ANNALES

DE L'INSTITUT D'ÉTUDES MARITIMES

D'OSTENDE

MÉMOIRE N° 4

CONTRIBUTIONS A L'ÉTUDE DU HARENG «GUAI» DANS LE SUD DE LA MER DU NORD PENDANT LES ANNÉES 1930 à 1938

PAR

G. GILSON

DIRECTEUR DE L'INSTITUT D'ÉTUDES MARITIMES D'OSTENDE

Mémoire déposé le 1 septembre 1938

— — LIERRE — Joseph VAN IN & C^ie^, Imprimeurs-Éditeurs — Grand'place, 37 — —

ANNALES

DE L'INSTITUT D'ÉTUDES MARITIMES

D'OSTENDE

MÉMOIRE N° 4

CONTRIBUTIONS A L'ÉTUDE DU HARENG «GUAI» DANS LE SUD DE LA MER DU NORD PENDANT LES ANNÉES 1930 à 1938

PAR

G. GILSON

DIRECTEUR DE L'INSTITUT D'ÉTUDES MARITIMES D'OSTENDE

Mémoire déposé le 1 septembre 1938

— — LIERRE — Joseph VAN IN & C^ie^, Imprimeurs-Éditeurs — Grand'place, 37 — —

CONTRIBUTIONS A L'ÉTUDE DU HARENG « GUAI » DANS LE SUD DE LA MER DU NORD

PAR

G. GILSON

DIRECTEUR DE L'INSTITUT MARITIME

I. -- Introduction.

Le terme « guai » est une expression du vieux français appliquée encore aujourd'hui, dans le Pas-de-Calais, aux harengs de tout âge qui ont récemment évacué leurs œufs et leur laitance. Les termes « ijle », haring et « scheen » haring lui correspondent respectivement en flamand neerlandais et dans le dialecte des pêcheurs de la côte Belge.

On observe depuis longtemps qu'un rassemblement de ces harengs « vides » se forme chaque année au voisinage de la côte, entre le Cap Gris-Nez et l'Escaut. Ils y restent pendant environ 3 mois, de décembre à mars, et y donnent lieu à une pêcherie spéciale assez importante exercée surtout par des navires Belges, de moyenne et de petite dimension.

Cette concentration très intéressante par elle même prend une importance particulière au point de vue de l'étude biologique générale de l'espèce. Celle-ci trouve, en effet, une circonstance exceptionnellement favorable au progrès de ses recherches dans le fait du retour périodique d'une aggrégation presque pure d'individus d'âge divers, mais traversant tous la même phase bien déterminée de leur évolution annuelle. Ce retour très régulier rend possible l'établissement d'un service continu d'observations méthodiques conforme aux exigences de la Science moderne qui réclame l'examen de grands nombres d'individus et des observations maintes fois répétées et contrôlées, dans le but de minimiser l'effet des causes d'erreur et d'éviter les conclusions hâtives, souvent boîteuses. C'est la mission des Instituts de recherches de poursuivre longuement des observations en séries. Celles-ci fournissent des bases solides à l'investigation et deviennent souvent révélatrices.

Ces remarques nous décident à réunir en un fascicule des Annales de l'Institut Maritime les communications successives que nous avons présentées chaque année au Conseil International pour l'Exploration de la Mer, depuis la publication de notre premier mémoire sur le Hareng dans lequel nous avons exposé l'état des questions et celui des méthodes telles qu'elles se présentaient en 1931 (1). Cette réunion permettra aux chercheurs de se rendre plus aisément un compte exact de la complexité des questions qui ont été abordées ou qui ont surgi au cours des recherches.

Les organisateurs et, plus tard, les exécutants de notre vaste plan d'observations continues, océanographiques, météorologiques et biologiques, dans le Sud de la Mer du Nord et dans la Manche trouveront aussi, plus facilement, dans ce fascicule, des indications au sujet des corrélations existantes entre les variations de l'état physique de la mer et celles des conditions biologiques des régions affectées.

Un exemple remarquable de ce genre de corrélation vient d'être signalé par le Dr. J. N. Car-

(1) G. Gilson. *Recherches sur la Biologie du Hareng « gaui » et sur sa pêcherie entre Ostende et le Cap Gris-Nez* Annales de l'Institut maritime. Mémoire nº 1.

RUTHERS, du Fisheries Laboratory de Lowestoft, entre la variation du volume d'eau de la Manche introduit dans la Mer du Nord et celle de l'abondance du hareng guai indiquée par nous dans les concentrations côtières hivernales. Les graphiques de ces deux variations se suivent avec une régularité remarquable pendant une séries d'années. (1) On verra de plus en plus que les Services chargés de l'observation des conditions physiques et biologiques de la mer se rendent une mutuelle assistance et qu'il incombe aux Pouvoirs Publics d'en assurer l'exécution et la continuité.

Il faut donc que l'Institut maritime poursuive les séries de minutieuses observations qu'il a conduites, depuis 8 ans, sur un objet aussi remarquable que le hareng guai et aussi intéressant pour la petite pêcherie.

Sans doute, il est bien des points de la biologie de notre hareng méridional qui ne pourront être élucidés que par l'emploi constant d'un navire de recherche bien adapté et disponible à tout instant pour le travail en mer.

Cependant nous croyons avoir montré qu'il est certaines parties de la biologie qui peuvent être au moins partiellement investiguées à l'aide de moyens simples, tels que l'analyse des matériaux de pêcherie. Mais les résultats obtenus dans ces conditions grâce à de laborieux efforts ne font que rendre plus évidente la nécessité de moyens plus puissants.

Loin de nous l'idée de présenter la simple réunion des notices exposant le progrès de nos investigations annuelles comme une étude complète de notre hareng méridional. Pareille étude devrait exposer, rapprocher et commenter les beaux résultats obtenus par LE GALL, qui en a fait une étude spéciale, et toutes les observations océanographiques et biologiques faites dans la Manche, dans le Détroit et dans la Mer Flamande, par LE DANOIS, FORD, TESCH, BUCKMANN, HODGSON, CARRUTHERS, LUMBY, GRAHAM et beaucoup d'autres.

Nos divers travaux ici rassemblés ne forment qu'une modeste contribution à l'étude de la biologie encore pleine de mystère, du hareng qui passe dans notre région une période de repos et de reconstitution *post partum*.

Au texte de ces communications présentées en langue anglaise au Conseil international de Copenhague nous n'ajouterons que quelques notes explicatives ou complétives. Elles aideront le lecteur à suivre le développement des faits acquis sur la biologie et la pêcherie du hareng guai, ainsi que d'apprécier certaines interprétations qu'il nous arrive d'en donner.

La connaissance des langues principales étant aujourd'hui suffisamment répandue dans les milieux scientifiques, nous nous abstiendrons de faire subir au texte de ces communications le traitement corrupteur de la traduction.

(1) Voir : J. N. CARRUTHERS. Fluctuation in the Herrigg of the East Anglian Autumn Fishery, the Yield of the Ostend spent Herring Fishery and the Haddock of the North Sea, — in the Light of relevant Wind Conditions. Cons. Internat. Rapports et Procès-Verbaux. Appendices. 1938.

II. -- Remarques sur les observations et les études réunies dans ce fascicule.

1. Les Classes d'Age.

Il est rappelé que l'âge du hareng et d'autres poissons peut être déterminé par l'examen de l'écaille.

L'ensemble des individus nés la même année forme une *Classe d'age*.

2. L'Escalier biologique du Hareng guai.

C'est ainsi que nous appelons le diagramme columnaire indiquant les variations du pourcentage des individus de chacune des classes d'âge composant les concentrations annuelles consécutives. Un gradin est ajouté à cet escalier, chaque année, après la clôture de la saison. L'escalier complet, arrêté en 1938, est reproduit p. 26 et 27, sous une forme améliorée : le pourcentage y est indiqué en tête de chaque colonne et des flèches montantes ou descendantes indiquent que le pourcentage est en croissance ou en décroissance sur celui de l'année précédente.

3. Balancement des Pourcentages.

En lisant ces diagrammes columnaires il faut tenir compte du phénomène du balancement des pourcentages. Ainsi, il ne faut pas penser que la décroissance générale des colonnes à partir de la 5e trouve sa mesure exactement et uniquement dans la mortalité qui frappe toutes les générations. La variation de chacune d'elles est, au contraire, influencée inversement par celle de toutes les autres colonnes. En effet, la variation d'un pourcentage a toujours une répercussion inverse sur tous les autres. Cette règle élémentaire est parfois perdue de vue dans des travaux de statistique. La figure 2 du travail de 1935, p. 15, donne un exemple de cet effet de balancement à propos du gradin de la saison 1934-35.

4. Fluctuation et Oscillation.

La signification attribuée à ces deux termes est indiquée dans le texte des communications de 1935 à 1938.

La Fluctuation *des classes* est la variation du pourcentage moyen d'individus d'une *classe d'age suivie* dans la succession des années. Ainsi, la fluctuation de la classe de III ans, par exemple, s'échelonne sur la 1re colonne à gauche sur toute la hauteur de l'escalier biologique figure p. 26 et 27.

On peut aussi appliquer le terme à la variation de la richesse totale d'une concentration annuelle ; c'est la fluctuation *de l'abondance* du hareng dans les saisons successives.

L'*Oscillation* est un terme proposé par nous en 1935 pour désigner la variation du pourcentage des individus *d'une même génération* considérée dans la succession des années depuis sa première apparition jusqu'à son extinction. Fig. p. 26 et 27.

Tandis que la fluctuation peut être affectée par la variation des actions externes, l'oscillation ne dépend que de causes internes.

L'oscillation présente un caractère remarquable dans notre concentration côtière : elle est normalement en ascension à la 4e année, — deuxième apparition à la côte, — puis elle devient descendante jusqu'à la disparition totale vers la 15e année. Une curieuse exception à cette règle se présente en 1937-38 ; elle sera étudiée et commentée dans les communications ultérieures.

5. Vertèbres.

Le nombre des pièces constituant la colonne vertébrale est un caractère morphologique important. Ce nombre est constant chez beaucoup de Vertébrés. Chez le hareng il varie dans des limites restreintes. Certaines variantes supérieures ou inférieures au nombre typique 56,50, sont employées, avec d'autres caractères, pour établir la diagnose de divers groupements régionaux auxquels on donne le nom de *races*, sans prendre ce terme dans son sens strictement biologique.

L'étude de longues tables de numération de Vertèbres, dressées par nous-même et par d'autres observateurs, nous a conduit à proposer le terme « *Indice vertébral* » pour indiquer le nombre par rapport auquel se groupent les pourcentages d'in-

dividus possédant les divers nombres de vertèbres observés. L'indice vertébral du hareng est 56,50.

Nous avons proposé aussi les termes « *Oligospondyle* » et « *Polyspondyle* » pour désigner les harengs possédant respectivement 56 vertèbres, ou un nombre inférieur, — et 57 vertèbres ou un nombre supérieur.

Ces divers points sont traités surtout dans notre premier mémoire, de 1931. Voir p. 34 et 43 (1).

6. Prévisions. (Forecasts.)

La question des prévisions, toujours demandées par l'industrie, apparaît de plus en plus ardue à mesure que progressent la connaissance de la mer et celle de la biologie marine. De nouvelles difficultés surgissent sans cesse et des causes d'erreur insoupçonnées se révèlent. Il s'établit aujourd'hui que certaines prédictions hardiment formulées autrefois, étaient basées sur des observations insuffisantes ou des faits mal interprétés et étaient aussi injustifiées que décevantes pour la pêcherie. Notre communication de 1933 contient certaines indications au sujet des prévisions qui sont admissibles, pourvu que le degré de probabilité qu'on y attache soit nettement indiqué et qu'une place soit laissée à l'imprévu. On notera d'abord que des pourcentages obtenus au cours d'une saison donnée permettent de prévoir, dans une certaine mesure, les pourcentages de la saison suivante en tenant compte de l'allure normale de l'oscillation et du balancement des pourcentages. Mais, on ne peut jamais obtenir directement ainsi autre chose que des pourcentages, données qui ne présentent qu'un intérêt secondaire pour la pêcherie. Cependant, si on connaît l'histoire des saisons précédentes, on peut en tirer certaines indications au sujet de la richesse ou de la pauvreté probable de la concentration suivante.

Ainsi, par exemple, la classe née en 1929 a joué un rôle notable dans la saison 1932-33, avec un pourcentage de 24 %; mais cette saison était très pauvre, car le poids moyen d'une pêche n'y était que 4.544 kil. On pouvait donc prévoir que la saison suivante, 1933-34, serait aussi plutôt pauvre, tout en attachant une certaine importance à la forte proportion des harengs de 3 ans, classe de 1929 qui y fait sa première apparition et qui en 1933-34 devait encore en être au stade ascendant de son oscillation. En fait, la saison de 1933-34 a dépassé cette prévision justifiable et s'est montrée assez bonne, avec un poids moyen de 7.600 kil. Ceci résulte de la puissance imprévue avec laquelle la classe de 1929 a fait sa *deuxième apparition*, et c'est grâce à cette puissance que le poids moyen a pu être porté à 7.600 kil., malgré la faiblesse remarquable de la classe de 1930 qui venait d'apparaître. Cette importance de la classe 1929 pendant la saison 1933-34, c'est-à-dire en une bonne année, permettait de pronostiquer une forte saison pour 1934-35. Mais ici encore l'imprévu s'est produit : la nouvelle classe, celle de 1931, a apparu avec le fort pourcentage de 24 %, et cette classe s'ajoutant à celle de 1929 qui n'en était encore qu'au premier stade de sa décroissance, a porté la concentration de 1934-35 au plus haut degré de densité observé jusqu'ici, soit 14.632 kil. comme poids moyen d'une pêche.

Cet exemple ne donne qu'une idée fort imparfaite des difficultés de la supputation des possibilités de la composition et de la puissance des concentrations à venir. Trop de circonstances diverses peuvent influencer la formation, la dispersion et la composition de ces groupements temporaires. Nous n'avons qu'effleuré certains aspects des problèmes qui se posent. Il faudrait encore pouvoir remonter dans l'histoire des classes jusqu'à l'origine première de chacune et rechercher si les classes progénitrices étaient riches en individus et fécondes, puis si leur ponte a été abondante et si l'éclosion des œufs a été favorisée par l'état de la mer et si les larves issues de ces œufs ont rencontré des conditions favorables de salinité, de température, de plancton nourricier, de cheminement des eaux, etc., etc. Puis il faudrait suivre ces jeunes générations dans leur croissance pendant deux années, jusqu'à leur première apparition comme harengs guais, et observer en même temps toutes les autres classes d'âge attendues sur les fonds de ponte et ensuite à la côte.

Toutes ces données pourront un jour être obtenues grâce à l'organisation projetée d'un vaste système d'observations océanographiques, météorologiques et biologiques à faire à bord des bateaux-phares et en certains points des côtes et complété par des croisières périodiques internationales.

Mais seuls des Instituts consacrés aux recherches maritimes seront à même d'en assurer l'exécution méthodique et la continuité et de poursuivre l'étude ardue de la corrélation des phénomènes qui se passent en mer, où tout se tient et s'enchaîne.

(1) Soc. cit. p. 4.

III. -- Observations and Studies on Spent Herring

presented successively by G. GILSON,

to the Combined Nord Sea and Eastern Channel Committee.

I. Seasons 1930 to 1933

Recent observations on Spent Herrings and Remarks on Forecasting.

PARIS — MAI 1933.

An interesting shoal of herrings accumulates every year between the middle of December and the first days of March, along the continental coast, between Cape Gris-Nez and the mouth of the Schelde. They are nearly all « spent » at HJORT's stage VIII —II. In 1930-31, 97,51 % were at that stage and none at all were « full ». Although spent herring is of inferior commercial value an important fishing is due to its appearance on the Belgian coast. In 1931, the quantity landed at Ostend amounted to more than 18 million kg. sold by auction for the sum of 12.616.891 fr. This successful fishing amounted to more than 217 mill. individuals caught. The average weight of one fishing was 8,338 kg. (ships of all sizes included).

We have been following without interruption, the three successive fishing seasons 1930—31, 1931 —32 and 1932—33, and found that whilst the first was remarkably rich the two latter were among the poorest ever recorded.

Spent Herrings — Ostend.

Season	Quantity in kg.	Number of individuals	Average weight of one fishing
1927—28.....	3.857.383	44.745.643	4.739
1928—29...—	12.121.953	130.614.655	11.545
1929—30.....	11.282.163	130.873.091	7.302
1930—31.....	18.360.596	217.002.545	8.338
1931—32.....	3.353.455	34.976.536	5.435
1932—33.....	2.673.185	29.405.035	4.515

The results of these daily observations, during the said seasons, lead us to some remarks on forecasting in fishery matters, which I shall try to expose very briefly.

The forecasts that one may attempt to formulate in the case of a local herring fishery are three kinds :

1) Forecast of the relative proportion of each of the year classes for the next season; this may be called qualitative forecasting.

2) Forecast of the abundance or density of the shoal that is expected to concentrate in the region in the course of the next season.

3) Forecast of the abundance of the same concentration which is expected to return three years after the season considered. The last two may be called quantitative forecasting.

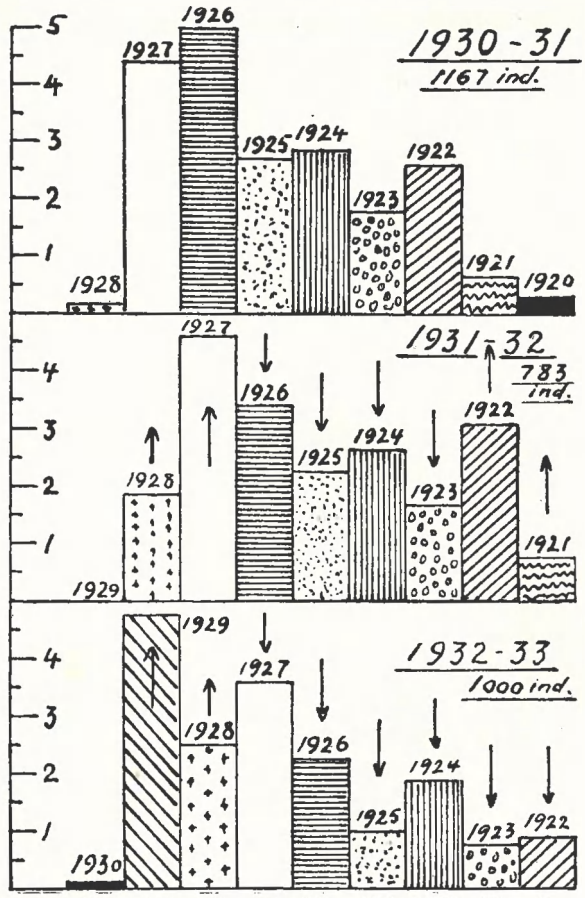
Let us take an instance of each of the three kinds of forecasts out of the diagram called « Biological Scale » of spent herring.

Each of the three steps of this scale corresponds to one early season; the columns are the percentage of individuals in each class, that is the proportion of each class in a hundred herrings supposed to have been caught at random from the shoal. Six classes have played an important part in the concentration of the season 1930—31; they are the classes born in the years 1922 to 1927. Herrings 3 and 4 years old were enormously predominating, whilst a good proportion of older herrings was still present, one column only being rather poor : that of the 1923 class which has always been a notoriously bad class all over the Southern North Sea, as clearly shown in several memoirs by JEAN LE GALL.

1. — Based on the figures of this diagram we have predicted that the diagram of the next season would also show an important percentage of young herrings one year older, i. e. 4 and 5 years old respectively, and a moderately high percentage of older fish (6 tot 9 years).

The second step of the scale 1931—32 shows that the forecast was successful. It shows also that a new group of three years old herring appears in our shoal with a fairly good proportion. From this second step of the diagram we could also foresee that the third season would still have a good, although reduced, proportion of young herring 5 and 6 years of age and a decreasing percentage of the older classes.

In fact, we find in the season 1932—33 a still good percentage of the two classes 1927 and 1926, that were predominating in the two previous seasons, and all the older classes, on the right greatly



	1930—31	1931—32	1932—33
Total value, francs ...	13,008,930	3,642,806	2,446,867
per 100 kg. — ...	71	108	91

for further details : see Table.

diminished. A peculiar feature that could not have been foreseen has appeared in the composition of the shoal : the unusual importance of the new class of 3 years old herring : 24 %. The column of 4 years has also increased notably. The decrease of the six older classes is partly a consequence of the increase of the percentage of the young ones (balancing of percentages).

2. — About quantitative forecasting let us remember first of all that the figures, in the material we are dealing with, are all percentages and these percentages cannot forecast anything but percentages. No quantitative prediction can be directly drawn from our diagrams. However, we may obtain probabilities out of this kind of diagrams when we have positive information âbout the history of certain classes. If some of the classes have played an important part in one of more good seasons passed, we may infer that there has been actually, an important number of individuals of those classes at that time in the sea, and that the survivors of that great shoal will still be numerous during the next season.

As regards the season 1931—32 : two classes, 1927 and 1926, having played an important part in the extremely rich season of 1930—31, we could reasonably forecast, not only a high percentage of young fish, but also a considerable absolute quantity of herring and a good fishing.

In fact, however, the season 1931—32, immediately following one of the richest concentrations on record, was an extremely poor one. The relative proportion of young herring was certainly in accord with the forecast; but the average weight of one fishing, which is the only criterion of the abundance of fish in a shoal, dropped from 8,338 kg. in 1930—31, to some 5,000 kg. in 1931—32.

This is undoubtedly a remarkable instance of the possible perturbations in the normal course of a biological phenomenon. Its causes are unknown to us but some may easily be guessed at; one may be found in the magnitude of the transgression of Atlantic water of high salinity pointed out by the British hydrographers. The encounter of repulsive plankton *Phaeocystis* or others, might also have turned the herring from their usual way back to the breeding grounds.

Another possible cause of the poverty of the concentration of 1931—32 may have been the intense fishing of 1930—31. The destruction of more than 217 mill. individuals may have heavily affected a community of herring which appears to be a relatively small one, never equal in size to the immense shoals of Northern North Sea. It seems possible that the concentration of 1930—31, although an extremely rich one, was too heavily taxed by the excessive destruction in that fishing season.

3. — The second kind of quantitative forecasting is that of the abundance of herring in the third year after a season just finished. This seems to be somewhat safer than the predictions for the immediately following season. especially when the two intermediate seasons are also known and analysed. The reason is that the first generation to appear as a notable element of a returning shoal, is the class

of three-year old herring, so that a given class is always largely dependent on the conditions of breeding in the season three years before.

Forecasts for the Season 1933-1934.

Although feeling very little inclination towards making predictions, I consider it expedient to call attention to certain signes that seem to forecast an abundance of young spent herrings in the next season along our coast.

The main consideration for this forecast is that the next season will be the third after the excellent concentration of 1930—31. We may safely admit that the extremely numerous, spent, herring of that rich season had given birth, previously to their coming to our coast, to an immense number of larvae. These are likely to come back as young mature herrings to breed in their turn and to accumulate afterwards for several weeks along our coast as spent herrings.

We may also consider in the diagrams the two intervening seasons 1931—32 and 1932—33, when two young classes, 1928 and 1929, were very well represented by percentage in their first appearance, which is always a promising feature.

Reservations.

It must, although, be kept in mind that hitches are always possible and that no prediction is infallible. Although the number of progenitors, and consequently the number of eggs, was enormous in the season 1930—31 we cannot be certain that the breeding has been a success. As long as quantitative data are not obtained about the larvae in the Straits of Dover and in the South of the Southern Bight there is room for doubt about the success of fecundation and hatching. Another uncertainty looms over the actual thriving of the larvae after the frail creatures have been carried away by the currents. Salinity, temperature, plankton and currents may have been unfavourable, both at the time of hatching and afterwards, and mortality may have been very great.

Let us remember also that coastal concentrations in a narrow passage of the sea are subject to great irregularities resulting from different causes, among which may be mentioned the intensity and variability of tidal currents in the Straits, the variable mixing which they cause between the different masses of water, of plankton, of larvae and even of adult herring belonging to the two varieties neighbouring in the boundary area. Conditions more favourable to forecasts are prevailing in open seas like the East Anglian region or the broad part of the Channel.

However, perturbations like the above mentioned, of what may be considered to be the normal course of annual displacements are possible everywhere. They show the necessity of continuous hydrographical observations and they teach us, objectively, how cautious we must be when we decide to turn prophets, if sincerely we wish to guide the fisherman to success and not to run the risk of leading him dangerously astray.

2. -- Season 1933-1934.

Annual Concentration of Spent Herring along the French and Belgian Coasts in 1933-1634.

COPENHAGUE — JUNE 1934.

An almost unmixed concentration of spent herring appears regularly every winter in the coastal region between Cape Gris-Nez and the Scheldt. This phenomenon has been studied continually at the Ostend laboratory since the year 1930, new series being added every year to the « biological scale » of the visiting shoals (see diagram attached).

The prominent feature for last season, 1933—34, was that the shoal remained, all the time, very far out in the western part of the coastal band, round about Calais and Cape Gris-Nez, and even further west in the Channel, and a long distance from the coast. As a consequence small motor boats from Ostend were prevented from carrying on a profitable fishery, on account of the cost of fuel. The spent herring fishery of this year was in fact a complete failure as far as the fleet of small crafts using the « stroop-net » was concerned. The larger vessels, however, contrived to make paying hauls with the trawl in the West, and from these vessels we obtained for study 60 samples of spents in good condition.

The result of the complete analysis of 1479 individuals leads us to the following remarks : —

1. As shown by the diagram, the year-class 1929 attained, in the ultimate series added to the biological scale in 1933-34, the unusually high proportion of 52.7 %.

2. An additional interest is imparted to this striking feature by the fact that a very high percentage of that same class, 1929, has been noticed simultaneously by various observers, thus : —

J. J. Tesch : 52.8 %;
J. le Gall : 50—60 %;
G. Gilson : 52.7 %.

This similarity of observations, made quite independently in different parts of the continental coast, shows the efficiency of the scalimetric method, as well as the accuracy of the work done, and can be considered very satisfactory.

3. Another peculiarity of the season is the fact simulataneously observed by Dr. Tesch, on the Dutch coast, and by Dr. Bückmann, in the German Bight, of the extreme scarcity of young herring, in the first post-larval stage that usually appear off the eastern part of the coast in May and June, whilst we, on the contrary, in and around the harbour of Ostend noticed an extremely abundant concentration of post-larval herring either in the pre-scaly stage or beginning to assume the characteristic silvery aspect. We found, by counting the vertebrae, that the catch made with a stramin-net contained only 1 % or 2 % of young sprat.

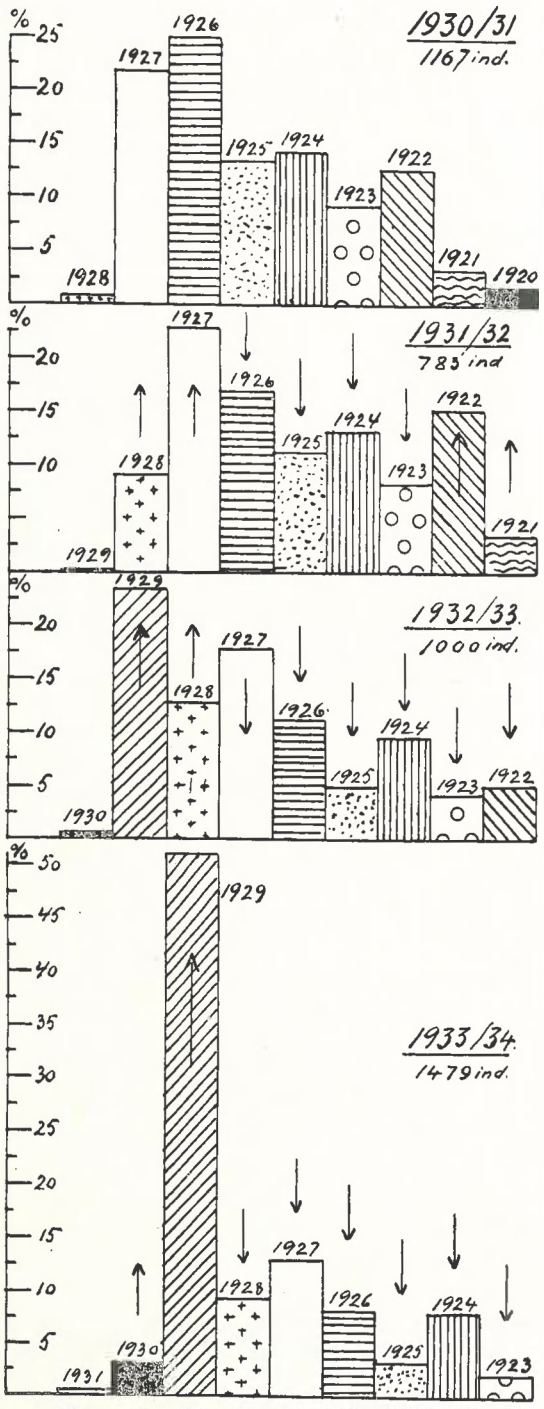
This unusual abundance of unscaled clupeids was striking enough to attract the attention of some fisbermen who considered the possibility of starting a whitebait fishery, should they be pelentiful next year, for the English market, whitebait not being consumed in Belgium.

4. Three sets of corresponding facts may be noted : 1. a scarcity of unscaled young herring in the East, — German Bight and Dutch coast;

2. an abundance of these same young fish in the West, — Ostend and the Belgian coast;

3. the continuance in the extreme West, of spent herring, — the progenitors of these shoals of unscaled young.

5. The cause of the persistance of the seasonal shoal of spent herring in the west seems to be connected with the small influx of Channel water into the North Sea as observed by British and French hydrographers, the annual submarine wave of Atlantic water, warm, highly saline and unsuited to herring. This season there seems therefore to have been no large migration to the Southern North Sea, the breeding concentration of herring, travelling from the north may have caused them to penetrate lower down the Channel, being there undisturbed by adverse, physical conditions. The low vertebral average observed by le Gall, Tesch and myself in all samples of southern herring, points to this conclusion. This, as well as many other considerations, makes us anxious to obtain at an early date, com-



Biological Scale, 1933—1934.

plete information from the extensive observations of the British hydrographers as well as the results of the recent cruises of the French research vessel, « Président Théodore Tissier » in Atlantic and Channel waters.

It is hardly possible, in the present state of our knowledge, to obtain a general impression of the life-history of the herring in the most southerly parts of the North Sea. As a working hypothesis, however, we may try to draw the following sketch of the phases through which the fish progress during the first years of its *curriculum vitae* :

In the late summer several successive shoals, coming from a northeasterly direction, appear in the region between the Hinders and the banks of the Thames estuary. They are nearly ripe and, in accordance with LE GALL's recent hypothesis, contranatant in regard to the residual current of CARRUTHER's. They travel South-West, until they meet Channel waters, salt, warm and unsuited to herring. At this point they stop their contranatant migration and, gradually maturing and abstaining from food, they simply keep swimming to and fro with the tidal currents. When entirely matured, at stage VI, they plunge into deeper water and reach the bottom in order to breed. The female lays its eggs, attaching them to solid objects, burrowing more or less into the ground and often swallowing sand, broken shells and even quantities of herring eggs deposited on previous occasions.

After breeding they remain some time in a condition of bodily weakness, drifting feebly with the tidal currents, taking no food and carried away more or less directly towards the continental coast, In that condition they are subjected to active fishing, mainly by Belgians, who have a market for spent herring at Ostend. Meanwhile they rapidly recover, fatten in their mesenteric lobes and reach the stage VIII-II of HJORT. About the middle of February they begin to take food again, consisting mostly, on our coast, of small copepods, especially *Temora longicornis*, and, shortly, after, they become actively denatant and swimming away with the residual current in a North-North Easterly direction, they soon disappear from the vicinity of the coast. They spend several months in some remote unknown region, perhaps in a state of dispersion, feeding, growing, and developing their gonads through stages III, IV and V. After a while they become contranatant again and swim South of lat. 52°. There, in some degree feeding and maturing rapidly to stage

VI they concentrate in breeding shoals and move towards the Channel in search of the above mentioned breeding grounds. The shoals may intermix, in various proportions with Channel herring, distinct from the Southern North Sea herring mainly by the higher number of vertebrae, as pointed out by LE GALL, FORD and HODGSON. Interfecundation between the two varieties, however, cannot occur frequently, as the Channel herring appear to breed later than the Southern North Sea variety, and thrive in water with a higher salinity. According to these views, the position of the spawning grounds is not necessarily the same every year, and it is very important for fishery information to locate them exactly by means of systematic dredgings, the presence of eggs and of stage VI and VII in the trawl of fishermen giving entirely insufficient indications. They may be situated in any position West of the Hinders or in the area of Sandettie—Ruytingen or even much further South, across the Straits, in the Channel.

The new generation, issued from the spent herring still hovering in the spawning regions, is hatched from the bottom eggs in a short time and the tiny larvae with yolk sac and passively planktonic, are carried away by the residual current. They soon loose their yolk sac and commence feeding on microplankton, growing in size and muscularity. Finally they transform themselves into shore larvae, and are soon able to swim towards the coast accumulating in certain places, in the form of whitebait, as they approach the scaly stage. It seems obvious that, when their birth place is situated far away in the West as was the case in 1933—34, they may reach the stage of shore larvae in western points of the coast, like Ostend, and fail to reach the North of Holland and the German Bight before becoming scaly. Conversely, when the spawning grounds are in an easterly region they may pass the Belgian coast, still in a planktonic condition, and attain the shore-larval form only when they arrive further East, accumulating as whitebait on the Dutch and German coasts. After some weeks in the scaly condition and growing rapidly to the size of 7 to 10 cm. in the immediate vicinity of the shore and in harbours or inlets, they leave the coast altogether and are not seen again, except later on when they are caught in abundant numbers by fishermen, intermixed in varying proportions with shoals of sprat.

Meanwhile, herring of the Channel type, with a higher vertebral mean, may have penetrated more or less into the Southern Bight, along the English coast (LE GALL), very likely under the different hydrological conditions prevailing there. They may be a really distinct local variety with a *curriculum vitae* somewhat diverging from those already described. There can, however, be a divergence of views about the fate of that larval offspring which is swept away by the residual current, such as also occurs in the case of planktonic larvae of the Southern North Sea variety. Do they afterwards separate and return to the Channel? A long series of observations is required before the real affinity and relationship between the two groups can be definitely settled.

This attempt to summarize the successive phases of the life-history of our southern herring is strictly conjectural, and in no way dogmatic; it is intended to emphasize mainly the necessity of international co-operation to solve the question of the annual return of the Southern Herring and of the frequent checks in its migration.

3. -- Season 1934-1935.

Herring Work in 1934-1935.

Spent Herring in the Coastal Zone of the Intermediate Channel — North-Sea Region.

COPENHAGUE — MAY 1935.

As emphasized on previous occasions, the shoal of herrings that regularly visits the French and Belgian coasts between Cape Gris-Nez and the Scheldt is a clearly distinct concentration of spent fishes and, as such, appears to be a favourable object for the study of the life cycle of the species in the Southern North Sea. It was, therefore, considered expedient to submit the shoal to continuous observations during successive years. The times of its appearance and disappearance and its occurrence along the coast were noted during the entire season. Daily samples of 30 herrings were analysed in order to follow the variation in abundance, year-class compostion, stades of gonads, weight, length, quantity of fat, number of vertebrae, etc., as well as the weight and value of the total capture and the total calculated number of individuals destroyed. The results obtained during the period of the last five years, as far as the percentage of individuals is concerned, are set out in the diagram, which we call the « Biological Scale » of the shoal — Fig. 1. Further data are found in the short texts in the margin of each of the steps of the scale. More details will be given in the memoir now in preparation. For the present we shall not go beyond a few preliminary remarks.

Remarks.

I) The composition of the annual steps of the Scale shows that each individual year-class is increasing in number up to the fourth year of age and then decreasing more or less rapidly down to the tenth year. (The very few that are still surviving after ten years are not marked in the diagram).

II) A class appearing in the shoal with a high initial percentage at the age of 3 years is likely to increase notably afterwards and to keep a still higher proportion in the two following years. (See classes 1927 and 1929).

III) Conversely, a class appearing in the shoal with a low percentage in its third year generally attains only a small proportion in the fourth and rapidly decreases in the following years, see classes 1928 and 1930.

IV) A special interest is attached to the year-class 1929 attaining in 1933—34, the highest percentage in our records : 52 %. The initial percentage of this class was 24 % in 1932—33, which is also the highest one recorded at the first appearance in the shoal, except that of the year-class 1931 which attained 25 %, in the latest season, 1934—35.

V) The entry into the shoal of the rich 1929 class had a lowering effect on all other classes in 1933—34, (balancing of percentages).

Fig. 2 shows what all the class-columns in 1934—35 would have been if the youngest class 1931 had been a poor one with a proportion supposed to have been only 5 %, instead of 25 %; the class 1929 instead of sinking from 52 %, down to 40 %, would still have been at more than 50 %.

VI) The mean weight of one day's capture being the only means of appreciating the abundance of a shoal of coastal spents it appears that the shoal of 1934—35 was the densest on record as shown in the table below :

1927—28	mean	weight	of	one	day's	capture	4.739 kg.
1928—29	—	—	»	—	—	—	11.545 »
1929—30	—	—	»	—	—	—	7.802 »
1930—31	—	—	»	—	—	—	8.338 »
1931—32	—	—	»	—	—	—	5.225 »
1932—33	—	—	»	—	—	—	4.514 »
1933—34	—	—	»	—	—	—	7.600 »
1934—35	—	—	»	—	—	—	14.632 »

Commercially, however, it was one of the worst seasons remembered, the average price per 100 kg. being as low as 31,52 fr. — which is also a record.

Biological Scale of Spent-Herring.

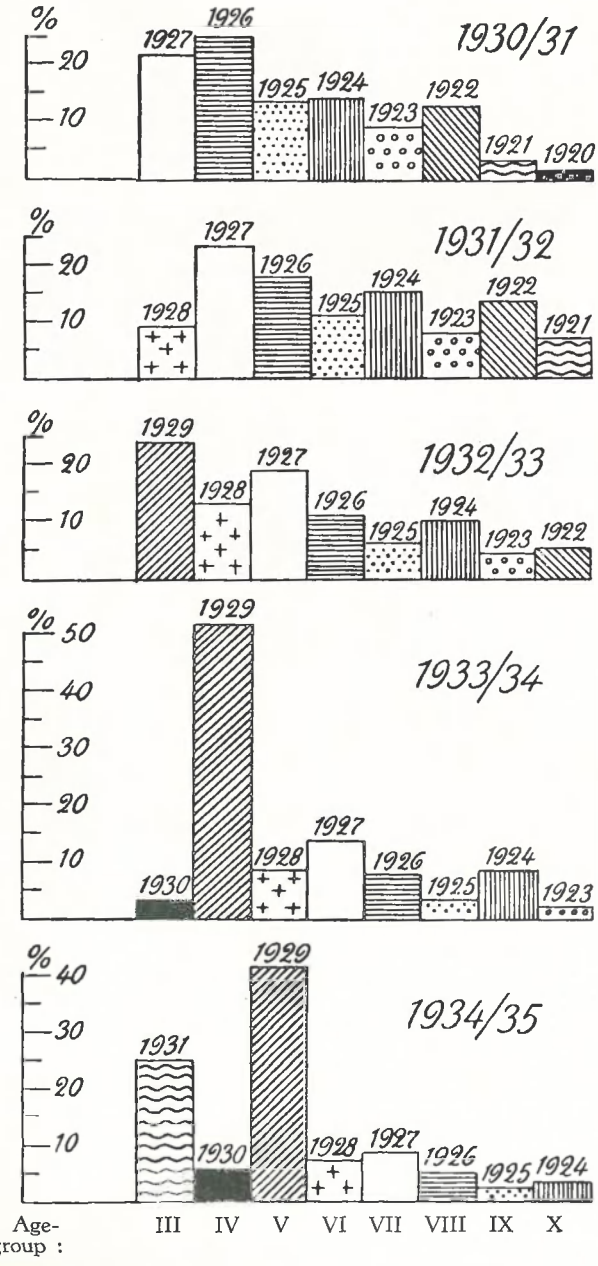


FIG. 1. Percentage number of indivuals in each year-class.

1930—31

Number of herrings examined	1.167
Mean weight of a day's capture	8.338 kg.
Total weight landed in the season	18.360.596 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 herrings examined	783
Mean weigh 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.	9a,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 weigh 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

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

Number of herrings examined in 5 years : 5.629.

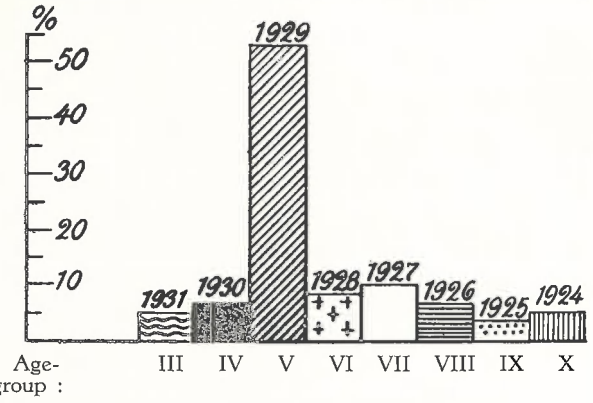


FIG. 2. Showing what would have been the height of each column if the new class 1931 had been only 5 %.

VII) Occurrence of the shoal of spents.

In 1934—35, as was the case in 1933—34, the shoal has kept all the time far to the west, off Calais and Gris-Nez, and has even penetrated further down into the Channel; it is likely that their spawning grounds were in the same westerly region. The consequences of this were :

a) that the smaller kind of boats of the Belgian seaports were prevented from partaking in the fishing for spents, on account of the long distance entailing an expense in fuel;

b) that the young herrings born on these westerly spawning grounds attained the scaly stage during their north-easterly migration before reaching the Belgian part of the coast. The result was that the young breed of herring when reaching the vicinity of Ostend was already in the scaly, silvery, condition, and that very little whitebait was observed at the entrance of Ostend harbour.

VIII) Previsions.

A. At the end of the season 1934 our forecast for the season 1934—35 was worded like this : « All considered, the prognostic for 1934—35 is in favour of the appearance of an important concentration of spent herrings ». It is worth noticeing that this forecast, based on the high proportion, in 1934, of two classes which previously had a high percentage in two good years : 1931 and 1934, was entirely successful.

B. Our forecast for 1935—36, based mostly on the study of the age composition in the biological scale, is as follows : « good season for spent herrings with a majority of individuals aged 4 and 6 years ». —

Principal considerations leading to that forecast :

a) The year-class 1929, with a very high percentage in the good season 1933—34, is still remarkably represented, aged 5 years, in 1934-35, which is the densest concentration recorded, and it is likely to come back in notable proportion in 1936.

b) Among the older classes, three have played an important part in the good season 1930—31 and, more recently, in 1933—34 and 1934—35, and the remnants of these generations are not yet exhausted.

c) The year-class 1931 is arising in the rich year 1934—35 with a high initial percentage foreboding a still higher proportion in the next year.

This forecast obtains a certain probability from the fact that it is simply a rational deduction from the methodical analysis of 5 successive shoals. Many, however, are the unforeseen events that may make the most cautious forecast either a satisfactory success or a complete failure. A thorough comprehension of the vital cycle of our southern herring might impart a greater security to the oracles of the biologist, but this cycle will never be made out, nor its mechanism thoroughly understood without intervention of the hydrographer and the meteorologist, and even when it will appear sufficiently known and understood, their constant collaboration will still be needed to find out the unforeseen in good time for prediction before each of the fishing seasons.

All this and many other considerations of pure as well as of applied science show well how consistent is the scheme of an international survey of the Intermediate Channel-North Sea Region and the necessity of the setting up of a continuous Patrol Service in this most interesting area. Meanwhile we must acknowledge the meritorious efforts made in advance by the British hydrobiologists BORLEY, CARRUTHERS, DAVIS, DODSON, HARDY, LUMBY, THURSBY-PELHAM, RUSSELL, SAVAGE, WALLACE, WIMPENNY and others, as well as of those who are studying the movement of water in the near Atlantic, Channel, Central and Nothern North Sea and Skagerak. — CARRUTHERS' recent paper on « The Flow of Water through the Straits of Dover » is of special interest with regard to the contemplated survey of the area.

4. -- Season 1935-1936.

Further Observations on Spent Herring with Remarks on Fluctuations and Oscillation.

COPENHAGUE — MAI 1936.

Systematic observations on the community of spent herring which accumulates every year along the French-Belgian coast have been carried on uninterruptedly during the fishing seasons of the last six years. This community of nearly pure spent herrings that returns regularly to our coast after the autumn spawning to remain for more than two months in a close vicinity to the shore, although very small in comparison with the immense shoals of the North Sea, offers excellent opportunities for general biological studies on the species. We beg to remind the readers of our previous papers, that our method consists in the analysis of a great number of small samples. Each sample of 25 fishes is obtained from the fishermen on each of the fishing days of the herring season. Each herring was submitted to the eight points of analysis which are now considered classical :

1) length
2) weight
3) sex
4) stage of gonads
5) quantity of mesenteric fat
6) age and growth from scales
7) number of vertebrae
8) content of stomach

It is intended to proceed with the same work for several years to come and to add yearly one step to the biological scale of the shoal. As seen in the diagram, the material collected in the season 1936 has been worked out already and a new step added to the scale.

A general Report on the results of the successive years will be plublished this year, may-be next year if the addition of the results of another year is found expedient.

For the present I shall simply call attention to certain peculiarities of the evolution of the year-classes that do not appear clearly enough in a columnar biological scale. In diagram nº 2, I have drawn a representation of the variation of percentages in a different way : each year-class is taken separately from its first appearance as fishery material and its evolution is followed to its extinction or near to it.

1. On the first coordinate, — on the left, — are plotted the percentages of each of the year groups of the six seasons that have been as yet under observation, at the time of their f i r s t a p p e a r a n c e, — that is at the age of 3 years. They occupy various positions on the line and their variation during this period of years, may be called a f l u c t u a t i o n.

2. If we take the same year-groups on their second appearance, — that is in their 4th year of age, we make a similar remark : the figures of all percentages still occupy different levels. But there is a more interesting feature to be noted : that is, that they are all higher than in the preceding year. There is thus a constant increase in the number of herrings on their second migration to our coast. No exception to that rule has been observed, up to the present.

3. The right hand part of the graph shows a remarkable uniformity in the direction of the lines of percentages : they all, invariably after the 4th year of age, take a s l o p i n g d i r e c t i o n indicating a gradual decrease in the number of herrings of each of the successive generations that have come to our coast after spawning, since the starting of our regular system of observation.

Forecast for the season 1936-1937.

Good shoals may be expected for the following reasons :

a) the 1931-class which has played an important part in the rich seasons 1934—1935 and 1935—1936, will in 1936—1937 be at the first stage of reduction only ;

b) a good remnant of the famous 1929-class is likely to survive ;

c) the youngest class, 1932, attaining in 1936 the highest percentage hitherto recorded at the first appearance, will be reaching in 1936—1937, the augmentative stage of 4 years.

Our diagram nº 2, exposing the fluctuation and evolution of successive year-groups continously re-

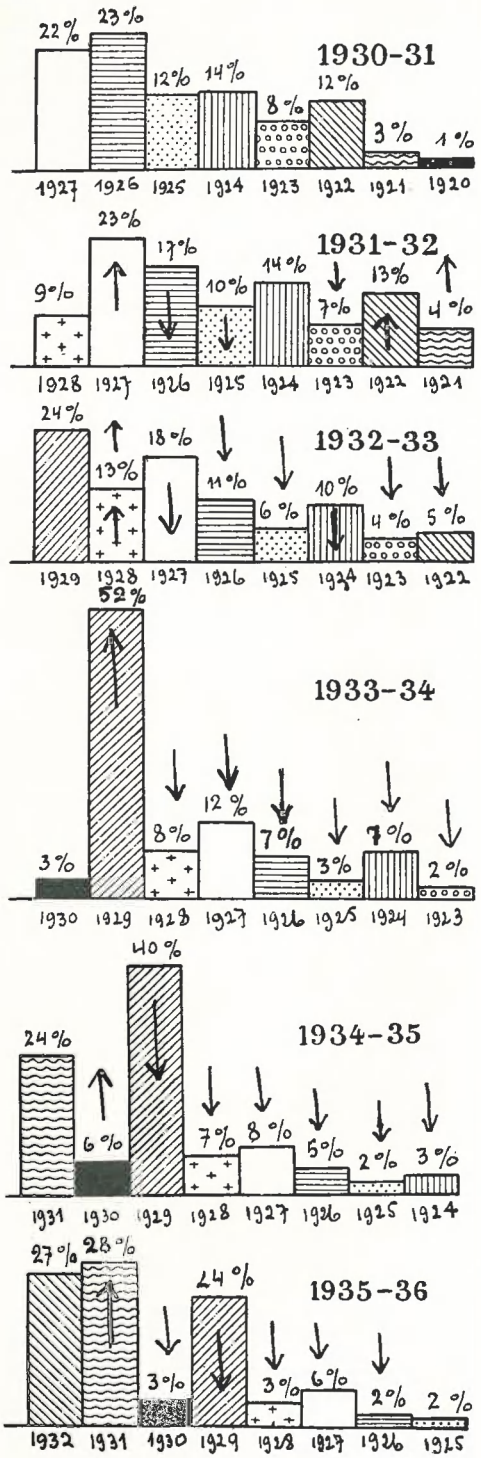


FIG. 1. Percentage number of individuals in each year-class.

1930—31

Number of herrings examined	1.167
Mean weight of a day's capture	8.338 kg.
Total weight landed in the season ...	18.360.596 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 herrings 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

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

Number of herrings examined in 6 years : 6.929.

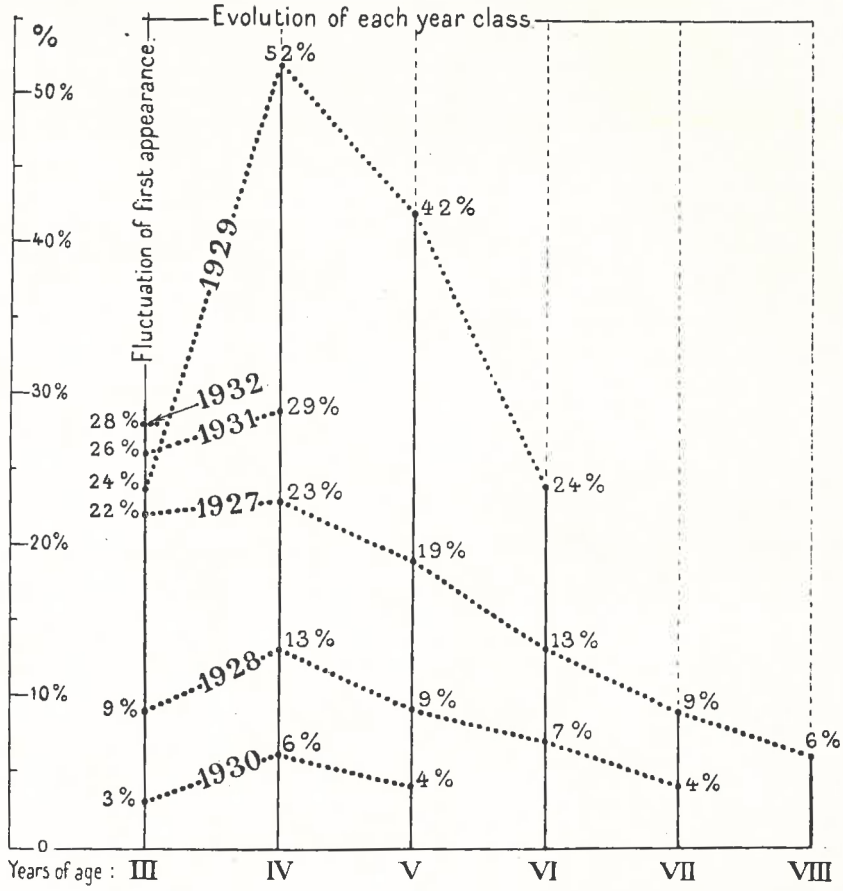


FIG. 2.

corded, may be useful for the drawing of forecasts concerning our shoal of littoral spents. Possibly also it could be adapted to the prevision of the future composition of certain larger communities of other kinds of herrings in the North Sea.

To these data I beg to add a few remarks concerning the probable cause of the fluctuation of the successive generations and of the strangely constant character of the evolution of each of them.

1° The causes of *fluctuations* may be of various orders :

a) a group may have been poor from its origin, as a consequence of a deficient production of eggs in the ovarires or of unfavourable external conditions at the time of hatching and first development of the larvae ;

b) external conditions prevailing after the spawning of the spent herrings may have been such as to directly favour, or, conversely, to oppose the coming of the spawners to our region in great number. External circumstances may thus have been partly the regulating factor of the abundance or scarcity of spent herrings in the resting place of our coast.

2° The cause of the strangely *regular oscillation* in the number of spents, reaching our coast in successive years, appears much more difficult to determine. Why do the spawners of any generation appear in larger number, as spents, on their second coming to our coast, — that is : why are they constantly more abundant at the age of 4 years than at 3 years ? Why are they always coming in greater number at four years than at three ?

As an attempt to explain this curious fact one may perhaps accept the following, somewhat risky, hypothesis : let us admit that, out of the lot of herrings that have spawned in the southernmost part of the Flemish Sea, not all but only a certain number come to our coast to recover after the fatiguing operation of spawning, — others, being less fatigued, are able actively to swin away with the residual

current and never touch our coast. The next year, however, as herrings of 4 years, they lay a greater quantity of eggs and, being more fatigued, they have a stronger tendency to remain in coastel water to rest. But, in the 5th year of age, and afterwards, they seem to suffer less from the spawning and a smaller number of them require a period of rest in the close vicinity of the coast, — the stronger ones leaving continuously the spawning grounds and swimming away to other regions. Meanwhile, the causes of mortality are in action and the number of herrings of each generation is gradually reduced to complete extinction.

I submit these facts, remarks and deductions to those of our colleagues who pay special attention to the general question of fluctuations and of their causes and mechanisms. Personnally, I am of the opinion that the results of a few more years of continuous observations are needed before the causes and mechanism of the fluctuation and of the general evolution of the successive generations composing our annual shoal of spent herrings can be determined with satisfactory precision. If confirmed by further records, these remarks may lead to the conclusion that variations, either angular or sinusoid, when presenting a certain degree of constancy and regularity, are due to causes inherent to the living organism, whilst the causes of irregular or unsettled variations of biological phenomena must be looked for preferably in the less regular play of external conditions of environment.

A corollary of this conclusion, if sound, would be that one of the most variable of external causes of mortality, the action of the fishery, — tremendous as it seems to be, — has not yet been able to affect the normal biological cycle of the herring, and, as yet, is by no means threatening to the fishing industry.

The above explanatory remarks I present a sa mere working hypothesis for further investigations and tending simply to show how urgently the solution of certain biological questions is in need of positive data that can only be expected from a continuous survey of the physical and biological conditions in the intermediate region Channel-North Sea.

5. -- Season 1936-1937.

Fluctuation and Oscillation in a Community of Pure Spent Herrings.

COPENHAGUE — JULY 1937.

On previous occasions I have called the attention of biologists to a remarkable shoal of pure spent herrings that concentratgs every year, from December to March, in the vicinity of the continental coast, between Cape 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 (1).

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.

(1) 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 indicates 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.

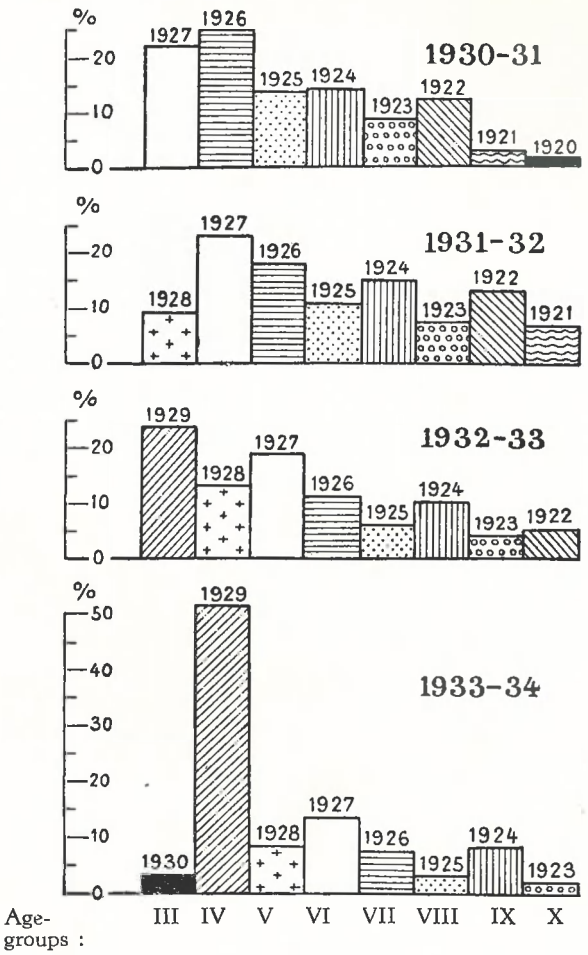
I have proposed this term (1), for want of a better one to indicate the rising and falling of percentages in the course of the evolution of o n e a n d t h e s a m e g e n e r a t i o n considered over a series of successive years.

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.

(1) G. Gilson, Further observations on Spent Herring, with Remarks on Fluctuation 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 ...	18.360.596 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 herrings 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



Balancing of percentages : number of individuals of each year-class in 100 fishes.

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

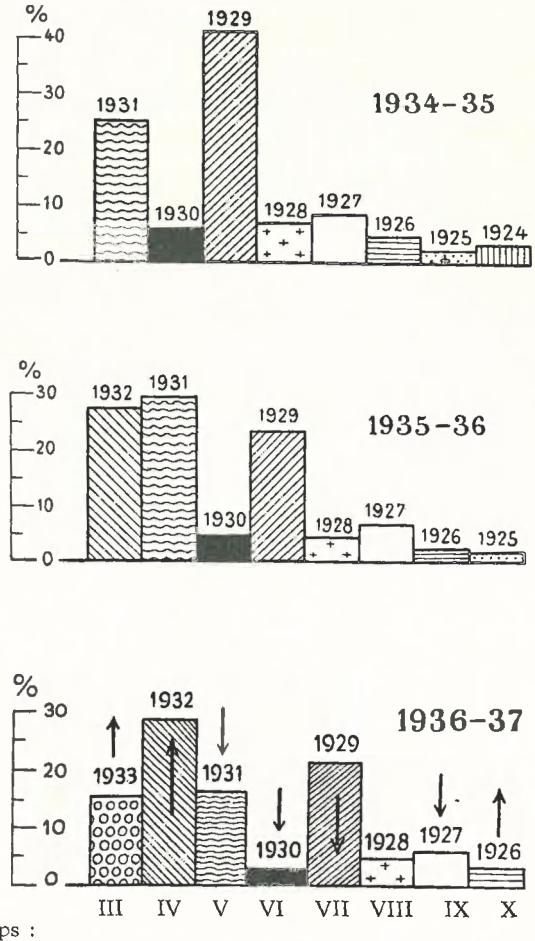
Causes of Fluctuation and of Oscillation.

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.

Bot 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



Balancing of percentages : number of individuals of each-year-class in 100 fishes.

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

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.

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.

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

Number of herrings examined in 7 years : 7.554

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 only at the first stage of reduction and the other being the famous class of 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 precentage 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.

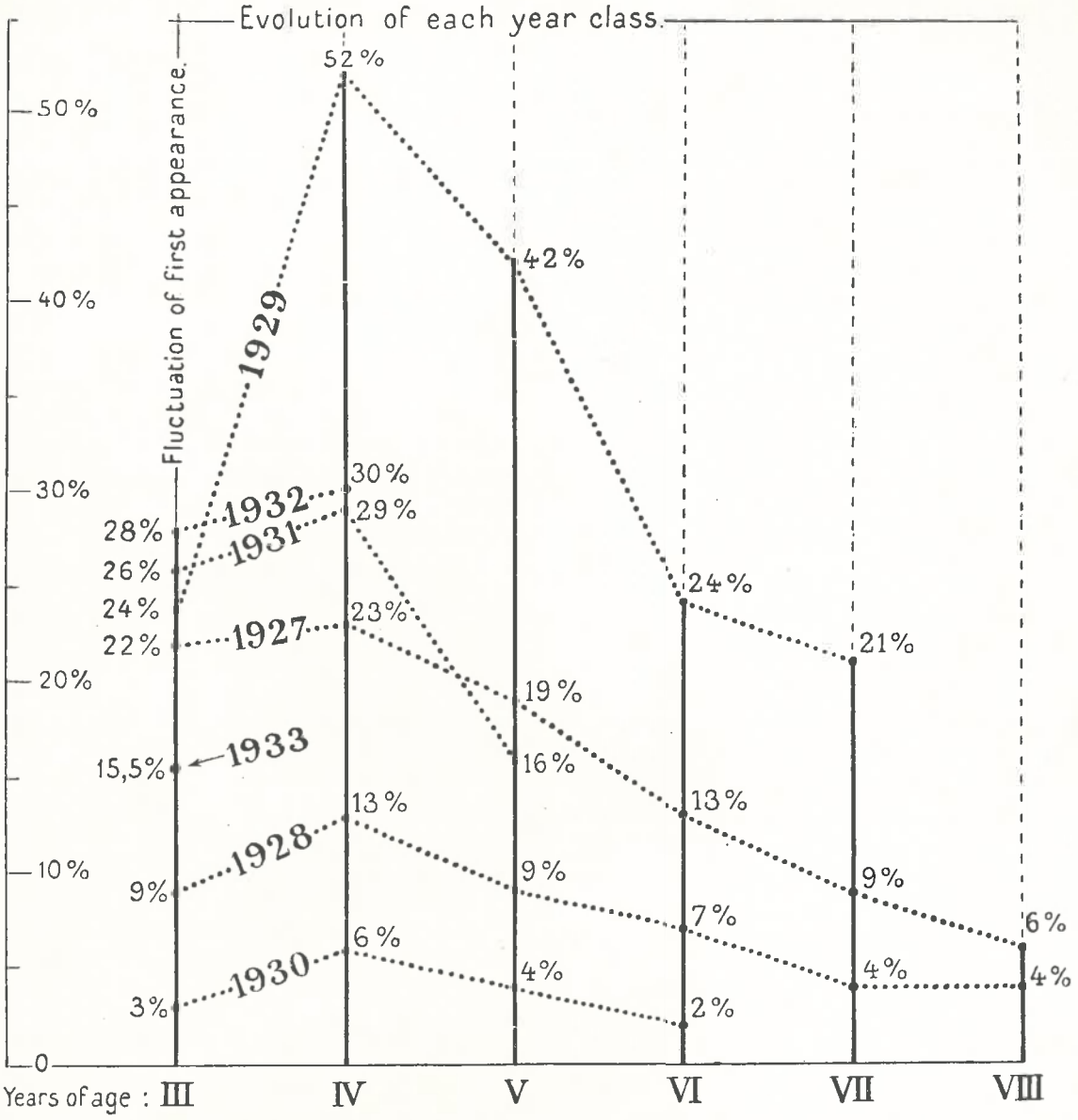


FIG. 2. Vertical lines = fluctuation. Dotted lines = oscillation.

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 observations : the mean weight of a day's capture being only 7.319 kg., whilst the season 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.

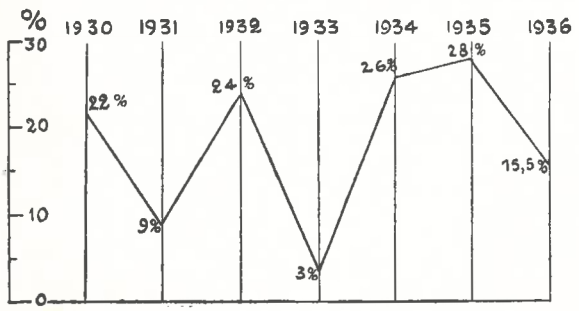


FIG. 3. Fluctuation at first appearance of 3-year-old recruits.

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 reward to the fishermen.

This failure of the quantitive 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 p e r c e n t a g e s, 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-groups with a remnant of year-class 1929, — the VIII-group, — and perhaps a good percentage of the new 1933-year-class.

Quantitatively, from p e r c e n t a g e s, 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.

6. -- Season 1937-1938.

Variation of Year-Classes in an annuel Concentration of Fish.

COPENHAGUE — MAY 1938.

Variations in the composition of a shoal of fishes depend either on internal agencies affecting the living organism itself, or on certain changes occuring in the environment.

Peculiar conditions observed in the sea may foretell alterations in the normal composition of certain fish concentrations, or, inversely, changes appearing in the composition of a shoal may reveal that, in the past, peculiar conditions must have been prevailing either in the constitution of the organism of the fishes or in their environment.

In fact, the nature and mechanism of the correlation between actions developing in the sea and qualitative or quantitative changes in the composition of shoals of fishes are not always easily detected, as will appear from a few remarks on the work done by us in late years on spent herrings in the intermediate region between the Channel and the North Sea.

In the diagram Fig. 1, are exhibited, in the form called « biological scale », the results of continuous observations made at Ostend during the last eight years on the remarkable concentration of spent herrings that come every winter regulary to the French-Belgian coast to spend there a period of rest without feeding. The step of 1937—38 in the biological scale is additional to the diagram of the years 1930 to 1937 presented last year to this Committee.

Fluctuation.

The superposition of the annual blocks in the first column on the left side of the scale, Fig. 1, when followed from 1927, above, downwards to 1938, shows the fluctuation in the concentration of three-year-old herrings considered at the time of their first appearance in the wintering station. The same fluctuation is also clearly shown in the linear diagram Fig. 2, first vertical line on the left side. The fluctuation figures for the following years are pointed on the next five vertical lines on the right.

The percentage of the latest class, born in 1934, is rather high : 26 %, which is satisfactory as, in the past years, a high initial proportion has always prognosticated a good percentage in the subsequent years.

Oscillation.

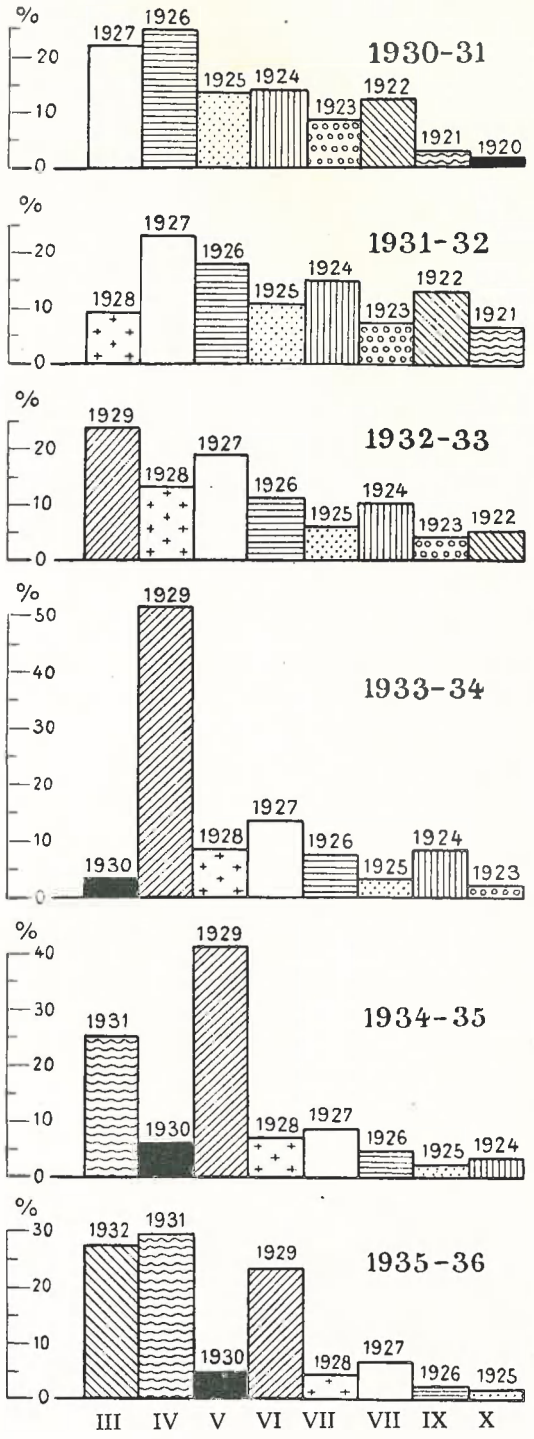
Concerning oscillation, let us first remember that we have proposed the term as indicating the variation of the percentage in the evolution of o n e a n d t h e s a m e g e n e r a t i o n of fish considered over a series of consecutive years. In the columnar diagram, Fig. 1, the oscillation may be followed from one year to the next by moving one column from left to right as one goes down one step. In the linear diagram, Fig. 2, the oscillation is marked by the dotted lines for each of the seven generations that have been under control since the year 1930.

The two diagrams, Figs. 1 and 2, show the remarkable fact that all year-classes (since the season 1930—1931) in their second appearance on the coast — that is to say at the age of four years — show a higher percentage than at three years. We have tried, last year, to explain this curious fact as follows :

> « The remarkable constancy of this phenomenon leads us to consider it as dependent upon an internal cause, inherent to the physiologie 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 (until the fourth year in the case of herring), again becomes more intense down to the complete extinction of the group ».

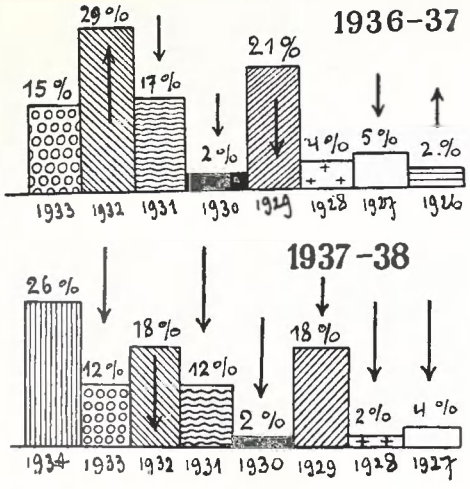
This year, however, we find for the first time a peculiar feature in the oscillation of one brood of spents, i. e., the young class born in 1933. Being now one year older than in the last season it ought to have shown a higher percentage than at its first appearance in 1936—1937.

1930—31	
Number of herrings examined	1.167
Mean weight of a day's capture	8.338 kg.
Total weight landed in the season	18.360.596 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 herrings examined	783
Mean wight 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
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



Balancing of percentages : number of individuals of each year-class in 100 fishes.

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



Balancing of percentages : number of individuals of each year-class in 100 fishes.

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

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

1937—38

Number of herrings examined	575
Mean weight of a day's capture	5.568 kg.
Total weight landed in the season ...	807.425 kg.
Mean value of 100 kg.	96 fr.
Total value of the season	774.629 fr.
Number of individuals destroyed ...	6.892.754

Number of herrings examined in 8 years : 8.129

Instead of this we find that its percentage is distinctly lower; it has fallen from 15.5 % in 1936—1937 down to 12 % in 1937—1938. Its oscillation line in the diagram Fig. 2, instead of bending upwards as might be expected, takes a downward direction.

It will be interesting in future seasons to follow the fate of the class 1933 and to investigate the cause of its low percentage appearing at the very time when an increase was expected and to see whether this reduction is final in the evolution of this class or will be mended next year by a belated addition of herrings then in their fifth year of age?

This seems to show that the rule of an increase of the percentage in a concentration of fishes between their third year of age and the fourth is not an unbreakable law, and that certain accidental causes may interfere with the normal play of hydrographical and biological phenomena.

Peculiar conditions prevailing in the sea may act on the fluctuation of fishes in two different ways : —

1. They may have an influence on the spawning and hatching of the eggs and the welfare of the young larvae, and so affect the abundance of the new generation which will appear in the third subsequent year, as spents, after their first spawning season.

2. They may exert an immediate influence over the then living spent herrings and either drive them in great numbers towards the coast or lead them away from it.

In both cases the fluctuation of the herrings in their usual resting station on the coast will be affected in one way or the other.

The low mean weight of a day's capture in 1937—38 seems to be in correlation with the particular conditions of wind and currents as observed on the « Sandettié » lightship during the period December 1937 — February 1938. See the article by Dr. CARRUTHERS in the Appendices.

As to oscillation, we do not see how it could be directly affected by external actions.

Changes in temperature, salinity, pH, wind, motion of water, plankton, etc., may very well have an influence on the total shoal of fishes living in a limited region and so affect the fluctuation in a succession of years. But no deviation from the normal play of natural forces could exert a selective action on one particular brood and affect its percentage separately in the composition of the annual concentration : all year-classes in the shoal would be affected at the same time and their proportion would remain unchanged under the law of the balancing of percentages. The density of the concentration might be altered, but not the percentage of any of the classes : the oscillation line, no other trouble arising, would suffer no deviation.

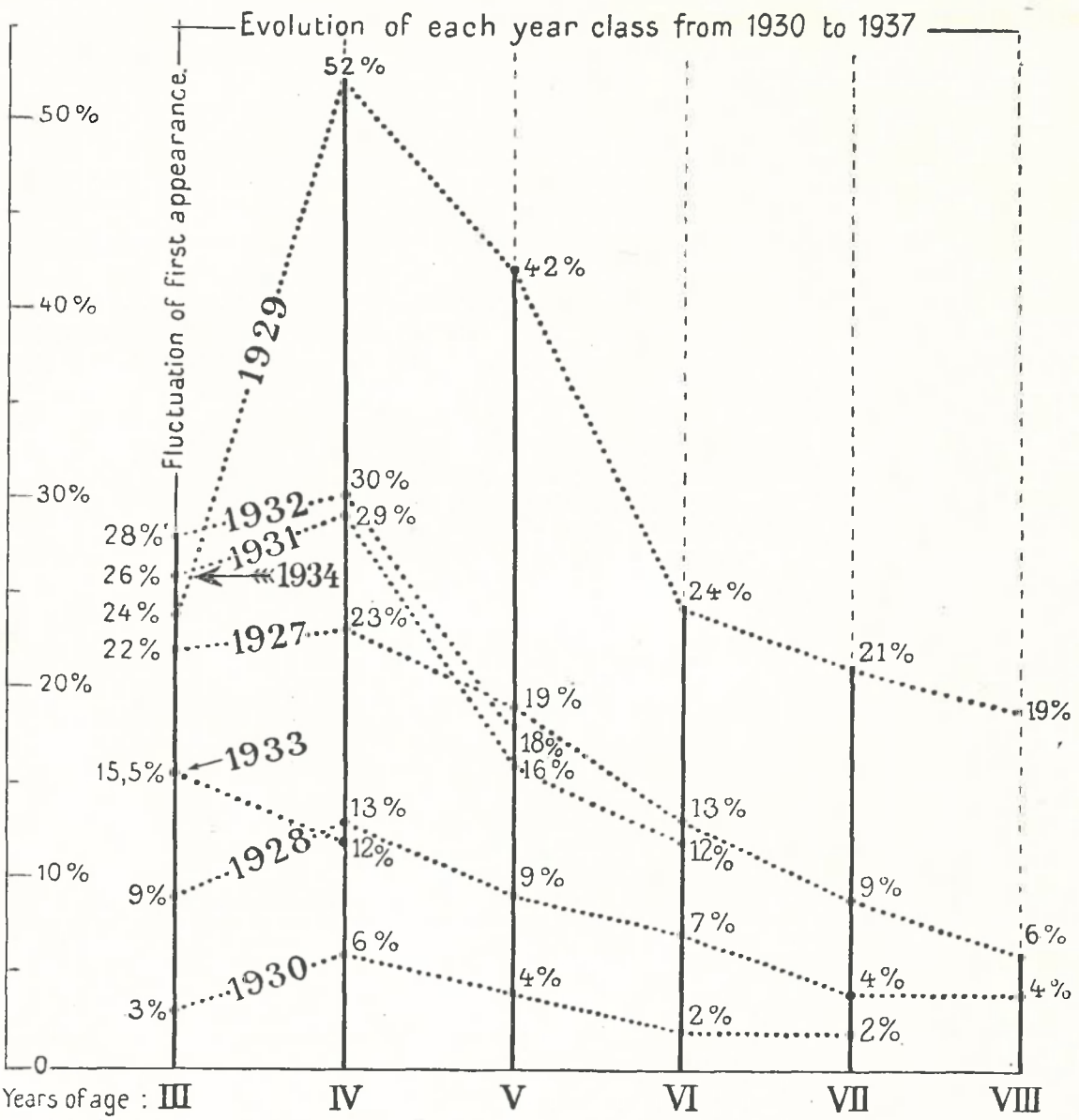


FIG. 2. Vertical lines = fluctuation. Dotted lines = oscillation.

We may conceive, however, that an entire year-class might be affected by a pathological or congenital predisposition, and so be liable to suffer from an alteration in the environment more deeply than the other classes in the shoal. But that very sensitiveness would be the effect of internal peculiarities or dispositions and the external actions would be only accessory in the reduction of the number of the units.

These remarks lead us to the conclusion that whilst affected by external actions prevailing in the environment, the oscillation of each particular age-class is dependent on internal organic conditions.

Forecasts.

As predicted in 1937, the concentration of 1937—1938 has shown a still good proportion of herrings of 5 and 6 years, with an important remnant of the remarkable class 1929. Besides that it was expected that the class 1933, just appeared with a passable initial percentage of 15,5 % and supposed to be in its augmentative stage, would also supply a passable percentage. In fact, however, this was not the case and the unusual reduction of class 1933 in its 4th year was a surprise.

For the season 1938—1939 is not possible seriously to draw a forecast, seven of the year-classes being already in their reduction stage, including 1933 that ought to have been in augmentation. We may expect that the remnant of the class 1934, then aged 4 years, will predominate, unless 1933 should show a not less unusual belated enrichment in units.

Quantitatively, there is no sign of a favourable fishing season and we can only wish for the fishermen that favourable meteorological and hydrographical conditions will prevail in the spawning grounds of the SW. and drive plenty of spent herrings towards Gris-Nez and Ostend.