

ABUNDANCE, MORTALITY AND PRODUCTION OF SPRING-SPAWNING BALTIC
HERRING LARVAE IN THE SEAS AROUND FINLAND IN 1979

by

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Abstract

In May-August 1979, weekly samples were taken at seven permanent field stations with the modified Gulf V sampler. The greatest abundance of herring larvae, on average 53 larvae per 10 m², was recorded in the Archipelago Sea (ICES subdivision 29, Kustavi). The lowest abundance, 4 per 10 m², was recorded in the Bothnian Bay (31, Kalajoki). No decrease can be observed in the larval abundance in 1974-79. In samples taken during a cruise along the Finnish coast, from 8 June to 2 July 1979, the number of larvae averaged 18 per 10 m².

The mean daily instantaneous mortality rate of small larvae in 1979 in subdivisions 29N, 30 and 31 (east) is calculated to be $Z = 0.0748$ and in subdivision 32 $Z = 0.0675$. The production of 10-15 mm larvae in 1979 in subdivisions 29N, 30 and 31 (east) is estimated at 5.63×10^{12} and in subdivision 32 at 1.87×10^{12} .

According to larval sampling, the year class 1980 is below average off the coast of Finland.

Résumé

De mai à août en 1979, les échantillons hebdomadaires ont été pris dans sept stations permanentes à l'aide de l'échantillonneur "Gulf V" modifié. La plus grande abondance des larves de hareng de la Baltique, en moyenne 53 larves au 10 m², a été notée dans la Mer de l'Archipel (CIEM sous-division 29, Kustavi). La plus basse abondance, 4 au 10 m², a été notée dans la Baie de Bothnie (31, Kalajoki). Aucune diminution de l'abondance des larves n'a été observée en 1974-79. Pendant une croisière du 8 juin au 2 juillet 1979 au large des côtes de Finlande on a noté que le nombre des larves était en moyenne 18 au 10 m².

En 1979, le taux de mortalité instantané des larves petites a été évalué, en moyenne par jour, à $Z=0.0748$ dans les sous-divisions 29N, 30 et 31 (est), et à $Z=0.0675$ dans la sous-division 32. La production de larves du groupe de longueur de 10 à 15 mm a été 5.63×10^{12} larves à l'année dans les sous-divisions 29N, 30 et 31 (est), et 1.87×10^{12} dans la sous-division 32.

D'après les échantillonnages de larves, le recrutement du hareng en 1980 au large des côtes de Finlande est au plus moyen.

Introduction

Information on the abundance of Baltic herring larvae at permanent sampling stations around Finland has been presented earlier (SJÖBLOM & PARMANNE 1975, 1976a, 1977, 1978, 1979). In 1979, samples were taken at 38 additional sampling sites off the coast of Finland. This report gives the results of the sampling in 1979, estimates of the total number of larvae, larval mortality and production, and a preliminary estimate of the strength of the herring year class 1980.

Material and methods

In 1979, as in earlier years, sampling was performed at the seven permanent field stations (Fig. 1). Samples were taken with the modified Gulf V sampler (SCHNACK 1974), the larval net used having a mesh size of 300 μm . The towing speed was 4 knots. At each station single oblique hauls to the bottom and up to the surface were made each week at the five or six places shown in an earlier report (SJÖBLOM & PARMANNE 1976a, Figs. 2-8). The sampling technique has also been described earlier (SJÖBLOM & PARMANNE 1975).

In addition, during the period 8.6.-2.7.1979 altogether 70 samples were taken from 38 further sampling sites, as the research vessel SILAKKA cruised along the coast of Finland from the eastern part of the Gulf of Finland (ICES subdivision 32) through the Archipelago Sea (29) to the northern part of the Bothnian Sea (30) and back again. There were mainly three sites per ICES statistical rectangle, each of which were sampled twice. The sampling technique was the same as at the permanent field stations, but double oblique hauls were made. The haul depth varied from 7 to 31 m.

Abundance of larvae

The mean monthly abundance of Baltic herring larvae in the permanent field stations in 1979 is given in Table 1. The greatest mean abundance was recorded in the Archipelago Sea (subdivision 29), Kustavi, the value for May-August being 53 larvae per 10 m^2 . The next highest values were obtained in the central part of the Gulf of Finland (32), Valko, 26 per 10 m^2 , and the Åland

Islands (29), 25 per 10 m². The lowest number, 4 per 10 m², was recorded in the Bothnian Bay (31), Kalajoki.

In the Archipelago Sea the monthly mean was highest in May - 125 larvae per 10 m², in the Bothnian Sea it was highest in June - 36 larvae per 10 m², and in the Gulf of Finland it was also highest in June - 55 larvae per 10 m².

Comparison with the results obtained in the previous years (Table 2) shows that the abundance of larvae in 1979 is at the same level as in 1978. In the central part of the Gulf of Finland (Valko) the larvae were more abundant in 1979 than in all the earlier years. Although the Finnish herring catch has increased by 20 % since 1974, no decrease can be observed in the spawning stock size (Anon. 1980) or in the abundance of larvae.

The numbers of herring larvae obtained during the cruise of 8 June - 2 July 1979 averaged 18 per 10 m² (Fig. 2). This is at the level of the weekly samples (19 per 10 m²) taken in May-August (Table 2), but less than the abundance of larvae at the seven permanent field stations in June, which averaged 29 per 10 m² (Table 1). During the cruise of the research vessel the larvae were most abundant in the inner bays, where spawning first begins.

Larval production

The numbers of Baltic herring larvae in the open sea are small (LINDBLOM 1973, SJÖBLOM & PARMANNE 1976b). Fig. 3 shows the larval numbers during the cruise of the research vessel SILAKKA in relation to the depth of the haul. The highest numbers were recorded in the depth range 10-22 m. If a regression line is drawn on the basis of the numbers obtained when the haul depth was ≥ 15 m (Fig. 3), the line crosses the x-axis at the point 27 m. In this work the depth of 27 m has been used as the theoretical outer limit of the larval distribution area. The Baltic herring spawns from a depth of 0.4 m down to a maximum of 11 m (ANEER 1979). The fact that abundant larvae were taken at the field stations when the haul depth was 5 m (Table 1) supports the view that Baltic herring larvae occur in shallow waters, as well. In this study the whole 0-27 m depth zone has been treated as a larval production area.

The area of the 0-27 m depth zone can be calculated from the figures presented by DAHLIN (1973):

	Total area	0-27 m depth zone
Gulf of Bothnia (to the north of 60°N)	110 031 km ²	39 513 km ²
Gulf of Finland	30 526 km ²	14 268 km ²

In the Åland Islands the growth of autumn-spawning Baltic herring larvae is 0.18 mm per day (HALLING 1978). Various data have been presented on the growth of spring-spawning Baltic herring larvae. In the Gulf of Riga the daily growth is 0.5 mm (LISIVNENKO 1962). In the northwestern part of the Baltic Sea proper growth is 0.19-0.33 mm/day (ANEER 1979) and off Rügen 0.068-0.359 mm/day or 0.02 mm per day-degree (BRIELMANN & BIESTER 1979). If the growth off the coast of Finland is 0.3 mm/day, the larva spends 17 days in the length group 10-15 mm. If the length of the period when there are larvae in the length group 10-15 mm is 90 days, then the number of such 17-day periods in the whole summer will be 5.3. At the permanent field stations in 1979 the numbers of larvae belonging to the length group 10-15 mm in subdivisions 29, 30 and 31 averaged 5.8/10 m² and in subdivision 32 the average was 4.0/10 m². When the mean larval abundance is multiplied by the number of 17-day periods (5.3), the production of larvae in the length group 10-15 mm during the whole summer in subdivisions 29, 30 and 31 is 30.7/10 m² and in the Gulf of Finland 21.2/10 m². As has been reported earlier, the abundance of herring larvae in samples taken along the coast of Finland has been 62 % of that observed at the permanent field stations. If this is applied here the annual larval production in the length group 10-15 mm in subdivisions 29, 30 and 31 is 19.0 larvae/10 m², or 190 × 10⁶ larvae/km², and in subdivision 32 it is 131 × 10⁶ larvae/km².

Mortality

The weight of the spawning herring stock at the beginning of 1979 was 360 000 t in subdivisions 29N, 30 and 31 (east) and 113 300 t in subdivision 32 (Anon. 1980). For the fecundity of Baltic herring, KOSIOR and STRZYŻEWSKA (1979) have presented

the equation $F = 390.94 W - 2420.59$, where W = the weight of the fish in grams. When this equation is applied and the proportion of females in the spawning herring stock is assumed to be 50 %, the number of eggs at the beginning of 1979 in subdivisions 29N, 30 and 31 (east) was 67.9×10^{12} and in subdivision 32 it was 19.7×10^{12} (Table 3).

If the mean spawning time was 31 May, and the total mortality of fish in subdivisions 29N, 30 and 31 (east) was $Z = 0.343$ and in subdivision 32 was $Z = 0.55$ (Anon. 1980), the decline in the number of eggs by the end of May was 13.1 % and 20.2 %, respectively (Table 3).

The mortality of herring eggs in natural conditions in the Clyde is 3-6 % (BLAXTER 1971) and in the North Sea 0-11 % (HEMPEL & HEMPEL 1971). When Baltic herring eggs were brought to the laboratory, the hatching percentage ranged from 0.05 to 94.3, averaging 53.9 (ANEER 1979), but, as pointed out by HEMPEL (1971) and ANEER (1979), the transfer from the sea to the laboratory may cause additional mortality. In natural conditions the mortality of Rügen spring herring eggs was 9.9 % (BIESTER et al. 1979). If this value is used, the amount of larvae hatched in subdivisions 29N, 30 and 31 (east) was $53\ 135 \times 10^9$ and in subdivision 32 it was $14\ 159 \times 10^9$ (Table 3).

DAHLIN's (1973) paper does not show how the area with a depth of less than 27 m in the Gulf of Bothnia is divided between the eastern and western parts. The coast in the eastern part is shallower, and this part also contains the shallow Archipelago Sea. If the eastern part is assumed to constitute 75 % of the area, its extent is $29\ 635 \text{ km}^2$. The production of 10-15 mm larvae in subdivisions 29N, 30 and 31 (east) in 1979 can thus be estimated at 5.63×10^{12} . If the production off the Soviet coast is assumed to be of the same magnitude as off the Finnish coast the production in subdivision 32 can be estimated at 1.87×10^{12} larvae (Table 3). If the average age in the length group 10-15 mm is assumed to be one month, the mean daily instantaneous mortality rate (Z calculated from $N_0/N_t = e^{-Zt}$) in subdivisions 29N, 30 and 31 (east) was $Z = 0.0748$ and in subdivision 32 was $Z = 0.0675$ (Table 3). This mortality rate cal-

culated on the basis of the spawning stock and fecundity is bigger than the mortality rate of herring in Maine ($Z = 0.0148/\text{day}$, GRAHAM & DAVIS 1971), but is at the same level as in aquarium experiments with herring ($Z = 0.052 - 0.062/\text{day}$, calculated on the basis of figures presented by FOSSUM & JOHANNESSEN 1979) and in Rügen spring-spawning herring in natural conditions ($Z = 0.0911/\text{day}$, BRIELMANN & BIESTER 1979).

Of the larvae which belonged to the length group 10-15 mm in summer the proportion still alive at the end of the year was about 0.1 % (Table 3).

Discussion

The correlation between the year class strength (Anon. 1980) and the number of larvae ≥ 10 mm per 10 m^2 in June in the eastern part of subdivisions 29N, 30 and 31 is $r = 0.63$ and in subdivision 32 it is $r = 0.77$ (Figs. 4 and 5).

According to preliminary data, the abundance of larvae ≥ 10 mm in June 1980 in subdivisions 29N, 30 and 31 (east) was 3.7 per 10 m^2 , and the abundance off the whole Finnish coast was 5.7 per 10 m^2 . Thus, according to larval sampling, the year class 1980 seems to be below average off the coast of Finland (Table 4).

For more reliable estimates of the production of larvae in the northern Baltic Sea more data are needed, especially on the growth, mortality and distribution of the larvae.

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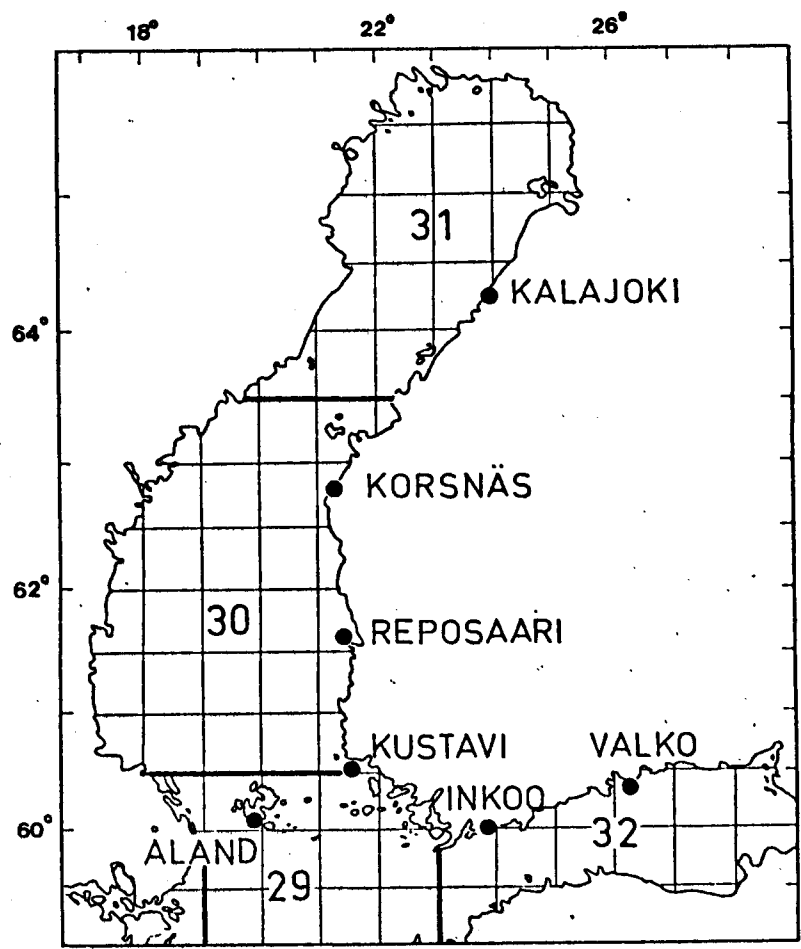


Fig. 1. Permanent field stations for sampling Baltic herring off the Finnish coast in ICES subdivisions 29 - 32.

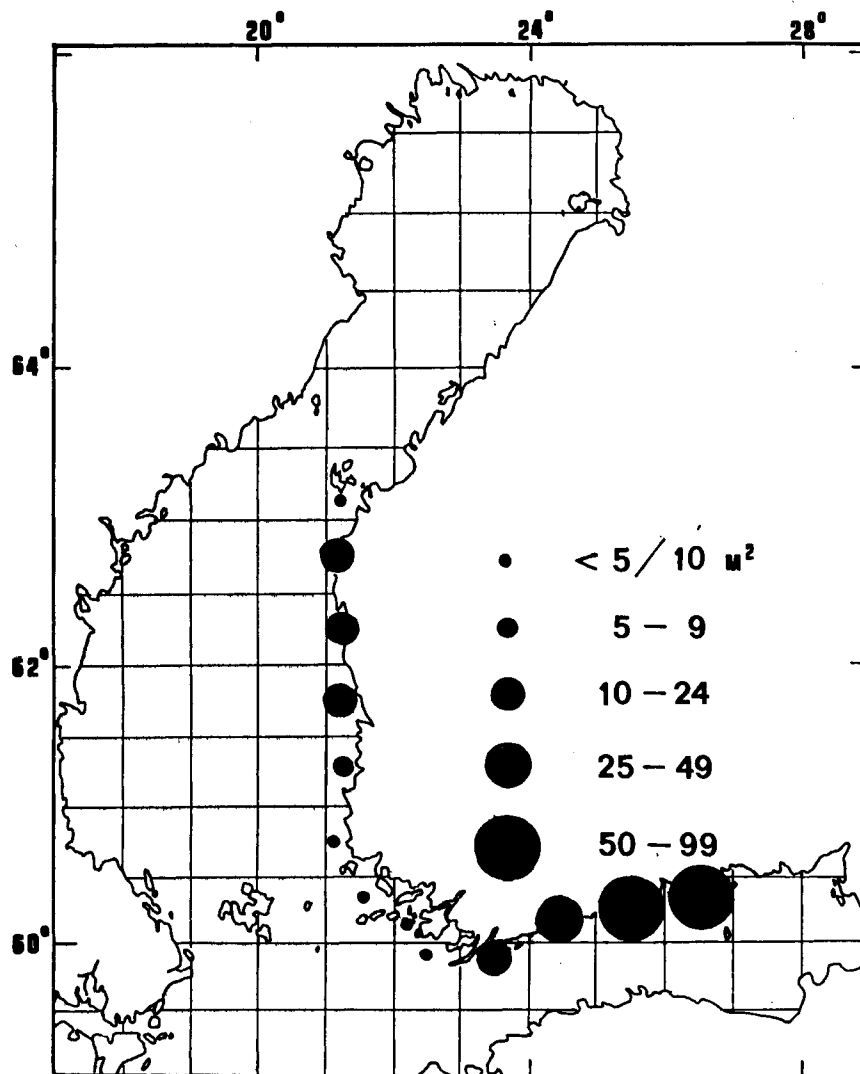


Fig. 2. Mean larval abundance in ICES statistical rectangles during the cruise of the research vessel SILAKKA, 8 June - 2 July 1979.

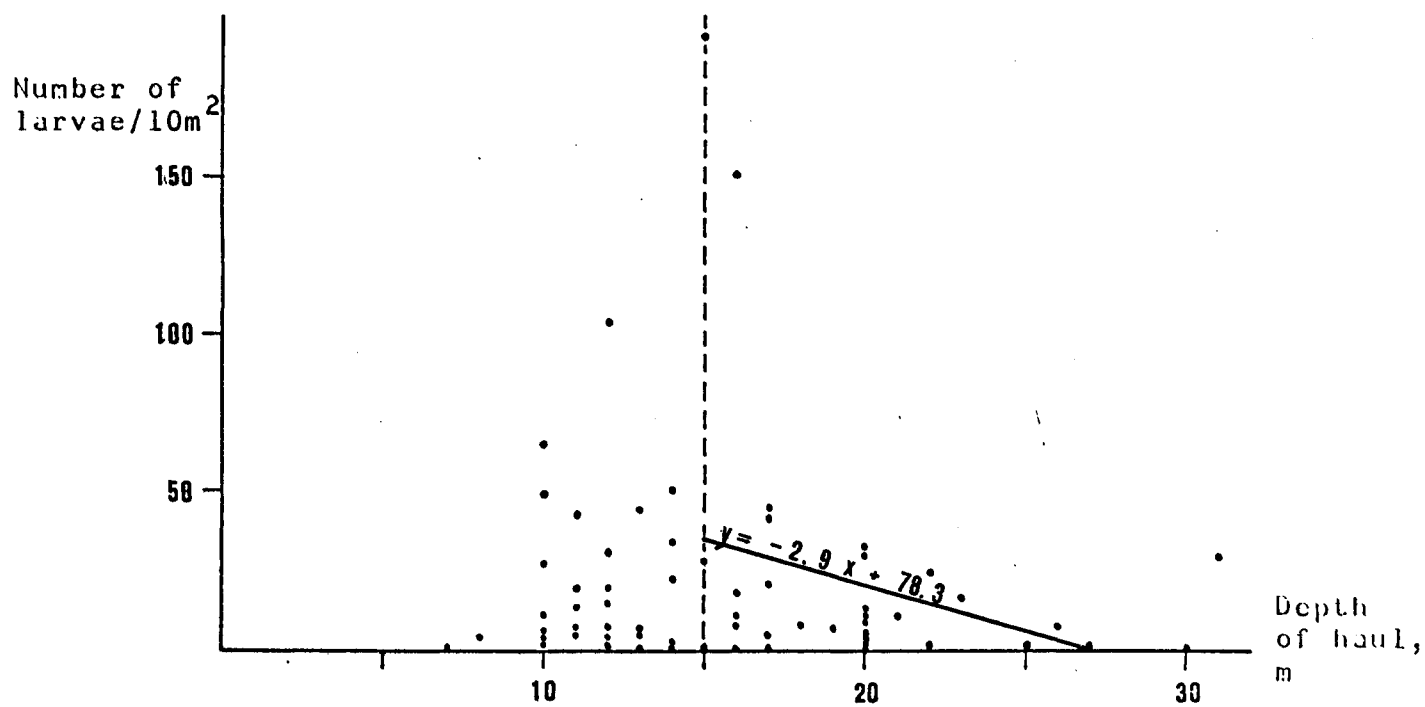


Fig. 3. Depth of haul and number of larvae caught during the survey of the research vessel SILAKKA along the coast of Finland, 8 June - 2 July 1979.

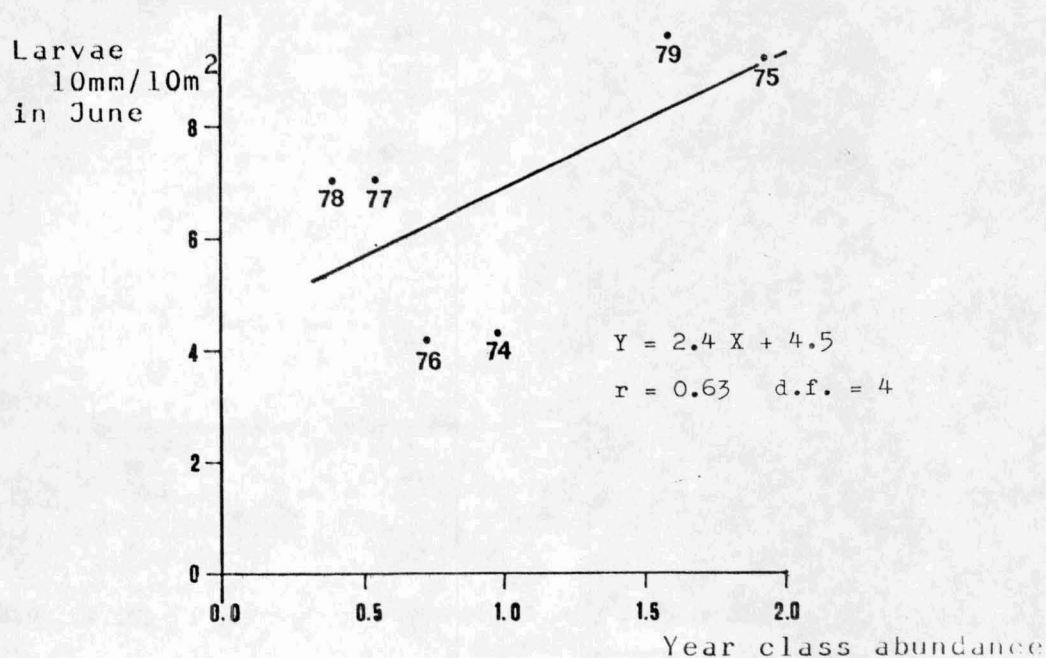


Fig. 4. Relative year class strength and number of larvae in subdivisions 29N, 30 and 31 (east) in the period 1974-79.

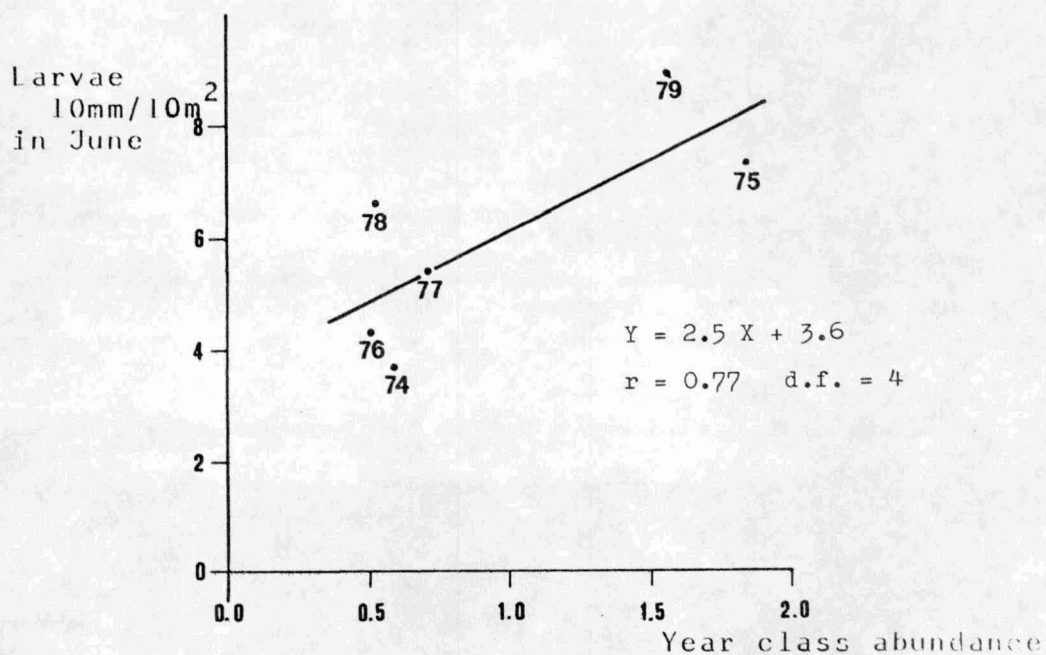


Fig. 5. Relative year class strength in subdivision 32 and number of larvae off the whole Finnish coast (subdivisions 29N, 30, 31 and 32 together) in the period 1974-79.

Table 1. The abundance of Baltic herring larvae <10 mm, 10 - 15 mm and >15 mm at various sampling sites in 1979. Mean monthly numbers below 10 sq. m of sea surface according to weekly samples.

Field station	Depth of haul, m	May			June			July			August			May-August		
		<10	10-15	>15	<10	10-15	>15	<10	10-15	>15	<10	10-15	>15	<10	10-15	>15
Aland Islands (29)																
1	11				62	38	3	9	16	3	0	0	0	24	18	2
2	9				28	4	0	6	0	6	0	0	2	11	4	3
3	15				7	5	0	8	9	2	5	2	5	7	5	2
4	9				9	0	0	20	11	4	28	21	11	19	11	5
5	10				4	0	0	20	3	1	7	2	4	10	2	1
6	10				6	0	0	50	11	0	7	16	2	21	9	1
1 - 6		-	-	-	19	8	1	19	10	3	8	7	4	15	8	2
Kustavi (29)																
1	9	391	17	0	73	59	8	18	2	3	0	0	1	121	20	3
2	10	212	7	0	40	27	2	2	6	2	2	1	0	64	10	1
3	18	0	0	0	72	10	0	2	13	1	11	5	4	21	7	1
4	10	91	0	0	27	16	2	10	6	1	0	1	0	32	6	1
5	8	32	0	0	26	7	1	11	9	1	0	0	0	17	4	1
6	14	0	0	0	5	1	0	9	5	1	18	4	2	8	3	1
1 - 6		121	4	0	41	20	2	9	7	2	5	2	1	44	8	1
Reposaari (30)																
1	8	0	0	0	21	3	1	11	9	3	0	7	5	8	5	2
2	7	0	0	0	37	12	0	8	9	2	0	4	1	11	6	1
3	15	0	0	0	11	10	1	5	11	2	1	2	2	4	6	1
4	5	0	0	0	6	6	1	4	4	2	1	4	2	3	4	1
5	8	0	0	0	35	23	3	7	12	2	1	3	0	11	10	1
6	6	0	0	0	33	9	1	10	12	3	2	3	4	11	6	2
1 - 6		0	0	0	24	11	1	8	10	2	1	4	2	8	6	1
Korsnäs (30)																
1	8				5	7	0	1	2	1	8	5	2	5	5	1
2	7				8	6	0	5	3	1	2	3	2	5	4	1
3	7				13	4	0	2	1	0	5	7	0	7	4	0
4	5				9	5	0	2	2	0	5	6	2	5	4	1
5	8				5	5	0	2	6	1	10	14	2	6	8	1
6	8				10	2	0	11	8	1	0	8	0	7	6	<1
1 - 6		-	-	-	8	5	0	4	4	1	5	7	1	6	5	1
Kalafoki (31)																
1	6				0	0	0	3	1	1	0	0	0	1	<1	<1
2	10				0	0	0	2	6	2	0	3	0	1	3	1
3	6				0	0	0	3	4	0	1	5	0	1	3	0
4	6				0	0	0	2	4	2	0	0	0	1	1	1
5	6				1	0	1	0	1	1	0	0	0	<1	1	<1
1 - 5		-	-	-	<1	0	<1	2	3	1	<1	2	0	1	2	1
Inkoo (32)																
1	10	0	0	0	8	1	0	5	3	1	0	0	1	3	1	1
2	12	0	0	0	7	1	<1	7	3	<1	0	13	7	4	4	2
3	9	0	0	0	13	3	1	20	4	2	0	3	4	8	3	2
4	8	0	0	0	2	<1	0	24	3	<1	0	7	1	7	3	<1
5	10	0	0	0	9	2	0	40	8	0	1	7	6	13	4	2
1 - 5		0	0	0	8	2	<1	19	4	1	<1	6	4	7	3	1
Valko (32)																
1	5	133	0	0	97	23	1	7	3	2	0	0	1	59	7	1
2	7	0	0	0	56	6	0	10	4	2	0	0	1	17	3	1
3	10	0	0	0	27	2	0	18	9	2	0	3	1	11	4	1
4	7	0	0	0	47	24	0	5	6	1	0	0	2	13	8	1
5	9	1	0	0	25	7	0	11	6	1	0	0	1	9	3	<1
6	12	0	0	0	14	1	0	35	10	1	0	0	0	12	3	1
1 - 6		22	0	0	44	11	<1	14	6	2	0	1	1	20	5	1

Table 2. Numbers of herring larvae below 10 m² of sea surface off the Finnish coast according to weekly sampling in May-August.

Subdivision	1974	1975	1976	1977	1978	1979
29	30	33	40	118	40	42
30	12	26	14	32	25	14
31	1	1	2	6	2	3
32	5	11	9	13	13	18
Mean	12	18	16	42	20	19

Table 3. Number of eggs and larvae and the mean daily instantaneous mortality rate in the northern Baltic Sea in 1979.

Subdivisions		Eggs	Eggs spawned	Larvae hatched	Larvae 10-15 mm	1-year-old fish
29N, 30 and 31 (east)	No. x 10 ⁻⁹	67 900	58 973	53 135	5 630	3.798
	Assumed date	1.1.	31.5.	10.6.	10.7.	1.1.1980
	No. of days	150		10	30	170
	Z/day	0.0009		0.0104	0.0748	0.0429
32	No. x 10 ⁻⁹	19 700	15 715	14 159	1 870	3.204
	Assumed date	1.1.	31.5.	10.6.	10.7.	1.1.1980
	No. of days	150		10	30	170
	Z/day	0.0015		0.0104	0.0675	0.0375

Table 4. Number of big larvae per 10 m² in June and the year class strength.

	1974	1975	1976	1977	1978	1979	1980
Number of larvae \geq 10 mm							
Subdivisions 29N, 30 and 31 (east)	4.3	9.2	4.2	7.0	7.0	9.6	3.7
Subdivisions 29N - 32	3.7	7.3	4.3	5.4	6.6	8.9	5.7
Relative abundance of year class (Anon. 1980)							
Subdivisions 29N, 30 and 31 (east)	0.98	1.93	0.72	0.54	0.39	1.58	-
Subdivision 32	0.59	1.84	0.50	0.70	0.52	1.56	-