International Council for the
Exploration of the Sea

C.M. 1962
Baltic-Belt Seas Committee
No. 116

# Comparative Estimation of the Condition of the Baltic Fish Stocks and Fluctuations in Their Abundance according to Soviet Research Data



By

T.F. Dementjeva

In 1961 fifteen years have passed since the beginning of wide complex investigations in the Baltic Sea. Quite naturally, at the first stage of work we concentrated mainly on ascertaining the phenomena observed and only in recent years many of these phenomena have been explained. The data collected during many years have helped to elucidate the causes of physical marine environment and population dynamics.

Some questions which were previously studied only in general are being thoroughly analysed now by numerous investigators. Different viewpoints appeared caused by further study of the peculiarities of the Baltic Sea and its inhabitants, including cod, Baltic herring, flounder and sprat. In this paper we would try to stress all those new things about estimation of the above-mentioned species stocks, which were obtained by Soviet scientists in recent years and proved in practice. Naturally, there is a lot of such problems, and it is very difficult to unite them in one report. We would like to discuss only some questions of methodical, practical or theoretical nature.

When determining initial positions and organizing investigations the works of the main investigators of the Baltic, such as Drs. Aa.J.C. Jensen, K. Demel, W. Cieglewicz, J. Lundbeck, R. Kändler, P. Meyer et al. were of great importance. The first research fishing expedition of 1908 under the leadership of E.K. Suvorov, A.A. Libedintsev et al. also carried out an important work.

When speaking about peculiarities of interconnection between hydrological conditions of a sea and distribution and reproduction of commercial fish one cannot but note that just this sea is the most obvious case of interrelation between vitality processes and physical environment of a sea, a fact that becomes obvious when analysing data from many years collected and generalized for a period of more than 50 years. Among works on this question papers by A. Glowinska, W. Mańkowski, A.M. Soskin, A.A. Nikolaev et al. should be mentioned. Last year a book written by G.K. Izhevsky was published in which the author made an attempt to reveal new forms of interdependence between fluctuations in abundance of some fish species and physical and organical nature of the Baltic Sea.

## Hydrology and climate

Our idea of the peculiarities of the conditions of the Baltic formed by comparison of works available in this field as well as by biological processes observed by us, can be summarized as follows:- it is known that the specific hydrological conditions in the Baltic are caused by the water exchange with the North Sea and by the intensity of discharge of large rivers draining into the Baltic Sea from the southern and eastern coasts.

Influx of the North Sea waters is not only due to a permanent current, but mainly due to separate incoming flows of different intensity. The influx is a result of sea-water coming in from Skagerak and Kattegat under the influence of various geophysical factors. There are different opinions about the nature of this influx of North Sea waters, but these problems will not be discussed here. We join I.M. Soskin (1956) in the opinion that in addition to the river discharge, the condition of the sea level which depends on reiteration of deep cyclons over Europe, is of great importance. When cyclons are coming in over North Europe an increased influx of North Sea waters into the Baltic is observed.

Oceanologists of all Baltic countries noted a sharp change in salinity composition of neak-bottom waters of the Baltic Sea which occurred after 1930. Since that time and up to the middle fifties a gradual increase in the salinity of these waters was observed, including four periods of an extremely high increase in the salinity. Soskin thinks that it is connected, as has already been mentioned above, with the increase in reiteration of deep cyclons over Europe and that shortly after the thirties the reiteration of such cyclons was above normal. It resulted in a great increase in the influx of waters to the Baltic Sea as well as in a decrease in precipitation in its basin. Thus, an alteration of the atmospheric circulation leads to the intensity of the influx of the North Sea water and to the change in the amount of precipitation.

According to Soskin the above-mentioned cycle is at present changing into another cycle with an opposite tendency in the course of salinity and by the beginning of the sixties the salinity value of the sea decreased to its average value during many years. In 1960-1961 a slight increase in the salinity was, however, observed.

In the end of 1961 the International Symposium on the problems of climate alteration was held in Rome. During the Symposium the Soviet Climatologists' point of view was confirmed, i.e. about a cold period lasting from the end of the last century until the twenties-thirties, and followed by a considerably warmer period. The latter lasted until the fifties. It is supposed that for the next 20-30 years there will be a general climatic tendency towards cooling. Such changes of the climate of different periods are caused by fluctuations in the radiation of the sun. (B.L. Dzerdzeevsky, 1962).

Without touching upon more short-term fluctuations of climate, commented upon by many investigators of the Baltic, since such fluctuations take place at the background of long-term alterations, I would like to stress a great importance of the latter, as they create the general characteristics of one or the other period.

Cod

A warm period which lasted from the thirties up to the fifties was of great importance for the Baltic Sea..Almost all scientists agreed on the opinion that the abundance of the Baltic cod had sharply increased just after the thirties (more exactly after 1934) which was promoted by an enlargement of the spawning grounds.

The area of the spawning grounds of the Baltic cod is determined by the isohaline position in 11-12‰. During the years of an increased influx of North Sea waters, i.e. in 1933-1934, 1937-1938, 1947-1948, 1951-1952 and, probably, in the early fourties, the upper boundary of this zone was raising in the deeps considerably, i.e. there was an increase of the volume of water where such amount of oxygen was dissolved (salinity being fixed) that was required for the survival of a corresponding number of eggs. These were exactly the years when abundant year-classes of cod were observed, i.e. in 1934, 1937-1938, 1942, 1945, 1947-1949, 1953, and 1954. In the periods of 3-4 years these year-classes used to increase accordingly the total catches and catches per hour of trawling. With the same salinity efficiency of spawning may differ if there is a lack of oxygen. E.G., in 1958 deficiency of oxygen in the Gothland Deep was so great that the generation of that year was extremely poor and the spawners were migrating westward (Rurkovich, 1958). An abundant year-class is usually observed just after the renewal of waters and often the next year-class is also productive, as e.g. the 1953 and 1954 year-classes.

The accordance of the intensive influx of the North Sea waters with the rich year-classes is a good proof of the basic importance of some abiotic factors on which the survival of embryos of cod depend. The other proof of dependence is the calculation of correlation between dead and alive eggs during the period of development, which was done on our recommendation. In the years of abundant year-classes the percentage of alive eggs was always higher than in the years of poor year-classes (N.P. Birjukov, G.I. Tokareva, and A.V. Seletskaya, 1960). Calculation of correlation between dead and alive eggs and the following registration of fingerlings and yearlings conducted by Tokareva in collaboration with BaltNIRO in the winter period help to forecast the recruitment of the spawning stock.

During the years when there is feeding zooplankton, the survival of larvae greatly increases as was observed in 1957. Data on food supply for larvae are still scarce. G. Alander (1947) is of the opinion that larvae feed in the upper water layers. G.B. Grauman (1956) corroborated the fact that the stomachs of cod larvae of up to 8 mm length at depths of more than 20 m were empty by 100 %. Hardly any data are available on the speed of vertical migration of larvae from depths, the speed and direction of the larvae drift from the cod spawning areas, and on other important ecological factors.

The process of feeding of adult cod has been studied much more thoroughly. The cod which had adapted themselves to the conditions of the relatively warm Baltic Sea were affected not only in reproduction but also in the process of feeding and growth.As the works of Professor F. Chrzan (1961), N.N. Spassky (1958) and others showed, the most intensive feeding takes place not in the summer months but in the autumn. In accordance with this the most intensive growth of cod is observed during the autumn (G.I. Tokareva, 1953), which in its turn, results in later maturing. (December-January).

The first maturity of the Baltic cod occurs during the third year of life. The amount of maturing three year-olds, which are a recruit stock, increases due to the better growth of fish during the first and second years of life (Tokareva, in press). Duration of life of the early maturing specimens is shorter on an average than that of the late maturing ones. It affects the rate of the commercial exploitation of year-classes and should be taken into consideration when calculating fishing mortality rate.

Thus, maturing leads to some rejuvenation of a commercial fish stock. At the same time, the process of rejuvenation goes on mainly with the increased intensification of fishing and especially overcatch of the young. Because of this fact rejuvenation of an early matured stock is not always noticeable.

For example, catch of the young of Baltic cod, i.e. fish below legal length (30 cm), was always big enough, especially during the years of abundant year-classes. It should be noted, that in 196 and 1962 the by-catch of the young was especially noticeable, for the new 1959-1960 year-classes was above the average and old year-classes were poor. All these facts prove keen necessity for fishing regulations in the Baltic. Protection of new year-classes is also required in order to maintain the total level of the abundance of cod stocks, which has now considerably decreased due to fishing some poor and non-productive year-classes (1956, 1957, and 1958). In connection with this, the catches in 1962 decreased considerably. The USSR carries out a programme on the protection of the cod stocks recommended by the Baltic-Belt Seas Committee of ICES.

Increase of salinity and oxygen content in 1959-1960 in the bottom water layers did not give expected results. The 1960 year-class is of a higher abundance than the previous 1958 and 1959 year-classes, but it is not above an average level, as seen from the calculation of the young in Figure 1. Some scientists thought that at the early sixties a considerable increase in the abundance of the stocks of cod would take place, but so far we have no data confirming this supposition. Moreover, if a period comes which is contrary in phase to the previous one as was mentioned above, one would expect the total reproduction of cod to decrease.

Baltic herring (salaka)

There are several works on the biology of Baltic herring which characterize its stock dynamics and try to explain the reasons of fluctuations in its abundance. Among Soviet investigators M.N. Lishev, I.I. Nikolaev, L.A. Rannak, A.V. Seletskaya, L.N. Lesivnenko et al. should be mentioned. Without discussing all problems raised by these authors we would only note the fact that during the post-war period there was an increase in the abundance of spring-spawning herring, which later on was followed by a decrease.

In the southern regions of the Baltic a decrease in the abundance of the spring herring stocks began somewhat earlier than in the Central Baltic.

Systematic work on the calculation of the Baltic herring young (larvae) (L.A. Rannak, 1954) conducted in the northern part of the Gulf of Riga created a solid basis for predicting and judging about the reasons of fluctuations of herring abundance in the Gulf of Riga.

These reasons were explained on the basis of a thorough study of the interconnection of different factors, e.g. fluctuations of river discharge, plankton biomass and abundance of the spring herring year-classes. In the Gulf of Vistula the population dynamics of year-classes was synchronous to that of the Gulf of Riga during the period 1946-1952, but later on the productivity of the year-classes began to differ. In the southern part of the sea the 1952 year-class was richer than in the northern one. The reason for this has not yet been explained.

Later on the abundance of spring-spawning herring in the Gulf of Vistula began to decrease sharply. Since 1955 the kylka (sprat) stock began to recover and in short time the catch of sprat increased considerably and even exceeded the catches of the pre-war period (period of great abundance of sprat stocks). Some authors are trying to explain a decline in the abundance of herring stocks by the interspecies' relationship with the increased sprat stock. This explanation can, however, hardly be acceptable, as it is a well known fact that the destiny of Baltic herring and sprat is determined at the larval stage when changing for active feeding takes place, and that the critical period for herring is May-June, and for sprat June-July; the areas of reproduction of both species do not coincide. Sprat breeding is mainly bias to central regions of the high sea, and Baltic herring breeding to bays.

Effect of fishing and change to worse conditions for natural reproduction are among the reasons for a decrease in the abundance of spring-spawning herring.

Effect of fishing is highest in the Gulf of Riga, where trawl fishing has developed on a wide scale. The Gulf of Riga is the main region of reproduction of herring which stay in the gulf until the first maturity stage. Naturally, catch of the young is unavoidable, notwithstanding the introduction of restriction rules, as at the time of passing through the mesh of a trawl, the mortality rate of the young is high, as was observed by Lishev.

This is, however, not the main reason. Since a decrease in the abundance of fish takes place simultaneously with development of fishing in different areas of the Baltic

(Fig. 2), it is quite natural to suppose that the main reason of a decrease in the abundance of spring-spawning herring is worsening of the conditions of reproduction. I. Popiel and J. Elwertowski (1959) also note a decrease in the abundance of spring-spawning herring in the southern part of the sea.

It is interesting to note that earlier revealed interdependence between the value of plankton biomass and the productivity of the spring-spawning herring is not observed now - at the period of high level of water in the rivers - although it seems as if a great discharge of rivers should have resulted in great plankton productivity and, thus in a higher survival rate of the herring larvae.

Apparently, the reason of deviation from the regularity mentioned above is the variation of intensity of exchange of waters between the Gulf of Riga and high seas due to an increase of discharge of rivers as well as an increase of the current speed. One can suppose that more active transition of biogens across gulfs to the high seas favoured enrichment of the latter against productivity of the Gulf.

Now we shall attempt to trace changes in plankton biomass in the Gulf of Riga and in the high seas as thoroughly as Nikolaev has done in the Annales Biologiques for several years.

Average abundance of crustacea per 1 $m^3$ in the 20-0 m layer in the Gulf of Riga and in the 25-0 m layer in the high seas (according to Nikolaev)

| | | Year | | | |
|---|---|---|---|---|---|
| Area | Month | 1954 | 1955 | 1956 | 1957 |
| The Gulf of Riga | May | 5.5 | 6.3 | 8.0 | 25.9 |
| | June | 9.1 | 9.4 | 6.4 | 14.5 |
| Central Baltic | May | 5.4 | 10.1 | 8.7 | 49.3 |
| | June | 22.4 | - | 14.2 | 41.6 |

While comparing a productivity of surface waters of the high seas with that of the Gulf of Riga in previous years, Nikolaev pointed out, that in spring and summer periods (seasons with the greatest intensity of plankton development) indices of plankton productivity are always considerably higher in gulfs of the Baltic, than those in the high seas, since the gulfs receive a large amount of freshwater discharge. V.M. Bodnek wrote about these things by the data of 1949 (1952). Later on in 1954-1957 the productivity of the Baltic high seas increased as compared with that in the Gulf of Riga.

Sprat

These correlations confirm dependence of fluctuations of sprat abundance on dynamics and productivity of the Baltic waters which were discovered by Nikolaev in 1958. A sharp increase in the Baltic sprat stocks proved correctness of regularities established by Nikolaev. Nikolaev's work "Plankton and fishing productivity of the Baltic Sea" undoubtedly contributed to the study of environment processes which determine the Baltic productivity and its conditions (1960).

At present some decrease in sprat abundance is observed.

Flounder

Since flounder is not the main species in our fishery, a special study of this fish is limited. However, data from many years on the biological characteristics of flounder which were analysed in combination with environmental factors, fishing and interspecies relationship with other Baltic inhabitants, allowed us to draw some interesting conclusions of practical and theoretical importance. These works were primarily carried out by K.A. Zemskaya (1960). The result of his investigations can be summarized as follows:-

Flounder year-classes from recent years cannot be distinguished by their reproductivity. Its stocks are relatively stable and poor. A large recruitment of the stock has not been observed lately, therefore catches per effort have slightly decreased. All this points to the importance of rational fishing of flounder, particularly owing to their low mobility. Flounder 22-24 cm in length becomes a typically molluscous fish. At that time the intensity of its feeding sharply increases. On this basis M.V. Geltenkova once drew an assumption of a possible increase in the least measure of flounder taking into account intensity of an increase in weight after it had reached the length mentioned above. (1954). Zemskaya indicated that this peculiarity of the Baltic flounder can be observed by its growth. At the fifth year of a flounder's life its growth increases sharply for it starts to feed on large molluscs in spite of deceleration in previous years.

Since the population of flounder is small and the amplitude of fluctuation in abundance is little, flounder is provided with food at any time. Owing to this, there is no direct relation between the growth of individuals and feeding productivity of the Baltic Sea. Zemskaya refers to the investigations conducted by A. Bückmann, A. Kotthaus, and G. Hempel, who noted that only a very productive year-class of flounder has a slow growth.

Zemskaya made a comparison between the growth of fishes, density of stock, and feeding productivity of the sea, according to alteration of biogen discharge of the rivers since no data were available on feeding resources. An analysis did not show a dependence between these values. On the contrary, differences in the growth mainly correlated with thermic conditions created in the sea in a fattening period. These conditions regulate an intensity of fish metabolism as well as prolong or shorten a season of intensive feeding, which could be observed in the study of other fishes (Dementjeva, 1952). All the mentioned peculiarities of the growth are of great importance when determining the least measure, which is very complicated to do because of the area-wise variation in size of the flounder.

The work of N.I. Surkova (1961), showed that the flounder in the Gulf of Riga is of a smaller length than that in the Ventspils area, but is larger by weight having the same length and obviously richer fat content. The reasons for such differencies are not yet thoroughly studied and reasons affecting fluctuations in abundance of flounder, apart from fishing, are not well known.

All these questions which we discussed along with the assessment of Baltic fish stocks are of great importance for solving a number of general regularities which constitute the theoretical grounds of fish population dynamics. There are particularly some questions to be solved, such as significance of changes in biological characteristics of fish population according to the rate of fish growth and its maturity and hence to the duration of fishing of this population.

The first results in this direction were obtained at VNIRO. The significance of all these interconnected phenomena is often shaded by changes in population structure and particularly in rejuvenation processes of commercial fish stocks which are caused by intensification of fishing. Effects of fishing in such cases is rather high. Nevertheless one should take into account effects not only of this factor but of others too, which reflect the reaction of an organism to changes of environmental conditions.

A study of the complex of all conditions combined with the analysis of effects of fishing would help to understand properly acting processes and to apply the most expedient measures on regulation of the exploitation of fish stocks.

## References


| | | |
|---|---|---|
| Alander, G. | 1947 | "Cod in the Southern Baltic". Ann. biol., Copenhague, 2. |
| Birjukov, N.P., Tokareva, G.I., & Seletskaja, A.V. | 1960 | "On the stocks of main food fishes in the southern and south-eastern Baltic Sea". Soviet Fish. Invest. in North European Seas. VNIRO-PINRO. |
| Bodnek, V.M. | 1954 | "Zooplankton in the middle and southern Baltic Sea and the Gulf of Riga". Trudy VNIRO, 26. |
| Chrzan, F. | 1962 | "The food and feeding of cod in the Gulf of Gdansk". Prace Morsk. Inst. Ryb. w Gdyni, 11A. |
| Dementjeva, T.F. | 1952 | "The growth of fish in occordance with population dynamics problem". Zool. J., 31(4). |
| Dzerdzeevsky, B.L. | 1962 | The USSR Acad. Sci. Ed., Geogr. Ser., No. 5. |
| Kändler, R. | 1944 | "Untersuchung über den Ostseedorsch während der Forschungsfahrten mit dem Reichsforschungsdampfer 'Poseidon' in den Jahren 1925-1938". Ber. Deutsch. Wiss. Komm. Meeresforsch., 2(2). |
| Nikolaev, I.I. | 1958 | "On the long-term fluctuations in the abundance of Baltic sprat as related to the fluctuation in the productivity of plankton. Trudy VNIRO, 34. |
| Rannak, L.A. | 1958 | "Quantitative study of the Baltic herring, eggs and larvae in the northern part of the Gulf of Riga and principal factors determining their survival." Trudy VNIRO, 34. |
| Rutkowitz, S. | | "The progress of cod spawning in the southern Baltic in the spring of 1958". C.M. 1958. |
| Soskin, I.M. | 1956 | "Long-term fluctuations of salinity in the Baltic Sea". Trudy State Oceanogr. Inst., No. 32. |
| Spassky, N.N., & Mereginskaya, C.M. | 1958 | "Distribution and seasonal alterations in food resources and feeding of cod in the Klaipeda area of the Baltic Sea in 1956-1957". Trudy BaltNIRO, No. 4. |
| Suvorov, E.K. | 1913 | "On the Baltic ichthyofauna". Trudy Baltic Exped., No. 2. |
| Tokareva, G.I. | | "The methods of determining the age and the peculiarities of the growth of the Baltic cod". Trudy BaltNIRO. |
| Zemskaya, K.A. | 1961 | "Growth of fish in populations with inconsiderable fluctuations of abundance". J. Probl. Ichthyol., 1(4): 21. |

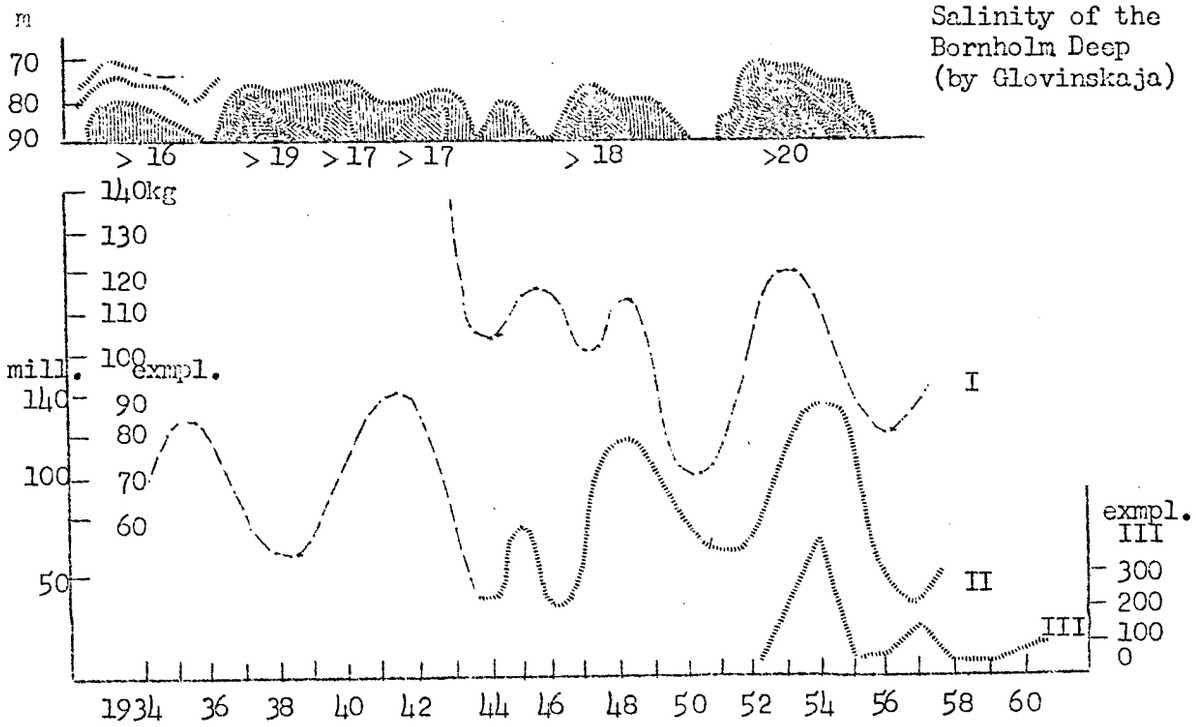


Figure 1. The dynamics of catches, values of year-classes and average catches of Baltic cod fingerlings by years as compared with alterations of salinity conditions in Bornholm Deep. I = Average catch per one hour trawling, taken as 3-4 years in advance; II = Value of numbers of year-classes in millions; III = Average catch of fingerlings per one hour trawling in numbers.

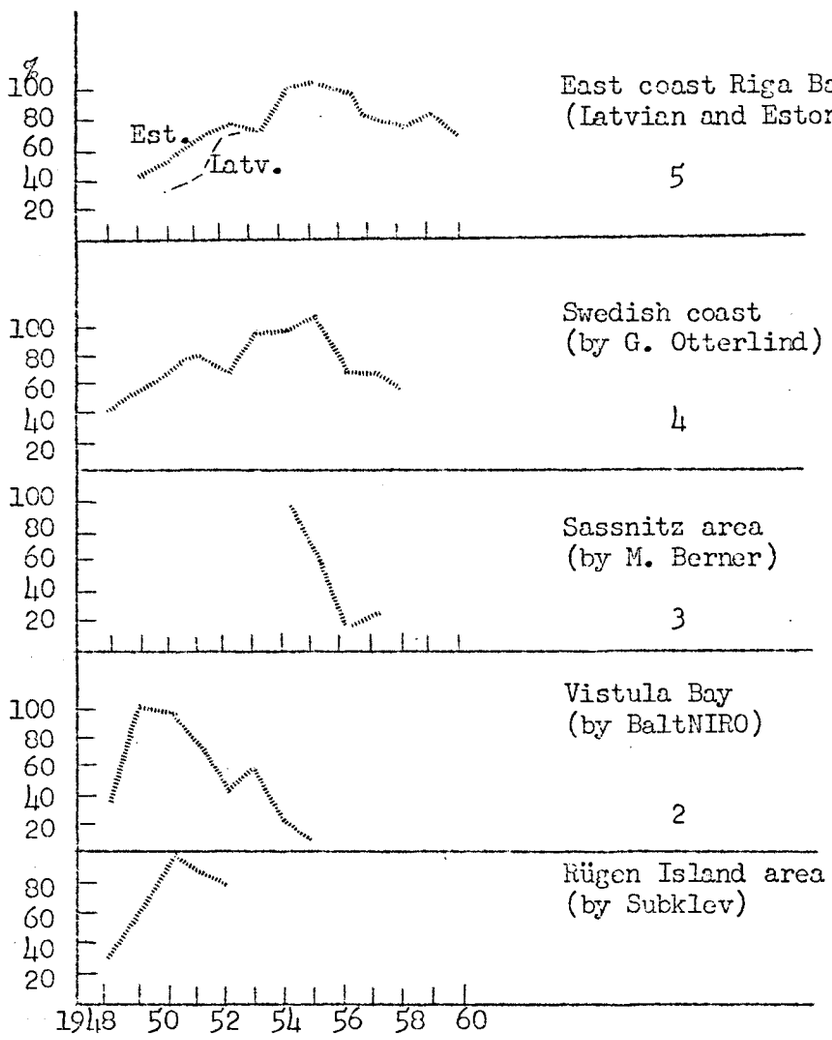


Figure 2. Dynamics of spring-spawning salaka (Baltic herring) in various parts of the Baltic in per cent.