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The vertical distribution of Baltic herring larvae in the Gulf of Finland

by

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Introduction

Herring larvae may appear quite near the surface (NELLEN & HEMPEL 1970). They are, however, found in abundance even at a depth of 150 metres and are even caught at a depth of 200 metres (RUDAKOVA 1971). Baltic herring larvae are caught in Schlei Fjord at all sampling depths or at from 0 to 4 metres (SCHNACK 1974). At hatching time and even after they are hatched, the fry live near the bottom (SCHNACK & HEMPEL 1971, SELIVERSTOV 1974). The older larvae, on the other hand, favour the surface water layer (NELLEN & HEMPEL 1971, SCHNACK & HEMPEL 1971).

Herring larvae undergo diurnal vertical migrations. In the daytime there is a maximum abundance in the mid water layer. At night there is no distinct maximum in the vertical occurrence. Thus the larvae are more abundant on the surface at night than in the daytime (ZIJLSTRA 1970, WOOD 1971). Diurnal vertical migrations depend on light and change with the size of the larva (ZIJLSTRA 1970, SCHNACK & HEMPEL 1970, WOOD 1971, SELIVERSTOV 1974). There are, however, some differences in the results of the various authors, and thus there is a need for more observations in different areas and under variable light conditions (cf. WOOD 1971).

The vertical occurrence of larvae is of great methodical importance in the assessment of larval abundance. To elucidate the vertical distribution of Baltic herring larva, observations and sampling were made in the Gulf of Finland in the summer of 1974 at the same place in different conditions.

Material and methods

In May - August of 1974 observations were made off the Finnish coast in the central part of the Gulf of Finland. Sampling of herring larvae was done in Sipoonselkä open water (60° 12' N 25° 22' E) at a site with an average depth of 23 metres. Sampling was performed every second week in a 24 hour period. The modified Gulf V sampler (NELLEN & HEMPEL 1969) was towed at depths of 0.2, 1, 2, 4, 8 and 16 metres. The samples were taken in the given order, and it took about three hours at a time to take the whole depth series. The sampler was towed at a speed of 4 knots for 20 minutes at each depth. The sample was taken from each depth in the middle of the day, in the afternoon, at night, at midnight, in the morning and in the forenoon.

According to the Lowestoft flow meter placed in the opening of the gear, with a diameter of 19.3 cm, the amount of filtered water during a haul was on average 84.3 cu. m. The amount of water passed through the sampler was determined by hauling the gear under test conditions several times to and fro for a distance of 1 765 metres. The amount of water which passed through the opening per reading of the flow meter was on average 2.29 litres per reading, with a range of 2.25 - 2.35 litres per reading.

The mesh size of the net was 300 µm. The filtering efficiency of the net was tested by towing the sampler the same distance at different depths with and without the net. The mean of six readings with the net was 99.5 % of the corresponding readings without the net. Thus the filtering efficiency of the gear was in this research area even preferable to experiments made elsewhere (cf. NELLEN & HEMPEL 1969). The filtering efficiency of the net with the same mesh size naturally varies with the species and quantity of the organisms to be filtered.

The sampler was handled from a small boat, 10 metres in length. It was lowered and lifted by hand, which is why an attempt was made to lighten it as much as possible by making its frame of aluminium. To reach the desired depth as quickly as possible, a depressor made for a foot rope of a mid water trawl was attached to the towline, about 5 metres in front of the sampler with a painter of 2 metres.

The towing speed was determined with the VDO pressure log. The depth of the sampler with different lengths of the towline was measured in advance with an echosounder from another boat. The length of the towline at different depths of the gear varied from 6 to 65 metres (Fig. 1).

The sampler was also fitted with a "baby hai" (SCHNACK 1974) for plankton sampling. The plankton samples and other fish larvae, mostly Gobiidae and Ammodytidae, are not included in this report. A total of 4 699 Baltic herring larvae was caught. The few Baltic herring, in all 23 larvae caught in August, are also excluded from the report.

In connection with every haul, light measurements were made with a Lunasix 3 exposure meter. The results are given in relative values proportional to the meter reading on a cloudless midday in the middle of the summer. Lunasix 3 readings cannot be used as absolute light values because of the convex opal glass instead of a glass plate in the photometer.

The temperature of the sea water was measured with a Ruttner sampler thermometer twice at every sampling depth, in the beginning and at the end of each trip.

Results

The abundance of the Baltic herring larvae is given in Fig. 2. At the end of May and in the beginning of June the larvae were at greater depths by day and nearer the surface at night. At the end of June and in July the larvae were on the surface by day. The occurrence at night was still at the same depths as in the beginning of the summer.

Early in the morning there were usually fewer larvae than during other times of the day. While the depth of the sampling site was on average 23 metres, it is possible that the larvae were at that time below the maximal sampling depth, 16 metres.

The distribution of the larvae in length groups is given in Table 1. The occurrence of the larvae on the surface in the middle of the summer does not seem to be due to the size of the larva. The larvae of the smallest length group also have their maximum occurrence on the surface. Diurnal vertical migrations do not depend on the size of the larva.

The results of the light measurements are given in Fig. 3. The differences in the daytime vertical distribution of the larvae seem to have no relation to the light on the days in question. During the cloudy days, June 12 and July 10, there was a decisive difference in the vertical distribution though the light was more or less the same on both days.

The temperature of the sea water during the sampling time is given in Fig. 4. According to this, the larvae seemed to rise to the surface when the temperature increased from 10 to 15 degrees C. In spite of the decrease in temperature back to 9 - 10 degrees on the last days of observations on August 7 - 8, the few larvae caught were almost all from the surface.

Discussion

The diversity of the results possibly caused by the sampling method and differences of the size of the larvae make it difficult to explaine vertical migrations. According to SELIVERSTOV (1974), herring larvae at the yolk sac stage with a length of 8.25 mm live on the coast of Norway near the bottom at a depth of over 100 metres. On the second day after hatching, before they begin to take food, the larvae move to the uppermost 50 metre water layer. After beginning to take food at the age of 6 - 9 days and at a length of 8.8 - 10.8 mm, the larvae start regular diurnal migrations. At the daytime they live near the bottom and move for the night towards the surface. The amplitude of the migrations can be 75 - 100 metres. At Shetland, too, herring larvae have been observed to move to the surface at twilight (WÖRNER 1974).

According to many observations, larvae in general live in the mid water and surface water layers. BRIDGER (1958) caught most of his herring larvae on the surface. In mid water and near the bottom they were almost equally abundant. In the North Sea small herring larvae but over a week old were most abundant on the surface both in the daytime and at night (SCHNACK & HEMPEL 1971). According to ZIJLSTRA (1970), the maximum abundance of herring larvae was at 15 metres in the afternoon, when the depth of the water was 30 metres. On the surface there were the least larvae. At night there was no clear concentration in the vertical occurrence. On the surface there were more larvae at night than in the daytime and their abundance increased toward deeper water. WOOD (1971) obtained the same results north and northwest of Scotland. In the daytime, herring larvae were most abundant in the mid water and surface layers. At night the vertical distribution was more even.

The data on the relation between the vertical occurrence and the length of the larvae also vary. In bright sunshine BRIDGER (1958) caught 16 - 25 mm long larvae at greater depths than 16 mm long larvae. According to ZIJLSTRA (1970), 11 - 15 mm larvae in the North Sea can stay at deeper levels in the daytime than larvae of lengths less than 11 mm. The same has been shown by SCHNACK & HEMPEL (1971). Larvae less than 10 mm in length were most abundant at 10 metres both in the day and at night. Larvae over 10 mm were most abundant at 30 metres and less abundant at 10 metres. At night there were no differences in the abundance of large larvae at different depths.

There are also some observations according to which small larvae do not occur in the surface layer. In the North Sea small larvae of herring and sprat avoid the surface (HEMPEL & NELLEN 1969, NELLEN & HEMPEL 1970). The mean length of herring larvae caught near the surface on the coast of Scotland was much greater than that of the larvae from other depths (WOOD 1971). At night near the surface, on the contrary, the length was slightly smaller than that at other depths. According to SCHNACK (1974), the mean length of Baltic herring larvae decreased at the end of May in the depth range from 0 to 3.3 metres with increasing depth. In bright sunshine in June 11 - 12 no change in mean length was observed.

In the Gulf of Finland larvae were deeper in May by day and at night moved nearer to the surface. In aquarium experiments, too, in natural light variation the larvae moved at night to the surface (BLAXTER 1973). At the end of June and in July larvae of Baltic herring were on the surface by day and deeper at night. When passive, larvae sink when they are heavier than their environment (BLAXTER & EHRLICH 1974). In aquarium experiments, larvae indicated a photocinetic reaction and positive phototaxis particularly in a small degree of light (WOODHEAD & WOODHEAD 1955). The movement of larvae downward at night may be passive sinking. The migration to the surface in the middle of the summer may depend on positive phototaxis. In the Atlantic larvae have been observed to avoid the surface on a bright day (BLAXTER 1958, WOOD 1971). Larvae in the Gulf of Finland may stay near the surface even in bright daylight because of the turbidity of the water. Larvae move upward untill the light is intense enough so the horisontal component of their swimming exceeds the vertical one (WOODHEAD & WOODHEAD 1955). On the coast of the Gulf of Finland this may take place nearer the surface than in the clear Atlantic water.

The vertical movements of the larvae may be explained by the photocinetic reaction, but it does not explain the difference in the vertical distribution of larvae by day in the beginning and the middle of the summer as shown in Fig. 2. The larger larvae have been observed to occur nearer the surface than the smaller larvae (WOOD 1971, SCHNACK 1974). The differences in the vertical distribution of the larvae in this report in the beginning and in the middle of the summer obviously cannot depend on the size of the larvae. Larvae with a yolk sac were also caught at midsummer near the surface. The temperature in the beginning of the summer, when the larvae were deeper by day, was low (Fig. 4). However, the material caught in August, few in number, suggest that the vertical distribution may not be explained by the temperature.

The aquarium experiments support the idea that herring larvae perform diurnal vertical migrations corresponding to those of plankton crustaceans, although their degree of adaptability is an open question (BLAXTER 1973). The plankton samples taken in connection with this study may show whether there is any correlation between the vertical distribution of the larvae and their food organisms.

Summary

A modified Gulf V sampler was towed during the developing time of Baltic herring larvae every second week at depths of 0.2, 1, 2, 4, 8 and 16 metres in the middle of the day, in the afternoon, at night, at midnight, in the morning and in the forenoon.

At the end of May and the beginning of June the larvae were in deeper water by day. At the end of June and in July the larvae were on the surface by day. The occurrence in the night was more abundant in the mid water layer during the whole season.

Early in the morning there were usually fewer larvae than during the other times of the day. At that time larvae were possibly below the sampling depth.

Neither the vertical distribution of the larvae nor the diurnal migrations seem to have any correlation with the length groups presented. The characteristic nighttime distribution of the larvae is well suited to the short twilight period in the middle of the summer.

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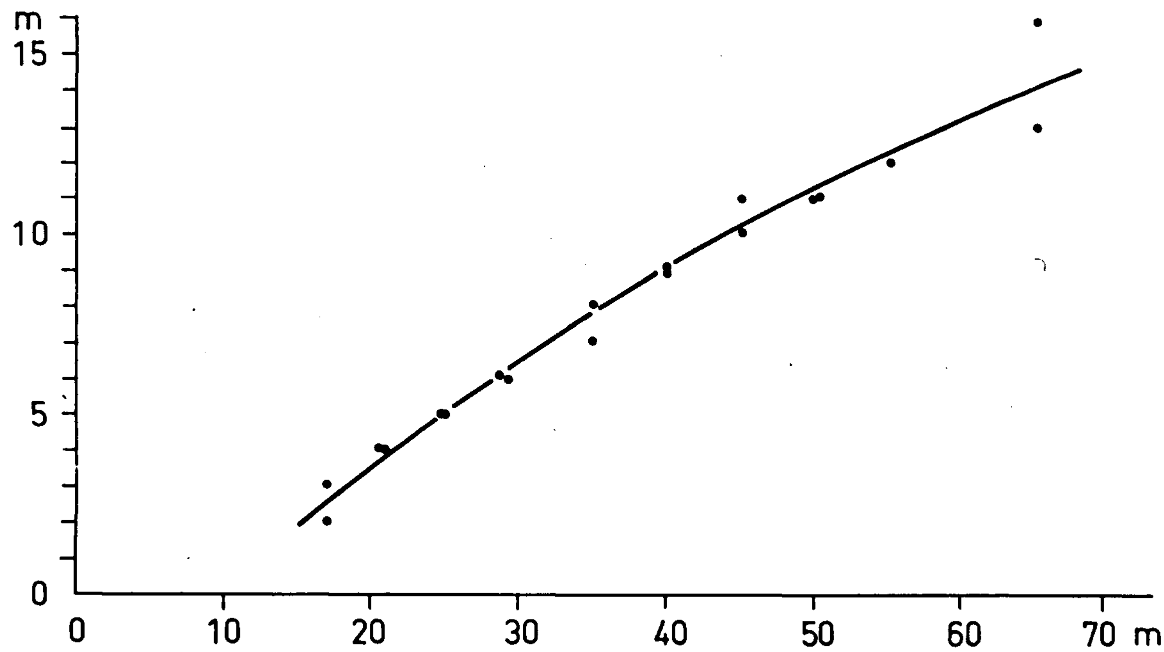

Figure 1. The depth of the modified Gulf V sampler at different lenghts of the towline at a towing speed of 4 knots.

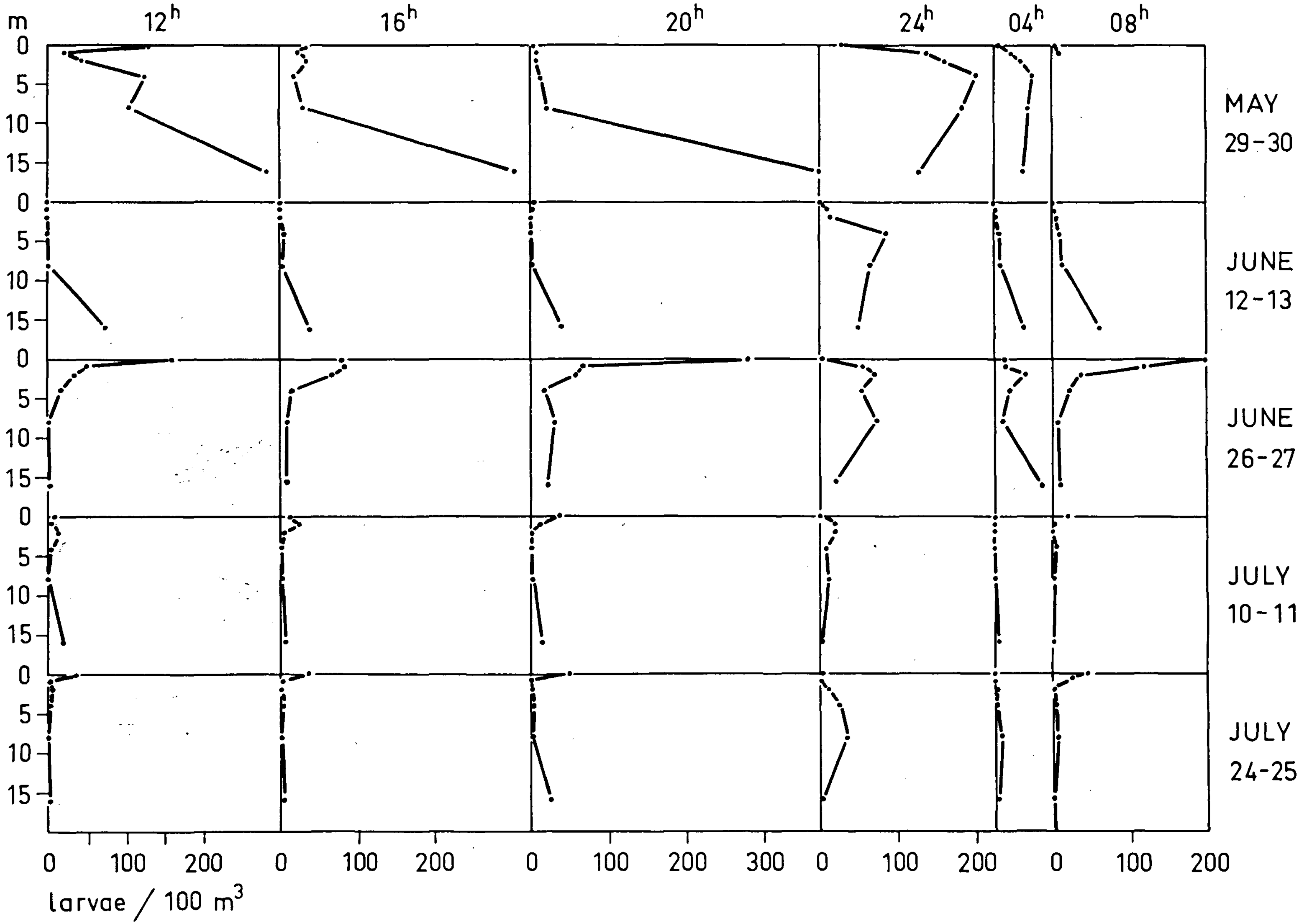

Figure 2. Abundance of Baltic herring larvae per 100 cu. m at different depths and on different dates.

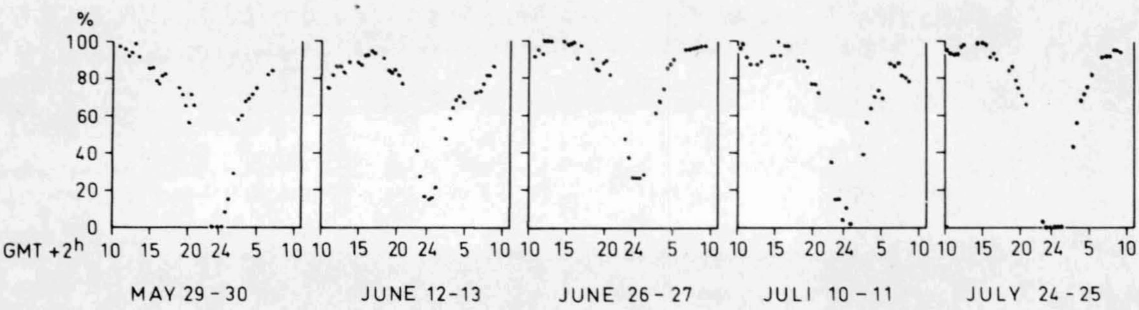

Figure 3. The interchange of light and darkness during the sampling time.

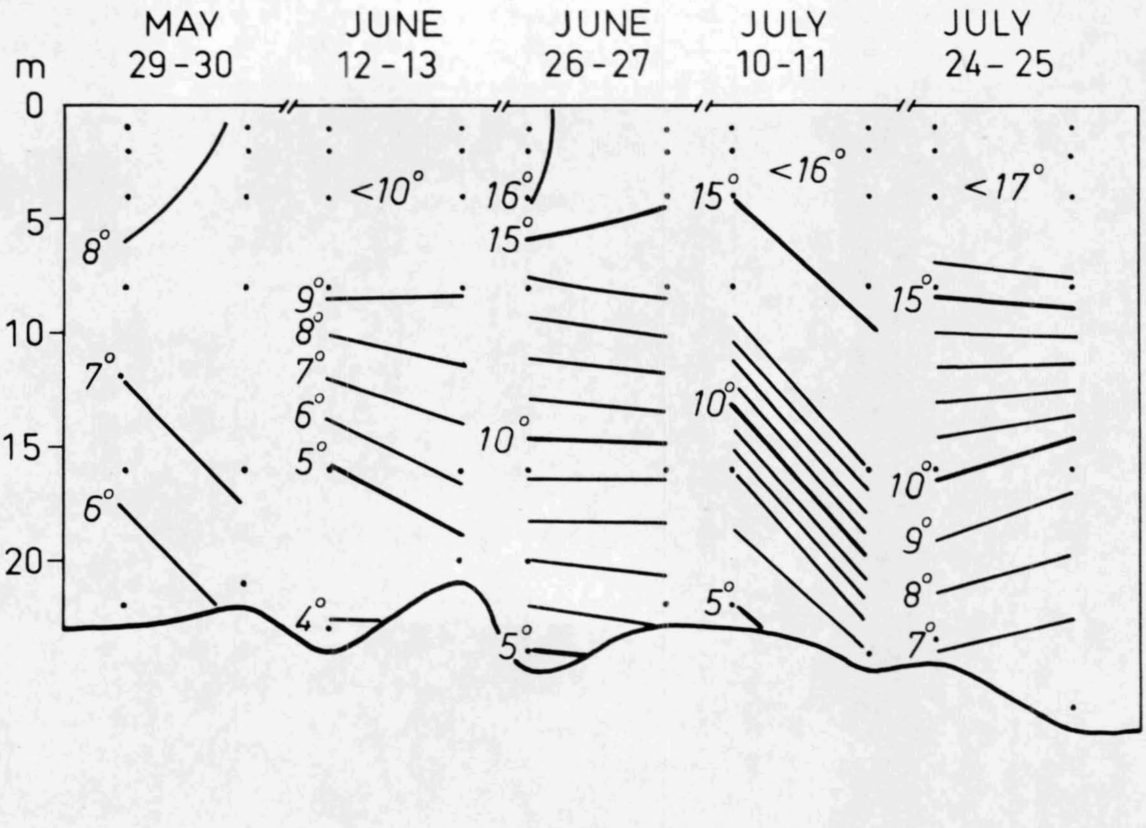

Figure 4. Temperature of the sea water during the sampling time.

Table 1. Numbers of Baltic herring larvae <10 mm, 10 - 15 mm and >15 mm per 100 cu. m at different depths.

	Depth	May 29 - 30						June 12 - 13						June 26 - 27						July 10 - 11						July 24 - 25					
	m	12^h	16^h	20^h	24^h	04^h	08^h	12^h	16^h	20^h	24^h	04^h	08^h	12^h	16^h	20^h	24^h	04^h	08^h	12^h	16^h	20^h	24^h	04^h	08^h	12^h	16^h	20^h	24^h	04^h	08^h
<10 mm	0	130	29	4	28	4	6	0	0	0	0	0	2	54	29	100	4	14	55	0	2	0	0	0	0	3	6	6	1	0	1
	1	22	22	9	129	23	10	0	0	0	1	4	4	27	39	49	45	11	68	1	1	0	0	0	0	0	1	1	0	0	4
	2	65	35	7	161	32	-	0	1	1	7	1	2	25	26	40	37	33	26	1	0	1	0	0	0	1	0	1	0	0	0
	4	117	18	14	199	44	-	0	5	1	38	3	8	11	11	14	37	17	19	1	0	0	0	0	0	0	0	1	6	0	1
	8	109	29	21	184	39	-	1	0	3	18	3	5	1	3	29	45	9	8	0	0	0	0	0	0	0	1	0	2	0	1
	16	277	301	361	130	36	-	13	12	8	5	9	18	3	4	9	7	38	8	0	0	3	0	1	0	1	1	0	0	1	0
10 - 15 mm	0	0	5	0	1	1	0	0	0	6	0	0	0	93	52	147	0	0	135	4	4	15	0	0	13	7	9	11	0	0	11
	1	0	1	0	9	0	0	0	0	4	10	0	0	12	43	15	11	4	47	4	10	9	12	0	2	0	0	0	1	0	10
	2	2	0	1	0	3	-	1	0	0	7	2	3	8	40	15	26	7	10	10	4	0	13	0	0	0	0	0	4	3	1
	4	6	0	0	3	6	-	2	1	0	49	4	3	5	3	4	16	2	3	4	1	1	4	0	4	0	3	1	6	1	2
	8	0	0	0	0	5	-	1	3	1	47	4	9	0	6	2	20	2	0	0	1	1	1	0	1	0	0	0	6	4	4
	16	4	4	10	0	1	-	60	26	31	0	28	43	1	4	13	10	23	3	10	4	9	0	3	1	0	1	7	0	1	0
>15 mm	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	34	1	0	8	5	6	21	0	0	7	25	23	32	2	0	31
	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	6	1	14	2	7	0	0	0	1	0	0	0	12
	2	0	0	0	0	0	-	0	0	0	0	0	0	1	0	2	8	0	0	3	0	0	7	0	0	2	1	0	7	0	0
	4	0	0	0	0	0	-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	1	1	3	0	11	1	1
	8	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	8	0	0	0	0	1	9	0	0	0	0	1	24	5	1
	16	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0	2	0	0	7	1	3	3	1	0	0	1	17	4	2	0