C.M.1980/H:15
Pelagic Fish (Northern) Committee

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DISTRIBUTION AND ABUNDANCE OF THE NORTH SEA SPRAT EGGS AND LARVAE IN 1972

Résumé

En 1972 l'AtlantNIRO a accompli 4 prospections ichthyoplanctoniques en mai-août par le filet iks -30 et deux prospections par le chalut aux juveniles de Danilevsky en juin-août, pendant lesquelles on a estimé l'abondance des oeufs et des larves du sprat de la mer du Nord. Dans la période de ponte du sprat les concentrations les plus denses des oeufs et des larves ont été enregistées dans les régions de haute mer. La durée de la ponte massive dans la région centrale a fait 3 mois environ. L' intensité la plus forte de la ponte est enregistrée dans la deuxième moitié du juillet. Il a été aussi enregistré le deuxième pic un peu plus petit de l'abondance des oeufs en mai, exprimé plus précisément d'après l'abondance des oeufs de I-II stades du développement.

La production saisonniere des oeufs durant la période essentielle de ponte (83 jours) est de $223,6 \cdot 10^{12}$; pour toute la période de ponte preme (110 jours) - $248,5 \cdot 10^{12}$. Considérant la fécondité moyenne de $13.5 \cdot 10^{3}$ et les proportions des sexes I:I le stock de ponte est de $33.13 \cdot 10^{9}$ à $36.81 \cdot 10^{9}$ ex. La répartition par taille des larves du sprat dans la partie centrale de la mer confirme la conclusion sur l'existense de deux pics de ponte. La postérité du premier pic de ponte en août a disparu de la haute mer. En même temps les larves et les juveniles du pic de ponte de juillet ont été captués dans la haute mer en août et septembre.

Dans de différentes régions de la mer les concentrations maximales de larves ont été liées avec les températures différentes.

Abstract

In May-August 1972 four ichthyoplankton surveys using the ICN-8 (Ichthyoplankton Conical Net), and in June-August two surveys using the Danilevsky fry trawl were carried out by AtlantNIRO with the purpose of assessment of the North Sea sprat egg and larva abundance. During the spawning period large concentrations of the sprat eggs and larvae were found in the open sea. In the central area the massive spawning lasted approximately 3 months. Most intensive spawning was recorded in the first half of July. The second, less considerable peak of egg abundance with eggs in stages I and II prevailing in number, was observed in May.

Seasonal production of eggs amounting to $223.6 \cdot 10^{12}$ resulted from the main spawning period (83 days), while the total number of eggs produced during the entire spawning season (110 days) was $248.5 \cdot 10^{12}$ sp. The spawning stock size ranged between $33.13 \cdot 10^{9}$ and $36.81 \cdot 10^{9}$ sp., given the mean fecundity of $13.5 \cdot 10^{3}$ and sex ratio of 1:1. Size distribution of the sprat larvae in the central area was consistent with the hypothesis that there occurred two spawning peaks. The generation from the first spawning peak disappeared from the open sea in August, and the larvae and fry produced from the peak in July were caught throughout August and September.

In different areas of the sea the largest concentrations of the larvae were associated with different temperatures.

In 1972, in the Laboratory of the Northeast Atlantic, AtlantNIRO, the assessment was made of the North Sea sprat egg and larva abundance based on the data from 4 monthly ichthyoplankton surveys conducted in May through August using the Danilevsky fry trawl. A total of 360 ichthyoplankton stations and 59 stations using the Danilevsky trawl was made with 176 hauls at different depth levels. According to Dekhnik (1973), all sprat eggs in the samples were sorted out by 6 growth stages. Then the abundance of eggs at each survey calculated with regard for the distribution area.

For the majority of fish with the pelagic eggs the duration of stages I and II, which include the fractionation period and the period of epithelial blastula, makes up 17-25% of the total incubation period (Dekhnik, 1973). Therefore, the duration of stages I and II for the sprat eggs was estimated at twenty-four hours, taking into account that the whole incubation period for the sprat eggs lasts 4-5 days (Lindquist, 1970). Thus, the mean abundance of sprat eggs per day of the spawning season could be taken as an index of the daily egg production. To calculate the seasonal production, such factors as the value of daily egg production and the duration of the spawning season estimated from the ichthyoplankton surveys on abundance were used. Mean fecundity was determined from the size composition of mature females in June-August 1972, and the ratio of the sprats length to their fecundity according to Bailey and Pipe (1977):

$$\log F = -7.708 + 5.6 \log L,$$

where F is the fecundity, and L is the length of the fish in mm.

Preliminarily, the size composition of the mature fish was smoothed with regard for the virtual population composition in 1972. Given the sex ratio of 1:1, the spawning stock size was estimated in two ways: (1) the duration of the spawning period was taken as the time between the middle of the first and last surveys (83 days); (2) the duration of the spawning period was calculated with regard for occurence of newly hatched larvae during the surveys in May and late August (110 days).

Results

During the spawning period large concentrations of the sprat eggs and larvae were found over considerable part of the sea, except for the north-eastern area, where their abundance was very low (figs 1-4). High egg abundance was observed as early as May (about 1.5 thous. sp./m^2). However, almost complete absence of larval sprat and high percentage of eggs in growth stages I and II (36%) indicate that in the central part of the sea the massive spawning does not occur before the second half of May. In June considerable egg concentrations were found between 56°30'-4°00'N and 0°-2°E, and east of Dogger Bank. High abundance of eggs was also reported from the southernmost part of the sea off the Thames estuary.

Summed egg abundance in the central area of the North Sea, and the per cent of eggs (16.9%) in stages I and II were lower

than in May. The egg distribution pattern observed in June maintained in July, although there occurred a marked increase in their abundance. Simultaneously, the proportion of eggs in different growth stages increased to 27%. In August, the distribution area of sprat eggs and their abundance considerably reduced (1.5 sp./m^2 on the average), the abundance of small larval sprat being relatively high (around 120 sp./m^2, 7 sp./m^2 on the average), which indicates that the spawning was completed in the second half of August. Thus, the massive sprat spawning in the central part of the sea most thoroughly covered with surveys totalled approximately 3 months. In Table 1 the sprat egg abundance is given with regard for the distribution area.

Most intensive spawning was recorded in the first half of July. The second, less considerable peak of egg abundance occurred in May. It was more clearly pronounced, provided that the spawning dynamics is considered in terms of egg abundance at early growth stages.

The sprat spawning stock size in 1972 was estimated from the data gained during the surveys on egg abundance. The mean fecundity value of 13.5 thous. sp. and sex ratio of 1:1 were taken. The routine of the spawning stock size caluculation is shown in Table 2. The estimate on the egg abundance is in close agreement with the spawning stock abundance calculated from V.P.A.

Since ichthyoplankton surveys are not a proper means to speculate on the spawning dynamics, the distribution of larvae

in the southern area presents a certain interest. The survey conducted in July indicated the presence of two peaks in larva abundance with modal lengths of 13 and 24 mm (fig. 4), which evidently correspond to two peaks of spawning intensity. In August, there occurred a sharp decline in the abundance of larvae in the southern part of the sea, which resulted in monomodal distribution with the modal length of 20 mm homologous to that of 13 mm in July. The larvae over 20 mm in length disappeared from the catches taken in August. This fact cannot be explained by the ability of the larvae to avoid the trawl, because other larval fish such as horse-mackerel of 59 mm and whiting of 90 mm in length were vulnerable to the gear. The absence of large larval sprat and fry can neither result from the mortality. Remembering that in July maximum concentrations of large larval sprats over 25 mm in length were found in the estuarine waters - off the Humber river mouth in the south-western area and in the vicinity of Wadden Zee in the south-eastern part of the sea - it can be suggested that the larval sprats produced by the first spawning peak leave the open sea for the coastal zone.

Size distribution of larval sprats in the central area also indicated the presence of two hatching peaks, which occurred later than in the southern area, perhaps, due to lower water temperatures. Less modal lengths can be considered as an argument in favour of this hypothesis. The first generation, which was apparently produced in May, was caught in July at the modal length of 17-18 mm, the second was recorded in August at the modal length of 14 mm and is likely to result from the spawning peak in early July. Thus, the size distribution of larval sprats in the central area substantiates the conclusion drawn from the

data gained during the surveys on egg abundance that there occur two spawning peaks. It should be noted that larval sprats caught in July at l = 17-18 mm were absent from the August records, which was also the case in the southern area.

The generation, which resulted from the first spawning peak in August, evidently migrated from the open sea to the coastal zone, where further growth might have taken place. Simultaneously, the larvae abd fry from the July spawning peak were caught in the open sea in August and September during the ichthyoplankton herring surveys, and in November during the trawl survey on the youngs-of-the-year of sprats.

The study of the larval sprat distribution indicated that in different areas of the sea the maximum larval sprat concentrations were confined to different temperatures. Considerable concentrations of larvae were reported from the surface layers at temperatures ranging between 14.2 and 16.4°C, 15.6°C on the average, in the southern shallow water area, where there is no thermocline available. In the central area, where the temperature stratification is clearly pronounced, large aggregations of larvae were found under the thermocline at depths of 30 to 50 m within the temperature range of 8-12°C, 10.4°C on the average. In the northern area, off the Scotland coast and Shetland Islands, where no temperature stratification was observed in summer, larval sprats were caught in the surface layers at the temperature of 12-13°C. In August, in the central area, the ratio of larvae caught below the thermocline and above it was 86% to 14%, however, simultaneously, at certain stations large concentrations were found above the thermocline of the temperatu-

re of 14–15°C. The differentiation of the North Sea sprat stock may be related to varying ecological condition, including the temperature factor, over the vast spawning ground. Two spawning peaks may bring forth the ecological forms that will differ in growth rate, the time of formation of the first winter ring on the otoliths, the length at first maturation. Such differences had been stated by Illes, Johnson (1962).

Conclusions

1. In 1972 the eggs and larvae of sprats were found between 51°N and 59°N both in the inshore and open sea waters.

2. The massive spawning of sprats in the central North Sea took place between the second half of May and mid-August.

3. Seasonal production of sprat eggs ranged between 223.6 x x 10^{12}, and the spawning stock size between 33.13 x 10^{9} and 36.81 x 10^{9} sp.

4. Two peaks of the egg and larva abundance were recorded indicating the periods of differing spawning intensity.

5. The differences in vertical distribution of the larvae and in temperature conditions of their distribution areas are noted.

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Table 1

Sprat egg abundance (x^{10}) in the central part of the North Sea in 1972

Growth stages	Time of surveys			
	19-25 May	14-27 June	3- 17 July	10-20 August
I-VI	1 074.2	922.5	1 697.3	12.0
I-II	386.7	155.9	458.3	3.1

Table 2

Estimation of the sprat spawning stock in 1972

Duration of spawning period	Daily egg production	Seasonal production	Mean fecundity	Spawning stock, sp.
22 May - 15 Aug (83 days)	$269.30 \cdot 10^{10}$	$223.6 \cdot 10^{12}$	$13.5 \cdot 10^{3}$	$35.13 \cdot 10^{9}$
10 May - 30 Aug (110 days)	$225.9 \cdot 10^{10}$	$248.5 \cdot 10^{12}$	$13.5 \cdot 10^{3}$	$36.81 \cdot 10^{9}$

List of figures

Fig. 1. The distribution of sprat eggs, 19-25 May, 1972.

Fig. 2. The distribution of sprat eggs, 14-27 June, 1972.

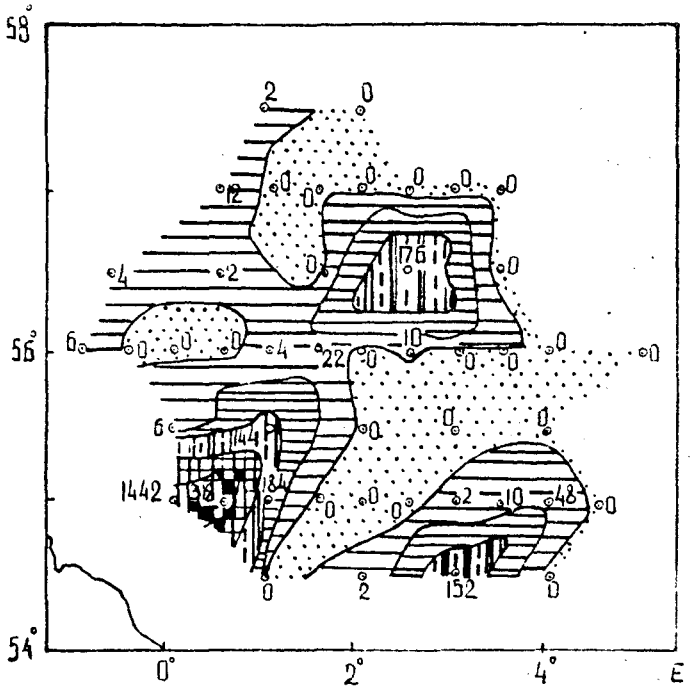
Fig. 3. The distribution of sprat eggs, 3-17 July, 1972.

Fig. 4. The distribution of sprat eggs, 10-20 August, 1972.

Fig. 5. Size distribution of larval sprats:

a) in the southern North Sea

b) in the central North Sea



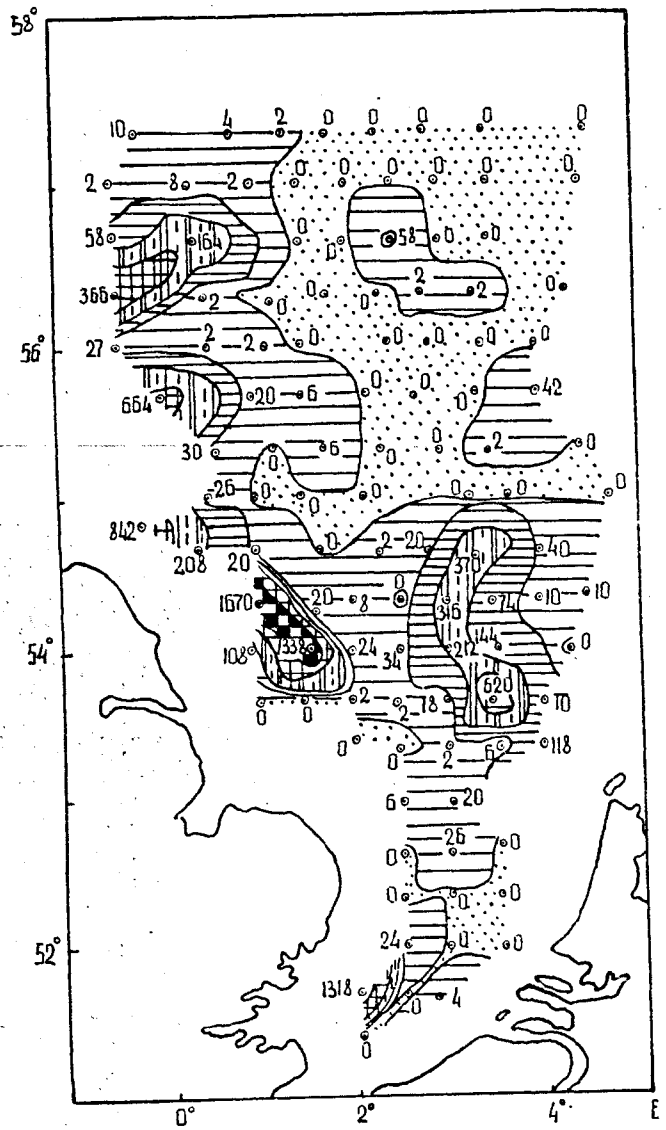


Fig. 2

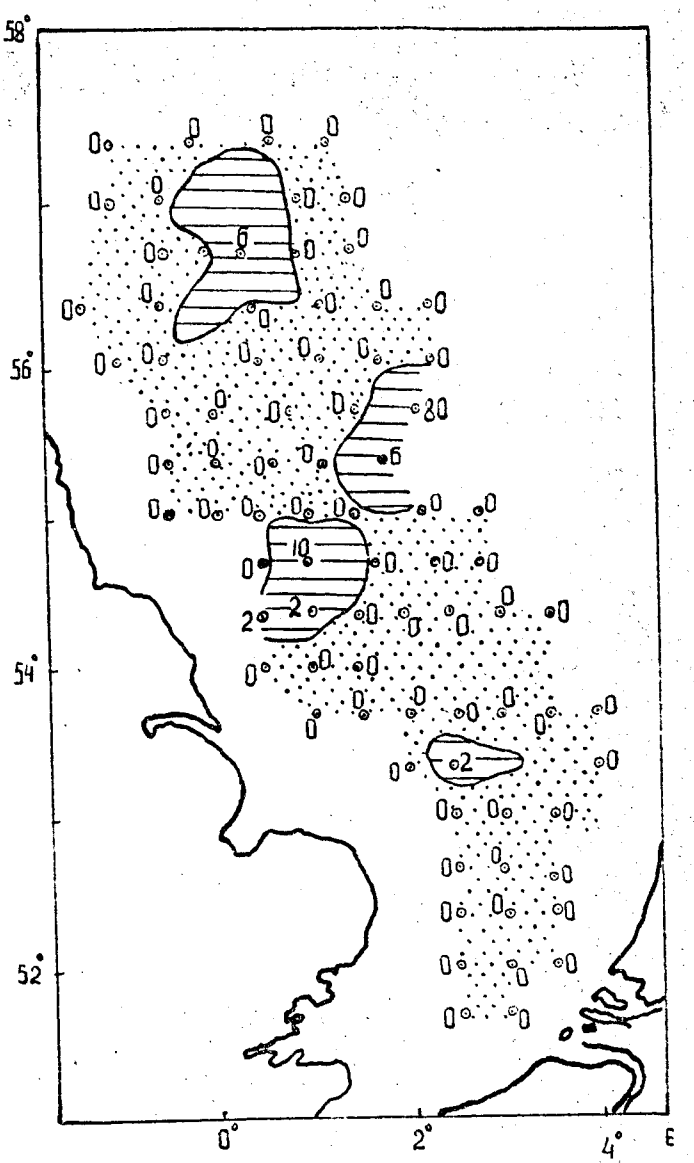


Fig. 4

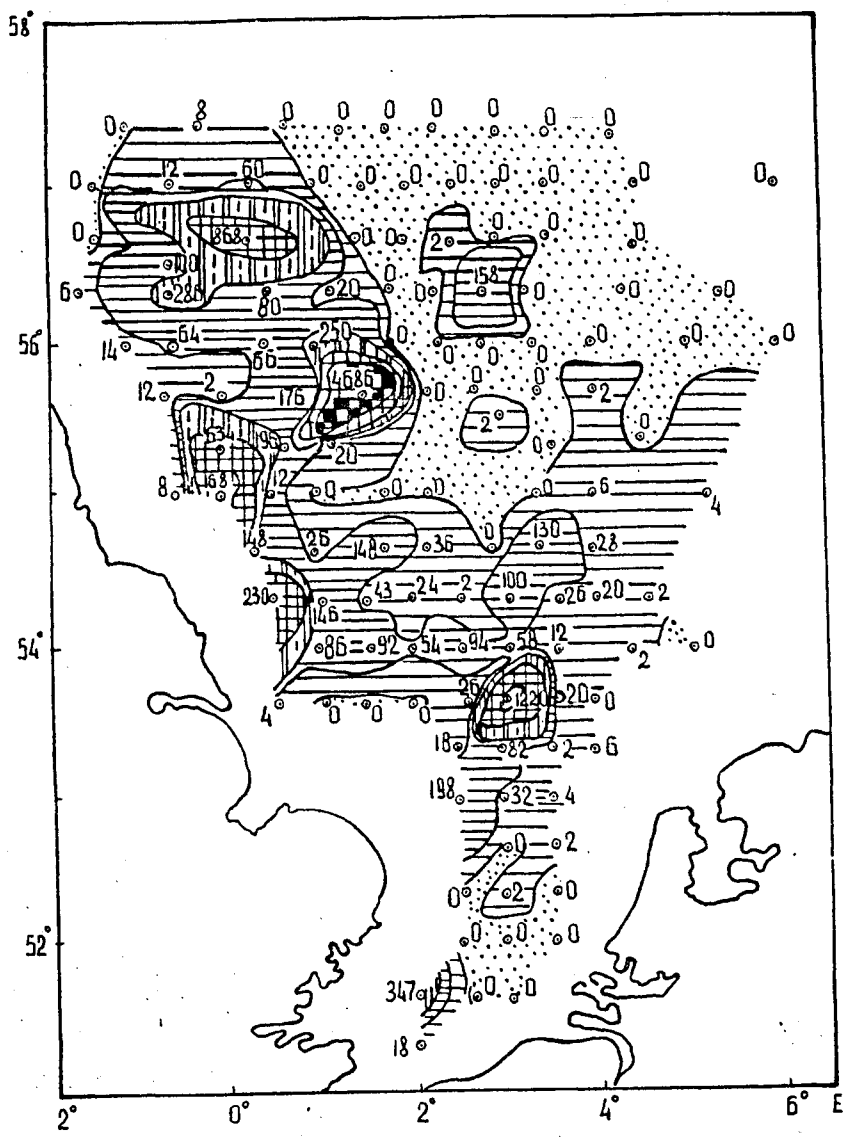
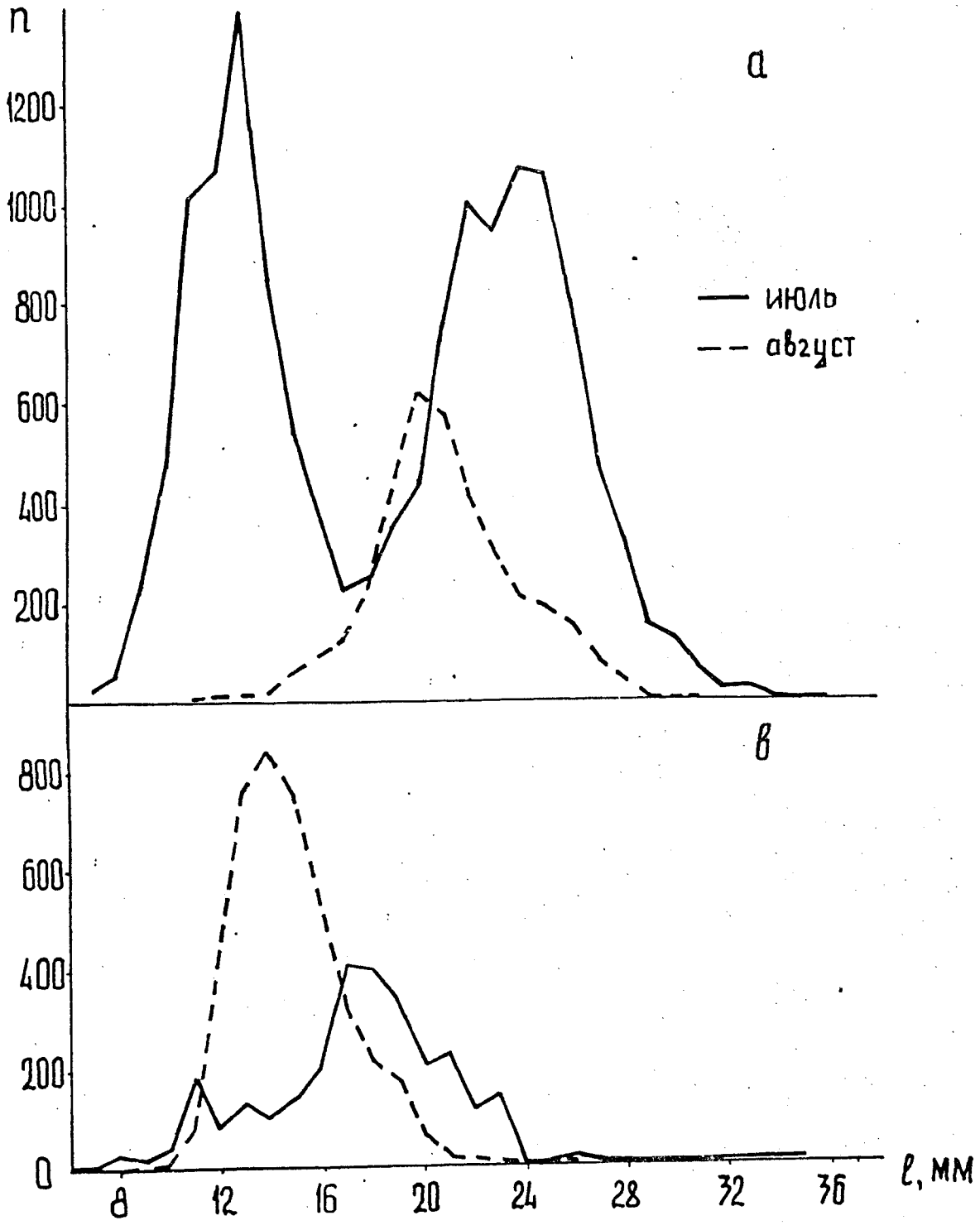


Fig 3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