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On the condition of herring larvae in the central and southern North Sea

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Introduction

Herring stocks are known to show large fluctuations in the success of their annual propagation, as appears from the considerable changes in year-class strength from year to year. The mechanism responsible for this fluctuating success of the different broods are not fully understood.

Among the factors, which are thought to be responsible for the fluctuations in year-class strength year-to-year variations in the feeding conditions of the larvae have been suggested (Hempel & Blaxter, 1963, Hempel 1963). In this concept the mortality in the larval stage or in part of the larval stage is thought to be dependent on food. For plaice such a relationship has indeed been indicated (Shelbourne, 1957). The availability of food for the larvae is most likely apparent from their condition, defined as the length/weight relationship.

$$\left(\frac{\text{weight}}{\text{length}^3} \right)$$

(Hempel & Blaxter, 1963).

This study intends to give information on the condition factor of herring larvae in the central North Sea in the years between 1957 - 1964. A small amount of information on the condition of larvae in the Downs area (southern North Sea) is also provided.

Besides information on the year-to-year variation in the condition of the larvae, the variation within a season has been studied. The survival chances of the larvae due to feeding conditions might vary in the course of a spawning season. If this were true, a short spawning season, as often occurs, when the stock is low or is built up mainly by a few age groups, would have fewer chances for success than a long spawning season in the case of a large stock and many age groups.

Variations in conditions have been related to other factors in the spawning area or of the spawning stock.

Material and Methods

The material used in this study has been derived from larval surveys, carried out in the central North Sea in the years 1957 - 1964 (1963 excluded) and in the Downs area in the years 1958, 1960 and 1961. The surveys in the central North Sea took place mainly in the area of the south-west side of the Doggerbank, roughly between 53°30' N.L. - 55°00' N.L. and between 0°30' E.L. - 3°30' E.L. in the period between September - November. In the years 1957 - 1960 four surveys were made per season, in 1961 - 1964 only two surveys. In the early years the spawning season in the area lasting from mid-September to the end of October was fully covered.

No attempt has been made to follow the larvae outside the spawning area, as the surveys were mainly aimed at determining larval abundance.

In the Doms area only one survey per season has been carried out, mostly in the first half of December.

The sampling instrument employed in the surveys was a modified Gulf III-sampler, with a monel gauze netting. When sorting the larvae for weight/length determination it was found that many were damaged, presumably by the catching operation. Undamaged larvae had to be selected from the samples. To obtain sufficient numbers per size-group, larvae of all hauls of each survey were taken together.

The larvae which were fixed in a formaline solution of appr. 3 - 4% were measured to the nearest mm. The weight was determined as dry weight. Yolk sac larvae were not used.

Dry weight has been determined of groups of larvae of the same size, rather than of individual larvae. The numbers in a group ranged from 10 to 100 appr., only in the case of large larvae (15 mm) numbers as low as 1 - 4 have been weighed. The larvae were rinsed in distilled water, dried in a desiccator at a temperature of 70° C and weighed to an accuracy of 0.1 mg. The condition factor was obtained from $\frac{\text{mean dry weight (mg)} \times 1000}{\text{length (mm}^3\text{)}}$.

Condition factors

The results of the weight/length analysis of the larvae of the central North Sea are shown in Figure 1.

The Figure shows (heavy line) the mean condition factor plotted against the length of the larvae, combining the material of all years and all surveys. It appears that initially the condition factor tends to decrease somewhat, between 6 and 8 mm, i.e. after yolk-sac absorbtion, remains fairly constant up to a length of 15 mm and starts to increase in the higher length-range. A similar pattern has been described by Hempel and Blaxter for larvae from the Clyde area. Changes in the condition factor could be caused by changes in body proportion or reflect changes in body reserves.

Figure 1 also presents the condition factors for the different years in the central North Sea, taking the larvae of all surveys together.

The data of the individual years show in general the same pattern as described above for the mean condition factor in relation to length. Besides, differences between the years are indicated, though somewhat veiled by the rather high variation between size-groups.

In order to obtain a better evaluation of these between-years differences Table 1 has been set up, showing the average condition factor per year for the length-groups 8 - 14 mm, thus in the length-range, when the condition factor is fairly constant. This procedure has the advantage that the numbers of observations in that length-range are quite numerous, which was not the case in the length-groups over 15 mm. A comparison of the larval condition in the length-range over 15 mm has, therefore, been omitted.

Year	Condition factor	Number of larvae
1957	0.154	292
1958	0.155	1264
1959	0.170	456
1960	0.183	556
1961	0.156	226
1962	0.132	394
1963	-	-
1964	0.153	290

Table 1. Conditions factors of herring larvae in the central North Sea September-November, average for length-groups 8-14 mm, in the years 1957-1964 (1963 excluded).

In four out of seven years the condition factors are fairly similar at a value of about 0.155, but in three years the values were rather different, namely high in 1959 and 1960 and low in 1962. Testing these differences for significance was difficult, as the condition factor has been determined on groups of larvae and not on individuals, which prevents the computation of a variance. It should be pointed out, however, that from Figure 1 it appears that the differences in condition factor between mm-groups in the length-range studied, was generally low within a year, especially in the year with a low or high condition, which might suggest that the differences found are real.

The variation in condition factors in the course of the season in shown in Table 2. The values presented are again averages for the size-groups 8 - 14 mm and are shown for periods of half a month.

Year	Period				
	1st half September	2nd half September	1st half October	2nd half October	1st half November
1957	0.135 (47)	0.219 (42)	0.155 (170)	-	0.090 (33)
1958	-	0.168 (91)	0.152 (636)	0.157 (537)	
1959	-	0.193 (13)	0.163 (127)	0.164 (245)	0.180 (71)
1960	-	0.171 (150)	0.186 (206)	0.178 (129)	0.188 (71)
1961	-	0.143 (118)	0.169 (108)	-	-
1962	-	-	0.135 (303)	0.121 (91)	-
1964	-	-	0.145 (113)	0.158 (177)	-

Table 2. Condition factors of herring larvae (8 - 14 mm) in different periods of the spawning season in the years 1957 - 1964 (1963 excluded). Number of larvae in parentheses.

The within-year variance in condition factor seems to be rather low in most of the years. This is remarkable, as the values obtained at different periods in a season are almost independent. During each survey in a year a different population of larvae has been sampled, presumably as the larvae are drifting out of the area and are growing out of the length-range considered. One might say that in most years the period estimates of the condition of the larvae are equally good to characterize the years condition factor. In one year, however, 1957, differences in the condition of the larvae in the course of a season were indicated. In that year the condition was highest in the second half of September and very low in the first half of November. In fact, the low condition factor in the beginning of November is at a level found by Hempel and Blaxter for starving larvae.

This study gives therefore only a slight support for the hypothesis that the survival changes of larvae fluctuate in the cause of a spawning season.

The material on Downs larvae was rather small. The condition factors of the Downs larvae are shown in Table 3, again for the length-range 8 - 14 mm.

Year	Condition factor	Number of larvae
1958	0.146	134
1960	0.170	119
1961	0.187	92

Table 3. Condition factor of Doms larvae (8 - 14 mm) in 1958, 1960 and 1961 in December.

The condition of the Doms larvae are not very different from those of central North Sea larvae, notwithstanding the fact the eggs of Doms spawners are about twice as heavy as eggs of Dogger fish, namely appr. 18 mg/100 eggs for Dogger herring, against appr. 35 mg/100 eggs for Doms fish. Between years the condition factors of Doms larvae differed, probably significantly.

Condition of herring larvae in relation to other factors

Differences in the condition of the larvae are most likely determined by the availability of food, of which no estimates were available. Temperature, too, might have had an effect on the condition of the larvae in regulating the metabolic rate and the activity, but no relationship can be found in the data, supplied in Table 4.

It is possible that competition for food between the larvae has played a role. Therefore, the condition of the larvae has been compared with larval abundance in the years studied. Table 4 demonstrates that no relationship is available. It must be mentioned here that a slight correlation is detectable between the temperature in the spawning area and larval abundance. Lower temperatures are found to coincide with higher larval abundance. This observation is interesting in the light of the correlation found by Postuma (this Symposium) between temperature on the spawning ground and recruitment. However, no clear relation exists between larval abundance and year-class strength, as given in Table 4.

The condition factors are most likely mainly determined by food supply, which will also affect the growth-rate. No relationship, however, could be detected between the average length of the larvae and the condition factors, as appears from the data in Table 4. This might be due to the fact that the length of the larvae is not only determined by the growth-rate, but also by the age of the larvae. The larvae caught in different years might have been of a very different age, caused by a different rate of transport out of the sampling area under the influence of wind, etc.

Finally, as stated in the introduction, larval mortality might be partly governed by food supply and, therefore, by the conditions of the larvae. In this concept a high condition factor of the larvae might lead to successful brood and a strong year-class, whereas poor feeding conditions and a low condition factor might result in a weak year-class. Table 4 shows an index for recruitment on the central North Sea spawning grounds. From a comparison with the condition factors of the larvae it is obvious that no clear relationship is available, although the year with the highest condition for the larvae produced the largest year-class.

		a	b	c	d
Year	Condition larvae	Temperature West Dogger at 20–30 fm.	Larval abundance (x 10⁹)	Length larvae (mm)	Recruitment (R^3) (x 1000)
1957	0.154	13.1 °C	232	8.3	2.0
1958	0.155	12.4 "	437	10.2	12.6
1959	0.170	15.4 "	97	8.9	0.7
1960	0.183	12.0 "	137	10.8	21.8
1961	0.156	14.5 "	59	9.2	6.0
1962	0.132	13.3 "	98	10.1	14.1
1964	0.153	13.3 "	52	12.5	(6.1)

For explanation of Table 4, please see page 5.

Table 4. Comparison of larval condition with

(a) Temperature on the south-western slope of the Dogger Bank in the second half of September, at a depth of 20 - 30 fm.

(b) Larval abundance, taking the average abundance of the surveys in the period from half September to the end of October (number x 10^9)

(c) Average length of all larvae caught during the surveys.

(d) Year-class strength of the spawning population in the Dogger area, calculated as recruitment as at three years of age (numbers per day trawling of a 500 B.H.P. vessel).

Conclusion

The condition of the larvae in the central and southern North Sea did show a small variation from year to year, and in the course of a season in a single year. In the period observed, i.e. up to about 1 - 2 months after spawning (in the case of the central North Sea, the main area sampled) the differences in condition were certainly not striking.

The condition of the young larvae showed no relationship with the strength of the year-class, which evolved from the larvae. Thus it seems that in the case of autumn-spawning herring of the North Sea the feeding condition of the larvae up to 1 - 2 months after hatching is not critical for the success of the year-class. This is not remarkable, as in the period investigated the food supply of the larvae will in general still be rather good, following close after the autumn plankton bloom. Moreover, between the early larval stages and recruitment at an age of three years lies a long period, in which the young fish has to overcome probably several difficult events. In the study of Postuma (this Symposium) it is suggested that year-class strength is at least partly determined at an age of half a year, somewhere in the coastal waters.

Therefore, the assumption, mentioned in the introduction, that the food supply and thus the condition of the larvae would determine, to a large extent, the success of a year-class is most likely incorrect, at least for autumn-spawning herring of the North Sea.

References

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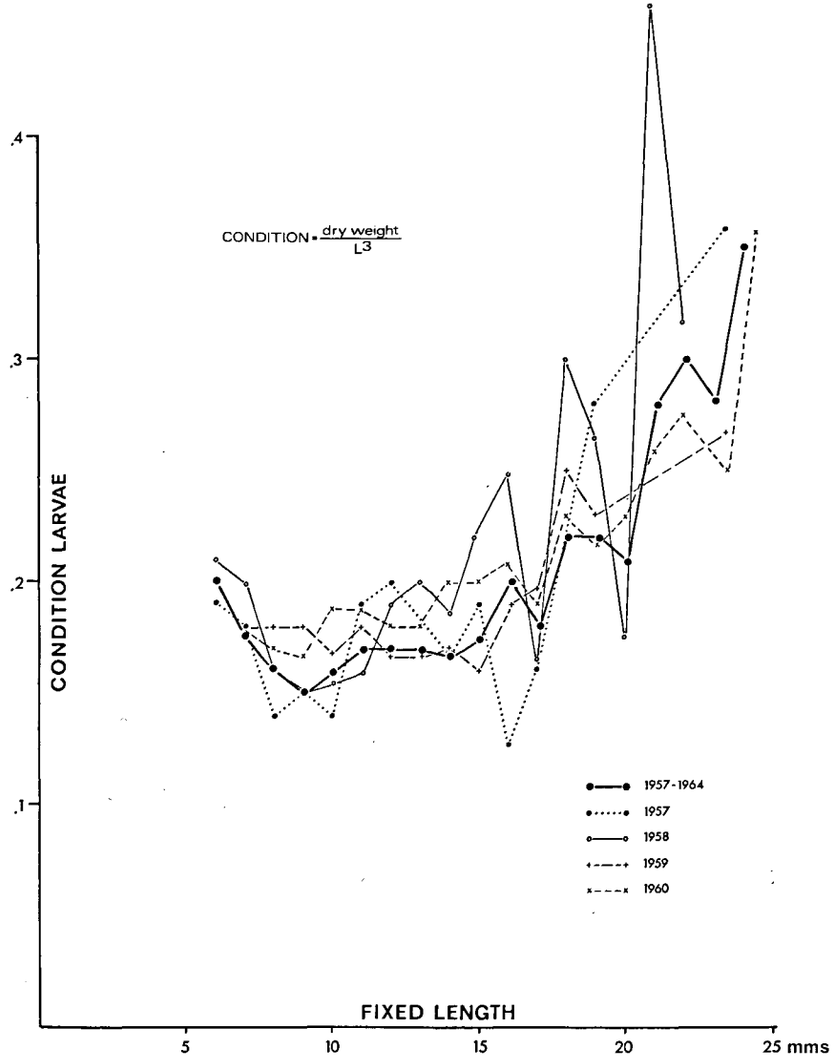
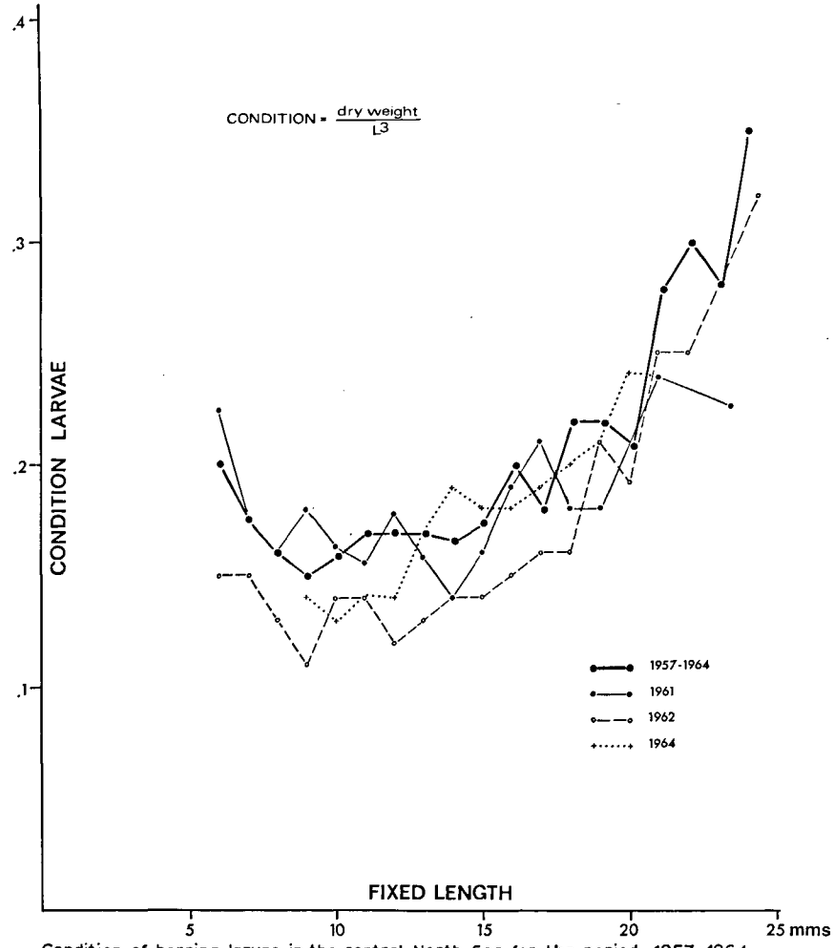


fig.1



Condition of herring larvae in the central North Sea for the period 1957-1964 (1963 excluded). Graphs showing condition plotted against length of larvae (mms) for each year and the mean value for all years.