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Investigations on Euphausids in some fjords on the west coast of Norway and at weathership station M in the Norwegian Sea.

Preliminary report.

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As is generally known Euphausids or krill play an important part in the food chain of the sea. Because of their ability to move comparatively rapidly the krill avoid ordinary plankton nets during daylight, and their relative importance in the biomass has often been underestimated. During the daylight, the krill also partly live in deeper water layers, in coastal waters even close to the bottom, (Mauchline 1960), rising to the surface layers at night. With modern high speed gear, such as the Isaacs-Kidd pelagic trawl (IKMT) the krill are easily caught during the day.

Most krill species swarm during spawning time, occasionally also at other times of the year, even in bright daylight. The swarming makes the krill very attractive for predators, from marine mammals to birds and fish. Krill are occasionally attracted by artificial light. This peculiarity has been exploited by fishermen in the Mediterranean, who lure the krill with powerful lamps at night, sometimes catching 50 - 100 kilograms per boat, for use as bait (Fisher, Kon and Thompson 1959). Swarming of krill is also known to occur in Norwegian coastal waters. During winter and early spring krill are occasionally attracted by lights located near the seashore. Under certain conditions of currents and high tide during the night, large quantities of krill are washed ashore, and may be collected the following morning. Such krill have been used both as bait, and as fertilizer on the fields.

In the Hardangerfjord south of Bergen, samples of krill taken in this manner and also with a dip net under the lights of a pier in the spring of 1964 were sent to the Bergen Aquarium, where the fishes and other animals eagerly accepted the krill as food. Experiments with feeding the krill to rainbow trout indicated that the flesh got a good quality and the desired red colour. A small fishery for krill developed in the Hardangerfjord south of Bergen, and the catches were

used both by the Bergen Aquarium and by farmers of rainbow trout. Investigations on the biology of the krill in the Hardangerfjord and adjacent areas started in the spring of 1965. Material was obtained partly from commercial and other catches in which the krill were attracted by the light from projectors placed on a pier and collected with a dip net, partly with a 3-foot Isaacs-Kidd pelagic trawl (IKMT). The trawl was operated from a research vessel at a speed of 5-6 knots, in the upper 50 m, mostly during the dark hours in January-June 1966. A few hauls were also taken during the day in June and August 1966 at depths between 100 and 200 m.

In May, June and August 1966 vertical hauls with a Juday "8/40" net were taken in the upper 100 m in the Hardangerfjord. All samples have been preserved with 5-10 percent of formalin and the krill investigated a few days afterwards. Displacement volumes were measured of the IKMT samples. If possible, a hundred specimens of each species, were investigated, sometimes more. The length was measured by stretching the individuals along a strip of plastic glued to a plastic plate and measuring the distance from the tip of the rostrum to the end of the telson to the nearest millimetre under a magnifying glass (2 x). The sex was determined only from the external characters (thelycum, spermatheca). Number of females with spermatophores attached was noted. Remains of food in the "basket" and in the stomachs have been investigated.

Some samples of krill were also obtained in surface hauls with a one metre egg net taken at night from the Norwegian weather ships at station M at position 66 degr. N. lat, 02 degr. E. long. in the Norwegian Sea.

Some material of krill both fresh and deep frozen, has been handed over to the Institute of Technological Research at the Directorate of Fisheries for determination of the nutritional value and biochemical properties.

Four species of krill have been identified in the material, viz. Meganyctiphanes norvegica (M. Sars), Thysanoessa inermis (Krøyer), Thysanoessa raschii (M. Sars) and Nyctiphanes couchii (Bell). Only the two former species occurred in appreciable quantities, M. norvegica being the leading one, both in volume and numbers. T. inermis was occasionally very abundant, especially in April and May. T. raschii occurred only singly. N. couchii was mainly taken in November-January, but was never abundant.

Quantities of krill in ml per n. mile in the catches with IKMT 3-foot trawl are shown in Fig. 1 from surveys in January-February, May and June 1966, the first cruise being the most comprehensive. Usually, 20-100 ml. per mile were taken, with a few hauls of 200 ml. or more.

The volume of water per n. mile filtered is roughly estimated to 1200 m^3. Random variations undoubtedly play a significant part, and the figure only shows that krill may be abundant in all parts of the fjord system.

Meganyctiphanes norvegica

Spawning.

Off the west coast of Norway Ruud (1928) found larvae of M. norvegica both in May and July, and Hjort and Ruud (1929) state that on the coastal banks the species spawns chiefly in summer. In the fjords near Bergen it spawns from March to July-August (Runnstrøm 1932). In Loch Fyne Mauchline (1960) found two peaks of eggs laying, at the beginning of April and at the end of June.

The plankton hauls taken in the Hardangerfjord in early May and June 1966 contained only a few eggs and no larvae of M. norvegica. In the middle of February, 50 percent of the females carried spermatophores, and from the middle of March, 100 percent did. The larger females got spermatophores first, with decreasing percent in the lower size-groups. The same phenomenon was observed by Ruud (1936) in the Mediterranean, while Mauchline (1960) did not find such features in Lich Fyne.- In samples from the Hardangerfjord area 16-27 August 1966 all the females carried spermatophores. A long spawning period, possibly from April to and including August is thus indicated in the area.

Growth.

In August 1966 small individuals, 10-20 mm, with modes at 12-15 mm, were taken (Fig. 2). This is probably the 0-group. In October 1965 the 0-group measured 11-26 mm, with peaks at 14-17 mm. In November the peak had moved to 17-19 mm, and some larger specimens, probably one year older, were present, measuring 30-36 mm.

In January the main peak had moved to 20 mm. At the beginning of February, males, females and immature individuals could be distinguished and were measured separately. The adults had a main peak at 25 mm, and other peaks at 20, 23, and 35 mm, while the immatures were smaller with the main peak at 20 mm.

At the end of February all individuals were mature. All length-groups increased somewhat in size to the end of March. The two main groups had then peaks at 28 and 35 mm respectively, probably representing the I(1965)- and II(1964) year classes.

The decrease in size to the beginning of May cannot be explained. Perhaps the larger individuals had not risen to the surface layers. In June the main peaks were at 28-30 mm and 35-37 mm, in August at 35, 38

and 41 mm.

From the increases in size of the various length groups it is concluded that the 0-group grows from about 13 mm in August to 35-38 mm as I-group in August of the following year. The two peaks possibly reflect a long spawning season, the smaller individuals originating from a peak in spawning in late summer or autumn. The I-group, measuring 32-36 mm in November 1965, may be followed as II-group throughout the period January-August 1966, probably represented by the small peak at 41 mm in late August.

The growth of the 0-group seems to be comparable with that found by Mauchline (1960) for Loch Fyne, (34-38 mm) while the I-group, if the samples are representative, does not attain the length of that in Loch Fyne (42-48 mm).

Mortality.

In most of the samples the 0-(I)-group constituted 60-75 percent, except for some samples taken with light in March-April, where the larger specimens dominated. Males were as a rule less numerous than females, only about 25 percent of the stock; in some samples taken with light and dip net in April males were completely absent. In the I-(II)-group of males there was evidently a great mortality from January to June, the proportion of this group decreasing from 25 to 2-3 percent. In August the II-group is scarcely represented in the males.

Size frequencies of Meganyctiphanes taken at station M in the Norwegian Sea are shown in Fig. 3. In September - November 1965 and in March 1966 relatively small individuals were taken, with peaks at 14-16 and 18 mm. In January-February larger individuals were taken, but the sexes could only be distinguished by investigation of the gonads.

The samples evidently do not represent the population as a whole.

Thysanoessa inermis

Spawning.

In Norwegian coastal waters T. inermis spawns in March-April (Ruud 1928, Hjort and Ruud 1929, Wiborg 1954).

In the plankton hauls from the Hardangerfjord area, eggs and larvae, with maxima of furcilia were found at the beginning of May, indicating a spawning in April. The sexes could be distinguished from the end of February, and at the beginning of April all females were carrying spermatophores.

Growth.

From November 1965 to February 1966 the size frequencies were mainly unimodal 10-22 mm, with the main peak at 16-18 mm (Fig. 4). Two samples taken 25 February and 14 March respectively have been pooled, consisting only of females with a peak in size of 20-21 mm.

From April to June males and females have been measured separately. The males are somewhat smaller than the females, with the peaks at 17 and 20 mm respectively. The curves inserted are from the Samnangerfjord north of the Hardangerfjord, indicating a local population with smaller individuals, but showing the same relative difference in length of males and females.

In August some further growth is indicated, but the sexes could not be distinguished. Simultaneously the new 0-group, 10-16 mm, is represented, with peaks at 13-15 mm.

From the size frequencies the conclusion is drawn that the species in annual in the Hardangerfjord, maturing and spawning at an age of 1 year. This agrees with Einarsson's (1945) statement for the Skagerak. A few specimens may survive for one additional year.

At station M (Fig. 5) the samples of T. inermis seem to be fairly representative. In October 1965 the 0-group had a peak in abundance at 10 mm, increasing to 12 mm in January. Larger individuals, 19-24 mm probably one year older, then appeared. Males and females could be distinguished from February onwards, and the smaller individuals disappeared. At first males and females had approximately the same size-frequencies, indicating that the larger males matured first, but in March the males were smaller than the females, as was also found in the Hardangerfjord area, but the adults were larger than those in the fjord, with peaks at 22 and 24 mm respectively. In the Norwegian Sea, T. inermis evidently needs two years to reach maturity, as was also found by Einarsson (1945).

Thysanoessa raschi

According to Hjort and Ruud (1929) this species often occurs in quantities in the Skagerak, and is common along the whole western coast of Norway.

Only two males have been found in the present material, both taken in the Sørfjord, adjacent to the innermost part of the Hardangerfjord.

Nyctiphanes couchi

According to Ruud (1936) the species occasionally is found as far north as off Møre on the west coast of Norway, but Skagerak is the northernmost spawning locality.

N. couchi was taken mainly with light and dip net from November 1965 to February 1966. It was never very abundant, maximum a hundred specimens were taken during one night. The size-frequencies were unimodal, 10-18 mm, with the mode at 13 mm, indicating a one year cycle.

Food.

It has been stated by various authors (e. g. Einarsson 1945) that krill eat both phytoplankton, zooplankton and detritus. This has been confirmed in the present investigation. Direct observations in the light of a projector during night showed that M. norvegica chased fish larvae and mysids, the remants of which were later found in the "basket' Other food items were Calanus finmarchicus, Paraeuchaeta norvegica, and chaetognaths. These observations are in accordance with those of Mauchline (1960). During the spring bloom of phytoplankton the stomachs of Meganyctiphanes were green coloured. Also T. inermis was seen to chase small organisms.

Fishery

The fishery for krill is based on the fact that it is attracted by light. Such fishery has already existed for many years in the Mediterranean (Fisher, Kon and Thompson 1953), mainly during the spawning season in January-February.

In the Hardangerfjord, the fishery mainly took place during February - April, but samples were also taken by light in August, and in October-January. The krill usually aggregated shortly after the light had been turned on, at first straying back and forth; but as the swarm grew denser an anticlock-wise movement began, finally comprising a dense mass of krill. With a dip net, one man could easily take 50-60 kilogrammes during the night, and on some occasions up to 500 kilogrammes were taken (Fig. 6).

On other occasions only a few krill appeared, swimming into and out of the light without evidently being attracted.

Stranding of krill occurred more seldom, although experiments were made with projectors placed on the beach. The catches were as a rule very scanty. In one locality, a greenhouse is placed close to the shore, and the lights are usually turned on during night. An old sprat

seine was spread on the beach in the middle of March, and one morning more than 500 kg of M. norvegica, exclusively females, were collected. During the coming season, experiments will be made with various gears for fishing the krill, and the investigation on the biology of the krill will be continued.

Summary

Euphausids or krill are very important in the economy of the sea. Because of their ability to rapid swimming, the krill are sometimes underestimated in biomass estimations.

In Norwegian fjords krill sometimes swarm near lights along the seashore, and are occasionally washed ashore on the beach in large quantities. Small local fisheries for krill have developed, the catches partly being used as bait, partly as additional food in the farming of rainbow trout and salmon. The krill have also been used as food for the animals in the Bergen Aquarium.

Investigations on krill have been carried out by the Institute of Marine Research since February 1965. In addition to samples from commercial catches, krill have also been taken in hauls with a three-foot IKMT trawl. For the sake of comparison a material of krill from surface hauls taken at night with a one meter egg net at the weather-ship station M in the Norwegian Sea has been used for comparison.

Four species have been identified in the samples, Meganyctiphanes norvegica, Thysanoessa inermis, T. raschi and Nyctiphanes couchi. Only the two former species occurred in commercial quantities, M. norvegica being the leading one.

In the Hardangerfjord south of Bergen, M. norvegica has a life cycle of 2-3 years, reaching maturity during the first year of life. Spawning probably starts in April and continues throughout August. In August, the 0-group specimens evidently measure 10-20 mm from the tip of the carapax to the end of the telson, with peaks at 12-15 mm, increasing to 35-38 mm as I-group in late August next year. In November 1965 the I-group measured 30-40 mm, but it was difficult to follow any increase in mean growth during the following months.

In November males and females could scarcely be distinguished from the secondary sexual characters.

In the middle of January about half of the stock consisted of immature individuals; at the beginning of February only 20 percent were immature and after the middle of the month only mature individuals were found in the samples. As a rule females predominated, with 60-90 percent of the stock. In some samples taken with light and dip net, males were entirely absent.

Older females got spermatopohores attached earlier than the younger ones.

The 0-group was as a rule dominating, making 75 percent of the total catch, but in some catches taken by light and dip net the I-group predominated.

At station M mostly small Meganyctiphanes, 16-18 mm, were taken with the exception of two samples in January-February, with specimens 20-34 mm.

Thysanoessa inermis predominated in a few catches, mainly in late April - early May. In the Hardangerfjord the species seems to be annual, a few individuals possibly surviving for one more year. In January - February, the mean length is 16-18 mm. Mature males are somewhat smaller than the females, with peaks in the length distributions of 17 and 20 mm respectively. Local populations with smaller adults are found in neighbouring fjords. Spawning starts in April.

At station M, T. inermis is biennial, reaching maturity during the second year. In October-January the 0-group measures averagely 10-12 mm. In February-April the I-group males and females have peaks in abundance at 22 and 24 mm respectively.

Two males of Thysanoessa raschi were found singly in the inner Hardangerfjord in May 1966.

Nyctiphanes couchi was taken in samller numbers with light and dip net in the Hardangerfjord from November 1965 to January 1966. The length distribution was unimodal, 10-18 mm, with a peak at 13 mm.

In 1965 and 1966 the fishery for krill yielded 1000 and 3000 kilogrammes respectively.

The investigations on krill in Norwegian fjords will be continued, and experiments made with various fishing methods. Samples of krill are being analysed at the Institute of Technological Research, Institute of Fisheries.

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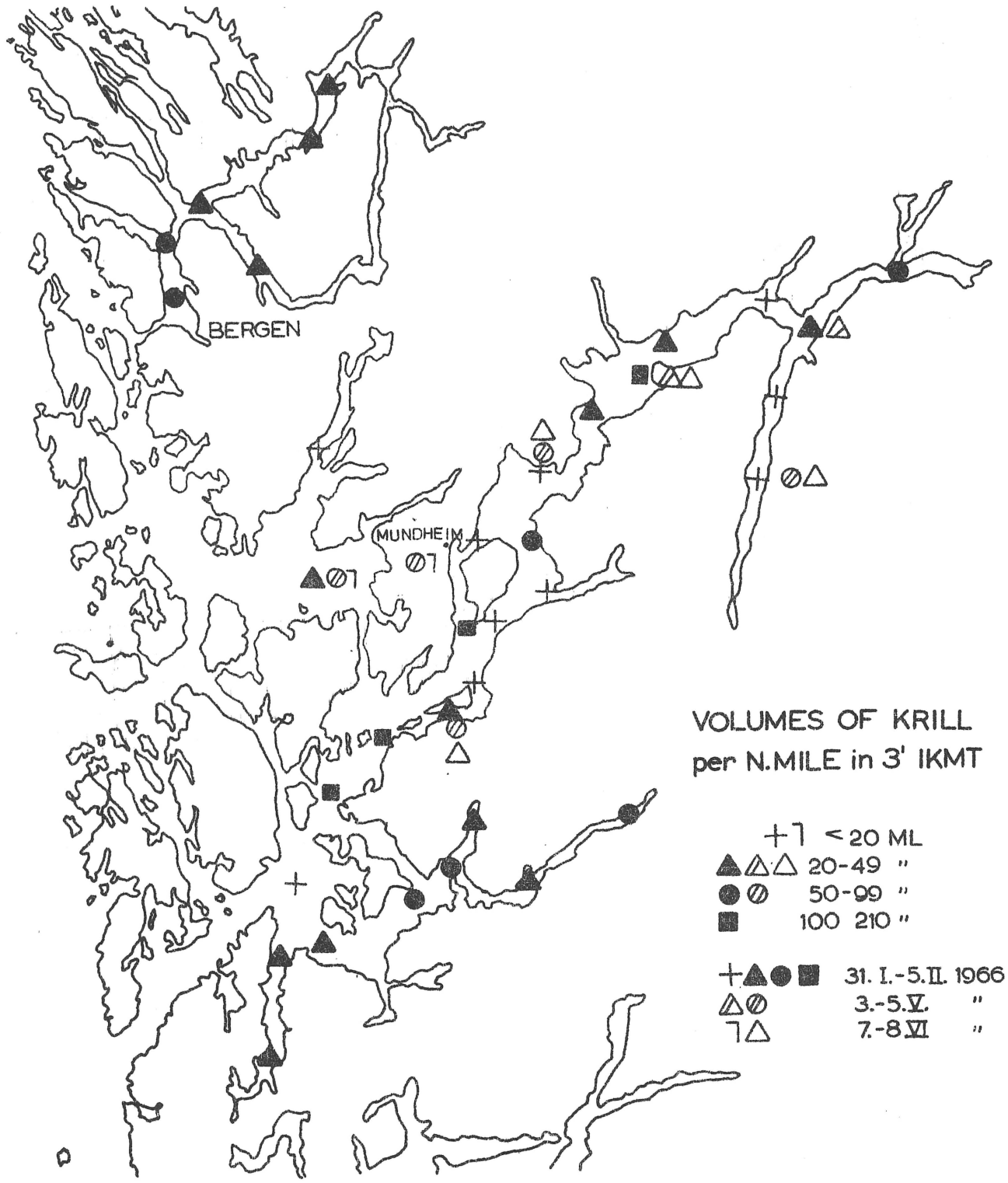

Figure 1. Volumes of krill in night hauls in the upper 50 m of the Hardangerfjord area with Isaacs-Kidd 3 ft pelagic trawl, per nautical mile. Approximate volume of water filtered: 1 200 m^3.

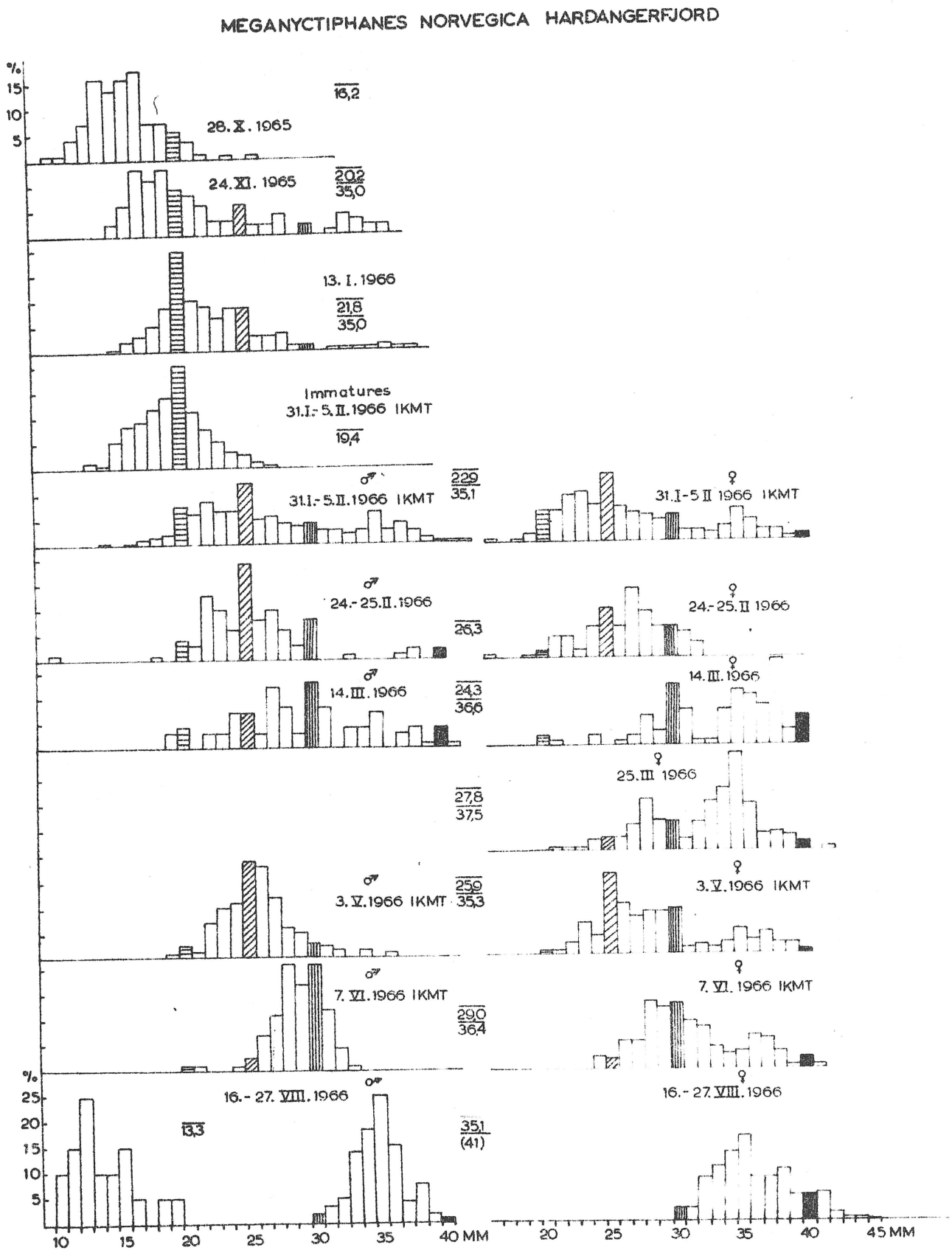

Figure 2. Percentage size frequencies of Meganyctiphanes norvegica in the Hardangerfjord 1965-66. Samples taken in Isaacs-Kidd 3 ft pelagic trawl are marked IKMT. Inserted figures with bars indicate mean length of the major size groups. For the sake of comparison the 20, 25, 30 and 40 mm columns have been hatched.

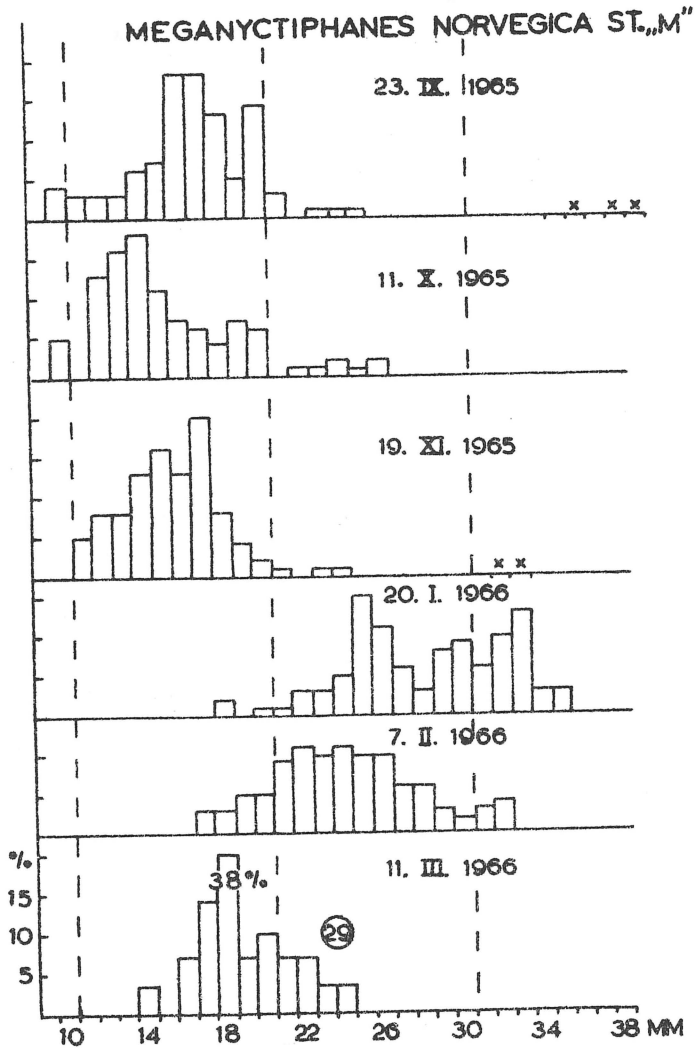

Figure 3. Size frequencies of Meganyctiphanes norvegica from nightly surface hauls 1965-1966 at weathership station M position 66 degr.N.lat., 02 degr.E. long.

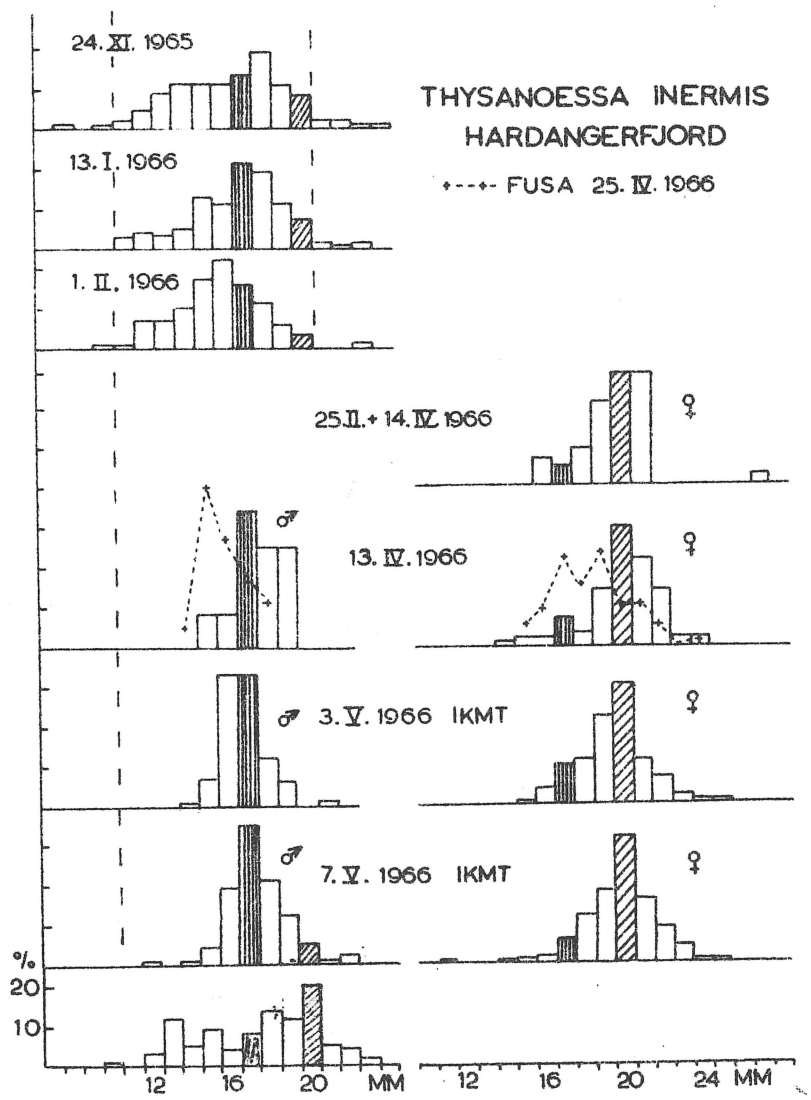

Figure 4. Size frequencies of Thysanoessa inermis, Hardangerfjord 1965-1966.

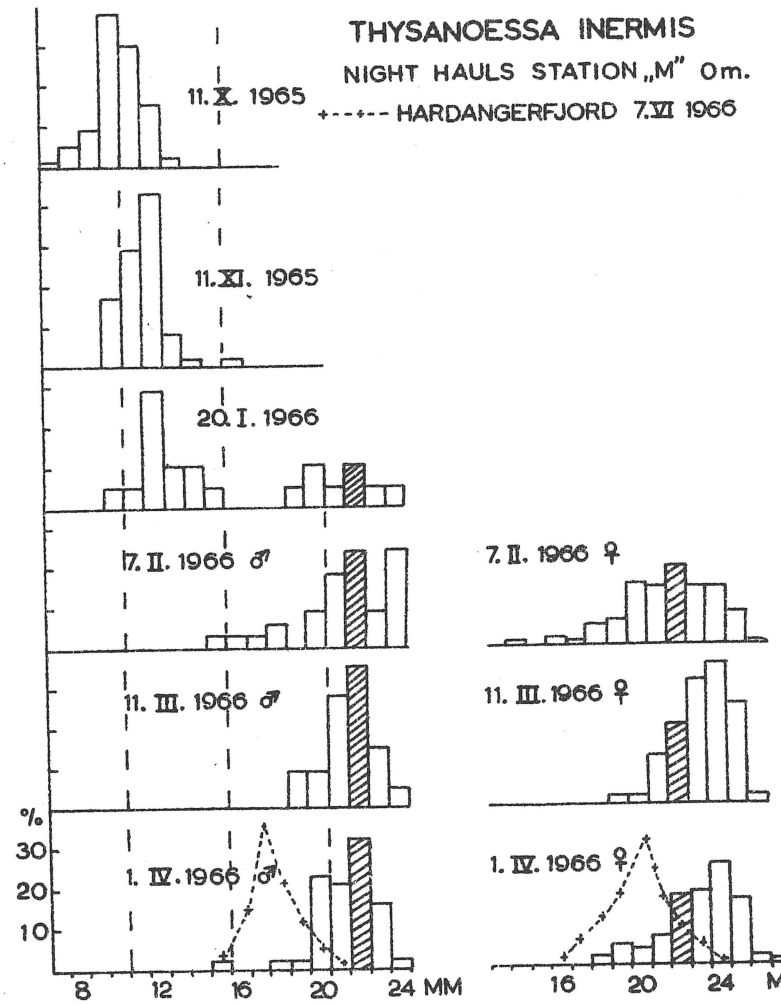

Figure 5. Size frequencies of Thysanoessa inermis from nightly surface hauls at weathership station M, position 66 degr. N. lat., 02 degr. E. long. 1965-1966.

Figure 6. Nesaurctiphanes norvegica crowding under a projector at the pier in Nundheim, in the Hardangerfjord, March 25, 1966. Photo: K. Hansen.

Tekst foregående side:

Figure 6. Meganyctiphanes norvegica crowding under a projector at the pier in Mundheim, in the Hardangerfjord, March 25, 1966. Photo: K. Hansen.