than 35 ⁰/₀₀. The coast water is on the whole moving along the coast as a continuation of the Baltic current, from the Skagerak to the Barents Sea. The North-Atlantic current passes along the North Sea plateau (Tampen) and then across the Norwegian Channel. Later it mainly follows the edge of the continental shelf northwards, but off Sunnmøre (63°—64° N) a little north of Ona, and off Lofoten (67°—68° N) vortices probably occur, according to the bathymetrical features of the sea basin. Along the shelf all parts lying deeper than 200 m are covered by water with salinities above 35 ⁰/₀₀, and also in the depths of the Norwegian fjords we usually find Atlantic water, unless there is a too shallow sill at the entrance. In the coast water the salinity is increasing along the route northwards, while in the Atlantic current the salinity is decreasing, indicating that some intermixing takes place in the boundary layers between the two currents.

Movements and Currents. There is a lateral movement in the coast water. In summer it is wide in extension but shallow in depth, while in winter it is narrow, but deep. According to the course of the 35 ⁰/₀₀ isohaline the extension of the coast water off the Sognefjord in 1906 was found to be 93 km in February, 104 km in May, 187 km in August and 70 km in November (HELLAND-HANSEN and NANSEN 1909). (At Ona the distance from the coastline to the edge is appr. 126 km).

It has been observed by DAMAS (1905) that a number of southern plankton organisms (e.g. salps) arrive at the west coast of Norway in the autumn, probably every year. It may indicate an influx of Atlantic water towards the coast in that season.

HELLAND-HANSEN and NANSEN state that the velocity of the coastal current varies greatly. Off Breisund (near Ona) the investigations revealed currents which in the upper 20 m ran seawards, but below 20 m towards the coast. Near the edge the currents at all depths were moving northeastwards along the continental slope. On some occasions the current was found to be moving very slowly (northwards) and vortex movements were supposed to occur. MARTENS (1929) on one occasion measured the current at Storeggen, the bank outside Ona, and calculated the water transport to 5 nautical miles per 24 hours. EGGVIN (1940) in February-March 1937 found current velocities in the upper water layers between Sognesjøen and Ona of 15.1 cm/sec., or approximately 7 nautical miles a day. For the Vestfjord EGGVIN (1931) has some details on the currents in the surface layers. One of his figures is quoted on page 40, where the direction of the current is also discussed.

BRAARUD and KLEM (1931) emphasize the importance of the wind, as westerly winds, especially in winter, add strongly to the homogenity of the water layers.

Temperature Variations in the Coast Water. We may generally distinguish between a surface layer with great variations in temperature, partly also in salinity, and a deeper layer with rather small variations in temperature and salinity throughout the year. According to EGGVIN (1944) the mean temperatures in March and August and yearly amplitude at 4 m level in the years 1935—1940 were as follows:

	March	*August*	*Yearly amplitude*
Sognesjøen	4,3° C	15.7° C	11.4° C
Ona	4.2° C	14.8° C	10.6° C
Vestfjord	3.0 °C	13.0° C	10.0° C

In the bottom water the following values were given for the same period:

Sognesjøen	July 6.77° C	January 8.18° C
Skrova	Sept. 6.73° C	March 6.95° C
Eggum	April 6.16° C	November 7.69° C

The Hydrographical Conditions during 1949—51.

By the courtesy of Dr. J. EGGVIN I have got the isopleth diagrammes for temperature and salinity at the investigated localities for the years 1949—1951, as shown in fig.s 2—9. The figures speak for themselves, and it is not necessary to give detailed comments. We are mainly interested in the variations which indicate changes in the hydrographical conditions caused by influx of water from other areas, and in table 1 I have compiled the most obvious fluctuations during 1949—51. In the following paragraphs I will mention briefly the general hydrographical features of the localities, and the major variations found during 1949—1951.

At *Sognesjøen* the upper 50 m have generally a salinity of 32—34 $^0/_{00}$. In the autumn the salinity may sink below 32 $^0/_{00}$ probably due to increased flow of the Baltic current, perhaps also to local rainfall or river flow. In the deeper layers an influx of more saline water, probably of Atlantic origin, was noticed in May—July and October of 1949, and November—December of 1951. The temperature of the deeper water layers was a little lower in May—August 1951 than in the same period of 1949 and 1950.

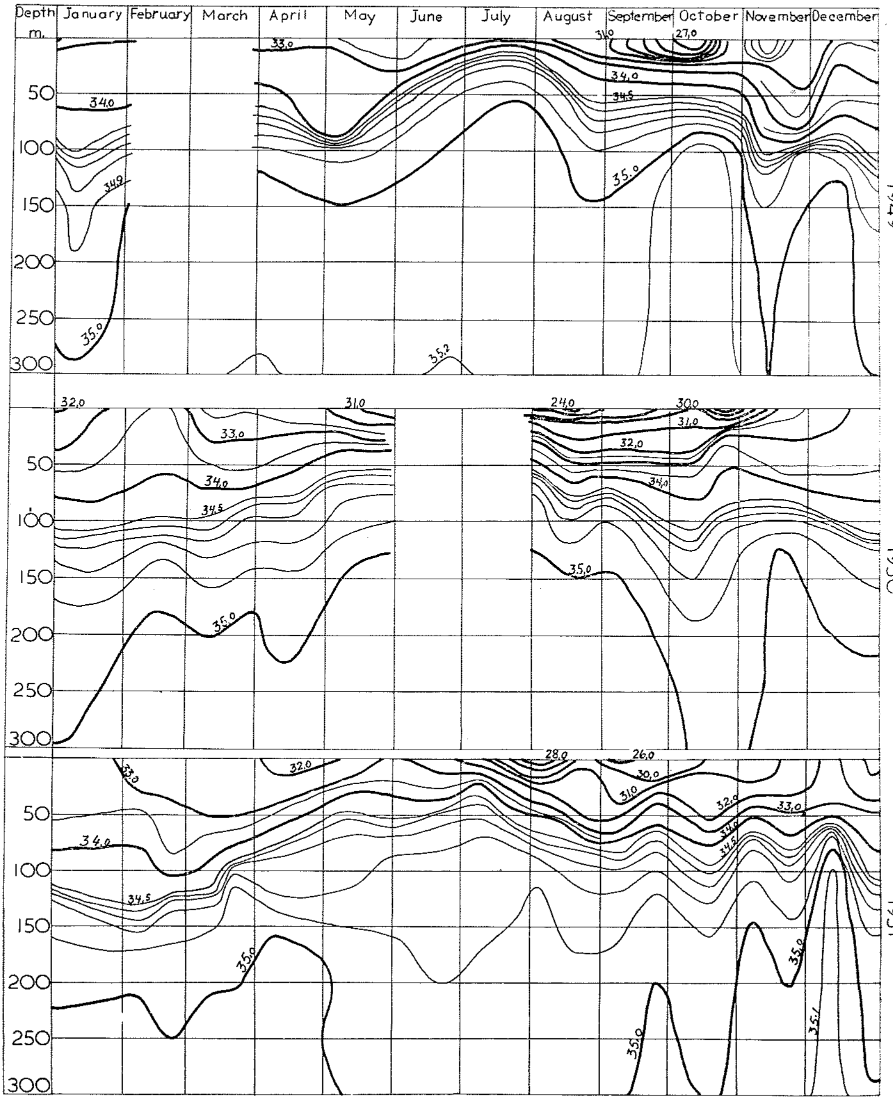


Fig. 2. Salinity isopleths at Sognesjøen in 1949 51.

At *Ona* the course of the isohalines indicates very variable conditions in the upper 50 m during the first six months of each of the three years. In the autumn, and especially in 1951, there was a clearly indicated decrease in the salinity of the upper layers. In the deeper layers, influx of Atlantic water is more felt than at Sognesjøen, in 1949 occurring in June—July and December, in 1950 in May and October—November, in 1951 between April and June, and in the middle of November.

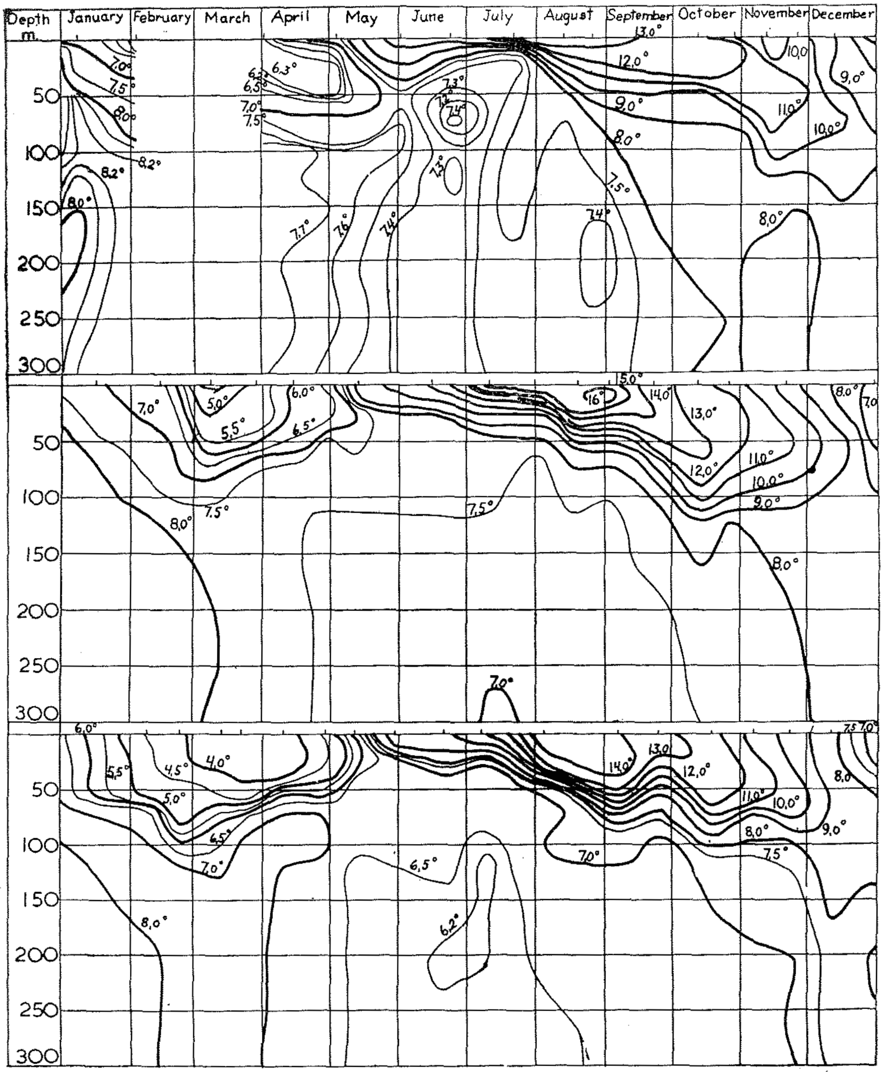


Fig. 3. Temperature isopleths at Sognesjøen in 1949 - 51.

The temperature conditions also indicate that the different water layers may be very well mixed, and both summer warming and winter cooling reach to the bottom in all years.

At *Eggum* the salinity of the upper 50 m is usually a little higher than on the west coast, but we find a corresponding decrease in salinity during the autumn and early winter months, most pronounced in 1950. The influx of water of 35 $^0/_{00}$ or more in the deeper water layers is less pronounced than at Ona, only being noticeable below 150 m in August

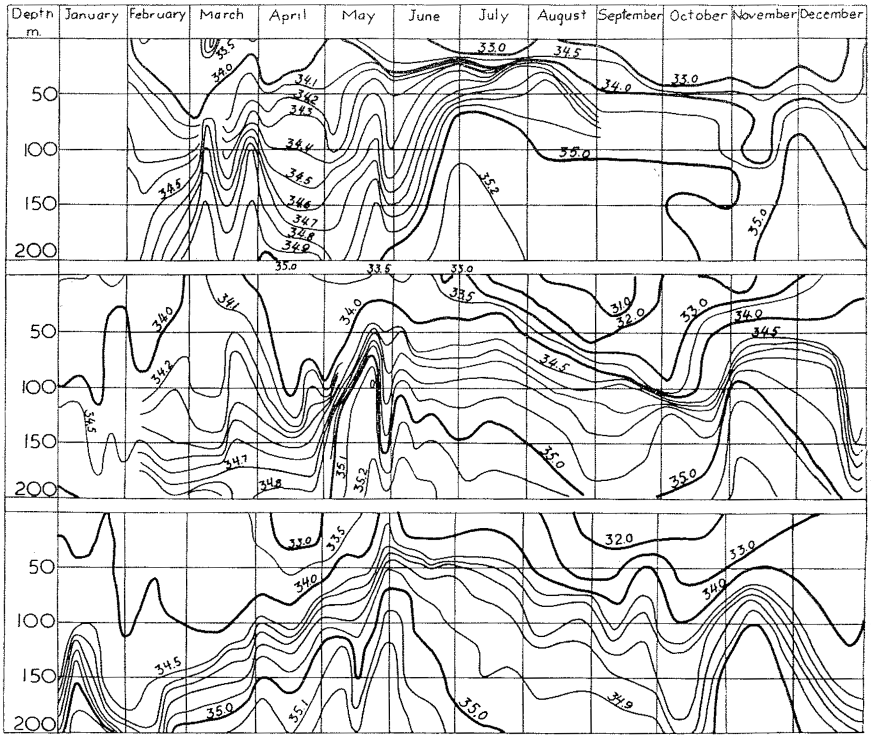


Fig. 5. Temperature isopleths at Ona in 1949 – 51.

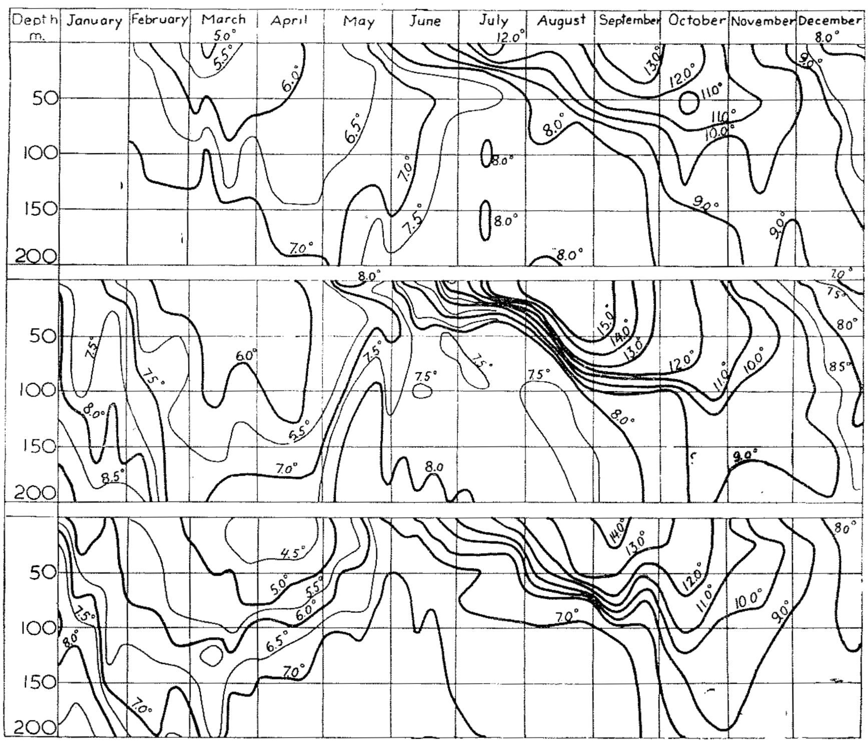


Fig. 4. Salinity isopleths at Ona in 1949—51.

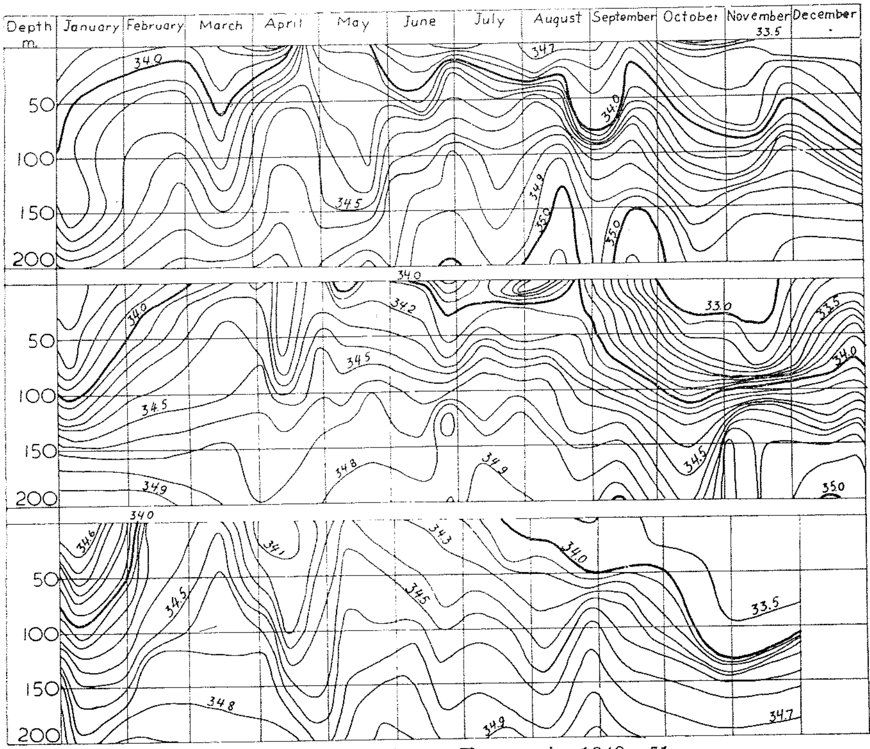


Fig. 6. Salinity isopleths at Eggum in 1949—51.

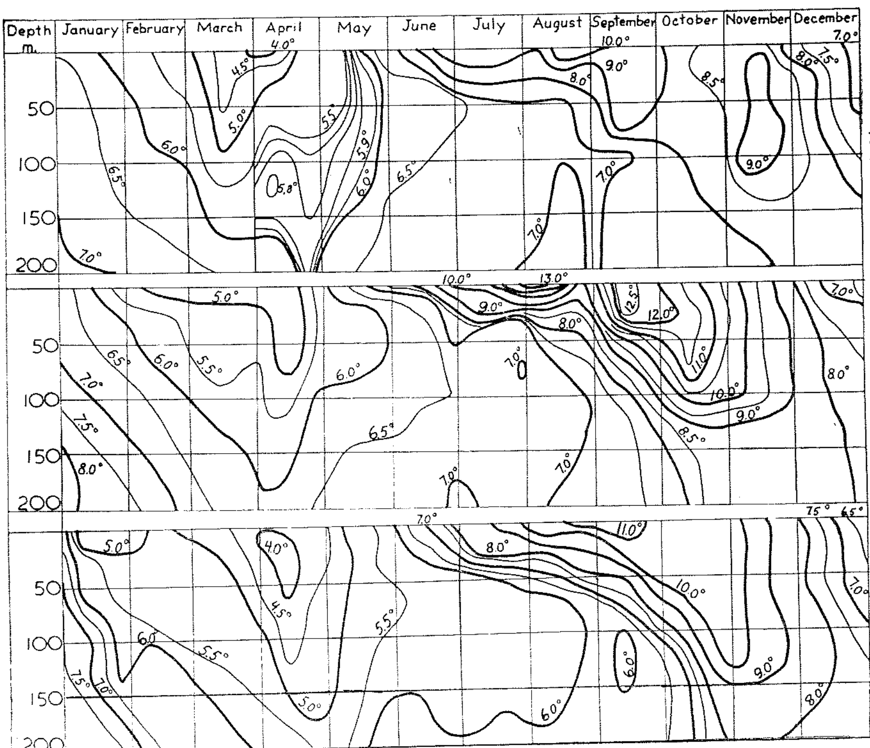


Fig. 7. Temperature isopleths at Eggum in 1949—51.

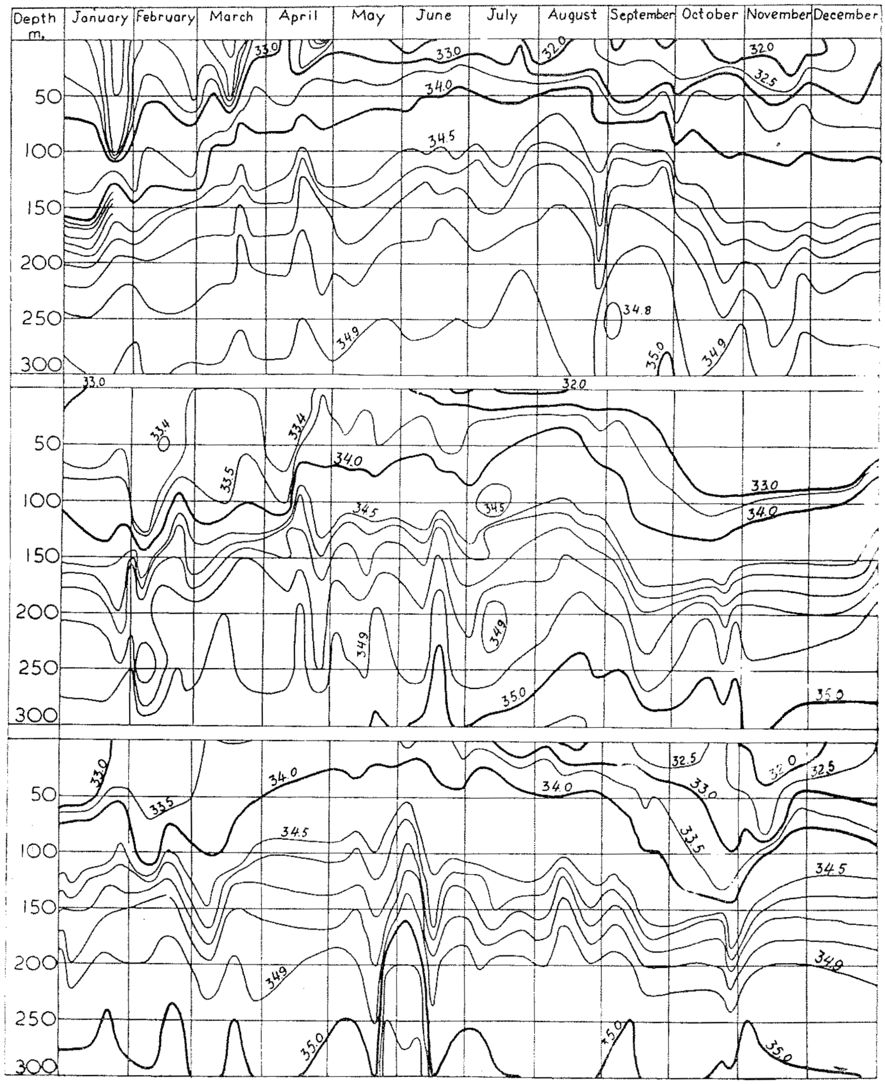


Fig. 8. Salinity isopleths at Skrova in 1949—51.

—September 1949, and near the bottom in September—December 1950. Both temperature and salinity variations indicate that the water is well mixed from the surface to the bottom both in spring, and in the autumn and early winter.

The *Skrova* station, situated in the inner part of the Vestfjord, exhibits more typical fjord conditions than the other localities. The salinity of the upper layers is somewhat lower than at Eggum, especially in the autumn, which may be due both to the coastal current and to local

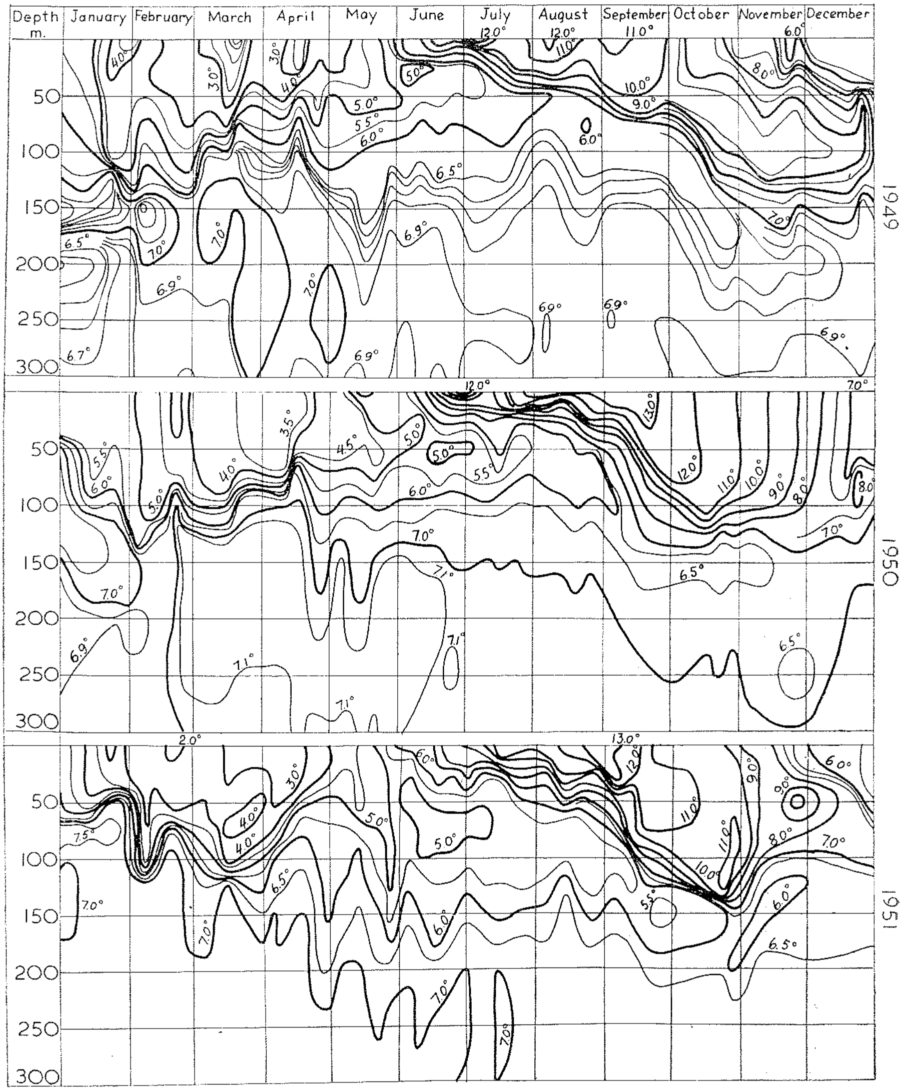


Fig. 9. Temperature isopleths at Skrova in 1949 – 51.

influx of river water and rainfall. In the deeper layers we usually find water of a salinity near 35 $^0/_{00}$, and new Atlantic water seems to have been introduced in January and July—October 1950, and in June 1951. — The temperature conditions in the upper water layers have also a fjord character, with lower temperatures during winter and higher during summer than at Eggum.

The different changes in the hydrographical conditions at the localities investigated will also be discussed later on in connection with the variations in composition and quantity of the zooplankton.

Table 1. *Major Changes in Temperature and Salinity at Sognesjøen, Ona, Eggum and Skrova during 1949—1951.*

	Year	Salinity			Temperature			
		Surface layers		Deeper layers increase	Surface layers		Deeper layers	
		decrease	increase		Minimum	Maximum	winter cooling	summer varming
Sognesjøen	1949	Sept.-Oct. below 32 $^{\circ}/_{oo}$	June-Aug.	May-July and Oct., above 35 $^{\circ}/_{oo}$	6°, March	13.9,° Aug.	No data	9° to 150m in December
Ona	»	July-Dec., Oct.-Nov. below 32 $^{\circ}/_{oo}$	May-Aug.	June-Oct., and Dec.	4.8°,March	13,7°,Sept.	to 150 m in March	to the bottom in Nov.-Dec.
Eggum	»	May, 34,5$^{\circ}/_{oo}$ below 150 m June-Dec., below 50 m	April-May	Small incr. in Aug-Sep. 35$^{\circ}/_{oo}$ below 150m	3.7°, Apr.	10.4°,Sept.	5.0° to 100 m in Mar.	to the bottom in Oct.
Skrova	»	Jan., below 33 $^{\circ}/_{oo}$ in the upper 100 m	No incr.	No changes	2.2°,Mar.	12.5°,July	to 100 m in April	9° to 125 m
Sognesjøen	1950	May, July-Nov. below 32 $^{\circ}/_{oo}$	No data	No changes	4.4°,Mar.	16°,-Aug.	6.5° to 75 m in March	9° below 100 m in October

Ona	»	July-Nov., Aug.-Sept. below $31^{\circ}/_{oo}$	March	May, Oct.-Nov.	5.6°,Mar.-April	15.7°,Aug.	6.5° to 150 m in Mar.-Apr.	10° below 100 m in October
Eggum	»	Aug.'50-Febr. 51, $34^{\circ}/_{oo}$ deeper than 100m	Mar.-June	No changes $35^{\circ}/_{oo}$ near 200 m in Sept.-Dec.	4.5°,Mar.	13.8°,Aug.	to the bottom in Apr.	9° to 125 m in Oct.-Nov.
Skrova	»	Oct.-Dec., below $33^{\circ}/_{oo}$in the upper 100m	No increase	January July-Oct.	3.0°,Apr.	15.1°,Aug.	5.0° to 100 m Febr.-Apr.	9° to 100 m in October
Sognesjøen	1951	June-Dec.	May-June, slight.	Nov.-Dec.	3.1°,Mar.	15,2°,Aug.	6.0°to100m End of Febr.	9° to 100m in Oct.-Nov.
Ona	»	Aug.-Oct., Sept.-Oct. below $32^{\circ}/_{oo}$	May-June	Apr.-June and Nov.	4.0°,Apr.	14.4°,Sept.	5.5°to 100m in March	to the bottom in Oct.-Nov.
Eggum	»	May-Novbr., $34.5^{\circ}/^{oo}$ at incr. depths	Febr.-July maximum May	No changes $35^{\circ}/_{oo}$ not occurring	4.0°,Apr.	12.0°,Sept.	5.0°below 150 m in April	9° to 150m in Nov.
Skrova	»	Sept.-Nov., below $32^{\circ}/_{oo}$ near the surf.	Mar.-May Apr.-July	Some in June	2.0°,Febr.	13.4°,Aug.	4.0° below 100 m in March	9° to 140m in Oct.-Nov.

The Zooplankton

Variations in Volume.

The West Coast of Norway between 61° and 63° N.

Sognesjøen. The variations in plankton volume at Sognesjøen during the years 1949—51 are shown in fig. 10.

From a minimum value of 1 ml in January the mean volume per total haul from bottom to surface (bottom row) has a steady increase to a maximum of 5 ml in April, a small decrease in May, and a second and larger maximum of 6 ml in June. From July the plankton volume decreases steadily to the end of the year, with the exception of a small peak in September.

In the upper 50 m we have mainly the same variations, and from March to June most of the plankton is concentrated in this layer.

The volume variations in the different years follow largely the same course as the mean volumes. As the observations during some periods are rather few, we may have missed the more accurate times of the different maxima. At Ona (see below) and in some fjords south of Bergen (GUNDERSEN 1953) the summer maximum usually occurs in July. The rather large volumes found at the end of March 1950 and in April 1951 were partly due to the presence of phytoplankton, but the samples nevertheless consisted mainly of copepods. The largest quantity of plankton obtained in a single haul, 8.7 ml, was taken on 1. June 1949.

Ona. The variations in plankton volume at Ona during the years 1949—1951 are shown in fig. 11.

The mean volumes for the whole period (bottom row) were of about the same size as at Sognesjøen, but the maxima occurred in April and July, and the second maximum with a value of more than 15 ml was far above the June maximum at Sognesjøen.

The vertical distribution of the plankton resembled that of the last mentioned station, but a somewhat smaller proportion of the total volume was taken in the upper 50 m during April and May, and in June nearly all the plankton was found below 50 m.

The first maximum of the year occurred later in 1949 and 1950 than in 1951, the second maximum in all years in the middle of July. No third

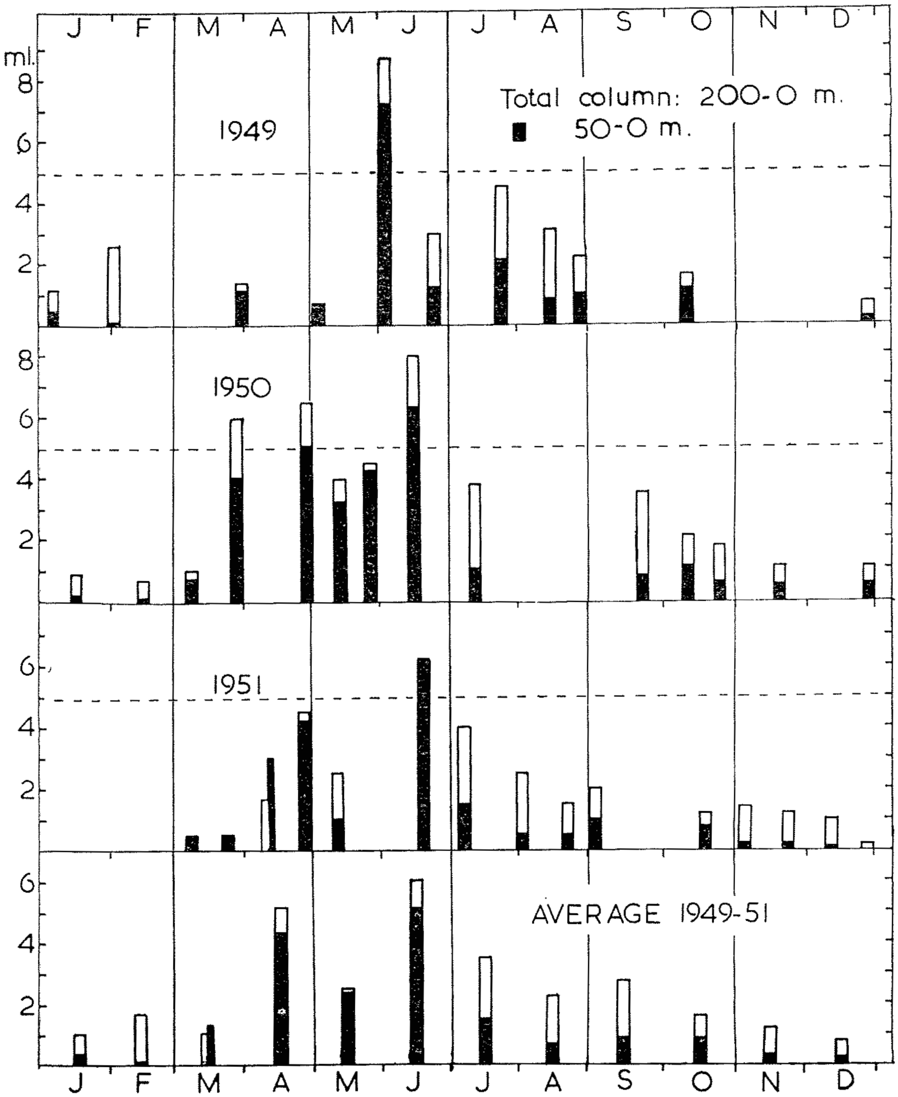


Fig. 10. Variations of plankton volume in vertical Nansen net hauls from bottom to surface at Sognesjøen in 1949—51.

maximum is clearly indicated. The rather large volumes in October are mainly due to remnants of medusae, which could not be removed from the samples.

The mean volumes for the years 1949—1951 were 2.9 ml, 4.3 ml, and 4.7 ml respectively. If we exclude the observations from July for all the years, the yearly mean volumes will be 2.0 ml, 2.2 ml and 4.2 ml, or approximately the same as at Sognesjøen.

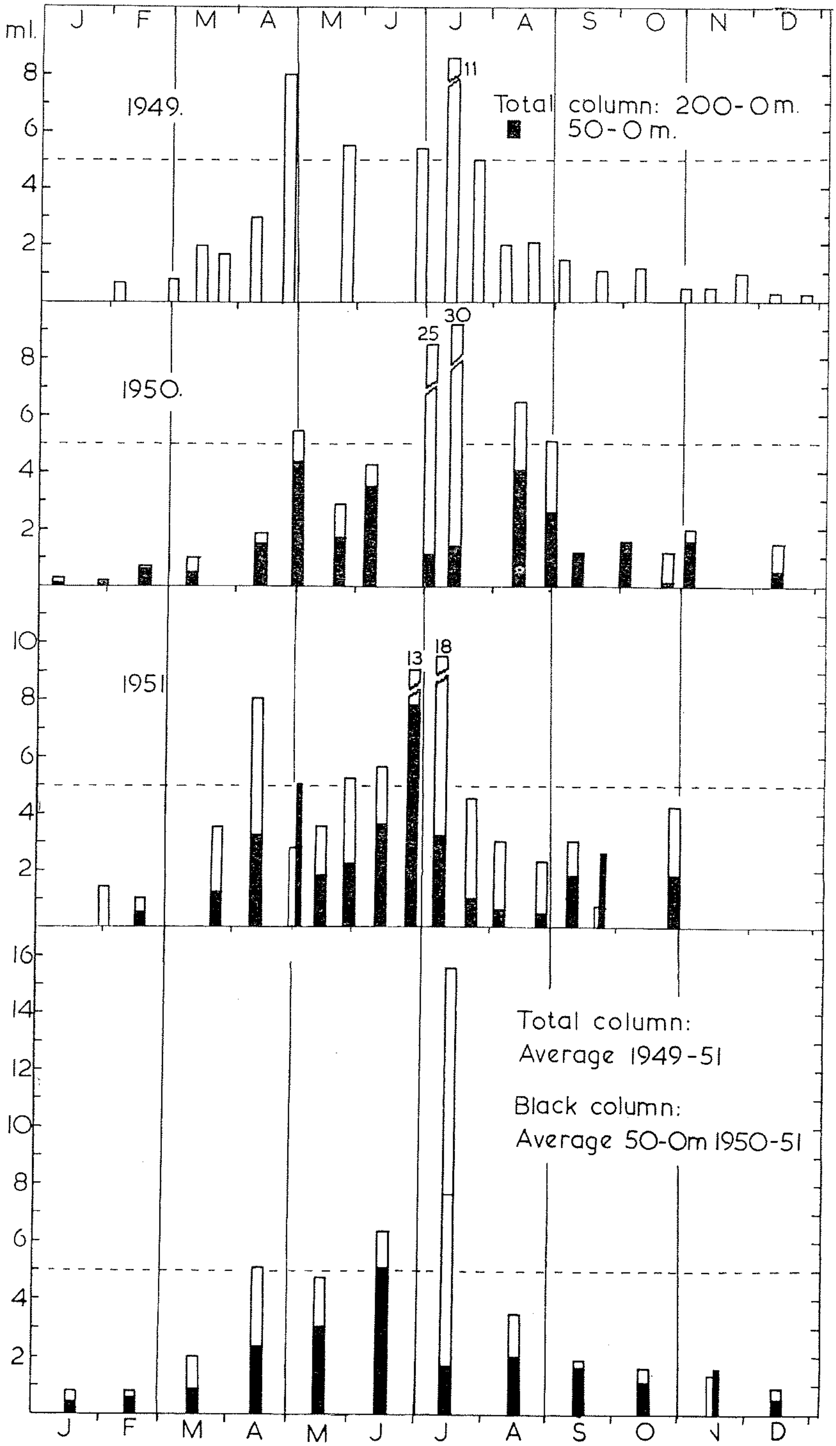


Fig. 11. Variations of plankton volume in vertical Nansen net hauls from bottom to surface at Ona in 1949—51.

Table 2. *The Mean Plankton Volumes in Vertical Nansen Net Hauls from Bottom to Surface at Ona in the Years 1927—1939 and 1949—1951, in ml.*

Period		Jan.	Feb.	Mars	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1927—39 ..	Mean Vol.	—	1.0	1.8	5.4	7.7	—	13.1	—	—	2.2	0.8	3.9
	No. of Obs.	—	3	1	4	7	—	2	—	—	1	2	2
1949—51 ..	Mean Vol.	0.9	0.8	2.0	5.1	4.8	6.4	15.6	3.5	1.8	1.7	1.4	0,9
	No. of Obs.	3	3	4	6	4	6	6	6	5	5	4	4

During the years 1927—1939 a number of vertical hauls were taken with Nansen net near the Ona station. The observations are very scattered, and usually only a few were taken from each year. The total volumes from bottom to surface have been averaged per month for each year, and then the monthly means have been averaged for the whole period, as shown in table 2. Plankton hauls are lacking for January, June, August, and September. For the other months there is quite good agreement between the observations from 1927—1939 and the present material. The high December value is explained by the fact that these hauls were taken at a locality with a depth of more than 400 m.

Table 3. *The Mean Plankton Volumes at Ona in 1926—27 recalculated from Ruud's st. "B" (1929), and in 1949—51 (the present Paper), in ml.*

	1926—27 (Ruud)		1949—51 (author)	
	Mean	maximum in a single haul	Mean	maximum in a single haul
March	3.8	12.9	2.0	3.5
April	8.1	10.8	5.0	8.0
May	10.0	13.4	4.9	5.5
June	7.6	10.0	6.4	13.2
July	6.3	8.3	15.7	29.5

Ruud (1929) took a number of vertical Nansen net hauls off Møre in the years 1925—1927. His station «B» is situated approximately at the permanent station at Ona. The volumes of the plankton samples were measured by the settlement method. As mentioned above (page 10) volumes obtained by settlement must, on an average, be divided by

4 to be comparable to displacement volumes. In table 3 Ruud's figures for st. «B» for the years 1926—27 have been recalculated and compared with the plankton volumes at Ona during 1949—1951. The largest volumes obtained in single hauls are given as well.

Although the figures calculated from Ruud's table must be regarded with some reservation, there seems to be some agreement between the two series, except for May and July. In the first of these months Ruud's figures are considerably above those of the author, in the second month considerably below. As Ruud's plankton hauls were taken at the end of July, he may have missed the maximum, which according to the present investigation seems to occur in the middle of the month.

The Coast and Bank Waters in the Lofoten and Vesterålen Areas.

Eggum. The variations in plankton volumes at Eggum during the years 1949—1951 are shown in fig. 12.

From January to March the monthly mean volume (bottom to the right) is low, 1—2 ml. The increase starts in April, and in May the volume reaches a maximum of nearly 40 ml. A minor decrease in June is followed by a second maximum of 50 ml in July. In August the plankton volume has fallen off to 12 ml and decreases steadily during the autumn and winter until December.

In the upper 50 m the volume has a minimum in January and rises to a maximum in May. In this period more than half, in May even more than 3/4 of the total volume of plankton is taken in the upper haul, but in the other months the bulk of the plankton keeps below 50 m.

In 1949 there seem to have been maximum volumes at the beginning and the end of May, in the first few days of August and at the beginning of September. In 1950 the maxima occurred in the last half of May with the very large quantity of 118 ml, most of which was taken in the 50—0 m layer, and in the middle of September. In 1951 the peaks appeared at the beginning of June, in the last half of July and at the end of August. The rather large volumes in October mainly consisted of medusae remains. Minimum values in all years occurred in the period November—March. The yearly mean volumes were as follows:

1949: 5.5 ml, 1950: 15.7 ml, and 1951: 17.6 ml.

A few vertical Nansen net hauls have been made in localities near the Eggum station during the years 1927—1939. Observations are lacking for the months January, February and June. The volumes of the samples have been measured and treated in the same way as mentioned for Ona. In table 4 are given the monthly averages for the years 1927—1939 and 1949—1951

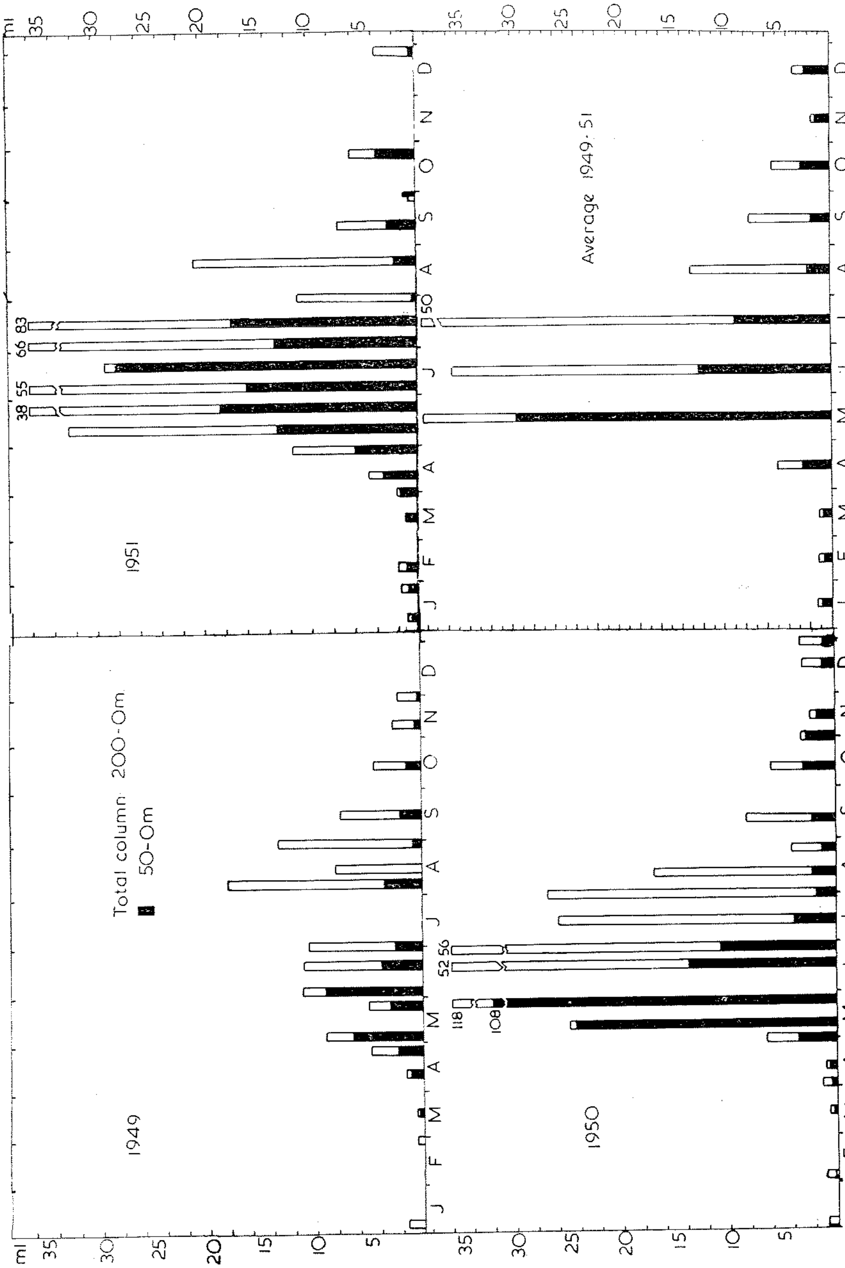


Fig. 12. Variations of plankton volume in vertical Nansen net hauls from bottom to surface at Eggum in 1949—51.

Table 4. *The Mean Plankton Volumes in Vertical Nansen Net Hauls from Bottom to Surface at Eggum in the Years 1927—1939 and 1949—1951, — in ml.*

Years		Jan.	Feb.	Mars	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1927—39 ..	Mean Vol.	—	—	1.2	3.1	*17.0*	—	9.4	1.4	1.7	2.8	3.7	1.8
	No. of Obs.	—	—	4	4	1	—	6	2	1	3	1	1
1949—51 ..	Mean Vol.	1.3	1.2	1.1	5.0	*38.4*	33.5	*50.2*	13.1	7.6	6.1	2.6	3.4
	No. of obs.	4	3	5	6	7	6	4	6	5	3	4	3

The agreement between the two series is not very good, the values from 1927—1939 being far below those of 1949—1951. In the first period most of the plankton hauls were made at some distance from the Eggum station, and as will be shown later on, local differences may be of considerable importance. But one cannot exclude the possibility that the plankton in the earlier years investigated might have been poor, or the years 1949—1951 very rich.

Skrova. The variation in volumes of plankton at Skrova in the years 1949—1951 is shown in fig. 13.

The monthly mean volume (bottom row) is about 7 ml in January and decreases to 5 ml in March. From April we have a steady rise to a maximum of 12.5 ml in June, some decrease in July and a second maximum of 23 ml in August. From September to December the volumes are of about the same size as at the beginning of the year.

The volume in the 50—0 m layer varies in the same way as the total volume. From April to June more than half of the total quantity of plankton is taken in this layer, but from July onwards the plankton volume diminishes very rapidly, already in August being only little above 1 ml. Quantities below 1 ml occur in January, February, and from September to December.

There are considerable differences between the years 1949—1951 both regarding quantities of plankton and the time of the different maxima. In 1949 peaks occurred at the end of April, in the middle of June, latter half of July, and at the beginning of September and December. In 1950 the most obvious peaks were observed on 11 April, 20 May, 22 July and 5 August. In 1951 there were maximum volumes on 26 May, 16 June and on 4 and 13 August. No observations were taken during the rest of the year. Some of these maxima may however be due to random variation. The yearly mean volumes vary considerably, in 1949: 5.5 ml, in 1950 8.3 ml, and in 1951 16.3 ml. In order to get

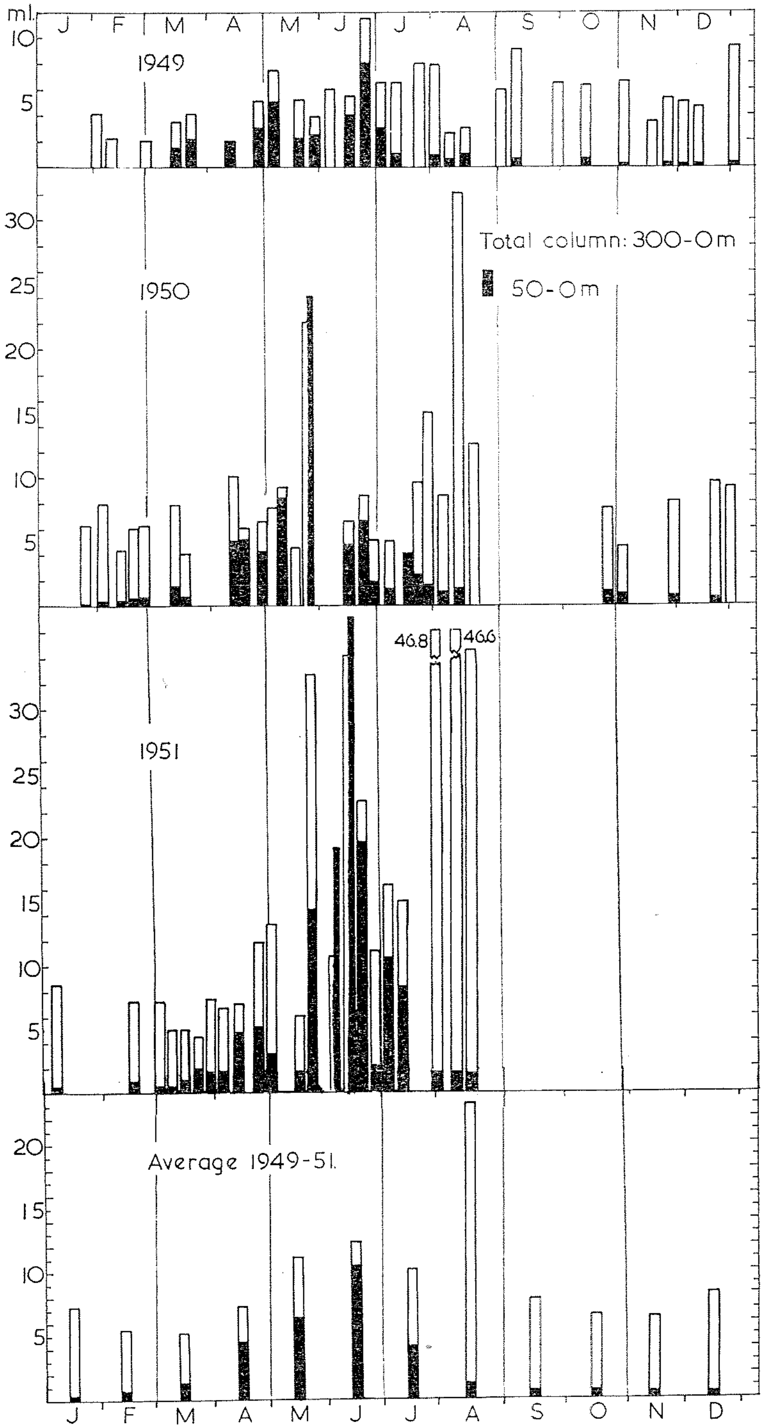


Fig. 13. Variations of plankton volume in vertical Nansen net hauls from bottom to surface at Skrova in 1949—51.

comparable values for all the years we may take the months April—August, the mean volumes for this period being 5.7 ml, 11.3 ml, and 21.3 ml respectively. We note that there is the same increase in mean volume from 1949 to 1951 both at Eggum and Skrova, and with the exception of 1950, the mean figures are of nearly the same size. For the period April—August we get the following values:

	Skrova	*Eggum*
1949	5,7 ml	8.8 ml
1950	11.3 -	33.2 -
1951	21.3 -	35.1 -

At Eggum the summer plankton is far more abundant than at Skrova, but the winter stock is very poor. The latter fact can be explained by the hydrographical conditions. At Eggum the influx of the coastal current is felt strongly in all depths. The deeper water layers will be steadily renewed, and during the autumn and winter they are replaced by water masses poor in plankton content. The conditions during the summer will be discussed later on.

At Skrova the plankton volume in winter is as a rule, 4 ml or more.

In all years the vertical distribution of the plankton follows the average variation, with the exception of the summer of 1950, when most of the plankton was concentrated below 50 m until the end of May, but later in the upper 50 m, at least until the middle of July.

During the years 1927—1939 a considerable number of vertical hauls were made in the Vestfjord near Skrova, especially in the first months of the year. The volumes of the samples have been averaged in the same way as for the Ona station in table 5. The mean figures for the period 1949—51 are given in the bottom line.

Table 5. *The Mean Plankton Volumes in Vertical Nansen Net Hauls from Bottom to Surface at Skrova in the Years 1927—1939 and 1949—1951, in ml.*

Period		Jan.	Feb.	Mars	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1927—39 ..	Mean Vol.	—	1.8	2.5	7.7	8.2	*12.8*	6.7	—	3.8	5.0	—	6.6
	No. of Obs.	—	2	10	10	3	1	4	—	2	2	—	1
1949—51 ..	Mean Vol.	7.3	5.5	5.2	7.3	11.1	*12.3*	10.1	23.1	7.8	6.3	6.3	8.2
	No. of Obs.	2	8	9	9	10	10	11	7	2	4	4	4

There is on the whole a very good agreement between the two series of observations, the old material giving somewhat lower values. Before 1949 however, all Nansen net hauls were taken in steps and closed at different depths, and as mentioned above (page 11) this may lead to loss of plankton material.

In the period investigated the plankton volumes at the stations in Northern Norway are on the whole much larger than further south. The yearly mean volumes at Ona and Sognesjøen vary from 2.2 ml to 4.7 ml, in the Lofoten area from 5.6 ml to 17.6 ml. The difference is still more pronounced if we only take the period April—June.

One feature is common to all stations. There is a gradual increase in the quantity of plankton from 1949 to 1951. This agrees very well with the statement by RAE (1951) that *Calanus finmarchicus*, the dominating species in the plankton, in 1950 was much more abundant along the Plankton Recorder routes in the North Sea and from Bergen to station «M». than ever before in the Recorder surveys.

The Lofoten and Vesterålen Area during Spring and Early Summer of 1949—51. During the spring and early summer of the years 1949—51 a considerable number of hauls were made with the Clarke-Bumpus plankton sampler in the Vestfjord and on the banks off the Lofoten and Vesterålen islands. The technique has already been mentioned (page 8). The plankton silk (No. 2) which was used in the nets will not catch all plankton organisms quantitatively. According to measurements (WIBORG 1948 b) *Calanus finmarchicus* eggs and the nauplius stages I—IV, *Metridia* spp. nauplii, all stages of *Oithona similis* and some copepodite stages of *Microcalanus pusillus* and other organisms of these sizes may be able to pass through the meshes. However, at the time of the year when the plankton sampler hauls have been made, the stock of *Calanus finmarchicus*, the dominating species in the plankton, is mostly made up of the copepodite stages I—III, which are all retained by silk No. 2. Further, as will be shown later on, the main part of the plankton is also found in the upper 75 m or less, so we may assume that the samplers take the main part of the plankton present. The volumes have been calculated as ml of plankton below 1 square metre of sea surface. Usually two cruises were made during each season, at the beginning of May, and at the end of May or beginning of June. The quantitative distribution of zooplankton in the investigated areas during the spring of 1949—1951 is shown in fig.s 14—19. Areas with plankton volumes below 30 ml/m^2, 30—50 ml/m^2, 50—100 ml/m^2, and more than 100 ml/m^2, have been distinguished by different hatching.

At the beginning of May 1949 the innermost part of the Vestfjord was poor in plankton, mostly less than 30 ml/m^2 (fig. 14). With the

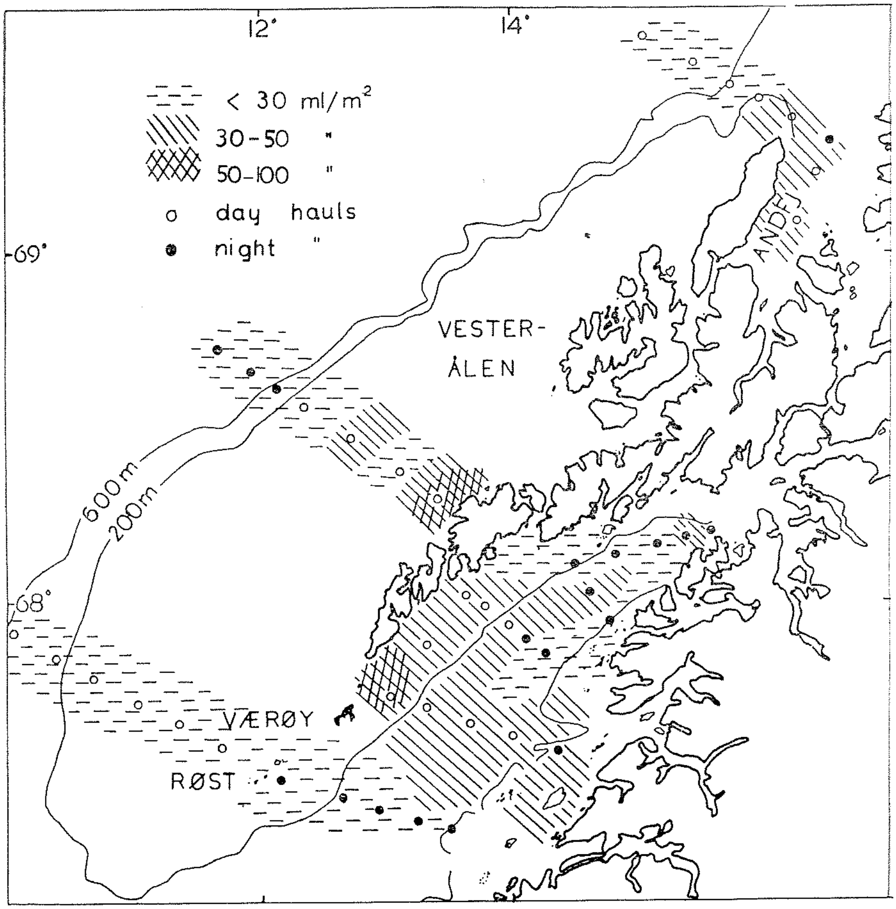


Fig. 14. Plankton volumes in ml/m² of the upper 75 m in the Lofoten and Vesterålen areas, 2–7 May 1949. C.B. samplers.

exception of one station the poor area extends southeastwards along the southern side of the fjord. In the central and outer parts of the fjord there were generally from 30—50 ml/m², In the mouth of the fjord, and in a section from Røst to the edge of the continental shelf the water is again poor in plankton content. The same feature is repeated in the outer part of the bank a little further north. Only along the shore is there some concentration of plankton. Moderate quantities of plankton also occur in the Andfjord.

One month later the conditions have changed (fig. 15). The inner part of the Vestfjord is still poor in plankton, and so is the northwestern part. A small bay in the inner fjord, the Austnesfjord, contains more than 60 ml/m², and there is also a rich area in the center of the Vest-

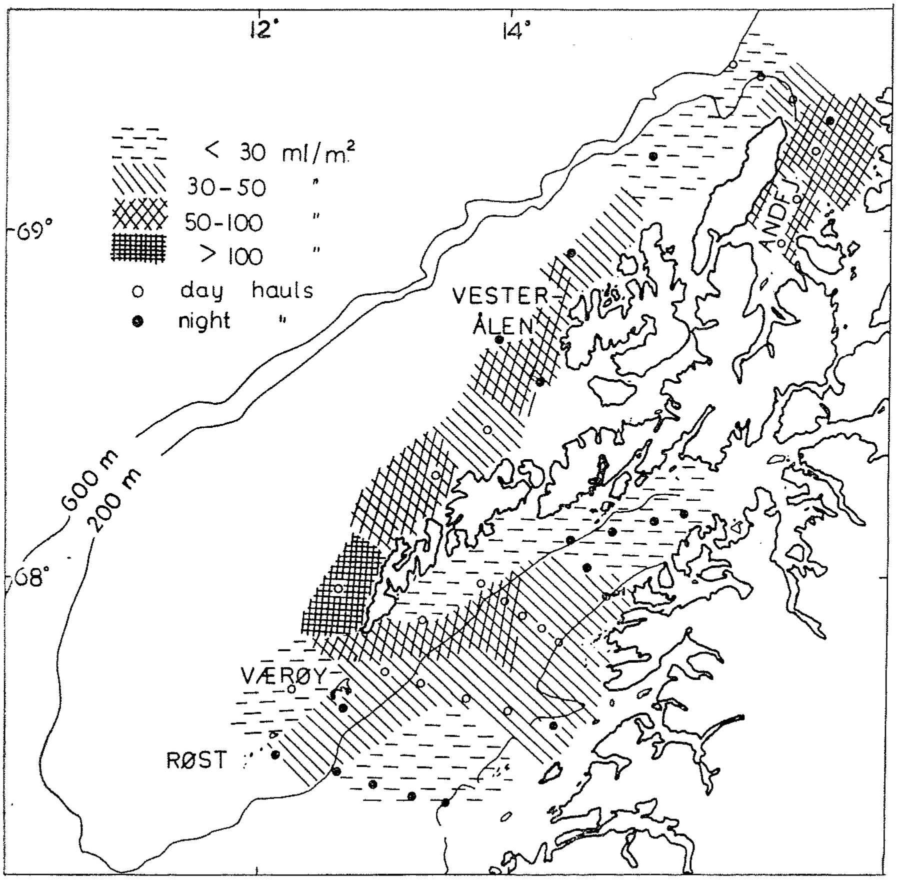


Fig. 15. Plankton volumes in ml/m² of the upper 75 (50) m in the Lofoten and Vesterålen areas, 31 May-3 June 1949. C.B. samplers.

fjord. In the mouth of the fjord the quantities of plankton are again small. Along the outer shores of the Lofoten Islands plankton is abundant, in some places 90—100 ml/m² or even more. The Andfjord has also a rich plankton, with volumes of 60—115 ml/m².

In 1950 hauls with the Clarke-Bumpus samplers were taken from 3 to 7 May and from 31 May to 3 June. An additional series of stations was worked from 8 to 9 June.

At the beginning of May (fig. 16) plankton is scarce in the central area of the fjord and in the innermost part. Moderate quantities, 30—50 ml/m², occur along the northwestern and southeastern shores. Patches of 50—100 ml/m² are seen in the center of the fjord and near Røst. On the banks outside the Lofoten Islands plankton volumes are moderate

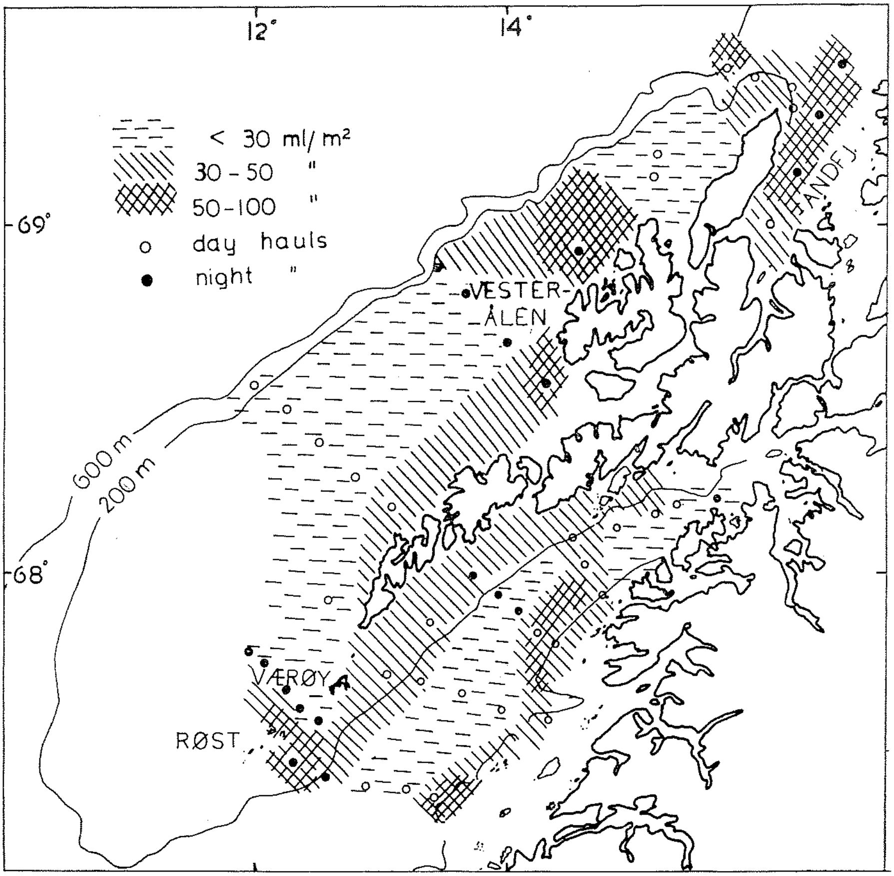


Fig. 16. Plankton volumes in ml/m² of the upper 75 m in the Lofoten and Vesterålen areas, 3—7 May 1950. C.B. samplers.

or small, but a patch of 50—100 ml/m² is found off Vesterålen. The Andfjord is again on the whole rich in plankton.

At the beginning of June (fig. 17) the plankton has generally increased in quantity, but in the Vestfjord there are considerable local differences. Scanty areas are found on the Lofoten banks and at the entrance to the fjord, whereas patches of 50—100 ml/m² or more occur in the centre of the fjord and in the Austnesfjord. Along the outer side of the Lofoten Islands we have mostly from 30 to 50 ml/m², with patches of abundant plankton off Vesterålen. In the Andfjord there is a rich plankton with 160 ml/m² at the central station.

In 1951 the first cruise was made from 30 April to 10 May. Most of the Vestfjord stations were visited from 2 to 4 May, the outer banks and the Andfjord from 5 to 10 May. The second cruise lasted from 22 to 30 May.

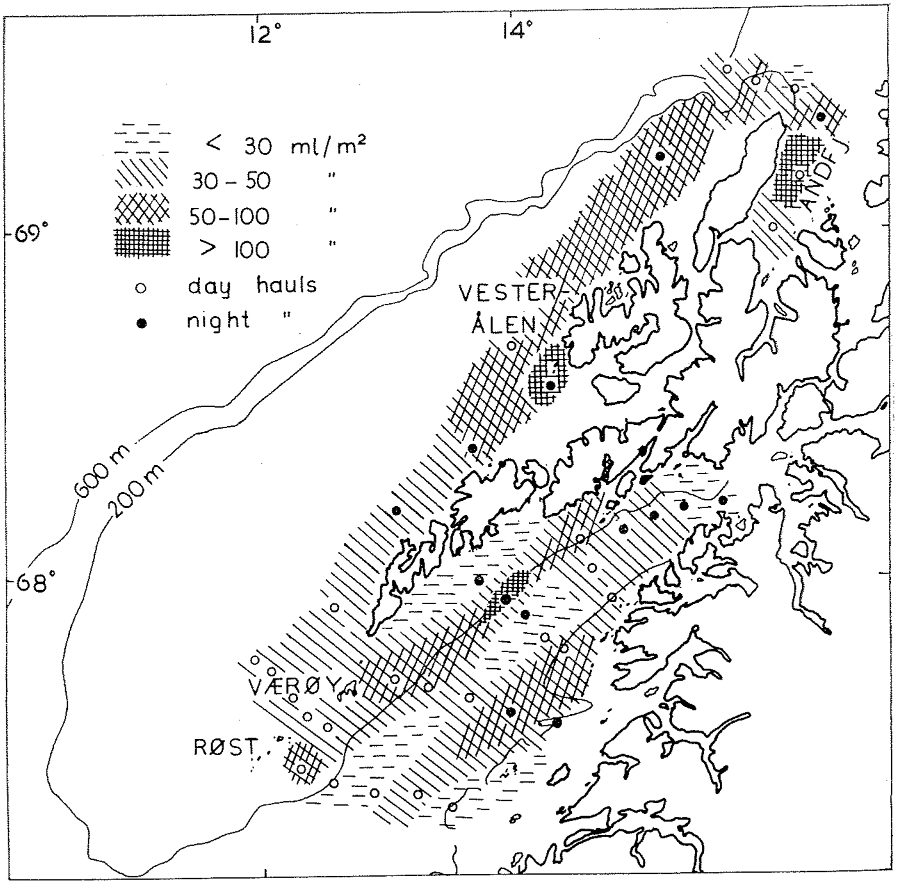


Fig. 17. Plankton volumes in ml/m² of the upper 75 m in the Lofoten and Vesterålen areas, 31 May—3 June 1950. C.B. samplers.

At the beginning of May (fig. 18) moderate quantities of plankton are found in the northeastern area and in the mouth of the fjord, separated by a more scanty area extending from the inner part and across the fjord to the outermost islands. On the outer banks and in the Andfjord the plankton is abundant, mostly 50—100 ml/m², but in some other localities it is scarce.

At the end of May (fig. 19) plankton has increased in volume in all areas, except in the innermost part of the Vestfjord. In the outer fjord there is a comparatively wide area with quantities above 100 ml/m². Patches of more than 100 ml/m² are found at 3 localities, one of these patches containing 192 ml/m², the greatest quantity found in plankton sampler hauls during these observations.

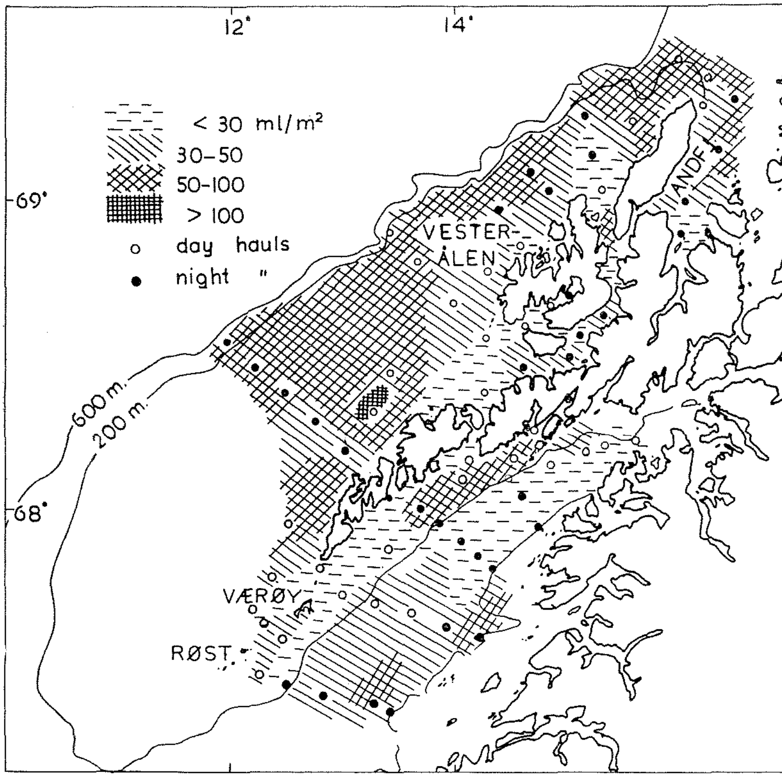


Fig. 18. Plankton volumes in ml/m² of the upper 75 m in the Lofoten and Vesterålen areas, 30 April – 10 May 1951. C.B. samplers.

Some features seems to be repeated from one year to another. In the Austnesfjord and in the Andfjord the plankton is very abundant during May and June, whereas minimum quantities occur in the innermost part of the Vestfjord. Patches rich in plankton are found along the outer shores of the Lofoten Islands.

Causes of Uneven Distribution of Plankton.

a. *Diurnal Vertical Migration.* The possibility has been considered that diurnal vertical migration of the plankton might cause richer catches during the night, even if the decrease in light intensity at night is not so pronounced in these latitudes during May and June. Experimentally, plankton hauls made between 6.00 p.m. and 6.00 a.m. have been considered as night hauls.

In table 6 are given the number of stations yielding more, less than 50 ml/m² in the different cruises during 1949—50—51 in the Vestfjord

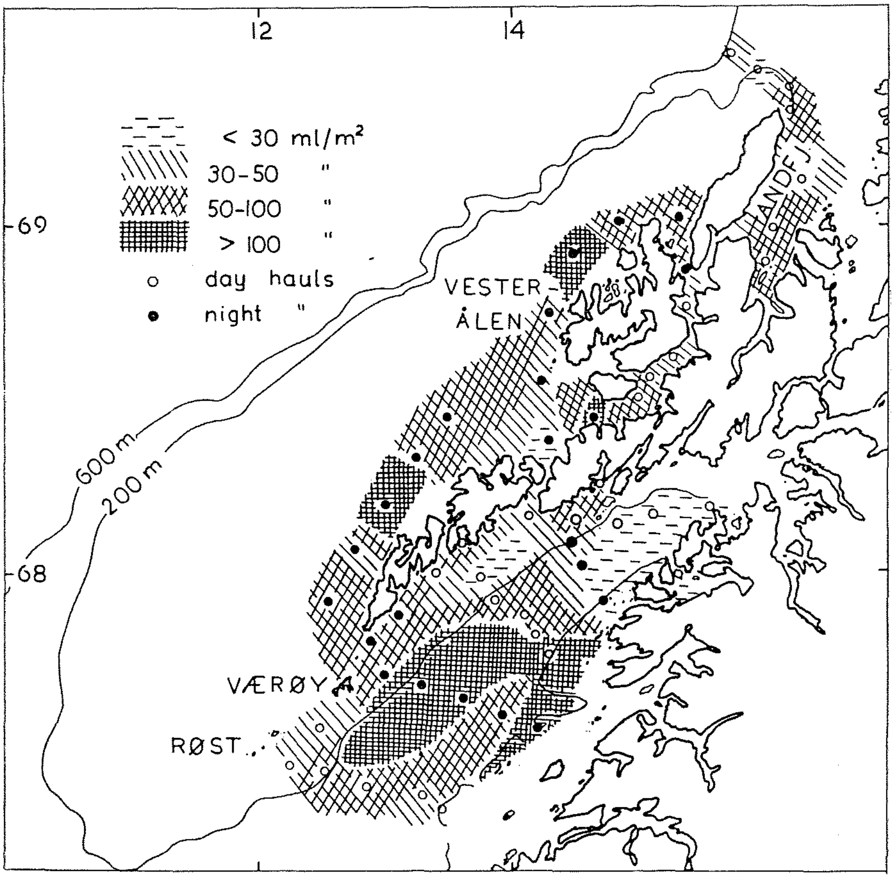


Fig. 19. Plankton volumes in ml/m² of the upper 75 (50) m in the Lofoten and Vesterålen areas, 22—30 May 1951. C.B. samplers.

and on the outer banks, including the Andfjord. Day and night hauls have been distinguished in the way mentioned.

In the Vestfjord there were on the whole more stations with quantities above 50 ml during the day than during the night, but for the Vestfjord and banks combined the conditions were the reverse. The difference however, is not very pronounced. In fig.s 14—19 the stations taken by day are distinguished as open rings, those at night as black dots. There is apparently no connection between the horizontal distribution of the plankton and the day and night hauls.

If vertical migration had taken place within the upper 75 m, surface currents would undoubtedly influence the horizontal distribution of the plankton. In order of study the possible vertical migration within the 75—0 m layer, the percentage of the total catch taken in the different

Table 6. *Number of Stations yielding more, resp. less than 50 ml/m² in Day and Night Hauls with Clarke-Bumpus Plankton Samplers during the Spring Months of 1949—51.*

		Vestfjord only		Vestfjord and outer banks combined	
		Night	Day	Night	Day
1949	more than 50 ml	1	3	4	9
	less than 50 ml	27	15	33	32
1950	more than 50 ml	2	7	12	12
	less than 50 ml	13	25	17	35
1951	more than 50 ml	9	10	27	23
	less than 50 ml	13	23	25	50
Total	more than 50 ml	12 (18.5%)	20 (24%)	43 (36.5%)	44 (29.2%)
	less than 50 ml	53 (81.5%)	63 (76%)	75 (63.5%)	107 (70.8%)

hauls has been calculated, as shown in table 7. Only the two upper hauls are included in the table.

As there are usually great variations in the vertical distribution of the plankton from one station to another, the results from this table must be regarded with some caution. At the beginning of May 1950 and 1951 there is a clearly indicated increase in percentage in the upper 25—5 m hauls from day to night both in the Vestfjord and on the outer banks, and a corresponding decrease in the 50—30 m hauls.

In May 1949 the movements in the Vestfjord seem to be exactly the reverse, with decreasing quantities of plankton in the upper layers at night, while on the outer banks the percentage of the total catch increases in the two upper hauls during the night. In the Vestfjord there is on the whole a greater concentration of the plankton in the upper 50 m than on the outer banks.

At the end of May and beginning of June 1951 we find the same increase in percentage of the total catch in the uppermost haul during the night, whereas in 1949 there were no differences in the vertical distribution in the Vestfjord from day to night, and but slight differences on the outer banks. At the beginning of June 1950 there were greater percentages in the uppermost haul at night, but the percentages of the two upper hauls combined were almost constant.

Bogorov (1938), Manteufel (1941) and others also report that no vertical diurnal migration takes place in the southwestern part of the

Table 7. *Percent Distribution of Catch in 3 Oblique Hauls with Clarke-Bumpus Samplers between 75 m and the Surface in Day and Night Hauls in the Vestfjord (V) and on the Outer Banks (B) during 1949—51. The Deepest Haul Omitted. A + or ÷ indicate an Increase or Decrease in Percentage from Day to Night.*

Date	Haul	Day Night	1949		1950		1951	
			V.	B.	V.	B.	V.	B.
Early May	25—5 m	Day Night	65.5 53.6 ÷	52.3 57.8 +	54.6 66.6 +	53.7 58.3 +	47.4 63.5 +	38.7 45.7 +
	50—30 m	Day Night	20.2 31.1 +	25.1 27.1 +	38.4 24.1 ÷	26.1 28.1 +	34.6 25.0 ÷	44.8 27.9 ÷
End of May to beginning of June	25—5 m[1]	Day Night	56.7 56.6 +÷	54.4 53.5 +÷	73.5 61.2 ÷	61.2 48.1 ÷	37.9 72.0 +	31.7 51.2 +
	50—30 m[2]	Day Night	34.8 35.8 +÷	26.0 32.0 +	22.0 34.0 +	34.5 37.3 +	56.2 20,4 ÷	33.4 30.9 ÷

[1] Vestfjord 1949 15—5 m, 1951 20—5 m [2] Vestfjord 1949 30—20 m, 1951 40—25 m

Barents Sea during the summer, the plankton then being concentrated in the uppermost layers, but in August a very pronounced diurnal vertical migration starts, lasting to the beginning of November. After that time most of the plankton is found in the deeper water layers during both day and night.

b. *Hydrographical Conditions.* Temperature, salinity and current conditions undoubtedly influence the horizontal quantitative distribution of the plankton in the Vestfjord. Very little has been published on current measurements. From EGGVIN (1931) I submit a chart (fig. 20) of the surface currents in the Vestfjord in April 1924. It is assumed, that the main features are characteristic of the surface currents in the Vestfjord, at least during the spring and summer months.

The coastal current flows in along the southeastern shore of the fjord, makes a sharp bend, passes across and again flows out and northwards between and past the outermost islands. In the northwestern part of the Vestfjord the surface currents usually flow southwestwards on the bank, some of the water passing out at Værøy. According to my own observations in this area the tides may sometimes reverse the currents in the southwestern part of the fjord.

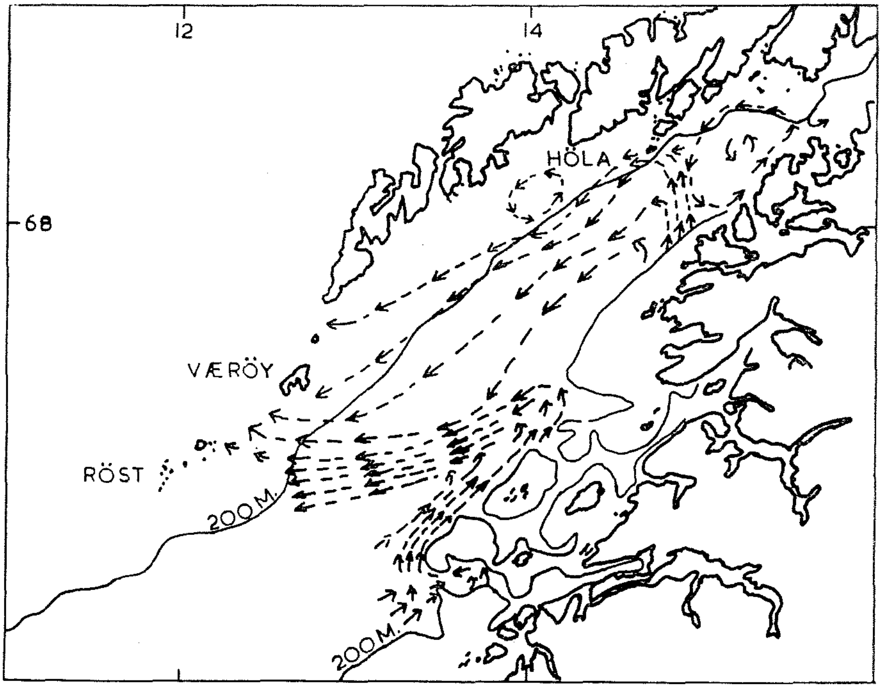


Fig. 20. Currents in the upper 50 m of the Vestfjord in April 1924. From Eggvin 1931.

The temperature in the surface layers of the coastal current is usually one degree C° or more above that of the central and inner part of the Vestfjord.

The isopleths of the plankton volumes on some occasions seem to have the same direction as the current lines, especially on the Lofoten bank and in the mouth of the fjord, although the picture is far from clear. The rich patches found along the outer shores of the Lofoten islands may correspond to eddies formed by the coastal current. Similar concentrations of plankton in eddies are also mentioned by Fish and Johnson (1937).

Temperature observations have been taken simultaneously with the plankton hauls, but they do not give very much explanation of the distribution of plankton, and I therefore find it of no use to give them here.

Comparison between Hauls with the Nansen Net and with the Clarke-Bumpus Plankton Sampler.

In vertical hauls with the Nansen net we do not know the exact amount of water filtered. If the net is hauled slowly enough, we may assume that all the water passing the mouth of the net is filtered. As the opening of the net is 0.4 m² the volumes and figures have to be multiplied by 2.5 in order to get figures per m² of sea surface.

When we compare data from Nansen net hauls with the results from oblique hauls with the Clarke-Bumpus plankton sampler, we have also to take into consideration the different mesh size, the Nansen net being made of silk No. 8 in the lower part and No. 0 in the upper cylindrical part, the sampler nets of silk No. 2 (A comparison between the catches by these two gear has been made earlier (WIBORG 1948)). In addition, the Clarke-Bumpus samplers have only fished between 75 m and the surface, while the Nansen nets have filtered the entire water column from bottom to surface. However, in May and June, when the plankton samplers have been used, we have reason to believe that most of the plankton organisms are concentrated in the upper 50 m or less, and are of such a size that they are sampled quantitatively by both kinds of gear.

Vertical hauls from 100 m to the surface have been made with the Nansen net immediately before the Clarke-Bumpus sampler hauls at a number of stations, and we are thus able to make a direct comparison between the volumes of plankton sampled by both gear. Below are given the results from 32 stations in the Lofoten area during May and June 1949 and 1950. The volumes of plankton taken with the Clarke-Bumpus samplers were calculated per m² of sea surface, and the quotients calculated between these volumes and the volumes per vertical haul with the Nansen net on the same stations.

C.—B. sampler (75—0 m) / Nansen net 100—0 m	0.7—1.0	1.1—2.0	2.1—3.0	3.1—4.0	4.1—5.0	5.1—6.0	<6.0
No. of stations	4	4	10	7	2	1	4

The range of variation is quite wide, from 0.7 to more than 6, the extreme value being 14. This wide range may partly be ascribed to differences in plankton volume of the sea water within short distances, as shown earlier (pp. 31—36). Half the number of the stations have a quotient of 2.1—4.0, and the mean for all stations is also 2.5, which is the theoretical value. Some of the C.B. hauls were taken at the permanent stations at Skrova and Eggum at nearly the same date as the Nansen net hauls, and a comparison has been made between the plankton quantities taken by the two gear (table 8).

At Skrova there is in most cases quite good agreement between the volumes per m² of sea surface calculated from the two gear. At Eggum there are greater divergences, but as the currents probably are of greater importance on the outer banks than in the inner part of the Vestfjord, they may be responsible for rapid changes in the plankton content of the sea water.

Table 8. *A Comparison between Plankton Volumes per m² of Sea Surface Calculated from Vertical Hauls with Nansen Net and from Oblique Hauls with Clarke-Bumpus Plankton Samplers at Skrova and Eggum in 1949—51.*

	SKROVA				EGGUM			
	Nansen net		C.-B. sampler		Nansen net		C.-B. sampler	
	Date	ml/m²	Date	ml/m²	Date	ml/m²	Date	ml/m²
1949	Apr. 30.	18.7	May 3.	20.5	May 2.	22.5	May 5.	65.0[1]
	May 28.	15.0	June 3.	15.5	May 31.	28.0	June 1.	58.0[2]
	May 2.	19.0	May 3.	41.5	May 8.	62.5	May 6.	42.8
1950	May 20.	60.0						
	June 10.	13.2	June 2.	58.5				
1951	May 5.	34.0	Apr.	38.5	May 9.	80.1	May 4.	101.5
	May 26.	81.3	May 29.	70.8	May 23.	96.0	May 24.	69.5

[1] Next station 21.8 ml.. [2] Next station 35.0 ml.

Volume Variations in the Norwegian Sea during 1950—51.

1. *In the upper 100 m at station «M» and in Adjacent Areas.* A very extensive material of zooplankton has been collected from the Norwegian weather ships at station «M», on 66° N, 2° E, in the years 1949—1951. Vertical hauls have been made with Nansen net from 100 m to the surface at least once a week. In addition hauls have also been taken once a month from 2 000—1 000 m, 1 000—600 m, and 600—100 m. The plankton material from 1949 has been worked up in detail by ØSTVEDT (in press).

In fig. 21 are shown the variations of plankton volume in the 100—0 m layer at station «M» during 1950 and 1951. The mean volume for the two years is below 1 ml in January and February, increases to 5 ml in April, further to 16.5 ml in May and reaches the maximum of the year with 17.0 ml in June. In August the mean volume has decreased to 3 ml, and there is a steady decrease from now on to December, when the figure is below 1 ml. The detail variations for the years 1950 and 1951 follow largely that of the average volume, the more exact date for the maxima being in the middle of June 1950 and from the end of June to the beginning of August 1951. On some occasions great variations in volume occur within intervals of a few days. In addition to random variations, which may in part account for the differences, hydrographical conditions may also be of importance, as the plankton samples

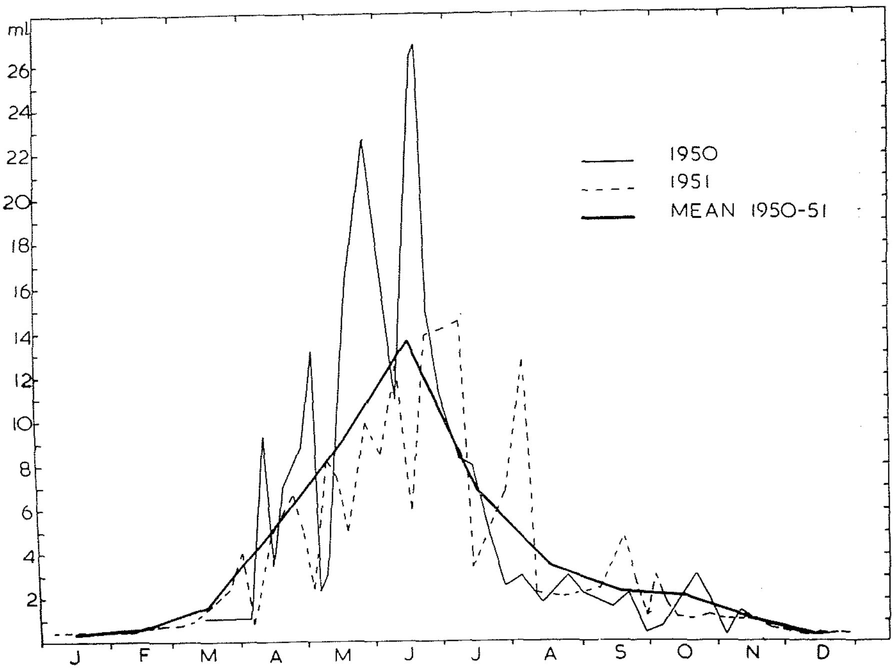


Fig. 21. Variations in plankton volume of the upper 100 m at station «M» in 1950—51. Nansen net.

in question showed on cursory inspection great differences in composition of the species of organisms. At station «M» the North-Atlantic current forms a large eddy (see HELLAND-HANSEN and NANSEN 1909). We may within short distances meet water of purely Atlantic origin, or more or less mixed with water perhaps originating off the Norwegian west coast or in other areas. In the deeper layers there is cold water originating in the East Greenland current. As the ship has not always been in exact position, and the course of the currents may also change, we may within short intervals or distances have met water masses of different origin, which may explain the difference in composition and quantity of the plankton samples.

There are considerable variations in the quantities of plankton in the two years. In 1950 a haul of 27 ml was made in June, the average of the month being 16.1 ml, for the months April to August 8.3 ml, whereas in 1951 the maximum volume was only 14 ml and occurred at the beginning of July. Average for the period April—August was 6.8 ml. The high records for 1950 agree very well with the observations of RAE (1951). In 1951 there was a second maximum in volume in August. (The same was also found in 1952).

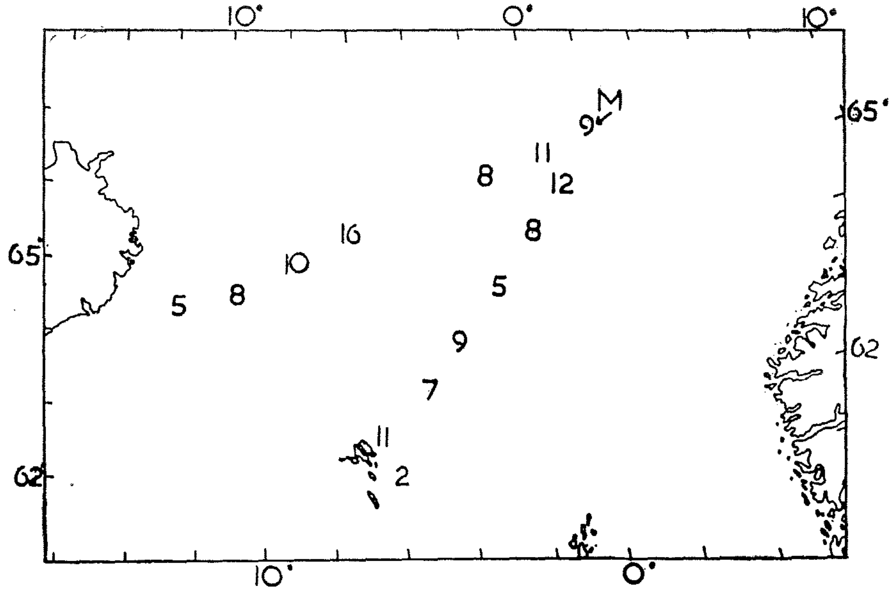


Fig. 22. Plankton volumes of the upper 100 m in the waters between the Faeroes, station «M» and Iceland 16 - 17 July 1950. Nansen net, ml.

Temperature observations were made regularly at station «M». Below are given the temperature variations at 0 m and 100 m during April and for the period April—August of both years.

	April		April—August	
	0 m	100 m	0 m	100 m
1950	6.4°—8.3°C	6.0°—7.4°C	6.4°—13.4°C	6.0°—8.3°C
1951	4.5°—6.5°C	4.5°—6.4°C	4.5°—11.0°C	4.5°—7.5°C

The temperatures were lower in 1951 than in 1950, especially in April. There may be some relation between the difference in the quantities of plankton, delay of time of the maximum, and the variation in the temperature of the upper 100 m.

A number of vertical hauls with Nansen net have been taken during cruises by the «G. O. Sars» in the Norwegian Sea. In 1950 hauls from 100—0 m were made between the Faeroes, station «M» and Iceland on 16—17 July, (fig. 22). Between the Faeroes and «M», the plankton volumes varied between 5.0 ml and 11.5 ml, mean 6.5 ml, from «M» to Iceland 5.8—15.5 ml, mean 9.3 ml. At station «M» the plankton volumes on 14 and 21 July were 8.0 ml and 5.0 ml respectively.

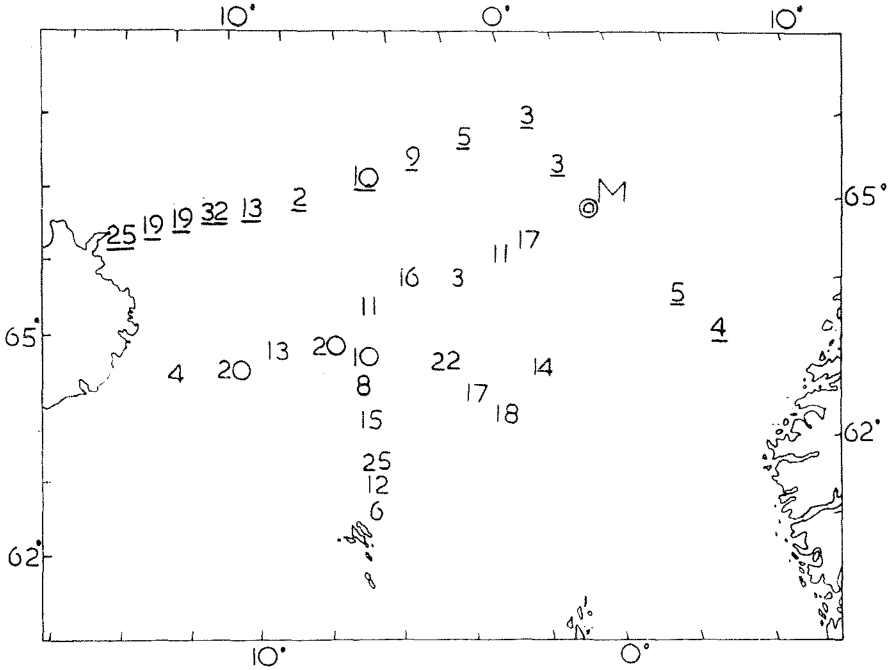


Fig. 23. Plankton volumes of the upper 200 m in the waters between the Faeroes, station «M» and Iceland 28 June–2 July, and 27–30 August 1951 (underlined figures). Nansen net, ml.

In 1951 a number of hauls were made from 200—0 m between the Faeroes, «M» and Iceland on 28 June — 2 July, and on 27—30 August (fig. 23). In the first period volumes in this area varied from 6.0—25.4 ml, mean 15.0 ml. At station «M» plankton volumes on 29 June and 6 July were 14.0 ml and 14.4 ml respectively.

In the last period plankton volumes on 4 stations near Iceland varied from 13.2 ml to 32.0 ml with a mean volume of 20.0 ml. At the next 10 stations the volumes varied from 1.8 ml to 10.0 ml, mean 5.4 ml. At «M» the plankton haul on 24 August yielded 2.0 ml.

We may therefore assume that the 100—0 m hauls at station «M» are representative of the upper layers of a comparatively wide area of the central Norwegian Sea.

2. *In the total Water Column at Station «M».* In table 9 are given the mean volumes in the different water layers at station «M» during 1950 and 1951. The hauls from 2 000—1 000 m and 1 000—600 m have been pooled. For the deeper hauls the volumes of copepods are given separately. Figures have also been calculated per 100 m of hauls. In the 100—0 m hauls no separation has been made, as the plankton here

Table 9. *Plankton Volumes in ml at Station "M" 1950—51, Nansen Net Hauls.*

	Depths:	2 000—600 m		600—100 m		100—0m	2000—0m
		Total haul	pr. 100m	Total haul	pr. 100m	Total haul	Total
Jan.	Copepod Vol.	15.6	1.1	5,4	1.1	0,3	21.3
	Total Volume	31.0	2.2	11.4	2.3		42.7
Feb.	Copepod Vol.	>10.9	—	2.1	0.4	0.5	>13.5
	Total Volume	>26.1	—	4,0	0.8		>30.6
Mar.	Copepod Vol.	11.2	0.8	6.6	1.3	1.5	19.3
	Total Volume	18.8	1.3	9.5	1.9		29.8
Apr.	Copepod Vol.	8.9	0.6	8.9	1.8	5.1	22.9
	Total Volume	16.4	1.2	15.8	3.2		37.3
May	Copepod Vol.	10.7	0.8	11.9	2.4	9.1	31.7
	Total Volume	24.3	1.7	24.6	4.9		58.0
June	Copepod Vol.	16.8	1.2	11.3	2.3	13.5	41.6
	Total Volume	33.0	2.4	21.8	4.4		68.3
July	Copepod Vol.	21.8	1.5	4.5	0.9	6.8	33.1
	Total Volume	25.6	1.8	10.6	2.1		43.0
Aug.	Copepod Vol.	18.6	1.3	5.3	1.1	3.4	27.3
	Total Volume	28.6	2.0	11.3	2.3		43.3
Sep.	Copepod Vol.	23.4	1.7	6.3	1.3	2.2	31.9
	Total Volume	38.1	2.7	11.8	2.4		52.1
Oct.	Copepod Vol.	21.5	1.5	4.6	0.9	2.0	28.1
	Total Volume	34.7	2.5	9.0	1.8		45.7
Nov.	Copepod Vol.	26.7	1.9	4.8	1.0	0.9	32.4
	Total Volume	49.5	3.5	9.5	1.9		59.9
Dec.	Copepod Vol.	23.6	1.7	5,0	1.0	0.3	28.9
	Total Volume	42.0	3.1	10.7	2.1		53.0

almost entirely consisted of copepods, with the exception of a few hauls rich in salps, which were sorted out and excluded from the volumes.

The total volumes are always largest in the deepest hauls, the copepods usually yielding half the quantity of plankton. When we consider the quantities per 100 m of haul, the highest values occur in the upper 100 m, with 13.5 ml as the mean volume for June. But in this water layer the yearly variations are great, and minimum values of 0.3 ml are found in January and December. In the 600—100 m layer the maximum per 100 m of haul is 4.9 ml in May, but in the other months the values are mostly more than 2 ml/100 m, with a minimum of 0.8 ml in February. Below the 600 m level the maximum concentration is found in November with 3.5 ml/100 m. The range of variation is insignificant, with a minimum in April of 1.2 ml/100 m. If we exclude the larger organisms from the calculations, all the figures below 100 m will be reduced by approximately one half.

In the 2 000—600 m layer the ratio largest to smallest volume is only 3 to 1, in the 600—100 m layer somewhat greater, 6 to 1, but in the upper 100 m, 40 to 1. For the whole water column the ratio will be 2.3 to 1.

When we compare the conditions found at station «M» with those of Norwegian coastal waters, we will find that during the period April—August, when the most intensive production of zooplankton takes place, the average content of plankton is considerably higher in the upper 50 m off North Norway than in the 100—0 m layer at station «M». In 1950 the mean volume at Eggum for the said period was 17.0 ml, in 1951 11.9 ml, compared with respectively 8.3 ml and 6.8 ml at station «M».

In coastal waters the localities which maintain a larger population of plankton animals during winter are restricted to fjords and bays, where the deeper water layers move comparatively little, such as in the inner part of the Vestfjord, where the station at Skrova is located. As shown previously (page 30) there is at Skrova a more or less constant stock of plankton animals below 50 m. If we consider the variation in the 300—50 m layer, the ratio of largest to smallest volume during the years 1949—51 is on an average 11 to 1, for the upper 50 m 30 to 1, and for the whole water column from bottom to surface, 4 to 1. At Eggum, where the plankton is almost entirely swept away during winter, the ratio for the whole water column is 45 to 1, for the upper 50—0 m as for Skrova, 30 to 1. Thus there is nearly the same relative change in the plankton population of the upper water layers as at station «M», and the 300—50 m layer at Skrova may to some degree be compared with the 600—100 m layer at station «M».

In fig. 24 are given the mean monthly plankton volumes in the total column from bottom to surface at the coast stations during 1949—51 and for the 600—0 m column at station «M» during 1950—51. The volumes of «non-copepods» in the 600—100 m hauls are indicated by a different shading. The figure illustrates quite clearly the variations in plankton volume in the different water layers throughout the year and from one locality to another. There is a pronounced increase in the amount of plankton from the Norwegian west coast between 61°—63° N to the Lofoten area further north. At station «M» there is below 100 m a

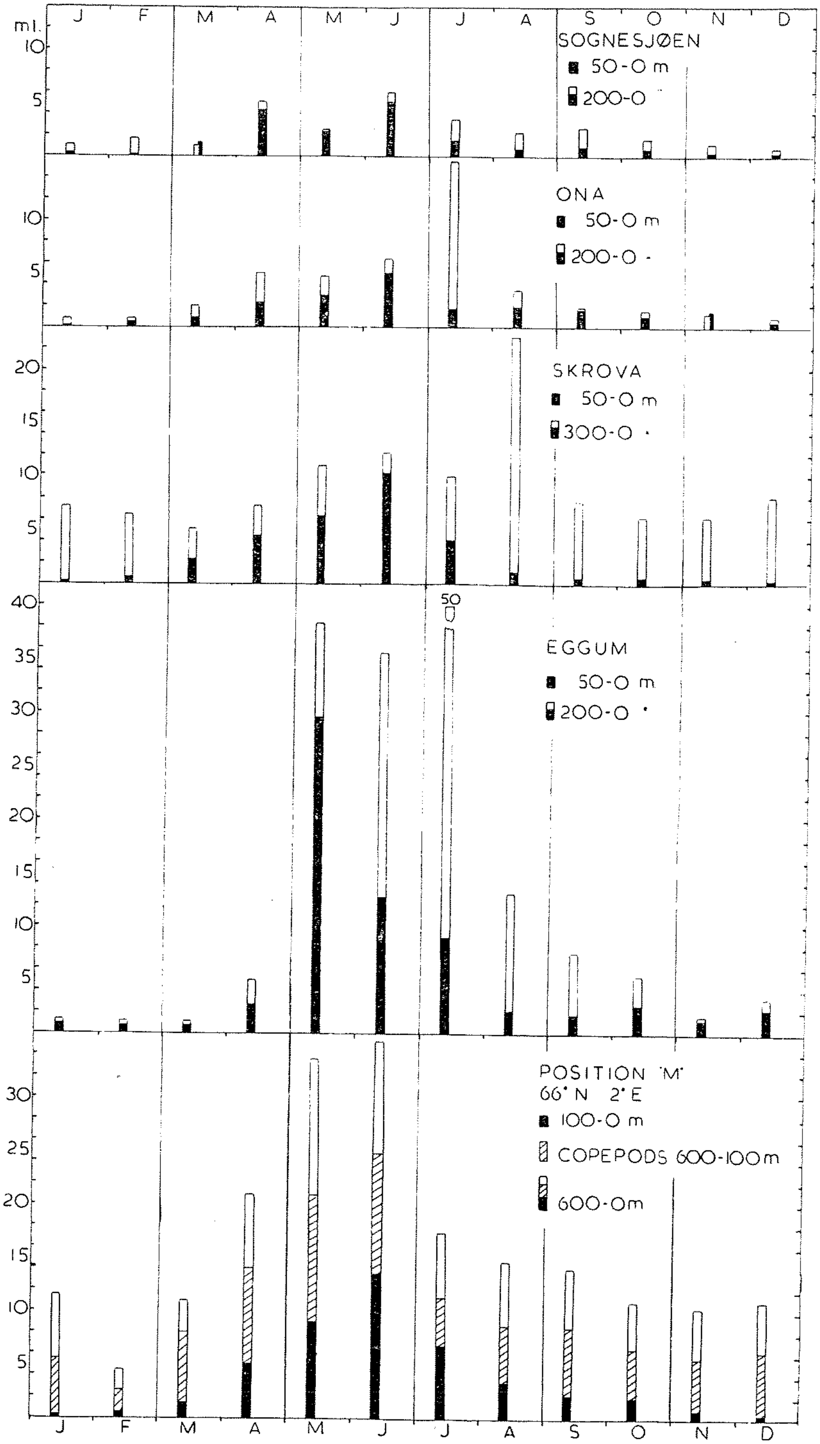


Fig. 24. Mean monthly volumes of plankton in the coastal areas of Norway 1949—51 and at station «M» 1950—51. Nansen net.

Table 10. *Plankton Volumes in ml of Displacement below 1 m² of Sea Surface in some American and North European Waters.*

	USA, East Coast Georges Bank (Riley and Bumpus 1946)	North Coast of Norway (author)		Norwegian Sea 66°N, 2°E (author)		South-western Barents Sea (Jaschnow 1939)
		Eggum	Skrova	100—0m	600—0m	
Jan.	11.1	3.3	18.3	0.8	29.9	—
Febr.	—	3.0	13.8	1.3	11.3	—
March	58.2	2.8	13.0	3.6	27.5	—
April	81.3	12.5	18.3	12.8	52.2	46.0
May	*152.6*	96.0	27.8	23.6	84.0	—
June	60.1	89.0	30.8	*33.8*	*88.2*	124.0
July	—	*125.0*	25.3	17.0	43.5	—
August ..	—	32.0	*57.8*	8.5	36.8	*188.0*
September	38.1	19.0	19.5	5.5	35.0	—
October ..	—	13.5	15.8	5.0	27.5	—
November	—	4.3	15.8	2.3	26.0	—
December	—	8.5	20.5	0.8	27.5	96.0

permanent stock of plankton organisms which is maintained throughout the year, but the maximum quantity of plankton found in the upper 600 m is considerably below the figures observed at Eggum, even if we include the volumes of all the plankton organisms.

Comparison with Other Areas.

The gear used in the present investigation, the Nansen net and the Clarke-Bumpus plankton sampler, will not catch quantitatively all the organisms present in the plankton, but we may assume that they will give a nearly correct picture of the relative abundance of plankton in the areas investigated, when we exclude the swifter moving animals e.g. adult euphausiids and larger fish larvae.

A number of observations on the quantity of zooplankton in the sea has been made both in European and American waters, but the gear and methods used have varied considerably. Figures have been given as cc (ml) of plankton measured either by settlement or by displacement, per haul, or per 100 m of haul with different kinds of gear. Sometimes volumes are calculated per m² of sea surface or m³ of sea water. In table 10, a comparison is made between some areas in European and American waters which are supposed to be very rich in plankton. The figures are given as ml of plankton below 1 m² of sea surface for the different months of the year. Settlement volumes have been recalculated into displacement volumes by dividing by 4, the figures given by SAVAGE (1931) by 3 from his own statement.

Table 11. *Monthly Mean Volumes of Zooplankton in ml/m³ in the Upper Layers of the Sea in some European Waters.*

Month	Southwest. North Sea (*Savage* 1931) Av. depth. 65 m	Iceland. coast (*Jespersen* 1940) 25—0 m	Ona (author) 50—0 m	St. «M» (author) 100—0 m	Eggum (author) 50—0 m	Barents Sea (*Manteufel* 1941) 25—0 m	Murman coast (*Pchelkina* 1939) 25—0 m
Jan.	—	—	0.01	0.01	0.05	—	—
Feb.	—	—	0.03	0.01	0.04	—	—
Mar.	—	0.04	0.04	0.04	0.04	—	0.05
Apr.	—	—	0.12	0.13	0.14	0.4—0.8	0.17
May	—	0.49	0.15	0.23	1.48	2.0—20.0	—
June	0.38	0.09—0.45	0.26	0.34	0.62	—	—
July	—	0.25—0.74	0.09	0.17	0.45	0.01—0.08	3.06
Aug.	0.33	0.15	0.10	0.09	0.11	0.4	0.58
Sept.	0.33	—	0.08	0.06	0.09	—	—
Oct.	0.33	—	0.06	0.05	0.14	—	—
Nov.	0.32	—	0.08	0.02	0.07	—	—
Dec.	—	—	0.03	0.01	0.12	—	—
Max. found	2.30	1.45	0.39	0.68	5.40	36.00	—

RILEY and BUMPUS (1946) suppose that the dry weight of zooplankton corresponds approximately to one quart of the wet weight of the sample measured by displacement. BIGELOW and SEARS (1939) found that 1 ml of plankton measured by displacement weighed 1 gr. Accordingly figures for dry weight given in milligrammes (JASCHNOW, MANTEUFEL) have been converted into ml of plankton by multiplying by 0.004.

The maximum quantities are of approximately the same size at Eggum, on Georges Bank and in the Barents Sea, increasing in the order mentioned, but occur in different months of the year, on Georges Bank in May, in the Norwegian Sea in June, in North Norwegian coastal waters in July and August, and in the Barents Sea in August. If the development of the plankton at Georges Bank is, as it seems, two months earlier than at Eggum, we may compare the months March—June there with May—August at Eggum. The mean volumes for these periods are 88 ml and 86 ml respectively. The September value at Georges Bank is higher than at Eggum, but the January volume is comparable to that of Skrova. In the Barents Sea the plankton quantities are very high in June and August, and also considerable in December.

On occasion the amount of plankton may be far above the average values. At Eggum a vertical haul in May 1950 yielded 295 ml/m², a series of hauls with the Clarke—Bumpus plankton sampler outside the

Lofoten Islands at the end of May 1951, 192 ml/m^2 (see also pp. 31—36). At Skrova a vertical haul in August 1951 gave 117 ml/m^2.

In some American and European waters observations have also been made on the quantity of zooplankton per m^2 of sea water, and in tables 11—12 some data have been compiled from different authors. In table 11 I have only considered the plankton in the uppermost water layers. The data from the southwestern North Sea (from SAVAGE 1931) have been included, as the average depth in that area is only 65 m.

During all months of the year the figures calculated for the upper 50 m at Ona are of almost the same size as those for the upper 100 m in the Norwegian Sea. Recent observations (unpublished) have, however, shown that in the Norwegian Sea the plankton during the summer and autumn is mainly concentrated in the upper 50 m and this would mean that the figures from station «M» probably have to be doubled to be comparable to those from Ona. In the southwestern North Sea the conditions also seem to be comparable to Ona in June, but from August to November the concentration of plankton is maintained, while at Ona the surface layers were poor in plankton from and including July. The Icelandic coast waters are possibly richer than those of Western Norway, but not so rich as the Lofoten area.

At Eggum the density of plankton in the 50—0 m layer was considerably above that of Ona from May to July, with an average volume of 1.48 ml/m^3 in May. If we on the other hand extend our comparison to the Barents Sea, the plankton concentrations there are still greater, with 2—20 ml/m^3 in May and also high values for the months April, July and August.

The maximum concentrations of plankton found in the surface layer were as follows: For the southwestern North Sea 2.3 ml/m^3, at Ona 0.39 ml/m^3, at Eggum in vertical hauls 5.4 ml/m^3, plankton sampler hauls in the upper 25 m 6.4 ml/m^3. BIGELOW and SEARS (1939) found a maximum concentration of 6.9 ml/m^3 off the east coast of USA. From the Barents Sea concentrations of 20—50 ml/m^3 are not unfrequently reported (JASCHNOW, 1939, MANTEUFEL 1941). If schools of euphausiids or great accumulations of medusae or salps are taken into account, the concentrations of plankton may be considerably higher.

Finally we may consider table 12 on the concentrations of zooplankton in the total water column from bottom to surface on the east coast of USA, northwestern coast of Norway and in the Barents Sea. For the months May to November conditions seem to be quite similar in the Cape Cod area of USA and in the Barents Sea, quantities ranging from 0.32—0.92 ml/m^3. At Eggum the concentration of plankton is approximately the same from May to July, but small during the other months of the year.

Table 12. *Volumes of Zooplankton in ml/m³ in the Total Water Column of the Sea in some European and American Waters. Monthly Averages.*

Month	Cape Cod East Coast of USA (Bigelow & Sears 1939)	Barents Sea (Jaschnow 1939)	Eggum, NW Coast of Norway (author)
January	—	—	0.02
February	0.40	0.12[1]	0.02
March	—	—	0.01
April	0.50	0.19	0.06
May	0.80	—	0.48
June	0.70	0.82	0.45
July	0.80	—	0.63
August	—	0.92	0.16
September	—	—	0.05
October	0.40	—	0.07
November	—	0.32	0.02
December	—	—	0.04

[1] Manteufel 1941.

From what has been said above the plankton quantities off the west coast of Norway and in the upper 100 m of the central Norwegian Sea area are of approximately the same size during the period April—August, and also comparable to the conditions in the North Sea. In the coast and bank waters in the Lofoten area the plankton is richer during the period of production than further south. In summer still greater quantities of plankton are met with off North Cape (4—12 ml/m³, MANTEUFEL 1941), and especially in the Barents Sea, which area has the greatest concentrations of plankton in northern waters yet described, but it is possible that in summer similar concentrations may exist in the coastal waters surrounding the southwestern Norwegian Sea, along the Faeroes, Iceland and Jan Mayen.

Variations in Number of Organisms.

In fig. 25 are shown the variations in total number of organisms in the vertical hauls from bottom to surface during 1949 and 1950 at the localities investigated.

In 1949 there are on the whole two main periods of abundance. At Ona the first period extends from March to the middle of July and the second from August to September. The April figure at Sognesjøen is based on one observation only. At the northern stations Eggum and

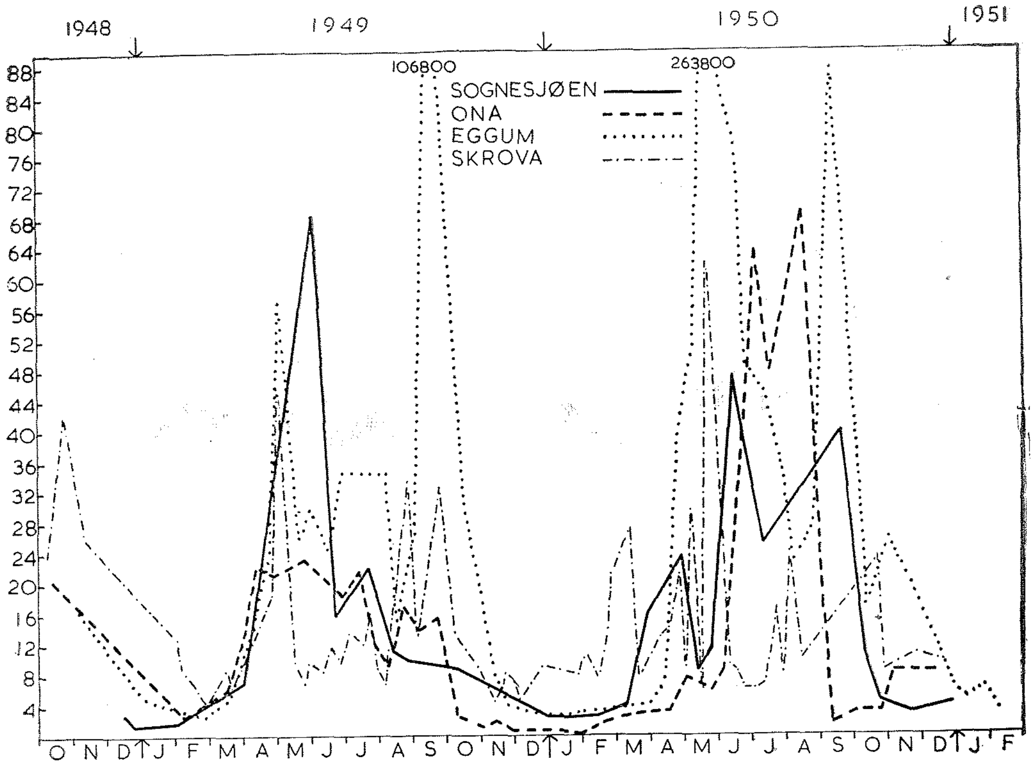


Fig. 25. Variations in total number of organisms 1948—50.

Skrova the numbers are on the whole higher than on the west coast. The rich periods extend from April to May and from August to October.

In 1950 there were 3 peaks in numbers at Sognesjøen, in April, June and the middle of September, at Ona only one period of abundance, from the end of June to the middle of September. At the northern stations the main maxima occurred a little later than in 1949, but at Skrova a peak also appeared in March. Observations are lacking here between 13 August and 23 October. Numbers were on the whole higher in 1950 than in 1949 and Eggum was the leading station both years.

The Composition of the Plankton.

In coastal plankton we usually find several species of organisms. Larvae of bottom invertebrates are numerous during spring and summer, and fish eggs and larvae may also at times be well represented. Aggregations of medusae and salps occur occasionally, mainly in summer and autumn, but on the whole pelagic crustaceans, above all the copepods, will account for the bulk of the plankton, both numerically and by volume.

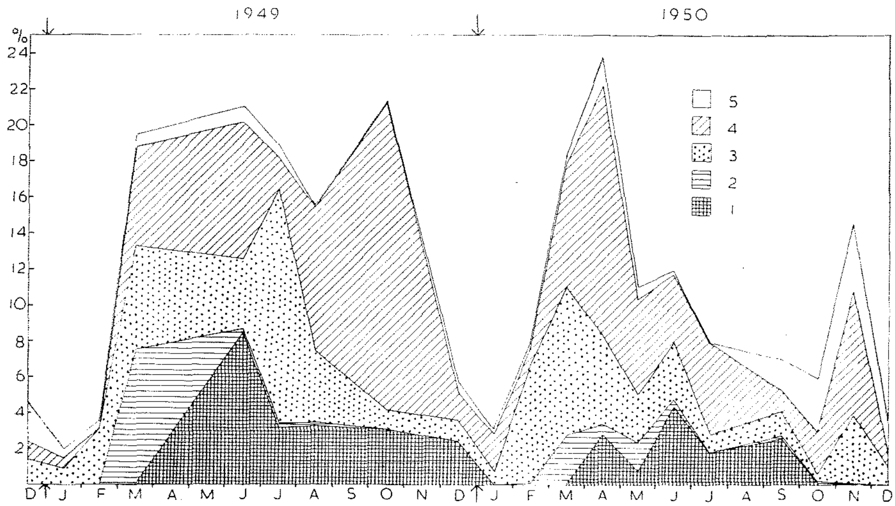


Fig. 26. The relative importance of «non-copepods» in the plankton at Sognesjøen in 1949—50. 1. Cladocera. 2. Euphausiid eggs and larvae. 3. Copelata. 4. Bottom invertebrate larvae. 5. Other organisms.

At the coastal stations the copepods during the years 1949—50 generally constituted 80—90 per cent of the total number of organisms, with a few exceptions. As the most important groups besides the copepods are considered the Cladocera, eggs and larvae of Euphausiids, Copelata, and Larvae of bottom invertebrates. At Skrova the Chaetognatha and Ostracoda were fairly abundant and have been separated as individual groups. Organisms which occur more rarely or sporadically such as Fish eggs and larvae, adult Euphausiids, Amphi- and Isopods, Medusae and others, have been lumped as «Other organisms».

In fig.s 26—29 are shown the variations in relative percentage of the various groups besides the copepods at the localities investigated during 1949—50. Only the monthly mean values have been considered. Details will be found in the tables 37—40 at the end of this paper.

At Sognesjøen and Ona the composition of the plankton is very much the same. Benthonic invertebrate larvae usually range between 4 and 7 %, except at Ona in June 1950, when a swarm of cirripede larvae increased the percentage to 43. This group is of greatest relative importance in March—April, June, and October. Eggs and larvae of euphausiids may yield 0.5—4 %, and have their peak in March. The cladocera are most abundant at Sognesjøen in June, at Ona in September. In the group «Other organisms» fish eggs and larvae were most prominent at Ona in February—March 1950, and *Limacina retroversa* at Sognesjøen Ona in August—November 1950.

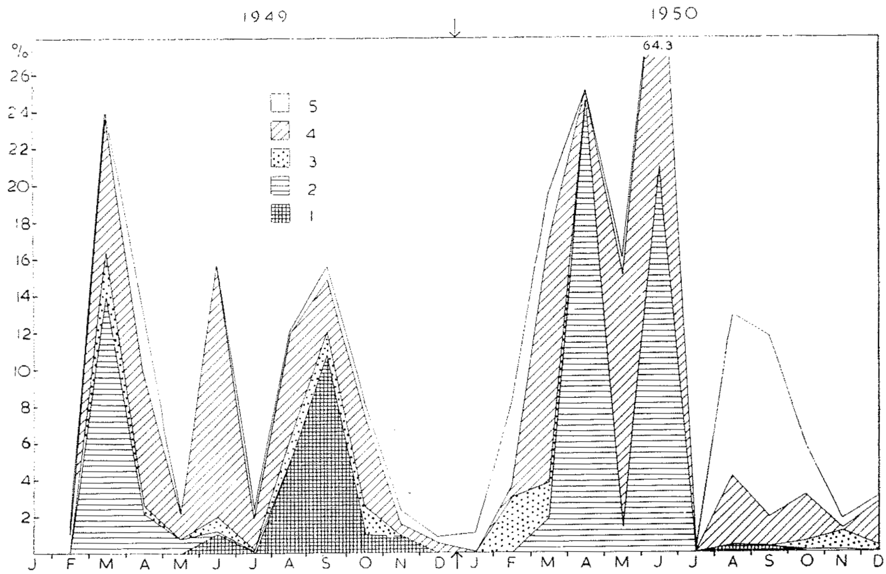


Fig. 27. The relative importance of «non-copepods» in the plankton at Ona in 1949--50. 1. Cladocera. 2. Euphausiid eggs and larvae. 3. Copelata. 4. Bottom invertebrate larvae. 5. Other organisms.

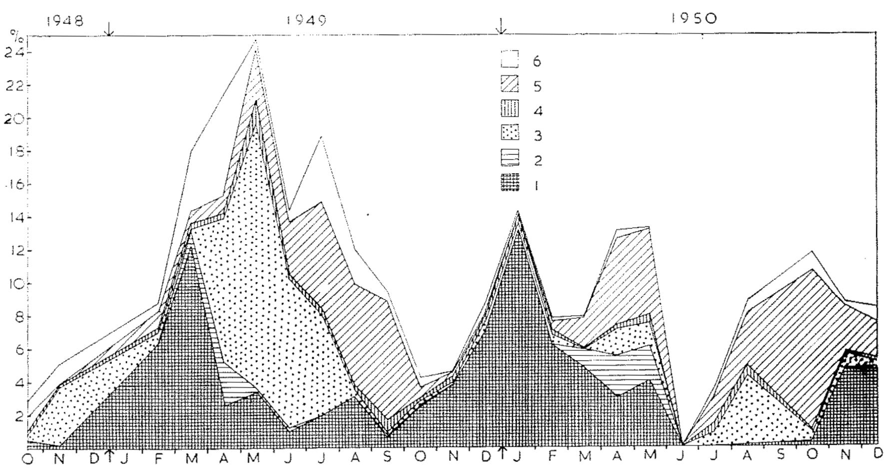


Fig. 28. The relative importance of «non-copepods» in the plankton at Skrova in 1949—50. 1. Ostracoda. 2. Euphausiid eggs and larvae. 3. Copelata. 4. Chaetognatha. 5. Bottom invertebrate larvae. 6. Other organisms.

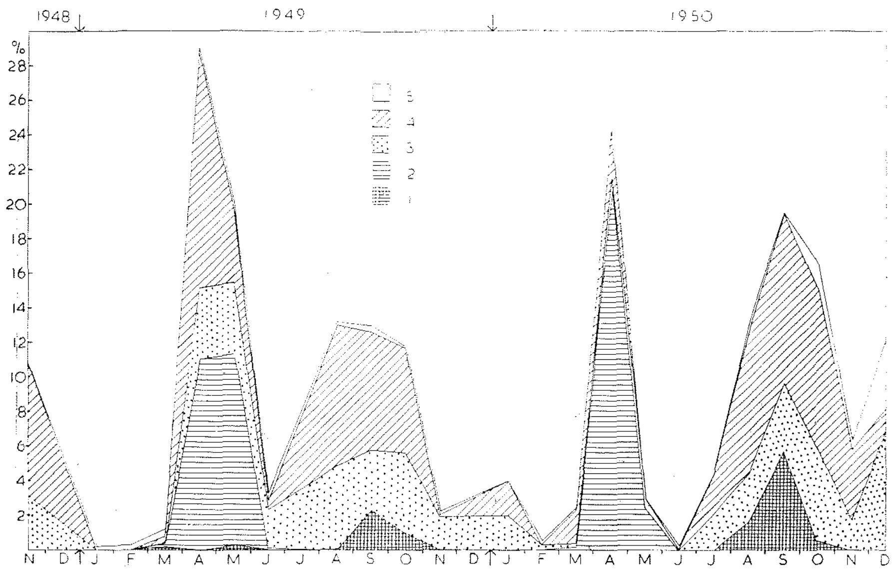


Fig. 29. The relative importance of «non-copepods» in the plankton at Eggum in 1949—50. 1. Cladocera. 2. Euphausiid eggs and larvae. 3. Copelata. 4. Bottom invertebrate larvae. 5. Other organisms.

At Skrova and Eggum the cladocera are sparsely represented, while the other groups have approximately the same relative importance as at Ona and Sognesjøen. Eggs and larvae of euphausiids are strictly seasonal, occurring in April—May. The percentages are higher at Eggum (11—20 %) than at Skrova (2.6 %), and, as will be shown in the special part of this paper (page 186) this also applies to the total number. The copelata are present all the year with an average percentage of 2—4, on some occasions rising to 16 (Skrova May 1949). The chaetognaths are most abundant in the deeper water layers at Skrova. The percentage is low, about 0.5 %, but rather constant throughout the year. — The benthonic invertebrate larvae seldom exceed 10 %, the yearly mean being 2—4 %.

Variations in the Composition of the Stock of Copepods.

As already mentioned, copepods are the dominating element in the coast plankton both by number and by volume. A total of 38 species has been identified, but only 8—9 of these occur regularly or in considerable numbers. Some of the rarer species may be important as indicators of currents or of water masses of different origin.

It is well known that copepods may vary considerably in size. e.g. from the large *Pareuchaeta norvegica* with a total length of 11 mm, to the small *Oithona nana* which scarcely exceeds 0.6 mm. Within the

Table 13. *The Relative Volume of Different Species and Stages of Copepods, (Calanus finmarchicus stage V = 100). Measurements: Ona 24/5 and 27/9—1949.*

Calanus finmarchicus:		*Metridia longa:*	
adults	160.0	females	100.0
stage V	*100.0*		
» IV	49.0	*Metridia lucens:*	
» III	17.0	adults	58.0
» II	6.0	stage V-IV	15.0
» I	2.0	» III-I	3.0
nauplii and eggs	0.5	*Metridia* nauplii	1.0
Calanus hyperboreus:		*Acartia clausi:*	
stage V	970.0	adults	5.0
Pseudocalanus elongatus:		*Centropages hamatus:*	
adults	9.0	adults	10.0
stage V	7.0	copepodites	4.0
» IV	6.0	*Centropages typicus:*	
» III	3.0	adults	20.0
» II	2.0	copepodites	9.0
» I and nauplii	1.0	*Scolecithricella minor:*	
Paracalanus parvus:		adults	9.0
adults	4.5		
copepodites	2.0	*Oithona similis:*	
Microcalanus pusillus:		adults and copepodites	1.5
adults and copepodites	3.0	*Oithona spinirostris:*	
Pareuchaeta norvegica:		adults and copepodites	4.0
stage V	740.0	*Oncaea borealis:*	
Temora longicornis:		adults	1.5
adults	6.0	*Harpacticoida:*	
copepodites and nauplii	1.5	adults	1.5

same species there may be great variations in size from the first larval stages to the adults, and in addition, considerable differences in size may also occur within the same stages of development. Thus the number of copepods is not always an adequate expression of the relative importance of the species in the production of organic matter, or as food for plankton feeders. On the other hand, the presence of a large number

Table 14. *The Relative Volume of Different Species and Stages of Copepods, (Calanus finmarchicus stage V = 100). Measurements: Skrova 23/10—48, 2/5 and 27/8—49, 25/4 and 25/10—50.*

Calanus finmarchicus:		*Metridia longa:*	
adults	160.0	females	100.0
stage V	*100.0*	stage V-IV	20.0
» IV	40.0	» III-I	5.0
» III	14.0		
» II	5.0	*Metridia lucens:*	
» I	2.0	females	24.0
nauplii	0.5	stage V-IV	7.0
		» III-I	1.4
Calanus hyperboreus:		*Metridia* nauplii	0.5
females	580.0		
stage V	300.0	*Acartia longiremis & clausi:*	
» IV	120.0	adults and copepodites	4.4
» III	60.0		
» II	20.0	*Centropages hamatus:*	
» I	7.0	adults	4.0
nauplii	1.0		
Pseudocalanus elongatus:		*Centropages typicus:*	
females	6.0	adults	15.0
stage V	4.0		
» IV	2.4	*Scolecithricella minor:*	
» III	1.3	adults	13.0
» II	0.7		
» I and nauplii	0.5	*Candacia norvegica:*	
Paracalanus parvus:		adults	15.0
adults	4.0		
copepodites	1.0	*Oithona similis:*	
Microcalanus pusillus:		adults and copepodites	0.8
adults and copepodites	1.1	*Oithona spinirostris:*	
Pareuchaeta norvegica:		adults and copepodites	1.2
males	450.0		
females	1150.0	*Oncaea borealis:*	
stage V	350.0	adults	0.8
» IV	180.0		
» III	50.0	*Harpacticoida:*	
» II, I and nauplii	7.0	adults	0.8

of small plankton organisms may be of importance e.g. as food for small fish larvae, as pointed out by MARSHALL (1949) and others.

LOHMANN (1908) calculated the volumes of most of the common copepods (not *Calanus*), but only as mean volumes of copepodites and adults. BOGOROV and PREOBRAJENSKAYA (1934) give the dry weights of *Pseudocalanus, Centropages* and *Acartia.* BIGELOW and SEARS (1939) made a volumetric study of the zooplankton of the northeastern coast of USA and calculated the relative volumes of the different species from direct measurements.

I have calculated the relative volumes of the copepods indirectly. The animals were considered as cylinders, the length and the diameter of the cephalothorax being measured in a microscope with a built-in micrometer, and the volume calculated of this cylinder. When available, at least 10 specimens of each stage were measured. Thereafter the volumes of the different species and stages were converted into units equalling the volume of copepodite stage V of *Calanus finmarchicus* (tables 13—14).

It is stressed that this method of comparison must be very rough, the main reason being that the unit will not be of a constant size, but the picture we thus get of the relative importance of the different species of copepods will nevertheless be more correct than the numbers alone. In the tables 13—14 are given the relative importance of the most usual copepods occurring, measured against *Calanus finmarchicus* stage V. Measurements have been made separately for the stations at Ona and Skrova.

At Ona one specimen of *Calanus finmarchicus* stage V is equivalent to nearly 50 copepodites of stage I or approximately 200 nauplii, or 11 adults of *Pseudocalanus* elongatus, or 70 adults and late copepodites of *Oithona similis,* whereas 7—9 stage V of *Calanus finmarchicus* are equivalent to one specimen of *Calanus hyperboreus* copepodite stage V, or *Pareuchaeta norvegica* stage V. It may be mentioned that in figures for *Calanus finmarchicus* obtained by weighing (BOGOROV 1933) one specimen of stage V equals 1.4 of stage IV, 6.4 of stage III and 17 of stage II and I.

In fig.s 30—33 is shown the percentage distribution by number and by volume of the most important species of copepods in 1949—50. For details see the tables 41—48 at the end of this paper.

At Sognesjøen (fig. 30) 9 species of copepods, *Calanus finmarchicus, Metridia lucens, Pseudocalanus elongatus, Microcalanus pusillus, Oithona similis, Acartia clausi, Paracalanus parvus, Temora longicornis* and *Scolecithricella minor* together form more than 90 % of the total number of copepods. In 1949 *Calanus finmarchicus* was numerous in the first half of the year with a maximum of about 60 % in April, but scarce from July to December. *Oithona similis* is next in percentage, varying from about 20 to 40 % all the year. *Pseudocalanus* and *Microcalanus* are also relatively abundant, while *Temora* and *Metridia* are best represented in the second half of the year.

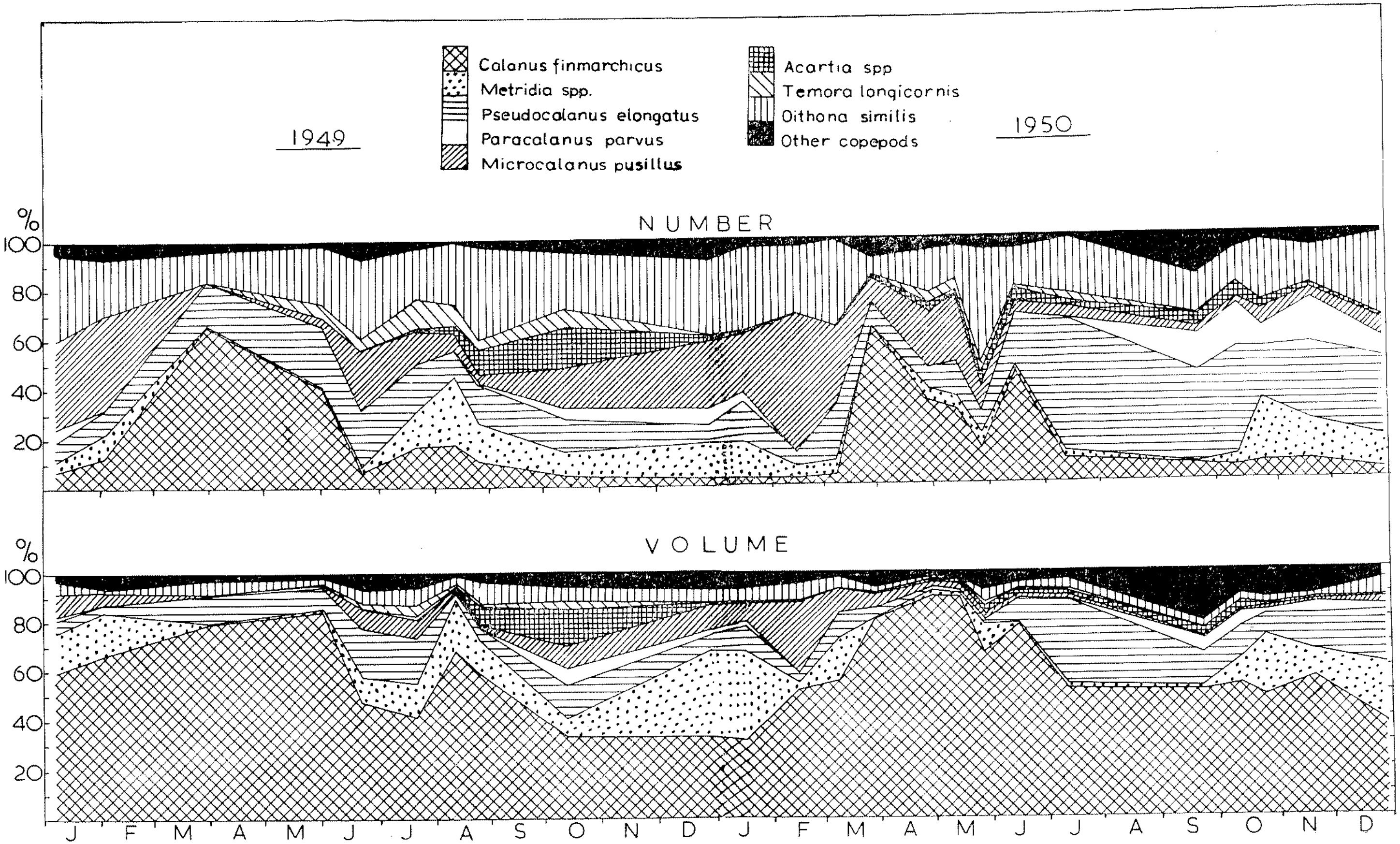


Fig. 30. Variations in the percentage composition of the copepod stock at Sognesjøen 1949—50.

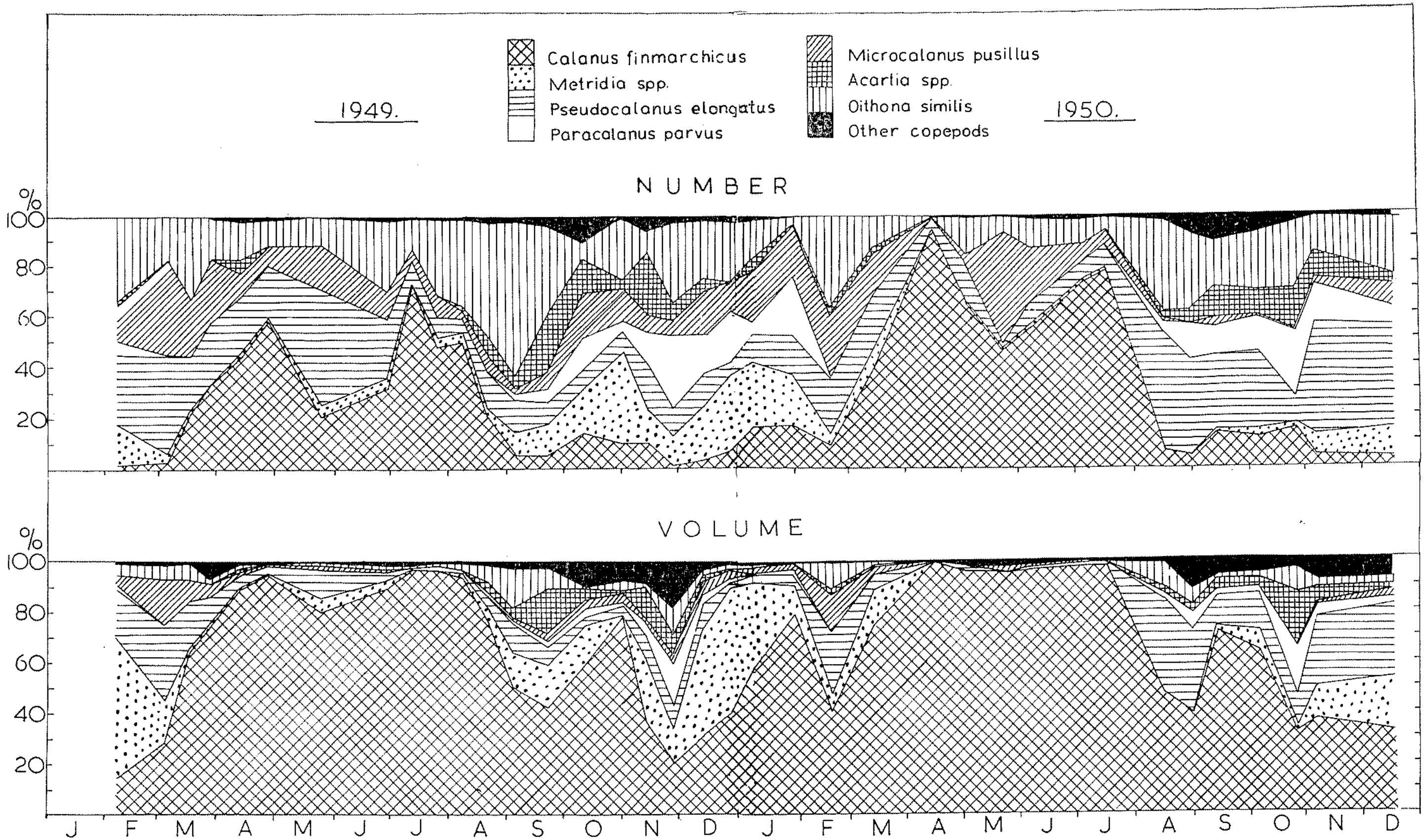


Fig. 31. Variations in the percentage composition of the copepod stock at Ona 1949—50.

When we consider the relative importance of the different species by volume, we get another picture. *Calanus finmarchicus* is responsible for 40—80 % of the copepod volume, with the greatest percentage in the period of general abundance occurring in the spring and summer. Next in importance come *Pseudocalanus, Metridia, Microcalanus* and *Acartia,* while *Oithona* because of its small size is very insignificant in volume, never exceeding 10 %.

In 1950 the numerical percentage variation is similar to that of the preceeding year, but *Microcalanus* play a greater part from January to July, *Pseudocalanus* from July to December. The volumetric composition again shows that *C. finmarchicus* is by far the most important species, sometimes exceeding 60 % of the volume, with *Pseudocalanus* second. In the group «Other copepods» *Centropages typicus* dominates entirely in September.

At Ona (fig. 31) the composition in species of copepods is very similar to that at Sognesjøen. In 1949 *C. finmarchicus* has two peaks of relative numerical abundance. *Pseudocalanus* has a high percentage during the first half of the year, while *Oithona* is more dominant in the autumn, *Metridia, Acartia* and *Paracalanus* are of some importance in the autumn, while *Microcalanus* is constant in percentage.

In volume *C. finmarchicus* dominates entirely nearly all the year except between November and February. In September the other groups are a little more prominent.

The 1950 picture is in general similar to that of 1949. *C. finmarchicus* is still more significant in number from March to July, and entirely dominates the volume of copepods from March to September. *Pseudocalanus* is most important in the autumn.

At Eggum (fig. 32) *C. finmarchicus, Microcalanus* and *Oithona* are dominant in 1949. *Pseudocalanus* and *Metridia* are of some importance in the first and last parts of the year respectively. *C. finmarchicus* makes up the greater part of the volume almost all the year round.

In 1950 *Microcalanus* is relatively numerous at the beginning of the year, *Oithona, Pseudocalanus* and *Paracalanus* in autumn and early winter, but in volume *C. finmarchicus* is of overwhelming importance.

At Skrova (fig. 33) the numerical composition of the copepods in 1949 is dominated by *C. finmarchicus* and *Oithona* spp. the former from April to August and in November—December, the latter in July—October and in January. *Calanus hyperboreus* may also be numerous in spring while *Microcalanus* is more constant in percentage.

In volume *C. finmarchicus* is the leading species, but *C. hyperboreus* and *Pareuchaeta,* though generally scarce in number, are also of considerable importance. Together these three species dominate the volume entirely. The rather large number of *C. hyperboreus* in early spring is

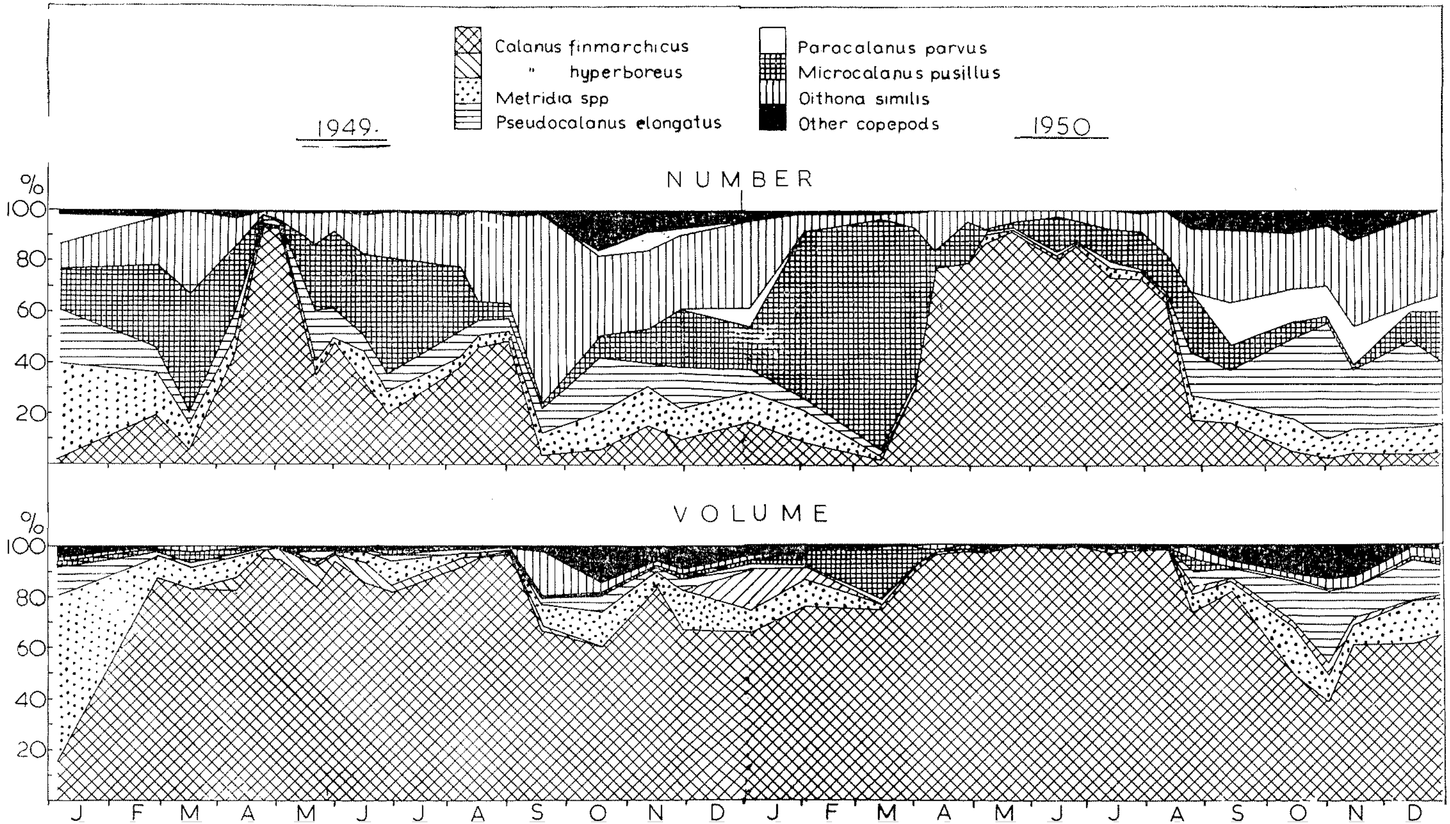


Fig. 32. Variations in the percentage composition of the copepod stock at Eggum in 1949—50.

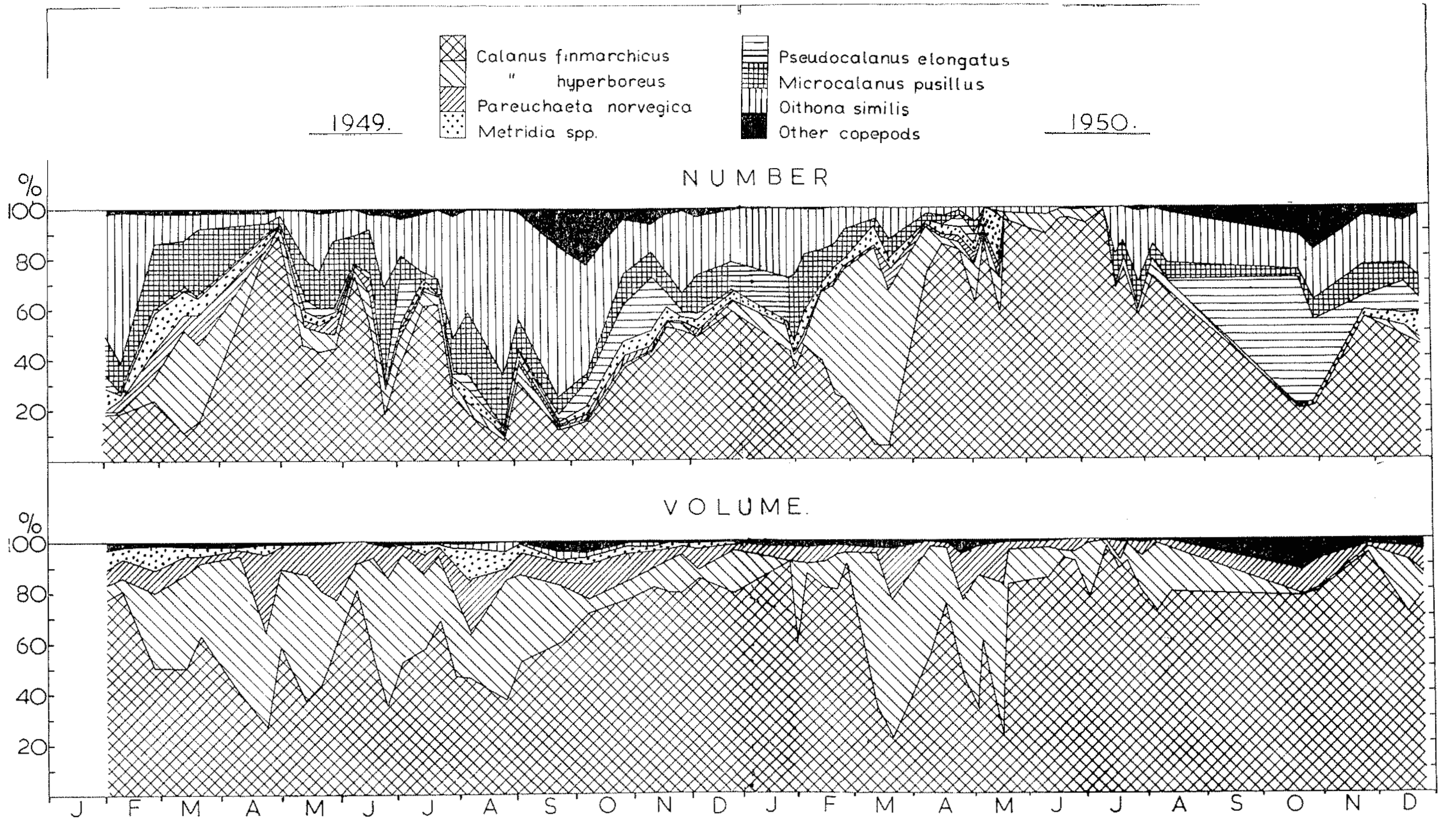


Fig. 33. Variations in the percentage composition of the copepod stock at Skrova in 1949–50.

made up of nauplii and eggs and has no noticeable influence on the volume.

In 1950 *C. finmarchicus* is strongly represented numerically. In addition *C. hyperboreus* is abundant at the beginning of the year and *Pseudocalanus* in the autumn, while *Oithona* is relatively more scarce than in 1949.

In volume *C. finmarchicus* seems to preponderate entirely from March to December, but observations are lacking for the period 13 August—23. October. A comparison between variations in number and in volume of *Calanus finmarchicus*, calculated in the way mentioned, is given in the Special Part.

The Different Types of Components in the Plankton.

The origin of the plankton organisms found in a certain area have been the subject of intensive studies by a number of workers. Cleve (1897) and Gran (1900, 1902) established different plankton types or plankton communities in order to characterize various ocean regions at certain seasons. Fish and Johnson (1937) also characterized the different organisms in the plankton according to their probable origin.

Here I shall abstain from commenting upon the conclusions of the workers mentioned, and merely restrict myself to a discussion of the present material.

As the first main group (A) we may consider those species which can be regarded as *autochtonous*, i.e. belonging to the area all the year. This group may be split into the following subgroups: 1) Organisms which live in the deeper water layers and therefore are only subject to transport with the surface currents during the spawning time (usually in winter or early spring), when the animals may migrate to the surface layers and stay there for shorter periods during the 24 hours. If the organisms have diurnal vertical migrations, they may be transported by surface currents at other times of the year also.

2) Animals inhabiting the surface layers both as young and adults for a longer period of the year, and which therefore may be transported by the currents for longer distances.

3) Forms which are restricted mainly to the southern part of the coast, but may be carried northwards with the currents, especially in autumn, and winter.

As the second main group (B) we will regard animals which are partly autochtonous, partly *allochtonous*, brought in from other areas, chiefly the Skagerak, the North Sea or the North Atlantic. Here we may again distinguish:

1) Forms which are able to establish a stock of their own in Norwegian waters for a shorter or longer period, but also get a considerable supply from other areas.

2) Forms which, brought in only singly or a few at a time, are unable to reproduce in the coast water, and when introduced, disappear fairly soon.

It is immediately clear that a number of organisms cannot be characterized as only belonging to one or another group, as transitions from one group to another take place. Furthermore, a grouping which may be found valid in one year, may fail in another, but it will nevertheless be useful to discuss the problems from this angle.

A. 1. *Autochtonous Deep Water Species.*

As the most characteristic forms within this subgroup may be considered the copepods *Pareuchaeta norvegica*, *Calanus hyperboreus*, *Microcalanus pusillus* and *M. pygmaeus*, *Oithona spinirostris* and a number of less numerous deep water copepods, further *Sagitta elegans*, *Eukrohnia hamata* and different ostracods. We may also include the euphausiids *Thysanoessa inermis* and *Meganyctiphanes norvegica* as belonging to this group. It is emphasized, however, that the grouping mentioned is only valid for the Norwegian coast waters inclusive of the fjords.

A. 2) *Autochtonous Surface Species.*

In this subgroup we may place the most important animal of the Norwegian coast plankton, *Calanus finmarchicus*, and also the copepods *Pseudocalanus elongatus*, *Temora longicornis*, *Acartia clausi* and *Oithona similis*. Of «non-copepods» we mention *Fritillaria borealis* and *Limacina retroversa*.

The statement that these animals sometimes constitute the main part of the zooplankton in the Norwegian coast water, does not exclude the possibility that they can be brought in from other areas and therefore may also be referred to group B, 1). Both at Ona and at Eggum populations of *C. finmarchicus* which are clearly of more southern origin, are introduced in late summer and autumn.

Among the animals which are usually restricted to the surface layers *Pseudocalanus elongatus* showed little difference in the length distributions from one locality to another during most of the year. In common with most of the species included in group B, 1) *P. elongatus*, *A. clausi* and *O. similis* have a late autumn maximum.

A. 3). *Southern Autochtonous Species.*

To this group I have only referred the copelate *Oikopleura dioica*, but on a thorough investigation more species, especially of medusae, could undoubtedly be added. *O. dioica* had both years maximum occurrence at Sognesjøen in June. At Ona it did not appear until August—September, off Eggum singly at the end of August, not being numerous until September. Most of the stock of *O. dioica* is without doubt carried northwards with the coastal current from the southern and southwestern parts of the coast. The possibility that local stocks may exist in more closed fjords and bays cannot, however, be excluded.

B. *Allochtonous Species.*

To the second main group we refer a number of organisms with maximum occurrence in the late summer and autumn. As already mentioned, a number of species which have been classified in group A. 2), can also partly be included here. As the most important forms have been considered *Metridia lucens, Paracalanus parvus, Centropages typicus, Corycaeus anglicus, Anomalocera patersoni* and *Sagitta setosa*, with numerical importance in the order mentioned.

All these species, except *Sagitta setosa*, seem to be of a very complex origin, partly from the Skagerak and the North Sea, partly from the North Atlantic. The proportion of the stocks derived from the different regions may vary considerably during the year, and from one year to another.

Metridia lucens has frequently been reported as an indicator of water of Atlantic origin, at all events in the North Sea (RAE and REES 1947), but an isolated stock seems to be established in the Skagerak (FARRAN 1911). As the adults and most of the copepodites usually resort to intermediate or deeper water layers, at least during the day, *M. lucens* is not so dependent on the surface currents, and this may perhaps be of importance for the establishment of local stocks. It will be shown later on (page 158) that the length distribution of the females of *M. lucens* at Sognesjøen differs somewhat from that of the northern stations. *M. lucens* was always most numerous in the autumn, but minor peaks of abundance were also found in May, especially in 1950. It may be worth mentioning that RAE (1951), using the Plankton Recorder, found *M. lucens* to be unusually abundant in the North Atlantic off the west coast of Ireland from March to June 1950, and in moderate numbers between Scotland and Shetland in May, while there was no sign of these concentrations between Bergen and station «M» and the species did not appear there until late in the autumn.

Paracalanus parvus in all localities mainly occurred between August and March, the single individuals taken during the first months of the year undoubtedly being remnants of the late autumn stock. The maximum numbers were usually found in August on the west coast between 61°—63° N and in the middle of September in the Lofoten area. It may seem as if this species is partly neritic and more related to *Oikopleura dioica* in its nature, but in other areas it has a very wide, almost cosmopolitan distribution, although restricted to temperate and tropical areas (FARRAN 1910), and we must therefore assume that the local populations also get a supply from other areas. A small number of *Paracalanus* may perhaps survive in the fjords of Northern Norway, propagating when the conditions are favourable.

Centropages typicus has probably a centre of abundance in the Skagerak (WIBORG 1940), but RAE and REES (1947) find that in the North Sea it is mainly introduced from the north, under favourable circumstances being able to establish a stock of its own. In 1949 *C. typicus* appeared at Sognesjøen as early as in June, at Ona in July, but at Eggum not until September. In 1950 its appearance was similar to *Paracalanus*, and we may assume that both species have a double origin, partly being introduced from the Skagerak, partly from the North Atlantic.

Corycaeus anglicus has a centre in the southeastern North Sea (RAE and REES 1947) but is also known to occur in the North Atlantic (SARS 1918). It was not observed in 1949, but in 1950 it was found at all stations in the autumn. As it was accompanied by a number of Atlantic species, we may assume a double origin for this species also.

Anomalocera patersoni occurred singly at Sognesjøen in June 1949 and January 1950 and is probably of coastal or more local origin.

Sagitta setosa is a typical representative of the North Sea plankton, according to FRASER (1937) and RUSSELL (1939). RUNNSTRØM (1932) found it common in fjords near Bergen from February to November, numerous between April and August. The individuals recorded from Sognesjøen and Ona in August—October 1950 may therefore have a local source, although it is possible that they have been introduced from the North Sea together with e.g. *Corycaeus anglicus*. MARSHALL (1938) mentions finds of *S. setosa* with the plankton recorder off the Norwegian coast between March and October 1939, possibly being associated with the Baltic outflow.

The forms which are referred to subgroup B 2), have all presumably been brought in by the North Atlantic current. They occur mainly in autumn and winter, and usually only single specimens are found. The inflow of Atlantic water must have been unusually strong in the autumn of 1950, as the indicator species were very well represented, and the

Table 15. *The Occurrence of Plankton Organisms of Atlantic Origin in 1948—50.*

		Aug.	Sept.		Oct.			Nov.			Dec.			Jan.		Feb.	Mar.	April	May
		Ona	Sognesjøen	Ona	Sognesjøen	Ona	Eggum	Sognesjøen	Ona	Eggum	Sognesjøen	Ona	Eggum	Sognesjøen	Eggum	Eggum	Sognesjøen	Eggum	Sognesjøen
Rhincalanus nasutus	1949																		
	1950							x			x							x	
Clausocalanus arcuicornis	1949		x		x	x	x		x	x		x	x		x				
	1950		x		x					x	x	x	x						
Pleuromamma robusta	1949																		x
	1950																		
Pleuromamma abdominalis	1949												x						
	1950												x			x			
Candacia armata	1949				x														
	1950				x			x				x							
Conea rapax	1949													x					
	1950																		
Oikopleura parva	1949																		
	1950							x			x			x			x		
Appendicularia sicula	1949				x														
	1950																		
Fritillaria borealis truncata	1949																		
	1950									x		x							
Salpa fusiformis	1949																		
	1950	x	x			x	x		x	x									
	1951			x	x			x											

same was probably the case in 1951. For this year only the salps have been investigated. (See also table 15).

The origin of *Clausocalanus arcuicornis* is somewhat disputable, as the only records of its occurrence in European waters are from west of Ireland, where the species is strictly oceanic (FARRAN 1920). It was, however, taken as frequently at Skrova as in the other localities, and we may assume that *Clausocalanus*, when introduced in coastal waters, may reproduce, and the offspring be carried into the Vestfjord by the coastal current.

The salps are supposed to be very good indicators of Atlantic water. According to APSTEIN (1911) *Salpa fusiformis* usually appears at the Irish coast in May, off the Shetland Islands in July, and off Bergen, Norway, in September—October. In November 1905 salps were carried right into the Skagerak. FRASER (1951, 1952) reports that salps entered the North Sea via the Orkney passage in June 1950, but were not observed north and east of Shetland until November. On his chart No. 13 (1952) there is however a single record in August in the Faroe-Shetland Channel. On the plankton recorder route between Bergen and station «M» salps appeared in late August 1950. Salps were observed at Ona on 30 August 1950, at Eggum they probably arrived between 12 September and 13 October, and at station «M» on 29 September (see page 196).

Finally I would like to draw attention to the information given by MANTEUFEL (1941) that in the Barents Sea the conditions changed considerably after the year 1931, in that organisms which had earlier been recorded as extremely scarce, now began to appear more frequently, e.g. *Anomalocera patersoni, Pleuromamma robusta, Candacia armata, Physophora hydrostatica* and others. In the same connection MANTEUFEL mentions the second generation of *Calanus finmarchicus*, which was not found there in earlier years (cfr. Special Part, page 89).

It is beyond the scope of this paper to discuss climatic changes of the sea, but similar changes to those in the Barents Sea are likely to have occurred along the Norwegian coast also. The appearance of *Clausocalanus arcuicornis* may perhaps be attributed to such a change, as FARRAN (1917) reported that *Clausocalanus* did not extend beyond the north coast of Ireland.

On the Use of Length Frequencies of Copepods in Biological Investigations.

It has been found that the same species of copepods may be subject to great variations in length, both from one locality to another, and in succeeding generations in the same area during the different seasons of the year (GRAN 1902, ADLER & JESPERSEN 1920, MARSHALL 1933, SØMME 1934 and others). It is generally accepted that the length varies inversely with the temperature of the surrounding water during development, although the amount of food present may perhaps also be of importance (USSING 1938). USSING also stresses that the length attained by a certain stage is the result of a number of increments during the previous moults, which may have taken place under varying conditions. Another cause of size variation which must be mentioned, is the existence of races or varieties of the same species. REES (1949) states that in the Southern North Sea, in addition to the usual *C. finmarchicus* also exists another variety, *C. helgolandicus*, which is generally larger than the former. This variety was described as a separate species by SARS (1903), but later workers have generally not separated it from *C. finmarchicus*. According to REES (1949) this variety does not seem to occur in any numbers outside the North Sea.

Length frequency distributions have also been used to distinguish copepod populations of different origin (RUUD 1929, STØRMER 1929, SØMME 1929, JESPERSEN 1939, REES 1949, CUSHING 1952).

The Origin and Drift of Copepod Stocks.

Calanus finmarchicus winters in the deeper water layers mainly in stage V. In early spring the copepodites migrate towards the surface and moult into adults during, or immediately after this migration (SØMME 1934). The length of the adults probably bears a nearly constant relation to that of stage V. According to MARSHALL and ORR (1952) the females sometimes survive for two months or more. They may therefore be carried for long distances by currents. A study of the size frequencies of stage V and of the females in a certain area will give a lot of information both regarding the number of generations and the origin of the stock, and supply knowledge of the water movements. In order to illustrate the idea more clearly, a number of females of *C. finmarchicus* taken in different localities along the western and northern coast of Norway and in the open ocean in the period 11—23 April 1950 were measured and the size frequencies are shown in fig. 34.

At Ona the curve is bimodal, with peaks at 2.4 mm and 3.1 mm, the latter probably referring to females of the spring brood. At station «M» in the Norwegian Sea the maximum lies at 2.5—2.6 mm. Farther north there is a peak at 2.7 mm near Skrova. At Eggum two maxima occur, at 2.4 mm and 2.7 mm respectively. The same distribution is repeated at st. 110 further north. In the open ocean between North Norway and Bear Island st.s 114 and 117 both show maxima at 2.7 mm, but the curves are more flattened than further south. At all the stations hitherto mentioned, the temperatures at the 10 m level vary between 4.1° C and 7.0°C. At st. 119 the main peak is still at 2.8 mm, but the curve extends towards increasing lengths, the largest females measuring more than 4.0 mm. The temperature is 0.4° C. St. 120 has pronounced maxima at 3.1 mm and 3.6 mm, very few females smaller than 2.9 mm, and a temperature of ÷ 1.0° C. At St. 123 we have again a very wide range in size, similar to st. 119, with peaks at 2.7 mm and 3.2—3.5 mm respectively, the temperature being 0.4° C. Finally, at st. 124 there is a length distribution very like that of st. 117, and also nearly the same temperature.

As already shown, there is almost the same length distribution of the *C. finmarchicus* females at station «M», and at the st.s 114, 117 and 124.

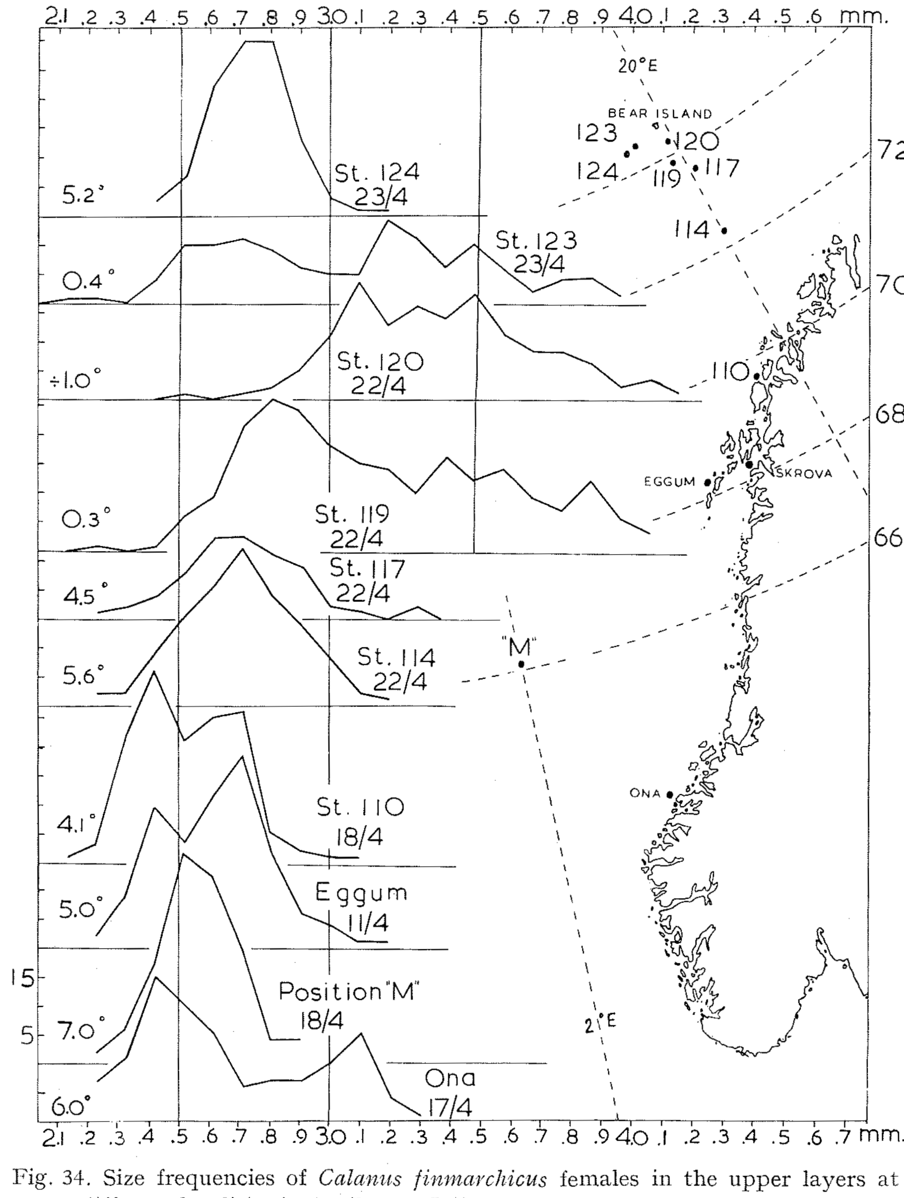


Fig. 34. Size frequencies of *Calanus finmarchicus* females in the upper layers at different localities in April 1950. Left: sea temperatures at 10 m level.

From what is known of the surface currents in the area the *Calanus* may originate partly from the central or southern Norwegian Sea, at the northern stations also in part from Norwegian coastal areas. The length distribution at Skrova is very similar, but here the population is evidently of local origin. Off Eggum and at st. 110 the populations may be derived from different sources, in coastal waters further south (compare

Ona) or from local areas. At st. 119 and st. 123 we have very clearly a mixture of two or more populations, one grown in warmer water (the peak at 2.7—2.9 mm) and another in water of low temperature (the peak at 3.2—3.6 mm). The latter population is represented more particularly at st. 120, probably brought in by the south-going cold current on the eastern side of Bear Island. Earlier workers (MRAZEK 1902, DAMAS and KOEFOED 1907, WITH 1915, FARRAN 1936) found a great variation in length of *C. finmarchicus* in the waters around Spitzbergen. BOGOROW and PREOBRAJENSKAYA (1934) also show variations in the length of *C. finmarchicus* in relation to the areas of warm and cold water in the Barents Sea.

The length distributions of females (and also of stage V) of *C. finmarchicus* during the early spring may thus give information as to the origin of the population, and also supplement our knowledge of the surface currents and degree of mixing of water of different origin.

In September—November 1950 the copepodites of stage V of *C. finmarchicus* occurring in the upper 100 m at station «M» were very small, the mean length being only 2.04—2.20 mm. Simultaneously a number of salps were found, indicating that the plankton had partly been introduced from the North Atlantic. At Eggum the copepodites found in October—November of the same year were likewise small, and were also accompanied by a number of salps. In this case both the small individuals of *C. finmarchicus* and the salps seem to indicate an influx of water of Atlantic origin in two different localities.

Metridia lucens is repeatedly reported to be an indicator of Atlantic water. According to BOGOROV and PREOBRAJENSKAYA (1934) it is also found in the warm area of the Barents Sea, presumably in late autumn or early winter. Its southern origin can be confirmed still further by the length distribution. The same authors found a mean total length in December of 2.29 mm, corresponding to a cephalothorax length of 1.46 mm. From my own observations the minimum mean length in Norwegian coastal water in 1949—50 was 1.55 mm. The difference is negligible, and may easily be explained by the measuring method, or more probably, that the observations are from two different years.

SØMME (1929, 1934) studied the length variations of *Calanus hyperboreus* in different areas. The individuals taken in Norwegian coastal waters were small, those in Arctic waters large. In the eastern part of the Norwegian Sea the population was supposed to consist of immigrants from Arctic waters.

Measurements have been made of a number of females and stage V copepodites of *C. hyperboreus* from deep water at station «M» in 1952. In June the mean length of stage V varied from 4.66—4.90 mm. A number of plankton samples were taken in the upper 200 m on a cruise in June with the «G. O. Sars» in the sea northeast and southeast of Jan Mayen. Stage V of *C. hyperboreus* measured 4.66—4.98 mm on the average. As pointed out by ØSTVEDT (in press) the stock of *C. hyperboreus* at station «M» is probably partly introduced by the cold current flowing southeastwards between Jan Mayen and Iceland, and gradually attaining deeper levels. — In Norwegian coastal waters stage V of *C. hyperboreus* has a mean length of only 3.98—4.17 mm.

The length distributions of the closely allied species *Microcalanus pusillus* and *M. pygmaeus* at station «M» also show some very interesting features. *M. pusillus* is found mainly in the 600—100 m layer. It has a length variation throughout the year nearly identical with that found in Norwegian coastal waters. *M. pygmaeus* lives mainly below 1 000 m. The length of the females is practically the same as that given by SARS (1900) for Arctic waters (0.89—0.91 mm total length). There is the possibility that the stock of *M. pygmaeus* may have grown up in the deep water layers at station «M», where the temperature is usually below zero, but it nevertheless seems probable, that part of the stock is introduced by the Arctic current in the same way as *C. hyperboreus*. Certain peculiar changes in the length distributions in the deepest water layers also point in this direction (see the Special Part, page 142). *M. pygmaeus* is also found sparsely in the deeper water layers in some Norwegian fjords, but the individuals are much smaller than those at station «M» (total length 0.72 mm).

REES (1949) showed that the two forms (or perhaps species) *Calanus finmarchicus* and *C. helgolandicus* usually differed in size, when they were found together. In the same way I have found that the closely related species *Pseudocalanus elongatus* and *P. minutus*, and *Microcalanus pusillus* and *M. pygmaeus*, usually have quite different size distributions. This applies both to the populations found in Norwegian coastal waters and in the open ocean.

All the examples given show very clearly how studies of the size frequencies of copepods may be useful for determining the origin and drift of copepod populations, and may increase the value of the species as indicators of certain water masses and currents. In the Special Part of this paper more details can be found both on the size frequencies of the different species, and how the closely allied species were distinguished by means of the size frequencies.

Some Aspects in the Production of Zooplankton.

In the chapter on hydrography it was stated that the waters along the west coast of Norway are constantly moving northwards. Near the coast we have the Baltic current which can be followed from the Skagerak to the North Cape, and outside, the North Atlantic current, striking the Norwegian coast approximately at Møre and on the way northwards gradually mixing with the coastal current. Under such circumstances it is very difficult to discuss the production of zooplankton in relation to temperature and salinity at a geographically fixed point. Nor are the localities investigated thus situated that we may follow the same population drifting with the currents for a longer period, as REDFIELD (1941) did on Georges Bank off the east coast of USA. We must restrict ourselves to a study of the variation in composition and quantity of the plankton at different times of the year. We may, however be allowed to regard the conditions found in one locality as more or less characteristic of a somewhat wider area of the coast. — It was found that the plankton was generally more abundant in the Lofoten and Vesterålen area than at Sognesjøen and Ona on the west coast, and the spring increase started at successively later times as we proceeded northwards.

Phytoplankton observations in connection with the zooplankton hauls had been very desirable. In 1947—48 phytoplankton was collected at some of the permanent stations. The material has recently been worked up, and a report by T. BRAARUD, Oslo, will soon be published. — In earlier years the phytoplankton was studied during the spring and summer at Møre (GRAN 1929) and in the Lofoten area in the spring (FØYN 1929) and the quantitative results discussed by GRAN (1930). He states that the phytoplankton is generally more abundant in the Lofoten and Vesterålen area than at Møre. The spring outburst of diatoms started earlier off Bergen than at Møre, and still later in Lofoten, as was also found for the zooplankton. At Møre the spring maximum in number of copepods occurred at the end of April, one month after the phytoplankton maximum (RUUD 1929). In the Lofoten area the spring increase in the phytoplankton usually started in the last third of March and lasted from a fortnight to a month. When we study the work of SØMME (1934) it appears that the spawning of *Calanus finmarchicus* may start before the flowering of the spring diatoms. MARSHALL (1949) in a Scottish fjord found that the spring brood of most of the copepods was correlated with the spring outburst of diatoms, but later in the year there could be both positive and negative correlation between the respective maxima. She points to the possible importance of nannoplankton as part of the food of copepods. MOSSENTSOVA (1939) states that the Ciliata, which in the Barents Sea develop in May—June, when the spring phytoplankton is decaying, form an important food for the first copepodite stages of *C. finmarchicus*.

Finally I would like to draw attention to some points which need further investigation: It has been known for a very long time, that the zooplankton is specially rich along the coastal banks of Norway, near to the continental shelf. SARS (1886) mentions that in summer large masses of *Calanus* exist at the edge of the coastal banks, along the eastern border of the North-Atlantic current. RUUD (1929) also states that in summer there was a maximum of *C. finmarchicus* along the edges of the coastal banks off Møre, and a minimum in the central part of the North-Atlantic current towards the Norwegian Sea. Similar phenomena have been observed in other waters (BIGELOW 1926, FARRAN 1927, EINARSSON 1951), while CLARKE (1940) found more plankton in coast water than on the slope off the eastern part of U.S.A. — It has been shown above that the banks off Eggum are very barren in early spring, but the plankton increases in quantity very rapidly, and during spring and summer may be extremely abundant.

When we take a section across the banks and over the edge of the continental shelf in early spring, the quantity of plankton will usually increase considerably in the edge area. This can be demonstrated very clearly. Below I give the volumes of plankton in ml taken off Eggum in vertical Nansen net hauls, on the bank from bottom to surface, in the edge area in the upper 75 m.

Plankton Volumes, ml.

Year	Month	Date	Stations on the Bank	The Edge	Immediately outside the Edge
1928	March	26	0,8 0,8	0,6	7,6
1932	April	12	2,4 1,3 0,8	2,6	2,2 3,2 4,2
1936	»	16	1,4 2,5 3,4 3,2	5,0	2,0
1928	»	17	4,0	6,7	14,0
1931	»	23		14,0	6,3
1929	»	24	3,4 2,0	7,0	2,8

The plankton samples mainly consisted of stage V and adults of *C. finmarchicus*.

To which extent this population of *C. finmarchicus* 1) originates from the depths of the ocean immediately outside, or 2) has been brought northwards by the North-Atlantic current from the Norwegian Sea, where a rich population is known to exist, or 3) comes from coastal areas further south, may be a point of interest for future investigations. All three sources are probably of importance. We refer to the size frequencies shown on page 72. These large prespawning accumulations along the edge in spring are undoubtedly of importance for the development of the huge masses of *C. finmarchicus* existing in summer from the coastal banks of Northern Norway far into the Barents Sea and northwards to Bear Island and Spitzbergen. GRAN (1900) was of the opinion that *C. finmarchicus* stayed in deep water off the coast of Nordland all the year round, but that part of the large quantities filling the fjords in June and July were derived from an influx in May. According to FØYN (1929) and GRAN (1929) a rich phytoplankton also exists along the edge in spring, both at Møre and off Lofoten. GRAN (1930) concludes that the highest productivity is found in areas where the coastal current mixes with Atlantic water, but that the great production of phytoplankton in spring is on the other hand limited to the waters of the coastal current. BRAARUD and KLEM (1931) found that in spring the Atlantic water in this area is richer in nutrient salts than the coastal water before the production of phytoplankton starts. They infer that the bicentric development of the phytoplankton, on the edge and in the fjord, is due to the hydrographical conditions. The late development in the intervening area of the bank is in part caused by the vigorous churning of the water masses. On the edge of the continental shelf the deeper parts of the Atlantic current, rich in nutrients, mix with the adjacent coastal water. In this way the nutrient salts are added to the surface layers and utilized by rapid growing phytoplankton forms found there. They state further (l.c. page 73): «The profusion of plankton which is always found in the border-areas between Atlantic water and coastal water in the Norwegian Sea....would thus be due to an addition of nutrient substances from the Atlantic water and organisms from the coastal water where the remains of the enormous production at the time of the spring maximum, furnish the initial material for a subsequent output».

Similar conditions are most probably found all along the edge of the continental shelf from Møre and Northwards. SUND (1929) reports that in the Lofoten area the Atlantic water is also richer in nutrient salts than the coastal water.

We have thus an ample basement for a rich production of zooplankton along the edge of the continental shelf in spring and early summer. As mentioned earlier MARSHALL and ORR (1950) carried out some very important experiments on the egg-laying of *C. finmarchicus*. The rate of egg-laying was dependent on the amount of food present, slowing down or ceasing entirely when food was scarce or lacking, but on the other hand being resumed when food was again available. In the laboratory, individual females survived for more than two months, producing as much as 500 eggs. — With these facts in mind it is better understood how such enormous quantities of *Calanus* may be produced along the edge of the continental shelf in spring and early summer. The conditions are favourable, there is both a large prespawning stock of *C. finmarchicus* and an abundance of food for the development and growth of the larvae. MANTEUFEL (1941) reports that this «stream» of rich *Calanus*-plankton reaches the northernmost part of Norway in April, the Murman coast in May. The term «stream» may to some extent be understood literally, as the individual females may be carried by the current for two months or more, and during this period produce eggs more or less continuously, but local stocks will join underway.

How the winter population of *C. finmarchicus* is re-established in the deep water outside the Norwegian coast will be a problem for future investigations. For the central part of the Norwegian Sea the question has been treated by ØSTVEDT (in press).

It is very likely that the amount and kind of plant food available in spring, probably also at other times of the year, has a similar influence on the spawning of other plant-eating copepods, perhaps also on euphausiids, as on *C. finmarchicus*.

For studies of the production of zooplankton in different areas it will therefore be very important to carry out simultaneous investigations of the phytoplankton.

SPECIAL PART

The Biology of the Different Species

Copepoda Calanoida.

Calanus finmarchicus (Gunn.).

Numerous and extensive papers have been published on the biology of this copepod. They will not be quoted here, but only referred to when necessary.

The variations in number at the localities investigated during 1949—50 are shown in fig.s 35—38. The black parts of the columns signify the numbers in the upper 50 m. Drawn lines indicate the variation of the stock in Calanus-units, i.e., the different stages have all been converted into stage V in the way mentioned on page 59.

At Sognesjøen (fig. 35) there were at least 3 maxima in stock during the year, a spring maximum at the end of March, most obvious in 1949, but both years consisting of about 70—80 % of nauplii, a second peak in June, made up mainly of copepodites I—IV and some nauplii, a third maximum in July, not observed in 1950 because of insufficient observations, and a possible 4th peak in September. The curve of the Calanus-units follows the variation in total number, but the June peak is higher than that of April.

At Ona (fig. 36) the spring increase seems both years to start in the middle of March or beginning of April. After a slight decrease in May there is a second rise in June, culminating in the second and greater maximum in July, which was considerably greater in 1950 than in 1949. By September the stock has usually decreased to an insignificant size.

The curve for the Calanus-units largely follows the numerical variations except in May—June, when the decrease is very slight. In July, the maximum is much higher than the peak in spring, indicating that *C. finmarchicus* is now in the later stages of development.

At Eggum (fig. 37) the spring increase in 1949 started in the first half of April, and reached first maximum at the beginning of May. A second maximum occurred at the end of May, a third and fourth maximum in August. From September numbers were very low. In 1950 the increase also began in early April and in the first part of May

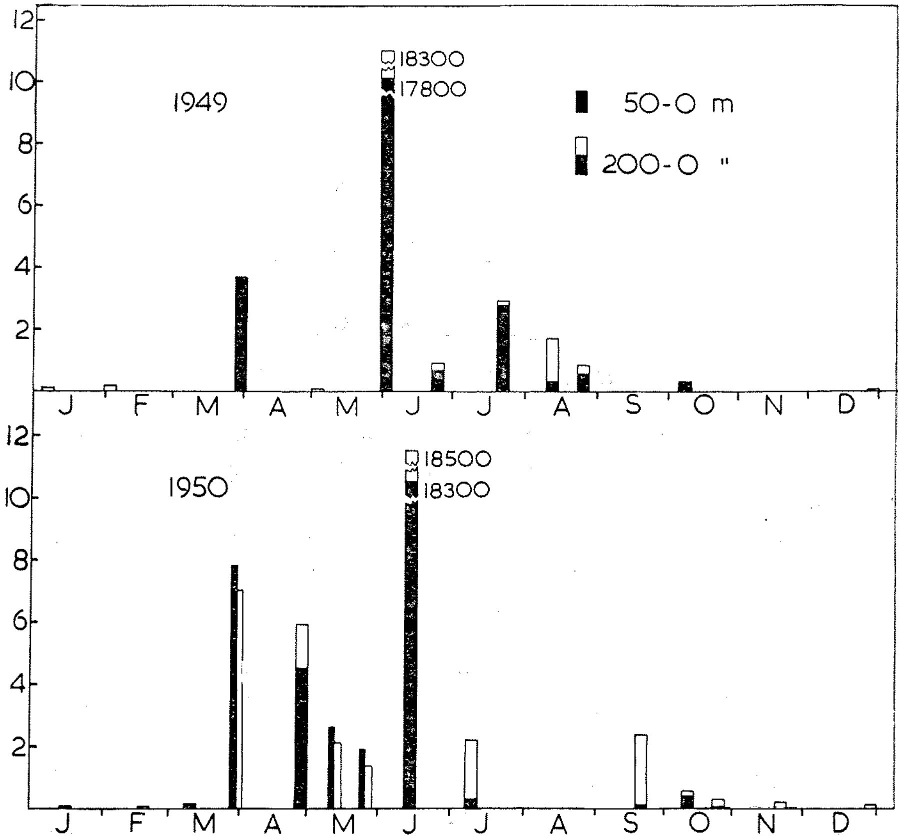


Fig. 35. Numerical variation of *Calanus finmarchicus* at Sognesjøen in 1949 and 1950, in 1000' s.

the stock was a little larger than at the same time in 1949. The increase continued throughout May and in the last half of the month the stock reached the very high number of 238 600, corresponding very well with a large volume of plankton, 118 ml (see page 26). The stock decreased largely throughout June—August, but again rose to 12 000 in the middle of September. From October to December the stock was nearly at zero.

In 1950 some of the 50—0 m hauls yielded more than the 300—0 m hauls. This may in part be ascribed to random variations, the two hauls sampling the total population of *Calanus*, but the possibility cannot be excluded that the nets had been clogged during the hauling from 300 m to 50 m, or had been washed insufficiently between the 300—0 m and the 50—0 m hauls.

The spring maximum of the Calanus-units in 1949 was second to the summer maximum, and the figures were also very high in August

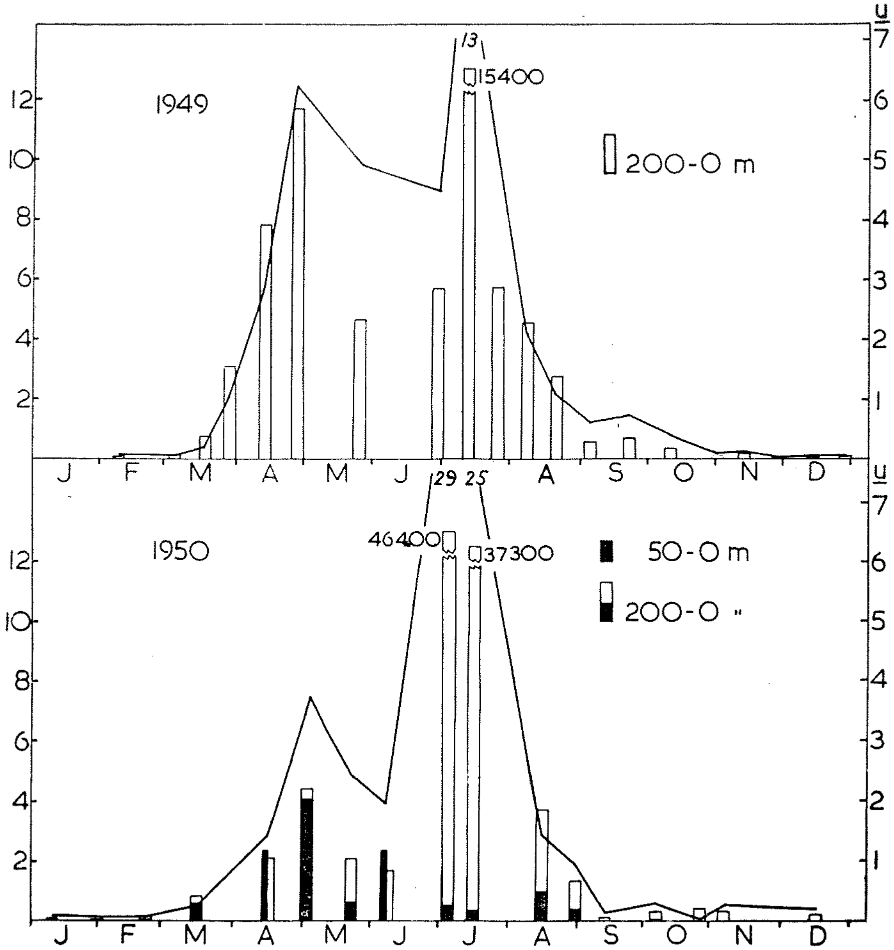


Fig 36. Numerical variation of *Calanus finmarchicus* at Ona in 1949 and 1950, in 1000's. Curves and figures in italics: 1000's of Calanus-units.

and September. In 1950 the May maximum is by far the greatest, both in number and in units, and all the summer, till the middle of September, the figures are far above those of the preceding year.

The stock variation of *C. finmarchicus* at Skrova during 1949—50 is shown in fig. 38.

In 1949 the stock was very small till April, but increased considerably during the last half of the month. In May there was a minimum, then some increase to June, a decline at the end of June and a third maximum in July. Later there was again decrease and irregular variations in number. In 1950 the stock numbered about 4000 in January—February, falling off to a minimum in March. The spring increase again took place

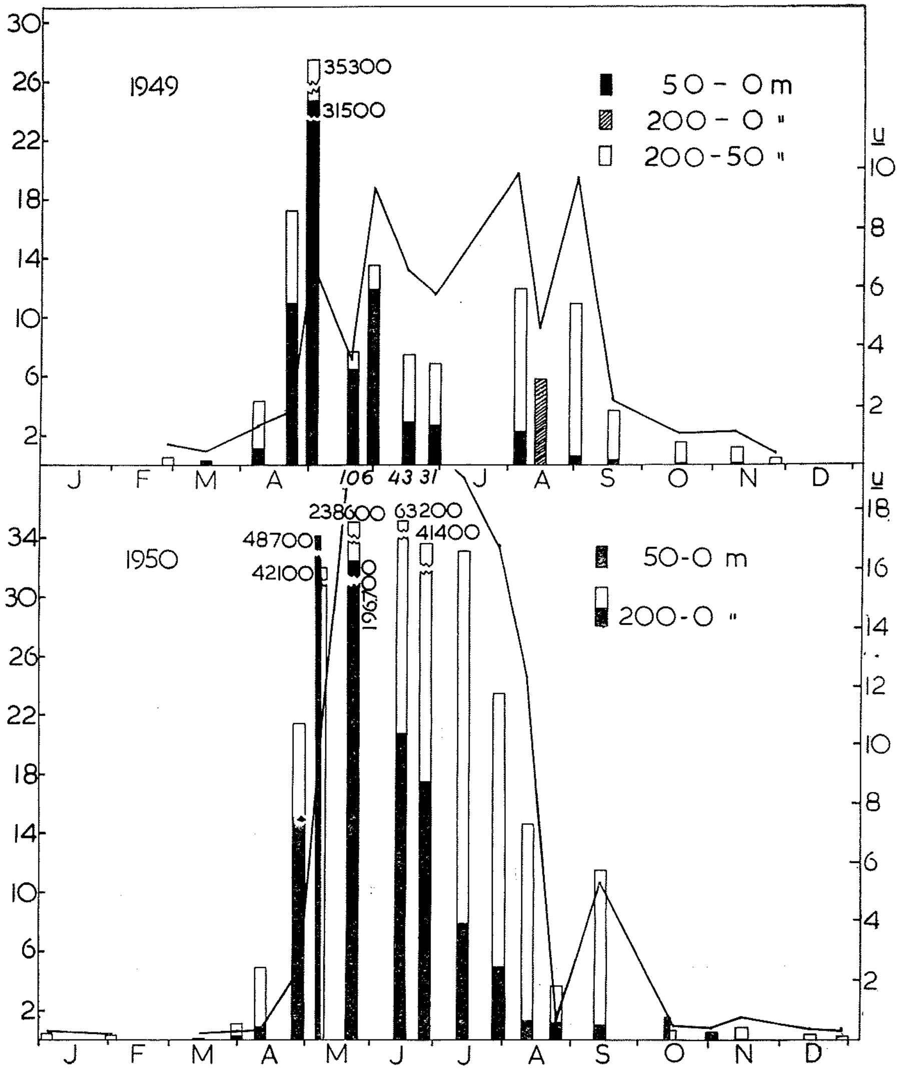


Fig. 37. Numerical variation of *Calanus finmarchicus* at Eggum in 1949 and 1950, in 1000's. Curves and figures in italics: 1000's of Calanus-units.

in April and culminated in the middle of May. Numbers were higher than at the same time in 1949. A marked decrease occurred in June and the first part of July, but some increase was found during the last half of the month (with the exception of the last few days) and a further rise took place in the beginning of August.

Observations were unfortunately lacking for nearly two months, from August to October, but it is assumed that the variations in stock

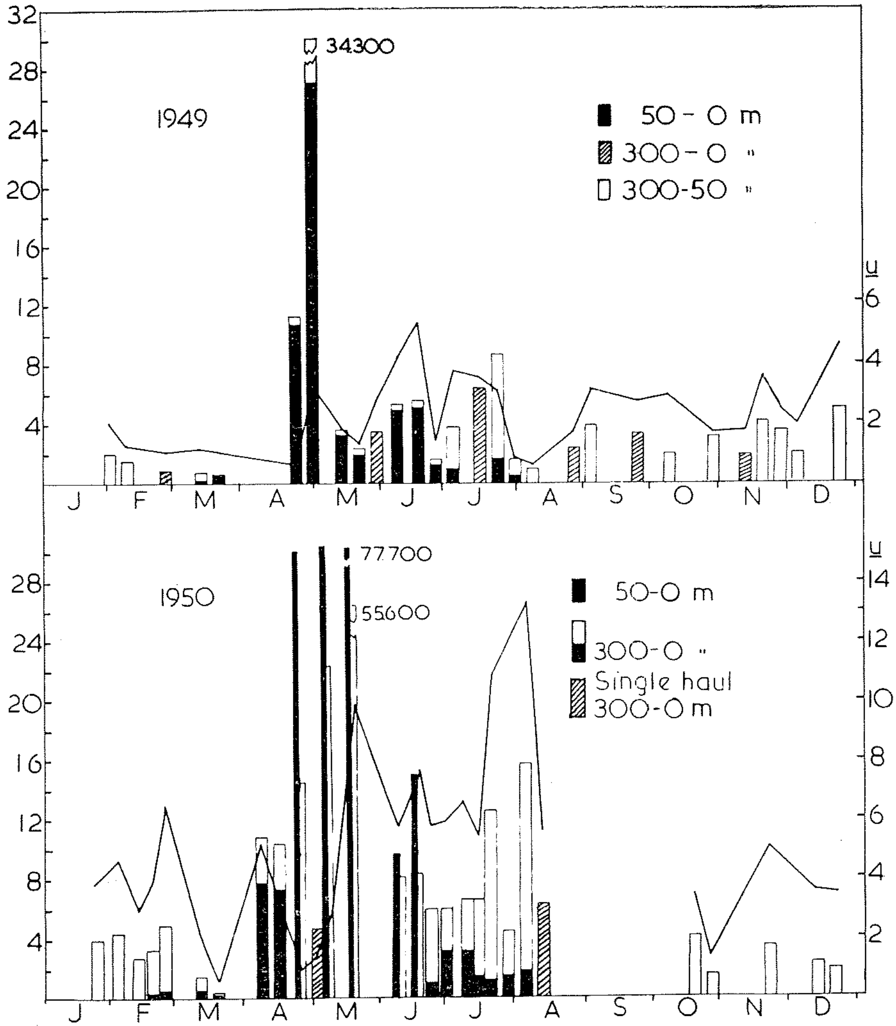


Fig. 38. Numerical variation of *Calanus finmarchicus* at Skrova in 1949 and 1950, in 1000' s. Curves: 1000's of Calanus-units.

were irregular in the same manner as in the preceding year. From October there was a further decline to December.

At Ona and Sognesjøen the highest number of *C. finmarchicus* was always found during the last half of the year, at Skrova in April—May, but the August stock at Skrova was nevertheless larger than the autumn stock at the southern stations. The great decline in the stock after the spring maximum may in main be ascribed to mortality, but a considerable number of *Calanus* may also be carried away by the surface currents.

The maximum in number usually coincided with the peak of Calanus-units. In June and July of 1949, however, all the unit-figures were higher than those in April. In summer the *Calanus* are in the later stages of development, and in spite of their lower number the volume of the stock is greater than in spring. In September 1949 and from November 1949 to February 1950, high numbers of units are also met with, in the last month even exceeding the June maximum of 1949. In April 1950 the unit-figures were much lower, In May there was again a maximum of 9 900 units (16 600 in the 50—0 m haul). In June the figures were of about the same size. and the two maxima in July and August yielded 10 900 and 13 400 units respectively. From October to December the unit-values usually varied between 3 500 and 5 000.

In the discussion of the quantitative variation of *C. finmarchicus* in the Lofoten area it might be of interest to compare the data with the volume variations of the plankton in this area in May and June 1949 and 1950, when this species was responsible for the main part of the plankton.

In the first days of May 1949 the plankton volumes were small near Skrova, less than 30 ml/m². The number of Calanus-units was 1 500 in a vertical haul on a station near Skrova. At Eggum the volumes were larger, 50—100 ml/m², the number of Calanus-units on 2 May being 6 900. Between 31 May and 3 June plankton was still scarce near Skrova. 2 800 units on 28 May. Further out the plankton was more abundant, in the center of the fjord 50—100 ml/m², and 16 200 units in a vertical haul 100—0 m. At Eggum there was also 50—100 ml/m², the number of Calanus-units, on 28 may being 9 400.

In 1950 plankton volumes on 3—7 May were between 30 and 50 ml/m² in the inner Vestfjord and near Eggum. Calanus-units at Skrova on 2 May numbered 1 400 and at Eggum on 28 April 2 400. Between 31 May and 3 June plankton volumes had increased to 50—100 ml/m² near Skrova and the Calanus-units to 9 900 (16 600) on 20 May. On 10 June 5 800 units were found. Near Eggum the quantity of plankton was 30—50 ml/m² between 31 May and 3 June, but increased towards the northeast, indicating that some days earlier the amount of plankton may have been larger at Eggum, when we take into consideration the direction of the coastal current. We have only observations at the permanent station on 22 May, when the number of Calanus-units was 106 500, which corresponded to a plankton volume of 295 ml/m², and on 14 June with 43 000 units and 130 ml/m². Thus a minimum in plankton volume and *Calanus* at the beginning of June 1950 has possibly been missed in the observations from the permanent station.

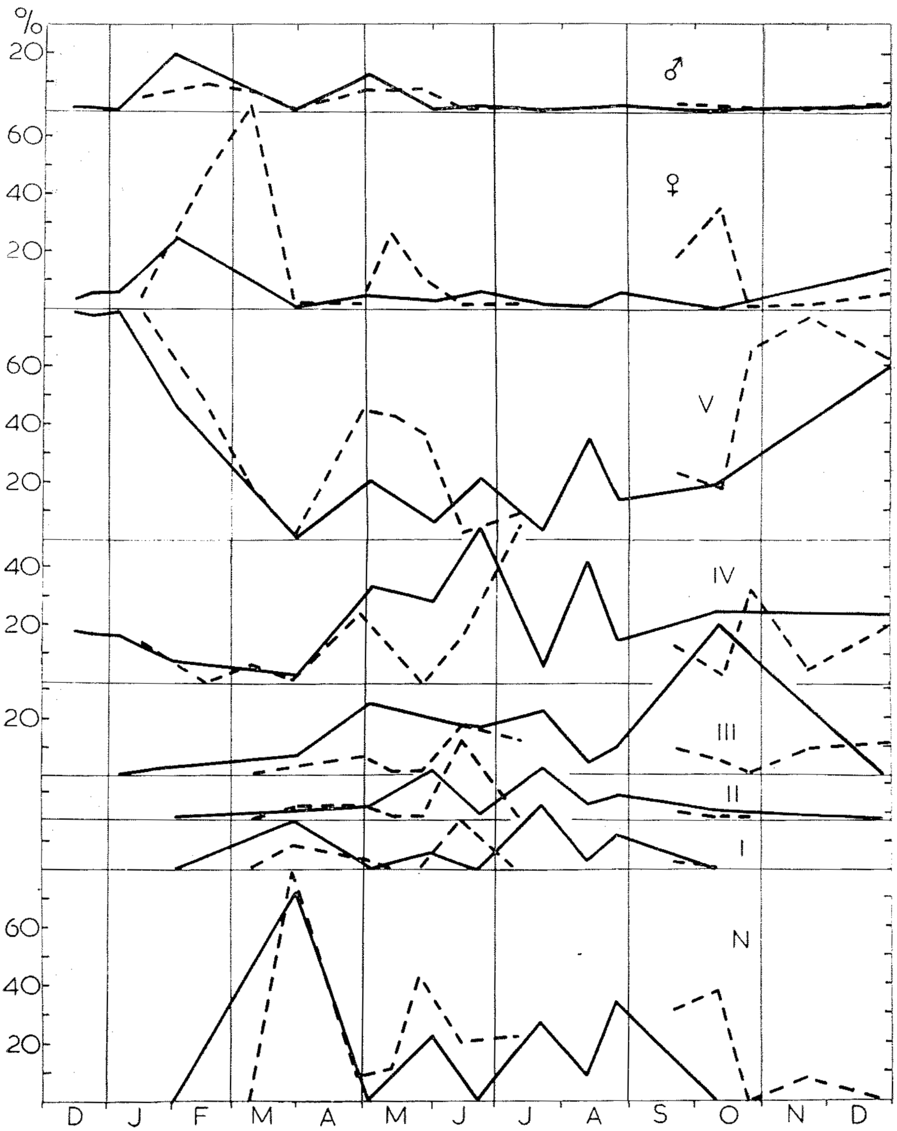


Fig. 39. Variations in percentage of each stage of *Calanus finmarchicus* at Sognesjøen in 1949 (drawn) and in 1950 (broken).

Propagation.

In fig.s 39—42 are shown the variations in the stage distribution of *C. finmarchicus* at the investigated localities during 1949—50.

Sognesjøen (fig. 39). In 1949 there were maximum percentages of adults in the first days of February, of males at the beginning of March also, but a small proportion of adults were found during the whole year. The nauplii had a main maximum in March and secondary maxima in May, July and

August—September. The copepodite stages I—II were scarce, while stage III showed a main maximum in October, IV in May—June, and V in January and December.

In 1950 the females had 3 pronounced maxima by percentage, in February, May and October, the males two maxima, in February and May. The nauplii had again peaks in late March and late May, and there was also a high percentage in October. The copepodite stages I—III occurred more sparsely, while stage IV had a main maximum in July, stage V peaks in January and April, and increasing percentages from October and onwards. Observations are lacking between 10 July and 21 September.

In 1949 maximum spawning seems to have occurred in *March* and periods of minor spawning in *May, July* and *September*. In 1950 the main spawning again occurred in *March*, the second spawning in *May*. Nothing can be said about the conditions in July and August, but there was apparently a maximum in spawning at the beginning of *October*.

We must bear in mind that the population of *Calanus finmarchicus* is not stationary, but new stocks are brought in by currents, presumably from coastal areas further south (see page 72). This applies especially to the spring and summer, when most of the *Calanus* is found in the upper water layers.

RUNNSTRØM (1932) found in the fjords near Bergen nauplii of *C. finmarchicus* numerous in March, in moderate numbers from April to June, scarce in July—August and again numerous in September—October. South of Bergen GUNDERSEN (1953) observed spawning in March, May and August—September.

Ona (fig. 40). In 1949 the females had peaks in early March, in May, August and the end of October, the nauplii in the middle of March, August, October and November. The maxima of nauplii in March and August can be traced through the different copepodite stages to the adults. We may probably have lost a maximum of nauplii in June, owing to too great a span of time between observations.

In 1950 the adults showed a peak at the end of January. A second maximum occurred in May and of the females also at the beginning of June. The nauplii had three distinct maxima, in late February, in August and in October, which all could be followed up to the copepodite stage V. Also this year we have probably lost a June maximum of nauplii, which is likely to have occurred because of the preceding peak of females in May.

In both years there seems to have been four separate spawning periods, 1) late *February*-beginning of *March*, 2) early *June*, 3) *August*, 4) *October*. The two first spawnings seem to be most important and connec-

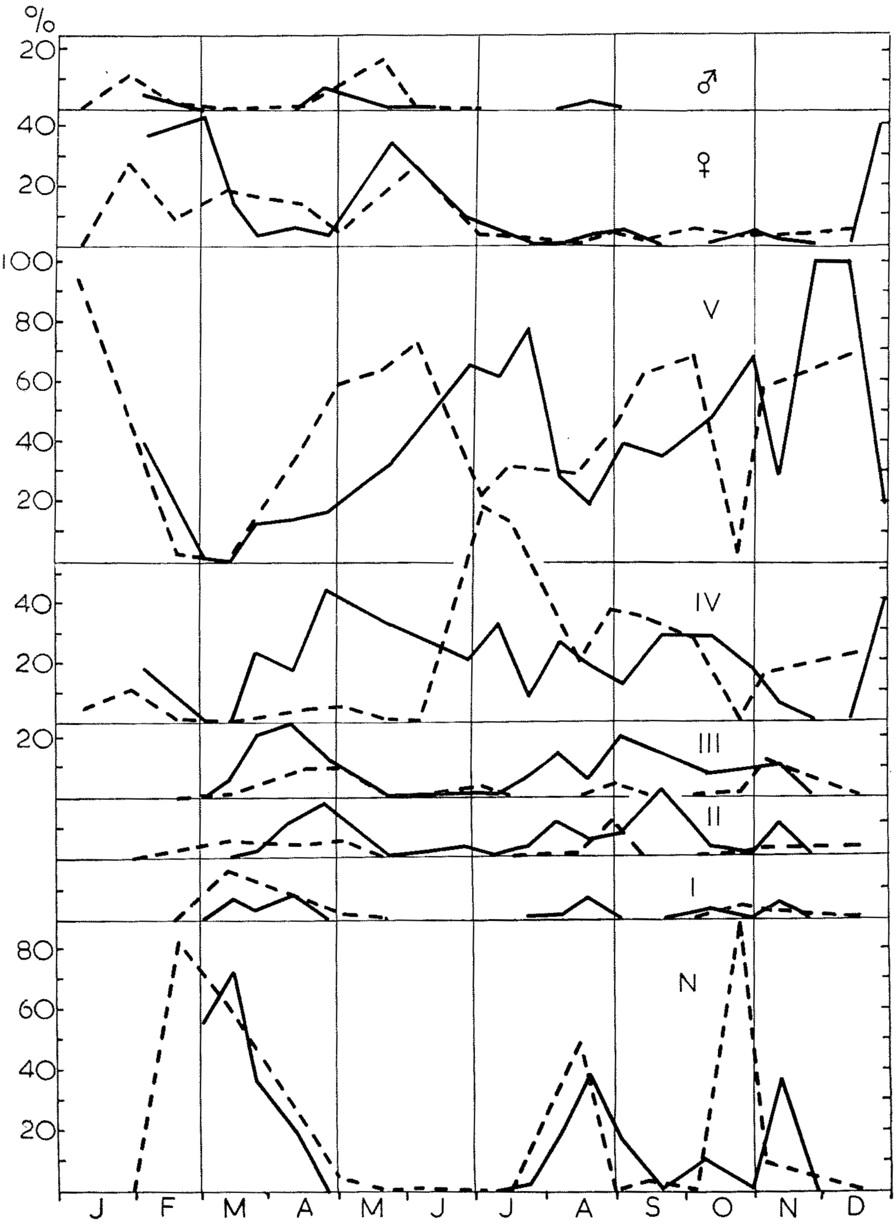


Fig. 40. Variations in percentage of each stage of *Calanus finmarchicus* at Ona in 1949 (drawn) and in 1950 (broken).

ted with an increase of the stock. The spawning periods correspond quite well with the conditions found at Sognesjøen.

Ruud (1929) stated that *C. finmarchicus* at Møre had two spawning periods, in February—March and in May—June. His observations however, did not extend beyond the end of July.

If we analyse the stock of *Calanus* at the first maximum, we find that in April 1949 it consisted of copepodites stage I—IV, in May 1950 of 60 % of nauplii and the remainder of stage I and females. In July of both years however, the maxima in stock were entirely made out of copepodite stages IV—V. Ruud (1929) draws attention to the possibility that large numbers of nauplii and copepodites spawned further south on the coast may be introduced in the waters off Møre in March—April. Large numbers of *C. finmarchicus* were also found at the edge of the continental shelf (Storeggen) in April and May and may well have spread and mixed with the stock from the coastal water. Ruud is of the opinion that the stock found at the coastal shelf must either have been carried in by the North-Atlantic current from west of the Shetland Islands, or have migrated up from the depths of the Norwegian Sea early in spring and then propagated near the shelf. Both these explanations may account for the large numbers of *Calanus* occurring at Ona in July. The spawnings which apparently took place in August and October may refer to populations which have been introduced with the North-Atlantic current. This hypothesis is supported by the length distributions (see page 94) and by the fact that a number of warm-water organisms, e.g. salps, also occurred at Ona in September—October 1950.

Eggum (fig. 41). In 1949 the females had a peak in the middle of March, and were also present from May to September. Males were scarce, a few occurring in March and May. Nauplii were found in a high proportion from the first half of April to the end of May, with maximum in April. A second lower peak occurred in June, and a third at the beginning of September. The first one can be followed through to stage IV at the end of May-beginning of June. There was a second maximum of stage IV in August which cannot clearly be traced back through the lower stages, and a third peak in October, which is preceded by maxima of copepodite stages I—III in the middle of September.

In 1950 the maximum of females again occurred in March. A few females are also found during the whole year. The males were relatively more numerous than in 1949, present from January to March, some also in August and October. The nauplii showed a large percentage throughout April, followed by successive peaks of the copepodite stages I—III to a maximum of stage IV at the end of May. A second small maximum of nauplii in July cannot be traced further, but the third maximum in August was followed by peaks of stages I—III in August—September and of IV at the beginning of November.

The main spawning thus occurred in *April* both years with subsidiary broods in *June* and in *August—September*.

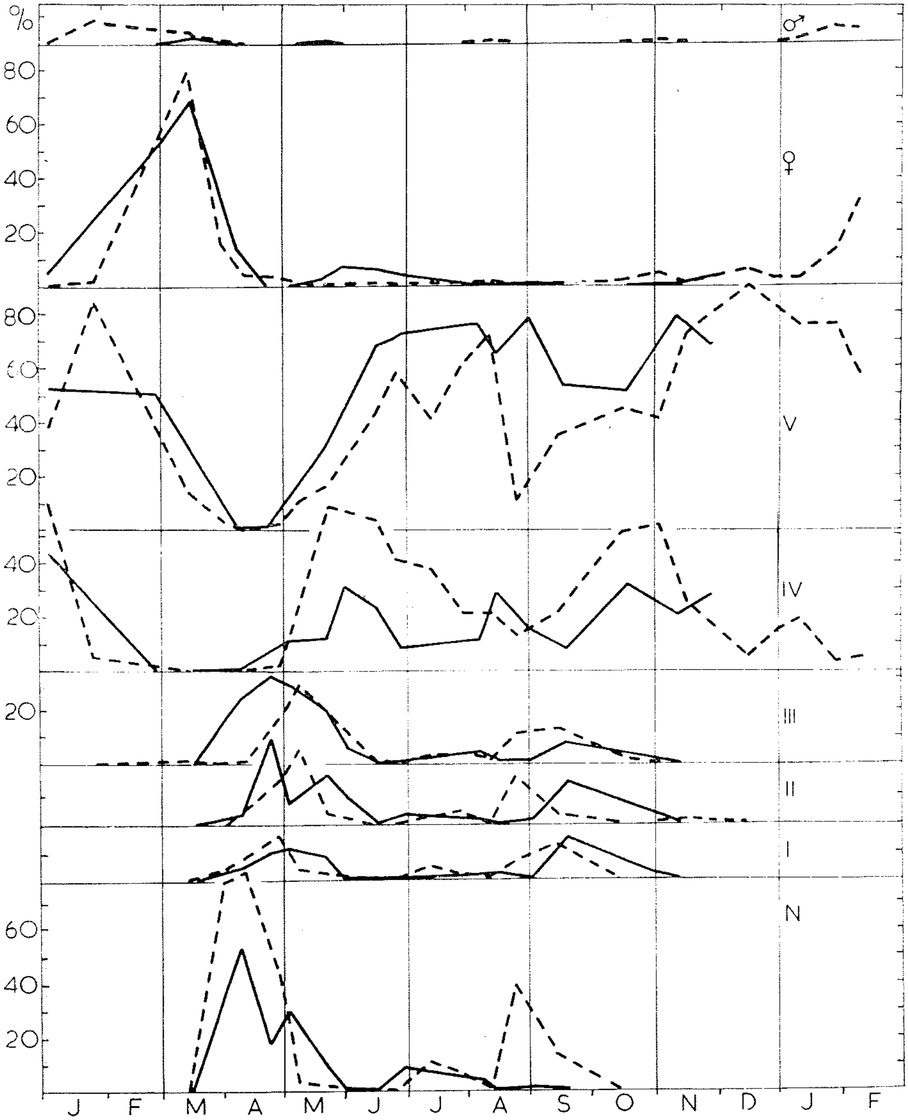


Fig. 41. Variations in percentage of each stage of *Calanus finmarchicus* at Eggum in 1949 (drawn) and in 1950 (broken).

MANTEUFEL (1941) reports that a second generation of *C. finmarchicus* (stages I—III), which had probably been produced along the northwestern coast of Norway, was in some years found between North Cape and the Barents Sea from July to September.

This agrees very well with the two subsidiary spawnings mentioned above.

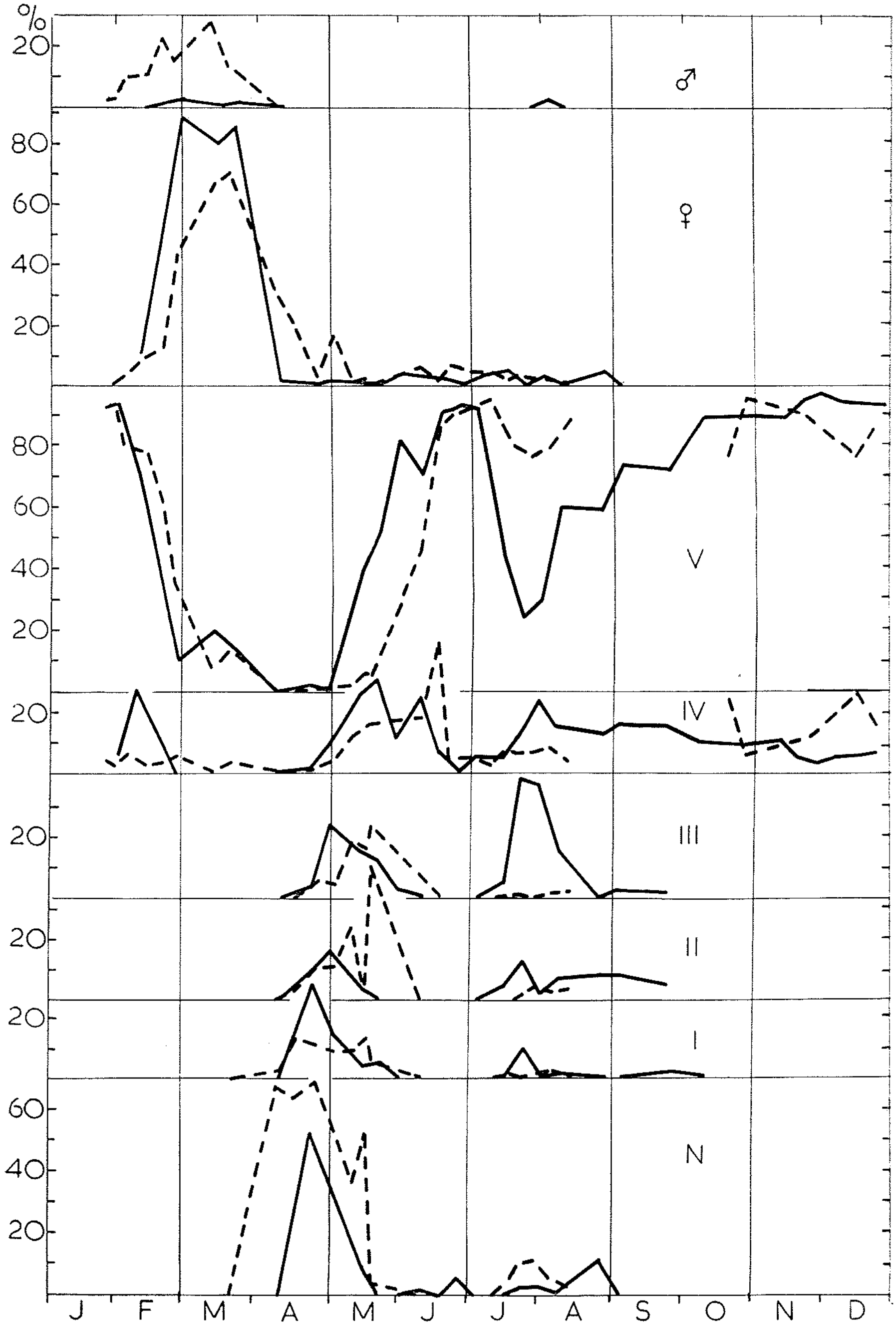


Fig. 42. Variations in percentage of each stage of *Calanus finmarchicus* at Skrova in 1949 (drawn) and in 1950 (broken).

In 1949 the first maximum in stock of *C. finmarchicus* at Eggum was mainly made out of nauplii, next of stages I—IV, the July and September peaks mainly of stage IV—V. It seems therefore reasonable that the stock gets a supply from other areas in summer and autumn.

Skrova. (fig. 42). In 1949 the females had a very marked maximum in March, constituting more than 80 % of the stock. They were also present in a small proportion during the summer until September. Males were found, though sparsely, from February to April, and in August. Nauplii had a main maximum in April—May and secondary peaks in June, the middle of July and end of August. The first maximum can be followed through successive peaks of the copepodite stages up to stage V in June, and the second maximum of nauplii in June can be traced with some certainly to stage IV in July. The August brood does not seem to have developed beyond the nauplii. In 1950 the stage variation was very similar to that of 1949, but the period of abundance of the nauplii was somewhat extended and a little delayed. In return the second maximum did not appear until July—August.

At Skrova there is, accordingly, one main spawning period, in *April—May*, and subsidiary spawnings in *June* and *July—August*, of which the June spawning may be of some importance.

MARSHALL and ORR (1952) state that individual females of *C. finmarchicus* can spawn in the laboratory for a period of more than two months, producing more than 500 eggs. When we at Skrova get two peaks of nauplii at intervals of 4—8 weeks, these nauplii may very well have been produced by the same females. This assumption may, of course, also be valid for the other localities.

Observations on the Spawning of C. finmarchicus in the Vestfjord in Earlier Years.

According to SØMME (1934) eggs of *C. finmarchicus* were observed for the first time in 1922 on 18 March, and spawning was still continuing on 27 April. In 1929 the spawning lasted at least from 4 to 29 April. During the fisheries research cruises a number of vertical hauls have been taken with the Nansen net in the Vestfjord from the year 1922 up to the present, and from this material selected samples have been analysed. Owing to the mesh size of the Nansen net the eggs of *C. finmarchicus* are not sampled quantitatively (WIBORG 1948), but when they are present in numbers, we may get an impression of the relative numerical strength.

In 1930 no eggs were found on 18 March, but a large number on 22 March. Eggs were still present in numbers on 12 April, but had disappeared on 24 April. In 1939 no eggs were seen on 20 March, but occurred

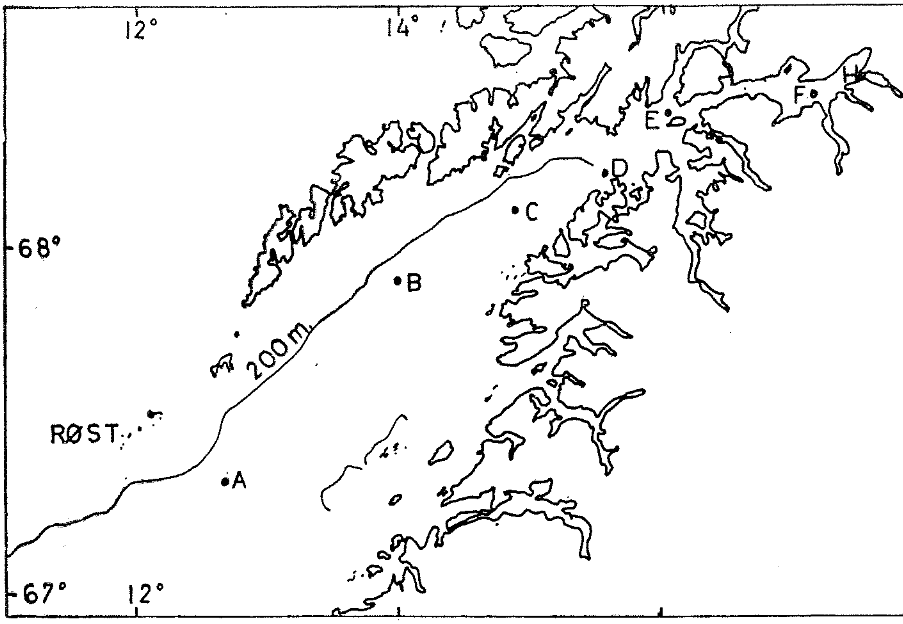


Fig. 43. Plankton stations in the Vestfjord in April—May 1947.

abundantly on 1 April. In 1947 eggs were observed singly on 17 March, in numbers throughout April, and a few were still found on 3 May. At Skrova the eggs of *C. finmarchicus* were not included in the countings from 1949. In 1950 no eggs occurred on 20 March, 3 000 eggs were found on 11 April, 1 850 eggs on 15 April, and again no eggs on 25 April.

All these data show that the spawning of *C. finmarchicus* in the Vestfjord usually starts about the 1st of April and lasts for 3—4 weeks. In some years the spawning may be extended and last from about 20 March to the beginning of May.

Sømme (1934) states that in the Ofotenfjord, a continuation of the Vestfjord, the spawning of *C. finmarchicus* starts 1—2 weeks later than in the outer Vestfjord.

In 1947 a number of vertical hauls were taken in a longitudinal section of the Ofotenfjord and the Vestfjord during the last days of April, and another series of hauls on 7—8 May (fig. 43). The percentage stage distribution of *C. finmarchicus* in these sections is shown in table 16. The eggs have been included in the stage distribution.

In April there were maxima of copepodite stage I and of nauplii. Some eggs were also present. Passing inwards in the Vestfjord, the maximum is gradually shifted towards nauplii. In the Ofotenfjord there was still a maximum of nauplii, but some females were also present.

Table 16. *The Percentage Stage Distribution of C. finmarchicus in the Vestfjord and the Ofotenfjord on 24—26 April and 7—8 May 1947.*

Date	Station	A	B	C	D	E	F	H
	♂	—	—	—	—	0,4	0.3	0.8
	♀	0.5	0.8	1.8	0.5	*11.4*	*43.9*	*18.1*
	V	2.4	0.2	0.1	—	0.2	0.3	1.4
	IV	5.8	1.0	0.2	0.6	—	0.3	5.9
24.—26. April....	III	4.4	8.1	3.4	3.9	0.8	2.3	2.4
	II	9.2	14.3	8.2	*10.5*	3.7	6.8	*14.1*
	I	*16.3*	*31.6*	*12.8*	9.0	*13.8*	*12.5*	7.0
	N	*57.2*	*43.9*	*70.3*	*72.2*	*69.9*	*33.8*	*39.9*
	Eggs	4.2	—	3.2	3.3	—	—	—
	♂	4.3	—	—	—		—	-
	♀	5.9	0.3	1.2	4.8		*55.1*	
	V	*30.4*	0.7	1.6	1.5		2.7	
	IV	*39.1*	6.4	9.3	8.9		8.7	
7.— 8. May	III	5.7	*28,7*	*20.9*	8.5		7.5	
	II	4.2	*36.2*	*24.4*	*15.1*		2.7	
	I	2.5	11.5	11.5	12.0		5.4	
	N	7.9	16.2	*31.1*	*48.0*		*17.8*	
	Eggs	—	—	—	1.5		—	

The total stock of *C. finmarchicus* was very small compared with that of the Vestfjord. At the two innermost stations in the Ofotenfjord the percentage of females was still greater, nauplii were scarce, and no eggs were observed.

At the beginning of May the stage distribution was irregular in the innermost part of the fjord, with maximum of females but also many nauplii. In the middle of the fjord there was a maximum of stage II—III, outermost of stage IV—V. We thus find a delay in the development when we pass from the outer fjord and inwards, confirming SØMME's observations.

Vertical Distribution.

The vertical distribution of *C. finmarchicus* will appear from the figures 35—38 where the 50—0 m hauls are shown as black columns. At Ona and Sognesjøen the bulk of the stock was found in the upper m. 50 At Eggum and Skrova the *Calanus* seems to be concentrated in the uppermost layers in May and June, but later in the year the quantity taken in the 50—0 m hauls decreases very rapidly, and after the beginning or middle of August the entire stock was found below 50 m. The copepodite stages I—III and the nauplii have almost exclusively been taken in the upper 50 m, but a few were also found below 50 m, especially at Skrova and Eggum in April.

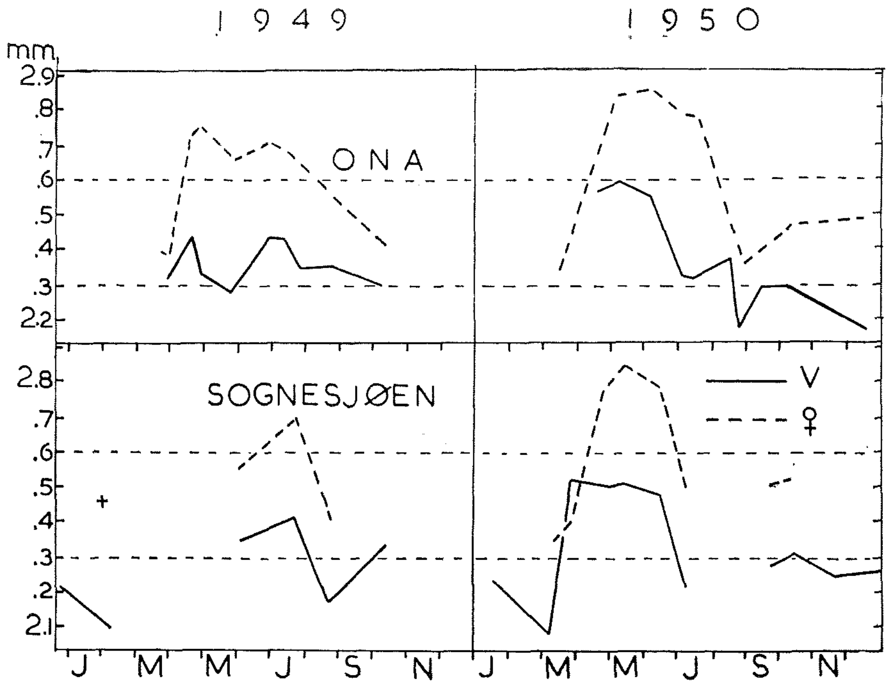


Fig. 44. Variations in mean length of *Calanus finmarchicus* stage V and females at Sognesjøen and Ona in 1949—50.

A number of vertical hauls taken in steps from bottom to surface, and a series of hauls with the Clarke-Bumpus plankton sampler in the years 1947—52 have shown that from early May to the middle of June all the *Calanus* in the Vestfjord stayed in the upper 25 m both during day and night. At night the stock was sometimes concentrated in the upper 15 m or less.

Variations in Size of C. finmarchicus.

A. *At the Norwegian Coast.* The variations in mean size of *C. finmarchicus* females and stage V copepodites at Ona and Sognesjøen during (1948)— 1949—50 are shown in fig. 44. At Sognesjøen stage V copepodites measured on an average 2.22 mm in December 1948 and 2.10 mm in February 1949. The stock was very small in March, and no mean values were worked out. At the end of May the length of stage V had increased to 2.34 mm, and it rose further to 2.41 mm in July. A small increase followed in August, but in October the length was the same as in July. The females measured 2.4 mm in February, 2.6 mm at the beginning of June, 2.7 mm in July, and decreased a little in length in August. In 1950 stage V again showed minimum length in the first days of March, increasing to 2.5 mm at the end of the month.

With small variations this length was maintained throughout June, but dropped to 2.2 mm in the last days of the month. Later there were small variations. The females varied in size in nearly the same way as stage V, with a minimum length in March, some increase in April, and maximum in May. In July a decrease followed, and the mean length then remained nearly constant throughout September and October.

At Ona females and copepodites of stage V were too scarce to give reliable mean lengths till the middle of March 1949. Stage V then measured approximately 2.3 mm and the mean size increased to 2.4 mm in April, dropped a little in May and increased somewhat in June—July. In August and later there was again a decline in mean length. The females showed minimum length in March, maximum in April, the latter length being maintained with small variations till the end of July. In September the mean length had again decreased.

In 1950 copepodites of stage V were scarce until the middle of April, when the mean length was approximately 2.6 mm, remaining nearly constant till the beginning of June, and decreasing throughout July and August. In September we again note some increase in the mean length, but the number measured was small, and the length distribution irregular (see fig. 45). In December the lengths were as in August. The females had approximately the same variation in mean length as in the preceding year.

The individual length distributions of stage V during 1949 and 1950 are shown in fig. 45 (see also table 49, pp. 225—228).

In 1949 stage V had a bimodal size distribution from 18 July to 11 October. In 1950 the curves were very irregular in shape from the middle of July to October. From the occurrence of foreign plankton elements, (e.g. salps) and from the hydrographical conditions we learn that in this period there took place a considerable influx of water from other areas, which brought in other populations of *C. finmarchicus*. But we must also expect continuous breeding throughout the summer.

The length distribution of the females was bimodal in the middle of April 1949 with maxima at 2.5 mm and 2.9 mm, indicating the presence of individuals both of the winter and spring generation. The same feature was repeated in the middle of April and at the beginning of May 1950.

At Sognesjøen the mean length of females and stage V of the brood generated in March—April was greater in 1950 than in 1949. The surface layers were colder in March 1950, (the temperature in the upper 50 m varying between 4.5°—5.5° C), than in 1949 (6.3°—6.5° C), thus confirming the generally accepted theory that length varies inversely with the temperature during growth. At Ona we also find some difference in mean lengths in the period April—June of the two years, with lower

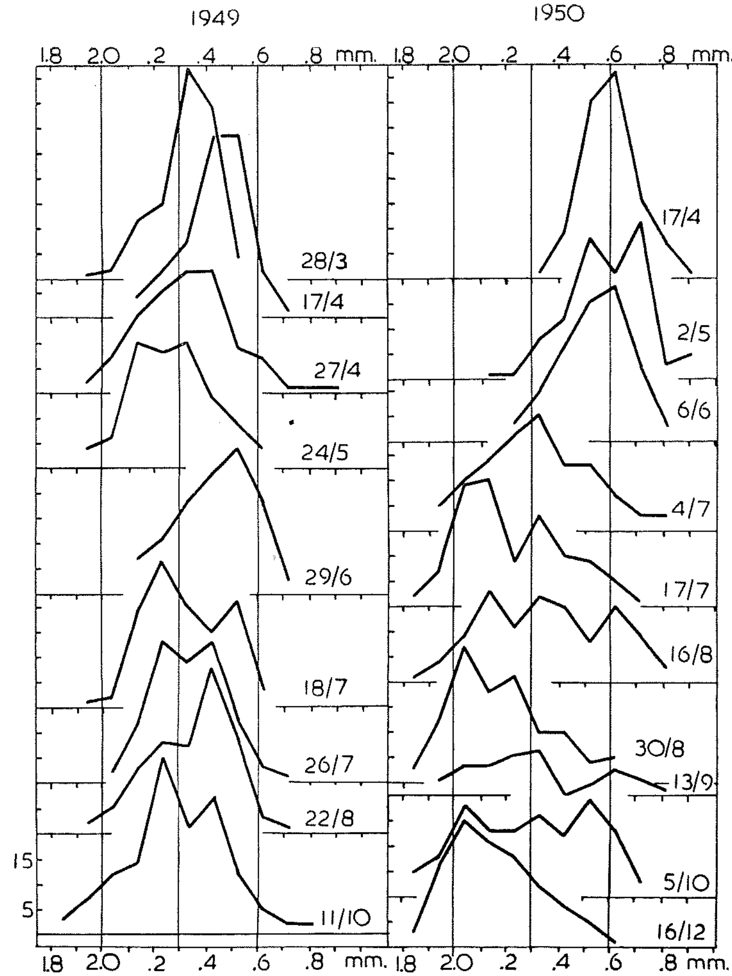


Fig. 45. Size frequencies of *Calanus finmarchicus* stage V at Ona in 1949 and 1950.

values in 1949, but there was no clearly indicated rise in temperature, on the contrary, the temperature was a little lower during March of 1949 than in March of 1950. It is therefore probable that the stock of *C. finmarchicus* present at Ona in May—June, has in both years been introduced from other areas.

The variations in the mean length of females and stage V at Skrova and Eggum during (1948—) 1949—50 are shown in fig. 46.

At Skrova the mean length of stage V was near 2.5 mm in October 1948 and remained constant to the beginning of February 1949.

From the middle of the month there was a sudden drop in size to 2.24 mm, simultaneously with the appearance of the females. In the

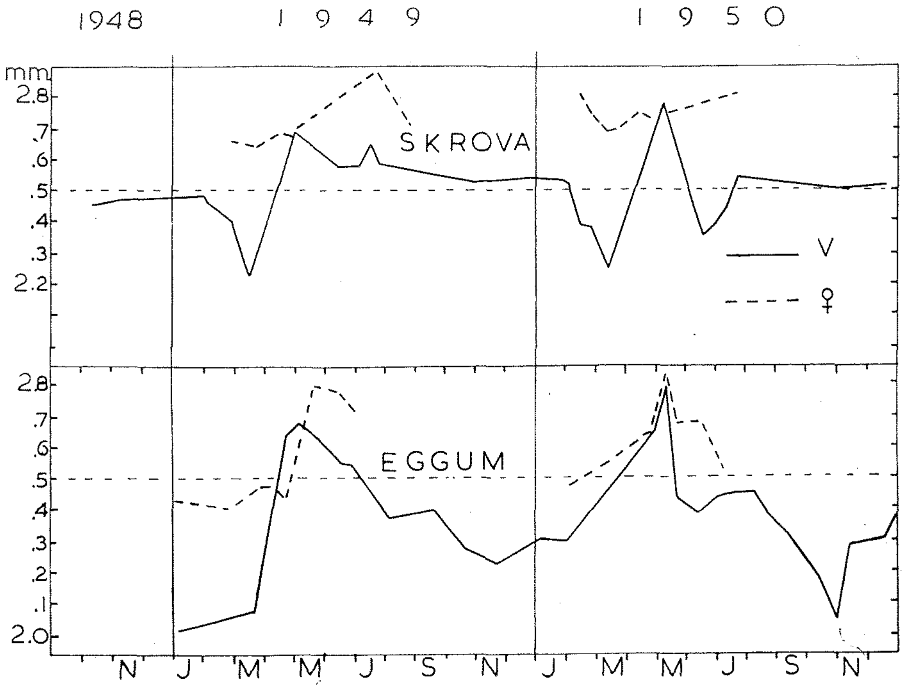


Fig. 46. Variations in mean length of *Calanus finmarchicus* stage V and females at Eggum and Skrova in 1949—50.

last half of April the spring generation had advanced to stage V with a mean length of 2.7 mm. From April to December there was generally a slight decrease in mean length, In 1950 there was a sharp decrease from May to June, but again a rise to July, and later small variations.

The females occurred in representative numbers only from February to August. The mean length varied from about 2.7 mm in the period February—March to 2.9 mm in July, and decreased to 2.7 mm in August. In 1950 the variations were very small, 2.7—2.8 mm between February and July, and within the limits of the mean error.

The drop in mean length of stage V from January to March each year is very striking. Measurements have also been taken of stage V from the spring of 1951, and the same phenomenon was again observed. A possible explanation is that part of the stock goes through two generations during the course of the year (see page 91). In spring the large individuals of stage V, which grew to this stage during the previous spring, moult into adults, and the small individuals of stage V, which reached this stage last summer and autumn, remain and moult later, if at all. Smaller individuals of stage may also have been introduced by the currents from other areas, presumably further south (cfr. Eggum).

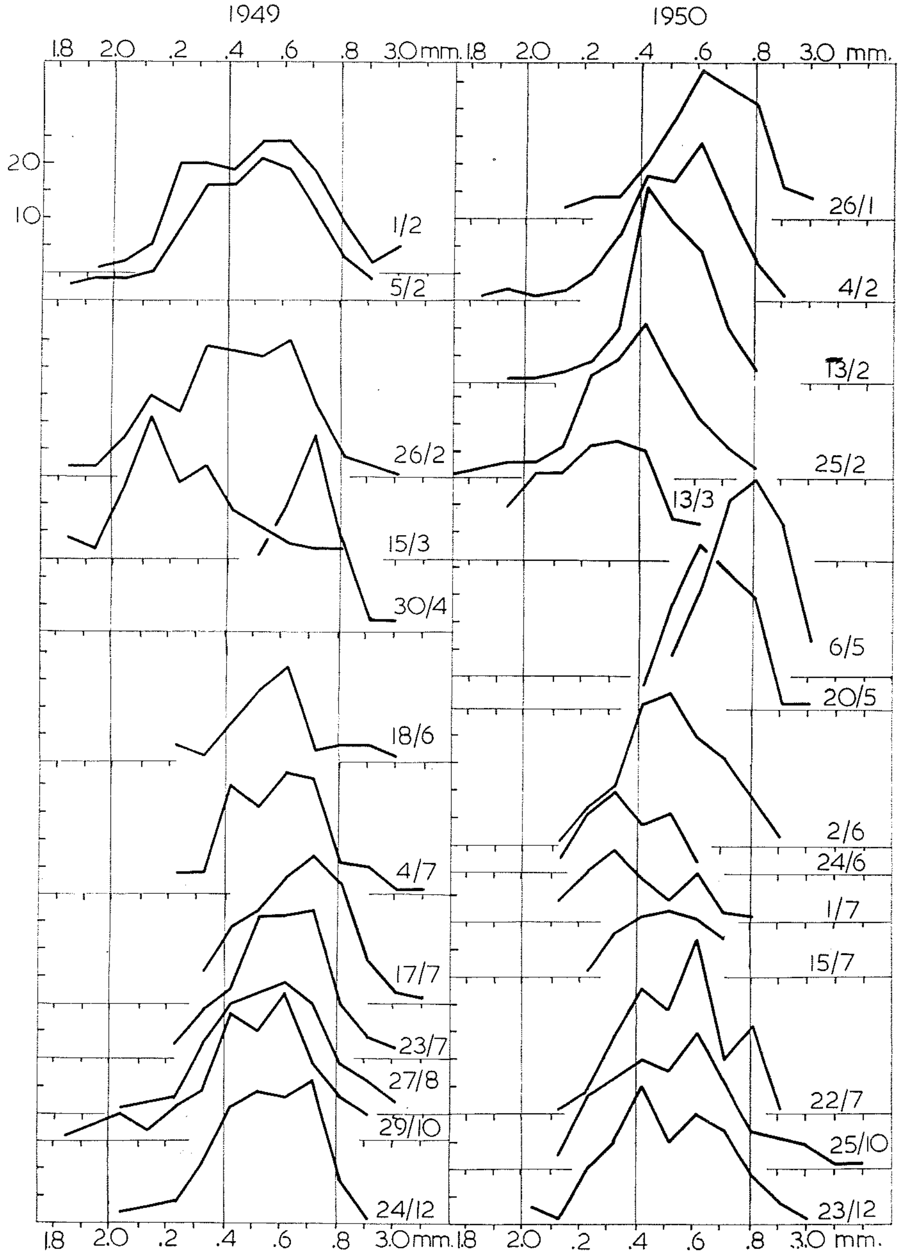


Fig. 47. Size frequencies of *Calanus finmarchicus* stage V at Skrova in 1949 and 1950.

The size distributions (fig. 47) are bimodal at the beginning and end of February, although not very pronounced.

The maximum size of stage V was nearly the same in the two years, and the temperature of the upper 50 m did not differ essentially from one year to another.

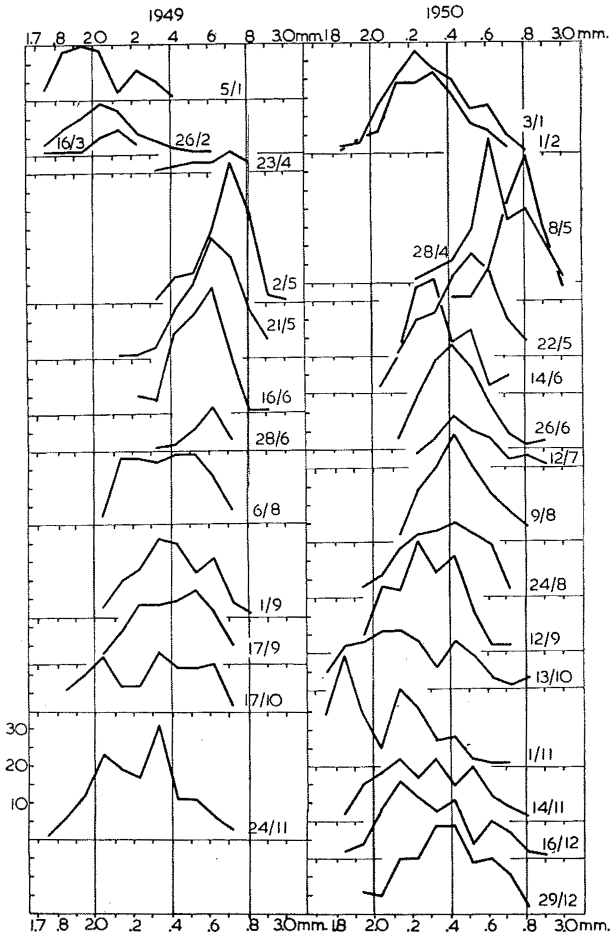


Fig. 48. Size frequencies of *Calanus finmarchicus* stage V at Eggum in 1941 and 1950.

At Eggum the mean length of stage V was only 2.0 mm in January—March 1949, but increased to 2.7 mm in April, the same size as at Skrova. During the following months the mean size decreased considerably, and except for a little rise in October, dropped to a minimum in November and rose but slightly to the end of March 1950. A maximum of 2.8 mm then occurred at the beginning of May, but a fortnight later the mean size declined to 2.4 mm and remained thereafter nearly constant till the beginning of August, Another decrease followed in October, but in December the mean size had again increased.

The females measured approximately 2.4 mm in January—April 1949. In May the size increased to 2.8 mm, remaining nearly constant until July, when the females disappeared from the plankton. In 1950 there was an increase in mean length from 2.4 mm in January to 2.6 mm in April and further to 2.8 mm in May, some decrease in July, and then the females disappeared.

The size frequencies are shown in fig. 48. In January 1949 the copepodites showed a bimodal distribution, with peaks at 1.9 mm and 2.2 mm. From August to November the maxima were little pronounced, but in October there were peaks at 2.0 mm, 2.3 mm and 2.6 mm, the two former also occurring in November. In 1950 the curves were unimodal until August, but more irregular from September to December (see also table 49, page 225).

There are some common features in the length variations of *C. finmarchicus* at Skrova and Eggum, and the same maximum size in April—May, but in 1949 the decrease in mean length after April was much more pronounced at Eggum.

It is obvious that the mean length of stage V at Sognesjøen in February 1949 was very near to that of Eggum in January—March. From July to October the mean length at Ona is only a little below those at Eggum. In 1950 however, there were no such similatities.

The difference in the length variations at Eggum and at Skrova may be explained briefly as follows:

At Skrova the stock of *C. finmarchicus* is more stationary and only supplemented from areas near by, while Eggum gets a continuous supply from other areas, in April—May probably from the Vestfjord, during summer and autumn mainly from the south.

B. *At Station «M»*. A series of length measurements of copepodites of stage V and females of *C. finmarchicus* has been carried out on material from station «M» in the Norwegian Sea during 1950. The measurements have been taken from all the different water layers, usually in the 100—0 m, 600—100 m, 1 000—600 m and 2 000 (1 500, 1 800)—1 000 m hauls.

In fig. 49 are shown the variations in mean length of stage V in the different hauls during 1950.

In the upper 100 m the mean length was approximately 2.2 mm in the middle of March, remained nearly constant to the beginning of April, but rose to above 2.5 mm in the middle of the month. Apart from a minor decrease in May this length remained constant throughout June and July. From August there was a continuous decline to 2.1 mm in October, some increase in November, and a final drop at the end of November.

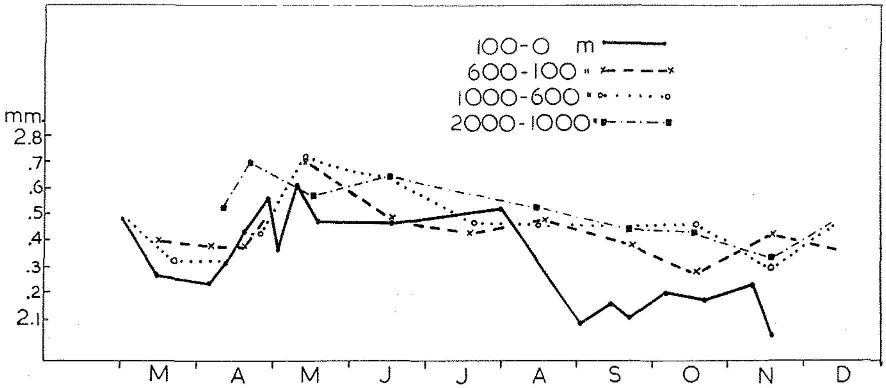


Fig. 49. Variations in mean length of *Calanus finmarchicus* stage V at station «M» in 1950.

In the 600—100 m layer the mean length remained almost constant, 2.4 mm, from February to April, increased to 2.7 mm in the first part of May, then fell off gradually to 2.5 mm in July and varied but little the rest of the year.

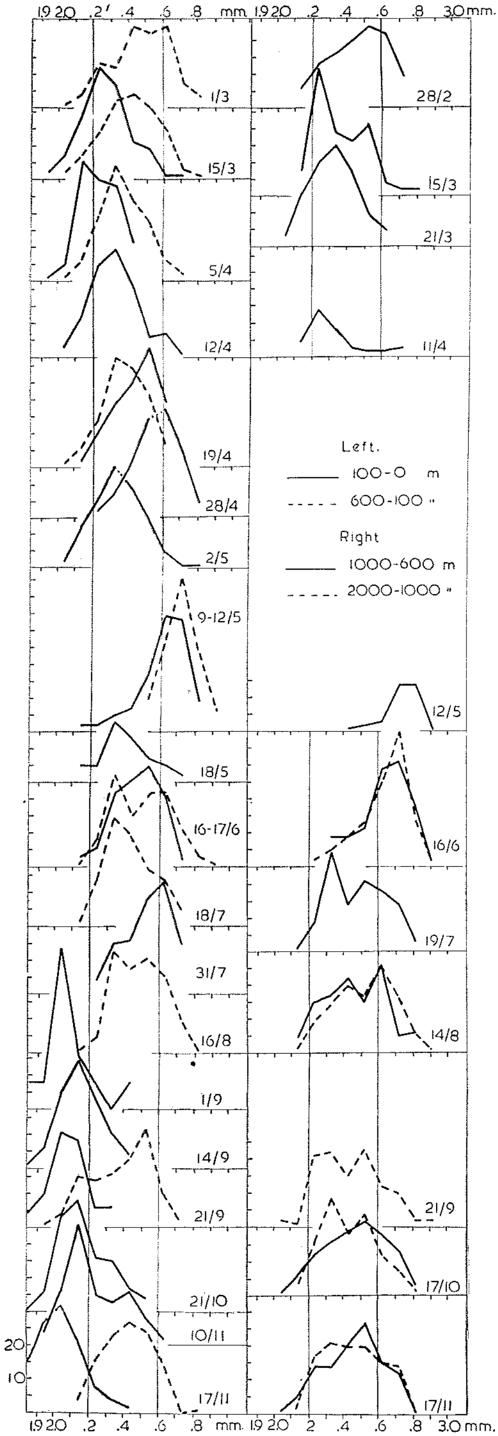
In the 1 000—600 m layer the variation was nearly identical with that of the 600—100 m layer.

Below 1 000 m the mean length also varied in a similar way as in the 600—100 m and 1 000—600 m hauls, but the individuals were slightly larger. It must be noted, however, that the plankton hauls were taken more frequently in the 100—0 m and 600—100 m than in the deeper layers.

The females were measured from 1 March to the end of July. The mean length varied very little in this period, on most occasions being 2.7—8 mm, except from the middle of March to the middle of April, when it was 2.5—6 mm (see also table 49, page 234).

The length frequencies of stage V at station «M» during 1950 are shown in fig. 50. In the upper 100 m the curves were always unimodal, except on 11 November, when there were peaks at 2.1 mm and 2.4 mm. From 1 March to 31 July the usual mean length was 2.5—2.7 mm. Exceptions were the length distributions on 2 May and 18 May. On 28 April and 9 May the copepodites were larger than usual, and the same also happened to the females. It seems as if other populations of *C. finmarchicus* had been introduced.

Below 1 000 m bimodal size distributions are observed on several occasions. There are apparently 3—4 different size groups with maxima at 2.1—2.3 mm, 2.5 mm, and 2.7 mm. In September—November copepodites of stage V occur in the upper 100 m with peaks at 2.0—2.1 mm.



ØSTVEDT (in press) in 1949 observed two spawnings of *C. finmarchicus* at station «M», the main one in April and a second one of minor importance in August. If the stage V copepodites from both spawnings are wintering in the deeper water layers, we should expect to find bimodal size distributions. As stated above, this is also the case, as we have bimodal size frequencies below 100 m from August to December, and also in March—April. It is, however, difficult to explain the bimodal size distributions in the intermediate water layers in June and July, and the changes in size from one water layer to another. It is suggested that the copepodites from the two spawnings migrate to the surface at varying speed or at different times of the year.

That the conditions at station «M» must be very variable is easily seen by the size distributions of the copepodites on 9—12 May and 16—17 June. The large individuals present apparently belong to a different population. It seems as they migrate into the deeper water layers, but in July they have entirely disappeared. These copepodites may have been brought in by surface currents from the waters southeast of Iceland, where investigations at the end of June 1950 revealed a unimodal size distribution with

Fig. 50. Size frequencies of *Calanus finmarchicus* stage V at station «M» in 1950.

the peak at 2.6 mm (mean length 2.5 mm) or possibly from the coast of Norway, where the mean length at the beginning of May was 2.6 mm at Ona and 2.8 mm at Eggum.

Bimodal size distributions of stage V have also been observed at a number of stations in the central part of the Norwegian Sea at the beginning of July. These observations will be dealt with more thoroughly in a subsequent paper.

The small copepodites of stage V found in the uppermost water layers at station «M» from September to November must have grown to this stage at a comparatively high temperature. They may have been brought in by the North-Atlantic current from the Faroe-Shetland area, or perhaps from the North-Atlantic. A number of warm-water organisms, especially salps were taken together with the *Calanus* in September.

If we compare the variation in mean length of stage V at station «M» with the size variations at Eggum (fig. 46) we find that from July and onwards the curves have a similar course, but at Eggum the minimum lengths occur one or two months later. A great number of salps were also found at Eggum during the autumn, the first ones observed on 13 October (The previous haul was taken on 12 September), and we may suppose that the *Calanus* occurring at «M» and at Eggum during the autumn are of the same origin.

Calanus hyperboreus Krøyer.

This arctic species has been found in numbers in some Norwegian fjords, where it mainly keeps to the deeper water layers. At Møre (near Ona) it is scarce on the coastal banks, but rather common in the fjords. (Ruud 1929).

Numerical Variation.

At Sognesjøen single copepodites of stage IV—V were taken in June 1949 and May, June and October 1950. Some 250 nauplii which probably belonged to this species were caught on 28 March 1950.

At Ona single copepodites also occurred between March and August both years, maximum number 18 on 28 March and 15 on 29 June 1949.

At Eggum there is apparently no endemic stock of *C. hyperboreus*, the deeper water layers being in constant motion and not well suited for the wintering of this species. No individuals were found between February and April either year. On 8 April 1949 some 250 nauplii and copepodites of stage I—III were found, later varying numbers (50—200) of stages IV—V and females, but only single specimens between September and December. In 1950 the conditions were much the same. A few nauplii occurred on 28 April, thereafter 20—100 of the older stages, and after 10 September the species was entirely absent.

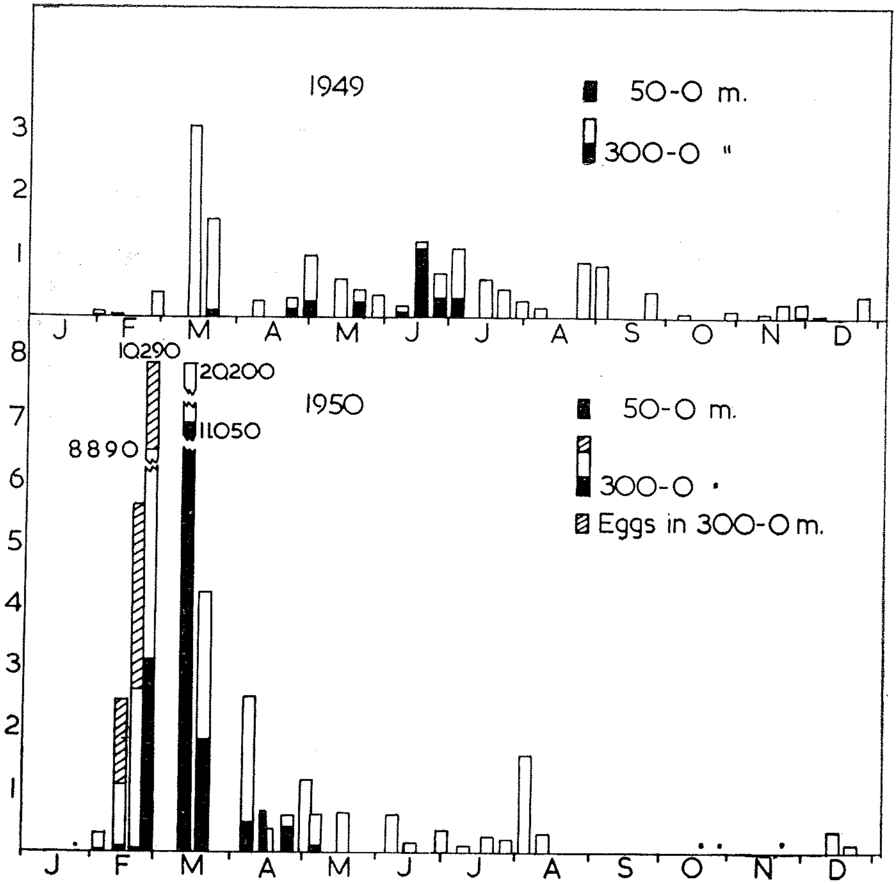


Fig. 51. Numerical variation of *Calanus hyperboreus* at Skrova in 1949—50, in 1000's.

It is reasonable to suppose that the specimens taken at Eggum had been introduced from other areas, presumably from the Vestfjord.

Sømme (1934) found a rather large stock of *C. hyperboreus* in the deeper parts of the inner Vestfjord. The species may sometimes keep very close to the bottom. Therefore we cannot always rely entirely on the samples taken in vertical hauls, as part of the stock may still be below the net, and will not be caught.

The variation in number of *C. hyperboreus* at Skrova during 1949—50 is shown in fig. 51.

In 1949 the stock was very small during the first months of the year, but increased in March to about 3 000 individuals, mainly nauplii. Shortly afterwards there was a sharp decrease, and the stock later remained low most of the year, with minor peaks in May, June, July and August.

Table 17. *Numbers of the Different Stages of Calanus hyperboreus in the Total Hauls at Skrova in January—May 1949 and 1950.*

1949	1/2	5/2	13/2		26/2	15/3	19/3			25/4	30/4	2/5	16/5	24/5
♂	*2*	1	—	—	—	1	—	—	—	—	—	—	—	—
♀	19	13	—	—	*100*	*109*	40	—	—	33	30	42	5	5
V	15	—	—	—	10	75	60	—	—	166	200	158	*350*	*325*
IV	51	—	—	—	10	50	83	—	—	100	700	*1100*	250	102
III	—	—	—	—	—	—	—	—	—	16	*50*	—	—	—
II	—	—	—	—	—	—	—	—	—	—	—	—	—	—
I	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N	—	—	—	—	250	*1850*	*1350*	—	—	—	—	—	—	—
Eggs ..	few	—	—	—	few	—	—	—	—	—	—	—	—	—
1950	**31/1**	**4/2**	**13/2**	**21/2**	**25/2**	**13/3**	**25/3**	**11/4**	**15/4**	**25/4**		**2/5**	**16/5**	**20/5**
♂	*83*	2	1	33	—	—	1	—	—	—	—	—	—	—
♀	100	31	50	83	42	*650*	183	*500*	133	42	—	150	16	36
V	150	6	9	42	—	25	75	*300*	83	58	—	150	300	*420*
IV	100	—	16	9	—	—	16	—	—	83	—	*600*	200	160
III	—	—	—	—	—	—	—	—	—	42	—	*250*	—	—
II	—	—	—	—	—	—	—	*300*	—	150	—	—	—	—
I	—	—	—	—	—	—	—	*500*	—	100	—	—	—	—
N	—	—	400	2450	8850	*19500*	3900	900	150	100	—	—	100	—
Eggs ..	—	*250*	*1350*	*3000*	1400	—	—	—	—	—	—	—	—	—

At the beginning of February 1950 *C. hyperboreus* was again scarce, but the number increased very rapidly throughout February to a maximum of about 20 000, nearly all nauplii, in the middle of March. Eggs were found in February, and their number is indicated by the shaded parts of the columns. As in the previous year, the number soon decreased considerably and remained low during the summer and autumn, with the exception of a small rise in August.

Propagation.

It has been shown by SØMME (1934) that *C. hyperboreus* in the Vestfjord only propagates once a year, in February—March.

In table 17 are given the numbers of the different stages during the first five months of the years 1949 and 1950.

At the beginning of February 1949 there was a maximum of females and copepodite stages IV—V. Single males and a few eggs also occurred. In the last days of February some nauplii appeared, reaching a maximum of 1850 in the middle of March. No hauls were made between 19 March and 25 April. During April and May the stock consisted mainly of stage IV—V and a few females. A few stage III were taken in April.

At the end of January 1950 the stock of *C. hyperboreus* was made up of adults and stage IV—V in almost equal proportions. Four days later a number of eggs occurred while the older stages were scarce. Throughout February the number of eggs increased, reaching a maximum in the last half of the month. No eggs were found in March. Nauplii appeared in the middle of February, culminating in number in the middle of March, and decreasing rapidly to 25 April. After that time the nauplii disappappeared.

The females were rather well represented from the middle of March to the beginning of May, together with a varying number of stage V. The first copepodites of the new generation occurred on 11 April, and on 25 April all stages were represented, with a maximum of stage II. Stage IV had a maximum on 2 May and 16 May and later stage V took the lead. Throughout the years 1949 and 1950 copepodites of stage IV and V were present all the time, similar to that found in other areas. (ØSTVEDT, in press).

From the stage distribution it is evident that *C. hyperboreus* spawns in February, but there seems to have been great variations in the intensity of spawning from one year to another. It is very difficult to follow the development through maxima of successive copepodite stages. This may partly be due to irregularity in spawning and a great mortality of the younger stages, partly due to their being carried away by surface currents.

The copepodite stages I—III are very scarce and only present in April and the first days of May.

The spawning of *C. hyperboreus* seems to take place partly in deeper water, but the nauplii gradually seek the upper layers. This was clearly seen in 1950. No eggs were found in the 50—0 m hauls before 25 February. At this date and later the numbers of eggs and nauplii were twice as large in the 300—0 m hauls as in the upper hauls.

The bulk of the stock of *C. hyperboreus* was as a rule taken below 50 m.

Table 18. *Number of the Different Stages of Calanus hyperboreus in the Total Hauls at Høla in the Vestfjord 22 March — 10 April 1946.*

Stages	22/3	28/3	3/4	6/4	10/4
♂	—	—	—	—	—
♀	*21*	—	2	13	2
V	—	—	7	9	7
IV	—	—	—	3	—
III	—	—	—	—	22
II	—	—	7	130	*249*
I	—	—	550	405	197
N	*3280*	1140	275	50	*800*

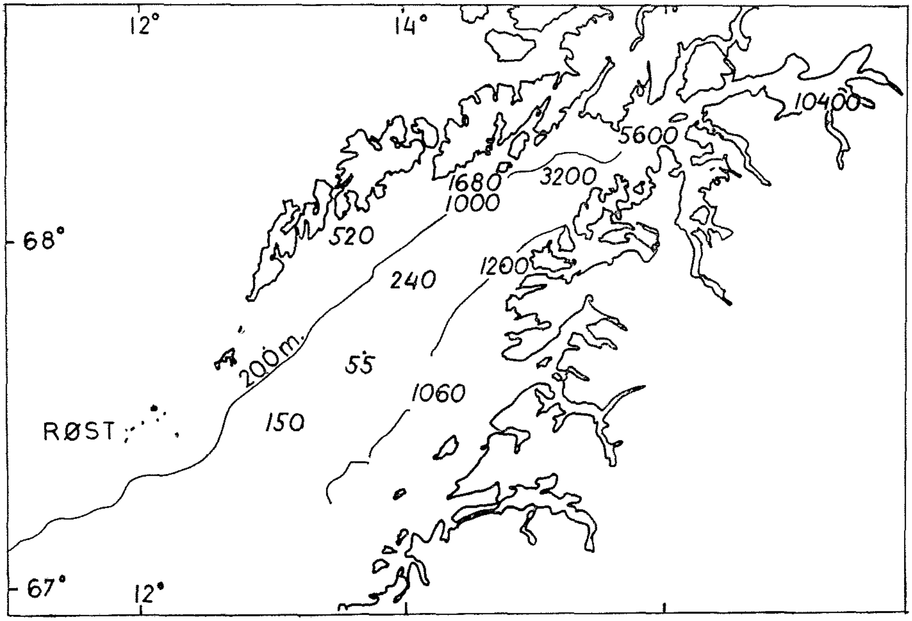


Fig. 52. Number of *Calanus hyperboreus* nauplii at different stations in the Vestfjord, 2 February—4 March 1939.

The Propagation, Vertical and Horizontal Distribution of Calanus hyperboreus in the Vestfjord in the Years 1930, 1939, 1946 and 1947.

In order to supplement the material from 1949—50 I have examined a number of plankton samples taken in earlier years in the Vestfjord. In 1930 vertical hauls were made at Høla, near the Skrova station. On 22 and 29 March 6 800 and 3 000 nauplii respectively were found in the total hauls. On 5 April there were 1 300 nauplii, 1 900 copepodites of stage I and 150 of stage II. In 1946 the same station was visited repeatedly during March and April, and the numbers of the different stages are given in table 18.

The figures were very similar to those observed in 1930. Of the younger stages only nauplii occurred until the end of March, but at the beginning of April the copepodites appeared, with maximum of stage II on 10 April.

In the spring of 1939 a number of vertical hauls were taken all over the Vestfjord. In fig. 52 is shown the number of nauplii of *C. hyperboreus* in the total hauls from bottom to surface at the different localities in the period 28 February — 4 March 1939. The largest numbers of nauplii occurred in the Ofotenfjord and the inner Vestfjord, decreasing outwards, with the smallest numbers in the outer central part of the Vestfjord. In the middle of March the number of nauplii was approxi-

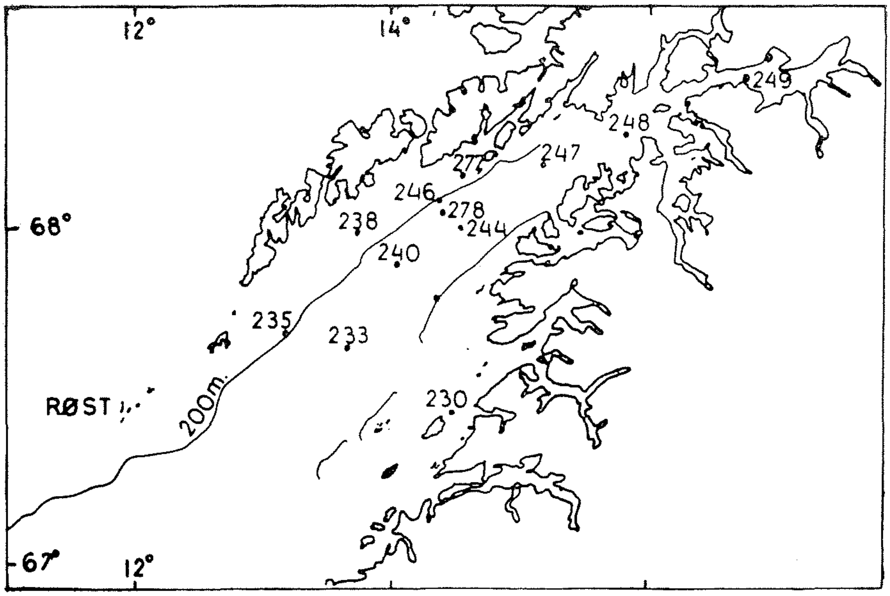


Fig. 53. Plankton stations in the Vestfjord 4—5 April 1939. (table 20).

mately 4 000 at the localities near Skrova. On one station were also found 1 000 copepodites of stage III.

The number of the different stages of *C. hyperboreus* in the Vestfjord 4—5 April 1939 are given below. (Table 19 and fig. 53).

In the outer part of the fjord there was a fairly large number of nauplii and copepodites of stage I—II. Females and stages IV—V were also present, but scarce. In the inner fjord there was a higher number of

Table 19. *Number of the Different Stages of Calanus hyperboreus in the Vestfjord on 4—5 April 1939 (fig. 53).*

Station	230	233	235	238	240	242	244	246	247	248	249
♀	24	37	26	64	32	65	37	*473*	*280*	650	*236*
V	10	30	23	57	13	72	29	*558*	*214*	*775*	*229*
IV	—	2	1	21	5	7	7	8	—	—	7
III	—	7	—	—	—	—	—	—	—	—	—
II	150	150	175	75	—	50	150	200	43	25	—
I	505	*750*	*250*	*200*	50	50	*350*	*1250*	*114*	*200*	29
N	*700*	300	200	100	*80*	*200*	*350*	*1600*	25	—	*1700*
Total of new brood	1400	1200	625	375	130	300	850	*3050*	182	225	*1729*

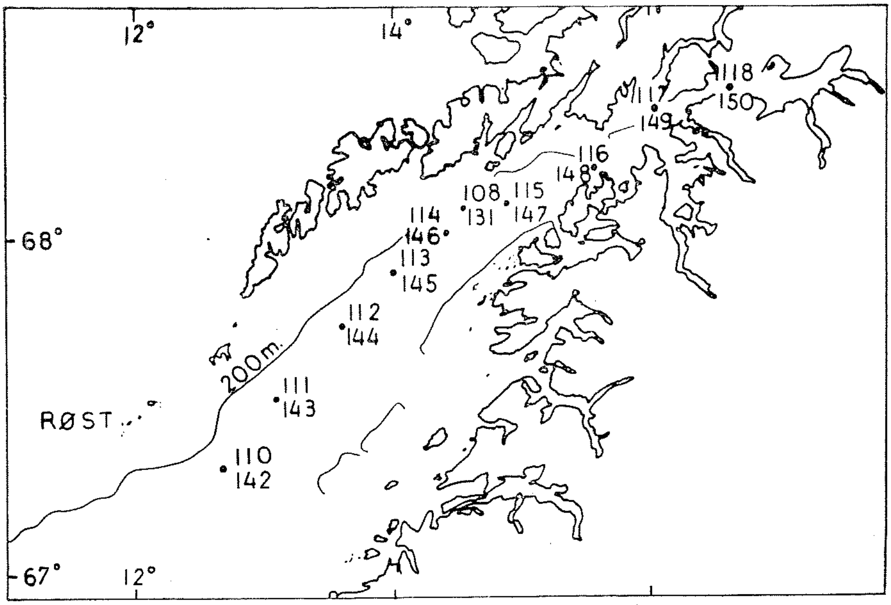


Fig. 54. Plankton stations in the Vestfjord in the spring of 1947 (table 21—22).

females and stage V, and in addition a good number of nauplii. At no stations were the hauls taken deeper than 150 m, but the bottom depths are considerable greater in the inner fjord.

Below is shown the number of the different stages of *C. hyperboreus* at two stations near Skrova on 17 April 1939.

Station	277	278
♀	79	50
V	101	58
IV	50	7
III	*2000*	*400*
II	*2450*	*100*
I	150	10
N	100	—

We have now a pronounced maximum of copepodites of stage II—III.

It seems as if the development from eggs to copepodite stage III has taken 1½—2 months.

In 1947 vertical hauls were taken near Skrova (st. 108, fig. 54) on 27 February, and 380 eggs of *C. hyperboreus* were found in the 250—75 m haul, but none in the 75—0 m haul. Nauplii were lacking. Vertical hauls

Table 21. *Vertical Distribution of the Different Stages of Calanus hyperboreus in the Ofotenfjord and in the Vestfjord in April (upper series) and May 1947. (for location, see fig 54).*

Stations	117—149			116—148				112—144		
Intervals, m.	400—90	90—50	50—0	500—300	300—100	100—50	50—0	240—50	50—25	25—0
♀	85	1	240	13	13	16	33	21	—	—
V	135	5	300	22	20	50	67	24	—	—
IV	15	2	100	—	—	25	325	33	3	2
III	15	2	100	—	5	15	350	42	17	17
II	—	20	30	—	—	—	50	33	50	100
I	—	—	—	—	—	—	—	158	100	1500
N	—	—	—	—	—	20	20	200	100	1500
Intervals, m.	400—75	75—25	25—0	500—100		100—50	50—0	240—75	75—25	25—0
♀	340	—	145	356		—	57	90	—	—
V	260	1	230	665		1	167	5	1	—
IV	150	1	25	350		3	133	15	—	—
III	—	—	—	7		1	8	—	—	—
II	—	—	—	—		—	—	—	—	—
I	—	—	—	—		—	—	—	—	—
N	—	—	—	—		—	—	—	—	

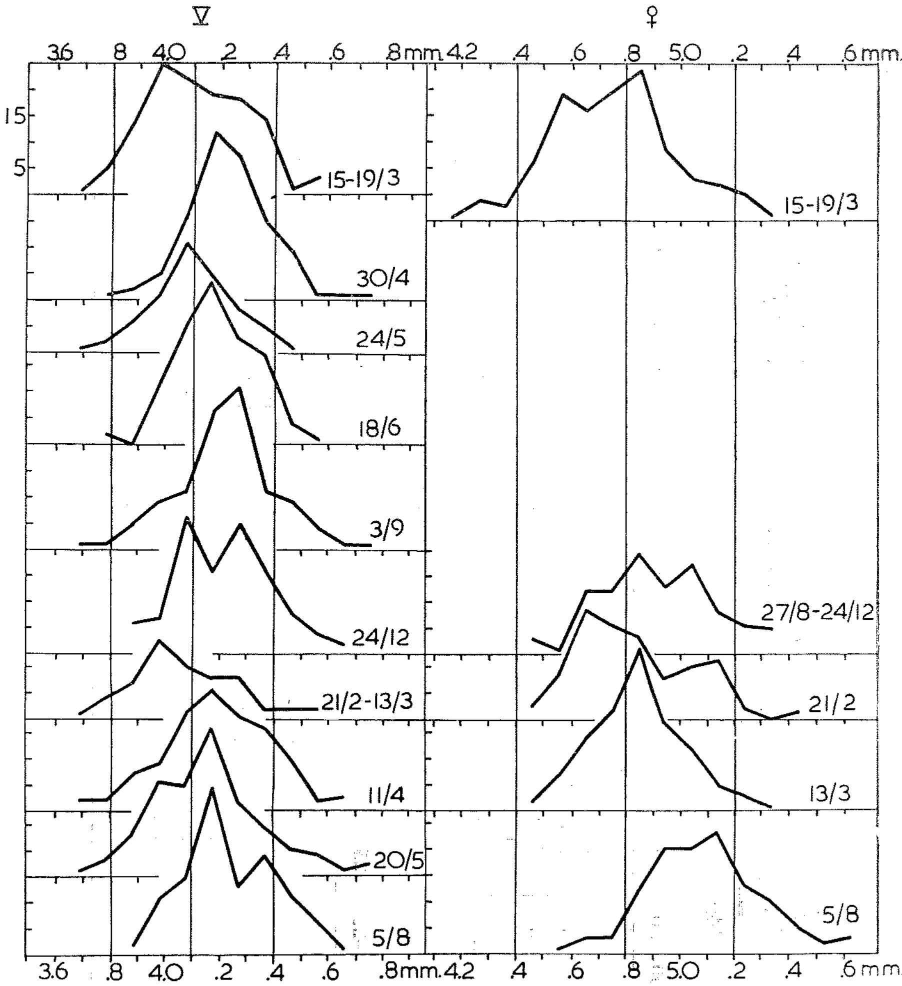


Fig. 55. Size frequencies of *Calanus hyperboreus* stage V (left) and females at Skrova in 1949—50.

successive change in the proportion between younger and older stages from the upper layers towards deeper water in the central part of the Vestfjord (st. 112), and in May the survivors of the stock were found below 75 m.

Length Variations of Calanus hyperboreus.

From Norwegian waters there are comparatively few measurements of the cephalothorax length of adults and older copepodites of *C. hyperboreus*. According to RUUD (1929) the length of stage V in the fjords at Møre was 4.05—4.50 mm and of the females 5.18—5.63 mm. In open water the corresponding lengths were 4.53—4.89 mm and 6.07 mm.

For the Vestfjord SØMME (1934) gives length measurements of the carapace of the different stages. The corresponding cephalothorax lengths would approximately be 4.1—5.1 mm for stage V and 5.2—5.9 mm for the females.

Length measurements have been carried out of a large number of females and copepodites of stage V during the two years (fig. 55). The complete series of measurements are given in table 50 at the end of this paper.

It is immediately obvious that the variation in size distribution is insignificant. The females usually range from about 4.37 mm to 5,64 mm, and the mean lengths from 4.68—5.10 mm. For stage V the corresponding values are 3.5—4.75 mm, and 3.98—4.17 mm. In stage V there is a slight increase in the mean lengths from February—March to April both years, and the females also show some increase in length from the spring to the autumn. The differences, however, cannot be regarded as significant.

SØMME (1934) also reports that *C. hyperboreus* exhibits no special seasonal changes in length. He found that 27 % of the stock did not attain maturity during the spring, but remained in stages IV—V for perhaps 10 months (l.c. page 117—8). This would indicate a two year cycle for this part of the stock, and if the copepodites of stage IV moulted into stage V the following spring, they might then increase the mean length of stage V somewhat from February—March to April.

Length measurements have also been carried out on plankton material from stations 116, 117, 147, 148, and 149 in 1947, in order to study the length variations of *C. hyperboreus* in the surface layer and deeper layers during April and May. The sample from the deep haul at st. 148 had unfortunately been lost, and individuals from the deepest haul at st. 147 were measured instead.

The size distributions are shown in fig. 56 . There is a small increase in the mean length of stage V when we pass from the surface layers to the bottom water at the innermost station, both in April and May (st.s 117, 149). Further out, at st. 116, no such difference occurs, but the number of copepodites measured is small. For the stock taken as a whole the mean length is a little above that found in the deeper layers at st. 117. In May, the mean length is less in the deepest haul at st. 179 than in the surface layers at st. 148. The differences are, however, all within the limits of three times the standard error.

The females do not show any difference in mean length between the stock in the upper and deeper hauls, either in April or in May. The mean length is nearly the same at st. 116 and st. 117. From April to May there is a slight increase in mean length, too small to be considered really significant.

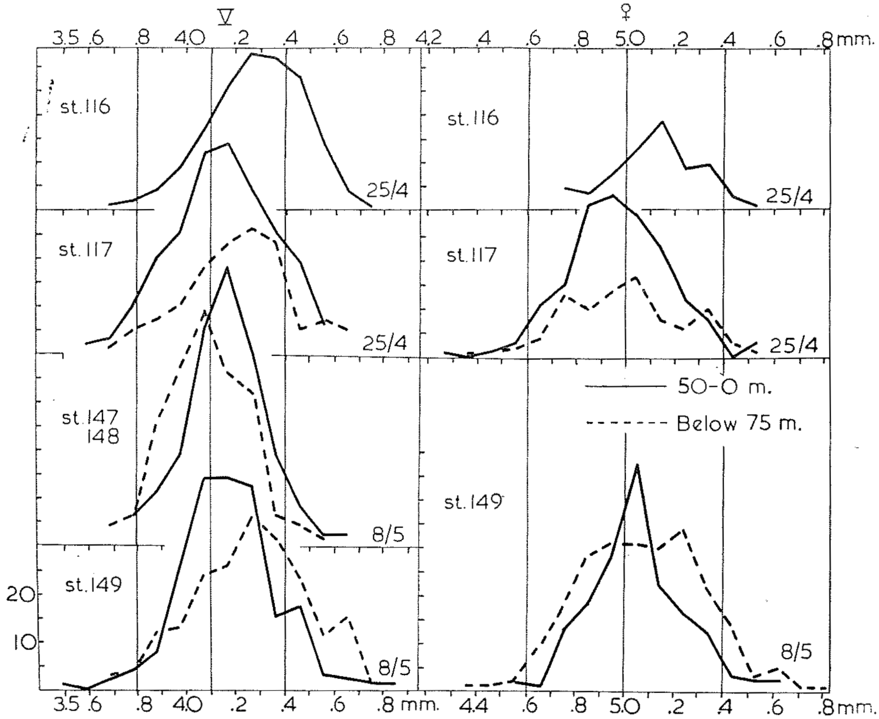


Fig. 56. Size frequencies of *Calanus hyperboreus* stage V and females in the upper 50 m and below 75—100 m in the Vestfjord in April—May 1947. For localisation, see fig. 54.

JESPERSEN (1939) in East Greenland waters observed a slight increase in the mean length of *C. hyperboreus* with increasing depth.

Paracalanus parvus. Claus.

According to earlier investigations on the west coast of Norway (RUNNSTRØM 1932, WIBORG 1944) *Paracalanus parvus* is numerous mainly from July to December, scarce or absent during spring and summer.

Numerical Variation.

In fig. 57 is shown the numerical variation of *Paracalanus* during the periods of abundance from October 1948 to February 1951. It will be seen that the occurrence is mainly limited to the months August—January, although some individuals may also be found in February—March and in July.

In October 1948 *Paracalanus* was scarce at Sognesjøen, but numerous at Ona, in the beginning of November also abundant at Eggum, where

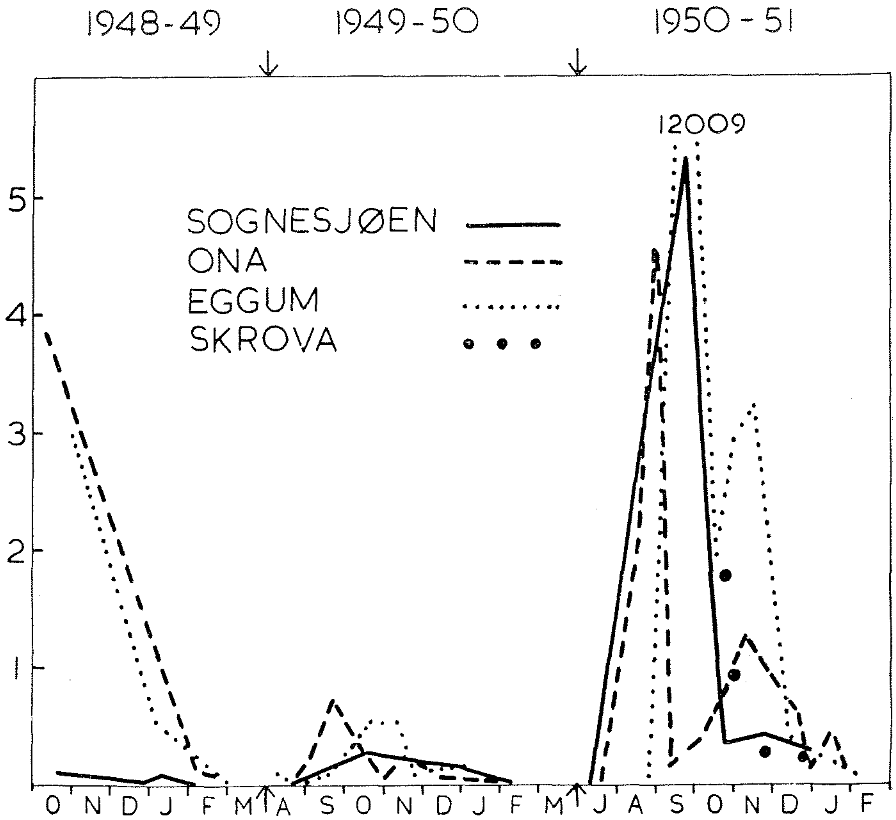


Fig. 57. Numerical variation of *Paracalanus parvus* in 1000's in the periods of abundance in 1948—51.

a stock of about 500 specimens still existed in January 1949. In March *Paracalanus* had disappeared. At Skrova *Paracalanus* was absent in this period.

From August 1949 to March 1950 *Paracalanus* occurred much more sparsely than in the preceding season. The Sognesjøen station was visited in August and October only, and the date for the maximum number therefore cannot be stated exactly. At Ona the peak occurred in September, at Eggum in October—November. As in the year before, *Paracalanus* disappeared in March. At Skrova a few specimens were also found from November to February.

From August 1950 to February 1951 *Paracalanus* was very abundant in all localities. At Sognesjøen maximum numbers occurred in the middle of September or before, at Ona at the end of August, with the addition of a second peak in November. The station at Eggum ranged highest in number, with 12 000 specimens in the middle of September and another peak in the middle of November. At Skrova observations were lacking between 13 July and 23 October. A large stock of *Paracalanus* was found there on 23 October, but the number decreased greatly to November.

In all areas, *Paracalanus* thus varied in the same way, being comparatively numerous in the autumn of 1948, scarce or absent in 1949, and very abundant in 1950.

Propagation.

Males, females and copepodites were counted separately. Most of the nauplii, and some of the younger stages of the copepodites will probably pass through the meshes of the Nansen net (WIBORG 1940). It has been very difficult to find any clear periodicity in the occurrence of the adults and the copepodites, and accordingly, I consider it would serve no purpose to give any figures. The males were usually scarce, less than 10 % of the stock caught, and in many cases totally absent. The females usually amounted to 30 % of the stock. At Ona maximum of spawning probably occurs in April and October. According to previous investigations it must be assumed that propagation goes on more or less continuously when *Paracalanus* is present in numbers. Near Bergen *Paracalanus* had 2, possibly 3 broods between July and October (WIBORG 1944).

Vertical Distribution.

When the plankton hauls were divided, most of the *Paracalanus* were taken in the upper 50 m, but on some occasions a few individuals were found below 50 m. Being an inhabitant of the surface layers *Paracalanus* is entirely dependent on the currents, and therefore we probably have a connection between the stocks at Ona and at Eggum. The occurrence of a large stock of *Paracalanus* at Skrova in the late autumn of 1950 would also indicate a strong influx of the coastal current. The salinity was low in the surface layers in October—December 1950 (see page 21).

Paracalanus is also reported from areas farther north. In 1938 a fairly large number was taken in the Lyngsfjord, near Tromsø, and it may also be carried into the Barents Sea.

Pseudocalanus elongatus Boeck.

SARS (1900 and 1903) distinguished between 3 species of *Pseudocalanus, P. elongatus* Boeck, *P. major* G. O. Sars, and *P. gracilis* G. O. Sars. Many subsequent workers, e.g. DAMAS (1905), and DAMAS & KOEFOED (1907) had difficulties in separating the different species, and WITH (1915) considered them all as varieties of the same species. *P.*

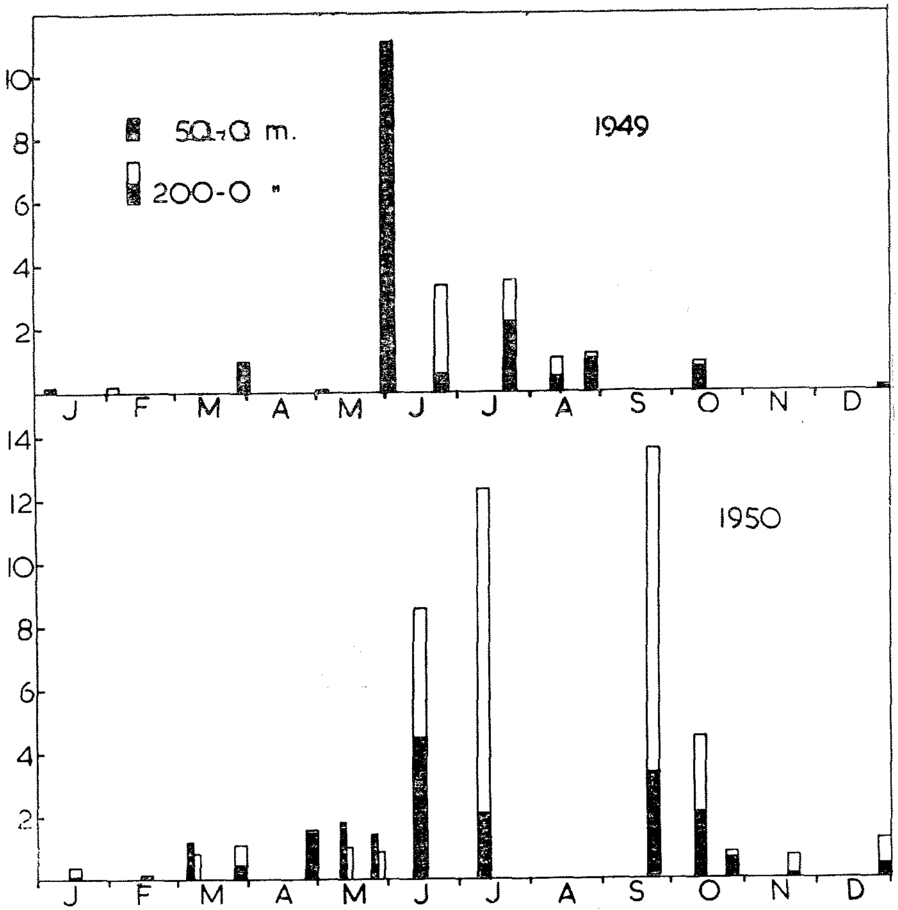


Fig. 58. Numerical variation of *Pseudocalanus elongatus* in 1000's at Sognesjøen in 1949 and 1950.

minutus (Krøyer) and claimed to have found transition forms between them. He states however, that the three varieties have different habitats, *P. elongatus* mainly occurring in coast waters, near the surface, *P. gracilis* being a northern and oceanic form, and *P. major* mainly existing in arctic waters. JESPERSEN (1923) states that *P. gracilis* was dominant in West Greenland waters, and FARRAN (1951) also considers this form as arctic.

WITH's view of one species, *P. minutus* (Krøyer) has been accepted by most of the subsequent workers. For reasons mentioned below (page 131). I am now of the opinion, that SARS (1900, 1903) was right in establishing 3 species of *Pseudocalanus*. WITH (1915) had the opportunity of re-examining the specimens used by KRØYER (1842—47) in his description of *Calanus minutus*, and writes (l.c. page 57) that they «were

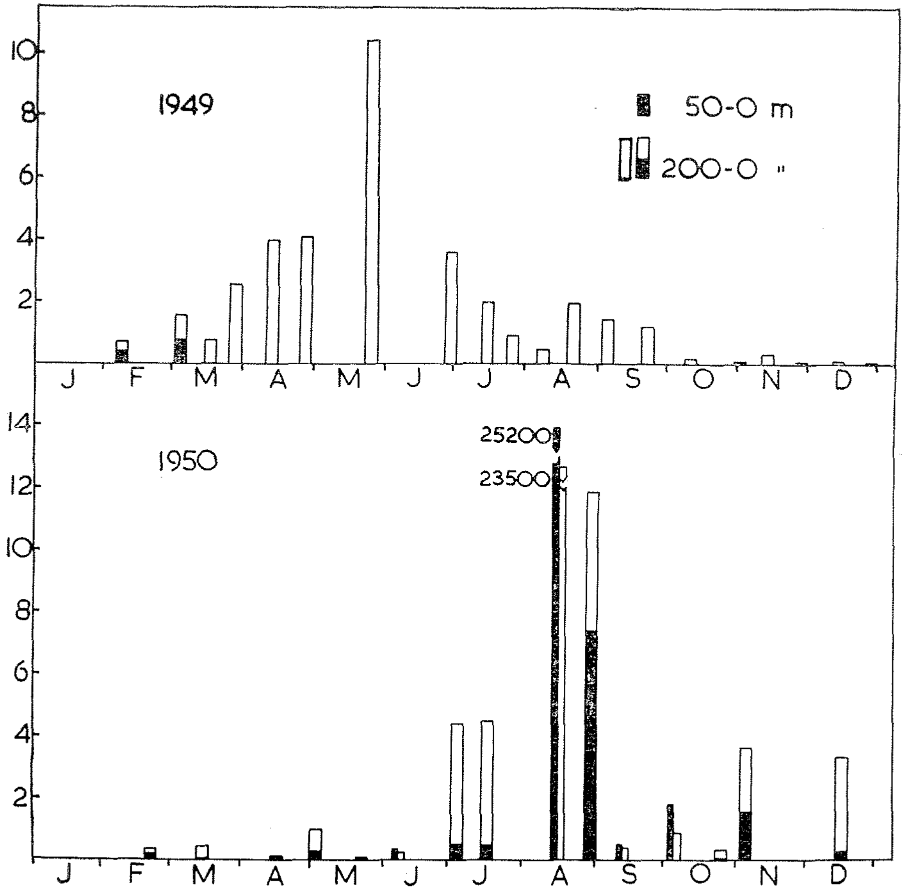


Fig. 59. Numerical variation of *Pseudocalanus elongatus* in 1000's at Ona in 1949 and 1950.

in the shape of the head most like *Ps. gracilis*, and were of middle size». If the three forms are accepted as separate species, the name *P. gracilis* G. O. Sars should accordingly be altered to *P. minutus* (Krøyer), while *P. elongatus* Boeck is retained. Regarding *P. major*, nothing can be stated with certainty as yet, it may be an independent species or a large-sized *P. elongatus*.

P. elongatus is very common in Norwegian coastal waters. Off Møre it propagates all the year round with main spawning in March and July (RUUD 1929), and is at least as numerous as *Calanus finmarchicus*. The largest numbers usually occur in late summer or in the autumn.

Numerical Variation.

In fig. 58 is shown the numerical variation of *P. elongatus* at Sognesjøen during 1949—50.

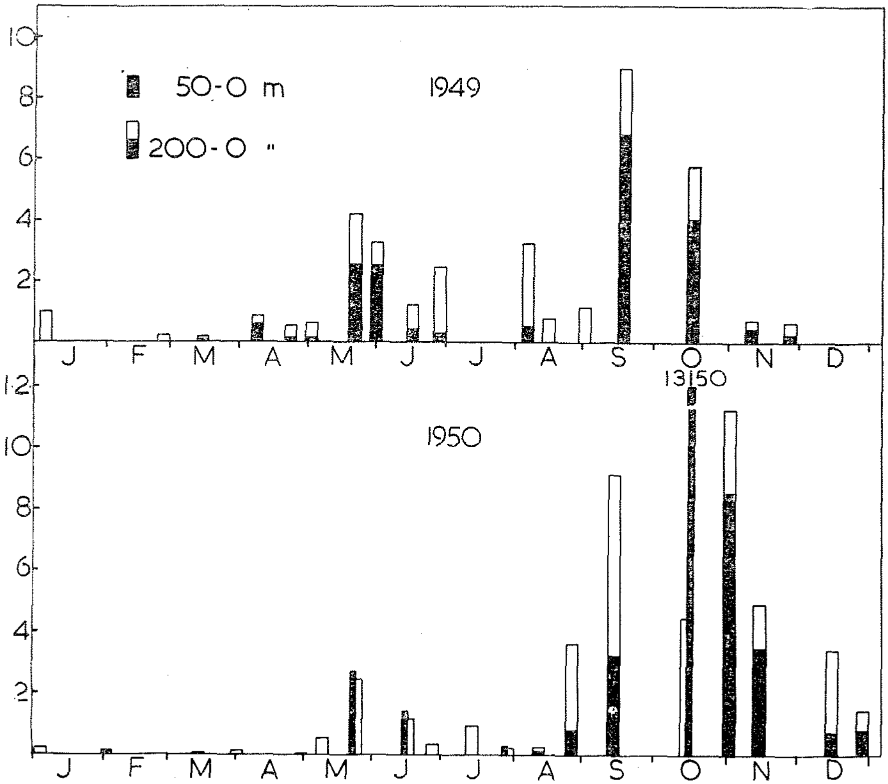


Fig. 60. Numerical variation of *Pseudocalanus elongatus* in 1000's at Eggum in 1949 and 1950.

The stock was very small from January to May 1949. At the beginning of June there was a maximum of more than 10 000 specimens, but the number decreased to about 3 000 in the last half of the month and was of the same size in July. In August and October the stock numbered about 1 000. No hauls were taken in September.

In 1950 there was an increase in number from February to April, some decrease in May, a sudden increase in June, and a further rise to July. No observations were made from the middle of July to the last half of September, when we have the maximum of the year, about 13 000 individuals. Later the stock decreased rapidly to a minimum in November.

At Ona (fig. 59) the numerical variation in 1949 was almost identical with that of Sognesjøen, but owing to more frequent observations we can follow the increase in detail from the middle of March to a maximum at the end of May. The stock fell off greatly at the end of June, and with minor variations the decrease continued to the end of the year. In 1950 the stock was small from January to the first part of June, increasing

Table 22. *The Monthly Mean Numbers of Pseudocalanus elongatus in the Total Hauls at Skrova in 1949—50.*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1949	—	249	79	215	270	265	694[1]	203	800	1303	533	78
1950	70	64	40	430[2]	335	—	166	165	—	6558[3]	550	780

[1] 4/7: 1800. [2] 25/4: 835. [3] 23/10: 10800.

throughout July to a maximum in the middle of August of more than 23 000 specimens, decreasing somewhat at the end of the month. In September the stock was very insignificant, but was again somewhat larger in November and December.

Off Eggum (fig. 60) peaks occurred in the last half of May and beginning of August, the main maximum of the year in the middle of September. The stock was still large in October but decreased to a low level in November. In 1950 the variations were similar to those in 1949. There were peaks at the end of May, middle of October and the main maximum occurred in the first few days of November. Afterwards the numbers decreased till the end of the year, but were much higher than at the same time in 1949.

At Skrova *P. elongatus* was as a rule of minor importance, but was occasionally quite numerous. In the autumn of 1948 the stock on 10 October amounted to 300, on 23 October 15 700 and on 12 November 5 900—individuals. In table 22 are given the monthly mean numbers of *P. elongatus* during 1949—50.

Throughout 1949 *Pseudocalanus* numbered scarcely more than 200—300 specimens, except on 4 July (1 800 nauplii, which possibly belonged to *Paracalanus*) and from 25 September to 22 November (500—1 300) with maximum 9—29 October. In 1950 *Pseudocalanus* was also very scarce from January to August, with the exception of a small increase in April—May. On 23 October the stock numbered nearly 11 000, decreasing to 2 300 at the end of the month, and in November—December varying from 500 to 1 000.

Propagation.

The percentage stage distribution of *P. elongatus* at Sognesjøen during 1949 and 1950 is shown in fig. 61.

As females and nauplii are nearly always present, spawning undoubtedly goes on most of the year. Judging by the peaks in percentage most intensive spawning in 1949 probably took place in March, May—

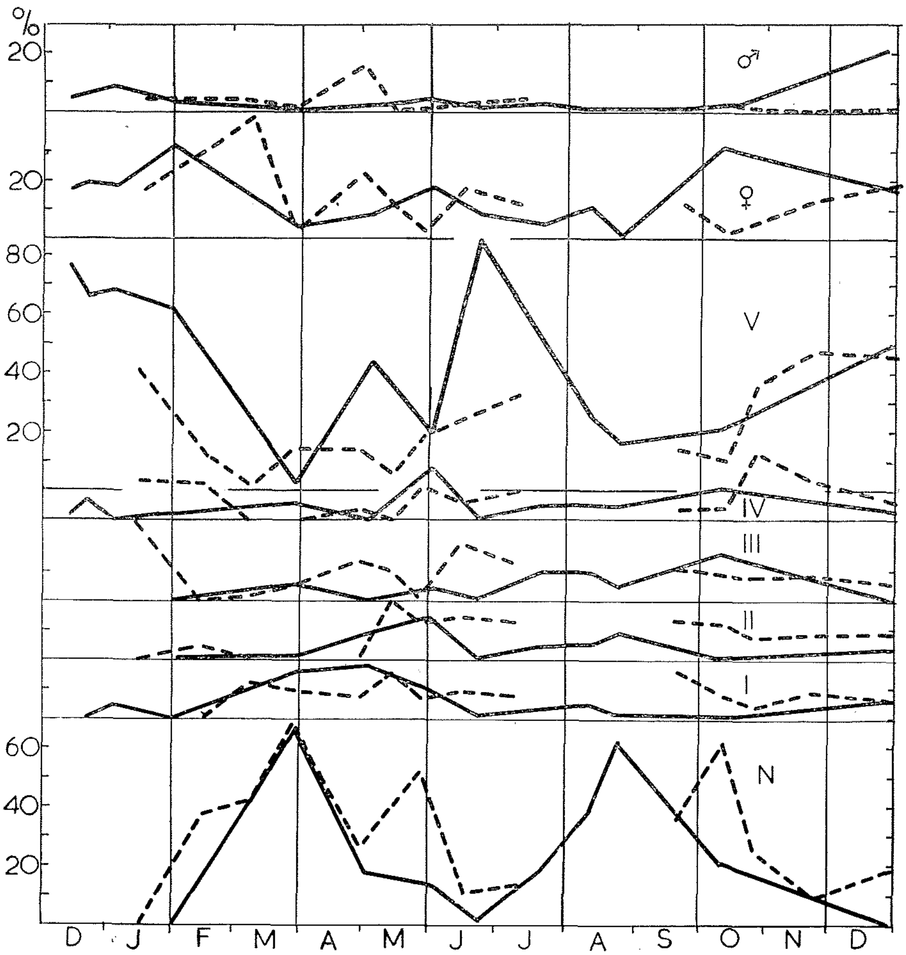


Fig. 61. Variations in percentage of each stage of *Pseudocalanus elongatus* at Sognesjøen in 1949 (drawn) and 1950 (broken).

June, August and October. The second spawning may be responsible for the maximum stock occurring at the beginning of June, consisting mainly of stages III—V and of females.

In 1950 maxima in spawning seem to have taken place in March, May, July—August and October, with favourable results in May and in July—August.

As the maxima in the size of the stock never coincided with maxima of nauplii or the lowest copepodite stages, we may assume that the observations have never been made at, or immediately after, the actual maxima in spawning, and that the stocks present when we have a maximum in number, have been introduced from other areas, presumably further south. The same lack of correspondence has also been reported

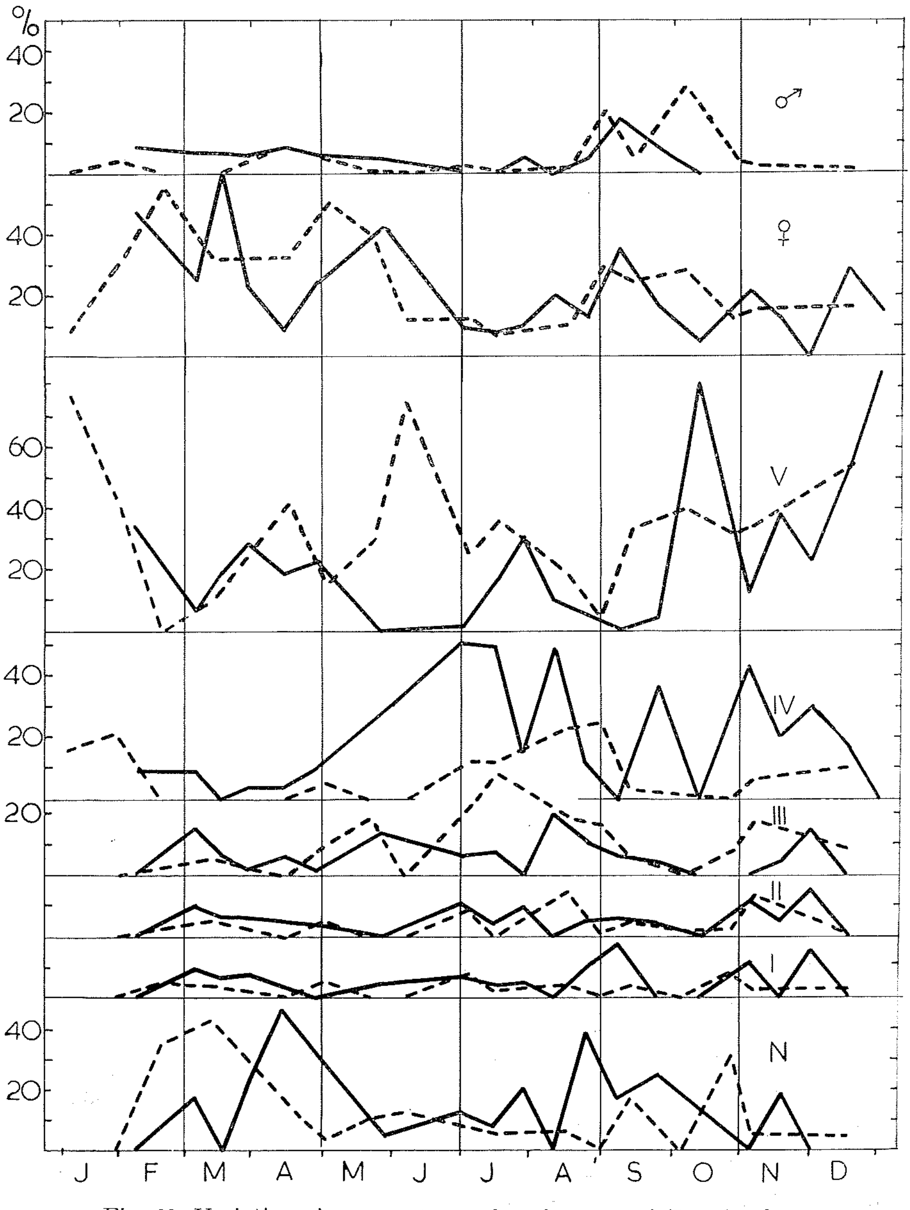


Fig. 62. Variations in percentage of each stage of *Pseudocalanus elongatus* at Ona in 1949 (drawn) and 1950 (broken).

from more sheltered waters (Loch Striven in Scotland, MARSHALL 1949). We must bear in mind, however, that the lower nauplius stages are not caught quantitatively.

At Ona the variation in composition of the stock of *P. elongatus* in 1949—50 is shown in fig. 62.

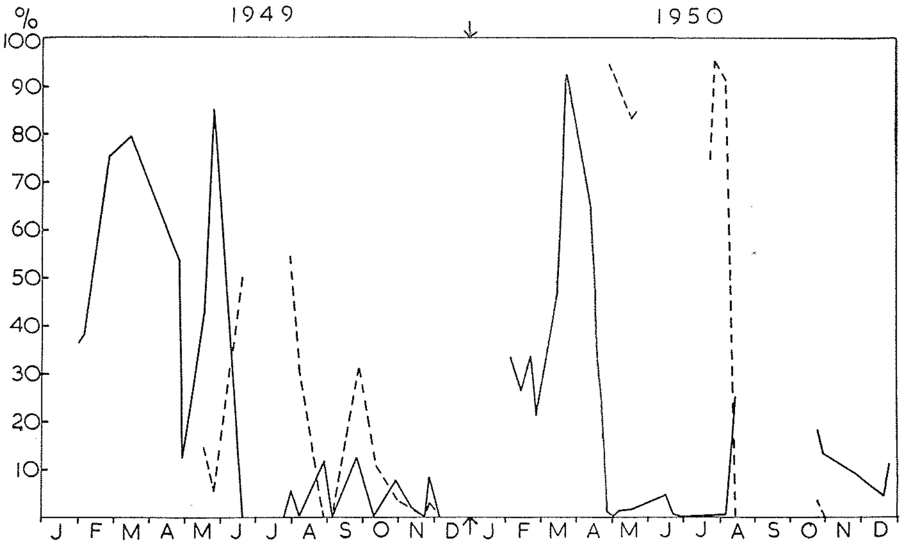


Fig. 63. Variations in percentage of *Pseudocalanus elongatus* females (drawn) and nauplii (broken) at Skrova in 1949—50.

From the occurrence of females and nauplii we may conclude that the main spawning periods in 1949 fell in March—April, May—June, August—September and perhaps in October—November, in 1950 in February—March, May, and September—October. The last period may possibly be split into two separate spawnings, August—September and October—November.

When we compare the percentage variation of the different stages and the variation in the size of the stock, it is obvious that horizontal movements of the water may obscure the picture of the spawning periods. In August 1950 especially, the stock consisted mainly of older copepodite stages and adults, which apparently have been introduced from other areas, probably from further south. It will be remembered that there was a considerable stock of *P. elongatus* at Sognesjøen in June and July, which may very well on its drift northwards have produced the stock found at Ona in August. The same features may have been repeated in October—November.

The water transport from Sognesjøen to Ona may take from 4—6 weeks. (See page 12).

From the variations in the size and composition of the stock of *P. elongatus* RUUD (1929) concluded that there were 3 main spawnings at Møre, one in March, (probably still earlier further south), a second in May, and a third beginning at the end of July. This is well in accordance with the present observations, especially from 1949.

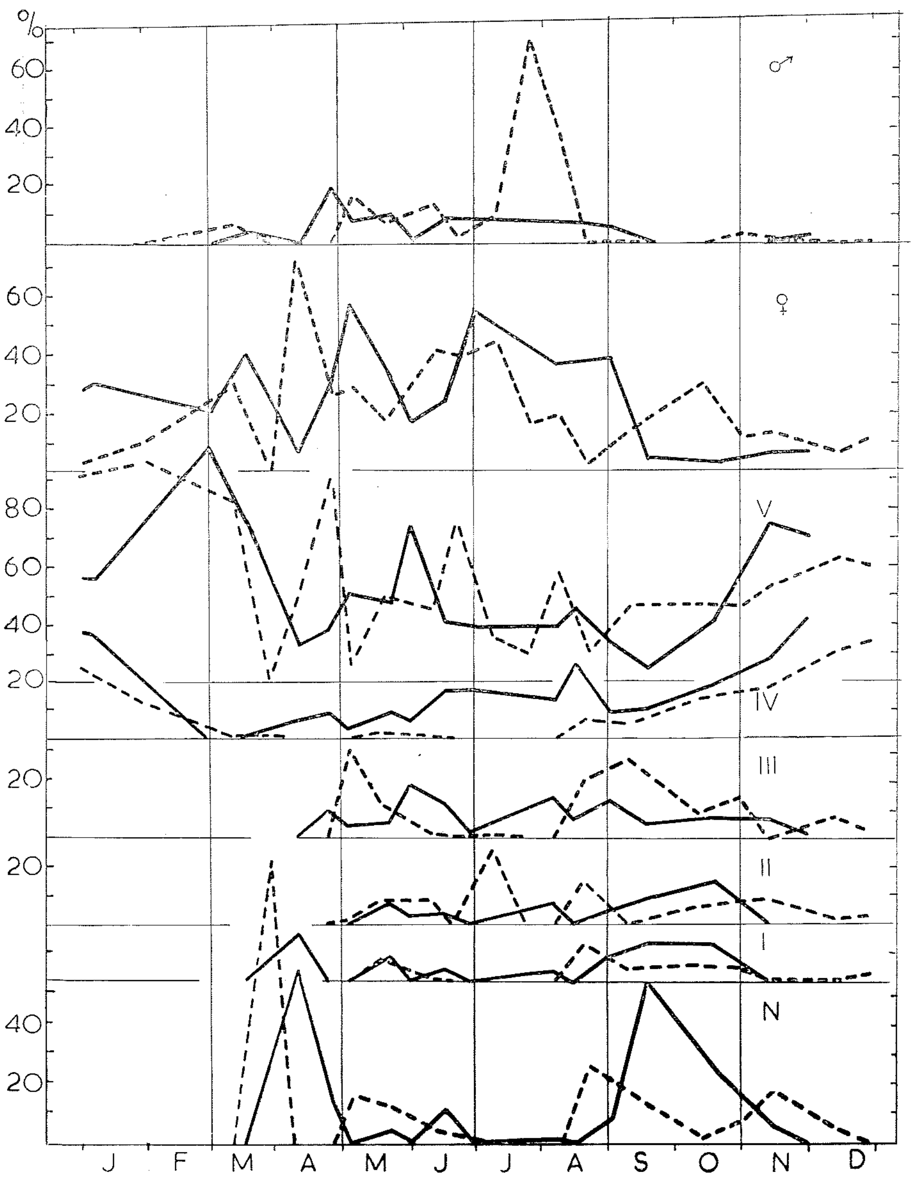


Fig. 64. Variations in percentage of each stage of *Pseudocalanus elongatus* at Eggum in 1949 (drawn) and 1950 (broken).

At Skrova the stock of *Pseudocalanus* in October—November 1948 mainly consisted of copepodites of stage II—IV, females and a few nauplii. The variation in percentage of females and nauplii at Skrova during some periods of 1949—50 is shown in fig. 63. In 1949 there were larger peaks in percentage of the females in the middle of March and end of May, of the nauplii in June—July and the end of September. We may assume that some succesful spawning took place in March, May, June and September. In 1950 spawning may have been more intensive at the beginning of April, and in July—August, but the observations were scattered and based on too low numbers to be quite reliable.

At Eggum percentage curves of the different stages of *P. elongatus* are shown in fig. 64.

In 1949 there have probably been maxima of spawning in March—April, June, and September. It is, however, difficult to correlate the peaks of females with the spawning periods, with the exception of the first one in March. We must ascribe the discrepancies to the effect of the coastal current, carrying the populations of *P. elongatus* northwards. In 1950 the spawning periods may be set to March, May, August and November.

In the localities investigated we can seldom correlate the peaks in percentage of the lower copepodite stages with a real increase of the

Maxima in Stock

1949

Sognesjøen ..	End March (N)	*Beg. June* (N—♀)	End July (N, V)
Ona	Beg. March (N—♀)	*End May* (III, IV, ♀)	Middle July (N—III, ♀)
Eggum	Beg. April (N)	Middle May (V, ♀)	Beg. Aug. (III-V, ♀) *Middle Sept.* (N)

1950.

Sognesjøen ..	End Apr. (N—♀)	*August—Sept.*	Beg. Nov. (II—V, ♀)
Ona	Beg. May (N, V, ♀)	*Mid. Aug.* (II—IV, ♀)	Mid. Sept. (N, IV—V)
Eggum	End May (V, ♀)	Mid. July (V, ♀)	*Beg. Nov.* (IV—V)

Main Spawning Periods

1949.

Sognesjøen ..	Beg. March	May—June	(August)	October
Ona	March	May—June	Aug.—Sept.	Oct.—Nov.
Eggum	March—Apr.	May—June	September	
Skrova	March	May—June	September	

1950.

Sognesjøen ..	March	May	July—Aug.	October
Ona	Febr.—March	May		Sept.—Oct.
Eggum	March	May	August	October
Skrova	Beg. April	May	July—Aug.	

stock. This may partly be caused by too long intervals between observations. In the table (p.125) I have given the times of the maxima in number and in spawning at the different localities. Data in cursive mean the greatest maximum of the year.

At Ona and Sognesjøen the main maxima in stock in 1949 occurred in May—June, in 1950 in August—September, at Eggum both years correspondingly later, in the middle of September and in November. One reason why we do not get a maximum in stock of nauplii and lower copepodite stages may be, that there is a more or less continuous spawning, but a retarded development of the older copepodites, and thus an accumulation of the stages III—V, similar to that found in a fjord near Bergen (WIBORG 1944).

The spawning periods seem to be nearly the same in all the localities investigated, at Eggum sometimes a little delayed.

Vertical Distribution.

The vertical distribution of *P. elongatus* varies greatly. At Sognesjøen the main part of the total stock in 1949 was taken in the upper 50 m, except at the end of June and in the middle of August. In 1950 more than half of the stock was apparently concentrated below 50 m in June—July and September—October.

At Ona the vertical distribution can only be seen from the 1950 material. At the beginning of June, and from August to the beginning of October the entire stock evidently kept to the upper 50 m. At other times we find the main quantity below 50 m. In July there was a greater proportion of stage V and of adults in the deeper hauls, while the nauplii were relatively more abundant in the shallow hauls.

Length Variations in Pseudocalanus elongatus.

ADLER and JESPERSEN (1920) have shown that *P. elongatus* in Danish waters has a yearly variation in length, the size of the females increasing from a minimum in March to a maximum in the middle of April, and later decreasing gradually throughout the summer and autumn. Similar variations are reported from British waters (MARSHALL 1949, DIGBY 1950).

In fig. 65 is shown the variation in mean length of the females of *P. elongatus* at the investigated localities during 1949—50. At Sognesjøen sufficient material for calculating reliable mean lengths was not obtained until June.

The variations are nearly the same in all localities. From January to March 1949 the mean length was small, but increased sharply from the end of March to the middle of April. At Ona the mean length decreased as early as the end of April, at Eggum not until the last half

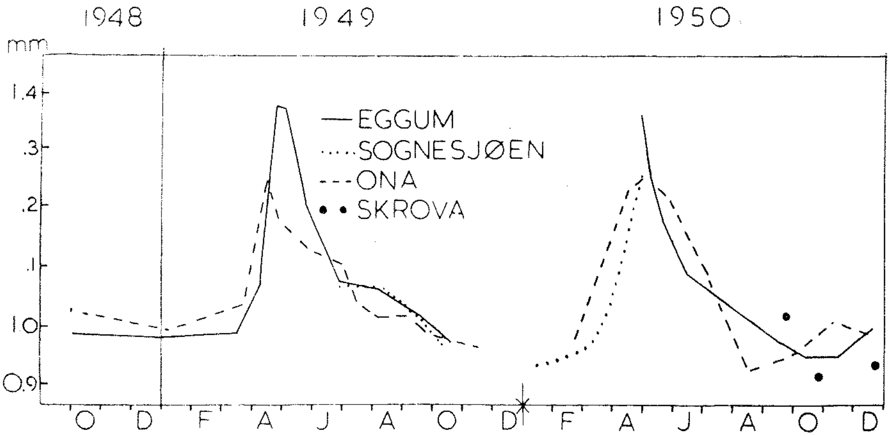


Fig. 65. Variations in mean length of *Pseudocalanus elongatus* females in 1949—50.

of May. At the latter locality the maximum mean length was above that of Ona (1.27 mm against 1.55 mm) but this fact may be caused by the presence of some small females of the old generation at Ona, as will be shown later on. From June to November all localities exhibit almost the same variation.

The maximum size of *P. elongatus* females given by MARSHALL (1949) for Scottish waters was 1.203 mm, occurring at the end of April. In the Barents Sea BOGOROV and PREOBRAJENSKAYA (1934) in June 1930 found a mean total length of 1.39 mm, corresponding to a cephalothorax length of 0.99 mm. The largest specimens measured 1.85 mm (ceph. = 1.22 mm).

In 1950 the mean length was again greater at Eggum in April than at the other stations, and the variations otherwise nearly the same as in the year before. At Ona and Sognesjöen there was an increase in the mean length from August to November, at Eggum from November to December. A similar increase is reported from the Kattegat (ADLER and JESPERSEN 1920), possibly related to an early autumn brood, with the offspring growing up in water of decreasing temperature.

Some of the individual size distributions of the *Pseudocalanus* females are shown in fig. 66. Further details can be found in table 51 at the end of the paper.

At Ona the curve for February 1949 is unimodal and compact. In March some larger females occur, but the peak of the curve does not move until the end of the month. From now on to the end of April the size distributions are bi- or trimodal with a large range of size. It is likely that apart from females of the local spring brood, individuals

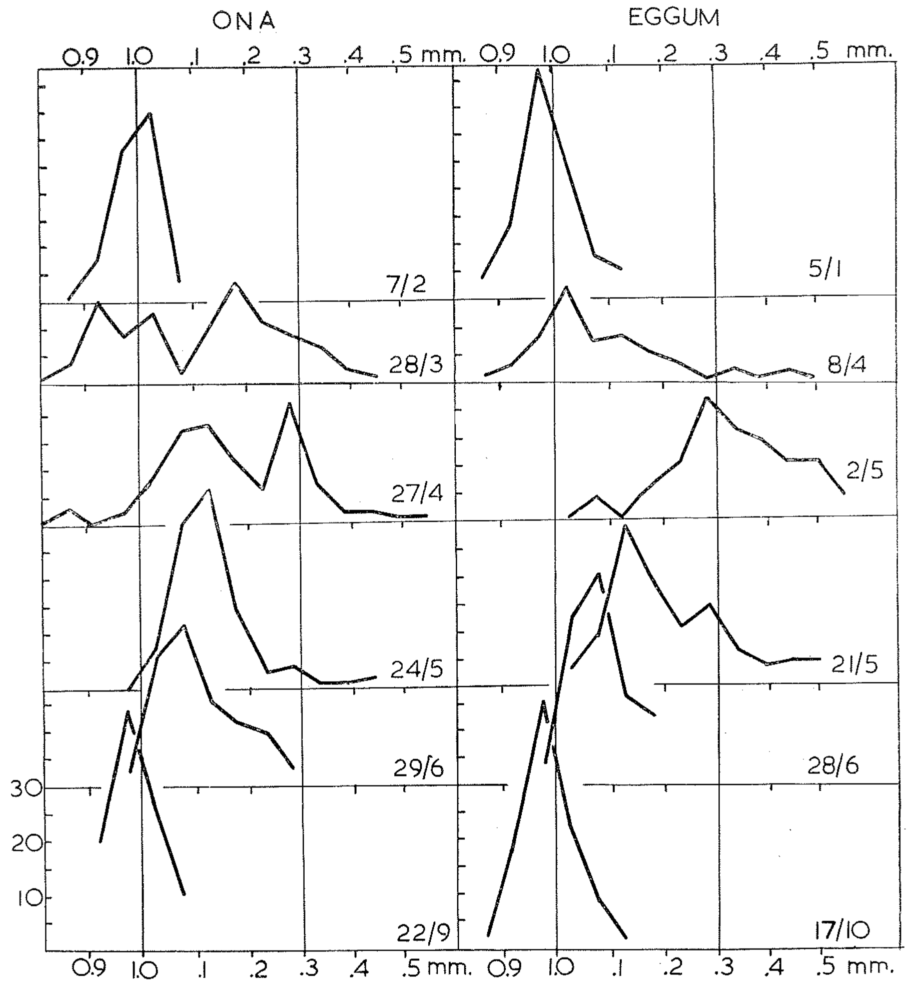


Fig. 66. Selected size frequencies of *Pseudocalanus elongatus* females at Ona and Eggum in 1949.

of both the old and new generation may have been brought in from other areas. At the end of May the size distribution is again unimodal, and the large females have disappeared. The size distributions remain largely unchanged from July till the beginning of September. This might indicate that females deriving from the possible brood in May (see page 123) do not spawn until August. On 22 September there is again a change towards smaller lengths, and the same curve we also find in February 1950. We might therefore assume, as will also be seen from the stage distribution, that part of the stock of *P. elongatus* spends the winter as females. During 1950 we find broadly the same cycle in the length distributions as in the previous year.

At Eggum the size distribution remained unchanged from November 1948 to the middle of March 1949. Large females appeared in small numbers at the beginning of April and had entirely replaced the small ones on 23 April. Throughout May and June there was a rapid change towards smaller lengths. The size distributions changed little from June to the middle of September, but in the middle of October there was again a decrease in size. In 1950 the length variations were broadly as in 1949.

The rapid changes in the size distributions which usually occur at Eggum during May and June may be considered a rather certain indication that the stock of *Pseudocalanus* has been brought in by currents. We also note that except from the end of March to the beginning of May the length distributions of the females are as a rule unimodal and compact with very pronounced maxima, perhaps indicating that the periods of propagation are comparatively well defined.

Pseudocalanus minutus (Krøyer) (= *P. gracilis* G. O. Sars).

DAMAS (1905) stated that *Pseudocalanus elongatus* had an area of abundance in the central part of the Norwegian Sea. He did not however, distinguish between *P. elongatus* and P. *minutus*. — At station »M« in the middle of DAMAS' area ØSTVEDT (in press) found a population of *Pseudocalanus* of the *gracilis* type, occurring in the upper 100 m only during the months May—July, at other times of the year below 100 m, from August to March the total stock being even taken below 600 m. There was only one spawning period a year, in April—May.

Pseudocalanus elongatus is a neritic species with a pronounced epipelagic habitat, being found in the surface layers for a greater part of the year, and having 3—5 annual spawning periods. — The temperatures of the upper layers at station «M» are not essentially different from those in Norwegian west coast waters, in 1950 varying between 5.6°—13.6° C at the surface and 5°—9°C at the 100 m level. There must therefore be other factors, perhaps the salinity, of decicive importance for the distribution of *P. minutus*.

I have had the opportunity of examining the plankton material from station «M» from the years 1950—52, and can verify ØSTVEDT's observations. The *Pseudocalanus* were all typical *P. minutus* (*gracilis*). In 1952 the females were found between March and June. A large number were measured. The size frequencies were unimodal and compact, the range of variation 0.97—1.44 mm, the mean lengths 1.12—1.14 mm. A few females of *P. elongatus* were seen in March and in November. They were considerably smaller than the *P. minutus* females, measuring 0.72—0.97 mm.

GRAN (1902) reports a mass occurrence of *P. elongatus* in the innermost part of the Porsangerfjord in North Norway, in the bottom layers, where the temperature was below 0°C. It seems very probable that these were *P. minutus*. SARS (1903) took a few *P. minutus* (*gracilis*) in the Lyngenfjord in North Norway and in the sea between Norway and Bear Island. Myself, I have found *P. minutus* in the Balsfjord, Ulsfjord and Porsangerfjord in North Norway, but always together with *P. elongatus*, and inferior to this species in number. I have also found single *P. minutus* in the Hardangerfjord south of Bergen.

BOGOROV (1932) mentions a very peculiar vertical distribution of *P. elongatus* in the Barents Sea, with two maxima of abundance in the same water column under entirely different conditions, in the upper 25—10 m with a salinity of 29,2—34.4 $^{\circ}/_{oo}$ and a temperature of 0.6°—6.0°C, and in the 160—100 m layer, salinity 34.87—34.98 $^{\circ}/_{oo}$ and a temperature of ÷ 1.2°— ÷ 1.9°C. BOGOROV regards these populations as two ecological races, but it seems more likely that we have to do with two separate species, *P. elongatus* in the surface layer and *P. minutus* in the bottom layer.

A few specimens of *P. minutus* were taken at Sognesjøen in February and July of 1949 and in March 1950, at Ona in May, July and November 1950, at Eggum in May—July 1950, and at Skrova from November 1948 to April 1949 and in March—August 1950. Nearly all individuals were found below 50 m.

Some stage V copepodites and adult females of *P. minutus* were measured from 5 samples at Skrova in the period 1 February—25 April 1949. For comparison some individuals of *P. elongatus* were measured from the same samples. The results are shown in table 23.

P. minutus was exclusively taken below 50 m, with the exception of one female and 3 copepodites. The individuals of *P. elongatus* mea-

Table 23. *Cephalothorax Lengths of Pseudocalanus minutus and P. elongatus Stage V and Females at Skrova 1. Febr. — 25. Apr. 1949. One Div. Line = 0.509 mm.*

	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	Mean mm
P.elongatus V	9	7	20	9	—	—	—	—	—	—	—	—	—	—	0.795
P.minutus V	—	—	—	—	3	7	10	6	2	3	—	—	—	—	1.030
P.elongatus ♀	3	3	2	4	10	6	2	—	—	—	—	—	—	—	0.882
P.minutus ♀	—	—	—	—	2	1	2	4	2	2	1	—	1	1	1.131

sured in the table, were also taken in the deeper hauls, but the copepodites and females found in the upper hauls had all the same size distribution. In November 1948 13 stage V copepodites of *P. minutus* were taken in a 300—50 m haul at Skrova. They measured from 0.96 mm—1.27 mm, while copepodites of *P. elongatus* from the same sample measured 0.71—0.92 mm.

At Ona 8 females of *P. minutus* taken on 24 May 1950 measured from 1.07—1.37 mm, 12 females of *P. elongatus* in the same sample 0.97—1.22 mm.

It is evident that there is usually a pronounced difference in size between the two species. Observations from plankton hauls taken in sections from the Norwegian coast into the Norwegian Sea the end of May 1952 showed, however, that at this time of the year, the females of both species had approximately the same length. It seems likely, that *P. minutus* in Norwegian coast waters has only one spawning period a year, in March—April. Another proof would be, that the stage V copepodites taken in November 1948 at Skrova were of the same size as those found in February—April of 1949.

It is very difficult to find any characteristics, in addition to the shape of the body and the different length of the second antennae, which clearly distinguish *P. elongatus* from *P. minutus*. Nevertheless, I have had no difficulty in distinguishing the later stages and the adults of the two species, and am quite convinced that they are two clearly defined species, with strictly different habitats. In Norwegian waters *P. minutus* has probably a distribution similar to *Calanus hyperboreus*, present in the depths of a number of fjords. It may be supposed that the stock in some places may get a new supply from the Norwegian Sea with the influx of the Atlantic current in spring or early summer.

It is stressed that the mean length of the females both at Ona and Skrova was very near to that observed at station «M».

P. elongatus and *P. minutus* will without doubt prove useful as indicators of different water masses, the former of coast water, the latter of oceanic water. An investigation has been started on this question in the Norwegian Sea, and the subject will be treated in a subsequent paper.

Microcalanus pusillus G. O. Sars.

The genus *Microcalanus* was established by Sars (1903) with the two species *M. pusillus* and *M. pygmaeus*, the latter previously described as *Pseudocalanus pygmaeus* (Sars 1900). With (1915) considered both species as varieties of *M. pygmaeus*, and the same view has been adobted by a number of workers (Ruud 1929, Størmer 1929, Jespersen 1934,

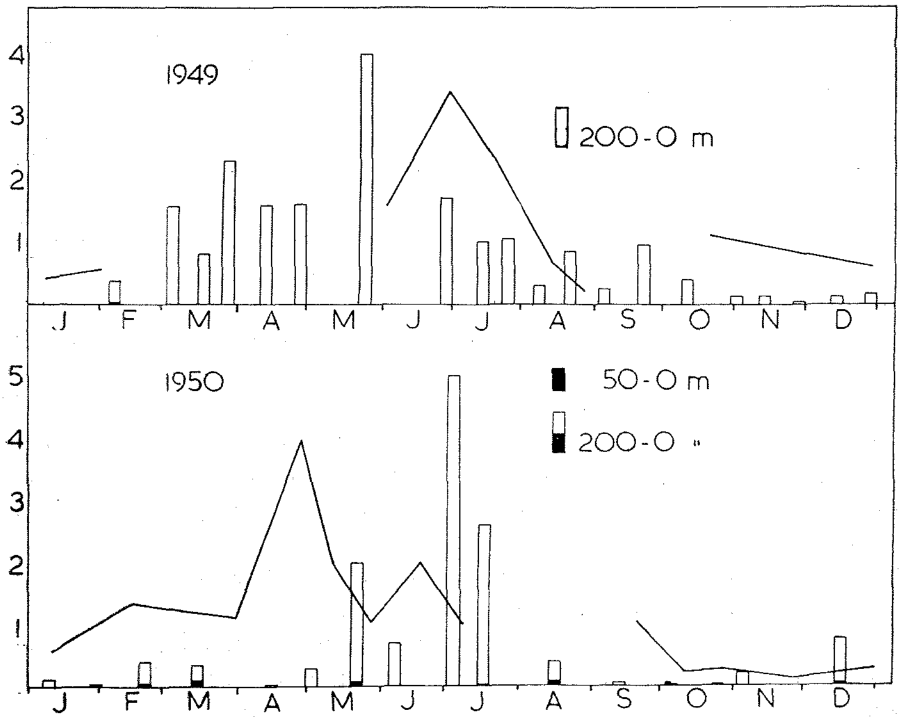


Fig. 67. Numerical variation of *Microcalanus pusillus* at Sognesjøen (curve) and Ona (columns) in 1949 and 1950, in 1000's.

1939, Ussing 1938, Wiborg 1940, 1944, Marshall 1949 and others). Farran (1951) lists them as two subspecies, *M. p. pygmaeus* and *M. p. pusillus*, the former occurring mainly in arctic waters, the latter in temperate and boreal areas. Wilson (1942) reports that *M. pygmaeus* was taken very frequently in the Pacific, both in tropical and other areas, even close to the surface. It seems very unlikely that an otherwise arctic form should thrive at the high temperatures prevailing in the tropics, and I am inclined to believe that Wilson's determination must be incorrect.

For reasons mentioned below (page 141) I am now of the opinion that *M. pusillus* and *M. pygmaeus* have to be considered as two separate species, as originally stated by Sars (1903).

M. pusillus occurs regularly in all the localities investigated, sometimes fairly abundantly, as already mentioned in the composition of the copepod stock (pp. 59—65).

Numerical Variation.

In fig. 67 is shown the numerical variation of *M. pusillus* at Sognesjøen (curves) and Ona (columns). At Sognesjøen observations

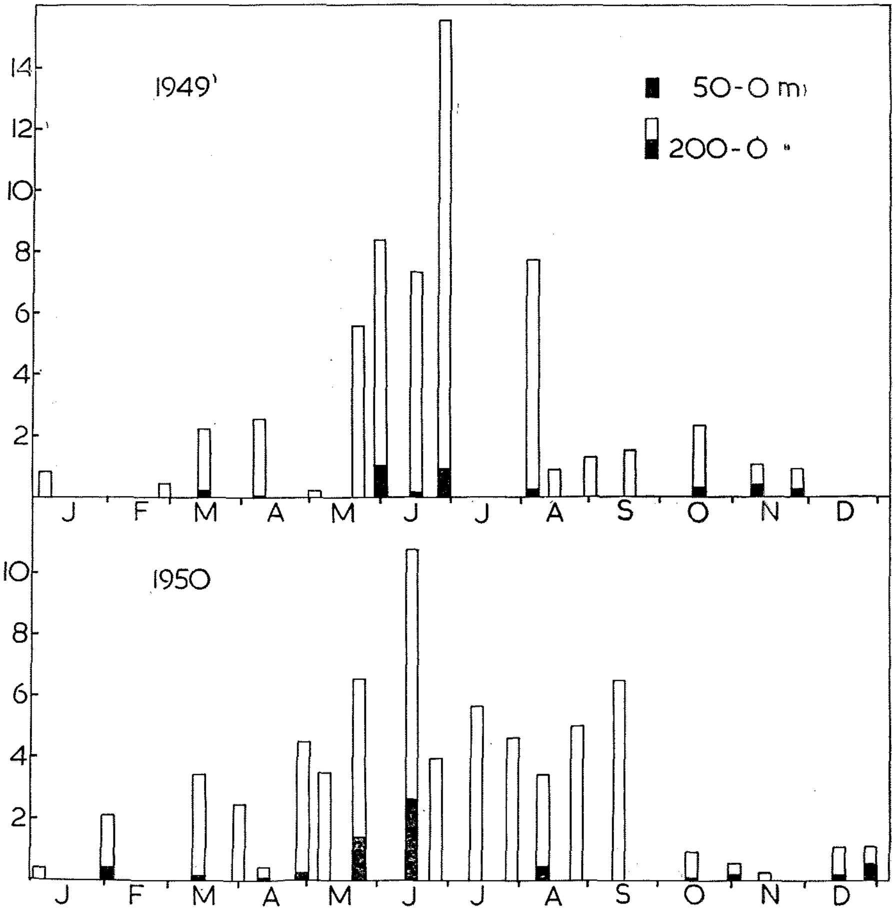


Fig. 68. Numerical variation of *Microcalanus pusillus* at Eggum in 1949 and 1950, in 1000's.

were scarce during the first months of 1949. There was a small stock of *M. pusillus* in January and February. From 1 June the number increased to a maximum at the end of the month and then decreased gradually to the end of August. In 1950 a slight increase took place from January to February, a sharp rise throughout April to a maximum at the beginning of May, a minimum at the end of the month, and a second small peak in June. Figures were low in September and later.

At Ona the variations in number were often irregular. Major maxima occurred in the stock in March and May 1949 and in May and July 1950. The stock was very small during the last half of both years, and from January to May 1950.

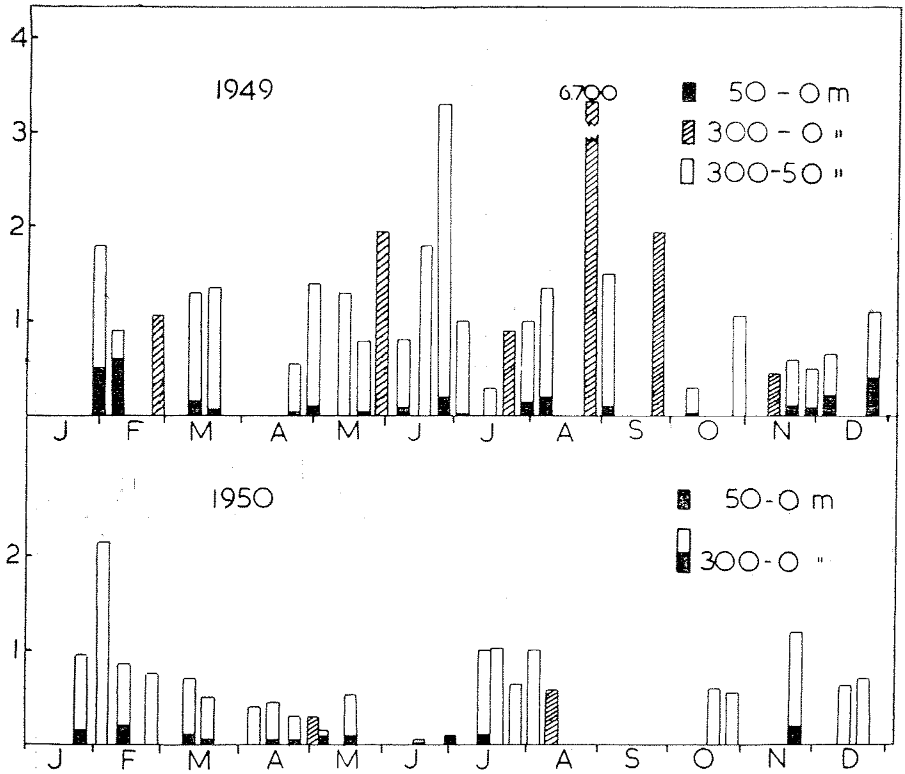


Fig. 69. Numerical variation of *Microcalanus pusillus* at Skrova in 1949 and 1950, in 1000's.

At Eggum (fig. 68) *Microcalanus* was sometimes very abundant. Numbers were low at the beginning of 1949, but rose to a peak in April. The main maximum occurred at the end of June, other peaks at the beginning of August and in October. In 1950 more marked maxima are indicated in March, June, July and September, and there was also a slight increase in December.

At Skrova (fig. 69) the numerical variation was very irregular in 1949. Maxima occurred at the end of January, end of June and end of August, but there were also peaks in nearly every month. In 1950 the highest numbers were observed at the beginning of the year, but from the middle of June till the middle of July the samples were not very well preserved, and some of the small *Microcalanus* may have been destroyed. Moreover, observations are lacking from the middle of August to the middle of October, in which period maximum numbers occurred in 1949.

Propagation.

Males, females and copepodites have been counted separately. As stated earlier (WIBORG 1948) all nauplii and some of the smaller

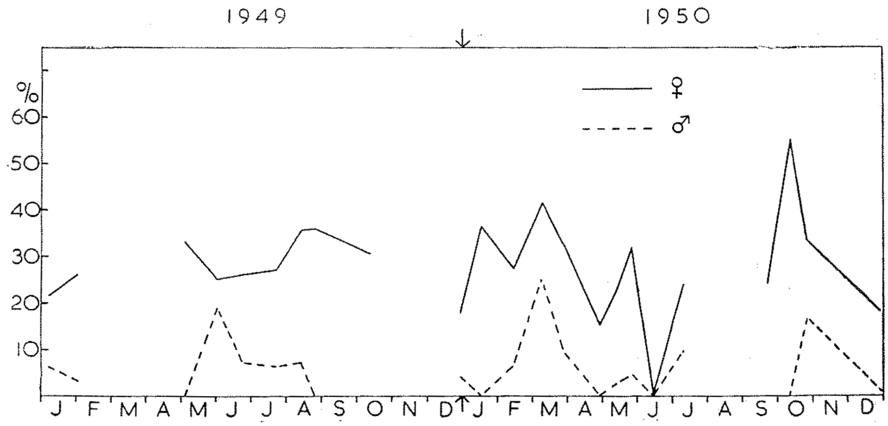


Fig. 70. Variations in percentage of *Microcalanus pusillus* females and males at Sognesjøen in 1949—50.

copepodites will pass through the meshes of the Nansen net. In order to locate the spawning periods I have calculated the relative percentages of males, females and copepodites, the variations in percentage of the adults being shown for Ona and Sognesjøen in fig.s 70—71 for the years 1949—1950.

At Sognesjøen there were maxima in percentage of the males in June 1949 and in March and October 1950, of the females in August 1949 and in March and May 1950.

At Ona, where the observations were made more frequently, the males showed maxima in March, June and September of 1949, and in

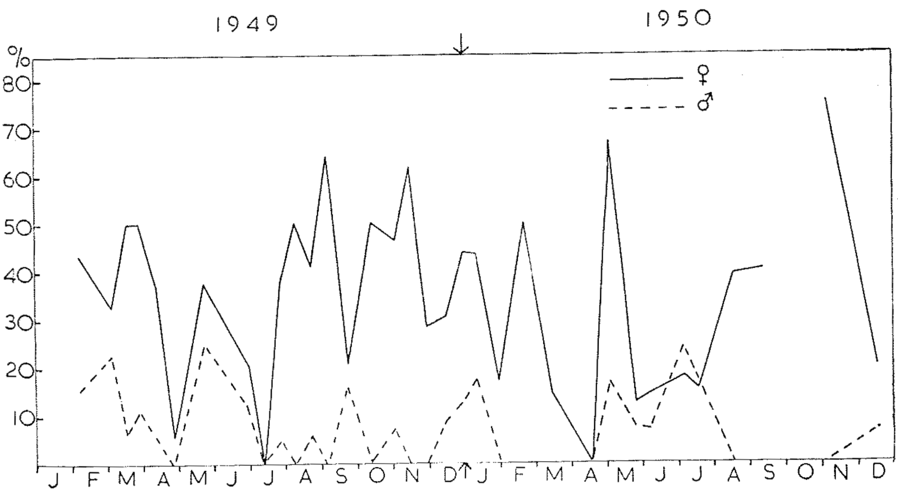


Fig. 71. Variations in percentage of *Microcalanus pusillus* females and males at Ona in 1949—50.

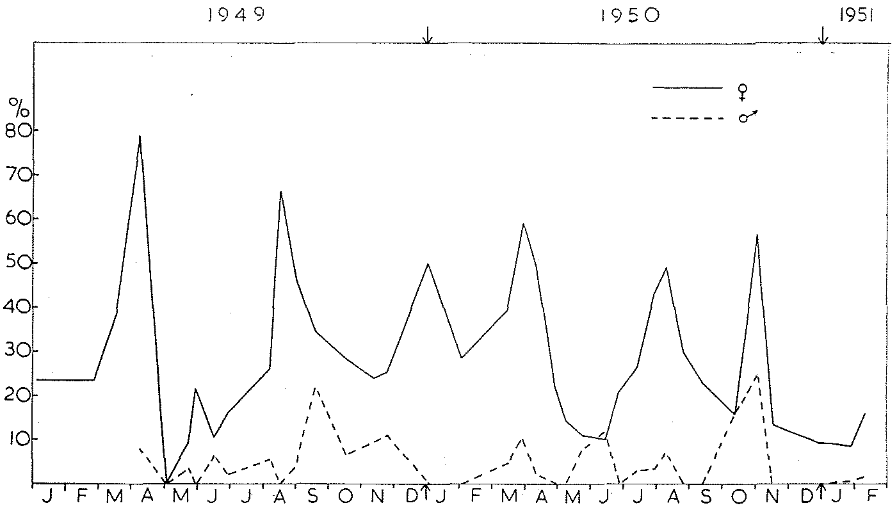


Fig. 72. Variations in percentage of *Microcalanus pusillus* females and males at Eggum in 1949–50.

January, May and July of 1950, the females in April, June, August and November 1949, and in January, April—May, and from August to November 1950. When we take into account the variations in the size of the stock, the rise in number from February to March 1949 may be due to a brood in February, any spawnings which took place in September and November having evidently been unsuccessful. In 1950 the increase of the stock in February may have been caused by a spawning in February, and the rise at the end of May by a brood in April—May. Furthermore, the considerable increase at the beginning of July would indicate propagation in June. In August and later any spawnings which may have taken place have been unsuccessful.

In 1949 the spawning periods at Ona may be determined to January, March—April, June—July, September and November, in 1950: January—February, April (May), June, and August or later. These observations are in accordance with Ruud (1929) who judged the spawnings to be in or before March and between the middle of May and the end of June. In Loch Striven in Scotland Marshall (1949) found broods of *Microcalanus* in January, March—April, May—June, and August—September.

The percentage variations of males and females of *M. pusillus* at Eggum and Skrova during 1949—50 are shown in fig.s 72—73.

At Eggum the females had maxima in April, May and August of 1949 and January, March—April, July—August and November. When we combine the percentage variations with the stock variations, the

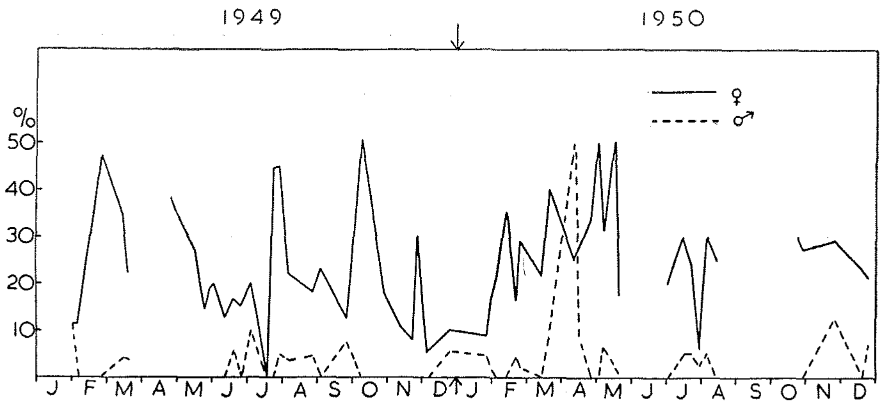


Fig. 73. Variations in percentage of *Microcalanus pusillus* females and males at Skrova in 1949—50.

spawnings may be said to take place in January (February), April, May—June, August, and perhaps November of both years, nearly identical with those at Ona, but the late autumn spawnings seem to have been more successful.

At Skrova the percentage variations are much more irregular then at Eggum, but we can distinguish some major fluctuations. The females in 1949 had peaks in February, April, July, October and November, in 1950 in February, March, May, July—August (probably), and in November—December. Males were more scarce and irregular in appearance, but some maxima are indicated. If we assume that propagation takes place some time after the maximum percentage of the females, and also take into account the fluctuations in the size of the stock, the main spawning periods for both years would be: February—March, May, July—August, October, and November—December.

The spawnings all seem to be delayed a fortnight or a month in relation to those at Eggum.

Vertical Distribution.

The bulk of the *Microcalanus* was usually taken below 50 m, but on some occasions a certain percentage occurred in the upper 50 m, at Eggum especially in May and June, at Skrova from December to February (Note the black columns in fig.s 61—68).

Length Variations of Microcalanus pusillus.

A number of females of *M. pusillus* have been measured throughout the year, at Eggum and Skrova in 1949, at Ona in 1949 and 1950. (See table 52, pp. 240—241). The variations in mean length are shown in fig. 74.

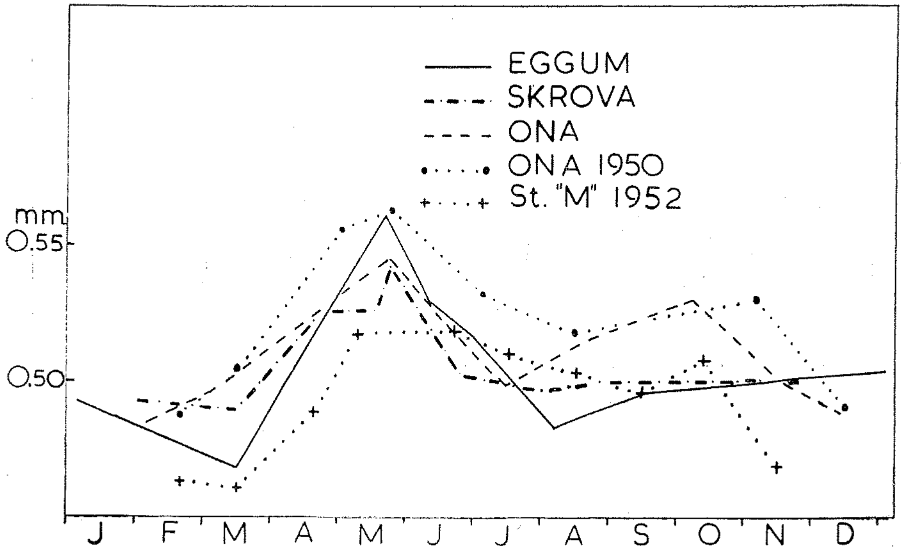


Fig. 74. Variations in mean length of *Microcalanus pusillus* females at Eggum and Skrova in 1949, Ona in 1949 and 1950, and station «M» (600—100 m haul) in 1952.

At Ona the mean length was minimum in February, rose slightly to March and then increased to a maximum at the end of May. Some decrease followed to July, but the mean length rose again in August and reached a second maximum in October. Then followed another decrease to December. Figures were higher in 1950, and the increase from August to October less pronounced.

At Eggum the variations were similar to those at Ona, but with minimum in March, maximum in June, a second minimum in August, and some increase in mean length till January 1950.

At Skrova the variations were less obvious than at Eggum. Minimum length was found in February—March, maximum in April—May, and then some decrease till June. Later the length remained constant.

A number of *M. pusillus* females were also measured from station «M» in the Norwegian Sea during 1952. The females were mainly taken in the 600—100 m hauls, sometimes also in the upper 100 m, but the length distributions proved to be quite identical in the two hauls. The mean lengths are inserted on fig. 74. The variation is similar to those on the coast of Norway, with minima in November—March and in September, maxima in May—June and in October. The extreme figures, 0.46 mm and 0.52 mm respectively, are both below the corresponding figures from Norwegian waters, but as the measurements were made on material from different years, too much stress cannot be laid on this difference.

Selected size frequencies of *M. pusillus* females from the permanent stations in 1949 are shown in fig.s 75—76.

At Ona the curves have a tendency towards bimodality in spring and summer. The increase in size from July to October may perhaps indicate that another population of *Microcalanus* has been brought in.

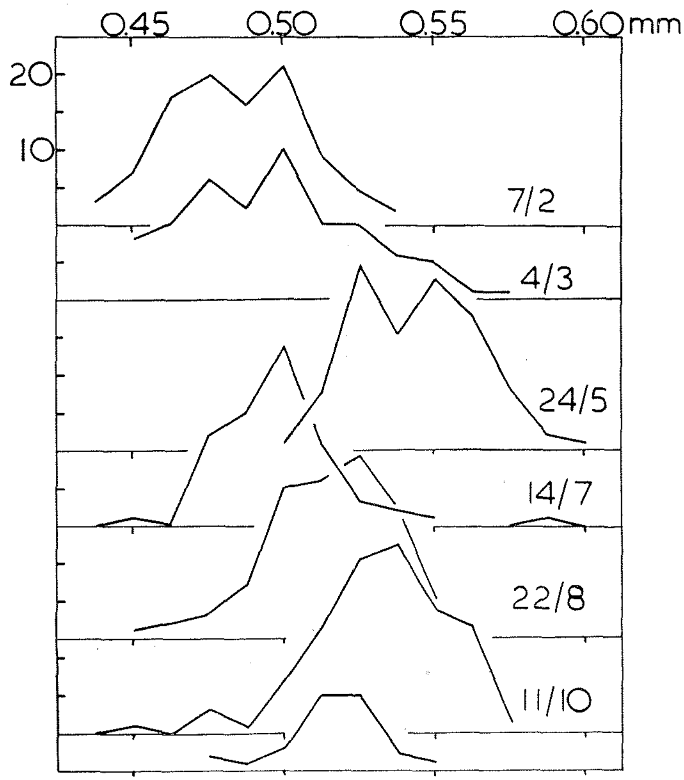


Fig. 75. Size frequencies of *Microcalanus pusillus* at Ona in 1949.

As shown earlier (page 20) there was an influx of water of high salinity in the deeper layers in May—August 1949. The range of variation, 0,41—0.60 mm is a little wider than that given by Ruud (1929). At Eggum (fig. 76) the curve is trimodal at the beginning of April, and individuals are undoubtedly present both from the winter and spring generation. In May and June there are also some small females. From the beginning to the end of June females of the summer generation make their entry. The length distribution found in August is maintained throughout the rest of the year.

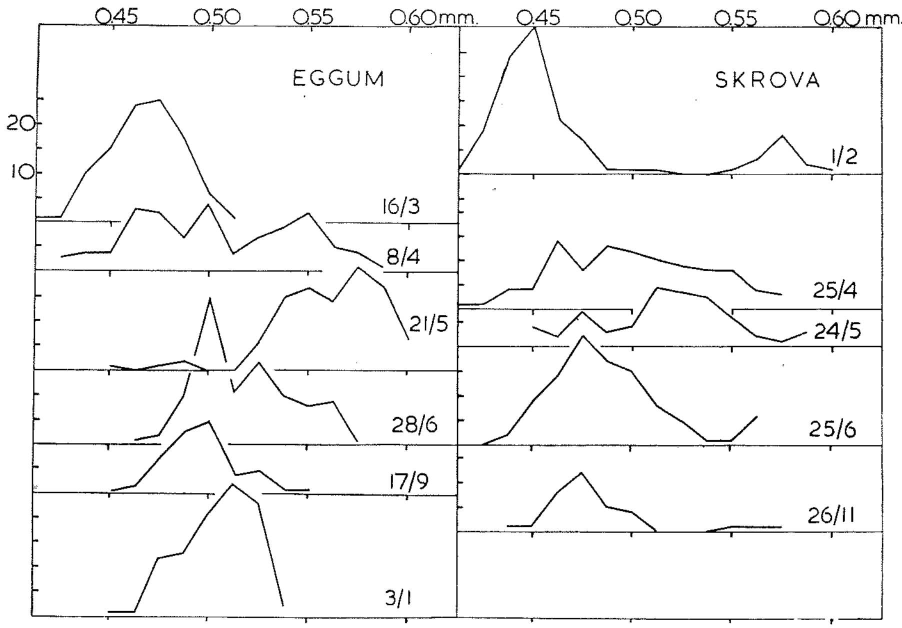


Fig. 76. Size frequencies of *Microcalanus pusillus* at Eggum and Skrova in 1949.

At Skrova (fig. 76) the length distributions in February and March are bimodal, with a major peak at 0.48 mm and a small one at 0.60 mm. As will be shown later (page 141) the large individuals proved to be *M. pygmaeus*. Before this fact was realized, the figures had all been included in the calculation of mean length. As *M. pygmaeus* was usually very scarce, the error involved is not essential. — In April the curve was quite irregular, and in May bimodal, the females present, probably deriving from the winter generation as well as from the spring brood. In the last few days of June the early summer brood has advanced to females, and afterwards the size distributions remain largely unchanged for the rest of the year.

Length Variations in Relation to Temperature. In Norwegian waters *M. pusillus* was as a rule taken below 50 m during the day. Nothing can be said about vertical migrations. At Ona the temperature at the 50 m level in 1949 varied between 5.5°C and 12°C, in 1950 from 6°—15°C. At Eggum the range of temperature in 1949 was 5.5°—11°C and at Skrova 3.5°—12°C at the 50 m level.

In the Scottish fjord Loch Striven MARSHALL (1949) found nearly the same length variations as in Norwegian waters, the mean varying from 0.51—0.58 mm, the total range being 0.45—0.66 mm. The temperature at sea surface varied between 4.5°—16.5°C, at 30 m 6.5°—13°C during the year (data from MARSHALL, NICHOLLS and ORR 1934) or nearly the same as at Ona.

At station «M» in the Norwegian Sea the temperature at 600 m level in 1950 varied between 0°C and 3°C, at 100 m 5.5°—9°C. I have not got the data for 1952, but it may be assumed that the variations were not essentially different from 1950. As mentioned above the females of *M. pusillus* were of the same size or even smaller than on the coast of Norway, and it may therefore be assumed that during development, *Microcalanus pusillus* in the Norwegian Sea do not live below 100 m. This would again lead to the assumption that the species may be distributed by the surface currents.

FARRAN (1936) reports the finding of *M. pusillus* in moderate numbers 80 nautical miles north of Spitzbergen. The females measured 0.63—0.67 mm total length which would correspond to cephalothorax lengths of 0.51—0.54 mm. These females had undoubtedly been carried northwards by the North Atlantic current.

In East Greenland fjords USSING (1938) measured a number of *Microcalanus* females throughout the year. The total range was 0.436—0.668 mm, with peaks at 0.49 mm and 0.565 mm. It is probable that both peaks refer to *M. pusillus*, but some of the larger individuals might be *M. pygmaeus*.

The temperature of the upper 25 m varied in the course of the year between ÷ 1.5°—10°C, and because of the length distribution it is again assumed that development takes place in comparatively warm water. There is also the possibility, though this is not mentioned by USSING, that the females of *Microcalanus* (*pusillus*) had been introduced from another area.

Microcalanus pygmaeus G. O. Sars.

As already mentioned, some large *Microcalanus* females were found at Skrova in February 1949. In addition to the size, they also differed from the ordinary females of *Microcalanus* present by the shape of the body, having a slightly thicker abdomen and a somewhat darker colour. On a closer examination they proved to be typical *M. pygmaeus* as described by G. O. SARS (1900) from the Polar Sea, but the total length was only 0.72 mm, (cephalothorax 0,54 mm) while SARS' specimens measured 0.86 mm. WITH (1915) claimed to have found intermediate forms between *M. pygmaeus* and *M. pusillus*, especially in the characteristics given by SARS, the spinulation of pes IV and the relative length of the second antennae. WITH's conclusions seem however to be based on rather scanty material, and he also admits «that a careful re-examination of a good material from the different localities is necessary before settling the qustion of the identification of the species.» (l. c. page 68).

Females and copepodites of *M. pygmaeus* were found at Skrova in nearly all months of the year. They were all of approximately the same size, indicating that there is either only one spawning period a year, or that *M. pygmaeus* keeps close to the bottom in uniform temperature surroundings all year round. In both cases the biology would be different from that of *M. pusillus*.

The presence of the otherwise arctic or deep water species *M. pygmaeus* in the Vestfjord may be a feature similar to the occurrence of *Calanus hyperboreus* in deep Norwegian fjords. I have examined some plankton samples from the deep of the Bømmelfjord south of Bergen (station F, GUNDERSEN 1953) from the beginning of May 1952, and found some specimens of *M. pygmaeus*. The females measured 0.72 mm, as at Skrova.

It may be assumed that the species also occurs in the Skagerak and in the outer Oslofjord.

At station «M» in the Norwegian Sea ØSTVEDT (in press) found that *M. pygmaeus* mainly kept below 1 000 m, clearly separated from the population of *M. pusillus*, which was mainly taken in the 600—100 m hauls.

A number of measurements has been carried out of females of *M. pygmaeus* at st. «M» during 1952 and some of these are given in table 24.

The length distributions are usually unimodal with a range of variation of 0.65—0.79 mm, and mean lengths 0.71—0.74 mm. The corresponding total lengths would be 0.79—0.96 mm and 0.89—0.91 mm respectively. In June a bimodal size distribution appeared in the 2 000 —1 000 m hauls with the main peak at 0.65 mm and only an indication of the usual peak at 0.73 mm. These smaller individuals were not found in the 1 000—600 m hauls. In July no hauls were taken below 1 000 m but in August the same phenomenon was repeated. The smaller individuals were then very scarce. At present no explanation can be given of this unusual length distribution. One might assume that a new population of *M. pygmaeus* had been introduced in the bottom water. If a spawning had taken place and the new brood developed at a higher temperature, it is strange that these individuals do not appear in the 1 000—600 m haul. The question will be investigated further and dealt with more thoroughly in a subsequent paper.

Pareuchaeta norvegica (Boeck).

A few individuals of this species were taken regularly at Sognesjøen, Ona and Eggum. This does not necessarily mean that *Pareuchaeta* is

Table 24. *Length Measurements of Cephalothorax of Females of Microcalanus pygmaeus at St. "M" in 1952. One Div. Line = 0.0125 mm.*

Date	Haul	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	n	Mean length, mm
18/4	1800—1000 m	—	—	—	—	—	3	4	11	9	22	26	16	8	1	—	1	—	101	0.716
	1000—600 -	—	—	—	—	2	2	7	10	18	30	15	9	6	—	1	—	—	100	0.710
20/6 ..	2000—1000 -	1	3	13	14	16	14	13	4	3	3	5	4	5	—	1	—	—	99	0.666
	1000—600 -	—	—	—	—	—		3	3	3	22	26	19	17	6	1	—	—	100	0.728
15/8 ..	1900—100 -	1	—	3	7	4	4	4	11	10	16	25	9	2	2	2	—	—	100	0.701
	1000—600 -	—	—	—	—		—	3	6	6	20	21	24	14	4	1	—	1	100	0.725
13/10 ..	1000—0 -	—	1	2	—	1	4	2	2	4	7	11	19	13	6	1	1	—	74	0.724
14/11 ..	1800—0 -	—	—	—	—	—	1	5	8	6	14	23	24	11	6	2	—	—	100	0.735

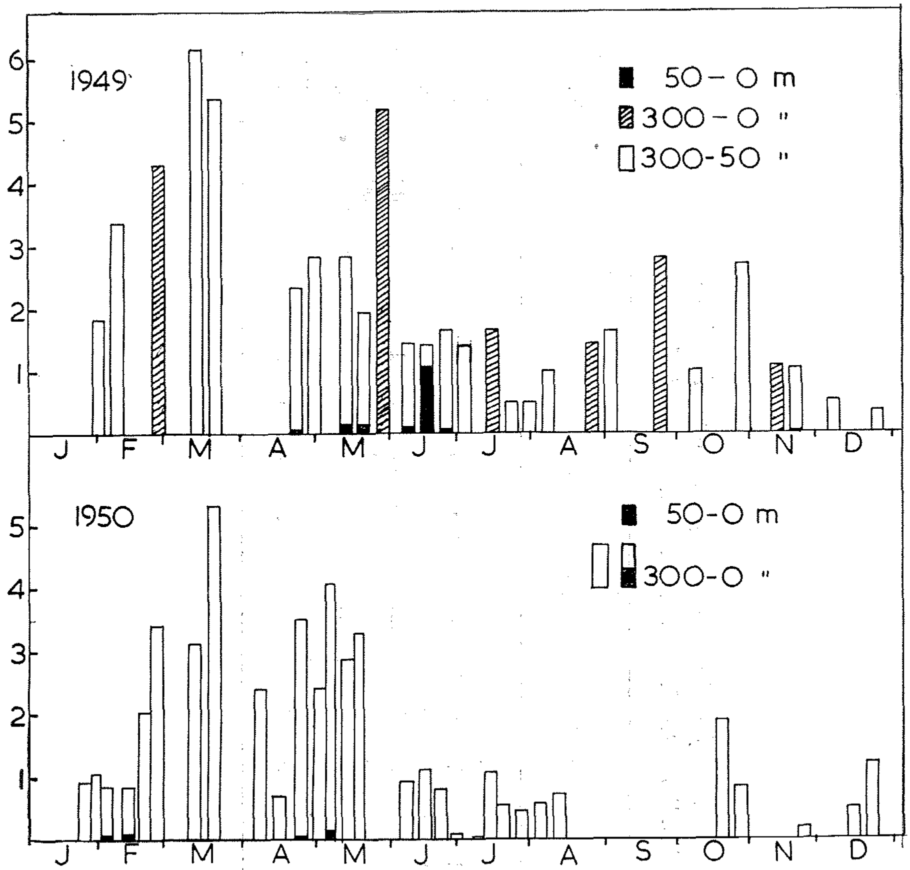


Fig. 77. Numerical variation of *Pareuchaeta norvegica* at Skrova in 1949—50, in 100's.

scarce in these localities. In the inner Oslofjord, where *Pareuchaeta* has previously been reported as very scarce (Wiborg 1940) recent investigations have shown that this species may occur in rather large numbers very close to the bottom (F. Beyer, verbal information), and this may also be the case in the localities investigated. In the deep Norwegian fjords *Pareuchaeta* is common (Sars 1903).

At Skrova *Pareuchaeta* was found regularly, sometimes in numbers, and as mentioned before (page 62) it may then account for a rather large propotion of the plankton volumes, especially in the deeper hauls. In fig. 77 is shown the numerical variation during 1949—50. The highest number usually occurred from February to May (maximum in March), and in September—October. As *Pareuchaeta* may not be caught quantitatively because of its living habits, the figures must be considered with caution.

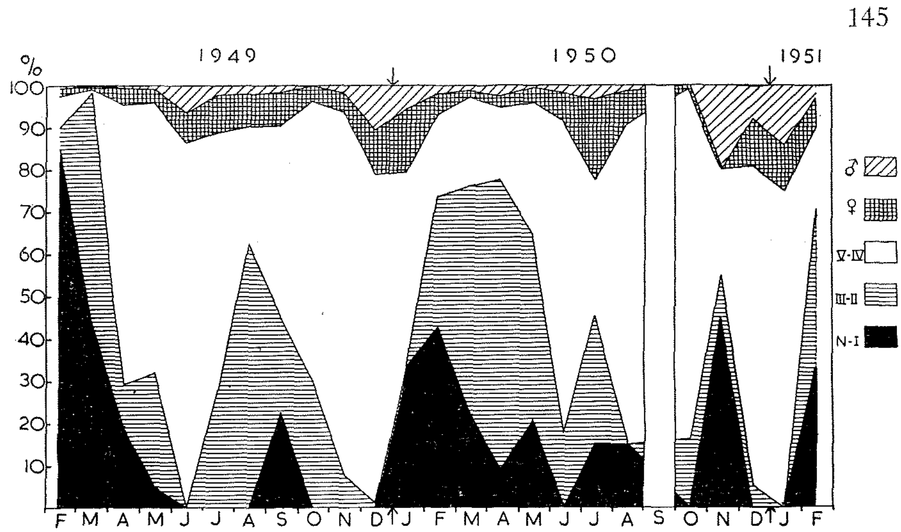


Fig. 78. Variations in the percentage stage composition of *Pareuchaeta norvegica* at Skrova February 1949—February 1951.

The entire stock was as a rule taken below 50 m. Single specimens, mostly females or older copepodites, were sometimes taken in the upper 50 m, and on one occasion the 50—0 m haul yielded most of the stock, mainly stage V copepodites.

Propagation.

The nauplii and all the different copepodite stages have been counted separately. As the number per haul was as a rule rather low, the figures have been added together for all the hauls in each month and the percentage stage distribution calculated per month.

In fig. 78 is shown the variation in percentage composition of the stock during 1949—50 and January—February 1951. For the sake of simplicity I have lumped the nauplii and copepodite stage I, and in the same way stage II and III, and IV and V.

There is a marked periodicity in the occurrence of all stages. In the course of the year the adults showed maxima in December—January and in June, the nauplii and stage I copepodites in January—February and in August—September, stages II—III in March (April) and August (not in 1950) with additional peaks in May and October, stages IV—V in June and November.

Females carrying egg-sacks were found in nearly every month of the year, and reproduction probably takes place all the year round, as stated by earlier investigators (Ruud 1929, Wiborg 1940 and others), but maxima in reproduction seem to occur in two periods, the first from

December to January, decreasing to May, and the second, somewhat more extended, in June—August. The latter period was perhaps unsuccessful in 1950, since the percentage of stages IV—V was very high both in August and in October.

RUNNSTRØM (1932) reports that propagation takes place from January to April and from June to September in the fjords near Bergen. In the Oslofjord maxima of reproduction occurred in February—April and in October (WIBORG 1940).

The females were about twice as numerous as the males, the percentages of males for the whole year being 26.0 and 27.0 for 1949 and 1950 respectively. ØSTVEDT (in press) found only 17 % of males in the Norwegian Sea. According to NICHOLLS (1934) and others the males of *Pareuchaeta* have rudimentary mouth appendages and are not able to feed. — In the copepodites of stage V the two sexes were represented in about equal numbers.

Length Variations of Pareuchaeta norvegica.

The cephalothorax lengths of all specimens of the copepodite stages V♂ and V♀, and of all the adults of *Pareuchaeta norvegica* found at Skrova during 1949, have been measured, altogether 411 specimens of stage V♂, 420 of V♀, 75 males and 158 females. As no notable changes occurred in the size distributions during the course of the year, the material has been compiled for two periods, February—July, and August—December. The results of the measurements are given as percentage curves in fig. 79.

Copepodites of stage V♀ were somewhat larger than stage V♂, average lengths 4.45 mm and 4.16 mm respectively in the period February—July. Both groups showed a slight decrease in length in the latter half of the year.

The males were only a little larger than stage V♂, average 4.42—4.44 mm, and the curves are very compact, but in the first period there is an indication of a second maximum at 4.57 mm.

The females have a wider length distribution, ranging from less than 5.2 mm to 6.4 mm, with an average length of 5.78—5.80 mm. There are no changes throughout the year. These lengths are nearly the same as those found by GAULD (1951) in Scottish waters.

Pareuchaeta lives in water where the temperature change very little in the course of the year, mostly varying between 6.5°—7.0°C. It may be of interest that in West-Greenland waters, south of Davis Strait JESPERSEN (1939) found *P. norvegica* females to vary in length between 5.0 mm and 6.5 mm, with a mean length of 5.68 mm. The temperature

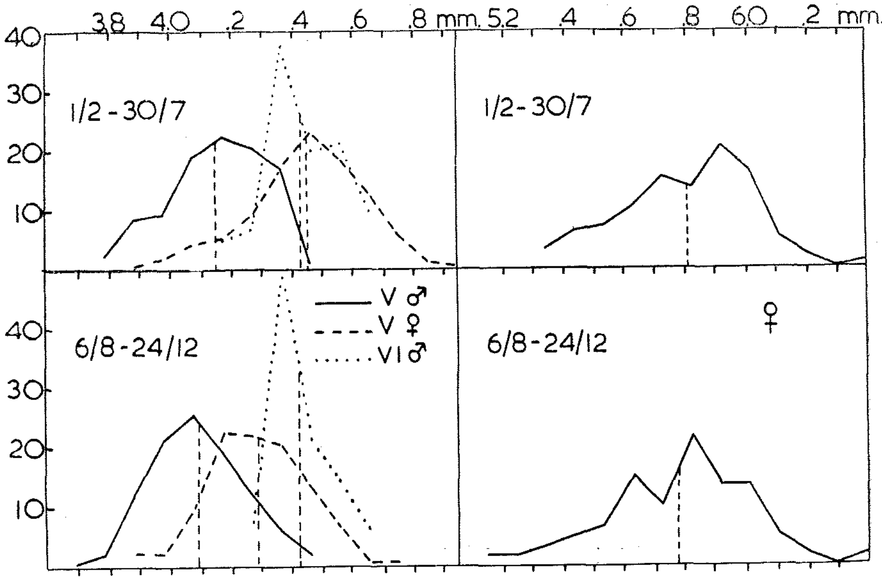


Fig. 79. Mean percentage size frequencies of *Pareuchaeta norvegica* stage V♂, V♀, and adults at Skrova in the first and second half of 1949. Vertical lines: mean lengths.

of the deeper water layers was 3.9°—4.7°C. If the length has a constant inverse relation to temperature one might suppose that at other times of the year the temperature of the deeper layers in East-Greenland waters must be considerably higher, or that the *Pareuchaeta* females occurring there have been introduced with Atlantic water. *P. norvegica* is also considered by RUSSELL (1935) to be an indicator species of oceanic Atlantic water.

In the warm area of the Barents Sea BOGOROV and PREOBRAJENSKAYA (1934) found females of *P. norvegica* of a total length of 8.4 mm (cephalothorax length = 5.62 mm), in the cold area of a total length of 9.0 mm (ceph. = 6.03 mm).

Centropages hamatus Lilljeborg and *Centropages typicus* Krøyer.

Centropages hamatus is considered to be a neritic species (SCOTT 1911). It occurred rather sparsely in the samples.

At Sognesjøen a few individuals were taken from June to October 1949 and from March to July 1950, at Ona single specimens in June and October 1949, and June, July and September 1950. At Eggum *C. hamatus* occurred in April and September 1949 and August—September 1950, at Skrova from August to October 1949 and in July—August 1950, single individuals only.

Centropages typicus is, according to SCOTT (1911), more Atlantic than *C. hamatus*. Near Bergen it occurs from June to November with maximum in reproduction in August— September (RUNNSTRØM 1932), and is also very abundant in October—November (NORDGAARD 1912). *C. typicus* is also numerous in the western part of the English Channel, in the Faeroe-Shetland area and in the Skagerak (OSTENFELD 1931).

At Sognesjøen the species was found from June 1949 to January 1950 and in September—October 1950. In the latter period it was rather abundant, and the following numbers were found:

	21/9	11/10
♂	650	58
♀	850	33
C......	3650	500
N......	500	50
T......	5650	641

We must however bear in mind that there is a gap in the observations between 10 July and 21 September.

At Ona *C. typicus* was more frequently found than at Sognesjøen, being present in October 1948, from September 1949 to January 1950 and from July to December 1950, very abundant from 16 August to 6 November as shown below:

	16/8	30/8	13/9	5/10	25/10	6/11	16/12	30/12
♂	16	830	35	42	7	25	1	
♀	33	500	20	66	6	9	5	1
C	750	330	70	60	42	50	2	
T	799	1660	125	158	55	84	8	1

At Eggum this species was also fairly common, present in November 1948 and September—October 1949, but as at Ona numerous in the autumn of 1950, as shown below:

	12/4	13/10	1/11	14/11	16/12	29/12
♂	25	75	42	25	1	
♀	75	58	33	100	2	
C	258	150	250	100	1	1
T	358	283	325	225	4	1

At Skrova *C. typicus* was very scarce. Single individuals occurred in July and September 1949, and 15 specimens on 29 October 1949. In 1950 160 specimens were taken on 23 October, 28 October: 16, 25 November: 7, and 28 December: 17 specimens.

The sudden appearance of *C. typicus* in the different localities clearly indicates that there are no local stocks in these waters. The species is brought in by the North-Atlantic current or the coastal current and then persists for some time. Other species have a similar occurrence, as will be mentioned later on.

At Eggum *C. typicus* seems to arrive one month later than at Ona. Some individuals are also carried into the Vestfjord. As no hauls were made at Skrova in September 1950 the exact date of arrival cannot be given.

C. typicus is an inhabitant of the surface layers, but some specimens are also found below 50 m.

Temora longicornis Muller.

Temora longicornis is known to be a neritic species with a tendency to occur in swarms (FARRAN 1911). In the localities investigated the occurrence was as a rule very patchy.

Numerical Variation.

The monthly mean numbers of *Temora* at the localities investigated are given in table 25.

Table 25. *The Monthly Mean Numbers of Temora longicornis in 1949 and 1950.*

1949.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Sognesjøen	—	2	*1511*[1]	*2052*	235	—	505	—	—
Ona	215	16	167	40	*397*[2]	*395*	57	0	0
Eggum	0	31	0	0	0	179	*1600*	4	0
Skrova	96	40	0	0	0	546[3]	*800*[4]	30	0
1950									
Sognesjøen	816	310	310	*807*	—	309	9	—	—
Ona	0	9	18	25	*248*	1	1	0	0
Eggum	0	0	0	0	426	*1033*	25	49	0
Skrova	25	5	-	11	10	—	*93*		0

[1] On 1. June: 2321. [2] On 22. August: 750. [3] On 25. September: 1050. [4] on 10. October: 1550.

At Sognesjøen *Temora* was scarce or absent till May 1949, but comparatively numerous from June to October, with maxima at the beginning of June, last half of July, and in September or October. In 1950 it was present for a longer period with maxima at the end of April, in July, and perhaps September.

At Ona *Temora* was more scarce, but regularly present from April to October 1949 with maxima at the end of the months April, June, August and October. In 1950 only one maximum was observed, in the middle of August. RUUD (1929) also found the largest stock on the bank in the autumn.

At Eggum *Temora* occurred very scattered and sparsely both years, but quite large numbers were found in October 1949 and in September 1950. The maxima occurred later than at Ona.

At Skrova *Temora* was quite common in October and November 1948, mean numbers 400 and 700 individuals respectively. In 1949 it was sparsely present in April and May, but abundant in the autumn from September to November with maximum at the beginning of October. In 1950 *Temora* was found regularly from April to the end of November, but in small numbers only, with a maximum in October. From the table it will be seen that the maxima in numbers occur successively later as we proceed northwards.

Propagation.

Males, females, copepodites and nauplii have been counted separately. The latter are not caught quantitatively. In table 26 is given the percentage composition of the stock of *Temora* at Sognesjøen from June to October 1949 and from April to September 1950.

If we take the presence of nauplii as a sign of propagation, it is evident that spawning must go on more or less continuously, when *Temora* is present in numbers. Judging from the maximum percentages of the different categories, it seems probable that spawning was more intense

Table 26. *The Percentage Composition of the Stock of Temora longicornis at Sognesjøen in 1949—50.*

	1949						*1950*					
	1/6	23/6	21/7	12/8	25/8	11/10	28/4	12/5	25/5	14/6	10/7	21/9
♂	6.9	*21.4*	2.4	6.8	—	*29.7*	2.0	2.9	*33.3*	8.1	—	—
♀	6.9	*28.5*	9.8	0.7	1.9	1.0	6.1	1.3	*50.0*	16.1	0.2	2.9
C	*64.7*	42.9	68.3	*86.7*	78.8	*69.3*	*42.8*	*47.9*	16.7	24.2	62.4	16.2
N	*21.5*	7.2	*19.5*	5.8	*19.3*	—	*49.1*	*47.9*	—	*51.6*	37.4	80.9

in May, July, and August—September of 1949, and April, June and September 1950. This assumption is in accordance with observations in the fjord Nordåsvatn near Bergen (WIBORG 1944).

At Ona the numbers of *Temora* were usually quite low and the percentage composition has not been computed. Nauplii occurred sparsely from the end of June to October 1949, but were not observed in 1950.

At Eggum nauplii were abundant in September and October 1949 and in September 1950, at Skrova also at the end of September 1949, but were scarce in 1950, as observations were then lacking in September.

Temora is an inhabitant of the surface layer in all localities, being mainly found above 50 m, and this fact characterizes its distribution. The high numbers sometimes found at Eggum and Skrova may be due to transport by currents from southern areas, but a small stock seems to exist in the Vestfjord during most of the year, and will perhaps produce a large number when the circumstances are favourable, as in September—October 1949.

Metridia lucens Boecek.

Two species of *Metridia* occur more or less regularly in all the localities investigated, *M. lucens* Boeck and *M. longa* Lubbock. The adults and copepodite stages IV—V of the two species are distinguished quite easily, but the lower stages and the nauplii can only be separated by measurements. In all the localities, except at Skrova, *M. longa* was very scarce in relation to *M. lucens*, and can be left out of consideration.

M. lucens is regarded as an Atlantic species, being brought in with the North-Atlantic current, but there is also an isolated stock in the Skagerak, (FARRAN 1910) which may be introduced with the Baltic current in the coastal areas of Western Norway. NORDGAARD (1905, 1912) reports that off Bergen *M. lucens* is sometimes very abundant and important as food for e. g. coalfish.

Numerical Variation.

The numerical variation of *M. lucens* at the investigated localities during 1948—50 is shown in fig. 80.

It is immediately clear that *M. lucens* is a summer and autumn form. At Sognesjøen there was a small stock in Desember 1948, decreasing to January 1949 and remaining low until June. From July there was a rapid increase to a maximum at the beginning of August. From September the stock decreased steadily in size until February next year. Between April and December 1950 the stock had 3 peaks of abundance, in April, June and October, but the numbers were much lower than in the summer of 1949.

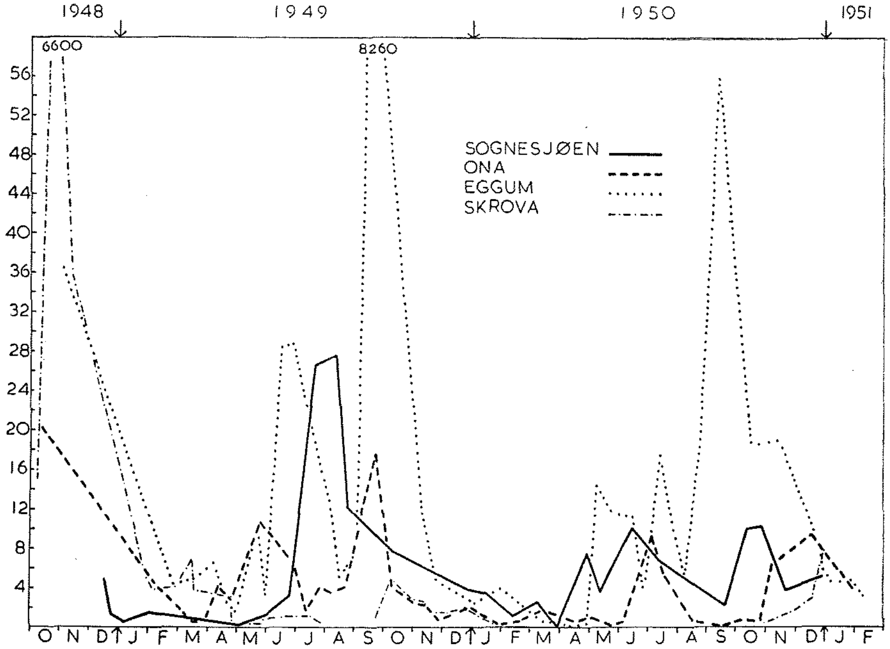


Fig 80. Numerical variation of *Metridia lucens*, October 1948 — December 1950, in 100,s.

At Ona the stock of *M. lucens* was very considerable in October 1948. In March 1949 the number was very low, but peaks occurred in June and in September. From October 1949 till June 1950 the stock was negligible, but two peaks were again observed at the beginning of July and in December.

At Eggum *M. lucens* was also numerous in the autumn of 1948, the stock decreasing to a minimum in February. Two minor peaks occurred in April and May of 1949, and then two main maxima in June—July and October. In 1950 minor peaks were observed in May and July, and a main maximum in September.

At Skrova *M. lucens* was very abundant in the autumn of 1948 and decreased in number to a minimum in February. A small increase followed in February, but some of the nauplii found possibly belonged to *M. longa*.

Throughout the summer and autumn the stock was inconsiderable, but in September there was a small increase, in October a maximum, and afterwards decrease to January 1950. In February there was again a rise to a maximum of about 1 000 individuals in March, mainly nauplii, but the identification was uncertain, and they may partly have belonged to *M. longa*. No copepodites were found. *M. lucens* was scarce or absent

Table 27. *Monthly Mean Percentages of the Different Stages of Metridia lucens at Sognesjøen in 1949—50.*

Year	Stage	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1949	♂	*38.6*	20.0	—	—	—	*19.4*	1.8	2.2	—	2.4	—	7.2
	♀	19.3	*53.3*	—	—	—	*61.4*	3.9	3.4	—	2.5	—	18.6
	V-IV ..	*22.8*	13.3	—	—	—	8.7	3.8	*35.0*	—	21.3	—	*22.8*
	III-I ..	1.8	3.3	—	—	—	2.5	17.0	25.2	—	*44.3*	—	7.2
	N ..	17.5	10.1	—	—	—	8.0	73.5	34.2	—	29.5	—	44.2
1950	♂ ..	*19.4*	2.6	0	6.7	*11.8*	0.6	2.7	—	0	*13.2*	3.6	8.7
	♀ ..	17.1	0.9	*47.8*	6.7	*14,7*	0.6	0.5	—	*25.9*	12.2	3.4	9.6
	V-IV ..	9.7	0.9	4.4	*26.6*	2.3	0.1	2.7	—	*29,5*	8.2	15.0	*24.0*
	III-I ..	9.7	4.4	0	0	4.2	*98.7*	34.3	—	22.3	8.0	*52.0*	4.8
	N ..	44.1	*91.3*	47.8	*60.0*	*67.0*	0	*59.8*	—	22.3	*58.4*	26.0	*52.9*

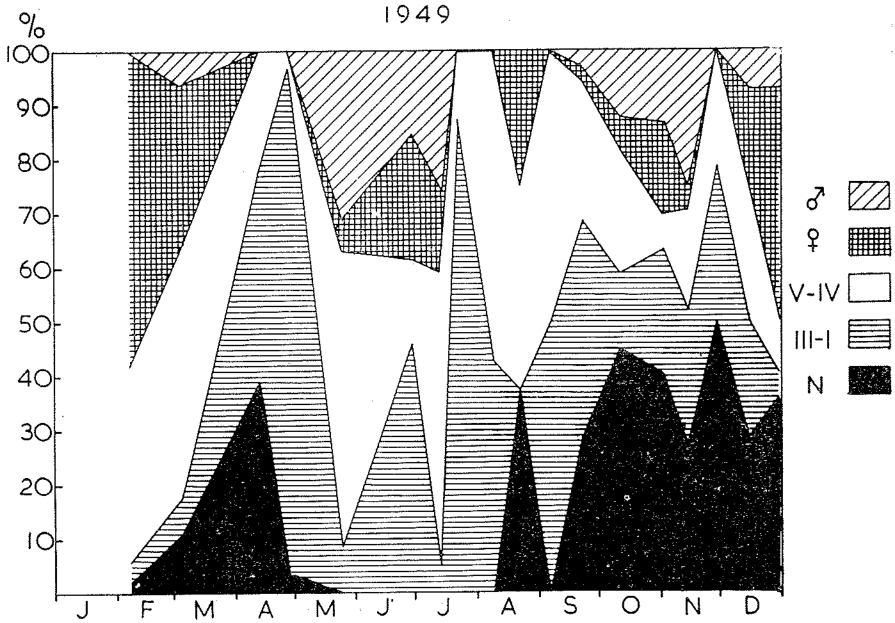


Fig. 81. Variations in the percentage stage composition of *Metridia lucens* at Ona in 1949.

throughout the summer and autumn of 1950, but reappeared in October and increased in number till December.

When we compare the different localities it is apparent, that the spring maximum in 1949 occurred first at Ona, second at Eggum and last at Sognesjøen. The same may also have been the case with the second maximum, but observations were lacking at Sognesjøen between 10 July and 21 September. In 1950 the conditions were more variable, as we do not have the same number of peaks in all the localities.

Propagation.

Males, females, stages V—IV, III—I, and the nauplii have been counted separately. In table 27 is shown the mean monthly percentage composition of the stock of *M. lucens* at Sognesjøen during 1949—50. Samples with less than a hundred specimens have been omitted.

The adults are present nearly all the year, with highest percentages in Jan.—Feb., May—June and Sept.—Oct. Females were also well represented in March 1950. Nauplii are also found the year round, with peaks in December—February, May, July and October, when we combine the observations of the two years. There are probably four main spawnings, in February, May, July and October, and indication of a fifth one in December—January.

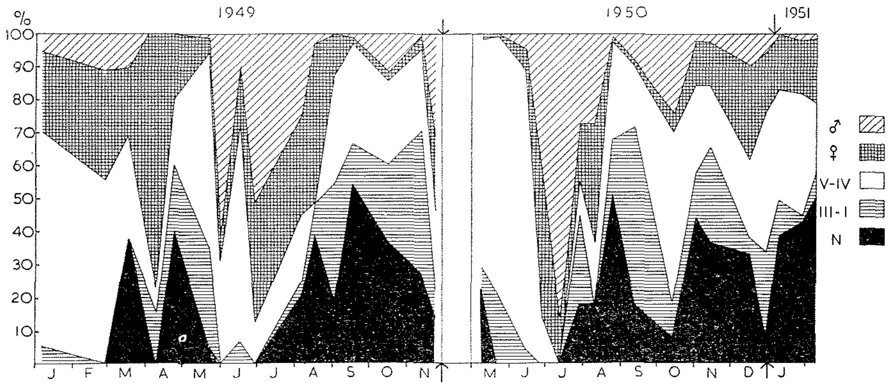


Fig. 82. Variations in the percentage stage composition of *Metridia lucens* at Eggum in 1949—50.

At Ona (fig. 81) the variation in stage composition is more irregular than at Sognesjøen, possibly caused by a double origin of the stock, as mentioned above (page 67).

Only the observations from 1949 are shown in the figure. The spawning periods seem to be nearly the same as at Sognesjøen, February, April, August, October and December. In the autumn however, there seems to be continuous spawning from September to January.

At Eggum (fig. 82) the adults are usually present in much greater percentages than further south, with pronounced maxima in February, April, June—July and November 1949 and in June—July, October and December 1950. Peak percentages of the nauplii in 1949 occurred in March, April, May, and from July to December, with maxima in August and October. In 1950 the peaks were more separated, occurring in May, August and November—December. There are probably four main spawnings, corresponding to the peaks of nauplii in February—March, April—May, August and October—November. As at Ona, the most intensive spawning at Eggum takes place from August to November, but all the peaks occur a fortnight or a month later.

At Skrova it is more difficult to give exact data on the percentage composition of the stock of *M. lucens* with the nauplii included, as the nauplii of *M. longa* have not been distinguished. With the percentage variations of the adults and the older and younger copepodites of *M. lucens*, and the number of *Metridia* nauplii per month, (tables 28—29) we may nevertheless be able to trace the spawning periods fairly accurately.

From the maximum percentages of stage I—III we may conclude that spawning took place in September and December 1948, in January and October—December 1949, and in September 1950. The occurrence of *Metridia* nauplii indicates that spawning may go on more or less con-

Table 28. *Monthly Mean Percentage of Adults and Copepodites of Metridia lucens at Skrova 1948—50.*

1948	Jan.	Feb.	Mar.	Apr.	May	Sept.	Oct.	Nov.	Dec.
♂	—	—	—	—	—	—	0	3.8	—
♀	No observations						5.2	42.3	—
V—IV	—	—	—	—	—	—	21.6	*46.3*	—
III—I	—	—	—	—	—	—	*73.3*	7.6	—
1949									
♂	—	9.5	20.0	33.3	0	10.4	—	*43.2*	5.0
♀	—	*53.1*	*69.3*	*66.7*	*61.6*	14.9	—	39.1	*49.3*
V—IV	—	24.0	10.7	0	38.4	*74.7*	—	13.5	24.1
III—I	—	13.3	0	T	0	0	—	4.2	21.6
1950									
♂	0	13.4	—	—	—	—	5.0	19.6	9.5
♀	*42.3*	*37.3*	—	—	—	—	29.9	*30.5*	9.5
V—IV	*41.5*	*49.2*	—	—	—	—	31.8	*30.5*	*69.0*
III—I	13.2	0	—	—	—	—	*33.3*	19.5	12.0

tinuously from October to May, when females of *M. lucens* are present. It is assumed that *M. lucens* is usually brought into the Vestfjord in September—October, and then survives for some months. In the autumn of 1948 a greater stock of *M. lucens* had probably been introduced.

With the work of MARSHALL and ORR (1952) in mind, we have reason to assume that the number of generations of *M. lucens* per year may be considerable less than the number of spawnings, If *M. lucens* takes the same time for the development from egg to the mature adult as *Calanus finmarchicus*, (minimum 1 month) and afterwards may survive for two months or more, this would give maximum 4 generations a year. As the temperature of the upper water layers where the spawnings may take place, is comparatively low during winter and early spring, the

Table 29. *Monthly Mean Numbers of Metridia Nauplii at Skrova 1948—50.*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
1948	No observations									*1233*	1000	200
1949	0	220	*375*	50	25	0	5	50	75	*300*	75	100
1950	130	440	*625*	400	343	5	10	0	—	25	100	*450*

development may be delayed. It is therefore likely, that in Norwegian waters the bulk of the *M. lucens* only go through 3 generations a year. The length variations (page 158) also support this view, and furthermore RAE (1951) reports the evidence of three distinct generations of *M. lucens* in the North Sea and Northeast Atlantic during 1950.

Vertical Distribution.

M. lucens is known to make pronounced vertical migrations, but may also be taken in the upper layers in daytime (RUUD 1929). Off the coast of Ireland (FARRAN 1947) females of *M. lucens* in 1931 accumulated in the upper 25 m after dark, while in 1932 they stayed below 50 m also at night. The younger stages were taken mostly below 50 m both during day and night.

As the present material has all been sampled during the daytime, we have to restrict ourselves to the general distribution during the day. Divided hauls were taken in 1949 only, and the percentage of the different stages above and below 50 m has been calculated for the stations Sognesjøen and Eggum as shown below:

	N		I—III		IV—I		♀		♂	
	above 50 m.	below 50 m.	above 50 m.	below 50 m.	above 50 m.	below 50 m.	above 50 m.	below 50 m.	above 50.m	below 50 m.
Sognesjøen	*90*	10	*60*	40	25	*75*	9	*91*	3	*97*
Eggum	*64*	36	39	*61*	26	*74*	6	*94*	7	*93*

As the development proceeds from the nauplii to the older stages, the larvae apparently seek deeper water, and the majority of the copepodites of stage IV—V and the adults are found below 50 m. At Eggum there is a higher percentage of nauplii and stage I—III copepodites below 50 m than at Sognesjøen, but in November a greater proportion of the copepodites was found in the upper 50 m, 38 % and 83 % of stage V—IV and III—I respectively.

Variations in Length of Metridia lucens.

A number of females of *M. lucens* have been measured from Sognesjøen, Ona and Eggum in 1949, and from Ona in 1950. The variations in mean length are shown in fig. 83.

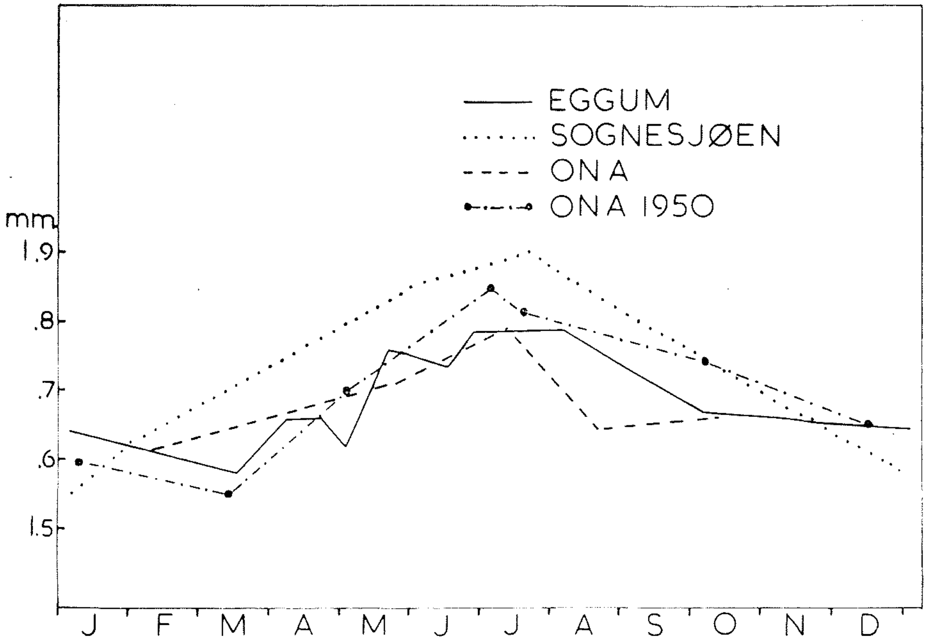


Fig. 83. Variations in mean length of *Metridia lucens* females at the investigated localities in 1949 and at Ona in 1950.

At Sognesjøen the mean length is at a minimum of 1.55 mm in January and rises but little to February. In May the figure has increased to 1.85 mm and increases still a little to July. Later the mean length falls evenly throughout the autumn and winter. At Ona the variation is the same as at Sognesjøen, but the figures are lower. Minimum occurs in March. In 1950 the maximum mean length was a little greater. At Eggum the variation in mean length corresponded closely with that found at Ona. Slight drops in mean length are indicated from the end of April to the beginning of May and from the end of May to the beginning of June.

The variation in mean length of *M. lucens* bears some resemblance to that of *Calanus finmarchicus*, but the increase in spring is more even. The mean lengths range from 1.55 mm to 1.90 mm.

In fig. 84 are shown selected size frequencies of *M. lucens* females at Ona and Eggum during 1949. The curves are mostly unimodal. The sizes vary from 1.33 mm to 1.90 mm.

From the Barents Sea Bogorov and Preobrajenskaya (1934) give the total length of *M. lucens* females as 2.29 mm (cephalothorax length = 1.46 mm) in December. This is below the minimum mean length found at the permanent stations, but as we have already seen, the

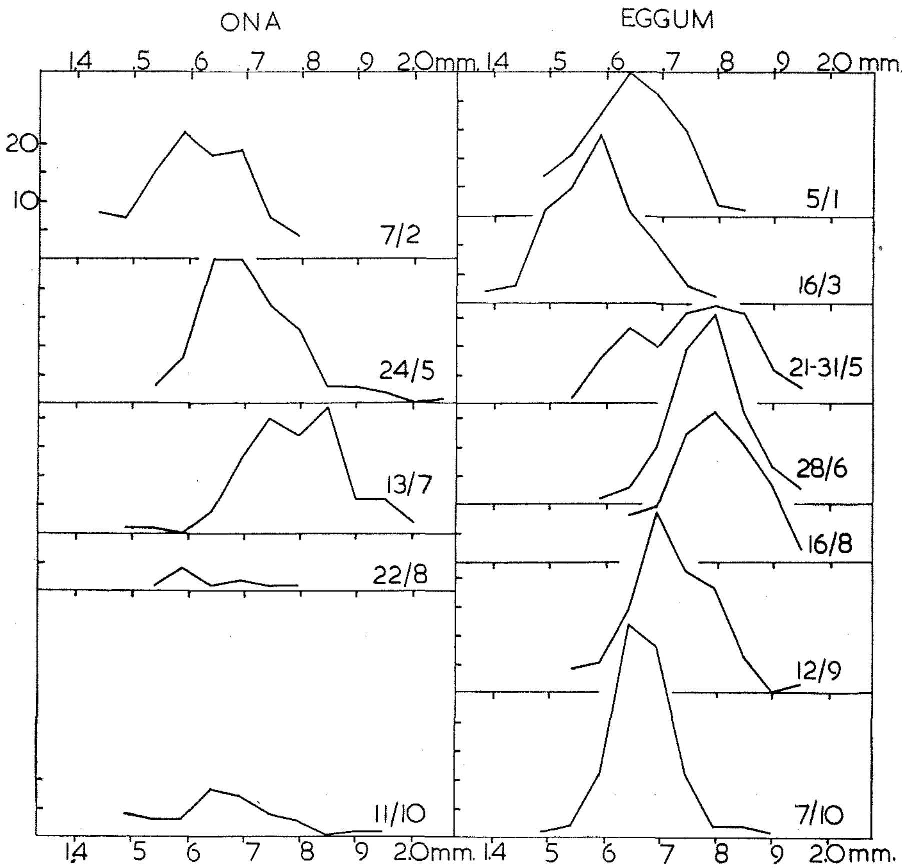


Fig. 84. Selected size frequencies of *Metridia lucens* females at Ona and Eggum in 1949.

lengths may vary from one year to another. In the Barents Sea *M. lucens* is only found in the warm area, and the stock is supplied by the North-Atlantic current from more southerly areas.

Metridia longa Lubbock.

M. longa is considered to be an arctic species, but is also found in the deep Norwegian fjords (Sars 1903). On the coastal banks it is scarce (Ruud 1929). Near Bergen maximum occurrence is met with in March and in September (Runnstrøm 1932), which is in accordance with the conditions found in the Oslofjord (Wiborg 1940), where propagation took place in February and in August—September.

Numerical Variation.

M. longa occurred very sparsely at Sognesjøen, Ona and Eggum. In the first locality 15—100 individuals, mostly stage V copepodites, were taken in April—May 1949 and June 1950, otherwise single specimens only. At Ona a few copepodites were found in November 1949 and stragglers in January, March, June and December 1950.

At Eggum the same distribution was observed, the largest number being 61 specimens in October 1949, on other occasions mainly single specimens.

Skrova is the only locality where *M. longa* had a regular occurrence, which confirms its nature as a fjord species. The average figures for the years 1949—50 are given below. As mentioned earlier, the nauplii are difficult to distinguish from those of *M. lucens*, and in the table only adults and copepodites of *M. longa* have been included.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	182	20	45	185	63	200	139	550	266	100	70	42
1950	49	39	117	50	92	9	23	33	—	38	45	67

The stock is of a moderate size. Maxima occur in January, April, June and August of 1949 and in March and May 1950.

Propagation.

A number of *Metridia* nauplii were found in February—March 1949, and it is assumed that they in part belonged to *M. longa*. At the end of April the lengths were measured of a number of *Metridia* copepodites, and it was seen that 80 % of stage I belonged to *M. lucens*, while 85 % of stage III belonged to *M. longa*. This would indicate that the spawning of *M. longa* had taken place in February—March. A few stage I copepodites of *M. longa* were also found in October.

Only single copepodites of *M. longa* were taken above 50 m. The entire stock kept to the deeper water layers.

Variations in Length.

A number of females of *M. longa* were measured at Skrova at different times of the year 1949. For a comparison I also measured individuals from the innermost part of the Oslofjord taken on 14 June 1933 and 23 February 1934 (see Wiborg 1940), and from station «M» in the Norwegian Sea in January—July 1952. The percentage length distributions from all localities are given in fig. 85.

At Skrova the variations in mean length were very small, from 2.50—2.60 mm during the year. The total range of variation was 2.31

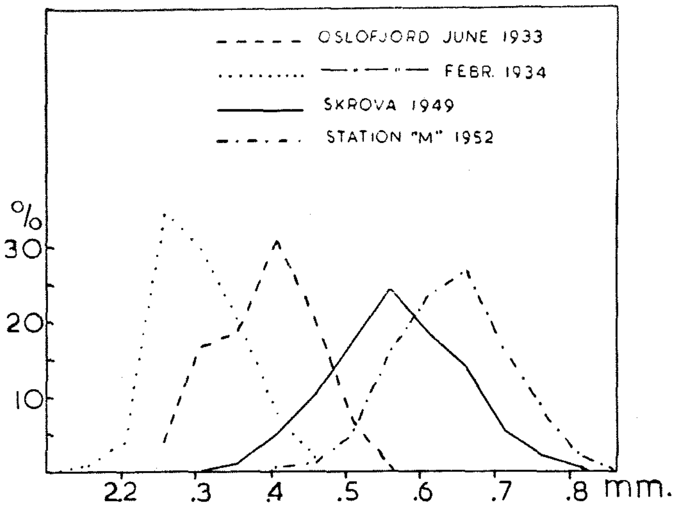


Fig. 85. Percentage size frequencies of *Metridia longa* females in the Oslofjord, at Skrova, and at station «M».

—2.82 mm. In the Oslofjord *M. longa* spawns twice a year, (WIBORG 1940) and the females taken in February accordingly represent the summer generation, those from June the spring generation, with mean lengths of 2.31 mm and 2.40 mm respectively. On station «M» the variations in mean length between January and July 1952 were but slight, the mean length in this period being 2.70 mm.

The Length Variations of M. longa in Relation to Temperature and Salinity. At Skrova *M. longa* is usually found in water with a salinity of 34—35 ‰ and a temperature of 6.5°—7°C most of the year. At 50 m level the temperature may sink to 4° C.

In the Oslofjord the deeper water layers have also a temperature of 6.5°—7°C, but the salinity is lower, 32—33 ‰ (BRAARUD and RUUD 1937). As the nauplii and copepodites of stage I—III were found to swim at higher levels than the adults (WIBORG 1940), they may be subject to higher temperatures, which may explain that *M. longa* females are smaller in the Oslofjord than at Skrova.

At station «M» the females of *M. longa* were taken mainly in the 600—100 m layer. At the 100 m level the temperature in January—May 1950 varied between 5° C and 7°C, at 600 m between 0°C and 3°C, and it is reasonable to assume that the temperature variations were not essentially different from those of 1952. By vertical migration within the 600—100 m layer *M. longa* may thus be subject to temperatures which may account for the larger size of the females.

In the White Sea BOGOROV (1932) gives the mean total length of *M. longa* females as 4.03 mm. The corresponding cephalothorax length would be 2.49 mm, or very near to that found at Skrova. In the White Sea the temperatures of the deeper water layers were from ÷ 0.1°—÷ 1.5°C, the salinity 28.48—27.94 ‰. One might have expected larger individuals at such low temperatures. However, as BOGOROV and PREOBRAJENSKAYA (1934) found in the warm water area of the Barents Sea (temperature 4.7°C) females of *M. longa* measuring, on the average, 3.66 mm total length (ceph. length = 2.26 mm), and in the cold water area near Frantz Josephs's Land (temperature ÷ 0.5°C) specimens measuring 4.00 mm total length (ceph. = 2.47 mm), the figures can apparently not be compared with the data from the present investigation. In East Greenland waters USSING (1938) found an average length of 2.65 mm, a range of variation of 2.34—2.80 mm. He also stated that there is no annual variation in size. JESPERSEN (1939) on the basis of a very extensive material gives the mean length of *M. longa* females as 2.78 mm and 2.70 mm respectively for East Greenland and West Greenland waters, the difference being attributed to differences in sea temperature.

Although it seems that the temperature is the most important factor in determining the length of the adults of *M. longa*, the possibility cannot be excluded that a low salinity may also be of importance as a limiting factor.

Acartia clausi Giesbrecht.

Of the two species, *Acartia clausi* Giesbrecht, and *A. longiremis* (Lilljeborg), the latter has been found in small numbers only, mainly as adults. It is impossible to distinguish the nauplii and first copepodite stage of the two species, but when adults and older copepodites of only one species have been found regularly, the lower stages may with a high degree of certainty be regarded as belonging to the same species.

In fig. 86 is shown the numerical variation of the total stock of *A. clausi* at the different localities, in the periods when the numbers exceeded 60. *Acartia* was also found at other times of the year, but mostly in very few examples, mainly females.

At Sognesjøen *Acartia* was present from 21 July to 11 October 1949 and from 28 March to 25 October 1950. In 1949 maxima were observed in August and in October. No observations were made during September, when the main maximum probably has occurred. In 1950 *Acartia* was more abundant than in the preceding year, and was present for a longer period, with maxima in April, June and September. Observations were again lacking for most of September. After 11 October the stock diminished very rapidly.

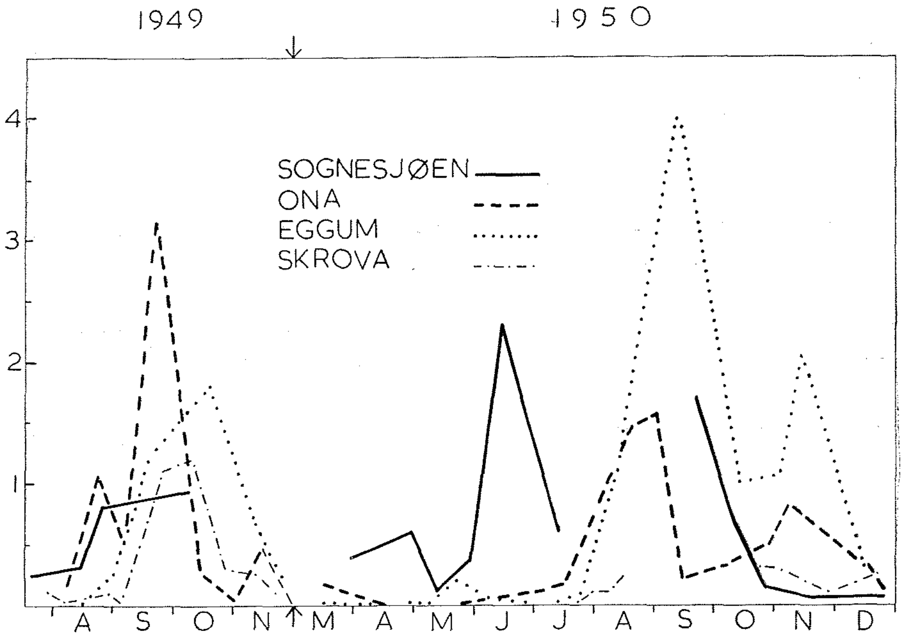


Fig. 86. Numerical variation of *Acartia clausi* in the periods of abundance in 1949 and 1950, in 1000's.

At Ona *Acartia* was very numerous in October 1948, with a stock of 3 800 specimens, nearly all (85.5 %) females. In April the stock numbered 1 000, of which 66,6 % were copepodites. From 27 April to 8 August the species was completely absent, and otherwise scarce in the periods not included in the drawing. Maxima occurred late in August, late in September and in the middle of November. In 1950 *Acartia* was more scarce, but present all the time, with peaks in March, late in August and in the beginning of November.

At Eggum *Acartia* was lacking in April and from 31 May to 16 August 1949, and was scarce in the other periods not included in the figure. Maximum numbers were observed in October 1949 and in September and November 1950. There were also some 200 individuals in the 50—0 m haul on 22 May 1950.

At Skrova *A. clausi* was very abundant in the autumn of 1948. The stock variation was as follows:

9/10	18/10	23/10	3/11	12/11	9/12
800	4 300	4 100	1 200	600	100

In the period 15 March—30 April 1949 no stock was found, and later only a few individuals until August. As will appear from fig. 86

maximum in stock occurred in September—October and the number decreased rapidly till the end of November. In 1950 there was a break in the observations from August to October.

Propagation.

Males, females, copepodites and nauplii have been counted separately. Most of the nauplii pass through the meshes of the net.

The variation in percentage composition of the stock of *A. clausi* at Sognesjøen in the periods of abundance in 1949—50 is shown in table 30.

Table 30. *The Percentage Composition of the Stock of Acartia clausi at Sognesjøen in 1949—50.*

	1949						1950					
	21/7	12/8	25/8	11/10	28/3	28/4	12/5	25/5	14/6	10/7	21/9	11/10
♂	—	—	—	10.8	—	30.8	9.2	5.1	0.7	16.7	14.7	15.4
♀	10.4	35.3	7.4	8.1	7.6	7.7	6.1	—	0.7	16.7	8.8	7.7
C	6.6	*48.6*	43.2	*75.7*	7.6	30.8	33.7	31.7	*86.9*	33.3	32.3	30.8
N	*83.0*	16.2	*49.3*	5.4	*84.8*	30.8	51.0	*63.3*	11.7	33.3	*44.2*	*46.2*

From the occurrence of the nauplii we may conclude that there were maxima in spawning in July and September 1949 and March, May, (August—)September and October 1950.

At Ona (table 31) the nauplii were usually more scarce than at Sognesjøen. In the autumn of 1950 the observations have apparently not coincided with the actual spawning periods.

Table 31. *The Percentage Composition of the Stock of Acartia clausi at Ona in 1949—50.*

Date	17/4	22/8	5/9	22/9	11/10	14/11	14/3	17/7	16/8	30/8	13/9	5/10	25/10	6/11
♂	9.0	—	17.3	11.1	15.8	12.8	—	5.4	29.4	26.6	36.4	16.7	40.0	24.7
♀	9.0	33.3	17.3	11.1	63.1	38.3	4.9	5.4	29.4	31.7	30.3	50.0	20.0	55.1
C	66.0	66.7	48.1	76.2	13.2	42.6	81.5	89.3	35.0	41.8	30.3	33.3	40.0	18.6
N	16.0	—	17.3	1.6	7.9	6.4	13.6	—	6.2	—	3.0	—	—	1.1

From the variation in the stage composition it seems likely that more intensive spawning takes place in March—April, and possibly in July, August and October. The large and sudden fluctuations which occur in the size of the stock, confuse the spawning periods. RUUD

(1929) also mentions such fluctuations, which are probably caused by the movements of the surface layers, carrying with them a varying quantity of *Acartia*.

At Eggum (table 32) nauplii were only found in October 1949, but the high percentage of copepodites in the middle of September points to a spawning in late August. In 1950 the maximum of spawning also occurred in August.

Table 32. *The Percentage Composition of the Stock of Acartia clausi at Eggum in 1949—50.*

	1949				1950						
Date	1/9	17/10	12/11	24/11	9/8	24/8	12/9	13/10	1/11	14/11	16/12
♂ ..	21.6	5.6	15.4	10.7	21.8	9.0	12.5	15.0	30.	31.7	—
♀ ..	28.4	38.9	76.9	82.4	28.4	25.0	8.3	30.0	30.6	43.9	66.7
C ..	50.0	38.9	7.7	6.9	50.0	66.0	75.2	55.0	38.9	21.9	16.7
N ..	—	16.7	—	—	—	T	4.0	—	—	2.4	16.7

At Skrova some nauplii were found in October 1948, and there was a high percentage of copepodites from the beginning of October till December. In the autumn of 1949 nauplii were more common, being present throughout October. During the winter females were the only representatives, usually occurring singly. In 1950 observations were lacking in September and for most of October. Later the percentage of adults increased steadily. It seems as if the spawning of *A. clausi* at Skrova took place mainly in October of all the years investigated.

Both at Eggum and Skrova *A. clausi* is probably brought in by the coastal current from the south, mainly in the autumn, and this fact may explain the irregular variations in spawning and in the size of the stocks.

Vertical Distribution.

In all localities the bulk of *A. clausi* was taken in the upper 50 m with a few exceptions: At Sognesjøen a greater proportion of the stock occurred below 50 m most of the year 1950, except in May. At Ona the major part of *A. clausi* was found below 50 m from the end of October to the middle of December. At Skrova sometimes one third to one half of the stock kept below 50 m.

At Sognesjøen and Ona the males seemed to live in deeper water than the females, as shown in the table below for Sognesjøen on 4 different dates in 1950.

Date	Haul, m.	♂ %	♀ %
28/4	50—0	21.4	35.9
	200—0	30,8	7.7
25/5	50—0	0	2.9
	200—0	5.1	T
21/9	50—0	9.7	2.6
	200—0	14.7	8.8
11/10 ..	50—0	24.2	48.8
	200—0	15.4	7.7

In the deeper haul the percentage of males nearly always exceeds that of the females. On 21 September there was apparently no difference in the proportions between males and females in the two hauls.

At Eggum and Skrova no such difference could be clearly seen, on the contrary, males were sometimes proportionately more abundant in the shallow hauls than in the deep ones.

Acartia longiremis Lilljeborg.

As mentioned above, this species appeared sparsely in all the localities investigated. It is known to be neritic (FARRAN 1910), and this may account for the scattered occurrence in the present material. LYSHOLM (1912) found *A. longiremis* in numbers in the Trondhjemsfjord but scarce or lacking in the offshore waters.

A. longiremis was present at Sognesjøen in October and December 1948, June—July and October 1949 and from April to July 1950. The highest number of specimens found was 250 in October 1949 and 200 in May 1950. At other times the number was always below 50. At Ona a few specimens were encountered in August 1949 and in January 1950. According to RUUD (1929) *A. longiremis* was taken irregularly on the bank off Møre. A single specimen was observed at Eggum in June 1950. At Skrova *A. longiremis* was found a little more regularly, in March 1949 and from January to August 1950, but only in numbers up to 25.

All specimens of *A. longiremis* were taken in the upper 50 m.

Other Calanoids.

The following calanoid copepods have been found more or less regularly, but in small numbers:

Rhincalanus nasutus Giesbrecht, *Clausocalanus arcuicornis* (Dana), *Spinocalanus longicornis* Giesbrecht, *Aetideus armatus* Boeck, *Chiridius* *armatus* (Boeck), *Diaixis hibernica* (A. Scott), *Scolecithricella minor* Brady, *Amallophora magna* (*Scaphocalanus magnus*) (T. Scott), *Pleuromamma robusta* (Dahl), *Pleuromamma abdominalis* (Dahl), *Heterorhabdus norvegicus* (Boeck), *Candacia norvegica* (Boeck), *Candacia armata* (Boeck), *Anomalocera patersoni* (Templeton).

Rhincalanus nasutus was taken singly at Sognesjøen on 11 November and 29 December 1950. At Eggum single nauplii and copepodites probably belonging to this species were found in September and October 1949 and one female was found on 28 April 1950.

Clausocalanus arcuicornis has hitherto not been recorded from Norwegian waters. Owing to its small size it is easily overlooked or mistaken for *Paracalanus* or *Pseudocalanus*. According to VERWOORT (FARRAN 1951) the three species of *Clausocalanus*, *C. arcuicornis* (Dana), *C. pergens* Farran and *C. paululus* Farran all resemble each other very closely and can only be distinguished by size, the females measuring 1.0—1.6 mm, 0.9—1.05 mm and 0.75—0.82 mm respectively. FARRAN is of the opinion that they are three races of the same species, *C. arcuicornis*. The individuals found in the present material were all females, measured about 1.0 mm total length, and have been determined as *C. arcuicornis*, formae *pergens* and *paululus*.

At Sognesjøen single *Clausocalanus* females were taken in October 1949 and in December 1950. At Ona they were noticed a little more frequently, in November 1948, from October to December 1949 and in December 1950, at Eggum in November 1948, and in January and October—December 1949 and 1950. At Skrova *Clausocalanus* was taken from October to November 1948, in September—December 1949 and in December 1950. The species has also been found in plankton material from earlier years, in November—December 1938 being present from Møre to the Lyngenfjord north of Tromsø. I also took some specimens at station «M» in the Norwegian Sea in December 1952. The females were of two size-groups, measuring respectively 0.90 mm and 1.06 mm.

As already mentioned, *Clausocalanus* may be easily overlooked and a closer examination would undoubtedly have shown it to be present more frequently in the samples. The individuals were all found in the deeper hauls.

The species of *Clausocalanus* are all reported from the Northeast Atlantic (FARRAN 1920, 1951), and may thus be carried into Norwegian coastal waters by the current. *Clausocalanus* was always taken together with a number of other copepods of Atlantic origin.

Spinocalanus abyssalis is known from the deep Norwegian fjords (SARS 1903). A single copepodite of stage V was taken in the 200—50 m haul at Sognesjøen on 29 December 1949, and 2 females on 16 January 1950.

Aetideus armatus is also a deep water form, occurring sometimes at the surface during the night (VERVOORT 1952). Single individuals, mostly females, were found at Sognesjøen and Ona at different times of the year. At Ona both males, females and copepodites occurred on 16 December 1950. At Eggum *Aetideus* was still more scarce, being found only in April and September 1949 and in December 1950. At Skrova this species was not noticed.

Chiridius armatus is likewise a deep water species. At Sognesjøen it was only taken during the winter months, from December 1948 to February 1949, October 1949—February 1950 and September—December 1950, mostly in single specimens, maximum 31 individuals on 17 December 1948, all stages being present, but the first stage copepodites most numerous. At Ona and Eggum *Chiridius* was only caught once, in March and February respectively, but at Skrova it occurred more regularly all the year round, numbers never exceeding 20. From other observations it is known that *Chiridius* generally keeps close to the bottom and thus avoids the ordinary nets.

Scolecithricella minor occurred regularly in all the localities investigated, but in rather small numbers, the stock seldom exceeding a hundred specimens. The monthly mean numbers at Sognesjøen in 1949—50 are shown below.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	45	93	—	—	5	400	50	63	—	150	—	90
1950	49	80	71	100	79	270	25	—	450	33	100	55

Maximum numbers occurred on 17 December 1948, 1 June and 11 October 1949, 12 May, 16 June and 21 September 1950 with respectively 190, 500, 150, 150, 270 and 450 specimens. At Ona this species was more scarce, in 1949 found all the year found, but seldom more than 1—10 specimens each time. In 1950 only a few stragglers occurred in May, November and December. At Eggum we find about the same occurrence as at Ona, but at Skrova *Scolecithricella* was a little more numerous. The monthly mean numbers were as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	—	63	33	18	20	100	133	42	50	20	9	6
1950	13	—	4	18	8	9	1	1	—	—	16	17

Maximum numbers, 300 specimens, occurred on 4 July 1949. *Scolecithricella* was nearly always found below 50 m, a few specimens sometimes being taken in the upper 50 m.

Diaixis hibernica was taken once, at Ona on 14 November 1949.

One female of *Scaphocalanus magnus* was found at Sognesjøen on 16 January 1950.

Pleuromamma robusta occurred three times, at Sognesjøen on 25 May 1950 and at Eggum on 1 February and 16 December 1950, all females. It was also recorded in plankton hauls at Møre in September 1937.

One male of *Pleuromamma abdominalis* was found at Eggum on 5 January 1949.

Heterorhabdus norvegicus lives in the deeper layers of the Norwegian fjords. Stragglers were encountered at Sognesjøen in February and December 1949, March, May and June 1950, and at Ona in December 1949. No *Heterorhabdus* were observed at Eggum, but at Skrova single specimens, mainly females, were again met with all the year round.

Candacia norvegica is considered to be a deep water species (FARRAN 1948). Single specimens have been found at Skrova in October and November 1948 and in December 1950.

Candacia armata is epiplanctonic and regarded as an indicator of Atlantic water (SCOTT 1911, RUSSELL 1939, RAE 1951). It was recorded singly at Sognesjøen in October 1949 and October—November 1950, and at Ona in December 1950. At Eggum a few copepodites of *C. armata* were found on 3 November 1948. In 1949 the species was lacking, but in the autumn of 1950 it occurred from 13 October to 29 December, the numbers varying from 2 to 59. All stages were found, included nauplii, on 13 October and 1 November. *C. armata* was also recorded in plankton material from the Vestfjord in November 1938.

Anomalocera patersoni belongs to the Skagerak and North Sea (SCOTT 1911, RAE and REES 1947). Single individuals were taken at Sognesjøen in June 1949 and January 1950.

Copepoda Cyclopoida.

Oithona similis Claus.

Oithona similis is one of the most common copepods in Northern waters, and is also very abundant, especially in the autumn. Only adults and copepodites have been included in the counts, as most of the nauplii pass through the meshes of the net. As shown earlier (page 59—65) *O. similis*, (nauplii excluded), is usually second to *Calanus finmarchicus* in number, constituting 20—30 % of the total number of copepods, but owing to its small size only forming 0.2—5 % of the copepod volume.

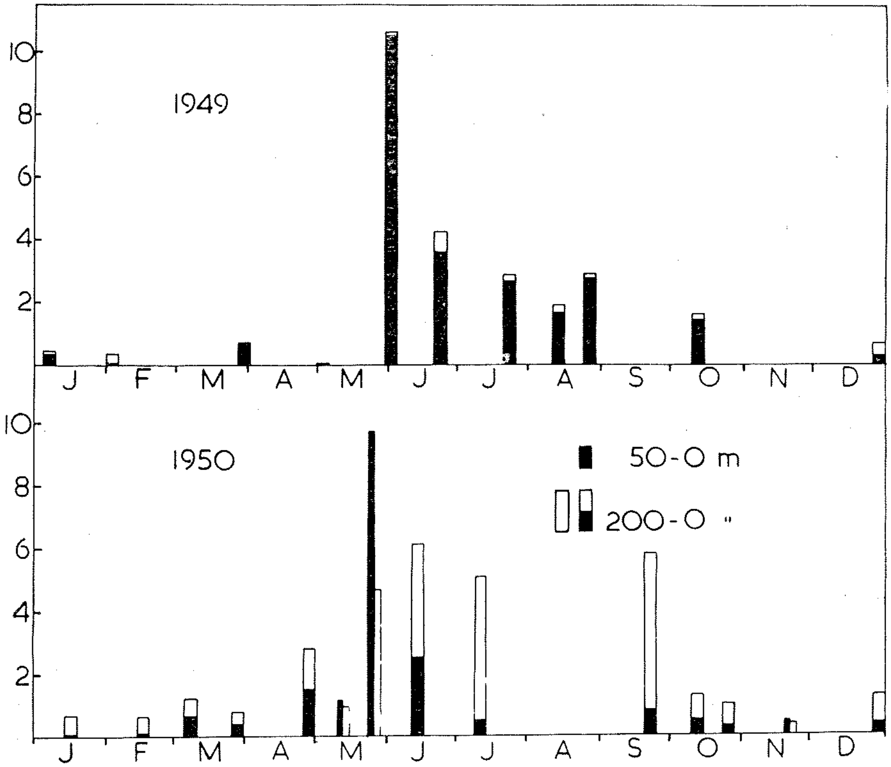


Fig. 87. Numerical variation of *Oithona similis* at Sognesjøen in 1949 and 1950, in 1000's.

Numerical Variation.

The numerical variation of *O. similis* during 1949—50 is shown in fig.s 87—90.

At Sognesjøen the species was usually scarce till the middle of May. Minor peaks are indicated in March and April (1950 only). The spring maximum seems to have occurred in May both years. At the end of May 1950 the 50—0 m haul yielded much more than the 200—0 m haul, probably because of random variation. Observations were lacking in September 1949, and in August and part of September 1950, in which period the main maximum of the year is likely to have occurred.

At Ona *O. similis* was more abundant. The main maximum of the year appeared in September 1949 and in August 1950. Secondary peaks were found in February, April, and June 1949, and in February, May, July and December 1950. *O. similis* was very scarce from October 1949 till June 1950, but was much more numerous in August 1950 than in the same month of 1949.

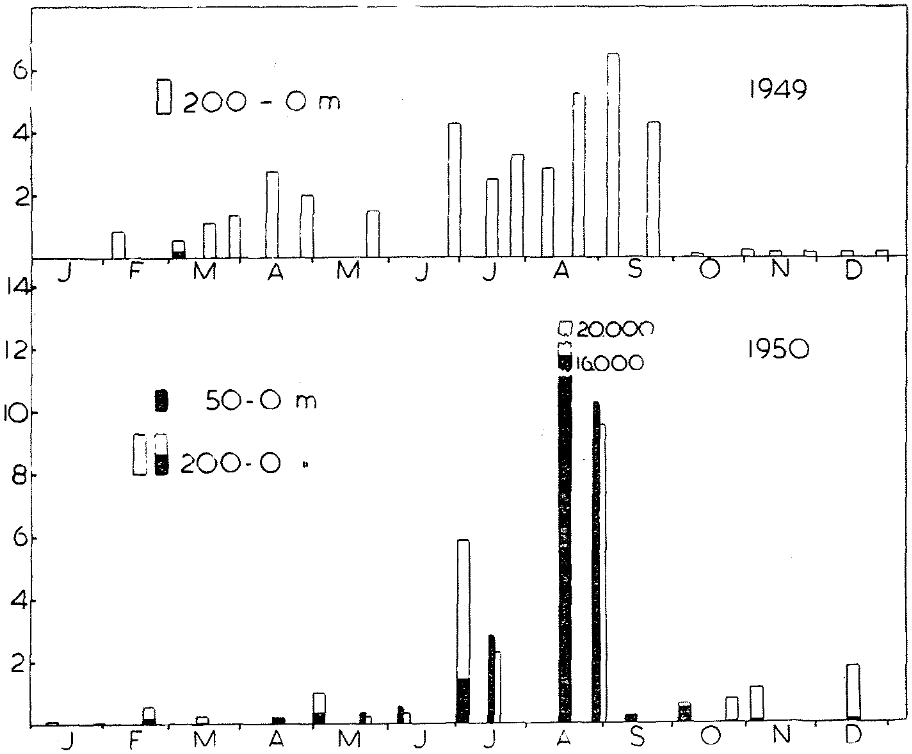


Fig. 88. Numerical variation of *Oithona similis* at Ona in 1949 and 1950, in 1000's.

At Eggum *O. similis* was still more strongly represented than at Ona, and the autumn period of abundance more extended. Both years the main maximum occurred in September, with additional peaks in March and June 1949, and in April, May, July and November 1950. *O. similis* was on the whole much more numerous at Eggum in 1949 than in 1950.

At Skrova the species was very abundant in the autumn of 1948, the total figures for October—November being: Oct. 9: 14 400, Oct. 23: 9 500, Nov. 12: 7 800. In 1949—50 *O. similis* was again less abundant, but with the main occurrence in the autumn. In 1949 the main maximum occurred in August and in September, other peaks at the beginning of February and in July. Minor peaks are also found in all the other months except April. *Oithona* seems also to be of some importance from October to March. In 1950 observations were lacking from the middle of August to the last days of October. At other times of the year *Oithona* seems to have been less abundant than in the corresponding periods of 1949. There are peaks in January, February, May, November and December.

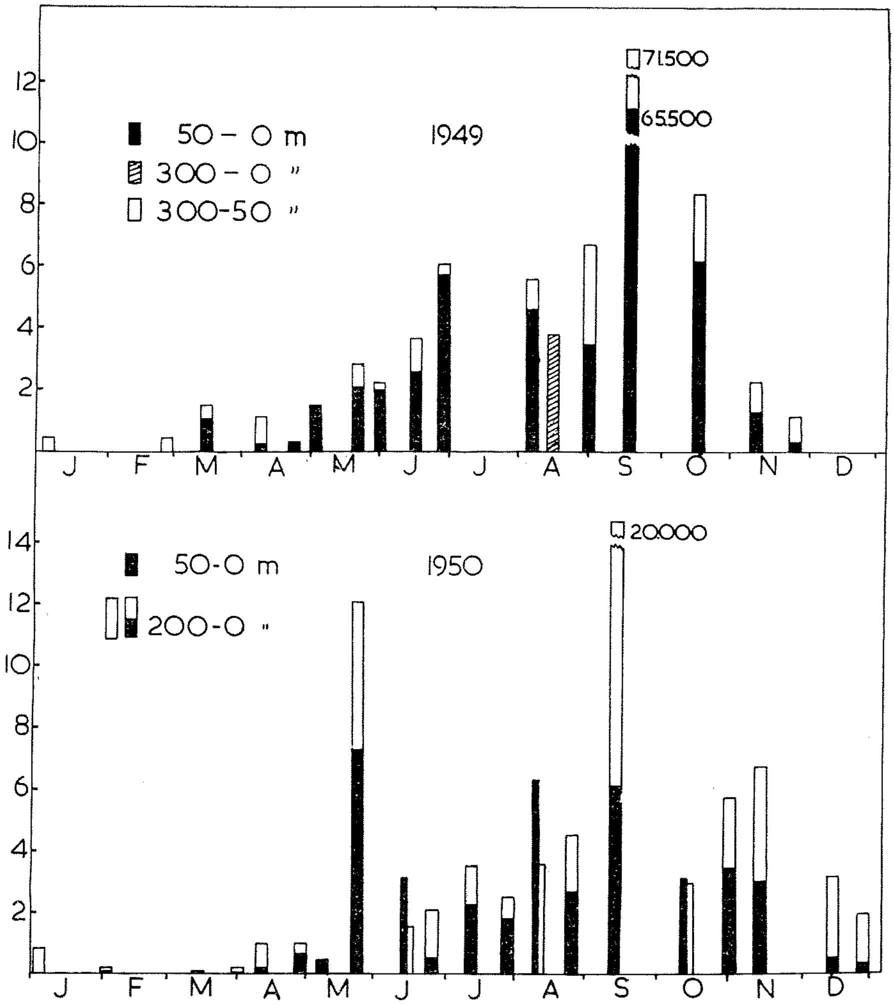


Fig. 89. Numerical variation of *Oithona similis* at Eggum in 1949 and 1950, in 1000's.

The maximum abundance of *O. similis* in late summer and autumn is in conformity with the observations of other plankton workers.

Propagation.

Males, females and adults have been counted separately, the nauplii are only caught to a small extent by the Nansen net and can be left out of consideration.

O. similis is known to be very prolific and to propagate most of the year. In an attempt to trace the possible periodicity in breeding, the relative percentages of the females have been calculated, and are

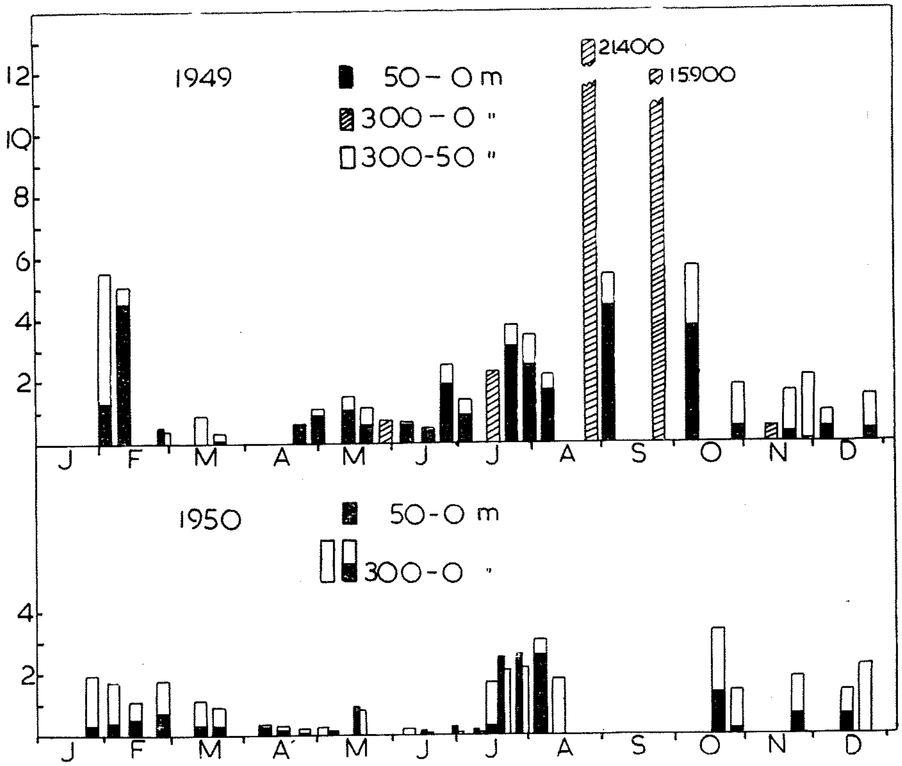


Fig. 90. Numerical variation of *Oithona similis* at Skrova in 1949 and 1950, in 1000's.

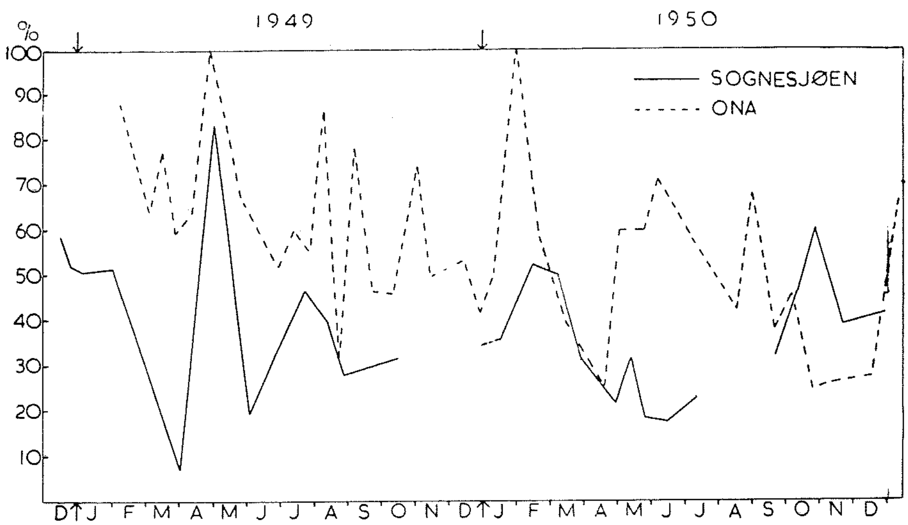


Fig. 91. Variation in percentage of the females of *Oithona similis* at Sognesjøen and Ona in 1949 - 50.

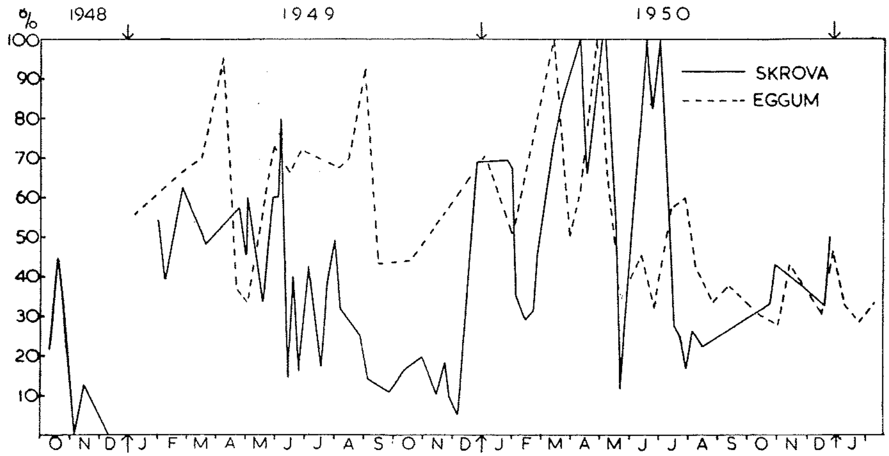


Fig. 92. Variation in percentage of the females of *Oithona similis* at Eggum and Skrova in 1949 50.

shown for Sognesjøen and Ona in fig. 91, for Eggum and Skrova in fig. 92.

At Sognesjøen there were peaks in percentage in January, May and July of 1949 and in February—March, May (small) and October 1940.

At Ona more conspicuous peaks were noticed in February, May, August, September and November of 1949, and in February, May—June and August—September of 1950. The next peak appeared in January or February 1951.

At Eggum the most prominent peaks appeared in March and September 1949 and in January, March, April and July of 1950.

At Skrova the percentage variations were very irregular, but major peaks are indicated in February, May and August 1949, and in January, April—May and June—July of 1950.

We must be careful in drawing too detailed conclusions from the percentage variations. It seems as if there are from three to five periods of more intense reproduction during the year, but the percentage of females is usually 25 or more most of the year, indicating that propagation may go on more or less continuously, as has also been shown for other areas (Marshall 1949 and others).

Vertical Distribution.

The black columns on the figures indicate the numbers in the upper 50 m.

In 1949 the entire stock at Sognesjøen was nearly always taken in the upper 50 m, while in 1950 a greater proportion, usually more than 50 %, swam below 50 m, except in May. At Ona nothing can be said of the conditions in 1949. In 1950 the maximum number was nearly always found in the upper layers. One some occasions, however, the major part of the stock of *O. similis* frequented the layers below 50 m.

At Eggum most of the *Oithona* was taken in the upper 50 m, a certain proportion always in the deeper layers, on some occasions more than 50 %, as in September, November and December of 1950.

At Skrova the major part of the 1949 hauls gave more *Oithona* in the upper 50 m, except from October to December. In 1950 *Oithona* was more abundant in the upper 50 m from the middle of April to the beginning of August.

Oithona spinirostris Claus.

This is considered to be an Atlantic form (FARRAN 1911). In the present work I have attempted to distinguish the copepodites of the two *Oithona* species, but some of the smallest copepodites may have been confused. The numerical variation of *O. spinirostris* during 1949—50 at the localities investigated is shown in table 33. Where more than one haul has been made in a month, the average figure is given. The number seldom exceeds a few hundred specimens.

Table 33. *The Monthly Mean Numbers of Oithona spinirostris at the Investigated Localities in 1949—50.*

1949	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
SN	45	26	0	—	—	200	*750*	365	—	50	—	100
O	—	25	117	—	*1000*	200	350	300	*450*	50	15	0
E	—	25	0	5	17	150	—	*800*	*830*	50	116	—
S	—	91	8	10	17	33	*168*	*100*	80	0	117	*170*
1950												
SN	100	20	33	*400*	55	*360*	150	—	150	90	42	60
O	2	0	9	0	16	16	*350*	85	—	9	—	66
E	0	25	4	*160*	93	8	85	*485*	160	150	145	58
S	88	92	1	0	8	30	25	63	—	5	16	59

At Sognesjøen maximum in occurrence was found in July—August 1949 and in April and June 1950. No hauls were made in August 1950. At Ona *O. spinirostris* was also comparatively scarce, sometimes entirely absent, with peaks in May, July and September 1949, and July 1950. At Eggum a maximum seems to have occurred at the end of August both years, and a small peak is also indicated in April 1950. At Skrova the figures, with small variations, were generally lower than at Eggum. The numbers were highest in February, (August—) September and December both years.

Some specimens of *O. spinirostris* were taken in the upper 50 m, but the main part of the stock came from the deeper hauls. Mainly females were caught, copepodites were less frequent, and the males very scarce.

Oncaea borealis G. O. Sars.

This species seems to be rather common in Norwegian fjords on the east and west coast (RUNNSTRØM 1932, WIBORG 1940) in the intermediate and deep water layers, but less abundant on the banks (RUUD 1929). P. JESPERSEN (1939) says it has its main distribution in colder, partly arctic areas. In the present material it was always scarce, except at Sognesjøen, where a moderate sized stock was present between March and August both years. In 1949 the number in this period varied between 150 and 750, with maximum on 23 June. In 1950 the figures were higher, 100—2 000, the main maximum occurring in the middle of June, another peak of 800 specimens on 28 April. Outside the period mentioned the numbers were always below a hundred.

At Ona *Oncaea* was scarce, but undoubtedly present most of the year, even if it was not always noticed because of its small size. In July 1950 300 specimens were taken, on other occasions the number never exceeded 50.

At Eggum *Oncaea* was likewise scarce, only being noticed from May to September 1949 and April—August 1950. A single specimen was also taken in December 1950. Maximum numbers were observed in June and August 1949 and in July 1950, 150, 250 and 360 specimens respectively.

At Skrova the species was found regularly all the year round, but numbers exceeded a hundred only on two occasions, in November 1948 (300) and in May 1950 (150).

O. borealis was usually equally distributed above and below 50 m at Sognesjøen in 1949, (58 % and 42 % respectively), but on many occasions the major part of the stock was taken below 50 m. At Eggum and Skrova the bulk of the *Oncaea* was nearly always taken in the deeper hauls.

Some 300 specimens of *Oncaea similis* G. O. Sars were taken at Sognesjøen on 28 March 1950, a few also on 21 September of the same year. This species has previously been recorded from some fjords near Bergen (SARS 1918, RUNNSTRØM 1932).

Oncaea minuta Giesbrecht. Single females were noticed in 1950 at Sognesjøen on 28 April and 16 December, at Ona on 6 November and 16 December. SARS found this species near Bergen.

Corycaeus anglicus Lubbock.

Corycaeus anglicus is shown by RAE and REES (1947) to be an autumn and winter form in the South-Eastern North Sea, being most abundant in European coastal waters from Denmark to Holland. It has also been found off Bergen from June to February (NORDGAARD 1912) and in the fjords near Bergen in the first months of the year (RUNNSTRØM 1932).

Corycaeus was not observed in 1949. In 1950 some 250 females were taken at Sognesjøen on 21 September, and later single specimens occurred until the end of December. At Ona single females were taken from 30 August to the end of December. At Eggum the species was present from 13 October 1950 to 9 January 1951. In November males, females and copepodites were all found, but the total number never exceeded 50. Other organisms of southern origin were taken at the same time, e. g. *Candacia armata* and salps. Single *Corycaeus* were also observed at Skrova from 13 October to 25 November 1950.

Most of the *Corycaeus* taken in Norwegian coastal waters probably originate in the Skagerak or the North Sea, and are carried northwards by the coastal current, but it can be assumed that some individuals have been introduced by the North-Atlantic current, as the species is also recorded from the North-Atlantic Ocean (SARS 1918).

Conaea rapax Giesbrecht. One male of this peculiar small copepod was found at Sognesjøen on 16 January 1950. It has not previously been recorded from Norwegian waters, only from the Atlantic Ocean (v. BREEMEN 1908).

Copepoda Harpacticoida.

Copepods belonging to this order were always scarce, mainly because so few species are really pelagic, and also because they are so small that they easily escape through the meshes of the Nansen net.

Microsetella norvegica Boeck was recorded in 1950 at Sognesjøen in March and May, at Ona in December, and at Eggum in February and March. At Skrova it was found more regularly from June to December 1949, highest number 300 specimens on 25 September, and in 1950 it occurred singly from January to May and in December, the apparent absence during summer probably caused by bad preservation of the samples.

Single *Halithalestris croni* (Krøyer) occurred at Sognesjøen in July 1950, at Ona in August and at Skrova in March of the same years.

Copepodites and nauplii of *Longipedia* spp. were taken in small numbers at Sognesjøen and Ona in August and September 1949 and at Eggum in July 1950.

Other harpacticoid copepods were found singly, but not determined.

Copepoda Monstrilloida.

Monstrilla longicornis J. C. Thompson. Single females at Ona on 16 December 1950, and at Eggum on 11 June and 12 November 1949.

Cymbasoma rigidum Thompson. One male at Eggum on 9 January 1951.

Other Organisms.

Cladocera.

Evadne nordmanni Lovén was numerous at Sognesjøen during the summer. The mean numbers per month in the total hauls during 1949—50 are shown below.

	Mar.	April	May	June	July	Aug.	Sept.	Oct.
1949	—	—	—	4250[1]	300	few	—	few
1950	9	550	100	2000	150	—	850	16

[1] 8200 specimens on 1 June.

The maximum in both years fell in the first half of June.

At Ona *Evadne* was more scarce, present from April to November, with maximum numbers in August—September. The monthly mean numbers were as follows:

	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
1949	few	—	200	—	300	450	16	1
1950		5	0	33	160	5	—	9

At Eggum the period in which *Evadne* occurred was still more restricted. In 1949 it was only present on 17 September, and in 1950 from 28 July till 14 November, the mean monthly numbers being: July: 1, August: 565, September: 2000, October: 100, and November: 1.

Skrova had a small stock of *Evadne*, never exceeding 200 specimens in the months July—October of both years.

The *Podon* spp. had about the same occurrence as *Evadne*. Three species occur, *P. leuckarti* G. O. Sars, *P. polyphemoides* (Leuckart) and *P. intermedius* Lilljeborg.

At Sognesjøen the figures were as follows:

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
1949	0	0	0	2000	400	250	—	250
1950	1	33	2	50	300	—	200	—

P. leuckarti was present from March to June, inclusive of the June maximum, and replaced by *P.polyphemoides* in July. A few specimens of *P. intermedius* were observed in October 1949.

At Ona the *Podon* spp. had their main abundance from July to September, but a few individuals were also encountered in January, April, October and November of 1950. The August maximum both years was entirely made out of *P. polyphemoides*.

	July	August	Sept.	October	Nov.
1949	0	1 400	1 108	9	50
1950	16	420	0	0	0

At Eggum the *Podon* spp. were present mainly from August to November, some specimens also being taken on 2 May 1949. The mean monthly figures were as follows:

	August	September	October	November
1949	16	750	300	—
1950	500	3000	—	9

P. polyphemoides was entirely dominating, but single *P. leuckarti* were observed in August 1950.

The *Podon* spp. were scarce at Skrova, present in 1949 in April and in July—September, in 1950 in May and July—August, perhaps also in September. During summer and autumn *P. polyphemoides* was more commonly found. The stock variation in the two years was the following:

	April	May	July	August	September
1949	100	0	150	125	110
1950		90	1	100	—

The cladocera were all mainly taken in the upper 50 m.

Decapoda.

Adult decapods were only taken on a few occasions. Single individuals of *Pasiphaea sivado* Risso were found at Sognesjøen in June and July 1949. *Pasiphaea tarda* Krøyer occurred at Skrova in January, June and December 1949 and in December 1950, always singly.

Larvae of different species of decapods were found quite regularly. The occurrence at the different localities during 1949—50 is shown in table 34.

Most of the decapod larvae are found in the months March—August, in sparse numbers. The *Munida* and *Pagurus* larvae were most numerous, especially from April to July.

Euphausiacea.

The euphausiids or krill are very important in the economy of the sea. A very good survey of the significance of this group as food for different sea animals, birds and fish is given by EINARSSON (1945 pp. 159—163). The present author has shown that euphausiids constitute the main food of cod of the O—I group in some Norwegian fjords (WIBORG 1949). Adult euphausiids are only occasionally taken in the Nansen net.

At Sognesjøen the following species were taken singly: (1) *Thysanopoda acutifrons* Holt & Tattersall, in June 1949, (2) *Meganyctiphanes norvegica* M. Sars, in January 1950, (3) *Nyctiphanes couchii* (Bell), in October 1950 and (4) *Thysanoessa inermis* (Krøyer), in June 1950.

At Ona *Thysanoessa* was caught in October 1948 and August 1950, *Meganyctiphanes* in January and September 1949 and *Nyctiphanes* in November and December 1949. RUUD (1928) found larvae of the latter species off Møre, but says that no adults had hitherto been recorded from Norwegian waters.

At Eggum *Meganyctiphanes* was taken in January, September 1949, and in May 1950, while at Skrova *Thysanoessa* and *Meganyctiphanes* occurred quite regularly, the former in October 1948, May, October and November 1949, and February, March, October and December 1950, the latter in October and November 1948, June, July, September and October 1949 and in October 1950. The numbers varied from 1 to 25. The euphausiids were mainly taken during the darker time of the year, and chiefly in the deeper hauls.

According to EINARSSON (1945) *Thysanopoda acutifrons* has its northern border of distribution restricted by the submarine ridge stretching from The Faeroes to Iceland and Iceland-Greenland. The adults occur mainly in the intermediate and deep water layers, the larvae in the upper 100 m, which may account for the presence of this species at Sognesjøen and Skrova, being brought in as larvae by the North-Atlantic current.

Table 34. *The Monthly Mean Number of Decapod Larvae in the Total Hauls at Sognesjøen, Ona, Eggum and Skrova in 1949, and 1950 (in brackets).*

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Sergestes articus	SN	—	—	—	(58)	(6)	1	—	—	—	—
Pandalus borealis	SN	—	—	—	(1)	—	1	—	—	—	—
	O	—	—	—	—	—	1	—	—	—	—
	E	—	—	—	8(3)	2 (1)	—	—	(1)	—	—
	S	—	(1)	—	2	2 (2)	1	2	—	—	—
Hippolyte sp.	SN	—	—	(2)	(1)	(1)	—	—	—	—	—
	O	—	(1)	7(7)	2	2	2(5)	—	10	—	—
	E	—	—	—	—	1(1)	(1)	(1)	—	—	—
	S	(1)	(2)	—	(12)	—	—	3(1)	—	—	—
Sabinea sɩp-temcarinata	E	—	—	—	—	(1)	—	—	—	—	—
Pontophilus norvegicus	SN	—	—	(1)	—	(1)	—	—	—	—	—
	E	—	—	—	(1)	1(1)	—	—	—	—	—
	S	—	—	—	1	2(2)	—	1	—	—	—
Galathea sp.	SN	—	—	—	—	—	—	(1)	—	—	—
	O	—	—	—	—	—	—	—	4	—	1
Munida sp.	SN	—	—	(1)	(2)	(7)	7(1)	2(1)	(1)	—	—
	O	—	—	—	15(2)	42(6)	6(7)	17(4)	3	—	—
	E	—	—	—	(14)	15(17)	10(15)	(1)	(3)	—	—
	S	—	—	(3)	2(1)	4(4)	5(3)	3(2)	1	—	—
Pagurus sp.	SN	—	—	—	—	(1)	(2)	3	—	—	—
	O	—	—	6	5	—	(2)	1	(1)	—	—
	E	—	—	(1)	17(2)	1(8)	6(2)	—	4	1	—
			—	(1)	1(8)	1(1)	10	1(1)	1	—	—
Hyas sp.	SN	—	—	(1)	—	(2)	—	(4)	—	—	—
	O	—	—	4	2	—	(2)	(1)	(1)	—	1
	E	—	—	1	2(4)	6(5)	2(1)	—	—	—	—
	S	—	—	—	(3)	2(3	5(1)	2	(1)	—	—

Eggs, nauplii, metanauplii and furcilia larvae of the euphausiids have been counted separately. In the figures all the different species of euphausiids have been taken together. The eggs and early nauplii of *Meganyctiphanes* can hardly be distinguished from those of *Thysanoessa inermis*, but the larvae of the latter species were usually dominating.

The numerical occurrence of eggs and larvae of euphausiids at Sognesjøen in 1949—50 is shown in fig. 93.

At the end of March 1949 eggs were abundant, and some nauplii also occurred. At the beginning of June mostly calyptopis and a few furcilia larvae were taken, about 2/3 belonging to *Meganyctiphanes*. In June and July a few eggs were again found. RUNNSTRØM (1932) states that near Bergen both *Meganyctiphanes* and *Thysanoessa inermis* spawn from March to July—August.

In 1950 a few euphausiid eggs were taken in February and the first days of March, but the bulk was again met with at the end of March. At the end of April the development had advanced to metanauplii and a few calyptopis. Again 2/3 of the larvae belonged to *Meganyctiphanes* and the rest to *Thysanoessa*. A new batch of eggs, probably of *Meganyctiphanes*, occurred at the end of May and in the middle of June. The larvae present were mainly *Meganyctiphanes*, but single *Thysanoessa longicaudata* furcilia were taken in May. A few larvae of *Meganyctiphanes* and *Thysanoessa inermis* were also found in September and October.

At Ona (fig. 94) in 1949 krill eggs were mainly present from the beginning of March to the middle of April. The nauplii were most numerous in the last half of March. Some eggs were found in the last days of May, and single eggs and larvae were also taken in the remaining months of the year. The larvae were nearly all *Thysanoessa inermis*.

In 1950 very few eggs and larvae were present in the middle of March, but eggs were abundant in April. In the 50—0 m haul 1850 eggs were taken. A second maximum of eggs appeared at the beginning of June, and this time the number was also the double in the 50—0 m haul. The older larvae present in April were mainly of *Meganyctiphanes*.

Off Ona at the end of April 1926 RUUD (1928) found exclusively larvae of *T. inermis*, but at the end of July of the same year, *Meganyctiphanes* and *Thysanoessa* were represented in about equal numbers. In May 1927, however, *Meganyctiphanes* larvae were much more abundant than *Thysanoessa* larvae. RUUD concludes that the conditions may change from one year to another both regarding the relative abundance of the different species of euphausiids and the time of spawning, and this theory seems to be supported by the present material. HJORT and RUUD (1929) state that off Møre *Meganyctiphanes* adults are most abundant in the summer at the edge of the continental shelf, while

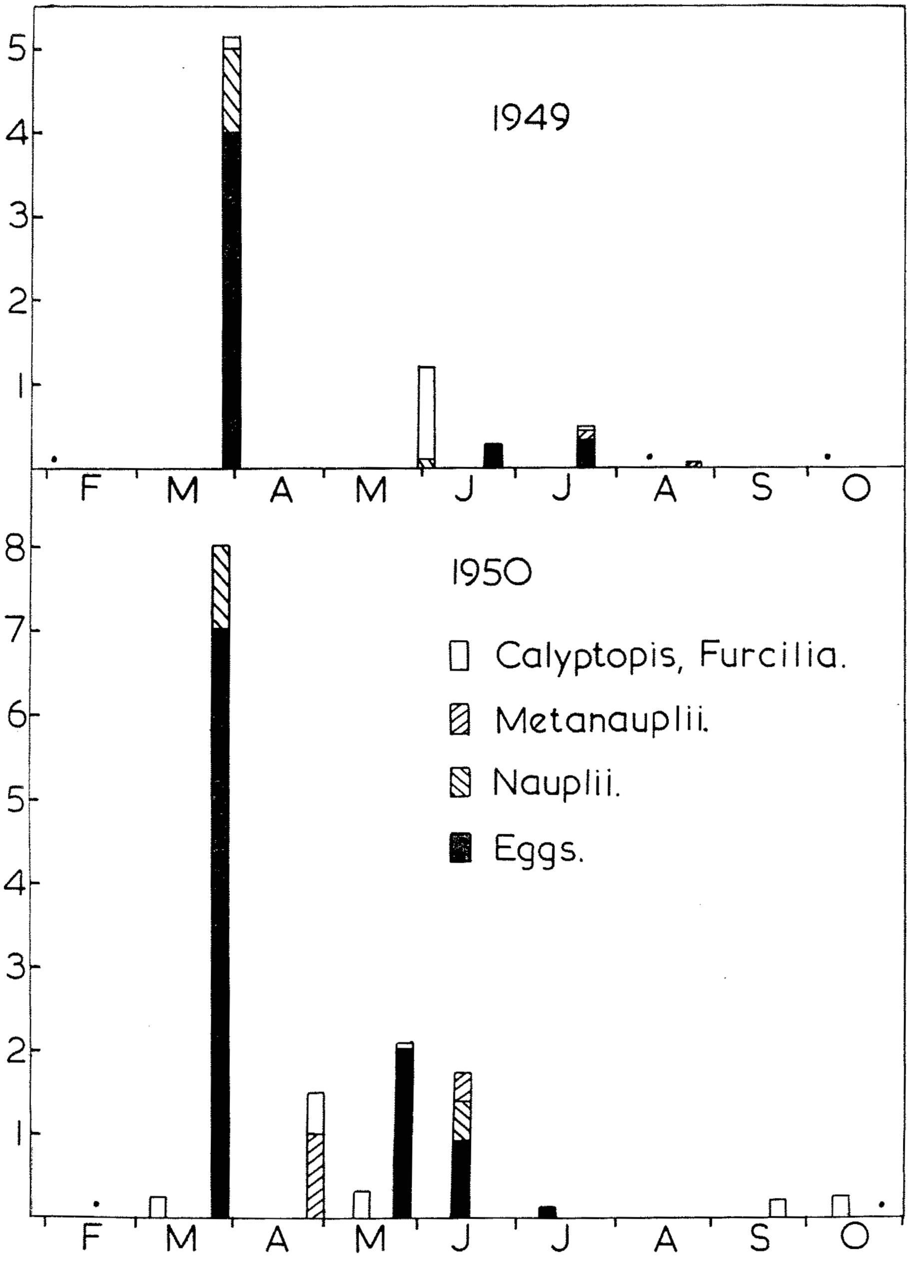


Fig. 93. Numerical variation of eggs and larvae of euphausiids at Sognesjøen in 1949 and 1950, in 100's. Dots: negative hauls.

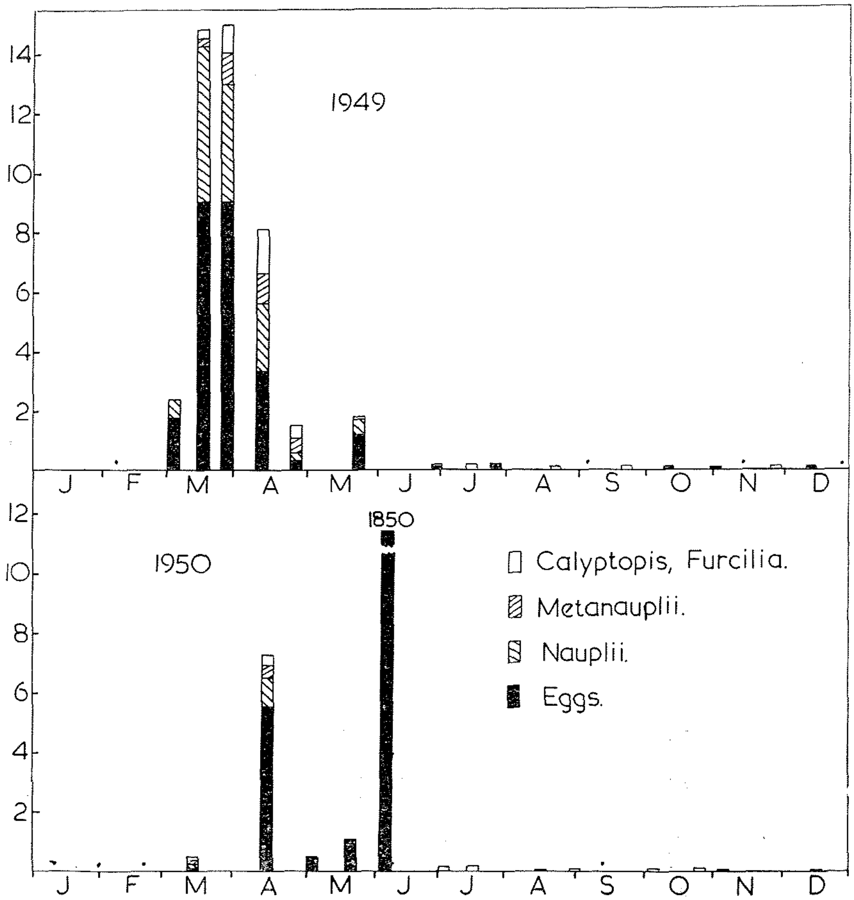


Fig. 94. Numerical variation of eggs and larvae of euphausiids at Ona in 1949 and 1950, in 100's. Dots indicate negative hauls.

Thysanoessa inermis has its maximum in the winter, on the coastal banks. Maxima of krill eggs and of nauplii, mainly of *T. inermis*, often occurred simultaneously in March—April. *Meganyctiphanes* spawns chiefly in summer.

In Icelandic coast waters *Meganyctiphanes* spawns in March—May (Einarsson 1945).

The occurrence of euphausiid eggs and larvae at Eggum in 1949—50 is shown in fig. 95. Both years the eggs and larvae are most abundant in April and May, with maximum number at the end of April or beginning of May. The figures are more than ten times as large as at Ona. It will be seen that euphausiid eggs were much more scarce in 1949 than in 1950, while the number of larvae was much higher in 1949. As the euphausiids usually swarm during the spawning time (Hjort

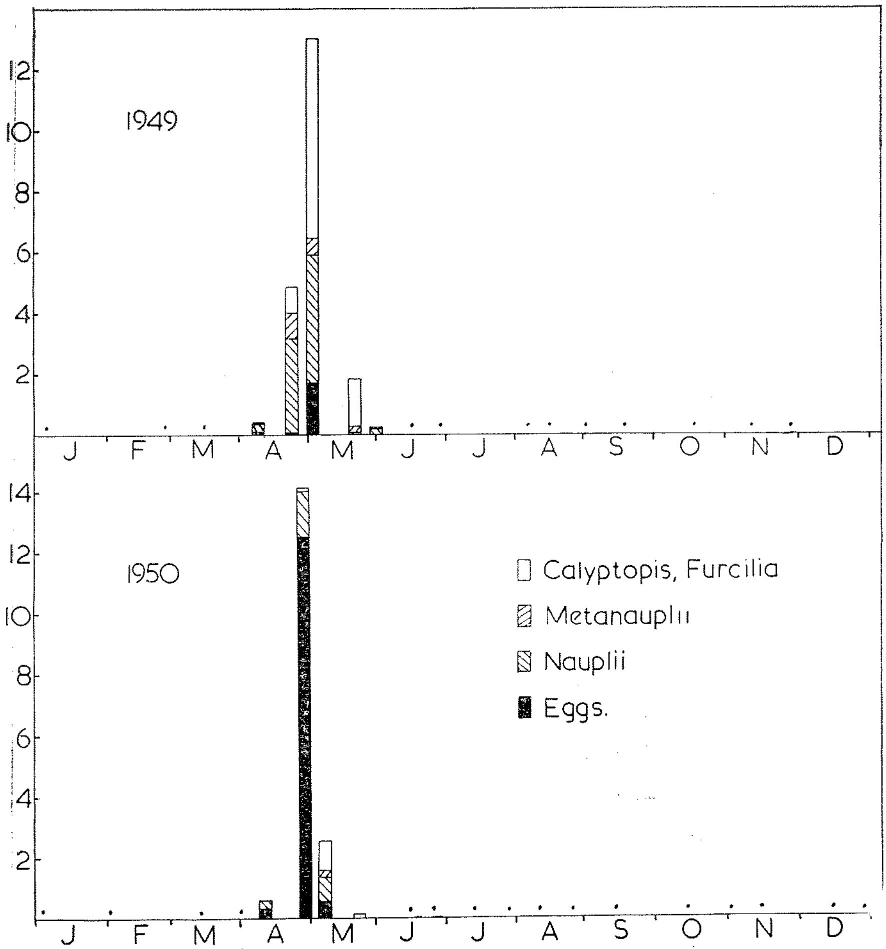


Fig. 95. Numerical variation of eggs and larvae of euphausiids at Eggum in 1949 and 1950, in 1000's. Dots indicate negative hauls.

and RUUD 1929) the occurrence of the eggs may be restricted both in time and area, and we may have missed the actual spawning in 1949. Off Eggum surface currents are very active, and have probably brought in the larvae found there in April—May 1949, and in 1950 carried away the larvae from the spawning area.

The larvae both years belonged mainly to *T. inermis*, but in May and June 1950 single larvae of *T. longicaudata* appeared. HJORT and RUUD (1929) state that *T. inermis* is the most important species of krill in the Lofoten and Finmarken area, while *Meganyctiphanes* is more scarce. *T. longicaudata* may be numerous in bank water in summer, but in spring it is only found far at sea in Atlantic water. The latter

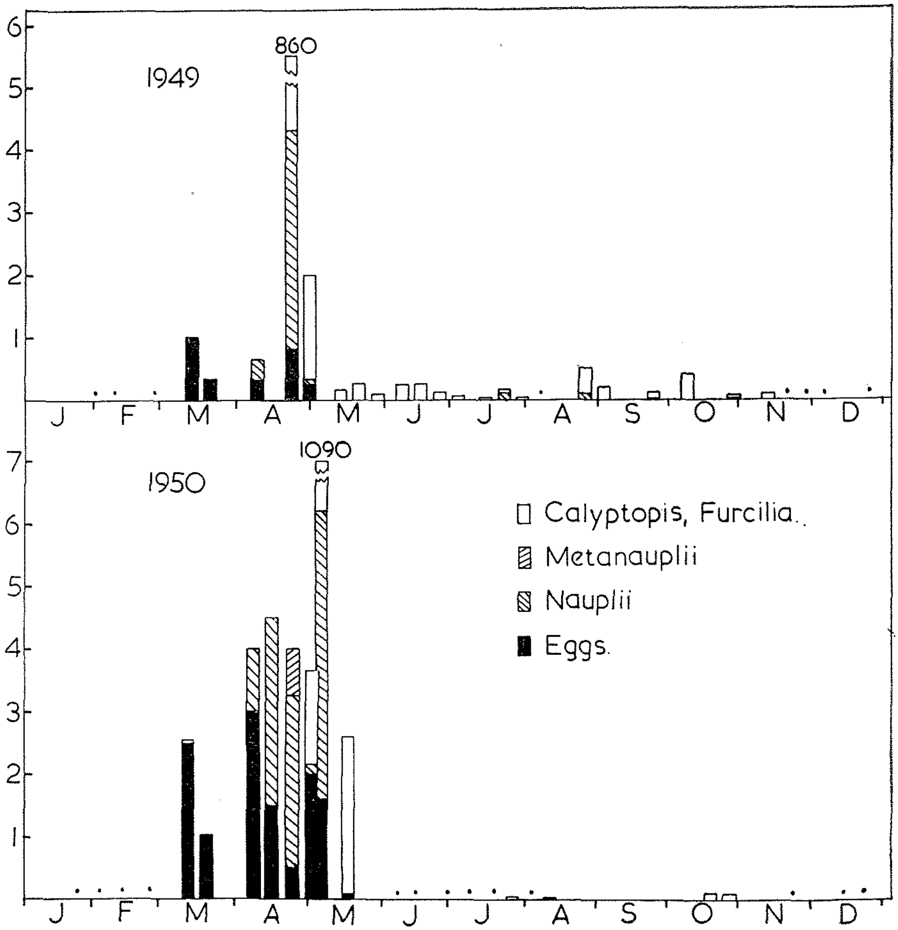


Fig. 96. Numerical variation of eggs and larvae of euphausiids at Skrova in 1949 and 1950, in 100's. Dots indicate negative hauls.

statement does not agree with the present author's experience, as adults of *T. longicaudata* were quite common just outside the continental shelf off Eggum in April and May.

At Skrova (fig. 96) the main occurrence of euphausiid eggs and larvae is restricted to the months March—May, with maximum at the end of April (1949) or beginning of May (1950). The figures are only 1/10 or less of those at Eggum. The bulk of the larvae belonged to *T. inermis*, but some *Meganyctiphanes* larvae were taken in May of both years.

Sømme (shown in Hjort and Ruud 1929, fig. 43) found that *T. inermis* and its eggs were very scarce in the northern part of the Vestfjord as compared with the southern (outer) part. This can also be shown very clearly in two series of vertical hauls from a longitudinal section of the Vestfjord at the end of April 1947 (table 35). For localisation see fig. 54, page 109.

Table 35. *Number of Eggs and Larvae of Krill in the Total Hauls in a Longitudinal Section of the Vestfjord on 24—25 April (upper series) and 7—8 May 1947.*

Stations	110	111	112	113	114	115	116	117
No. of eggs and larvae.	4150	1469	3947	453	246	128	325	96
Stations	142	143	144	145	146	147	148	
No. of eggs and larvae.	65	458	2687	335	346	835	20	

At the end of April the number of euphausiid eggs and larvae was decidedly greater in the outer part of the Vestfjord than in the inner fjord. A fortnight later the highest number is also found in the outer fjord, but not at the outermost stations. The larvae have now developed to furcilia stages, which are more mobile and able to avoid the net. A similar distribution of krill eggs and larvae in the Vestfjord was also observed in two cruises at the beginning of April and beginning of May 1949.

SØMME (1934) is of the opinion that the higher numbers of krill eggs in the outer part of the Vestfjord is due to the higher temperature and salinity prevailing there during the spawning time.

The larvae and eggs of the krill have always been found most abundantly in the upper 50 m, but a few eggs and larvae also occurred in the deeper water layers.

Amphipoda.

Themisto abyssorum Boeck (*Parathemisto oblivia* Krøyer) was taken singly at Sognesjøen in July, August and December 1949 and in September and November 1950. At Ona this amphipod was a little more numerous, but usually below 10 individuals per haul, being present from 29 June to 22 September 1949 and from 6 June to 30 December 1950. Both years the maximum numbers were found at the beginning of July, 32 and 13 specimens respectively.

At Eggum *Themisto* was present from 21 May to 17 September 1949 and from 1 February to 16 December 1950, the maxima occurring in the middle of August and in the middle of October 1950, respectively 18 and 24 individuals.

At Skrova *Themisto* was found all the year round, the numbers varying between 1 and 26 specimens. On 15 July 1950 some 250 small specimens were taken, probably from the breeding sacks of a few females in the sample. RUSSELL (1939) regards the species, when found in the Northern North Sea, as an indicator of water of mixed oceanic and coastal origin. Local stocks seem, however, to exist in Norwegian fjords and coastal areas.

T. abyssorum was mainly taken below 50 m.

Other amphipods occurred singly, e. g. *Scina borealis* G. O. Sars, at Skrova on 5 February 1949.

Isopods were occasionally found, mostly larvae and males of parasitic species.

Ostracoda.

The species within this group are mainly inhabitants of the bottom or deep water layers, but are occasionally found in the upper strata. In the present material exclusively representatives of the genus *Conchoecia* have been found.

At Sognesjøen the ostracods occurred sparsely in the months January—March and June—December of both years, the number varying from 1—100, highest during the winter months.

At Ona no ostracods were taken, and at Eggum they were also very scarce, 2—50 individuals at different times of the year.

Skrova was the only locality where the ostracods occurred regularly and in numbers, and the relative abundance of this group has been mentioned earlier (page 54).

The monthly mean number of ostracods at Skrova in 1949—50 is shown below:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	—	627[1]	933	600	333	100	288	250	175	257	297	465
1950	1200[2]	688	600	700[3]	483	0	9	13	—	42	500	450

[1] 1100 on 1 February. [2] 1700 on 31 January. [3] 1200 on 25 April.

The stock increases from October—November to a maximum in January—February, and it seems possible that the main propagation takes place in these months, but small individuals were abundant all the time from November to May. As the ostracods seem to swim mainly in the water layer close to the bottom, the figures have to be considered with caution. Very few specimens were taken in the upper 50 m.

The larger individuals were determined as *Conchoecia borealis* Sars, *C. elegans* Sars, and *C. obtusata* Sars. The small individuals could only be determined to genus.

Chaetognatha.

Sagitta elegans Verrill was taken regularly at Sognesjøen, Ona and Eggum, but the numbers were usually below 10, except at Sognesjøen in June—July 1949 (17—27 specimens) and at Ona on 13 July 1949 (102 specimens). The individuals then taken were very small.

At Skrova *S. elegans* was somewhat more numerous and the monthly mean numbers varied as follows:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	—	17	9	41	8	3	1	8	26	17	21	21
1950	21	17	3	42	40	0	0	0	—	1	1	6

Peaks occurred in April and September 1949 and in April—May 1950.

S. elegans was as a rule found below 50 m, and it may be assumed that at times it keeps close to the bottom and avoids the net. On the other hand, single specimens are often found in the upper 50 m.

Sagitta setosa J. E. Müller is, according to FRASER (1937), a typical North Sea species. RUNNSTRØM (1932) found it near Bergen from February to November, common in April—August. — Six specimens were taken at Sognesjøen on 21 September, and one on 11 October 1950. At Ona a few immature specimens were taken in August 1949, and August 1950 (see also page 68).

Eukrohnia hamata (Möbius) is considered by FRASER (1937) to be an indicator of oceanic mesoplankton, when present in open waters. EKMAN (1935) calls it a cold water cosmopolitan. It is very common in the depths of some Norwegian fjords (RUNNSTRØM 1932).

At Sognesjøen 16 specimens were taken on 24 December 1948, and a few individuals in January, March, October and December 1949 and in January, March, May and September—November 1950. At Ona single *Eukrohnia* were found on 3 occasions only, on 12 October 1948, 13 July 1949 and 5 October 1950. At Eggum single individuals occurred all the year round, while a stationary stock is found at Skrova, as shown below:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1948	No samples									102	54	—
1949	—	7	18	49	53[1]	26	56	50	38	7	9	16
1950	33	15	29	50	87[2]	0	90[3]	79	—	10	16	19

[1] 24 May: 141. [2] 6 May: 190. [3] 15 July: 200.

The highest numbers occur from April to August, with peaks in May and July. It may be assumed that the main propagation takes place in April—May, when many small newly hatched individuals are found. Small specimens have also been taken in February and March. The small *Eukrohnia* are easily distinguished from the young of *Sagitta*, in that they lack the eye pigment.

The *Eukrohnia* swim also mainly below 50 m, sometimes probably close to the bottom. Single small and immature specimens occur in the upper 50 m.

Copelata.

Oikopleura dioica Fol, *O. labradoriensis* Lohmann, *O. parva* Lohmann, *Fritillaria borealis acuta* Lohmann, *Fritillaria borealis truncata* Lohmann, and *Appendicularia sicula* Fol have been identified with certainty. A number of *Oikopleura* spp. have been determined to *O. vanhøffeni* Lohmann, but the identification of the individuals in question was somewhat problematic, as will be mentioned later on.

According to RUNNSTRØM (1932) and BÜCKMANN (1945) *O. dioica*, *O. parva* and *O. labradoriensis* all occur along the western coast of Norway. *O. vanhøffeni* is found in the Norwegian Sea southeast of Shetland (BÜCKMANN 1926) and also near the Faeroes (FRASER 1937, FRASER and SAVILLE 1949) which renders it possible that the species occurs along the western and northwestern coastline of Norway.

The numerical variation of the *Oikopleura* spp. at Sognesjøen in 1949—50 is shown in fig. 97.

The *Oikopleura* spp. were scarce or absent at the beginning of 1949, numerous at the beginning of June and end of July with an interlying minimum, and scarce in August and October. The first maximum was mainly made out of *O. dioica* (4050 individuals), next of *O. labradoriensis*. In July the latter species was more numerous (1300 *labr.* and 900 *dioica*) Later *O. dioica* again took the lead. In 1950 a few *O. parva* were found in January and March. In May both *O. dioica* and *O. labradoriensis* occurred, and a few uncertain *O. vanhøffeni*, which may turn out to be *O. labradoriensis*. The June maximum was mainly built up of *O. dioica*, which species also dominated the autumn samples. A few *O. parva* again appeared in November and December.

At Ona the *Oikopleura* spp. were usually scarce or absent. On 12 October 1948, 900 of *O. dioica* were taken together with single *O. laradoriensis*. The latter species also occurred sparsely in March, May and June 1949, while some *O. dioica* were again found in September and October. In 1950 only a few *O. dioica* were present in August, October and November.

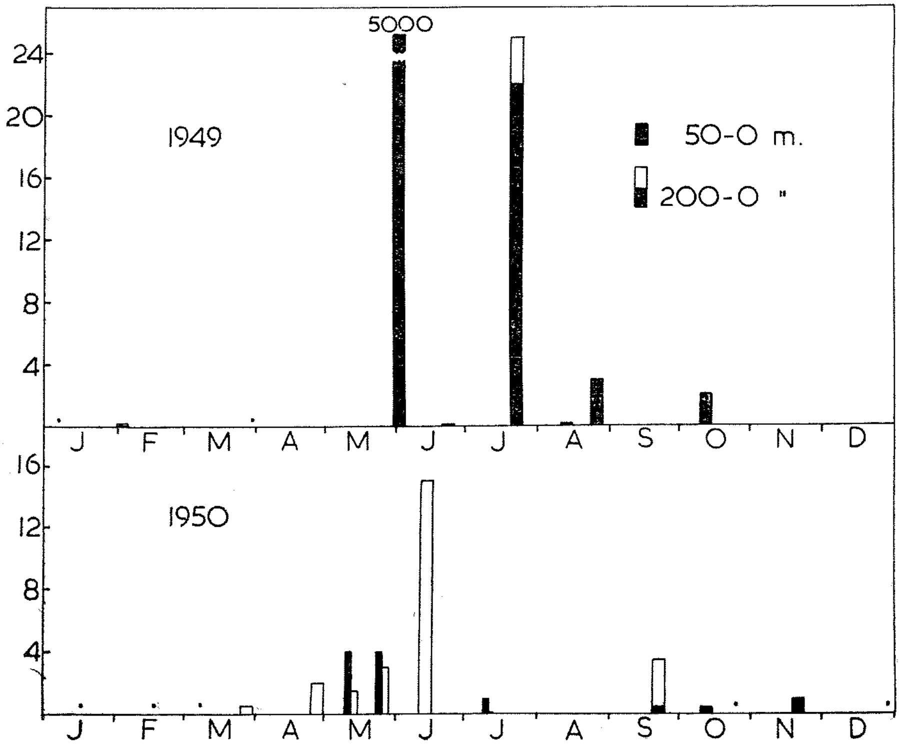


Fig. 97. Numerical variation of *Oikopleura* spp. at Sognesjøen in 1949 and 1950, in 100's. Dots indicate negative hauls.

At Eggum (fig. 98) the *Oikopleura* spp. occurred regularly from April to November 1949. In 1950 only stray individuals were met with until August, but later they were present in numbers the rest of the year. The dominating species during 1949 was *O. labradoriensis,* but from April to August a certain percentage were determined as. *O. vanhøffeni.* Single individuals of *O. parva* were taken in April, and of *O. dioica* in September and October. In 1950 single *O. vanhøffeni* occurred in April and May. From June to September *O. labradoriensis* was most common with maximum on 12 September (1300 specimens). Thereafter only single individuals were seen. *O. dioica* appeared singly at the end of August, was numerous in September (730 specimens), and entirely dominating the rest of the year.

At Skrova (fig. 99) 50—550 *O. labradoriensis* were taken from October to December 1948 together with single *O. parva* and *O. dioica.* In 1949 the occurrence of the *Oikopleura* spp. was mainly restricted to the period May—July, and few individuals were found at other times. The dominant species was again *O. labradoriensis,* but single *O. vanhøffeni*

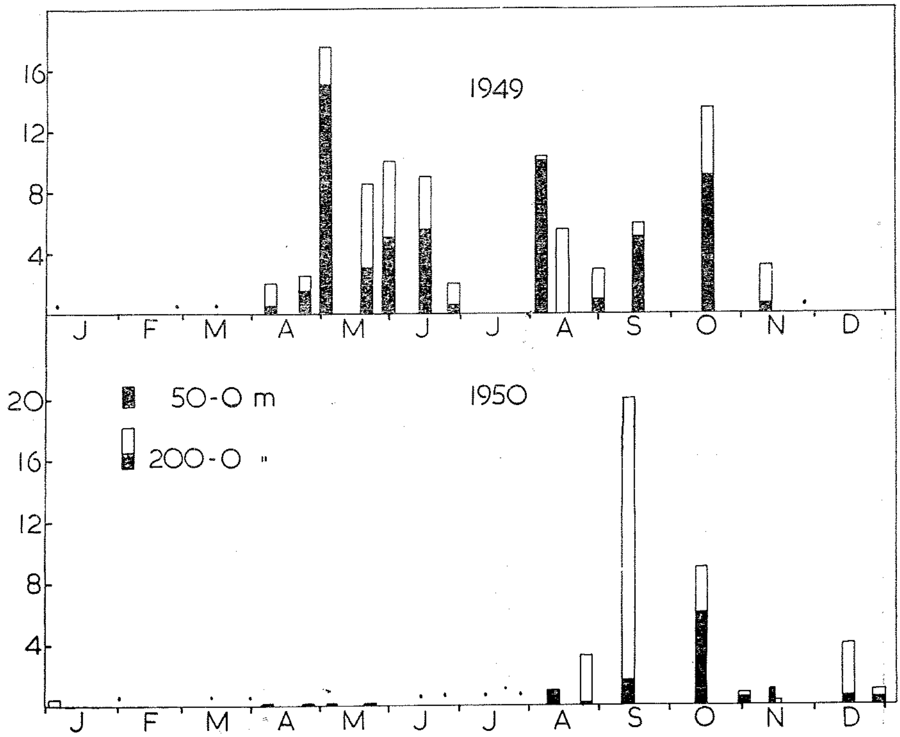


Fig. 98. Numerical variation of *Oikopleura* spp. at Eggum in 1949 and 1950, in 100's. Dots indicate negative hauls.

appeared in May and June. In 1950 no *Oikopleura* were found until the end of November, when 50—100 *O. labradoriensis* occurred together with single *O. dioica* and *O. parva*.

The appearance of *O. dioica* and perhaps also *O. parva* at Eggum and Skrova is undoubtedly dependent on supply from the coastal waters further south, and the high numbers taken at Eggum in the autumn of 1950 of this species, were accompanied by several other southern forms, as already shown above.

O. vanhøffeni is probably more common in the bank waters off North Norway than hitherto assumed. In cruises for fish larvae in the spring of 1948 and subsequent years single specimens were taken a little north of Eggum in the first half of April. At the beginning of May *O. vanhøffeni* was taken in numbers in the coast water from Torsvåg (70° 20' N, 18° 30' E) to Nordkyn (about 71° N, 28° E). The establishment of a stock of *O. vanhøffeni* in these waters may either be due to a local stock surviving in the nearby fjords, where suitable conditions may prevail, or to the presence of individuals carried by the currents from the Norwegian Sea. RUSSELL (1936) mentions that off the east coast

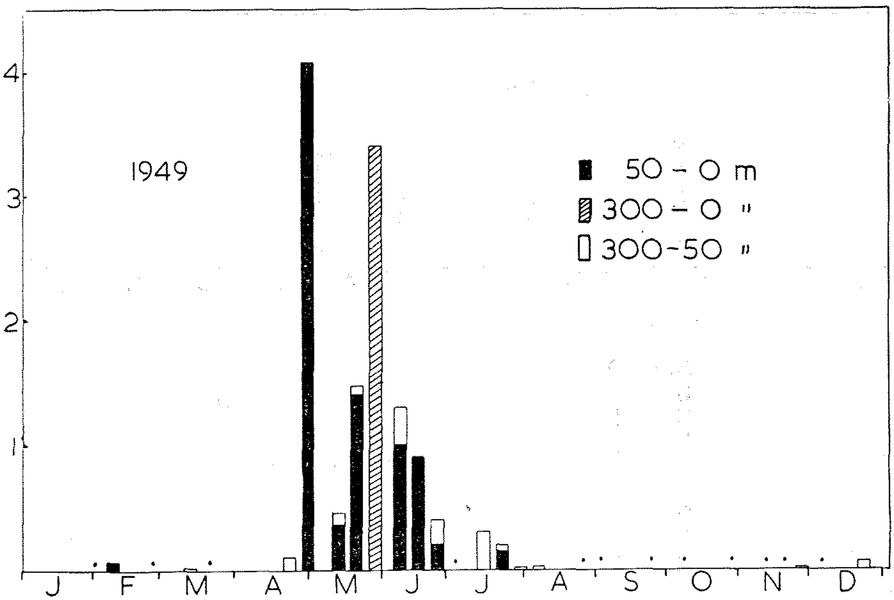


Fig. 99. Numerical variation of *Oikopleura* spp. at Skrova in 1949, in 100's. Dots indicate negative hauls.

of USA *O. vanhøffeni* is an indicator of arctic water. FRASER (1949) observed *O. vanhøffeni* near the Faeroes in May 1948, and lists it together with some other organisms as an indicator of arctic water (1952). Further investigations are needed to confirm the identity of the species in Norwegian waters.

As will appear from the figures the bulk of the *Oikopleura* spp. was taken in the upper 50 m, but on some occasions a considerable proportion was also found in the deeper hauls, especially at Eggum.

Appendicularia sicula was taken singly at Sognesjøen on 10 October 1949. As this species is rather small, it may have been present on more occasions but overlooked. It is regarded as a warm-water form (LOHMANN 1911), but of Atlantic species the plankton sample only contained single *Clausocalanus pergens* and *Candacia armata*. RUNNSTRØM (1932) found this appendicularian near Bergen in January and March.

Fritillaria borealis acuta.

The numerical variation of this species at Sognesjøen is shown in fig. 100. In 1949 *Fritillaria* was taken in January, March, June and July—August. Peaks are indicated in March, June and July—August. In 1950 the species occurred more regularly, with a maximum of 2500 specimens (3900 in the 50—0 m haul) at the end of March, and was also numerous in April. Other peaks appeared in July and in September.

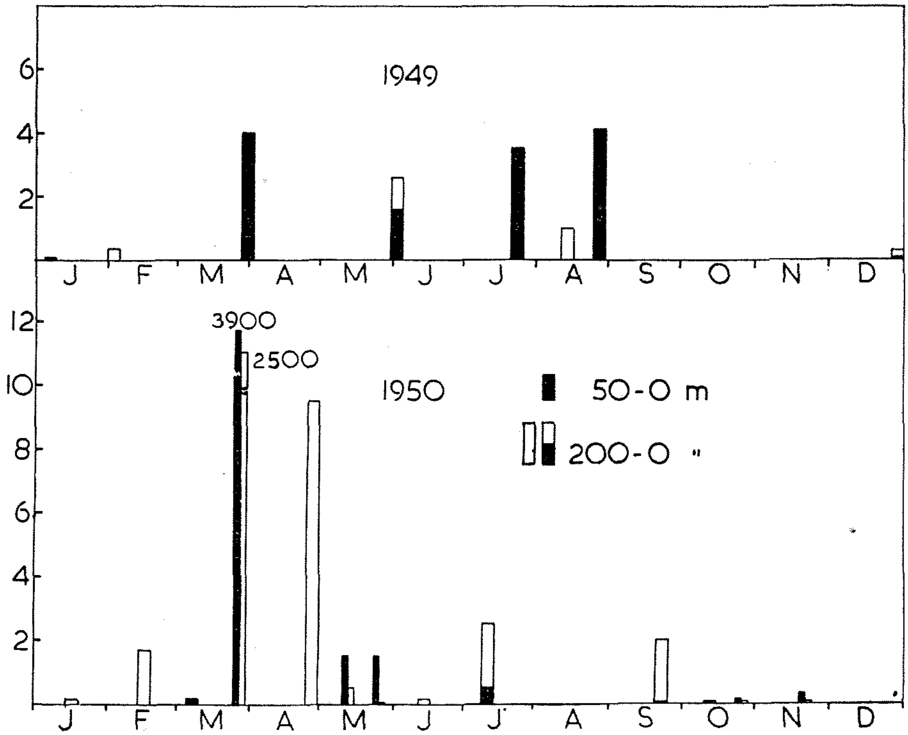


Fig. 100. Numerical variation of *Fritillaria borealis* at Sognesjøen in 1949 and 1950, in 100's. Dots indicate negative hauls.

The numerical variation is somewhat similar to that in the Nordåsvatn fjord near Bergen (WIBORG 1944).

At Ona *Fritillaria* was scarce in 1949,being present from the beginning of March to the middle of April, and from the end of August to the beginning of September. The numbers in both periods varied between 59 and 400. In 1950 it was more scarce, being taken from the end of February to the beginning of March and from the end of October to the middle of December, in numbers varying from 9 to 50.

At Eggum (fig. 101) the species was again more abundant but patchy in appearance, in 1949 present in April—May and August—October, with peaks at the beginning of May and middle of September. In 1950 *Fritillaria* occurred more sparsely in April, but in return was present from the middle of July to end the of December, abundant from the end of July to the middle of September ,with peaks in July, September, November and December.

At Skrova *Fritillaria* was taken in moderate numbers in October 1948. The numerical variation in 1949—50 is shown in fig. 102. In 1949 *Fritillaria* was present from February to May and from July to

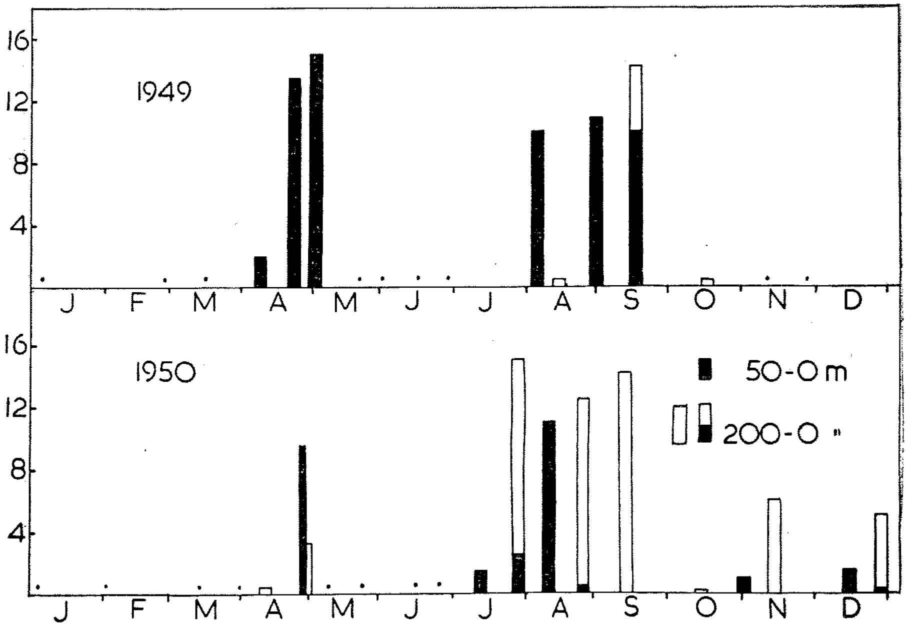


Fig. 101. Numerical variation of *Fritillaria borealis* at Eggum in 1949 and 1950, in 100's. Dots indicate negative hauls.

December, with peaks in February, April and August. In 1950 we have mainly the same distribution and peaks. The vertical distribution was, as for the *Oikopleura* spp., mostly limited to the upper 50 m. In July and August 1950 the deeper hauls at Sognesjøen and Eggum were sometimes considerably richer in *Fritillaria* than the 50—0 m hauls.

F. borealis truncata is according to LOHMANN (1911) a warm water species. Single specimens were taken at Ona in December 1950 and at Eggum in November of the same year.

Thaliacea.

Of this group only the Salpidae have been identified in the present material, only the species *Salpa fusiformis* Cuv. hawing been found.

S. fusiformis is of Atlantic origin, and its presence therefore indicates an influx of Atlantic water.

In 1949 no salps were observed on the coast of Norway, and only one specimen at st. «M» on 14 October (ØSTVEDT, verbal information).

In 1950 a single specimen was taken at Sognesjøen on 21 September. At Ona salps were abundant from 30 August to 6 December, the numbers decreasing from 199 to 2 in this period. Most of the individuals were small. The few larger specimens had chains of embryos inside, and it may well have happened that some of these had been broken and the

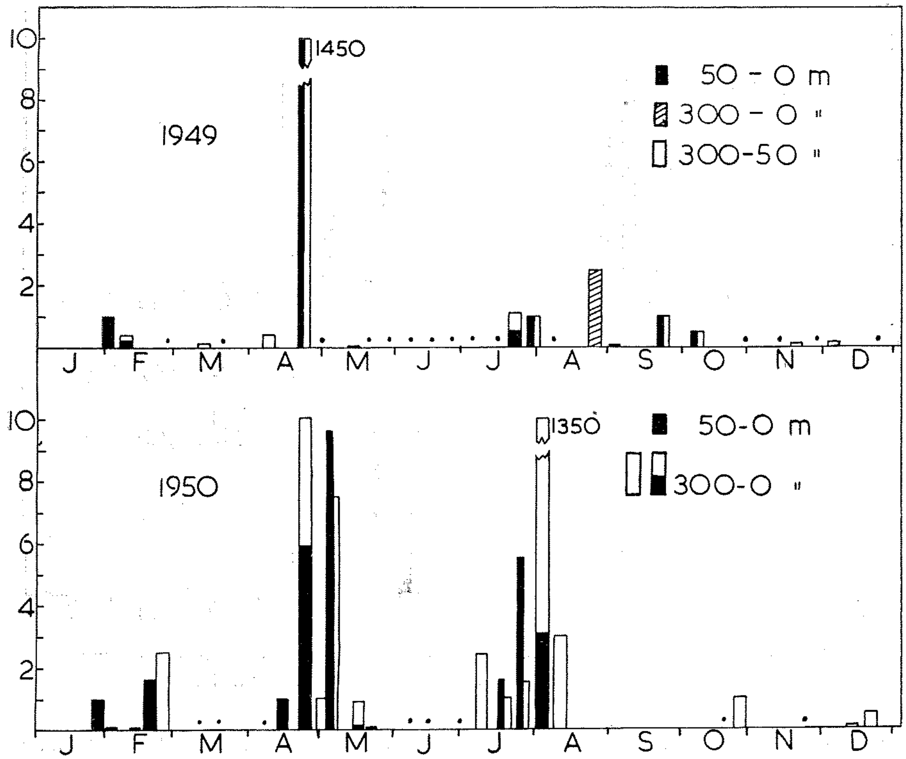


Fig. 102. Numerical variation of *Fritillaria borealis* at Skrova in 1949 and 1950, in 100's. Dots indicate negative hauls.

embryos distributed within the sample. At Eggum salps were taken from 13 October to 14 November, the numbers decreasing from 75 to 1 in this period. Salps were lacking on 12 September and 14 December. On station «M» salps were abundant on 29 September and 15 October, scarce on 17 October, and absent on 26 September and before, on 6 October and after 17 October.

In 1951 salps were numerous at Sognesjøen on 18 October and a few were present on 6 November, none on 22 November or later. At Ona they were abundant from 24 September to 29 October, but no salps were observed this year either on station «M» or at Eggum. However, a great number of salps was taken on a single station in a section off Møre on 29 August. It seems therefore probable that the salps may occur in patches.

Salps have also been found in plankton material from earlier years, thus 2 specimens near Ona on 17 September 1937. NORDGAARD (1912) found salps off Bergen in October, November. (For further comments, see pp. 69—70).

Gasteropoda.

Limacina retroversa (Flem.) is regarded as a temperate-water species, and may be abundant in more closed waters (LEBOUR 1932) as well as in the open ocean. It has been found on several occasions at the localities investigated. As the larvae and small individuals may have been confused with the larvae of neritic gasteropods, they will be treated here in common, and the number of *Limacina* which have been identified with certainty, will be given separately in the tables.

At Sognesjøen the monthly mean numbers of *Limacina* (L) and gasteropod larvae (G) during 1949—50 are shown in the table below:

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	L ..	1	0	1	—	—	1	25	5	—	0	0	2
	G ..	2	0	50	—	—	600[1]	10	280[2]	—	400	0	5
1950	L ..	0	1	0	0	1	0	0	—	0	0	0	0
	G ..	0	0	0	100	33	90	0	—	200	50	50	0

[1] 1000 on 1 June. [2] 450 on 1 August.

Single *Limacina* have been found from January to May and in December. The gasteropod larvae present in June—August and October 1949, and September—November 1950 are probably small *Limacina*.

For Ona the figures for *Limacina* and gasteropod larvae in 1949—50 were as follows:

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949	L ..	—	0	0	1	0	9	30	3	1	8	1	1
	G ..	—	9	36	45	90	50	188	250	88	50	5	3
1950	L ..	0	1	0	0	0	0	2	5665[1]	0	0	0	0
	G ..	0	9	0	0	0	0	0	2045[2]	20	58	9	9

[1] 11000 on 16 August. [2] 4000 on 16 August.

Both *Limacina* and the gasteropod larvae had their maximum of abundance in July—August 1949 and August 1950. RUNNSTRØM (1932) found *Limacina* near Bergen in June—August and in November.

The numerical variation of the said species at Eggum in 1949—50 is listed below:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949 L	1	0	0	1	0	2	—	0	1	0	9	—
G	0	0	0	0	76	33	—	1200	1600[1]	720	5	—
1950 L	0	2	0	0	3	2	3	13	9	0	5	0
G	0	0	0	0	330	55	48	1075[2]	6000	1450	623	55

[1] 2500 on 17 September. [2] 2000 on 24 August.

The high number of gasteropod larvae in August—October undoubtedly consists of small *Limacina*, and maximum both years is reached in September. Single *Limacina* are found during the late winter and spring.

At Skrova the *Limacina* and gasteropod larvae were usually much more sparsely represented than at Eggum. In 1948 from 200 to 1 000 small specimens were taken per haul in October and November. In 1949 from 10—15 specimens were found per haul in February—April and June, 600 specimens in July and 20 in August. In 1950 single individuals were taken in February, May and October, and 100 specimens in July.

Larvae of Bottom Invertebrates exclusive of Decapod and Gasteropod Larvae.

In table 37 are given the monthly mean numbers of the different groups of bottom invertebrate larvae not already treated at the localities investigated for the years 1949—50. If observations have been lacking in the month of one year, figures from the other year have been used.

The table is only shown in order to give an impression of the relative abundance of the different groups. Not too much stress is to be laid on the figures.

Cirripede larvae are most abundant at Ona and Sognesjøen in March and June, at Eggum and Skrova in April and July.

Polychaete larvae were most numerous at Sognesjøen, Ona and Skrova in April, at Eggum generally more scarce all the year.

Bivalvae larvae had peaks at Sognesjøen in April, June and October, at Ona in April, June and August, at Eggum in May and September and at Skrova in September.

Echinoderm larvae showed maxima at Sognesjøen in March—April and July, at Ona, Eggum and Skrova in April—May and August.

Cyphonautes larvae were abundant at Sognesjøen in March, June and September, occurred in moderate numbers at Ona from April to September, showed peaks at Eggum in April and August—September, and at Skrova in August—September.

Table 37. *The Monthly Mean Number of Bottom Invertebrate Larvae at Sognesjøen, Ona. Eggum and Skrova 1949—50.*

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	SN	0	10	20	*650*	29	15	25	8	9	2	0	0
Polychaeta	O	0	1	90	*110*	0	0	5	0	12	5	1	1
	E	0	0	1	6	31	3	*90*	*85*	*86*	21	15	9
	S	0	30	5	*193*	28	25	56	66	0	5	10	3
	SN	1	0	0	700	65	*1000*	175	275	200	450	150	5
Bivalvae	O	0	0	9	500	36	100	63	1000	30	35	10	50
	E	0	0	8	0	*723*	100	90	*1125*	*2020*	550	170	50
	S	0	25	0	25	1	8	129	188	*1775*	900	105	75
	SN	0	0	300	*800*	7	85	*330*	100	0	5	0	1
Echino-dermata	O	0	0	30	*150*	*275*	0	0	*2040*	0	30	0	0
	E	0	1	26	*214*	*540*	0	90	120	62	1	0	2
	S	9	38	213	*654*	*375*	50	*158*	*190*	10	0	0	1
	SN	0	5	*377*	200	200	*1071*	180	100	50	25	9	5
Cirripedia	O	1	8	*323*	270	342	*3000*	28	45	140	9	1	0
	E	0	0	2	*990*	104	100	438	128	165	58	0	0
	S	5	3	0	*545*	278	138	*480*	90	110	75	50	0
	SN	28	3	*375*	0	80	*263*	125	54	*650*	218	0	13
Cypho-nautes	O	0	0	0	48	28	75	30	75	50	7	7	5
	E	0	0	0	*75*	20	5	0	*85*	*254*	22	1	9
	S	0	50	0	0	75	0	37	250	100	80	10	85

Coelenterata.

This group has been given a more cursory treatment, as the specimens were often damaged by the nets and therefore difficult to identify. The pelagic coelenterates undoubtedly at certain times play a very important part in the plankton, and the brief survey given here will necessarily be very incomplete.

Ctenophora.

Beroë cucumis Fabr. was found in 1950 at Ona in March, at Eggum in June, and at Skrova in November—December. *Bolina infundibulum* Fabr. was not identified with certainty in the samples, but was observed in numbers during the cruises in the Vestfjord in May and June of the years 1949—52.

Siphonophora.

Diphyes arctica Chun was found quite regularly at all stations, but sparsely at Ona, mainly in the period June—October, in numbers from 1 to 22. Eudoxiae were observed in May, July and October.

Larvae and eggs of *Agalmopsis elegans* M. Sars occurred very often, at Sognesjøen in February 1949, and from June to August of the same year, at Ona in March and from September to December, at Eggum in January—March, and October—December, in the last period sometimes in numbers up to 200. At Skrova single larvae were found during the autumn and winter. Large specimens of *Agalmopsis* were taken at Ona in October 1948 and at Eggum in June 1949. According to VANHØFFEN (1903—06) M. SARS took this siphonophore at Florø (near Sognesjøen) from September to March, which agrees very well with the present observations.

Physophora hydrostatica Forskal was taken once, at Eggum on 3 January 1950.

Hydromedusae.

Sarsia sp., probably *princeps*, has not been recorded from the samples, but was frequently observed in the Vestfjord during cruises in May. A number of other small hydromedusae have been taken on different occasions, but not determined. At Sognesjøen, Eggum and Skrova the number usually varied between 10 and 150 in the months March to June. At Ona they were scarce.

Trachymedusae.

Aglantha digitale (Müller) is the only species found, at Sognesjøen it was abundant from April to June, maximum 920 specimens on 1 June 1949. The form *A. digitale* f. *rosea* (BROCH 1929) was most common. At the other stations *Aglantha* was scarce, usually occurring singly.

Fish Eggs and Larvae.

The vertical Nansen net hauls are not very suitable for catching fish eggs and larvae, firstly because the amount of water filtered is usually too small, unless spawning has been very intense, and secondly because larger fish larvae easily avoid the net. Some of the data from Eggum and Skrova have been treated in another publication (WIBORG 1952).

Fish eggs were scarce at Sognesjøen, seldom more than 10 eggs per total haul in the months April—June. Single eggs of *Myctophum glaciale* Reinh. occurred regularly in the deeper hauls from May—June to October in all localities investigated. At Ona fish eggs were a little more abundant, from 11—75 eggs per total haul in the period February—June. The majority were probably cod eggs. At Eggum the number of eggs, mainly of cod, fluctuated between 6 and 50 in February—May. At Skrova we are near the centre of the spawning area of the «skrei» or Arcto-Norwegian tribe of cod, and in April 1949 the eggs numbered more than 600, but in 1950 not more than 70—80.

Fish larvae most often occurred singly, or a few specimens at a time. Mackerel larvae were taken at Sognesjøen in June. Redfish larvae occurred at Sognesjøen in June, at Eggum in May, and at Skrova in May and June. A catfish larva was found at Eggum in April 1949. Pleuronectid larvae were present at Sognesjøen in June, at Ona in November, Eggum in August and Skrova in May. Of the gadoids, cod larvae were specially numerous at Eggum and Skrova in April—May 1949, maximum numbers 22 and 150 specimens respectively. In 1950 cod larvae were also present in the same period, but very sparsely. Other gadoid larvae occurred singly at all the stations in April—June. *Ammodytes* larvae were taken at Ona and Eggum in April. Single larvae of *Myctophum glaciale* occurred at Ona and Eggum in June and August. Two larvae of *Centriscus scolopax* L. were found at Ona on 22 August 1949. They measured only 2.9 mm and had probably been hatched not long before. The determination was made from the descriptions of SPARTA (1936). According to HOLGERSEN (1950) three specimens of this fish (one 135 mm in length) were taken along the southern and south-western coast of Norway in February 1950. Herring larvae were quite numerous at Sognesjøen and Ona in March of 1949 and 50 (10—38 specimens per haul). Single larvae were also taken at Sognesjøen in June 1949 and at Eggum in July 1950.

SUMMARY

1. Zooplankton samples, taken in vertical Nansen net hauls at permanent stations on the west coast of Norway between 61°—63° N and in the Lofoten area from October 1948 to the end of December 1951 have been used for a complete analysis of the variation in volume, plankton composition and biology of the species. A study has also been made of the variations in plankton volume of selected samples collected in the same area during 1927—39 and 1946—48 with the same gear, and during 1949—51 with Clarke- Bumpus plankton samplers. Plankton material from station «M» in the Norwegian Sea, taken in vertical Nansen net hauls in steps from 2 000 m to the surface during 1950—52 has been used for studies of variations in plankton volume and of variations in length of the copepods.

2. Volume measurements were made by draining or displacement, subdivisions of the samples by the improved Lea's plankton divider. All plankton has been preserved in formalin.

3. The hydrographical conditions of the investigated areas are discussed on the basis of previous investigations, and of observations taken simultaneously with the sampling of plankton. At the coastal localities more or less continuous changes take place in the body of water due to the influence of the Baltic current and the North-Atlantic current. At Skrova in the Vestfjord the conditions seem to be more stable. A survey of the more important changes during 1949—51 is given in table 1, pp. 20—21.

4. a. On the west coast of Norway between 61°—63° N the maxima in the volume of plankton usually occur in April and June—July, in the Lofoten area in May—June and July—August. The main quantity of plankton is found in the upper 50 m from April to July, with maximum in June. Generally, the plankton was most abundant in the Lofoten area, and in all localities there was also an increase in the yearly mean volumes from 1949 to 1951.

b. Plankton samples taken in earlier years show volume variations similar to those recorded in the present investigation.

c. The quantitative distribution of plankton in the Lofoten and Vesterålen area in April—June of the years 1949—51 based on samples taken with Clarke-Bumpus plankton samplers is shown. Surface currents seem to be of great importance for the distribution, while diurnal vertical migrations of the plankton organisms have no influence, the plankton in spring being concentrated in the upper 75 m. There is, on the average, quite good agreement between the quantities of plankton calculated per m^2 of sea surface from the hauls with the C. B. sampler and with the Nansen net.

d. At station «M» in the Norwegian Sea there was a maximum of plankton volume in the upper 100 m in June, minimum in the period September—March. The plankton was more abundant in 1950 than in 1951, the temperature of the surface layers being on an average somewhat lower in 1951. — The volumes were generally larger than in the upper 50 m on the west coast of Norway between 61°—63° N, but smaller than in the same layer in the Lofoten area.

e. A comparison is made between the quantities of plankton in various European and American waters. During spring and summer the bank water off Eggum is comparable in richness to the waters of Georges Bank off the east coast of U.S.A., and to those in the Barents Sea. The greatest concentrations of plankton hitherto recorded in Northern waters, are found in summer and autumn in the Barents Sea.

5. There are two periods of abundance in the total number of organisms, at Sognesjøen and Ona in March—July and August—September, in the Lofoten area in April—May and August—October. Numbers are generally higher in the Lofoten area, and were on the whole greater in 1950 than in 1949. The copepods always dominate, but cladocera, eggs and larvae of euphausiids, bottom invertebrate larvae, copelata, and some other groups may at times be of some importance.

6. The variations in the relative composition of the copepod stock are shown both as to number and volume. More than 38 species have been identified, of which only 4 are of any importance in number all the year, viz. *Calanus finmarchicus*, *Pseudocalanus elongatus*, *Microcalanus pusillus* and *Oithona similis*. Sometimes, especially in the autumn, *Metridia lucens*, *Paracalanus parvus*, *Temora longicornis* and *Acartia clausi* may also play a certain part. — In volume *C. finmarchicus* is always dominant but at Skrova *C. hyperboreus* and *Pareuchaeta norvegica* may also be of some importance.

7. The plankton organisms have been divided into different groups according to their origin and appearance in the plankton, and the renewal of the stocks is discussed. Organisms indicating influx of Atlantic water are listed.

8. Length distributions of copepods are shown to be useful for the determination of the origin of the populations and also for the determination of the origin and degree of mixing of different water masses.

9. The production of zooplankton in Norwegian coast waters is discussed in relation to the production of phytoplankton, likewise the greater abundance of zooplankton in spring near the edge of the continental shelf and the possible origin of the plankton populations there. The importance of the statement by MARSHALL and ORR (1952), that individual females of *Calanus finmarchicus* may survive and produce eggs for more than two months, is stressed.

10. The biology of the different species.

a. *Calanus finmarchicus*. At Sognesjøen and Ona maxima in stock occur in March, June—July and September, at Eggum and Skrova in April—May and August. Spawning periods at Sognesjøen and Ona in February—March, May—June, July—August, and September—October, in the Lofoten area in April—May, June, and July—September. Copepodite stage V had a minimum length in February—March, maximum length in April—July, and was again smaller during the autumn. The females showed a similar variation. At Skrova there was a very striking decrease in mean length of stage V from January to March each year. — At station «M» the length variations of stage V in the upper 100 m during the late summer and autumn of 1940 was very similar to that found at Eggum, and the possible relationship is discussed.

b. *Calanus hyperboreus* was scarce at all stations except Skrova, where a moderate stock occurs in the deeper layers all the year. Spawning takes place in February. Stage V and the females vary very little in length distribution during the year.

c. *Pseudocalanus elongatus* had maxima in stock in May—June and August—September, at Eggum also in October—November. Maxima in spawning at Sognesjøen and Ona occurred in March, May—June, August and October, at Eggum in March—April, May—June and September. The females showed a minimum mean length in January—March, maximum length in April, and decreased again in length from the end of April.

d. *Pseudocalanus minutus* (*P. gracilis* G. O. Sars) was shown to be distinct from *P. elongatus*. Scarce at all stations, being confined mainly to the deeper layers. Spawning probably occurs in March—April. Stage V and the females were larger than *P. elongatus* from the same samples. The dominance of *P. minutus* at station «M» is confirmed and discussed.

e. *Microcalanus pusillus* occurred in moderate numbers with 3 or more maxima in stock and 4—5 spawning periods a year. The females had maximum size at Ona in May and October, minimum size in February

—March and August. At Eggum and Skrova there was maximum length in May only. The length variations at station «M» were similar to those at Ona. The relation length-temperature is discussed.

f. *Microcalanus pygmaeus* is shown to differ from *M. pusillus* both in size and in appearance. It is scarce at Skrova, but present all the year, with one spawning period a year, in February. The individuals found in deep water at station «M» are larger than those at Skrova.

g. *Pareuchaeta norvegica.* Found in moderate numbers in deep water at Skrova. Spawning takes place all the year, with maximum in December—January and June—August. Females are more than twice as numerous as the males, but in the copepodite stage IV—V the proportion was 1:1. The mean length of stage V decreased slightly from the spring to the autumn.

h. *Metridia lucens* is an important component of the summer plankton, with maxima in stock in June—October. Four to five spawning periods occur. Nauplii are most common in the upper 50 m, but as development proceeds, the copepodites seek deeper water, and of the adults only 5—9 % are found in the upper 50 m. The mean length of the females showed minimum in January—February, maximum in May, and decreased again gradually during the autumn.

i. *Clausocalanus arcuicornis* is new to the Norwegian fauna, occurring sparsely from October to January.

k. *Oithona similis* was sometimes very abundant, with main maxima in August—September.

The other copepod species are of less importance numerically.

11. Other organisms.

a. Cladocera were present from March to October, most abundant in June—September.

b. Adult euphausiids were seldom taken. Eggs and larvae of euphausiids were numerous from March to June with maxima at Sognesjøen and Ona at the end of March (both *Meganyctiphanes norvegica* and *Thysanoessa inermis*), in Lofoten in April and May (mainly *T. inermis*).

c. Chaetognaths were most common on the deeper stations, especially at Skrova. *Sagitta elegans* and *Eukrohnia hamata* were the most commonly found species, but single *S. setosa* occurred at Sognesjøen and Ona.

d. Copelata. *Oikopleura dioica* was most abundant at Sognesjøen and Ona, *O. labradoriensis* in the Lofoten area. *O. vanhøffeni* occurred in moderate numbers at Eggum, singly at Ona and Skrova. *Fritillaria borealis acuta* was moderately numerous, but scarce at Ona.

e. Thaliacea. *Salpa fusiformis* was recorded in the autumn of 1950 at Ona, Eggum and station «M», in 1951 at Sognesjøen and Ona.

f. *Limacina retroversa* was numerous at all stations except Skrova from June—July to October.

g. Herring larvae were numerous at Sognesjøen and Ona in March, cod eggs and larvae plentiful in the Lofoten area in April—May, especially in 1949.

The other groups of organisms, amphipods and isopods, ostracods, gasteropod larvae, larvae of bottom invertebrates, coelenterates and others, were usually of minor importance numerically.

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Table 37. *The Composition of the Zooplankton Population at Sognesjøen December 1948 December 1950. Relative Percentages of the Various Groups.*

Year	1948	1949												
Month	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Total number of organisms ..	2 109	1 397	1 719	6 955			*42 126*	21 968	10 531		8 845		2 501	12 005
Copepoda	95,3	98,8	96,5	80,6	No	Hauls	78,9	81,3	84,7	No	78,5	No	94,7	86,8
Cladocera	T	0	0	0,1			8,5	3,2	3,3	Hauls	3,1	Hauls	2,4	2,6
Eggs and larvae of Euphausiids	0	0	0	7,4			0,2	0,2	0,2		0		0	1,0
Copelata	1.4	0,9	3,2	5,8			3,9	13,0	4,0		1,1		1,2	4,1
Benth. inv. larvae	1,0	0,6	0	5,5			7,6	1,8	7,9		17,0		1,5	5,2
Other organisms	2,1	0,5	0,4	0,7			0,9	0,7	0,1		0,2		0,6	0,5
		1950												
Total number of organisms....		2 409	2 583	10 043	*23 531*	9 693	*47 065*	24 966		*39 768*	7 659	2 899	4 108	15 884
Copepoda		97,0	92,3	82,2	76,1	89,5	88,3	92,2	No	93,3	94,2	85,6	97,6	89,8
Cladocera		0	0	0	2,8	0,8	4,3	1,8	Hauls	2,6	0,1	0	0	1,1
Eggs and larvae of Euphausiids		0	0,1	2,8	0,6	1,6	0,4	0		0,1	0,1	0	0	0,5
Copelata		0,7	6,6	8,2	4,9	2,6	3,2	1,0		1,4	0,4	3,8	0,8	3,1
Benth. inv. larvae		2,1	1.0	6,9	13,9	5,3	3,8	5,1		1,2	2,3	6,9	0,4	4,5
Other organisms		0,3	0,2	0,4	1,6	0,7	0,2	0		1,7	3,0	3,8	1,5	1,2

Table 38. *The Composition of the Zooplankton Population at Ona October 1948 — December 1950. Relative Percentage of the Various Groups.*

Year	1948	1949												
Month	Oct.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Total number of organisms ..	20 555		2 679	7 529	22 647	23 141	*18 501*	16 942	13 051	14 654	2 583	1 726	687	11 285
Copepoda	86,0	No	98,6	76,0	86,9	98,0	84,3	97,7	88,1	84,4	92,0	97,8	99,1	91,2
Cladocera	0	Hauls	0	0	0	0	1,1	0	5,0	10,8	1,0	0,9	0	1,7
Eggs and larvae of Euphausiids	0,5		0	13,9	2,2	0,8	0,1	0,1	0	0	0	0	0	1,6
Copelata	4,4		0	2,5	0,4	0	0,8	0	**1**,2	1,2	1,6	0	0	0,7
Benth. inv. larvae	6,3		1,0	7,1	7,3	1,3	13,6	1,8	5,8	2,9	4,9	0,7	0,5	4,3
Other organisms	2,9		0,4	0,5	3,3	0,1	0,1	0,5	0,1	0,7	0,7	0,7	0,4	0,7
		1950												
Total number of organisms ..		361	1 691	2 687	3 007	6 633	8 811	*55 784*	50 136	1 535	3 093	8 298	8 304	12 528
Copepoda		98,9	92,0	80,6	75,0	84,2	*35,7*	99,6	87,1	88,4	94,2	98,2	97,0	85,9
Cladocera		0	0	0	0	0	0	0	0,4	0,3	0	0,1	0	0,1
Eggs and larvae of Euphausiids		0	0	1,9	24,5	1,2	21,0	0	0	0	0,1	0	0	4,0
Copelata		0	3,0	1,9	0	0	0	0	0	0	0,5	**1**,0	0,3	0,6
Benth. inv. larvae		0	0,7	13,1	0,6	13,8	43,3[1]	0,2	3,7	1,6	2,5	0,2	2,4	6,8
Other organisms		1,1	4,5	2,6	0	1,0	0	0,1	8,8	9,8	2,7	0,5	0,3	2,6

[1] Cirripede nauplii.

Table 39. *The Composition of the Zooplankton Population at Eggum, November 1948 — February 1951. Relative Percentages of the Various Groups.*

Year	1948	1949														
Month	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mean
Total number of organisms	16 383	4 897	2 612	4 725	19 768	*37 590*	34 527		24 862	*66 669*	30 372	6 191				23 221
Copepoda	89,3	99,8	99,7	99,0	71,0	81,0	96,9	No Hauls	86,8	86,9	88,3	97,7	No Hauls			90,7
Cladocera	0	0	0	0,2	0	0,3	0		0	2,3	1,0	0				0,4
Eggs and larvae of Euphausiids	0	0	0	0,2	11,1	11,1	0,1		0	0	0	0				2,3
Copelata	3,1	0	0	0	4,1	4,1	2,2		4,9	3,5	4,6	1,9				2,5
Benth. inv. larvae	7,6	0	0	0,4	13,5	4,0	0,5		8,1	6,8	6,1	0,1				4,0
Other organisms	0,1	0,2	0,3	0,4	0,4	0,6	0,5		0,2	0,4	0,1	0,2				0,3
	1950													1951		
Total number of organisms		2 444	3 196	4 000	49 418	*157298*	63 418	40 063	25 624	*87 472*	17 219	24 161	8 711	5 529	3 492	40 252
Copepoda	No Hauls	96,0	99,5	97,6	75,8	96,9	99,6	96,0	87,1	80,0	83,7	93,7	89,4	90,3	92,2	91,3
Cladocera		0	0	0	0	0	0	0	1,7	5,7	0,6	0	0	0	0	0,7
Eggs and larvae of Euphausiids ..		0	0	0,2	20,9	2,5	0	0	0	0	0	0	0	0	0	2,0
Copelata		2,0	0,3	0,2	0,6	0	0	2,1	2,8	4,0	5,3	1,8	7,1	6,7	5,4	2,2
Benth. inv. larvae		2,0	0	1,9	2,7	0,5	0,1	2,4	8,4	9,8	9,2	4,1	1,2	1,8	0,8	3,5
Other organisms		0	0,2	0,1	0,1	0	0,2	0	0,2	0,1	1,5	0,5	4,1	1,4	1,9	0,6

Table 40. *The Composition of the Zooplankton Population at Skrova October 1948 — December 1950. Relative Percentage of the Various Groups.*

Year	1948		1949												
Month	Oct.	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Total number of organisms	32 993	25 187		8 815	7 463	*32 608*	8 731	9 690	12 236	20 312	*22 845*	11 119	6 763	6 920	13 409
Copepoda	97,3	95,5		91,1	81,9	79,0	75,2	85,3	81,1	88,0	91,0	95,9	95,3	91,4	86,8
Ostracoda	0,5	0,2	No	6,4	12,3	2,6	3,4	1,0	2,0	3,1	0,6	2,5	3,8	7,1	4,1
Eggs and larvae of Euphausiids	0	0	Hauls	0	0,8	2,6	0,2	0,2	0	0	0,1	0,1	0	0	0,4
Copelata	0,3	3,5		0,6	0,1	8,7	16,0	9,0	6,0	0,4	0,2	0,2	0,1	0,5	0,5
Chaetognatha	0,2	0,2		0,3	0,4	0,3	1,5	0,3	0,4	0,3	0,8	0,2	0,4	0,5	0,5
Benth. inv. larvae ..	0,9	0		1,0	0,8	1,1	3,0	3,2	6,5	6,1	7,2	0,6	0,2	0,1	2,7
Other organisms	0,9	1,2		0,5	3,5	6,1	0,7	0,7	4,0	2,1	0,5	0,6	0,1	0,6	1,7
			1950												
Total number of .... organisms			8 928	13 241	17 374	17 223	*26 467*	7 953	9 602	*17 090*		15 839	10 564	9 435	13 974
Copepoda			85,3	92,5	92,3	86,1	86,9	100,0	96,4	91,0	No	88,0	91,8	91,8	91.1
Ostracoda			13,1	6,2	4,8	3,0	4,0	0	0	0,1	Hauls	0,3	4,7	4,8	3,7
Eggs and larvae of Euphausiids			0	0	1,1	2,5	2,1	0	0	0		0	0	0	0,5
Copelata			0,5	0,6	0	1,6	1,4	0	0,9	4,2		0,6	0,9	0,3	1,0
Chaetognatha			0,4	0,3	0,1	0,3	0,5	0	0,6	0,6		0,1	0,1	0,2	0,3
Benth. inv. larvae. ..			0,1	0,4	1,8	5,2	5,2	0	1,6	3,2		9,7	2,8	2,2	2,9
Other Organisms			0,2	0,2	0,1	0,5	0,1	0	0,5	0,7		1,0	0,2	0,9	0,4

Table 41. *The Percentage Composition by Number of the Copepod Stock at Sognesjøen. December 1948 — December 1950.*

Year	1948	1949												
Month	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Total number	4 043	1 370	1 657	5 594	No Hauls	No Hauls	59 345	17 820	17 881	No Hauls	6 945	No Hauls	2 363	14 122
Calanus finmarchicus	11.3	6.9	12,4	65,6			23,5	16,4	14.1		4,4		2,8	18,3
Metridia lucens	14,6	4,2	9,1	0,9			1,4	14,3	21,1		9,8		14,9	9,4
Pseudocalanus elongatus	13,8	8,0	10,0	17,6			24,0	19,7	13,0		13,7		7,2	14,2
Microcalanus pusillus	22,3	35,4	38,0	0			13,8	13,5	5,2		16,6		27,5	18,8
Oithona spp.	24,9	35,8	22,7	12,6			27,8	20,5	31,6		23,8		31,6	25,8
Acartia spp.	2,2	0,3	0,7	0			0,1	1,6	6,7		16,9		1,5	3,5
Paracalanus parvus	2,0	5,3	0,2	0			0	0	0,5		4,3		6,8	2,1
Temora longicornis	0	0	0	0,3			5,1	11,5	6,0		7,3		0,2	3,8
Scolecithricella minor	5,7	3,3	1,8	0			1,5	0,3	0,7		2,2		4,5	1,8
Other Copepods	3,3	0,8	5,1	3,0			2,9	2,2	1,1		1,2		3,2	2,4
		1950												
Total number		2 335	2 381	14 801	17 921	17 368	41 507	22 981	No Hauls	37 013	14 512	2 479	3 995	16 175
Calanus finmarchicus		2,8	2,3	33,4	33,3	21,4	44,7	9,6		6,4	6,4	7,9	3,7	15,6
Metridia lucens		14,6	4,8	2,9	4,7	5,8	2,4	2,6		0,6	14,4	15,5	13,0	7,4
Pseudocalanus elongatus		16,0	5,1	16,2	8,7	11,3	20,6	53,8		36,9	32,2	30,2	31,4	23,9
Microcalanus pusillus		23,6	55,6	21,0	22,0	19,3	4,8	4,6		2,8	4,8	4,0	6,9	15,4
Oithona spp.		34,2	27,4	21,3	17,9	29,9	15,6	22,6		16,1	19,3	15,8	33,3	23,0
Acartia spp.		1,1	0,4	0,5	3,7	3,4	5,6	2,7		4,6	4,9	2,1	1,5	2,8
Paracalanus parvus		3,6	0	0	0	0	0	0		14,3	12,9	18,1	7,6	5,1
Temora longicornis		0	0	0,2	4,6	3,7	0,7	3,5		0,8	0	0	0	1,2
Scolecithricella minor		2,1	3,4	1,0	0,6	1,1	0,7	0,1		1,2	0,8	4,0	1,4	1,5
Other Copepods		2,1	1,3	3,7	4,7	4,3	4,8	0,5		16,3	4,3	2,3	1,2	4,1

Table 42. *The Percentage Composition by Volume of the Copepod Stock at Sognesjøen. December 1948 — December 1950.*

Year	1948	1949												
Month	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Calanus finmarchicus	54,43	59,70	66,75	79,10			65,47	41,10	63,65		33,42		32,90	57,6
Pseudocalanus elongatus	5,27	5,34	3,43	11,00	No	Hauls	14,31	18,50	3,67		14,10		6,39	9,9
Microcalanus pusillus	3,23	9,74	5,09	0			4,65	7,27	1,53	No	9,10	No	10,04	5,7
Paracalanus parvus	0,35	1,62	0,03	0			0	0	0,29	Hauls	6,48	Hauls	2,42	1,2
Temora longicornis	0	0,07	0	0,41			1,49	4,24	0,94		3,85		0,05	1,2
Metridia lucens	29,28	14,81	16,95	0,29			6,19	13,98	17,13		7,22		34,80	12,6
Acartia spp.	0,60	0,20	0,16	0			0,08	1,42	4,48		14,96		0,93	2,6
Oithona spp.	2,31	5,67	1,69	6,15			4,52	7,43	6,57		6,84		7,06	5,3
Other Copepods	4,57	2,81	5,98	3,07			3,31	6,04	1,77		4,00		5,41	4,0
Total	100,04	99,96	100,08	100,02			100,02	99,99	100,03		99,97		100,00	100,1
Year		1950												
Calanus finmarchicus		31.32	51.75	67.75	89.90	77.75	77.85	51.80		50.80	50.95	56.05	37,75	58,5
Pseudocalanus elongatus		10,55	4,33	7,76	1,74	1,48	10,25	34,70	No	13,80	10,35	14,73	21,23	11,9
Microcalanus pusillus		7,51	28,08	7,64	2,51	2,46	1,47	1,77	Hauls	1,10	1,29	1,03	2,47	5,2
Paracalanus parvus		1,64	0	0	0	0	0	0,01		5,43	4,31	4,80	2,83	1,7
Temora longicornis		0	0	0,03	0,32	0,69	0,20	0,68		0,17	0,20	0	0	0,2
Metridia lucens		31.60	2,62	8,99	1,96	6,41	0,91	1,56		1,65	17,36	10,76	23.36	10,2
Acartia spp.		0,59	0,35	0,50	0,70	1,26	2,86	1,75		2,96	2,65	0.89	0,89	1,4
Oithona spp.		6,61	7,30	3,89	1,28	2,94	2,60	4,58		3,24	3,03	2,36	7,66	4,1
Other Copepods		5,64	5,53	3,74	1,63	7,04	3,88	3,13		20,86	10,06	9,38	3,81	6,8
Total		99,96	99,96	100,00	100.04	100,03	100,02	99,98		100,01	100,02	100,00	100,00	100,0

Table 43. *The Percentage Composition by Number of the Copepod Stock at Ona. October 1948 — December 1950.*

Year	1948	1949												
Month	Oct.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Total number	17 657		2 641	17 125	37 602	22 651	15 604	33 138	22 245	24 699	2 370	3 425	1 361	16 624
Calanus finmarchicus	8,4		1,5	18,9	51,3	20,5	31,8	60,4	35,4	5,2	14,0	7,0	5,1	22,8
Metridia lucens.	11,6	No	16,4	1,9	1,9	4,7	4,2	2,1	3,5	11,1	17,3	20,5	25,6	9,9
Pseudocalanus elongatus	20,4	Hauls	27,5	27,9	21,5	46,0	23,1	8,7	10,1	10,6	7,8	12,1	9,0	18,6
Microcalanus pusillus	6,8		14,5	27,9	8,5	17,7	10,9	6,8	4,8	4,9	16,9	8,7	20,2	12,9
Oithona spp.	8,5		33,2	21,9	12,8	11,0	28,6	21,2	38,0	46,2	6,7	22,0	23,5	24,1
Acartia spp.	21,5		1,3	0,1	2,8	0	0	0	4,8	14,9	13,4	11,9	2,7	4,7
Paracalanus parvus	21,6		5,7	0,1	0,1	0	0	0	0	3,8	12,7	15,3	12,6	4,6
Other Copepods	1,3		0	0,2	0,6	0,2	1,6	0,3	3,3	3,3	11,4	2,6	1,5	2,3
		1950												
Total number		716	1 555	2 164	2 253	11 276	3 150	111201	84 767	1 354	5 820	8 139	8 044	20 037
Calanus finmarchicus		16,5	9,1	39,0	94,0	55,9	55,0	75,7	5,7	13,9	13,6	4,5	3,4	32,2
Metridia lucens		22,9	4,0	8,2	0,7	0,7	1,9	1,4	0	1,3	2,6	7,9	11,7	5,3
Pseudocalanus elongatus		13,4	22,4	21,6	4,4	8,2	8,4	8,1	42,8	29,6	20,7	44,3	40,8	22,1
Microcalanus pusillus		20,3	25,7	16,2	0,7	24,4	22,2	6,7	0,4	3,7	0,5	2,5	9,3	11,1
Oithona spp.		9,6	35,4	12,0	0,4	10,3	11,1	7,5	34,2	18,5	25,1	14,2	22,8	16,8
Acartia spp.		3,0	2,7	2,7	0	0,3	0,8	0,3	3,8	12,2	13,7	10,0	3,7	4,4
Paracalanus parvus		14,4	0	0	0	0	0	0	9,0	11,4	19,8	15,4	7,5	6,5
Other Copepods		0,1	0,1	0	0	0,2	0,7	0,3	3,7	9,5	4,1	1,5	0,9	1,8

Table 44. *The Percentage Composition by Volume of the Copepod Stock at Ona. October 1948 — December 1950.*

Year	1948	1949												
Month	Oct.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Calanus finmarchicus	30.80		14,68	55,80	92,20	80,15	89,80	96,80	84,95	46,30	58,60	45,40	35,75	63,68
Pseudocalanus elongatus	17,90		19,32	19,76	4,08	11,26	3,38	0,87	3,20	9,39	3,19	7,84	5,95	8,02
Microcalanus pusillus	2,21	No	3,75	10,66	1,12	2,00	1,02	0,42	1,10	2,17	3,29	3,04	4,60	3,02
Paracalanus parvus	6,63	Hauls	1,79	0,05	0,01	0	0	0	0	1,77	3,02	7,44	2,89	1,54
Metridia lucens	25,46		55,40	6,38	0,49	5,27	3,38	0,39	3,69	15,46	16,30	12,46	46,25	15,04
Acartia spp.	11,68		0,55	0,07	0,81	0	0	0	2,03	10,83	4,37	7,32	1,42	2,49
Oithona spp.	1,59		4,48	4,75	0,89	1,04	1,44	0,80	4,39	12,83	0,99	5,29	2,81	3,61
Other Copepods	3,75		0	2,48	0,38	0,29	0,96	0,75	0,70	1,28	9,80	11,29	0,32	2,58
Total	100,01		99,97	99,95	99,98	100,01	99,98	100,03	100,06	100,03	100,00	100,08	99,99	99,98
Year		1950												
Calanus finmarchicus		68,83	40,80	74,40	98,85	94,98	96,00	97,80	43,10	71,50	47,65	36,90	32,15	66,91
Pseudocalanus elongatus		3,79	24,94	6,08	0,49	0,97	0.84	0,81	34,94	11,04	13,40	27,46	29,50	12,86
Microcalanus pusillus		2,35	15,04	3,13	0,04	1,26	1,01	0,40	0,20	0,71	0,26	0,85	3,18	2,45
Paracalanus parvus		1,37	0	0	0	0	0	0	4,41	2,41	10,94	4,96	2,75	2,22
Metridia lucens		22,36	6,14	14,20	0,66	0,31	0,66	0,59	0,25	1,90	5,13	12,80	21,50	7,21
Acartia spp.		0,63	2,63	0,89	0	0,02	0,04	0,03	2,75	3,95	11,85	5,74	2,16	2,56
Oithona spp.		0,60	10,40	1,24	0,01	0,27	0,26	0,26	7,87	1,81	5,99	2,46	3,99	2,93
Other Copepods		0,07	0	0	0	2,26	1,24	0,13	6,49	6,90	4,73	8,82	4,77	2,95
Total		100,00	99,95	99,94	100,05	100,07	100,00	100,02	100,01	100,05	99,95	99,99	100,00	100,09

Table 45. *The Percentage Composition by Number of the Copepods Stock at Eggum. November 1948 — February 1951.*

Year	1948	1949														
Month	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mean
Total number ..	14 616	4 889	2 603	4 674	28 242	87 644	57 337		43 829	118549	26 783	12 032				38 658
Calanus finmarchicus	1,1	2,0	19,2	5,5	68,7	59,0	26,2	No	42,4	26,5	5,9	12,6	No			26,8
Metridia lucens ..	25,1	37,8	17,4	10,4	4,0	2,3	10,1	Hauls	4,1	6,0	14,4	14,0	Hauls			12,1
Pseudocalanus elongatus	45,1	20,4	9,6	4,5	6,2	11,0	6,3		8,4	7,3	21,6	13,2				10,9
Microcalanus pusillus	1,7	17,4	32,7	47,1	12,8	18,6	38,5		16,0	3,7	8,6	18,0				21,3
Oithona spp.	4,7	9,7	18,3	32,1	6,7	8,5	17,5		28,4	55,0	31,7	30,4				23,8
Paracalanus parvus	20,6	11,3	0,7	0	0	0	0		0,1	0,1	2,0	4,7				1,9
Other Copepods ..	1,9	1,4	2,3	0,5	1,6	0,6	1,1		0,9	1,5	16,0	7,4				3,3
		1950												1951		Mean 1950
Total number ..		2 344	3 181	7 801	33 534	309432	126434	77 404	43 924	70 263	14 375	45 227	15 654	9 980	3 220	58 696
Calanus finmarchicus		17,1	9,3	15,0	78,3	89,3	83,4	73,0	41,0	16,4	5,4	3,6	4,7	4,0	9,2	36,4
Metridia lucens ..		10,7	12,6	1,3	0,1	1,8	1,1	3,4	5,9	7,9	12,9	8,4	10,4	9,8	10,4	6,4
Pseudocalanus elongatus		8,9	4,2	2,8	0,1	1,0	1,1	1,4	9,1	13,0	31,0	34,8	29,9	13,7	13,4	11,4
Microcalanus pusil.		17,1	66,1	76,1	11,5	1,8	11,0	13,5	19,4	9,3	6,6	1,8	15,2	25,9	34,1	20,8
Oithona spp.		36,4	7,1	4,0	10,1	6,0	3,2	8,0	20,7	28,7	21,6	28,7	33,0	37,6	28,0	17,1
Paracalanus parvus		6,4	0	0	0	0	0	0	0	17,1	13,1	13,7	4,0	4,4	2,6	4,5
Other Copepods ..		3,6	0,9	0,8	0	0,1	0,2	0,8	3,9	7,7	9,5	9,1	2,3	4,6	2,5	3,2

Table 46. *The Percentage Composition by Volume of the Copepod Stock at Eggum, November 1948 — February 1951.*

Year	1948	1949														
Month	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mean
Calanus finmarchicus	15,95	20,63	87,50	83,20	89,08	90,73	83,90	No	93,30	81,70	60,10	75,08				76,5
Calanus hyperboreus	0	0	0,01	0	3,60	5,19	5,09	Hauls	2,29	1,60	0,20	0,94				1,9
Pseudocalanus elongatus min...	26,99	11,15	1,48	1,63	1,03	1,86	1,15		0,95	1,76	6,10	3,20	No			3,0
Microcalanus pusillus	0,37	2,58	1,26	4,33	0,91	0,80	1,75		0,50	0,32	1,48	1,43	Hauls			1,5
Metridia lucens ..	44,40	59,58	8,82	8,53	4,56	1,03	7,01		1,58	4,35	14,25	10,25				12,0
Acartia clausi	0,71	0,80	0,30	0,20	0	0	0		0	0	4,64	0				0,6
Oithona spp.	0,83	1.08	0,53	2,13	0,38	0,30	0,75		0,76	9,17	3,98	1,68				2,1
Other Copepods	10,75	3,87	0,08	0	0,42	0,09	0,35		0,63	1,12	9,28	7,35				2,3
Total	100,00	99,96	99,98	100,02	99,98	100,00	100,00		100,00	100,02	100,03	99,93				99,9
Year		1950												1951		Mean
Calanus finmarchicus		65,55	75,50	81,55	96,55	98,10	98,40	96,90	85,68	81,50	49,60	49,43	62,25	61,68	83,20	78,4
Calanus hyperboreus		0,79	0	0,02	0,20	1,22	1,01	1,04	0,33	0,60	0	0	0	1,87	0	0,4
Pseudocalanus .. *elongatus*		2,02	1,33	1,30	0,08	0,12	0,09	0,12	2,63	3,81	15,57	20,15	13,64	7,95	3,92	5,1
Microcalanus pusillus		1,15	5,76	14,45	1,55	0,20	0,20	0,31	2,75	1,09	0,98	0,39	2,33	4,29	2,85	2,6
Metridia lucens ..		8,32	10,75	1,92	0,32	0,36	0,25	1,38	3,71	3,89	18,90	9,15	15,50	11,58	5,66	6,2
Acartia spp.		0	0	0	0	0	0	0	0	0	4,12	5,61	0	0	0	0,8
Oithona spp.		1,68	1,78	0,47	0,46	1,19	0,06	0,04	2,28	2,46	2,38	4,23	3,75	4,75	1,72	1,7
Other Copepods		20,40	6,20	0,38	0,07	0,01	0,03	0,08	2,61	6,67	8,47	11,01	2,57	7,90	2,65	4,9

Year	1948		1949												
Month	Oct.	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Total number	64 049	24 571		23 942	12 679	52 680	19 865	25 738	41 880	37 937	40 956	21 339	19 214	12 701	28 085
Calanus finmarchicus	4,9	10,7		20,5	13,1	85,1	44,2	49,0	46,6	12,9	21,5	26,1	48,3	53,5	38,2
Calanus hyperboreus	0	0,2	No	3,4	35,4	2,4	6,9	7,8	5,8	2,8	4,1	0,7	2,3	2,3	6,7
Metridia spp.	11,6	14,7	Hauls	8,5	9,3	2,1	2,3	1,0	1,8	3,7	2,2	4,9	4,1	4,0	4,0
Paraeuchaeta norvegica	0,6	0,4		5,4	9,3	1,2	4,9	1,8	2,3	1,2	1,2	2,0	1,4	0,8	2,8
Pseudocalanus elong.	19,4	24,0		2,7	0,3	0,9	3,4	1,5	5,2	3,1	1,9	12,6	7,8	1,6	3,7
Microcalanus pusillus	9,4	8,6		17,5	22,0	3,9	19,2	22,6	8,2	22,8	9,5	7,3	9,1	13,5	14,1
Oithona spp.	45,3	33,0		40,7	9,0	3,7	17,7	15,1	28,4	53,4	51,2	33,6	26,0	22,3	27,4
Other Copepods[1]	8,8	8,6		1,4	1,0	0,9	0,7	1,5	2,3	0,4	8,6	13,4	2,5	2,1	3,2
Oncaea borealis								0,4							
Acartia spp.	6,7	4,9							0,4				2,1		
Scolecitricella minor								0,4	0,7						
Temora longicornis ..											5,3	5,9			
Paracalanus parvus ..														2,2	
			1950												
Total number			15 237	39 466	32 565	44 038	95 899	23 847	46 028	31 010		28 590	9 631	17 296	34 873
Calanus finmarchicus			44,2	33,4	5,4	80,8	75,8	93,7	78,4	69,5		19,9	55,7	46,6	54,9
Calanus hyperboreus			2,8	31,2	69,7	7,8	8,1	3,1	2,4	5,2	No	0	0,3	2,6	12,1
Metridia spp.			2,2	4,9	6,4	3,2	2,2	0,1	0,3	0,2	Hauls	0,9	2,3	6,8	2,7
Paraeuchaeta norvegica			1,3	1,3	4,5	1,5	3,0	1,2	0,4	0,5		1,1	0,2	1,0	1,5
Pseudocalanus elong.			0,9	0,6	0,3	1,7	2,5	0	0,7	0,4		41,7	5,7	9,0	5,8
Microcalanus pusillus			20,8	13,9	5,0	2,7	2,0	0,7	5,2	5,5		5,3	12,5	7,9	7,4
Oithona spp.			27,4	14,4	8,8	2,2	4,6	1,4	12,6	17,3		17,7	19,5	21,7	13,4
Other Copepods[1]			0,5	0,9	0,1	0.4	2,0	0,1	0,3	1,5		14,3	3,8	4,7	2,6
Oncaea borealis							3,3								
Acartia spp.							2,0			1,2				2,9	
Paracalanus parvus ..												10,4	2,7	2,6	

[1] Including the species below the line.

Table 48. *The Percentage Composition by Volume of the Copepod Stock at Skrova. October 1948 — December 1950.*

Year	1948		1949												
Month	Oct.	Nov.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Calanus finmarchicus . .	44,65	21,30		69,50	56,49	43,00	47,23	57,90	56,34	41,59	56,17	74,05	80,20	82,10	60,42
Calanus hyperboreus . .	0	9,06		13,57	32,95	33,45	33,80	32,28	32,83	32,28	28,63	6,10	11,40	10,43	24,34
Pseudocalanus elong.	16,66	12,50	No	0,32	0,13	0,24	0,25	0,06	0,12	0,34	0,22	1,05	0,60	0,09	0,31
Microcalanus pusillus	2,26	1,70	Hauls	0,64	0,69	0,29	0,33	0,40	0,26	0,76	0,37	0,22	0,16	0,24	0,40
Pareuchaeta norvegica	9,27	18,60		7,12	5,63	19,63	17,12	8,67	7,53	13,41	9,46	13,01	5,56	5,30	10,22
Temora longicornis . .	0,46	0		0	0	0,08	0,01	0	0	0	0,67	0,64	0	0	0,13
Metridia spp.	10,89	27,99		7,81	3,71	2,89	0,95	0,44	1,97	8,99	1,98	2,71	1,52	1,51	3,13
Acartia spp.	8,55	3,89		0,07	0,01	0,01	0,02	0	0,08	0,06	0,54	1,20	0,19	0,04	0,20
Oithona spp.	7,25	4,86		0,76	0,22	0,20	0,24	0,21	0,68	2,38	1,85	1,01	0,31	0,31	0,83
Other Copepods	0,07	0,12		0,21	0,20	0.08	0,07	0,07	0,18	0,28	0,17	0,03	0,01	0,02	0,12
Total	100,06	100,02		100,00	100,03	99,93	100,02	100,07	99,99	100,09	100,06	100,02	99,95	100,04	100,10
Year			1950												
Calanus finmarchicus			74,60	84,80	27,40	58,78	49,70	89.72	86,86	75,93		78,83	94,80	74,43	72,35
Calanus hyperboreus . .			16,99	8,16	58,20	31,23	38,03	6,21	9,64	21,54	No	0,46	1,96	14,70	18,83
Pseudocalanus elong.			0,06	0,06	0,05	0,09	0,07	0	0,01	0,01	Hauls	5,76	0,42	1,34	0,72
Microcalanus pusillus			0,38	0,33	0,17	0,11	0,06	0,01	0,09	0,04		0,24	0,25	0,16	0,17
Pareuchaeta norvegica			6,68	5,16	11,88	7,63	11,19	3,96	2,95	2,09		11,34	1,04	7,43	6,49
Paracalanus parvus . .			0	0	0	0	0	0	0	0		0,71	0,05	0,03	0,08
Temora longicornis			0	0	0	0,01	0	0	0	0		0,05	0	0	0
Metridia spp.			0,86	1,14	2,16	1,99	0,76	0,11	0,28	0,19		1,20	1,08	1,41	1,02
Acartia spp.			0,02	0,02	0	0,01	0,10	0	0,02	0,08		0,51	0,06	0,13	0,09
Oithona spp.			0,38	0,28	0,21	0,06	0,08	0,01	0,15	0,18		0,61	0,28	0,32	0,23
Other Copepods			0,04	0,02	0,02	0,07	0,03	0,01	0	0		0,33	0,05	0,07	0,06
Total			100,01	99,97	100,09	99,98	100,02	100,03	100,00	100,06		100,04	99,99	100,0	100,04

Table 49. *Size of Calanus finmarchicus 1948—50. Scale: 0.097 mm.*

Station	Date	Depth, m.	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	n	Mean length, mm
Sognesjøen	24/12—48	200—50	V	—	4	11	22	20	25	11	23	7	3	—	—	—	—	—	—	126	2.22
	2/2 —49	»		1	4	8	12	22	10	5	2	—	—	—	—	—	—	—	—	64	2.10
	1/6 —49	»	»	—	—	—	2	12	26	27	20	16	5	1	1	—	—	—	—	110	2.34
	1/6 —49	50—0	»	—	—	—	1	9	25	24	31	20	—	—	—	—	—	—	—	110	2.34
	21/7 —49	200—50	»	—	—	1	2	2	3	8	6	11	5	1	1	—	—	—	—	50	2,41
	12/8 —49	»	»		—	3	9	30	15	23	23	5	2	—	—	—	—	—	—	110	2.26
	25/8 —49	»	»	—	2	6	11	15	15	12	11	—	—	—	—	—	—	—	—	72	2.17
	11/10—49	»	»	—	—	—	3	3	9	9	13	7	1	—	—	—	—	—	—	45	2.34
	16/1 —50	200—0	»	1	1	5	4	15	9	14	12	1	1	—	—	—	—	—	—	73	2.23
	8/3 —50	»	»	1	2	—	5	6	—	—	—	1	—	—	—	—	—	—	—	15	2.06
	28/3 —50	»	»	—	—	—	—	—	—	1	5	13	5	1	—	—	—	—	—	25	2.52
	28/4 —50	»	»	—	—	—	—	—	5	16	27	31	26	4	—	—	—	—	—	109	2.50
	12/5 —50	»	»	—	—	—	1	—	3	11	29	27	27	12	—	—	—	—	—	110	2.51
	14/6 —50	»	»	—	—	—	—	1	2	10	8	20	7	2	—	—	—	—	—	50	2.47
	10/7 —50	»	»	—	—	3	15	36	25	15	12	3	1	—	—	—	—	—	—	110	2.21
	21/9 —50	»	»	—	—	3	16	19	13	23	25	4	6	—	—	—	—	—	—	109	2.27
	11/10—50	»	»	—	1	1	6	10	14	20	19	7	1	—	—	—	—	—	—	79	2.31
	20/11—50	»	»	1	—	6	11	21	16	15	17	3	3	2	—	—	—	—	—	95	2.24
	29/12—50	»	»	—	2	5	13	16	10	10	7	8	6	3	1	—	—	—	—	81	2.26

TABLE 49. (cont.)

Station	Date	Depth, m	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	n	Mean length, mm
Sognesjøen	2/2 —49	200—50	♀	—	—	—	1	1	7	5	2	4	3	1	—	—	—	—	—	24	2.38
	1/6 —49	»	»	—	—	—	—	—	3	4	8	15	13	4	6	1	—	—	—	54	2.55
	1/6 —49	50—0	»	—	—	—	—	—	—	11	25	34	22	18	—	—	—	—	—	110	2.53
	21/7 —49	200—50	»	—	—	—	—	—	—	—	3	1	4	4	8	1	—	—	—	21	2.70
	25/8 —49	»	»	—	—	—	—	—	5	4	3	5	1	1	—	—	—	—	—	19	2.40
	8/3 —50	200—0	»	—	—	—	1	15	25	33	20	15	6	1	—	—	—	—	—	116	2.34
	28/3 —50	»	»	—	—	—	—	—	10	16	12	4	5	2	1	—	—	—	—	50	2.40
	28/4 —50	»	»	—	—	—	—	—	—	—	—	—	5	3	5	5	—	1	—	19	2.78
	12/5 —50	»	»	—	—	—	—	—	—	—	—	—	5	23	35	31	12	4	—	110	2.84
	14/6 —50	»	»	—	—	—	—	—	—	—	—	5	8	9	13	11	3	1	—	50	2.77
	10/7 —50	»	»	—	—	—	—	2	4	7	12	4	5	3	2	1	3	—	—	43	2.50
	21/9 —50	»	»	—	—	—	1	—	1	19	20	35	23	11	—	—	—	—	—	110	2.50
	11/10—50	»	»	—	—	—	—	—	1	3	19	25	18	6	—	—	—	—	—	72	2.52
	2/2 —49	200—50	♂	—	—	—	—	—	2	6	6	3	4	2	—	—	—	—	—	23	2.45
	28/4 —49	200—0	»	—	—	—	—	—	—	—	—	3	8	12	21	6	—	—	—	50	2.75

TABLE 49. (cont.)

Station	Date	Depth, m	Stage	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	n	Mean length, mm
Ona	28/3 —49	200—0	V	—	1	2	12	15	42	34	4	—	—	—	—	—	—	—	—	110	2.32
	17/4 —49	»	»	—	—	—	4	9	15	36	36	9	1	—	—	—	—	—	—	110	2.43
	27/4 —49	»	»	—	2	7	15	20	24	24	9	7	1	—	1	—	—	—	—	110	2.33
	24/5 —49	»	»	—	4	6	25	23	14	9	4	—	—	—	—	—	—	—	—	85	2.27
	29/6 —49	»	»	—	—	—	7	11	18	24	29	18	3	—	—	—	—	—	—	110	2.43
	18/7 —49	»	»	—	1	2	19	29	20	15	21	3	—	—	—	—	—	—	—	110	2.41
	26/7 —49	»	»	—	—	2	12	28	24	28	12	3	1	—	—	—	—	—	—	110	2.34
	22/8 —49	»	»	—	2	5	13	18	17	33	18	3	1	—	—	—	—	—	—	110	2.34
	11/10—49	»	»	3	7	12	14	35	21	27	12	5	2	2	—	—	—	—	—	140	2.29
	17/4 —50	»	»	—	—	—	—	—	1	9	35	41	16	7	1	—	—	—	—	110	2.56
	2/5 —50	»	»	—	—	—	1	1	8	12	28	21	31	3	5	—	—	—	—	110	2.59
	6/6 —50	»	»	—	—	—	—	4	10	19	28	31	15	3	—	—	—	—	—	110	2.54
	4/7 —50	»	»	—	5	10	14	19	23	13	13	7	3	3	—	—	—	—	—	110	2.32
	17/7 —50	»	»	—	2	7	25	24	9	18	10	9	5	1	—	—	—	—	—	110	2.32
	16/8 —50	»	»	1	4	9	18	11	17	15	8	15	9	3	—	—	—	—	—	110	2.36
	30/8 —50	»	»	3	12	27	18	21	10	10	4	5	—	—	—	—	—	—	—	110	2.18
	13/9 —50	»	»	—	8	11	11	13	14	5	7	10	3	1	—	—	—	—	—	83	2.28
	5/10—50	»	»	5	8	18	13	13	16	12	19	13	3	—	—	—	—	—	—	110	2.29
	16/12—50	»	»	3	16	25	21	18	12	8	5	1	—	—	—	—	—	—	—	109	2.16

TABLE 49. (cont.)

Station	Date	Depth, m	Stage	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	n	Mean length, mm
Ona	17/3 —49	200—0	♀	—	—	—	5	13	20	25	9	10	2	1	—	—	—	—	—	87	2.36
	28/3 —49	»	»	—	—	—	3	15	33	27	18	7	5	2	—	—	—	—	—	110	2.38
	17/4 —49	»	»	—	—	—	1	2	10	12	15	10	5	10	20	12	10	4	—	110	2.73
	27/4 —49	»	»	—	—	—	—	2	2	6	10	17	20	14	21	10	6	2	—	110	2.76
	24/5 —49	»	»	—	—	—	—	—	1	4	18	35	35	15	1	—	1	—	—	110	2.66
	29/6 —49	»	»	—	—	—	—	—	1	6	15	23	29	21	9	3	3	—	—	110	2.70
	18/7 —49	»	»	—	—	—	—	—	4	5	16	28	26	19	7	4	1	—	—	110	2.68
	26/7 —49	»	»	—	—	—	—	—	—	3	3	9	5	3	1	—	—	—	—	24	2.66
	14/3 —50	»	»	—	—	1	3	13	16	10	6	1	—	—	—	—	—	—	—	50	2.34
	17/4 —50	»	»	—	—	—	—	7	11	25	20	15	6	7	7	10	15	4	1	128	2.67
	2/5 —50	»	»	—	—	—	1	1	10	3	12	17	21	22	19	24	27	10	3	170	2.84
	6/6 —50	»	»	—	—	—	—	—	—	3	1	7	18	28	30	15	5	3	—	110	2.86
	4/7 —50	»	»	—	—	—	—	1	3	1	4	15	22	30	21	10	3	—	—	110	2.78
	17/7 —50	»	»	—	—	—	—	1	1	2	8	13	17	30	25	9	3	—	—	109	2.78
	30/8 —50	»	»	—	—	—	6	8	25	8	8	2	2	—	—	—	—	—	—	59	2.36
	5/10—50	»	»	—	—	—	1	1	5	3	6	3	1	1	—	—	—	—	—	21	2.46
	16/12—50	»	»	—	—	—	—	—	3	4	7	1	1	—	—	—	—	—	—	16	2.48

TABLE 49 (cont.).

Station	Date	Depth, m	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	n	Mean length, mm
Eggum	5/1 —49	185—0	V	3	13	15	13	2	8	5	1	—	—	—	—	—	—	—	—	60	2.02
	26/2 —49	190—0	»	3	7	10	14	12	6	—	2	1	1	—	—	—	—	—	—	56	2.06
	16/3 —49	50—0	»	1	1	1	5	7	3	—	—	—	—	—	—	—	—	—	—	18	2.08
	23/4 —49	»	»	—	—	—	—	—	—	1	—	3	3	6	3	—	—	—	—	16	2.66
	2/5 —49	»	»	—	—	—	—	—	—	1	7	8	19	38	24	2	1	—	—	100	2.69
	21/5 —49	»	»	—	—	—	—	1	1	3	13	20	32	27	13	5	—	—	—	115	2.63
	16/6 —49	»	»	—	—	—	—	—	5	4	22	27	34	16	1	1	—	—	—	110	2.55
	28/6 —49	»	»	—	—	—	1	—	—	6	7	11	17	8	—	—	—	—	—	50	2.54
	6/8 —49	»	»	—	—	—	2	18	18	17	19	13	4	—	—	—	—	—	—	91	2.37
	1/9 —49	»	»	—	—	—	3	10	13	21	20	12	16	4	1	—	—	—	—	100	2.40
	17/9 —49	»	»	—	—	—	3	9	16	16	17	20	14	5	—	—	—	—	—	100	2.41
	17/10—49	200—50	»	—	6	10	15	7	7	16	12	12	13	2	—	—	—	—	—	100	2.28
	24/11—49	»	»	—	8	14	19	13	8	23	18	15	20	2	—	—	—	—	—	140	2.23
	3/1 —50	195—0	»	—	2	3	13	21	28	23	20	12	13	5	1	—	—	—	—	141	2.31
	1/2 —50	»	»	—	1	4	6	18	18	22	16	8	6	2	—	—	—	—	—	101	2.30
	28/4 —50	200—0	»	—	—	—	—	—	1	—	6	14	39	17	20	11	2	—	—	110	2.64
	8/5 —50	»	»	—	—	—	—	—	—	—	1	1	9	27	39	19	4	—	—	110	2.79
	22/5 —50	»	»	—	—	—	—	1	10	12	22	28	23	10	4	—	—	—	—	110	2.43
	14/6 —50	»	»	—	—	—	2	10	29	31	14	17	2	5	—	—	—	—	—	110	2.38
	26/6 —50	»	»	—	—	—	—	3	14	24	28	22	12	4	1	2	—	—	—	110	2.42
	12/7 —50	»	»	—	—	—	—	—	4	8	14	10	8	2	3	1	—	—	—	50	2.49
	9/8 —50	»	»	—	—	—	—	2	14	20	29	20	13	8	4	—	—	—	—	110	2.45
	24/8 —50	»	»	—	—	3	6	13	17	18	20	17	14	2	—	—	—	—	—	110	2.37
	12/9 —50	»	»	—	—	5	18	17	30	22	26	11	2	2	—	—	—	—	—	133	2.27
	13/10—50	»	»	5	12	13	16	16	13	6	13	9	3	1	3	—	—	—	—	110	2.15
	1/11—50	»	»	14	30	15	5	21	16	7	8	2	1	1	—	—	—	—	—	120	2.03
	14/11—50	»	»	—	2	10	13	17	12	17	10	15	7	4	2	—	—	—	—	119	2.29
	16/12—50	»	»	—	2	4	13	21	17	13	11	4	10	7	2	1	—	—	—	105	2.31
	29/12—50	»	»	—	—	6	5	15	15	24	24	14	15	11	2	—	—	—	—	131	2.38

TABLE 49 (cont.).

Station	Date	Depth, m	Stage	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	n	Mean length, mm
Eggum	5/1 —49	185—0	♀	—	—	1	1	2	8	3	3	—	—	—	—	—	—	—	—	18	2.42
	26/2 —49	190—0	»	—	1	9	12	14	25	13	15	4	—	1	—	—	—	—	—	94	2.41
	16/3 —49	»	»	—	1	2	13	25	33	13	15	12	6	—	—	—	—	—	—	120	2.46
	8/4 —49	200—50	»	—	2	5	11	18	32	16	13	15	2	5	1	—	—	—	—	120	2.47
	23/4 —49	50—0	»	—	—	—	2	3	5	1	1	2	—	—	—	—	—	—	—	14	2.43
	21/5 —49	»	»	—	—	—	—	—	8	2	6	6	16	11	13	3	—	—	—	65	2.80
	16/6 —49	»	»	—	—	—	—	—	4	6	9	32	20	20	8	—	—	—	—	99	2.77
	28/6 —49	»	»	—	—	—	—	1	—	5	11	13	10	9	1	—	—	—	—	50	2.72
	31/3 —50	»	»	—	—	1	5	18	12	16	7	6	4	1	—	—	—	—	—	70	2.47
	11/4 —50	200—0	»	—	—	—	2	9	24	18	26	33	16	6	4	1	1	—	—	140	2.63
	28/4 —50	»	»	—	—	—	5	6	17	19	26	17	6	6	1	1	—	—	—	104	2.64
	8/5 —50	»	»	—	—	—	—	—	8	13	13	13	19	4	8	9	8	5	1	101	2.82
	22/5 —50	»	»	—	—	—	—	—	—	1	5	1	1	1	—	—	—	—	—	9	2.68
	14/6 —50	»	»	—	—	—	—	—	3	2	6	6	4	1	—	—	—	—	—	22	2.68
	12/7 —50	»	»	—	—	—	—	10	20	38	22	8	1	2	1	—	—	—	—	102	2.53
	28/7 —50	»	»	—	—	—	—	5	4	15	11	4	3	3	1	1	—	—	—	45	2.53

TABLE 49 (cont.).

Station	Date	Depth, m	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	n	Mean length, mm
Skrova	9/10—48	300—50	V	—	—	—	4	12	15	20	28	20	22	18	6	5	—	—	—	150	2.46
	12/11—48	»	»	—	—	—	7	7	9	14	14	21	28	10	6	2	1	—	—	119	2.48
	1/2 —49	»	»	—	—	1	2	5	20	20	19	24	24	18	9	2	5	—	—	149	2.49
	5/2 —49	»	»	—	3	4	4	5	13	21	21	26	24	16	8	4	—	—	—	149	2.46
	26/2 —49	300—0	»	—	2	2	7	15	12	24	23	22	25	13	4	—	1	—	—	150	2.41
	15/3 —49	»	»	—	4	2	13	26	14	17	9	6	3	2	2	—	—	—	—	98	2.24
	30/4 —49	50—0	»	—	—	—	—	—	—	—	—	14	23	36	17	2	2	—	—	94	2.70
	18/6 —49	»	»	—	—	—	—	—	3	1	7	13	17	2	3	3	1	—	—	50	2.58
	4/7 —49	300—0	»	—	—	—	—	—	4	4	20	16	22	21	6	5	1	1	—	100	2.59
	4/7 —49	50—0	»	—	—	—	—	—	—	8	17	18	21	23	8	5	—	—	—	100	2.60
	17/7 —49	300—0	»	—	—	—	—	—	—	6	14	17	23	27	22	8	2	1	—	120	2.66
	23/7 —49	300—50	»	—	—	—	—	—	3	9	13	26	26	27	10	4	2	—	—	120	2.59
	27/8 —49	300—0	»	—	—	—	1	—	3	13	20	22	24	20	9	6	2	—	—	120	2.57
	29/10—49	300—50	»	—	1	—	5	2	6	9	23	20	27	14	8	5	—	—	—	120	2.53
	24/12—49	»	»	—	—	—	2	—	4	11	21	24	23	26	8	1	—	—	—	120	2.55
	26/1 —50	300—0	»	—	—	—	2	4	4	10	18	27	24	21	6	4	—	—	—	120	2.54
	4/2 —50	»	»	—	1	2	1	2	5	12	23	22	29	17	5	1	—	—	—	120	2.52
	13/2 —50	»	»	—	—	1	1	2	4	10	36	29	24	10	2	—	—	—	—	119	2.40
	25/2 —50	»	»	1	—	3	3	6	19	22	28	19	11	6	2	—	—	—	—	120	2.38
	13/3 —50	»	»	—	—	10	16	16	21	22	20	8	7	—	—	—	—	—	—	120	2.26
	13/3 —50	50—0	»	—	3	1	6	9	11	4	2	1	2	1	—	—	—	—	—	40	2.20
	6/5 —50	300—0	»	—	—	—	—	—	—	—	—	4	15	32	36	27	6	—	—	120	2.78
	20/5 —50	»	»	—	—	—	—	—	—	—	4	19	30	25	20	1	1	—	—	100	2.67
	2/6 —50	25—5	»	—	—	—	—	1	7	11	26	28	20	16	9	2	—	—	—	120	2.53
	24/6 —50	50—0	»	—	—	—	—	3	11	15	9	11	2	—	—	—	—	—	—	51	2.37
	1/7 —50	»	»	—	—	—	—	4	9	13	8	4	9	2	1	—	—	—	—	50	2.40
	15/7 —50	300—0	»	—	—	—	—	—	1	8	11	12	11	7	—	—	—	—	—	50	2.51
	22/7 —50	»	»	—	—	—	—	1	4	14	23	19	32	16	2	—	—	—	—	121	2.55
	25/10—50	»	»	—	—	—	—	3	14	17	20	18	25	7	10	4	1	1	—	120	2.51
	23/12—50	»	»	—	—	—	3	1	10	15	25	15	20	17	9	4	1	—	—	120	2.52

Table 49 (cont.).

Station	Date	Depth, m	Stage	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	n	Mean length, mm
Skrova	26/2 —49	300—0	♀	—	1	2	5	4	10	12	20	26	20	8	6	6	—	—	—	120	2.67
	15/3 —49	50—0	»	—	—	—	—	6	11	26	21	23	14	13	6	—	—	—	—	120	2.66
	19/3 —49	»	»	—	—	—	2	5	16	15	30	21	16	13	2	—	—	—	—	120	2.65
	30/4 —49	»	»	—	—	—	1	2	12	7	12	15	9	7	5	1	—	—	—	71	2.68
	17/7 —49	300—0	»	—	—	—	—	2	—	—	3	6	16	11	15	9	2	—	—	64	2.90
	27/8 —49	»	»	—	—	—	1	2	3	2	2	3	2	2	4	3	—	—	—	24	2.72
	13/2 —50	»	»	—	—	—	4	2	2	8	17	24	25	12	7	3	4	3	—	111	2.83
	25/2 —50	»	»	—	—	—	—	1	3	9	28	29	26	11	1	1	1	—	—	110	2.76
	13/3 —50	»	»	—	—	—	—	2	7	13	30	27	27	9	3	2	—	—	—	120	2.70
	20/3 —50	»	»	—	1	—	3	3	6	7	26	31	21	19	2	—	1	—	—	120	2.70
	11/4 —50	»	»	—	—	—	—	3	4	6	18	32	27	22	6	2	—	—	—	120	2.76
	25/4 —50	»	»	—	—	—	2	—	9	14	17	26	22	16	13	1	—	—	—	120	2.73
	22/7 —50	»	»	—	—	—	—	—	1	3	10	18	26	12	12	5	—	—	—	87	2.81
	13/2 —50	300—0	♂	—	—	—	—	—	—	3	27	44	34	9	2	1	—	—	—	120	2.73

TABLE 49 (cont.).

Station	Date	Depth, m.	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	n	Mean length, mm
«M»	28/2 —50	1000—600	V	—	—	—	—	6	13	16	20	24	22	9	—	—	—	—	110	2.46
	1/3 —50	600—0	»	—	—	—	1	4	13	12	24	22	24	7	3	—	—	—	110	2.48
	15/3 —50	50—0	»	—	—	2	7	19	33	27	11	9	1	1	—	—	—	—	110	2.27
	15/3 —50	100—50	»	—	1	1	7	10	15	14	12	5	—	—	—	—	—	—	65	2.26
	15/3 —50	600—100	»	—	—	—	2	7	14	23	25	21	14	3	1	—	—	—	110	2.40
	15/3 —50	1000—600	»	—	—	—	—	8	38	19	16	21	4	2	2	—	—	—	110	2.36
	31/3 —50	1000—585	»	—	—	—	3	16	25	30	22	9	5	—	—	—	—	—	110	2.32
	28/3 —50	2000—0	»	—	—	—	1	14	28	29	21	9	7	1	—	—	—	—	110	2.33
	5/4 —50	50—0	»	—	—	1	5	35	30	28	11	—	—	—	—	—	—	—	110	2.23
	5/4 —50	600—100	»	—	—	—	1	6	19	34	24	17	6	2	—	—	—	—	110	2.38
	10/4 —50	1900—100	»	—	—	—	—	—	1	1	—	7	1	2	—	—	—	—	12	2.52
	11/4 —50	1000—600	»	—	—	—	—	5	14	8	3	2	2	3	—	—	—	—	37	2.32
	12/4 —50	50—0	»	—	—	—	3	12	27	32	22	6	7	1	—	—	—	—	110	2,32
	12/4 —50	100—50	»	—	—	—	—	18	37	33	14	5	2	1	—	—	—	—	110	2.29
	12/4 —50	600—100	»	—	—	—	—	10	18	27	24	23	6	2	—	—	—	—	110	2.38
	18/4 —50	1000—600	»	—	—	—	—	3	5	3	8	7	3	2	2	1	—	—	34	2.43
	19/4 —50	50—0	»	—	—	—	—	2	10	19	25	35	19	—	—	—	—	—	110	2.45
	19/4 —50	600—100	»	—	—	—	1	6	14	32	29	21	6	—	—	—	—	—	109	2.37
	21/4 —50	2000—1000	»	—	—	—	—	—	—	—	—	—	2	3	1	—	—	—	6	2.70

TABLE 49 (cont.).

Station	Date	Depth, m	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	n	Mean length, mm
«M»	25/4 —50	1000—600	V	—	—	—	—	1	2	2	2	1	3	1	—	—	—	—	12	2.42
	28/4 —50	50—0	»	—	—	—	—	—	2	7	16	29	32	20	4	—	—	—	110	2.56
	2/5 —50	50—0	»	—	—	—	2	12	20	30	24	15	5	1	1	—	—	—	110	2.36
	9/5 —50	100—0	»	—	—	—	—	2	2	5	7	17	34	33	9	—	—	—	109	2.61
	12/5 —50	600—100	»	—	—	—	—	—	—	—	10	26	45	43	6	—	—	—	110	2.71
	12/5 —50	1000—600	»	—	—	—	—	—	—	—	1	2	3	14	14	1	—	—	35	2.72
	16/5 —50	2000—1000	»	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	2	2.57
	18/5 —50	100—0	»	—	—	—	—	5	5	18	13	7	5	2	—	—	—	—	55	2.47
	16/6 —50	600—100	»	—	—	—	—	1	8	27	15	22	22	11	3	1	—	—	110	2.48
	16/6 —50	1000—600	»	—	—	—	—	—	—	9	9	12	29	31	18	2	—	—	110	2.63
	16/6 —50	2000—1000	»	—	—	—	—	—	2	5	9	13	25	40	14	2	—	—	120	2.64
	17/6 —50	100—0	»	—	—	—	—	3	6	22	26	30	21	2	—	—	—	—	110	2.45
	18/7 —50	600—100	»	—	—	—	—	1	14	32	27	17	14	5	—	—	—	—	110	2.43
	19/7 —50	1000—600	»	—	—	—	—	1	9	30	14	21	18	14	3	—	—	—	110	2.47
	31/7 —50	100—0	»	—	—	—	—	—	4	15	16	28	33	14	—	—	—	—	110	2.52
	14/8 —50	1000—600	»	—	—	—	—	4	15	17	22	15	26	5	6	—	—	—	110	2.46
	14/8 —50	1800—1000	»	—	—	—	—	1	9	14	20	17	25	17	6	—	—	—	109	2.52
	16/8 —50	600—100	»	—	—	—	—	1	5	30	25	28	23	10	2	—	—	—	124	2.48
	1/9 —50	100—0	»	—	1	1	6	2	1	—	1	—	—	—	—	—	—	—	12	2.08
	14/9 —50	100—0	»	—	1	6	22	32	21	10	4	2	—	—	—	—	—	—	98	2.16

TABLE 49 (cont.)

Station	Date	Depth, m.	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	n	Mean length, mm.
«M»	21/9 —50	100—0	V	—	2	5	14	13	3	3	2	—	—	—	—	—	—	—	42	2.10
	21/9 —50	600—100	»	—	—	1	4	15	14	16	20	29	10	1	—	—	—	—	110	2.38
	21/9 —50	200—1050	»	—	—	—	2	1	21	22	15	23	12	10	2	2	—	—	110	2.44
	26/9 —50	0	»	—	—	—	—	3	18	24	34	17	14	2	—	—	—	—	112	2.41
	6/10—50	100—0	»	—	—	1	14	20	17	9	6	2	—	—	—	—	—	—	69	2.20
	16/10—50	2000—1000	»	—	—	—	—	3	16	29	18	24	12	7	1	—	—	—	110	2.42
	17/10—50	600—100	»	—	—	2	7	24	28	19	20	7	2	1	—	—	—	—	110	2.27
	17/10—50	1000—600	»	—	—	—	1	6	12	16	19	22	18	13	3	—	—	—	110	2.40
	21/10—50	100—0	»	—	1	6	28	33	16	45	7	4	—	—	—	—	—	—	140	2.17
	10/11—50	»	»	—	—	4	16	36	15	16	8	2	—	—	—	—	—	—	110	2.23
	17/11—50	»	»	—	16	27	32	21	8	4	2	—	—	—	—	—	—	—	110	2.04
	17/11—50	600—100	»	—	—	—	—	4	15	23	27	24	15	—	1	—	—	—	109	2.42
	17/11—50	1000—600	»	—	—	—	1	5	14	14	21	27	15	12	1	—	—	—	110	2.29
	17/11—50	1950—1000	»	—	—	—	—	2	17	21	20	20	15	14	2	—	—	—	111	2.33
	13/12—50	600—100	»	—	—	3	6	12	14	17	22	26	8	2	—	—	—	—	110	2.37
	13/12—50	1000—600	»	—	—	—	—	7	14	13	21	27	19	6	1	2	—	—	110	2.46
	15/12—50	1400—1000	»	—	—	—	—	3	14	21	19	20	21	11	1	—	—	—	110	2.46

TABLE 49 (cont.)

Station	Date	Depth, m	Stage	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	n	Mean length, mm
«M»	15/3 —50	50—0	♀	—	—	—	1	—	8	9	33	29	19	9	—	21	—	—	129	2.49
	15/3 —50	100—50	»	—	—	—	—	—	2	4	11	7	4	1	1	1	—	—	31	2.48
	28/3 —50	2000—0	»	—	—	—	—	—	—	1	2	—	7	4	3	4	—	—	21	2.69
	5/4 —50	50—0	»	—	—	—	—	—	5	15	38	41	25	4	2	—	—	—	130	2.49
	5/4 —50	600—100	»	—	—	—	—	—	—	3	15	30	28	21	10	1	1	1	110	2.61
	18/4 —50	50—0	»	—	—	—	—	—	2	6	17	36	32	19	4	4	—	—	120	2.58
	19/4 —50	»	»	—	—	—	—	—	1	1	10	22	37	21	13	2	1	—	108	2.63
	28/4 —50	»	»	—	—	—	—	—	—	1	2	5	19	31	41	12	6	2	119	2.80
	2/5 —50	100—0	»	—	—	—	—	—	—	2	7	6	21	13	12	4	4	1	70	2.68
	5/5 —50	»	»	—	—	—	—	—	—	2	12	21	33	31	15	5	—	1	120	2.65
	9/5 —50	»	»	—	—	—	—	—	—	1	6	14	25	34	16	13	1	—	110	2.69
	18/5 —50	»	»	—	—	—	—	—	2	3	4	9	19	35	31	13	3	11	120	2.71
	26/5 —50	»	»	—	—	—	—	—	—	—	3	7	17	25	13	11	3	—	79	2.73
	9/6 —50	»	»	—	—	—	—	—	—	—	1	7	19	27	23	15	4	4	100	2.76
	31/7 —50	»	»	—	—	—	—	—	—	—	1	7	16	40	26	13	4	3	110	2.75
	1/3 —50	600—0	♂	—	—	—	—	—	—	—	3	5	13	31	34	8	4	2	100	2.75
	15/3 —50	50—0	»	—	—	—	—	—	—	1	12	29	40	21	7	1	1	—	111	2.51
	15/3 —50	100—50	»	—	—	—	—	—	—	1	2	5	10	14	5	—	—	—	37	2.65

Table 50. *Size of Calanus hyperboreus in the Vestfjord 1947—50. Scale: 0.097 mm.*

St. nr.	Date	Depth, m	St.	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	n	Mean, mm.
116	25/4–47	50-0	V	—	—	1	—	2	6	4	13	14	15	12	4	1	1	—	—	—	—	—	—	—	—	—	1	—	73	4.28
116	»	100–50	»	—	—	—	2	2	1	4	6	9	7	1	3	1	—	—	—	—	—	—	—	—	—	—	—	—	36	4.17
116	»	300-100	»	—	—	1	2	4	9	17	26	33	32	23	14	4	1	—	—	—	—	—	—	—	—	—	—	—	166	4.30
116	»	500–300	»	—	—	—	—	—	1	2	2	5	4	4	4	1	—	—	—	—	—	—	—	—	—	—	—	—	23	4.25
117	»	50–0	»	—	2	3	10	20	25	42	44	34	25	19	6	—	—	—	—	—	—	—	—	—	—	—	—	—	230	4.15
147	8/5–47	325–75	»	—	—	4	6	25	37	49	36	32	6	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	200	4.09
148	»	50–0	»	—	—	—	6	11	19	45	58	40	19	8	2	2	—	—	—	—	—	—	—	—	—	—	—	—	210	4.16
149	»	25–0	»	1	—	2	4	8	26	44	44	42	15	17	3	2	1	1	—	—	—	—	—	—	—	—	—	—	210	4.18
149	»	420–75	»	—	—	3	4	12	13	24	26	36	31	23	11	15	1	1	—	—	—	—	—	—	—	—	—	—	200	4.26
116	25/4–47	50–0	♀	—	—	—	—	—	—	—	—	—	—	—	—	—	4	3	3	8	6	2	3	2	—	—	—	—	32	5.06
116	»	100–50	»	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	2	7	1	2	—	—	—	—	—	15	5.10
116	»	300–100	»	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	4	4	1	1	1	—	—	—	14	5.20
116	»	500–300	»	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	1	2	2	4	—	—	—	—	—	12	5.16
117	»	50–0	»	—	—	—	—	—	—	—	—	1	—	1	3	11	15	32	34	30	23	12	8	—	3	—	—	—	173	4.98
117	»	400–90	»	—	—	—	—	—	—	—	—	—	1	1	2	4	13	10	14	17	8	6	10	3	1	—	—	—	90	5.00
148	8/5 47	50–0	»	—	—	—	—	—	—	—	—	—	1	—	—	2	1	9	7	9	10	8	8	4	1	—	—	—	60	5.09
149	»	25–0	»	—	—	—	—	—	—	—	—	—	—	—	2	1	13	18	28	47	22	16	12	3	2	2	—	—	166	5.02
149	»	420–75	»	—	—	—	—	—	—	—	—	—	1	1	2	9	17	28	31	31	30	34	22	14	3	5	1	1	230	5.06

TABLE 50 (cont.).

Station	Date	Depth, m	St.	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	n	Mean mm.
Skrova . .	15/3–49	300–50	V	—	1	2	8	7	10	7	7	9	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	54	4.04
	19/3–49	»	»	2	1	5	14	25	22	19	18	14	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	124	3.98
	30/4–49	»	»	—	—	1	2	5	16	32	27	15	9	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	110	4.14
	24/5–49	»	»	—	1	2	6	11	21	14	8	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	69	4.00
	18/6–49	»	»	—	—	2	—	12	23	31	20	17	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	110	4.09
	23/7–49	»	»	—	—	2	3	13	31	34	14	10	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	111	4.06
	27/8–49	300–0	»	—	—	—	1	8	10	29	24	22	7	5	3	1	—	—	—	—	—	—	—	—	—	—	—	—	112	4.16
	3/9–49	300–50	»	—	1	1	5	9	11	26	31	11	9	4	1	1	—	—	—	—	—	—	—	—	—	—	—	—	110	4.13
	24/12–49	»	»	—	—	—	6	7	26	16	25	16	8	4	2	—	—	—	—	—	—	—	—	—	—	—	—	—	110	4.25
	21/2–50	300–0	»	—	1	3	1	7	2	4	2	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23	3.98
	13/3–50	»	»	—	1	4	7	15	10	8	8	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	59	3.99
	11/4–50	»	»	—	2	2	7	9	19	23	18	16	10	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	111	4.10
	20/5–50	»	»	—	1	3	8	18	17	28	14	9	5	4	1	2	—	—	—	—	—	—	—	—	—	—	—	—	110	4.06
	22/7–50	»	»	—	—	3	7	15	18	18	24	9	7	7	2	—	—	—	—	—	—	—	—	—	—	—	—	—	110	4.10
	5/8–50	»	»	—	—	—	2	11	15	32	13	19	11	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	110	4.13
	15/3–49	300–50	♀	—	—	—	—	—	—	—	1	4	3	11	24	21	25	29	13	8	7	5	1	—	—	—	—	—	152	4.78
	19/3–49	»	»	—	—	—	—	—	—	—	—	3	2	4	9	9	8	9	2	1	1	1	—	—	—	—	—	—	49	4.68
	30/4–49	»	»	—	—	—	—	—	—	—	—	—	—	—	—	1	2	2	5	3	3	5	—	—	—	—	—	—	21	5.02
	27/8–49	300–0	»	—	—	—	—	—	—	—	—	—	—	3	1	12	12	19	13	17	8	6	5	—	—	—	—	—	96	4.91
	3/9–49	300–50	»	—	—	—	—	—	—	—	—	—	—	1	1	6	5	11	3	5	4	1	3	—	—	—	—	—	40	4.90
	24/12–49	»	»	—	—	—	—	—	—	—	—	—	—	—	—	1	2	2	4	5	3	2	1	—	—	—	—	—	20	5.01
	21/2–50	200–0	»	—	—	—	—	—	—	—	—	—	—	3	9	21	18	16	8	10	11	2	—	1	—	—	—	—	99	4.83
	13/3–50	»	»	—	—	—	—	—	—	—	—	—	—	2	7	14	19	31	17	12	5	3	1	—	—	—	—	—	110	4.95
	11/4–50	»	»	—	—	—	—	—	—	—	—	—	1	4	5	9	15	17	18	16	13	7	2	2	—	—	—	—	109	4.92
	20/5–50	»	»	—	—	—	—	—	—	—	—	—	—	—	—	2	5	7	6	13	8	7	2	3	—	1	—	—	54	5.05
	22/7–50	»	»	—	—	—	—	—	—	—	—	—	—	—	—	—	5	8	3	9	7	9	1	1	1	—	—	—	44	5.05
	5/8–50	»	»	—	—	—	—	—	—	—	—	—	—	—	1	3	3	12	20	20	23	13	10	5	2	3	—	—	115	5.10
	21/2–50	300—0	♂	—	—	—	4	1	1	2	1	2	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14	4.08

Table 51. *Size of Pseudocalanus elongatus females 1949—50. Scale: 0.0513 mm.*

Station	Date	Depth, m.	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	n	Mean length, mm.
Sognesjøen	1/6 —49	50—0	—	—	—	—	—	2	27	42	22	5	1	1	—	—	—	100	1.08
	23/6 —49	»	—	1	1	8	13	15	3	5	2	1	—	—	—	—	—	46	0.97
	21/7 —49	»	—	1	—	1	6	9	12	4	2	—	—	—	—	—	—	35	1.00
	12/8 —49	200—50	—	—	2	20	15	28	27	7	1	—	—	—	—	—	—	100	0.97
	25/8 —49	50—0	—	2	3	2	—	3	—	—	—	—	—	—	—	—	—	10	0.87
	11/10—49	»	—	19	23	5	2	1	—	—	—	—	—	—	—	—	—	50	0.81
	16/1 —50	200—0	1	6	11	7	4	1	—	—	—	—	—	—	—	—	—	30	0.84
	8/3 —50	»	—	14	22	36	16	8	3	1	—	—	—	—	—	—	—	100	0.87
	28/3 —50	50—0	—	1	5	8	5	3	2	2	2	—	—	—	2	—	—	30	0.95
	28/4 —50	200—0	—	—	—	—	1	2	6	14	24	31	9	4	6	3	—	110	1.16
	12/5 —50	50—0	—	—	—	—	1	2	11	25	24	16	9	4	1	—	—	93	1.13
	25/5 —50	»	—	—	—	—	—	3	12	8	8	—	—	—	—	—	—	31	1.03
	14/6 —50	200—0	—	—	—	—	2	18	39	28	10	2	1	—	—	—	—	100	1.09
	10/7 —50	»	—	—	1	32	40	9	11	7	—	—	—	—	—	—	—	100	0.93
	21/9 —50	»	1	19	37	28	10	5	—	—	—	—	—	—	—	—	—	100	0.84
	11/10—50	»	2	11	19	27	23	16	2	—	—	—	—	—	—	—	—	100	0.88
	20/11—50	»	—	2	6	20	27	12	3	—	—	—	—	—	—	—	—	70	0.91

TABLE 51. (cont.)

Station	Date	Depth, m	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	n	Mean length, mm
Ona	7/2 —49	50—0	—	1	8	28	35	4	—	—	—	—	—	—	—	—	—	76	0.90
	17/3 —49	200—0	—	1	12	21	27	23	9	2	2	1	2	—	—	—	—	100	0.94
	28/3 —49	»	1	4	15	9	13	1	10	18	11	8	—	—	—	—	—	80	1.01
	12/4 —49	»	—	—	4	6	4	10	3	4	14	13	9	20	12	1	—	100	1.15
	27/4 —49	»	—	3	—	2	8	17	18	11	6	22	7	2	1	1	1	100	1.08
	24/5 —49	»	—	—	—	—	8	30	37	14	3	4	1	1	2	—	—	100	1.03
	29/6 —49	»	—	—	—	3	24	30	16	12	10	4	—	—	1	—	—	100	1.01
	13/7 —50	»	—	—	5	21	39	20	7	4	3	—	1	—	—	—	—	100	0.94
	8/8 —49	»	—	—	—	10	9	5	2	—	—	—	—	—	—	—	—	26	0.89
	22/8 —49	»	—	—	2	14	22	9	3	—	—	—	—	—	—	—	—	50	0.89
	5/9 —49	»	—	1	3	14	20	8	4	—	—	—	—	—	—	—	—	50	0.92
	22/9 —49	»	—	—	10	22	13	5	—	—	—	—	—	—	—	—	—	50	0.89
	14/11—49	»	—	1	7	8	4	—	1	—	—	—	—	—	—	—	—	21	0.87
	20/2 —50	»	1	12	5	24	19	7	2	—	—	—	—	—	—	—	—	70	1.13
	17/4 —50	»	—	—	—	—	1	1	2	4	2	2	1	2	—	1	—	16	1.13
	2/5 —50	»	—	—	—	—	—	1	5	19	30	21	13	8	3	—	—	100	1.16
	24/5 —50	»	—	—	—	—	—	—	6	3	3	5	1	—	—	1	—	19	1.12
	4/7 —50	»	—	—	2	8	10	12	6	4	8	—	—	—	—	—	—	50	0.98
	16/8 —50	»	1	9	25	14	1	—	—	—	—	—	—	—	—	—	—	50	0.83
	5/10—50	»	—	9	38	34	15	3	1	—	—	—	—	—	—	—	—	100	0.86
	6/11—50	»	1	—	8	30	46	11	4	—	—	—	—	—	—	—	—	100	0.86
	16/12—50	»	—	4	24	33	32	8	—	—	—	—	—	—	—	—	—	101	0.88

TABLE 51 (cont.).

Station	Date	Depth, m	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	n	Mean length, mm
Eggum	5/1 —49	195—0	—	2	7	21	13	4	3	—	—	—	—	—	—	—	—	50	0.88
	16/3 —49	200—50	—	1	1	17	5	2	1	—	—	—	—	—	—	—	—	27	0.89
	8/4 —49	»	—	2	3	8	17	7	8	5	3	—	2	—	—	—	—	56	0.97
	23/4 —49	190—50	—	—	—	—	—	2	—	—	1	1	2	3	3	4	2	18	1.28
	2/5 —49	195—50	—	—	—	1	1	2	1	3	5	11	8	7	5	5	2	50	1.27
	21/5 —49	»	—	—	—	—	3	9	29	18	10	14	6	3	4	4	—	100	1.12
	28/6 —49	190—50	—	—	—	2	15	19	8	6	—	—	—	—	—	—	—	50	0.98
	6/8 —49	»	—	—	—	4	15	18	12	1	—	—	—	—	—	—	—	50	0.97
	17/9 —49	200—50	—	8	10	11	31	34	6	1	—	—	—	—	—	—	—	101	0.92
	17/10—49	»	—	2	20	45	22	9	2	—	—	—	—	—	—	—	—	110	0.87
	28/4 —50	195—0	—	—	—	—	—	1	—	—	1	—	1	6	4	—	—	13	0.97
	8/5 —50	200—0	—	—	—	—	1	—	—	1	1	—	—	3	—	—	—	6	
	22/5 —50	»	—	—	—	—	4	4	4	2	5	4	1	1	1	—	—	26	1.08
	14/6 —50	»	—	—	—	3	8	22	10	5	—	—	2	—	—	—	—	50	0.99
	12/7 —50	»	—	—	—	4	5	5	6	—	—	—	—	—	—	—	—	20	0.96
	12/9 —50	»	1	13	26	29	11	11	6	3	—	—	—	—	—	—	—	100	0.88
	13/10—50	»	—	7	17	18	8	—	—	—	—	—	—	—	—	—	—	50	0.85
	14/11—50	»	1	7	19	13	9	1	—	—	—	—	—	—	—	—	—	50	0.85
	16/12—50	»	—	4	17	25	30	21	3	—	—	—	—	—	—	—	—	100	0.90
Skrova	25/9 —49	300—0	—	1	5	6	9	6	4	1	—	—	—	—	—	—	—	32	0.92
	20/3 —50	»	—	—	—	—	2	1	1	—	—	—	—	—	—	—	—	4	
	23/10—50	»	—	1	27	6	—	—	—	—	—	—	—	—	—	—	—	50	0.81
	18/12—50	»	—	3	11	3	4	1	—	—	—	—	—	—	—	—	—	22	0.84

Table 52. *Size of Micrŏcalanus pusillus females 1949—50. Scale: 0,0125 mm.*

Station	Date	Depth, m	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	n	Mean length, mm.
Ona	7/2 —49	200—0	—	—	3	7	17	20	16	21	9	5	2	—	—	—	—	—	—	—	100	0.48
	4/3 —49	»	—	—	—	8	10	16	12	20	10	10	6	5	1	1	—	—	—	—	100	0.50
	24/5 —49	»	—	—	—	—	—	—	—	1	8	25	15	23	18	7	2	1	—	—	100	0.54
	14/7 —49	»	—	—	—	1	—	12	15	24	11	3	2	1	—	—	1	—	—	—	70	0.50
	22/8 —49	»	—	—	—	1	2	3	7	20	21	24	17	5	—	—	—	—	—	—	100	0.51
	11/10—49	»	—	—	—	1	—	3	1	7	14	23	25	16	9	1	—	—	—	—	100	0.53
	14/11—49	»	—	—	—	—	—	2	1	3	10	10	2	1	—	—	—	—	—	—	29	0.52
	14/12—49	»	—	—	1	3	2	2	6	5	1	2	2	—	—	—	—	—	—	—	24	0.49
	20/2 —50	»	—	—	5	4	5	10	12	13	5	7	1	—	—	—	—	—	—	—	63	0.49
	14/3 —50	»	—	—	1	1	5	2	1	5	3	6	3	1	—	1	1	—	—	—	27	0.51
	2/5 —50	»	—	—	—	—	—	1	1	—	1	2	8	12	14	13	10	—	—	—	62	0.56
	24/5 —50	»	—	—	—	—	—	—	1	—	—	3	4	12	10	10	8	1	1	—	50	0,57
	6/6 —50	»	—	—	—	—	—	—	1	1	—	3	6	12	15	8	4	1	1	—	50	0.56
	4/7 —50	»	—	—	—	—	1	—	—	10	15	25	20	19	8	—	1	1	—	—	100	0.53
	6/11—50	»	—	—	—	—	1	—	1	5	5	3	6	1	2	—	—	—	—	—	24	0.53
	16/12—50	»	—	—	4	8	14	14	16	15	12	10	4	3	—	—	—	—	—	—	100	0.49

TABLE 52. (cont.)

Station	Date	Depth, m	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	n	Mean length, mm
Eggum	5/1 —49	185—0	—	—	—	2	11	21	21	16	15	10	4	—	—	—	—	—	—	—	100	0.49
	16/3 —49	195—0	1	1	10	15	24	25	17	6	1	—	—	—	—	—	—	—	—	—	100	0.47
	8/4 —49	200—50	—	3	4	4	13	12	7	14	4	7	9	12	5	4	1	—	—	—	100	0.50
	21/5 —49	195—50	—	—	—	1	—	1	2	—	—	6	15	17	14	21	17	6	—	—	100	0.56
	16/6 —49	»	—	—	—	—	—	3	9	8	12	22	23	16	6	3	3	—	—	—	105	0.53
	28/6 —49	190—50	—	—	—	—	1	2	10	30	11	17	10	8	9	2	—	—	—	—	100	0.52
	6/8 —49	195—50	—	—	—	2	6	14	18	8	1	1	—	—	—	—	—	—	—	—	50	0.48
	17/9 —49	200—50	—	—	—	1	2	8	13	15	4	5	1	1	—	—	—	—	—	—	50	0.50
	24/11—49	»	—	—	—	—	—	6	5	15	3	13	7	1	—	—	—	—	—	—	50	0.51
Skrova	1/2 —49	300—50	—	—	1	9	24	30	11	7	1	1	1	—	—	1	3	8	2	1	100	0.49
	15/3 —49	»	—	—	2	10	11	27	22	12	4	2	—	—	2	—	4	3	1	—	100	0.49
	25/4 —49	»	—	—	2	1	4	4	14	8	13	12	10	9	8	8	4	3	—	—	100	0.53
	16/5 —49	»	—	—	—	1	5	8	6	12	7	7	15	19	11	6	2	—	—	—	99	0.53
	24/5 —49	»	—	—	—	—	—	4	2	7	3	4	12	11	10	6	2	1	3	—	65	0.54
	25/6 —49	»	—	—	—	—	2	9	14	22	17	15	8	5	1	1	6	—	—	—	100	0.51
	30/7 —49	»	—	—	—	—	2	8	9	11	11	3	—	—	—	—	—	—	—	—	50	0.50
	3/9 —49	»	—	—	—	—	2	5	11	16	8	5	3	—	—	—	—	—	—	—	50	0.50
	29/10—49	»	—	—	—	—	1	4	10	15	11	9	—	—	—	—	—	—	—	—	50	0.50
	26/11—49	»	—	—	—	—	1	1	8	12	5	4	—	—	—	1	1	1	—	—	34	0.50
	24/12—49	»	—	—	—	—	—	6	3	8	3	2	—	—	—	—	1	—	—	—	23	0.50

TABLE 52. (cont.)

Station	Date	Depth, m.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	n	Mean length, mm.
«M»	17/1 —52	100—0	—	—	1	2	4	9	9	12	8	7	1	2	—	—	—	—	—	55	0.48
	19/2 —52	600—100	—	2	3	16	22	22	20	8	5	—	—	—	—	—	—	—	2	100	0.46
	14/3 —52	100—0	1	—	5	15	25	26	12	9	6	1	—	—	—	—	—	—	—	100	0,46
	18/4 —52	600—100	—	—	—	2	8	14	18	22	18	9	5	5	1	—	—	—	—	102	0.49
	9/5 —52	600—100	—	—	2	1	3	1	6	8	13	13	22	19	10	5	1	—	—	104	0.51
	20/6 —52	»	—	—	—	—	—	—	2	4	11	14	15	9	1	2	—	1	—	59	0.52
	16/7 —52	600—90	—	—	—	—	—	—	6	13	28	23	18	7	4	1	—	—	—	100	0.51
	15/8 —52	600—100	—	—	—	—	2	5	10	20	33	17	10	2	—	1	—	—	—	100	0.50
	21/9 —52	600—90	—	—	—	—	—	4	14	30	35	9	6	1	—	1	—	—	—	100	0.49
	13/10—52	100—0	—	—	—	—	—	—	2	7	10	11	11	1	—	—	—	—	—	42	0.51
	13/10—52	1000—0	—	—	—	—	—	—	3	19	25	26	18	5	2	1	—	—	—	100	0.51
	14/11—52	100—0	—	1	—	7	12	28	26	19	6	—	—	1	—	—	—	—	—	100	0.47
	14/11—52	600—100	—	—	—	8	21	25	19	13	8	5	1	—	—	—	—	—	—	100	0,47
	14/11—52	1800—0	—	—	—	1	2	5	5	3	1	1	3	—	—	—	—	—	—	21	0.48
	16/12—52	1000—0	—	3	8	20	19	20	12	12	3	2	—	1	—	—	—	—	—	100	0.46

Table 53. *Size of Metrida lucens females 1949—50. Scale: 0.0513 mm.*

Station	Date	Depth, m.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	n	Mean length, mm.
Sognesjøen	7/1 —49	200—50	—	—	2	1	2	1	1	—	1	—	—	—	—	—	—	—	8	1.55
	2/2 —49	»	—	1	1	5	3	13	13	7	6	2	—	—	—	—	—	—	51	1.63
	1/6 —49	»	—	—	—	—	—	1	—	1	3	13	8	8	6	4	—	—	44	1.85
	21/7 —49	»	—	—	—	—	—	—	—	1	4	12	18	28	22	10	4	1	100	1.90
	12/8 —49	»	—	—	—	—	—	—	1	2	4	8	13	15	6	2	—	—	51	1.86
	29/12—49	»	—	—	5	6	11	15	7	5	4	1	—	—	—	—	—	—	54	1.59
Ona	2/2 —49	200—50	—	—	8	7	15	22	18	19	7	4	—	—	—	—	—	—	100	1.61
	24/5 —49	200—0	—	—	—	—	3	8	25	25	17	13	3	3	2	—	1	—	100	1.71
	13/7 —49	»	—	—	—	1	1	—	4	13	20	17	22	6	6	2	—	—	92	1.69
	22/8 —49	»	—	—	—	—	1	4	1	2	1	1	—	—	—	—	—	—	10	1.65
	11/10—49	»	—	—	—	4	3	3	8	7	4	3	—	1	1	—	—	—	34	1.66
	14/11—49	»	—	—	—	1	1	1	4	4	7	2	1	—	—	—	—	—	21	1.70
	14/12—49	»	—	1	2	1	5	4	4	4	2	—	—	—	—	—	—	—	23	1.59
	9/1 —50	»	—	1	1	8	10	9	10	2	1	1	—	—	—	—	—	—	52	1.61
	14/3 —50	»	1	1	1	6	8	6	4	1	1	—	—	—	—	—	—	—	29	1.54
	2/5 —50	»	—	—	—	—	2	2	3	2	2	1	2	—	1	—	—	—	15	1.70
	4/7 —50	»	—	—	—	—	1	—	5	5	8	14	21	28	6	10	1	—	99	1.85
	17/7 —50	»	—	—	—	2	1	2	3	5	3	8	9	12	7	1	—	1	54	1.81
	5/10—50	»	—	—	—	—	—	—	—	1	3	1	—	—	—	—	—	—	5	1.74
	16/12—50	»	—	—	1	4	8	19	31	15	14	5	2	—	1	—	—	—	100	1.65