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Changes in the Recruitment to the Stock with Reference to the Environment and Mathematical Modelling with Notes to Changes

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The efficiency of regulation of a fishery and accuracy of prediction depend in some cases on how completely the causes of the changes in the stock are evaluated. Prior to making a judgement of the causes it is necessary to know how far the whole complex of factors is studied and checked up. The task facing ichthyologists is to assess the quantitative effect of some or another factor on the dynamics of population, and particularly the role of a governing factor.

Among other causes affecting the stock the governing factor may be such a cause by which - under certain conditions - a direct relation with the abundance of the population at one or another stage of development can be established.

The population of fish becomes specific while dwelling in a water body. This is the cause of a relative consistency of the governing factors to effect the survival of the population. The governing factors may be replaced by some others only on condition that fairly sharp changes both in the hydrologic regime and food resources take place or new fishing methods are introduced, aimed at the intensification of the fishery.

Among the main factors it is necessary to distinguish causes which bring about long-range fluctuations in the abundance of the stock, and causes affecting annual fluctuations in the sizes of the year-classes. No border can be established between them due to their close relation. Nevertheless, an approach should be differently chosen to gain some knowledge of their role as a factor governing either long-term or short-term fluctuations in the stock in some or other cases.

The annual recruitment size varies greatly, and thus the relation between the recruitment and survivers in the fishing stock also ranges, particularly in fishes with a short or medium span of life, bringing about changes in the relation between catches and abundance of fish.

Consequently, it is quite obvious that the causes of annual fluctuations in the recruitment size should be clearly elucidated. In most species the annual fluctuations bear close relations to the survival of embryos and food supply for larvae at the early stages. It is at this time that the heaviest mortality in fish is known to occur. Great fecundity of fish is an adaptive ability to compensate the early mortality, so that the abundance of the species should be kept. If the early mortality was reduced by some percentage or even by some friction it would lead to a considerable increase in the abundance of the species, of course, under favourable conditions.

This statement can serve as a basis for the establishment of a direct fishing management in the sea by increasing the food supply for larvae, and in this way facilitating the percentage of survival and fishing returns (England, Japan).

Let us consider some results obtained in the U.S.S.R. during the recent decade supporting the existence of a direct relation between the abiotic and biotic factors and survival of young fish at the early stages.

A lot of data exist on the relation between the availability of food plankton and survival of larvae when they turn to the active feeding, which undoubtedly indicate that this factor should be considered as a governing factor for the abundance of the year-class.

L.N. Lisivnenko (1961) studying the material collected in the period 1955-59 on the abundance of zooplankton in the Riga Gulf and that of larvae of the Baltic spring/spawning herring, found a quite clear, quantitative relation shown in Figure 1 as an S-formed curve. In some years when the larvae of the Baltic herring turn to the active feeding the small plankton was poor (1 organism in more than 100 cm^3 of water), so a shift in the normal feeding conditions could be observed and the year-classes were usually poor. On the contrary, in other years when the small plankton was relatively rich the frequency of occurrence of larvae and plankton organisms increases. If one organism occurs in the volume of less than 100 cm^3 of water the feeding conditions for larvae become normal and the survival is high.

The same relation is found for the Baltic anchovy (R.M. Pavlovskaya, 1961). As shown in Figure 2 there is almost a direct relation between the survival of the young fish and biomass of food zooplankton in the period 1949-58. The heaviest generations are observed with a concentration of more than 10,000 organisms or 500 mg per m^3 of water for 4-10 mm fish larvae. Of great importance is the duly development of food plankton in the period when the anchovy larvae appear in mass.

For the Baltic cod a direct relation between the salinity and aeration of off-bottom waters in the deeps (spawning places for cod) and survival of eggs was found. The fluctuations in the abundance of embryos are in compliance with the fluctuations in the mean catches of one-summer-olds and catches of adult fish at corresponding ages.

For the Barents Sea cod the relation between the abundance of year-classes and temperature which seems to affect the food supply for the cod larvae was established (Kislakov, 1959).

In all the inland seas there is a direct relation between the abundance of the migratory and semi-migratory fishes and the volumes of the river discharges which provide suitable spawning areas and food supply for the fish at early stages. Specific research in this field was carried out by L.A. Rannak on the Baltic herring, S.G. Kryzhanovsky on Sakhalin herring, V.I. Vladimirov on Danube herring, E.G. Boiko on bream and perch pike of the Azov Sea, T.F. Dementyeva, V.S. Tanasiychuk, A.G. Kuzmin on sea bream, perch pike and Rutilus rutilus of the Caspian Sea, A.A. Ostroumov on bream of the artificial Rybinsk water body and other workers, the results being similar.

The interrelation between the spawning of fish and abiotic and biotic environment is so distinctly expressed that it enables us to work out methods of calculating the stock population by using characteristics of environmental factors (G. Izhevsky, 1961) in view, of course, of the fishing mortality.

Due to the above-mentioned causes the wide range of the annual fluctuations in recruitment to the fishery stock should include the fluctuations in models on the dynamics of the population fished. The calculations of the recruitment size and possible changes can be obtained from the quantitative counts of the young fish at various stages of development. For this purpose annual observations on spawning should be carried out, the result of which can be assessed in various ways, as follows:-

1. By mean catches of spawned eggs at various stages of development in view of the percentage of living embryos and environmental conditions;

2. by mean catches of larvae at the stage of development after turning to the active feeding;

3. by mean catches of one-summer-olds to assess the density of their distribution per unit of area;

4. by mean catches of young age-groups (prior to maturation) per commercial or research fishing gear.

The method of counting one-summer-olds is likely more advantageous due to the fact that it enables us to assess the young fish at the stage when the heaviest mortality of eggs and larvae has already occurred. The evidence can be supported by a correlation between the fishery returns and mean catches of one-summer-olds of a certain year-class. Using this relation this index can be applied to calculations of the recruitment size to the fishing stock.

The counts of eggs and larvae may also be promising in making judgement of strength differences of the year-classes; however, the data obtained are, to a lesser extent, useful for the mathematical calculations.

In most cases they only indicate trends of fluctuations in the strength of the year-classes and may be suggestive in the studies of the causes conditioning the survival of embryos and larvae at early stages of development.

Summary

The efficiency of measures on regulation of fishery and precision of fishery forecasts depends in a number of cases on how clear reasons of fish stock fluctuations are.

For the majority of fish species annual fluctuations of stock depending on the value of recruitment are noted. These fluctuations depend upon the conditions of fetuses survival and food provision for larvae at the stage of their transition to external feeding. When the conditions for species being optimum the decrease in larvae mortality by some percentage or even by shares of percentage results in a considerable increase in fish population.

During the recent decade a great number of papers on investigations showing a direct relationship between abiotic and biotic factors and survival of young fish at early stages were published. In particular, some data available on the relationship between the number of food plankton and survival of larvae, allow us to consider this factor (that does not depend on the population density) to be of extreme importance when determining recruitment abundance. The data also show that in the case of species for which a critical period is that of transition to an active feeding, a level of plankton density is that at which an abundant year-class survives.

Thus, to estimate an abundant year-class of the Baltic herring it is necessary to have less than 100 cm^3 of water per 1 food organism (Lisivnenko, 1961); the density of plankton which is necessary to estimate an abundant year-class of the Black Sea anchovy, is counted in another form; such year-classes were observed when the density of food plankton for the larvae 4 - 10 mm long was above 10,000 organisms or 500 mg per 1 m^3 (Pavlovskaya, 1961). These data allow us to look for ways to determine the value of a stock of consumers on the basis of the value of plankton biomass.

Taking into consideration the wide range of fluctuations of annual recruitments of commercial fish stocks due to the above reasons, it is considered extremely necessary to show these fluctuations when making a model which expresses the dynamics of fishing population.

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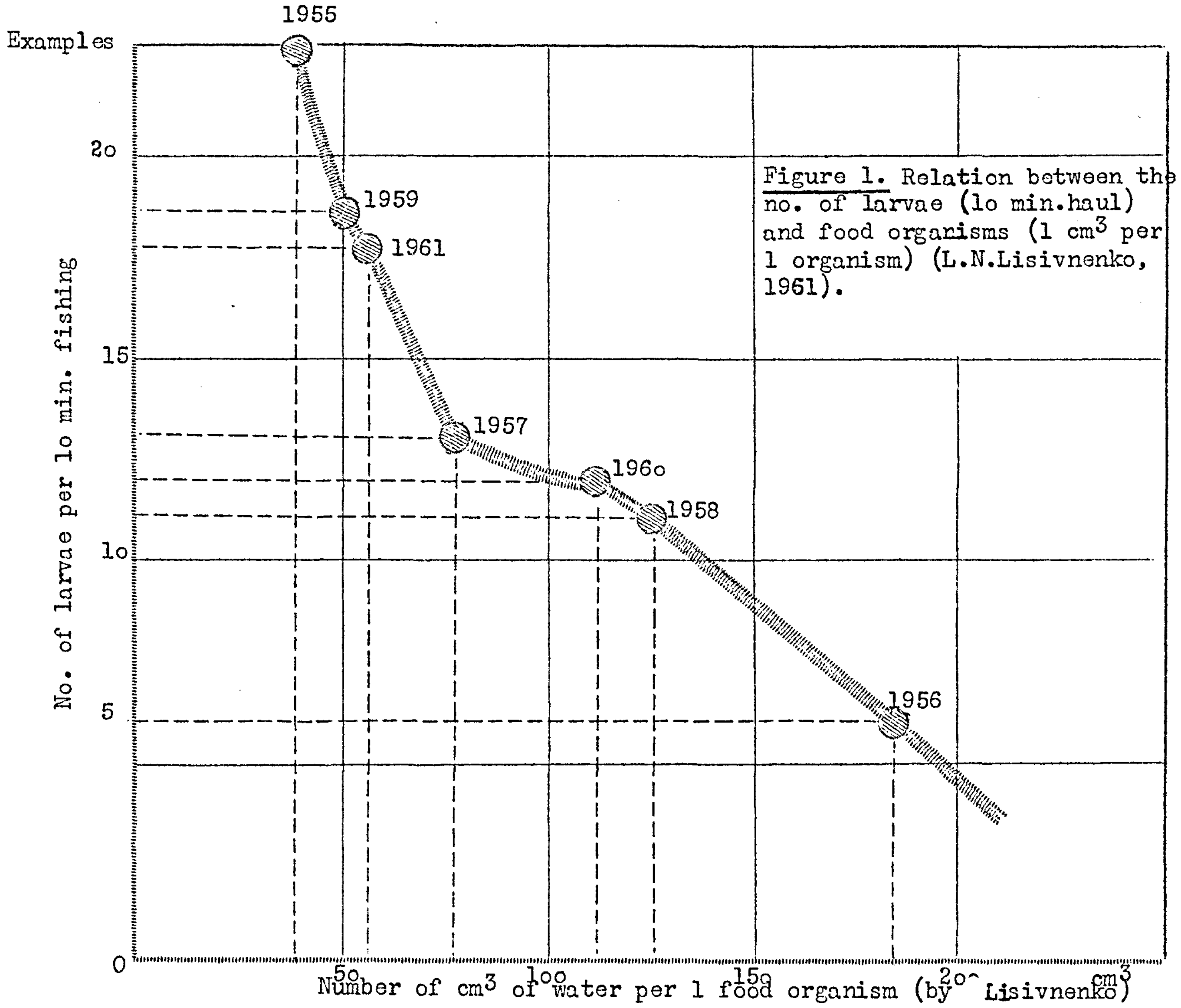

Figure 1. Relation between the no. of larvae (lo min.haul) and food organisms (1 cm^3 per 1 organism) (L.N.Lisivnenko, 1961).

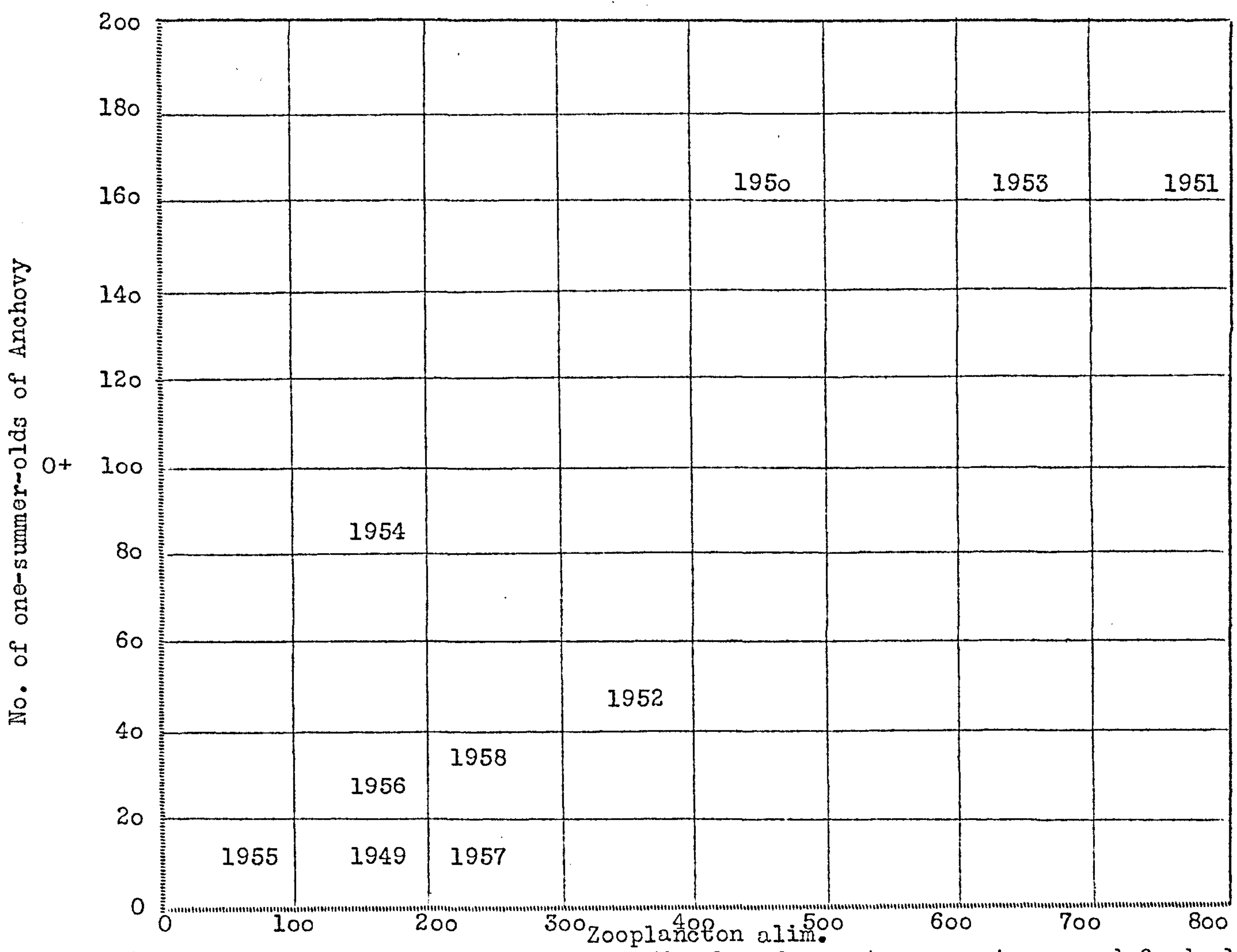

Figure 2. Relation between the strength of anchovy at young stages and food plankton biomass in the north-western Black Sea, 1949-58. (R.M.Pavlovskaya, 1961).

Black Sea