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THE STRUCTURE OF BALTIC SPRAT POPULATION AS A BASE FOR THE ASSESSMENT OF THE STOCK

by

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Abstract

Investigations on distribution of Baltic sprat during the spawning period and data on genetic-biochemical studies allow to accept the hypothesis on populational unity of Baltic sprat.

The genetic composition and density characteristics of the Baltic sprat population is heterogeneous. The distribution of genotypes has selective character and the selectivity is accomplished in relation to thermic factor. The consideration of populational structure is proposed as a regular distribution of genotypes in heterogeneous environment.

It is proposed to devide the population in several stock units which are considered as temporary regional units of stock management. This division is proved on the base of medium-term (2-5 years) data on abundance and distribution of concentrations of Baltic sprat.

Introduction

The necessity to regulate the Baltic sprat fishery put forth the problem of studies in sprat populational structure. For this purpose special methods of investigations were applied, i.e., morphometric approach (Biryukov N.P., 1980), studies of sprat otolith structure (Aps R.A. et al. 1986), genetic and biochemical analysis (Aps R.A., Tanner R.H., 1979; Veldre L.A., Veldre I.R., 1979; Koval L.I., 1979; Kozlovsky A.Y., 1988). In some cases authors revealed characteristics allowing to make statistically reliable distinctions between separate samples of sprat. Basing on those distinctions some authors distinguished populations (Biryukov, 1980) or subpopulations (Aps, Ustinova, 1986) of Baltic sprat. Division of Baltic sprat into "stock units" identified with populations or subpopulations was used for separate stock assessment till 1991.

However, studies of ichthyoplankton (Grauman, 1980, 1981, 1983) demonstrated the integrity of Baltic sprat spawning area, but investigations of sprat migrations and distribution (Shvetsov F.G., Gradalev E.B., Kalejs M.V.,1988; Shvetsov F.G., Gradalev E.B., 1989) showed the absence of clear boundaries between spawning concentrations, mixing and splitting of sprat concentrations, changes of their abundance in different years, high migrational ability of younger age groups. All these data along with the material on Baltic sprat growth (Aps R., Gentzens B., Shirokov S., Ustinova L., 1989) yield the basis to confirm the concept of Baltic sprat populational unity. This hypothesis was suggested already in 1978 (Aps R.A., 1978), but up to now it existed together with the mentioned hypotheses of Baltic sprat division into local populations.

Statistical differences between samples that have been exposed by morphometric and genetic-biochemical methods may contradict the biological data on populational unity only as long as the problem ranging these differences remains unsolved, i.e. , whether these differences are in or inter populations (Alekseyev, 1984).

The major argument as regards this direction is either presence or absence of reproductive isolation.

Sprat distribution during spawning.

Sprat spawning period stretches from the end of February-March till August. The earliest time of sprat spawning is recorded in the south-western part of the Baltic Sea (the Bornholm region), but advancing to the east ad to the north the spawning period shifts to later times. May-June manifests the peak of sprat spawning. During this period spawning is recorded in all areas of the sea. Therefore the analysis of sprat distribution for this period can most vividly show if there is or no reproductive isolation between sprat from different parts of the Baltic Sea.

In May of 1977-1979 we carried out detailed trawl surveys covering the sea area from the Bornholm island to the Gulf of Finland. Surveys were performed on board of fishery vessels using commercial pelagic trawls. In order to exclude the effect of sprat migrations on the pattern of its distribution the surveys were made in short time, no more than in 120 hours. About 12 sister-ships participated there at the same time. Data given in Fig. 1 show that separated , isolated concentrations were never detected in all years of surveys. Sprat was found everywhere from the Bornholm island to the Gulf of Finland. However, sprat distribution is not homogeneous in the considered area: several regions with higher density of concentrations can be distinguished. As a rule these regions are located above the Bornholm deep - the Stolpen grove, the Gdansk hollow and the Gotland deep. It can be explained by the fact that in that period the bulk of sprat still remains in deep sea layers limited by isooxygen 1 ml/l from below and by isoterm 4oC from above. Naturally these layers being favourable habitat for sprat are located only in deep sea layers. It should be noted that the locations of regions with high sprat density concentrations may differ sufficiently from year to year. For example, in 1978 three centres of concentrations could be clearly distinguished: 1st was in Subdivision 25, 2nd was in Subdivision 26 (in the Gdansk hollow), an 3rd was in Subdivision 28 (in the Gotland deep). In 1979 within the whole considered sea area sprat was represented as a single concentration with one centre in the southern part of the Gotland deep. This can be explained by the fact that deep water layers of the Baltic Sea were well aerated causing everywhere the formation of a quite large water layer favourable for sprat habitat (the thickness of a layer exceeded 30 m between isoterm 4oC and isooxygen 1 ml/02). But in 1979 signs of stagnation already appeared. Though in the Gdansk hollow and in the southern part of the Gotland deep the conditions for sprat habitat were favourable (layer thickness of sprat habitat was 30 m and more), still in the central and northern part of the Gotland deep (Subdivision 28) the thickness of this layer lessened till 15 m in May due to worsening of oxygen conditions. This was probably the cause for migration of a considerable part of sprat from Subdivision 28 to Subdivision 26 where maximum densities of concentrations were observed.

Thus, for Baltic sprat it is impossible to single out isolated concentrations of sprat in reproductive period.

Hence it can be assumed that there is a single sprat population in the Baltic Sea.

Populational structure is a regular distribution of genotypes in heterogeneous medium.

Genetic and biochemical investigations carried out in 1986-1989 revealed high inter-populational heterogeneity of Baltic sprat. For the analysis of samples we used genotype frequencies of HAD-dependent malat-dehydrogenase (MDh). We considered 233 samples (21862 ind.) which covered almost all Baltic sprat habitat. However, even regarding the mass character of material the comparison of mean frequencies of MDh gave reliable results only in several cases (Kozlovsky, 1988).

Reliable differences are recorded only sometimes and only on the level of genotype frequencies being of an irregular and unstable in time character.

Heterogeneity of Baltic sprat population that is unconvincing comparing genotype frequencies of different sprat concentrations still becomes evident when comparing samples taken from the density centres and from the periphery of a concentration (Table). In samples the genotype frequencies having differences within one concentration quite analogously vary in other concentrations. Thus, although MDh MM and MDh MS genotypes gravitated to the centres of concentrations, still the rest of genotypes (MDh FF, MDh FM, MDh FS, MDh SS) belonged to a more or less extent to the periphery of those concentrations.

Therefore heterogeneity of separate concentrations, and the whole Baltic sprat population is realised in non-random and inhomogeneous distribution of genotypes. The best illustration of non-random genotype distribution is the distribution of the most widely spread genotype MDh MM (Fig. 2).

The preference of one genotype for the centre but another for the periphery of concentrations points to the probable selectivity as regards environmental factors. This assumption is also allowed by the relationship of distribution with temperature factor. It seems to be logic to use data on functional differences of isozymes MDh, their differences at thermal stability, facts about cline variability (Kirpichnikov, 1987, Golubtsov, 1988).

The mentioned assumption is testified by revealed reliable dependence of MDh MM genotype frequency on the average temperature of sprat shoals distribution (Fig. 3). But this dependence is a linear dependence only within the boundaries of a separate sprat concentration being especially pronounced during spawning period.

As a whole the populational dependence is described by a curve remotely resembling a sinusoid (Fig. 4,5).

Even if the mechanism of this dependence is not quite clear, its stability, relative permanence of the optima testify to the existence of real temperature effect on distribution of Baltic sprat MDH-genotypes. Investigations of sprat migrations and distribution anyhow point to the decisive significance of temperature factor on formation of wintering and spawning concentrations (Rechlin, 1967, Shvetsov, Gradalev, Kalejs. 1988; Shvetsov, Gradalev, 1989)

Inter-populational spatial heterogeneity promoted by genotypes selective distribution at the same temperature factor seems to be the necessary property of sprat population living in heterogeneous medium. Hence it seems quite logic to postulate the interrelation between the environment and the genotypic composition of population during formation of concentrations, and in the end, spatial structure of Baltic sprat population.

Populational structure of Baltic sprat cannot be considered as a system of local populations due to isolation between spawning concentrations or groups of concentrations. However, the existence of clearly pronounced, especially in wintering period, centres of sprat concentrations, allows to assume inter-populational division of Baltic sprat. However, populational structure of Baltic sprat cannot be considered as a system of subpopulations as well, because this treatment contradicts with the problem of criterion.

What factors are sufficient to distinguish subpopulations for Baltic sprat? Whether the lack of considerable sprat migrations (Aps, Ustinova, 1986; Shvetsov, Gradalev, Kaleis, 1989), the differences in age composition (Aps, Shirokov, Ustinova, 1990), indicate the existence of subpopulations or they only describe the peculiarities of stretched Baltic sprat population? To our opinion the reproductive criterion cannot be practically applied for detection and description of Baltic sprat subpopulations.

Basing on the existing material on population studies we may suggest another approach to sprat population structure. We claim that unified but genetically heterogeneous population spread and is to be spread inhomogeneously in heterogeneous medium. Due to temperature conditions this inhomogeneity has a regular character revealing itself both in formation of high density zones, i.e. concentrations, and in genetic heterogeneity of the concentrations.

Thus populational structure of Baltic sprat can be considered as a regular distribution of genotypes forming the population in heterogeneous medium.

"Stock unit" is a temporal regional unit of fishery management.

The necessity to structurize Baltic sprat stretched population may somehow arise when there is a need to avert or weaken the sequences of local overcatches. Stock units may be represented both by the whole population, and by stable (at a certain period of time) concentrations differing from each other by such characteristics of abundance dynamics as age composition, growth, etc. The choice of stock units number is to be taken basing on middle-annual data (2-5 years) on abundance and distribution of Baltic sprat population. Therefore, "stock unit" is a sprat group that is discriminated for practical purposes, or a concentration with abundance dynamics differing from other concentrations; with temporal, though incomplete division; and considered as a regional unit for Baltic sprat stock management.

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Distribution of genotyps in concentrations of Baltic sprat

Year, season	Sampling sites	Mean genotype frequencies						Significance of difference
		FF	FM	MM	MS	FS	SS	
1987	Centre of schoaling	0.061	0.371	0.509	0.052	0.007	-	0.1
May-June	Outskirts of schoaling	0.128	0.394	0.439	0.032	0.007	0.003	
1988	Centre of schoaling	0.079	0.384	0.489	0.034	0.013	-	0.02
February	Outskirts of schoaling	0.134	0.435	0.384	0.032	0.015	-	
1988	Centre of schoaling	0.044	0.396	0.516	0.033	0.011	-	Non-significant
March	Outskirts of schoaling	0.081	0.374	0.455	0.030	0.050	0.010	
1989	Centre of schoaling	0.092	0.380	0.477	0.041	0.010	-	Non-significant
March	Outskirts of schoaling	0.103	0.433	0.425	0.025	0.012	-	
1989	Centre of schoaling	0.072	0.386	0.513	0.018	0.011	-	0.1
October	Outskirts of schoaling	0.110	0.398	0.447	0.034	0.010	-	

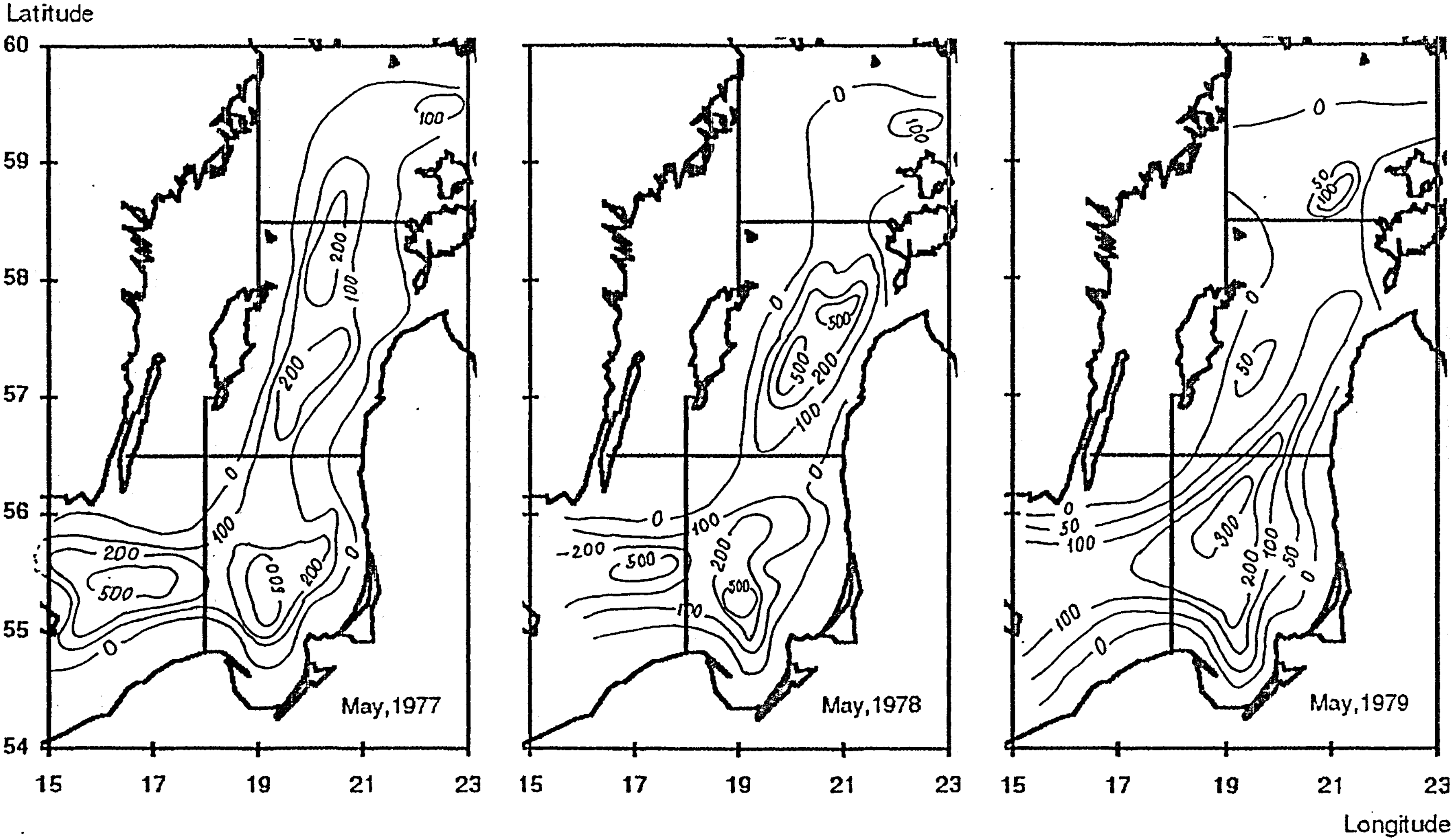

Figure 1. Distribution of spawning sprat in the Baltic sea (-500- isolines of catch effort, kg/hour of trawling)

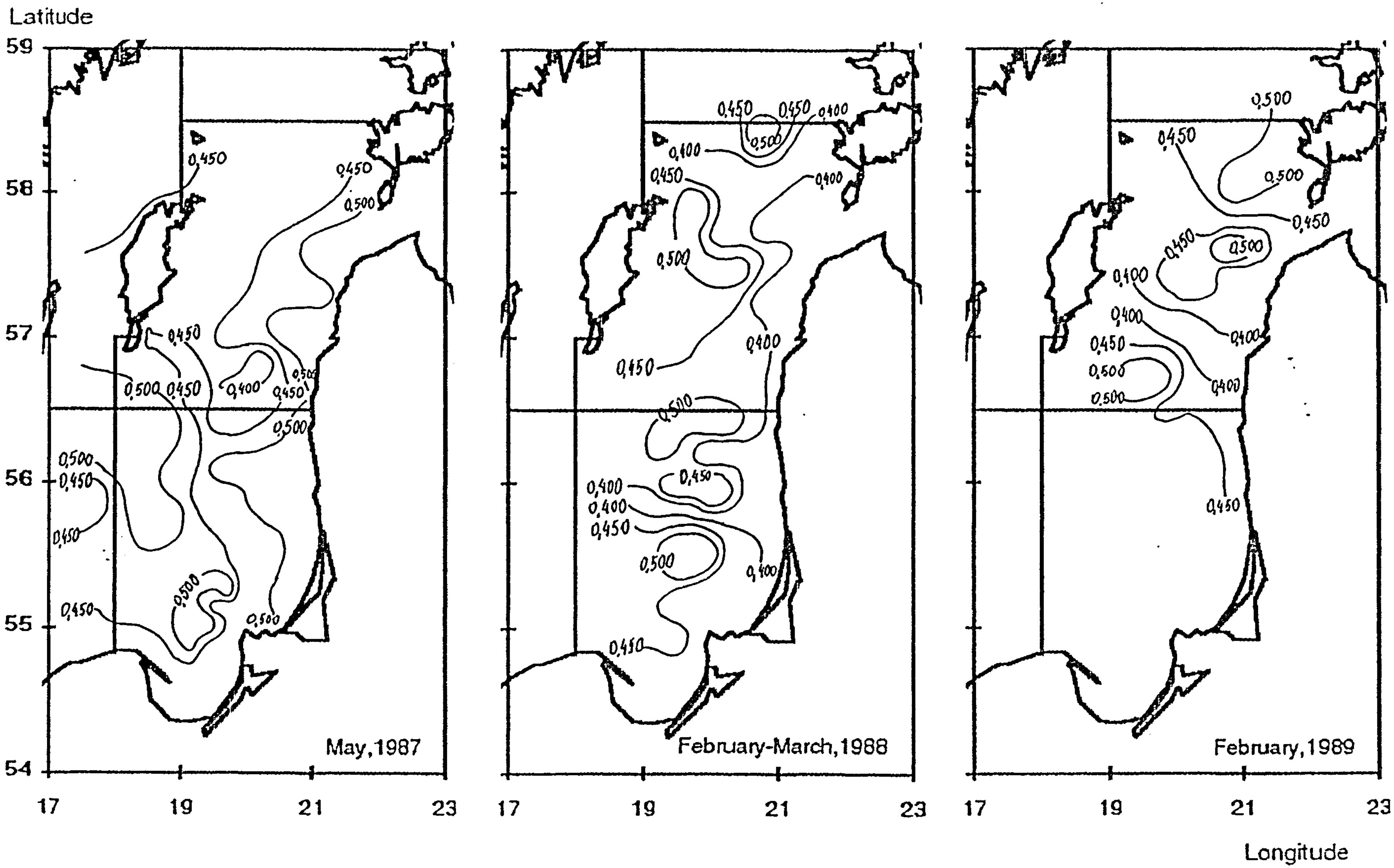

Figure 2. Distribution of Mdh^{MM} genotypes (-0.500- isolines of genotypic frequencies).

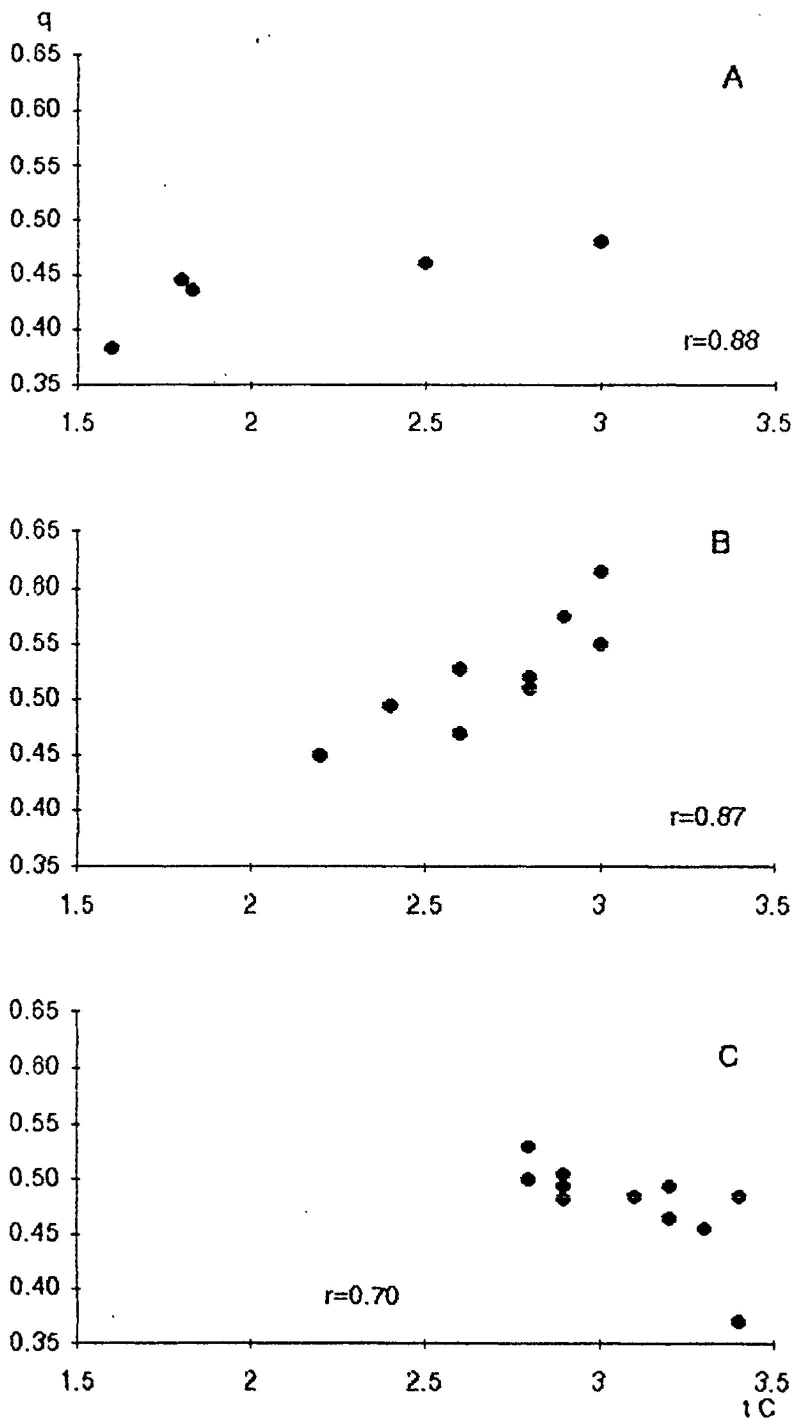

Figure 3. Dependence of Mdh^{MM} frequencies in the samples of Baltic sprat from mean water temperature (T°) in the layer of concentration of shoals (May, June of 1988): A - SD 32, B -SD28, C - SD 26.

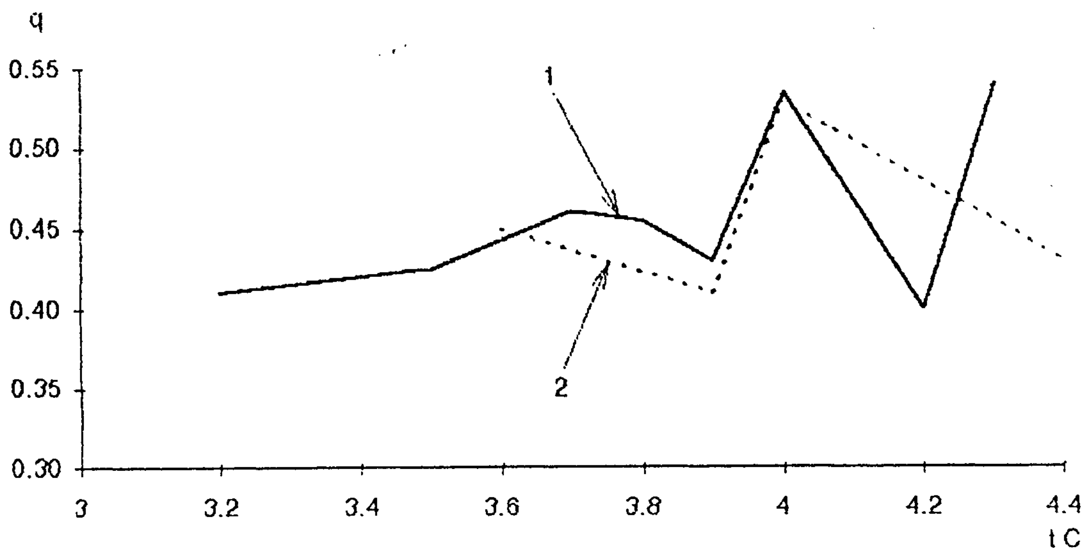

Figure 4. Dependence of Mdh^{MM} frequencies in the samples of Baltic sprat from mean water temperature (T°) in the layer of concentration of shoals (SD 28 and 29); 1 - February, March of 1988, 2 - February of 1989.

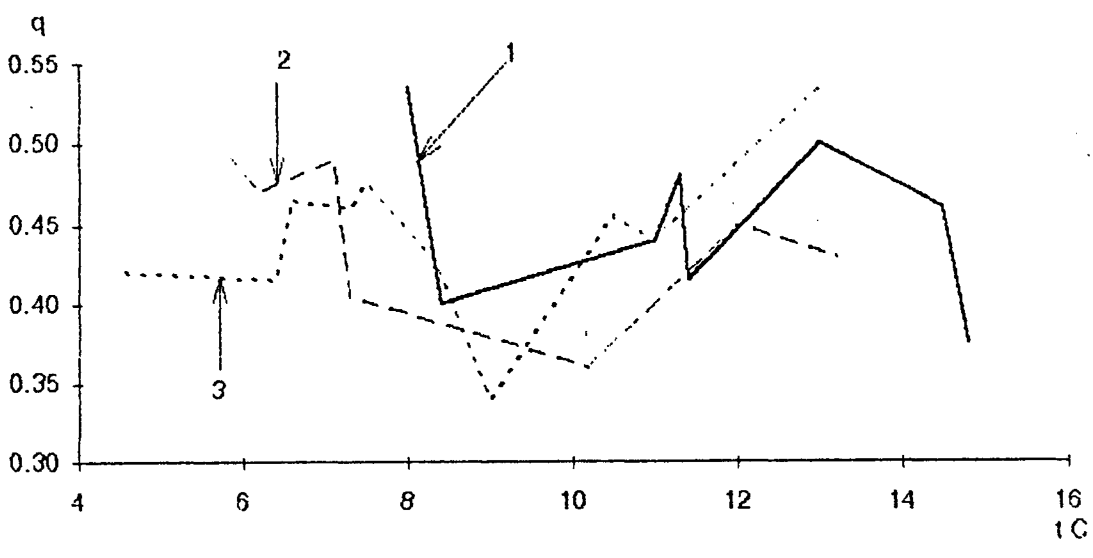

Figure 5. Dependence of Mdh^{MM} frequencies in the samples of Baltic sprat from mean water temperature (T°) in the layer of concentration of shoals (SD 26 and 28); 1 - september of 1986, 2 - September of 1987, 3 - October of 1988.