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Dynamics of some parameters of herring populations in the Northeastern Baltic in 1948-1979

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Abstract

The Väinameri-Hiiumaa, Gulf of Finland and Gulf of Riga spring herring stocks and the Gulf of Riga autumn herring differ considerably from each other by dynamics of year-class abundance, average length and weight at age and fishing mortality. Therefore they should be managed separately. The stock parameters depend principally on natural factors. However, up to now they have been increasingly affected by human activity, especially by fishery. By limitation of catches a decrease and stabilization of fishing mortality in all age-groups and by increasing the minimum mesh-size in herring trawl codends in the Gulf of Riga – considerable decrease in mortality of young herring in populations of that gulf has been achieved.

Résumé

Le hareng de la Baltique printanier de la Väinameri-Hiiumaa, du golfe Finlandais, du golf de Riga et le hareng de la Baltique automnal se distinguent par la quantité des générations, la biomasse, la longueure moyenne et le poids moyen des âge-groupes, ainsi que par la dynamique de mortalité industrielle. Pour cela il faut en raison de distribution des stocks, les examiner séparément. Sur les paramètres des stocks, qui dépendent, au

fond, du changement des actions naturelles, ont jusque ici de plus en plus influencáient aussi les effects antropologiques, surtout la pêche. Par limitation des captures on a abtenu la diminuation et la stabilisation de mortalité industrielle de tous les âge-groups des populations en question et par l'augmentation des cellules des chaluts, utilisés pour la pêche du hareng de la Baltique dans le golfe de Riga – une remarquable décroissance de mortalité du jeune hareng de la Baltique des populations de ce golfe.

Herring stocks of different areas of the Northeastern and Eastern Baltic (the Gulf of Finland, Gulf of Riga, Väinameri--Hiiumaa, Saaremaa-Ventspils) have been managed separately already for a long time, for in the dynamics of year-class abundance, growth pattern and other parameters of these stocks as well as in fluctuation of catches in corresponding areas important differences have been found (Rannak, 1954, 1971; Ojaveer, 1974; Ojaveer et al., 1975; etc.). On the ground of material collected in four larger herring groups of the Northeastern Baltic in 1948-1979, an attempt has been done to estimate expediency of management of these resources by mentioned unit stocks. Also, it is of special interest to elucidate peculiarities of different populations in long-term dynamics of some parameters for that allows to evaluate dependence of changes in these parameters on natural factors and human activity.

Material and methods

Parameters of the Väinameri-Hiiumaa, Gulf of Finland and Gulf of Riga spring herring and of the Gulf of Riga autumn herring will be discussed, for these groups constitute the main or important part in herring stocks of corresponding areas. Less abundant groups (the Gulf of Finland and Väinameri--Hiiumaa autumn herring) are not considered mainly because of the material sampled from these groups covers shorter period

and is less representative.

Data on Soviet herring pound net, net and trawl catches by months, seasons and years were used as well as information on age compocition, average length and weight at age found on the basis of samples taken from these catches. For determination of numbers of herrings of certain population in catches, from the catches got in the area of that population an estimated amount of herring not belonging to that population, was subtracted. The estimates were based on information on seasonal changes of fishing places, results of differentiation of herring populations by means of otoliths et c. Some data concerning the size of catches in the eastern part of the Gulf of Finland before 1965, their age composition and average weight at age is taken from literature (Morozova, 1967, 1971; Morozova et al., 1971). The material was processed by the method of virtual population analysis. The natural mortality coefficient was varied by age-groups and years according to the published data (Ojaveer, 1974) as well as by periods of absence or invasion of cod into the Northeastern Baltic (before 1955; 1965-1966; beginning from 1976-1977). Two sets of natural mortality coefficients was applied – one for the periods of invasion of cod and another for the periods of absence of cod (Fig. 1). Regarding the material published earlier (Ojaveer, 1974) it was supposed that in the periods of absence of cod the natural mortality coefficient is the lowest in the youngest age-groups of adult herring and it increases with age. It was also assumed that the natural mortality increases in the age-groups 1 and 0. Since cod consumes chiefly younger herring (Uzars, Lishev, 1967), in the periods of cod invasion the natural mortality of herring was increased the most in the age groups 1-3 (Fig. 1).

Results and discussion

1. Year-class abundance, population biomass and fishing mortality.

At the end of the forties the total biomass of the Väinameri-Hiiumaa population was moderate despite during the

World War II and some time after the war the intensity of stock exploitation was low. That is supported by low fishing mortality both adult and adolescent parts of population as well as by age composition of catches (Fig. 2,3; Table 1). The population was fished mainly with pound nets on the spawning grounds. In the late forties and in the early fifties in that population a number of relatively abundant year-classes occurred. That caused increase in population biomass and its high level in 1951-1955. However, in the middle of the fifties the abundance of year-classes diminished and during the period 1956-1963 that was very low since among very poor year-classes only these of 1957, 1959 and 1961 had somewhat higher abundance. By that time the intensity of pound net fishery on the spawning grounds had increased. The decrease in average abundance of year-classes in 1956-1963 and the intense fishery resulted in reduction of stock size and in decline of importance of older age-groups (Fig. 2, 3). From the middle of the sixties to the middle of the seventies there was a clear tendency for increase in abundance of year-classes in that population. Fishing intensity on the spawning grounds dropped. In the early sixties specialized trawl fishery for that population started (earlier it was exploited by trawl fishery only as bycatch in sprat fishery). That was accompanied with changes in the age composition of catches (Fig. 3) and with increase in the fishing mortality of immature herring (Table 1) although it remained on a much lower level than in other areas. Compared with the late fifties, the fishing mortality of adult herring diminished, hence the population biomass increased more rapidly than catches. The level of the fishing mortality was relatively low in the early seventies when limitation of Soviet catches was started in that area. In dependence on the abundance of year-classes having hatched and in accordance with increase in importance of trawl fishery in the first half of the seventies younger age-groups constituted an appreciable part in catches. The 1975 year-class of record abundance was followed by three relatively poor year-classes (according to preliminary estimates abundance of 1979 year-class is

above average). Therefore the population biomass has began to decrease. Consequently, during the years considered in the Väinameri spring herring population two periods of appearance of abundant year-classes and correspondingly two biomass maxima has occurred the latter maximum having been considerably higher than the former peak (Fig. 2).

It is problematic to consider the Gulf of Finland spring herring as one unit stock. In the eastern part of the gulf growth of herring is slower than in the western areas (see below), differences between these parts have been found in dynamics of herring catches, stock condition, age composition, fecundity (Rannak, 1970, 1971; Ojaveer, 1974, etc., Fig. 4). Therefore it can be supposed that herring does not mix randomly throughout the whole Gulf of Finland and the stock consists of a number of subunits with smooth transition between them. They can be combined into one unit stock only conventionally. The matter is further complicated with somewhat different intensity of stock exploitation in the eastern and western parts (Ojaveer, 1975). In the central and western parts of the gulf where the bottom relief is generally unsuitable for usage of bottom trawl, rapid development of trawl fishery started in connection with introduction of pelagic trawls in the middle of sixties. Before that time in the western part herring stock was exploited much less than in the eastern areas where the intensity of both pound net and trawl fishery was higher. However, at present the pattern and dimensions of herring migrations between various areas of the Gulf of Finland are unclear. Therefore the Gulf of Finland spring herring ought to be considered as one unit stock.

The nature of the material collected allows to consider the dynamics of population parameters of the whole Gulf of Finland herring together beginning from the late fifties. In the first half of the sixties the spring herring biomass was relatively low. The increase in the level of year-class abundance and in biomass beginning from 1964 was more abrupt than in the Väinameri-Hiiumaa population. The decrease of biomass due to decline in abundance of year-classes after 1975 occurred simultaneously with the population mentioned above. The fishing mortality of the Gulf of Finland herring increased faster and

it grew higher than in the Väinameri-Hiiumaa population. After limitation of catches had started at the beginning of seventies the fishing mortality decreased and stabilized (Fig. 2).

In case of exclusion of the 1975 year-class. in the Gulf of Riga spring herring the average abundance of year-classes hatched during the years 1961-1970 is distinctly higher than before or after that period (Fig. 2). Consequently, in the Gulf of Riga spring herring the period of occurrence of abundant year-classes coincides only in part with corresponding periods in the Väinameri-Hiiumaa and the Gulf of Finland populations. Completely different from other populations considered are the periods of occurrence of abundant year-classes and high biomass level of autumn herring of the Gulf of Riga. Nikolayev (1957) supposed that in the period of increase of spring herring stock the autumn herring stock decreases and vice versa. In the Figure 2 it can be seen that in some periods (1962-1965, 1968-1976) the trend in the biomasses of spring and autumn herring of the same area is opposite indeed. However in their biomass fluctuation also periods with similar trends have occurred (1966-1968; 1976-1979). It is noteworthy that in the Gulf of Riga abundant spring and autumn herring year-classes have hatched temporarily close to one another - in the same year (1961, 1964, 1970) or abundant spring herring year-class has occurred after appearance of good autumn herring year-class in preceding year (accordingly 1954-1955, 1956-1957, 1958-1959, 1960-1961; Figs. 2, 5, 6). Exceptionally in the year of hatching of the rich 1975 spring herring year-class or in the year before that no good autumn herring year-class occurred.

Due to influence of a relatively high fishing mortality, the curve reflecting changes in the Gulf of Riga spring herring biomass forms three waves with their crests in the years of occurrence of rich year-classes or just after these years. After a number of abundant year-classes had hatched during the second half of the fifties and the first half of the sixties the level of the autumn herring biomass was relactively high up to 1967. The second wave of high biomass was formed by the abundant

1970-1973 year-classes in the middle of the seventies.

The fishing mortality of the Gulf of Riga spring herring has been constantly higher than that of the autumn herring. Exception is the one-year-old herring, for in the second half of year the length of a considerable part of that age-group of the autumn herring exceeds the minimum length in force in that gulf. Two-year-old and older spring herring is exploited more intensely than corresponding autumn herring age-groups. Pound net fishery on the spring spawning grounds is more effective than net fishery on the autumn spawning grounds. Also, with the pelagic pair trawls that have turned into the main type of trawls in the Gulf of Riga after they had been introduced there in the early sixties, chiefly spring herring populating preferably higher water layers is caught; the bulk of autumn herring keeps into the bottom layers. For reduction of fishing mortality of younger herring, in 1972 in the Gulf of Riga the minimum mesh-size in herring codends was increased from 12 mm to 14 mm. That was followed by a decline in the fishing mortality of young herring (Table 1) and simultaneously in increase of rationality of stock exploitation (Shevtsov et al., 1976). As a result of more strict limitation of catches in the seventies the fishing mortality of adult part of the population decreased, too (Fig. 2).

Some year-classes of certain seasonal group of herring can be rich or poor throughout the whole Baltic Sea (Rannak, 1974) whereas the abundance of other year-classes varies in different parts of the sea. In the spring herring populations considered, in comparison with neighbouring year-classes those having hatched in 1951, 1953, 1955, 1959, 1961, 1964, 1967, 1970 and 1975 were rich and these having occurred in 1956, 1958, 1960, 1968, 1971, 1974 and 1976 – poor (Figs. 2, 3, 4, 5, 6). Undoubtedly, in formation of abundance of year-classes the most important role play natural conditions (Rannak, 1971; Ojaveer, 1974). However, with the increase in human activity the influence of anthropogenous factors grows. Based on the fact that the increase in the level of year-class abundance of the Väinameri-Hiiumaa and of the Gulf of Finland populations temporally coincides with a noticeable increase in concentration of biogenes in the surface layers of the sea and with an upward trend

in weight of younger herring feeding on plankton (see below) it can be supposed that the increase in productivity has, by increase in survival rate of larvae, influenced also the level of year-class abundance.

2. Average weight and length.

Trends in change of weights at age in the Väinameri-Hiiumaa and the Gulf of Finland spring herring substantially coincide. From the late forties to the early sixties no evident long-term trend can be seen in variation of weights at age on the spawning grounds of Väinameri-Hiiumaa and of the central part of the south coast of the Gulf of Finland (Fig. 7). But during the period 1960-1969 on these spawning grounds weight at age of younger herring and in the western Gulf of Finland that of all age-groups of herring has distinctly increased (Fig. 7, 8). On the spawning grounds of Väinameri-Hiiumaa and of the central part of the Gulf of Finland the weight at older ages was the highest in 1948-1960. In 1961-1962 it noticeably decreased. After that up to 1978 length and weight at older ages in the Väinameri-Hiiumaa population generally increased but on the spawning grounds in the central part of the Gulf of Finland the weight remained on about the the same level from the early sixties to the late seventies (Fig. 7, 8, Table 2).

In the dynamics of weights at age both spring herring of the eastern Gulf of Finland and spring and autumn herring of the Gulf of Riga clearly differ from the spring herring of Väinameri-Hiiumaa and of the western Gulf of Finland. In case of exclusion of extraordinarily high values of weight of 1978, in younger herring of the eastern Gulf of Finland from the late sixties to the late seventies no visible trends for change of weights can be stated, whereas weights of the older age-groups declined (Fig. 8).

Between the spring and autumn herring of the Gulf of Riga no principial differences can be seen in dynamics of weights at age. Both populations had a period of relatively good growth in the first half of the seventies. In 1959-1961, 1968-1969 and 1978-1979 their growth was poor (Fig. 8).

Changes in weights at age are naturally related to fee-

ding conditions of corresponding age-groups. It can be assumed that growth of herring younger age-groups depends mainly on zooplankton abundance whereas in older age-groups in addition to zooplankton, nektobenthos and benthos resources have importance. Other environmental conditions (temperature, food competition et c.) can have influence upon growth, too. Increase in growth rate of younger herring in the northern part of the Baltic proper and in the western part of the Gulf of Finland can have a bearing on the increasing trend in concentration of biogenes in the surface layer of the sea in the last two decades (Fonselius, 1972, Jurkovskij, 1980). Short-term noticeable decreases in weight of older herring of the Väinameri-Hiiumaa population in the beginning and in the late sixties during the deep water stagnation periods (Kaleis, 1976) can be connected with presumably substantial decrease in resources of food organisms important for older herring – in nektobenthos and zoobenthos stocks, due to oxygen deficit in deeper layers of the sea.

Results of determination of the von Bertalanffi growth parameters (Table 3) indicate differences between the populations in that respect and variations of the parameters by periods. Taking into consideration changes in herring food composition during its life one can presume that the main reason for long-term changes in herring growth parameters, including clearly deviating W_∞ and K values in the Väinameri-Hiiumaa herring in the periods 1948-1950 and 1955-1960, are variations in availability of food for different age-groups.

Table 1. Dynamics of fishing mortality coefficient of age-groups 1 and 2 of herring populations by periods.

Period	Väinameri--Hiiumaa		Gulf of Finland		Gulf of Riga spring		Gulf of Riga autumn	
	1	2	1	2	1	2	1	2
1948-50	0.00	0.03						
1951-55	0.01	0.10						
1956-60[1)]	0.02	0.10			0.17	0.63	0.18	0.49
1961-65	0.02	0.11	0.03	0.15	0.23	0.94	0.39	0.54
1966-70	0.05	0.16	0.20	0.37	0.29	0.82	0.41	0.79
1971-75[2)]	0.09	0.26	0.15	0.39	0.20	0.62	0.25	0.58

1) In the Gulf of Riga 1958-1960

2) In the Gulf of Riga 1972-1975

Table 2. Average length of age-groups of the Väinameri-Hiiumaa spring herring population in pound net catches on spawning grounds

Period	2	3	4	5	6	7	8	9	10
1948-50	14.0	16.2	18.6	20.6	21.9	23.5	25.1	27.0	27.3
1951-55	13.7	16.3	18.3	20.0	21.6	22.7			
1956-60	14.4	16.7	18.4	19.7	21.0	21.8	22.7	23.3	
1961-65	15.5	17.5	18.3	19.1	20.2	20.6	22.1	22.9	23.3
1966-70	16.0	18.7	19.7	20.5	20.8	21.2	22.0	21.4	22.3
1971-75	16.5	18.6	19.9	21.3	21.9	22.3	22.7	24.5	24.7
1976-78	16.0	18.8	20.4	21.0	21.5	22.1	22.0	22.5	

Table 3. Parameters of herring growth in weight in the Northeastern Baltic

Period	Väinameri-Hiiumaa			Gulf of Finland western part			Gulf of Finland eastern part			Gulf of Riga spring			Gulf of Riga autumn		
	W_∞	K	t_o	W_∞	K	t_o	W_∞	K	t_o	W_∞	K	t_o	W_∞	K	t_o
1948-50	836,8	0,062	-3,10												
1951-55	169,4	0,176	-1,42												
1956-60	388,8	0,102	-2,27							100,7	0,161	-2,85	105,4	0,150	-3,37
1961-65	163,7	0,147	-2,59							66,0	0,245	-2,37	64,7	0,245	-2,78
1966-70	119,6	0,183	-3,16	43,4	0,437	-1,39	42,7	0,251	-3,85	59,4	0,272	-2,28	74,6	0,206	-3,38
1971-75	145,0	0,149	-3,95	42,2	0,473	-1,24	32,6	0,529	-1,30	61,6	0,325	-1,67	62,6	0,310	-2,17
1976-78	146,6	0,170	-3,35	65,6	0,244	-3,25	39,2	0,355	-2,87	57,3	0,243	-2,67	59,9	0,170	-4,89

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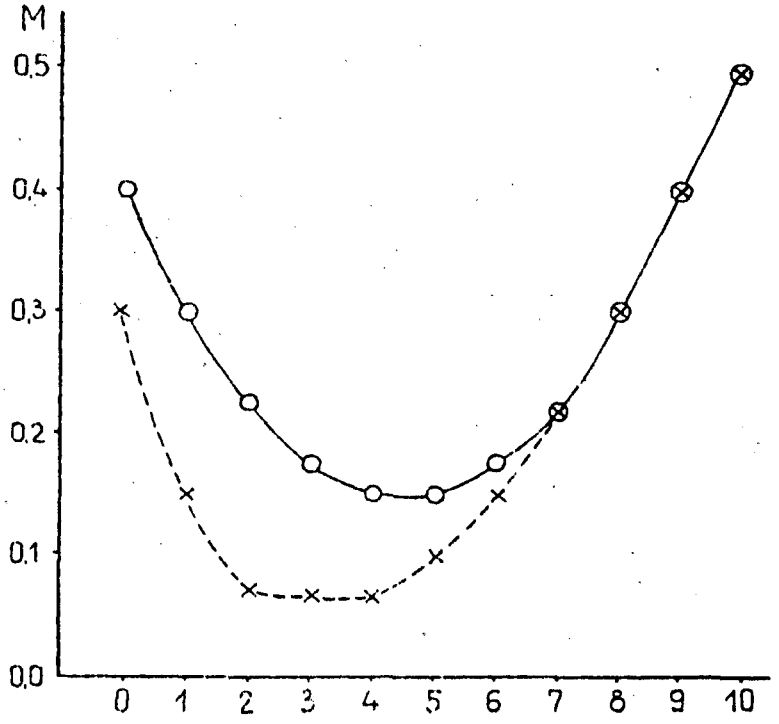

Figure 1. Graphs of sets of herring natural mortality coefficients in the Northeastern Baltic, applied in VPA.
o—o periods of cod invasion; x---x periods of absence of cod

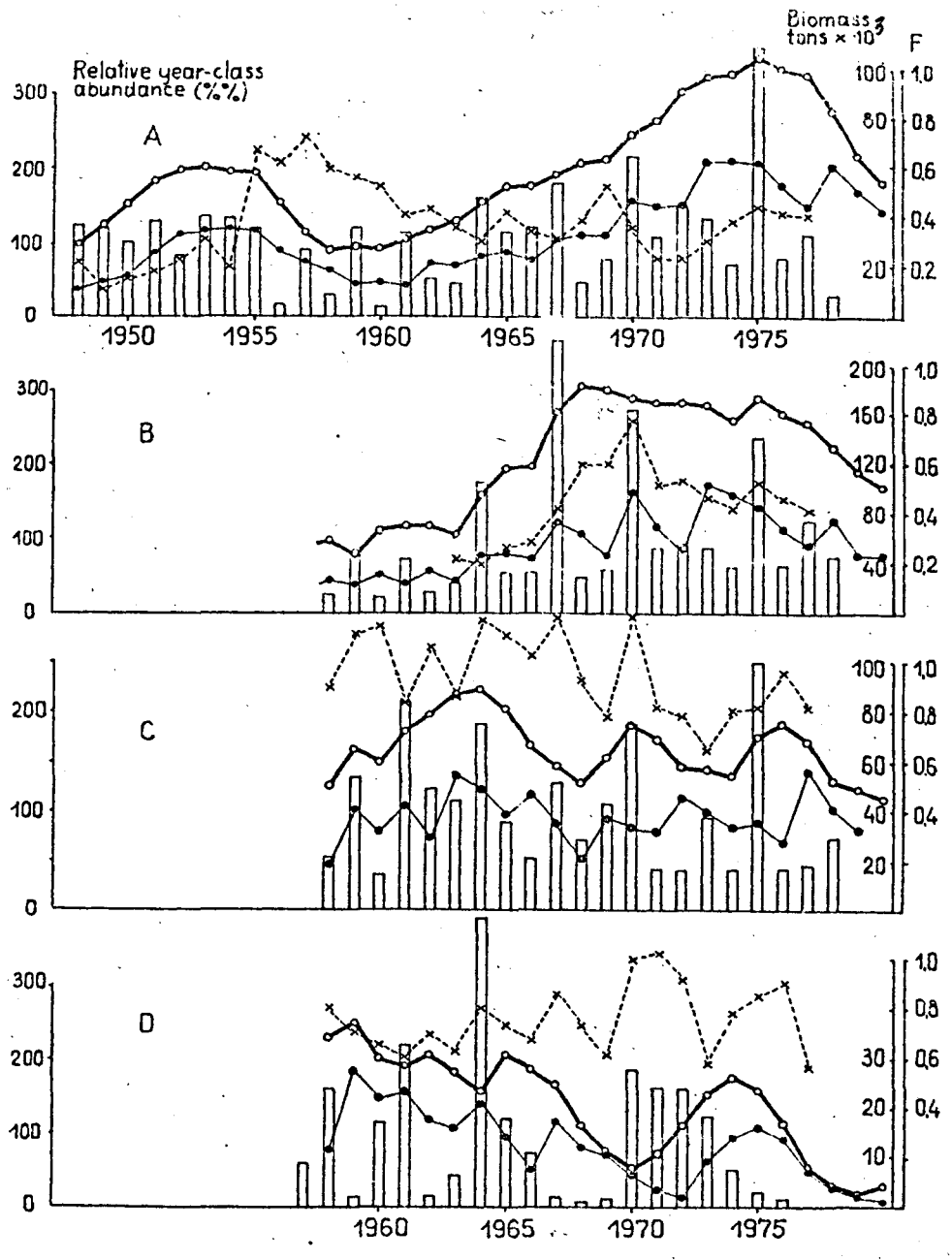

Figure 2. Long-term dynamics of relative year-class abundance (%% of average, bars), population biomass (═, 10^3 tonnes), spawning stock biomass (—, 10^3 tonnes, in the Väinameri--Hiiumaa and Gulf of Finland populations - age-groups 3 and older, in other populations - age-groups 2 and older), average fishing mortality of age-groups 3 and 4 (x---x) of spring herring Väinameri-Hiiumaa (A), Gulf of Finland (B) and Gulf of Riga (C) populations and of autumn herring Gulf of Riga (D) population.

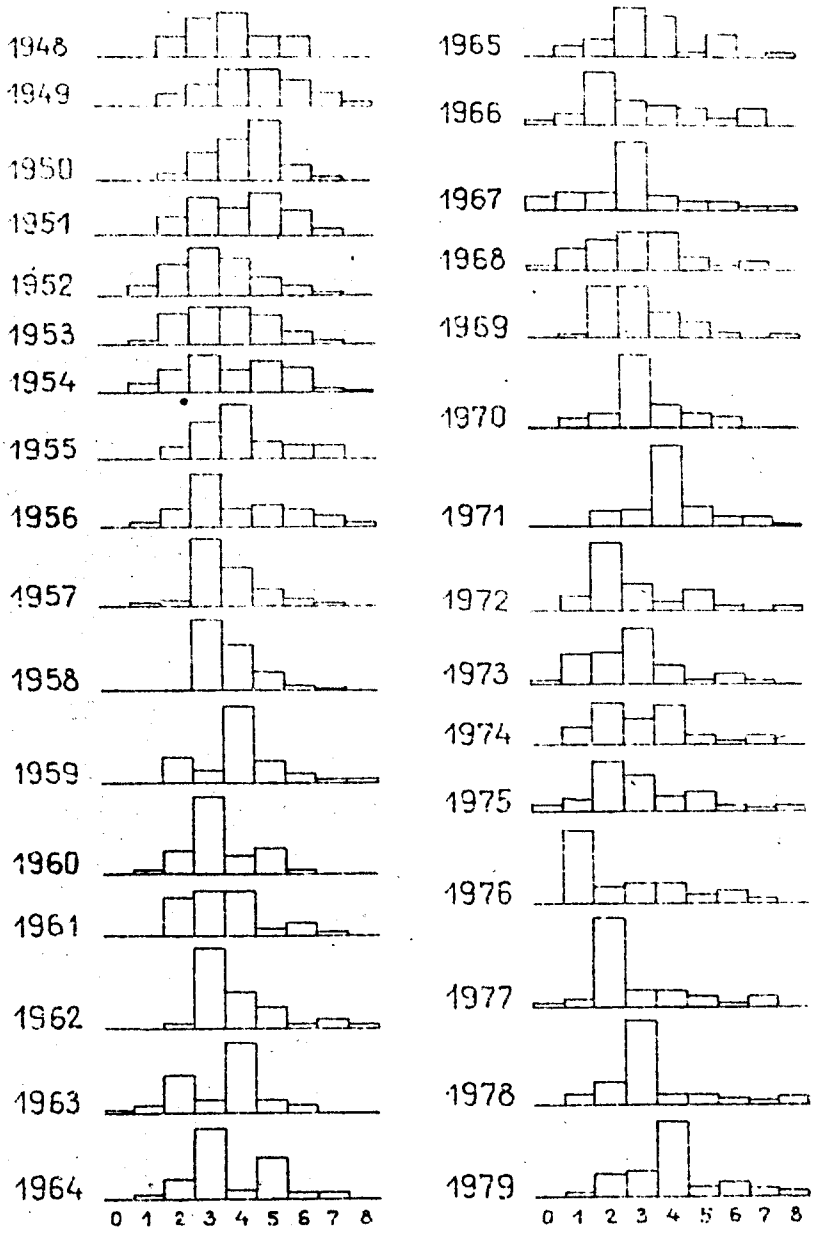

Figure 3. Age composition (%%) of the Väinameri-Hiiumaa spring herring population in catches in 1948-1979.

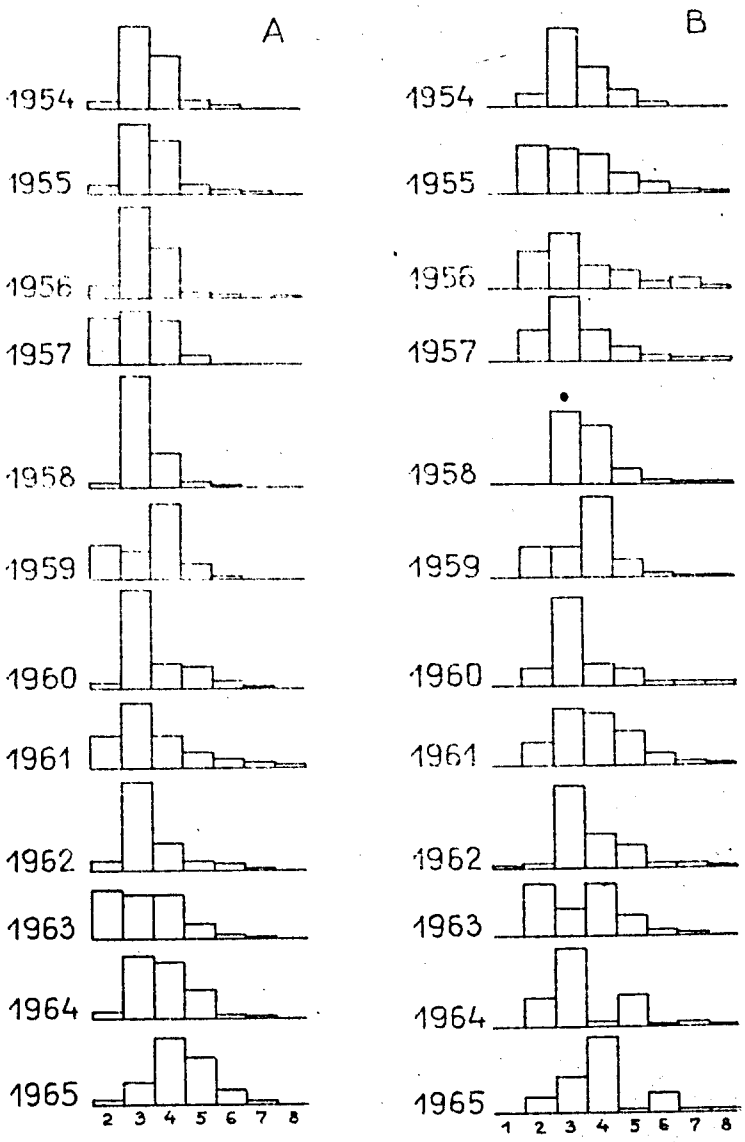

Figure 4. Age composition of catches on spawning grounds of spring herring in the eastern part (after Morozova, 1971; Morozova et al., 1971) (A) and in the central part of south coast of the Gulf of Finland (B) in 1954-1965.

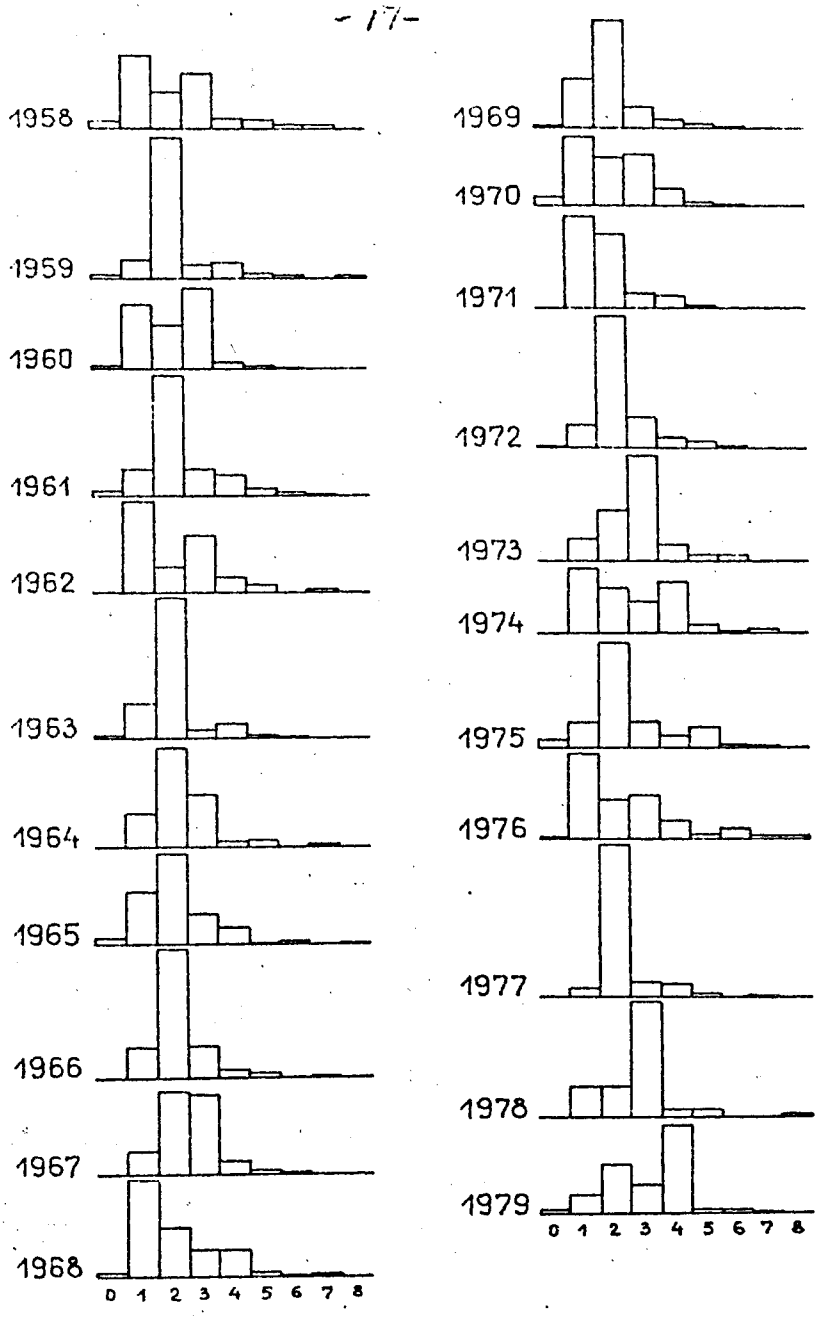

Figure 5. Age composition (%%) of the Gulf of Riga spring herring population in catches in 1958-1979.

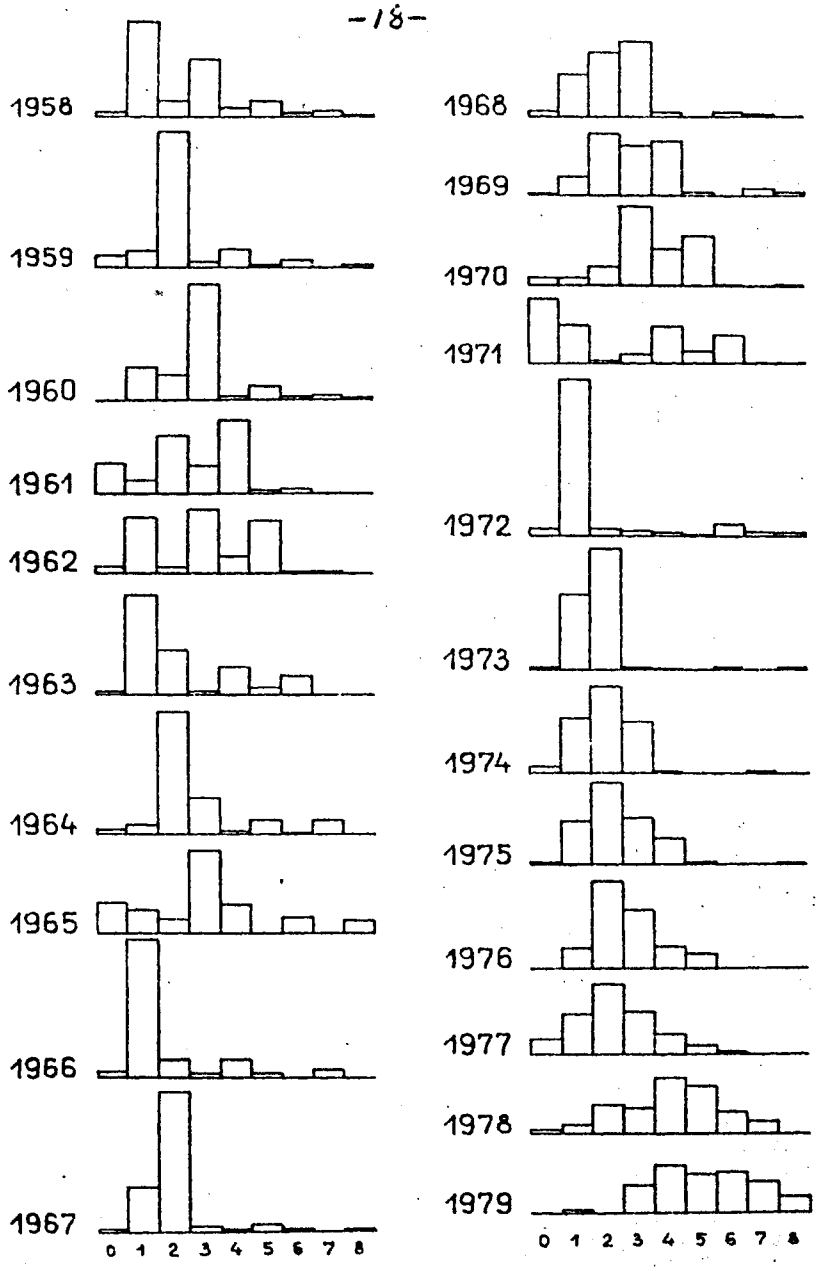

Figure 6. Age composition (%%) of the Gulf of Riga autumn herring population in catches in 1958-1979.

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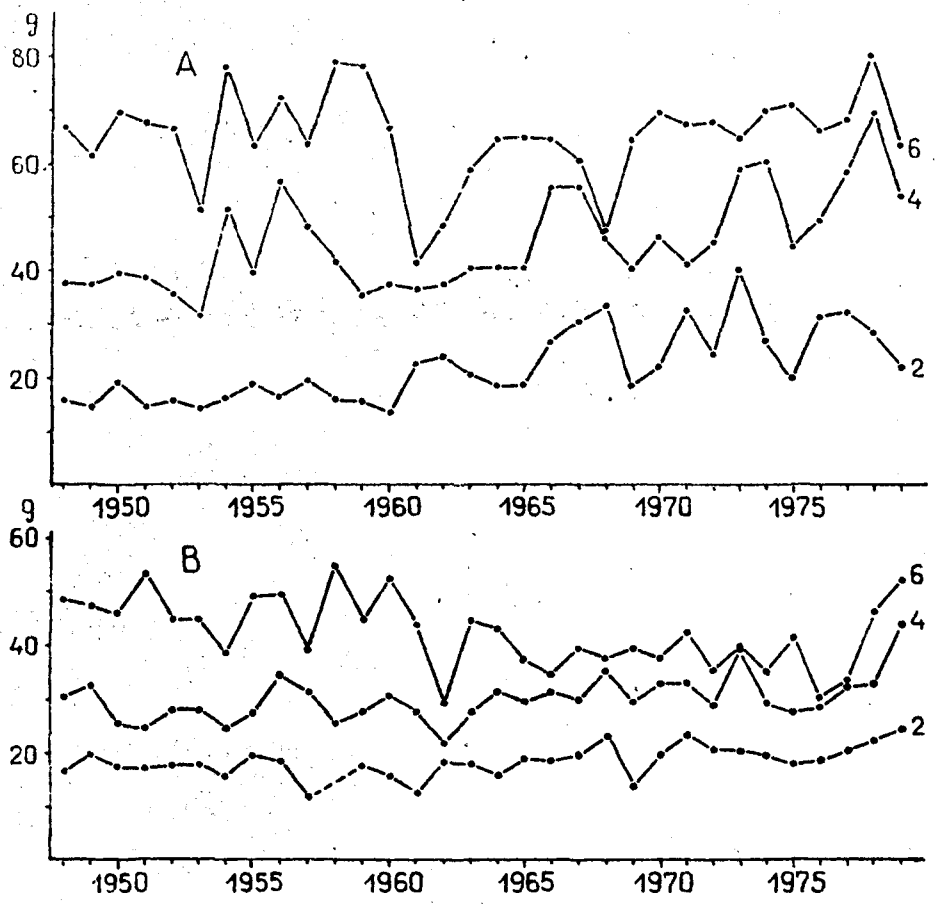

Figure 7. Dynamics of average weight of 2-, 4- and 6-year-old spring herring on spawning grounds in Väinameri-Hiiumaa area (A) and in the central part of the Gulf of Finland (B).

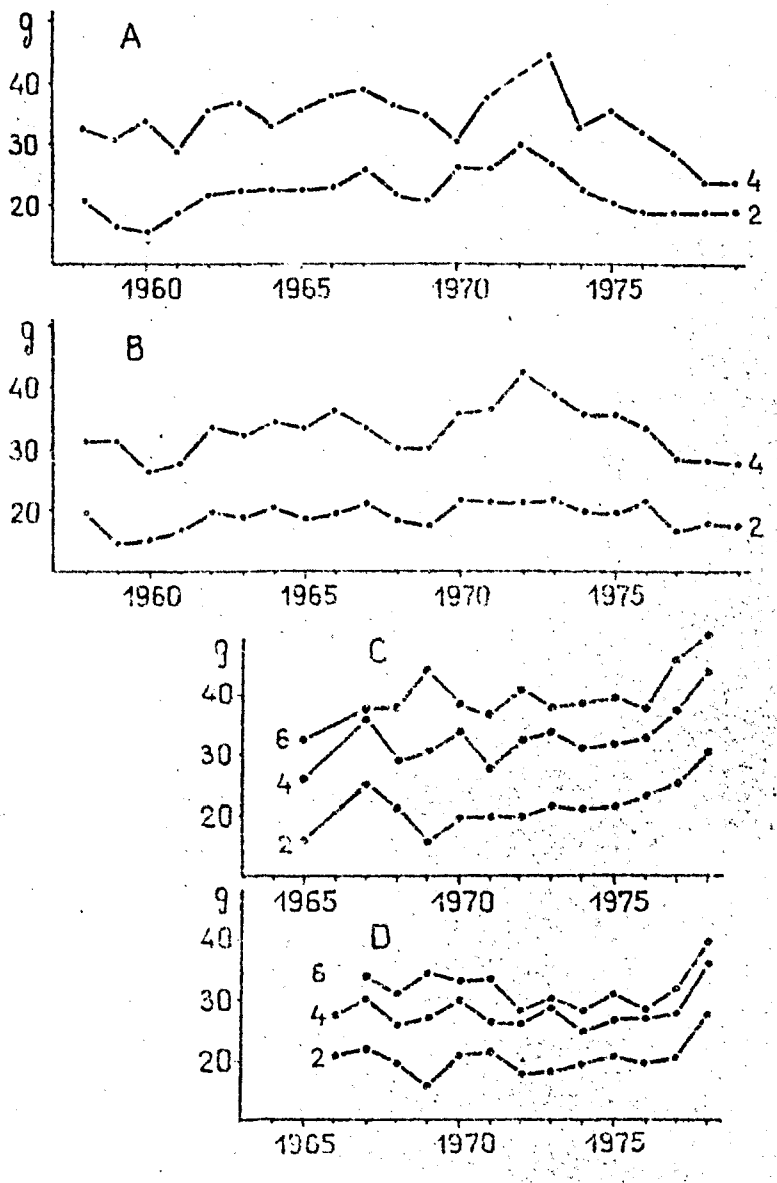

Figure 8. Dynamics of average weight of 2-, and 4- year-old Gulf of Riga spring (A) and autumn (B) herring and of 2-, 4- and 6- year-old spring herring of the western (C) and eastern (D) parts of the Gulf of Finland in feeding concentrations.