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## Fluctuation and Oscillation in a Community of Pure Spent Herrings.

By

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On previous occasions I have called the attention of biologists to a remarkable shoal of pure spent herrings that concentrates every year, from December to March, in the vicinity of the continental coast, between Cap Grisnez and the Scheldt. For seven years already we have been examining daily samples of 25 of these herrings supplied by the fishermen and we intend to continue the work for several years more.

Each fish was submitted to the eight analytical operations that are now accepted as classical.

The so-called "biological scale" of the shoal is the superposition of annual diagrams showing the percentage of individuals in each of the year-classes, in a succession of years. Every year a step is added to this scale after the closure of the fishing season and the completion of the laboratory work on the samples collected. Fig. 1<sup>1</sup>).

This arrangement clearly shows the annual change in the composition of the returning shoals and the sequence of the stages of increase or decrease in their evolution.

Another presentation of the data collected by the same continuous observations is given in the linear diagram, Fig. 2, in which each class is taken separately and its particular evolution made more conspicuous.

The graph, Fig. 3, shows the remarkable irregularity in the percentage of the 3-year-old recruits, — that is to say the number of 3-year-old individuals found in a lot of 100 herrings taken at random from the shoal. The variation extends from 3% in 1933, to 28% in 1935 — a rather extensive span of fluctuation.

<sup>1</sup>) A short legend is affixed to each annual diagram, indicating:

1) the number of herrings examined in the season; 2) the mean weight of a day's capture; 3) the total weight landed at Ostend in the season; 4) the mean value of 100 kg. obtained in the market; 5) the total value of the landing in the season; 6) the number of individuals destroyed.

The unfailing return to our shore of these spent herrings after the annual breeding is an interesting biological phenomenon and the fluctuation in the percentage of the yearly additional element seems well worth the attention of biologists.

### Remarks and Suggestions.

#### Fluctuation.

Applied to fishes the term fluctuation should indicate a succession of yearly generations, quantitatively dissimilar, considered over a series of years.

In Fig. 1, biological scale, the fluctuation is the superposition of the yearly percentage columns in the series of years 1930—1937. Each of the 8 vertical columns shows the fluctuation of percentage for the 8 year-classes considered in the course of the 7 years of observation. In the linear diagram, Fig. 2, the fluctuation of the percentage is pointed at different heights on each of the vertical lines corresponding to the 6 age categories considered.

#### Oscillation.

I have proposed this term<sup>1</sup>), for want of a better one to indicate the rising and falling of percentages in the course of the evolution of one and the same generation considered over a series of successive years.

In the linear diagram, Fig. 2, the oscillation of each of the consecutive generations, born in the years 1927 to 1933, is marked by the dotted lines.

In the columnar diagram, Fig. 1, oscillation must be followed from one year to the next by changing column from left to right as one goes down one step.

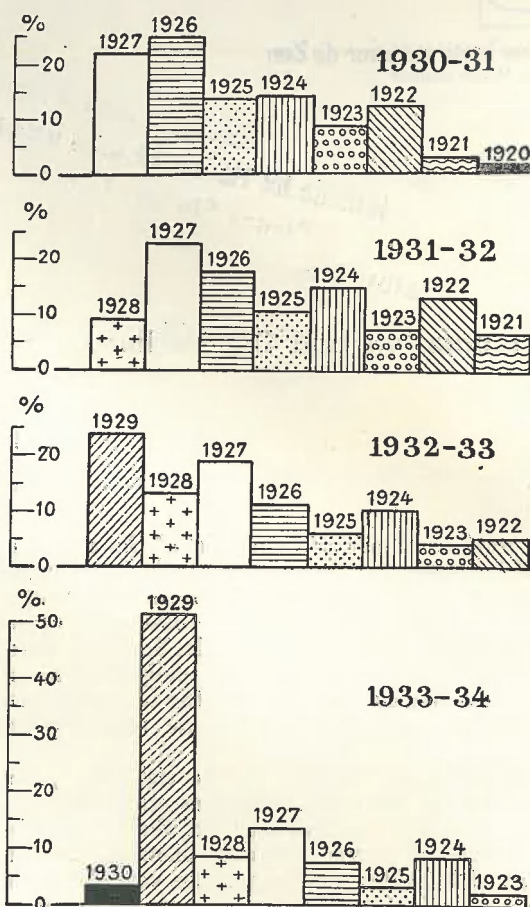
<sup>1</sup>) G. GILSON. Further observations on Spent Herring, with Remarks on Fluctuations and Oscillation. Cons. Intern. Rapp. et Proc.-Verb. Vol. C, III, 1936.

1930—31	
Number of herrings examined.....	1,167
Mean weight of a day's capture.....	8,338 kg
Total weight landed in the season.....	18,860,596 kg
Mean value of 100 kg.....	71 fr.
Total value of the season.....	13,008,930 fr.
Number of individuals destroyed.....	217,002,545

1931—32	
Number of herring examined.....	783
Mean weight of a day's capture.....	5,225 kg
Total weight landed in the season.....	3,383,750 kg
Mean value of 100 kg.....	108 fr.
Total value of the season.....	3,642,806 fr.
Number of individuals destroyed.....	34,992,241

1932—33	
Number of herrings examined.....	1,000
Mean weight of a day's capture.....	4,514 kg
Total weight landed in the season.....	2,673,185 kg
Mean value of 100 kg.....	91.50 fr.
Total value of the season.....	2,446,867 fr.
Number of individuals destroyed.....	29,405,035

1933—34	
Number of herrings examined.....	1,479
Mean weight of a day's capture.....	7,600 kg
Total weight landed in the season.....	7,455,800 kg
Mean value of 100 kg.....	75 fr.
Total value of the season.....	5,577,441 fr.
Number of individuals destroyed.....	76,861,050



Age-groups: III IV V VI VII VIII IX X  
Balancing of percentages: number of individuals of each year-class in 100 fishes.

Fig. 1. Percentage number of individuals in each year-class.

### Causes of fluctuation and oscillation.

I. Concerning fluctuation I have presented last year at the meeting of this Committee, a few remarks alluding only to the two sets of possible causes of quantitative variation in general: a) internal causes tending to increase or to reduce the production of ovarian eggs and the chances of success in their fertilization, deposition and fixation on the bottom of the sea: — b) external causes, physical or biological — (temperature, salinity, pH, plankton, motion of water, meteorological conditions etc.). These may have an action first on the eggs and larvae and, later on also, on the displacement, dispersion and reconcentration of the shoals of adults, and their drifting towards the spawning and fishing grounds, or away from them.

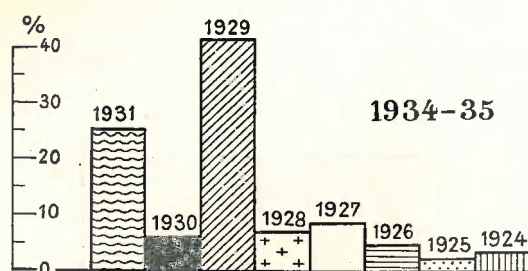
Both internal and external causes may be investigated and used for prognostication when, some day,

a regular system of continuous observations is organised in the southern part of the Flemish Sea and in the Eastern Channel.

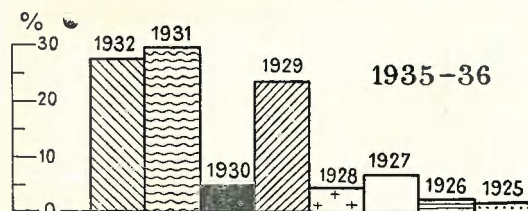
As to oscillation I have insisted, in a previous note, on the peculiar character of the quantitative evolution of all generations of our spent herrings: each of them presenting a rising, up to the age of 4 years, immediately followed by a more or less regular falling, down to extinction. — See diagram Fig. 2.

The remarkable constancy of this phenomenon leads us to consider it as dependent on an internal cause, inherent to the physiology of the fish. The fourth year seems to mark the critical age at which mortality, in a group of living organisms, being very high immediately after birth and having greatly diminished for a certain period, again becomes more intense down to the complete extinction of the group.

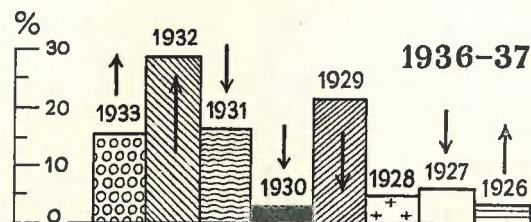




1934—35	
Number of herrings examined.....	1,200
Mean weight of a day's capture.....	14,632 kg
Total weight landed in the season.....	12,322,990 kg
Mean value of 100 kg.....	31.52 fr.
Total value of the season.....	3,856,044 fr.
Number of individuals destroyed.....	123,553,199



1935—36	
Number of herrings examined.....	1,300
Mean weight of a day's capture.....	11,120 kg
Total weight landed in the season.....	8,595,895 kg
Mean value of 100 kg.....	62 fr.
Total value of the season.....	5,328,754 fr.
Number of individuals destroyed.....	81,965,880



1936—37	
Number of herrings examined.....	625
Mean weight of a day's capture.....	7,319 kg
Total weight landed in the season.....	3,132,460 kg
Mean value of 100 kg.....	72 fr.
Total value of the season.....	2,258,225 fr.
Number of individuals destroyed.....	31,211,269

Age-groups: III IV V VI VII VIII IX X  
Balancing of percentages: number of individuals of each year-class in 100 fishes.

Fig. 1. Percentage number of individuals in each year-class.

The problem ought to be studied in larger communities than the small shoal of our coast, and attention should be paid to the possibility of outer agencies influencing either the ascending or the descending part of the oscillation, and it should be kept in mind that all figures in our diagrams being percentages, a change in one of them must affect all the others proportionately and inversely. I have given, in 1931 and 1935 several illustrations of this phenomenon which I have called "Balancing of percentages". It has sometimes escaped the attention of biologists and led them to erroneous conclusions.

#### Forecasts.

In 1935—36 our previsions for 1936—37 were that good shoals might be expected. These predictions were based on the fact that two classes, 1931 and 1929, that had played an important part in the good

season 1934—35, would be present with a high percentage, one of them, 1931, being then only at the first stage of reduction and the other being the famous class at 1929 and expected still to show a good percentage in 1936—37. Beside that, there would be a young class, 1932, appearing at 3 years with the highest percentage recorded, and entering in 1935—36 the augmentative stage of 4 years of age.

Qualitatively the prediction was rather successful: see step 1936—37 in the biological scale, Fig. 1, — although the column of 1931 had a greater reduction than expected. There was no disagreement concerning percentages.

But quantitatively, on the other hand, the season was very bad and the forecast was quite wrong. The density of the shoal was among the lowest recorded in 7 years of regular observation: the mean weight of a day's capture being only 7,319 kg., whilst the season

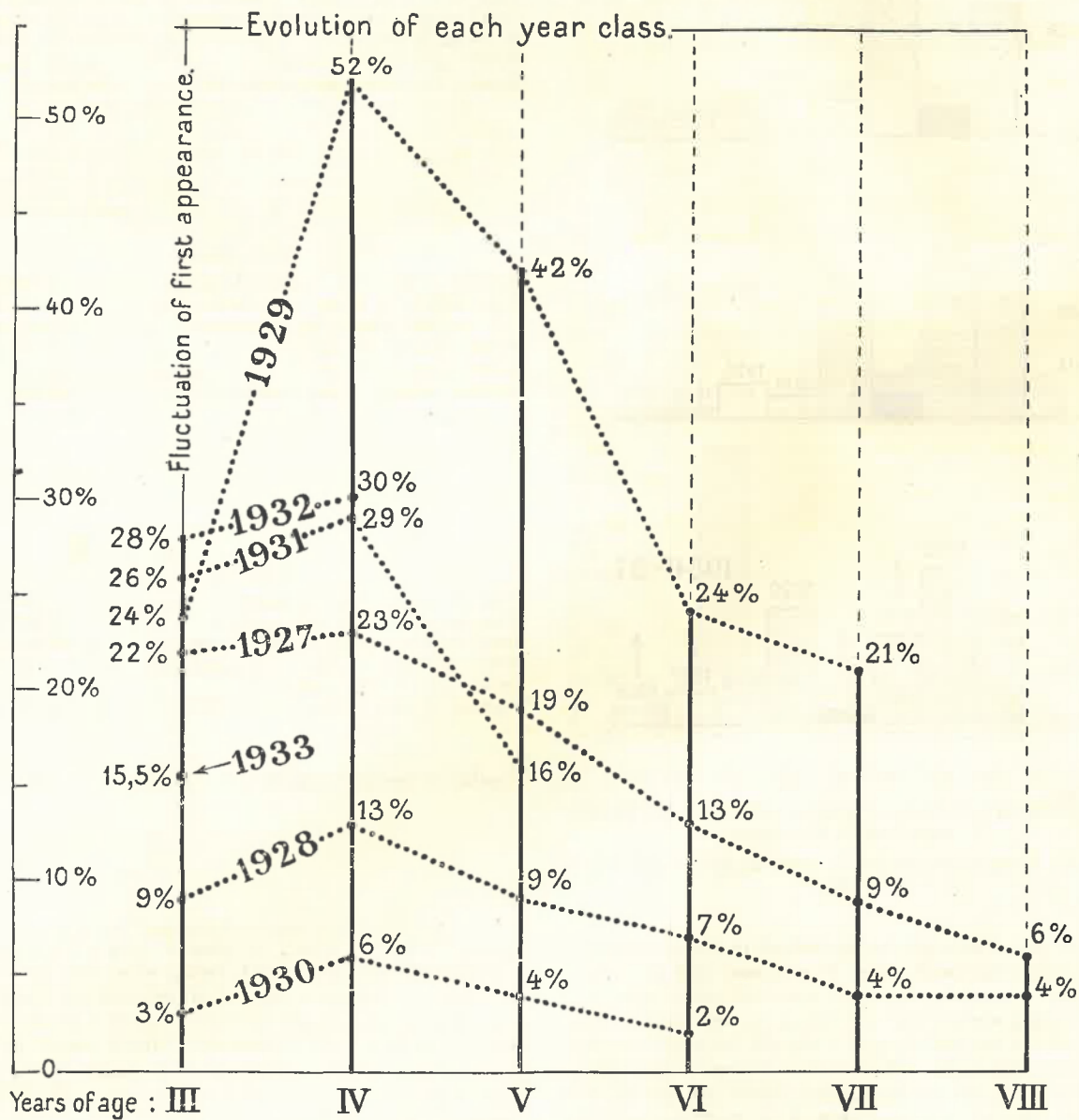


Fig. 2. Vertical lines = fluctuation. Dotted lines = oscillation.

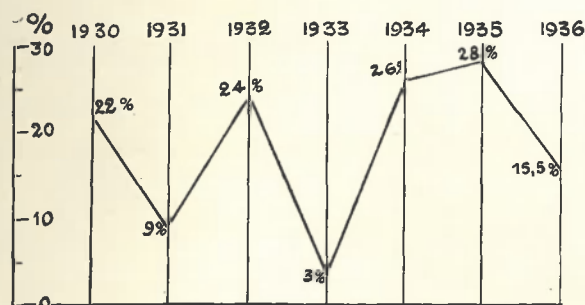


Fig. 3. Fluctuation at first appearance of 3-year-old recruits.

1934—35, in which the two classes 1931 and 1929 had played an important part, had the highest record hitherto obtained: 14,632 kg. for one day's fishing and consequently its shoal must have been very dense.

The fishing in 1936—37 was a failure and, although the market prices were high: 72 Fr. per 100 kg. — the fishermen were disheartened and gave up fishing with the herring trawl.

The spents were a little more abundant close to

the shore, in French territorial waters, but there also, — with drift nets, the only net allowed by French law within the 3-mile limit — poor catches were the rewards to the fishermen.

This failure of the quantitative forecast is very remarkable and instructive. It shows that data taken from the percentage only, even when completed with the notion of the density of shoal, are insufficient for reliable forecasts. We want information about the fate of the shoal of spents after they have left our shores, and that can scarcely be expected except from a continuous service of a complete and periodical scientific survey of the region.

As a further trial of the value of the method of percentages, we deduce from the step 1936—37 of the biological scale, that the new shoal of 1937—38 will show a majority of herrings of the V and VI-group with a remnant of year-class 1929, the VIII-group, and perhaps a good percentage of the new 1933-year-class.

Quantitatively, from percentages, the prognostics are rather bad, all classes being, in 1937—38, in stages of reduction, except the new class, 1933, which will be in augmentation and may, perhaps, save the situation.

