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Trends of variations in abundance of the main commercial fish of the Barents Sea in early ontogeny

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N.V.Mukhina

Polar Research Institute of Marine Fisheries
and Oceanography (PINRO), 6 Knipovich Street,
183763, Murmansk, Russia

ABSTRACT

Essential fluctuations are typical of ichthyoplankton species composition. A characteristic for variations in ichthyoplankton community of the northern latitudes ecosystem was given by the indices calculated for species diversity and "domination - diversity" curve. The calculated indices for species diversity were comparable with water temperature variations and with the values for total commercial fish stock in the Barents Sea and adjacent waters.

Eggs and larvae of 60 fish species, pertaining to 20 families, occur in the northeastern Norwegian and southwestern Barents Seas. 28 species of them are boreal, 20 - north-boreal, 11 - Arctic and 1 - cosmopolite. Index for species diversity varied from 0.10 to 0.40 and the "domination - diversity" curve was an S-shaped in the community pre-set.

Variations in species structure of ichthyoplankton community take place over the area surveyed by a type of allogenic succession. In the years of high heat content of water masses when the main commercial fish stock was at the high and average levels, eggs and larvae of commercial fish species were predominant in ichthyoplankton community with the index for species diversity being low. While cooling and reducing of the stock, the abundance of fish drops at stages of early ontogeny and the index for species diversity increases due to a growing number of eggs and larvae of non-commercial species.

INTRODUCTION

Reproduction of a majority of fish species, inhabiting the European North seas, takes place over a vast area. However, there are some sections, where the spawning intensity of complexes of fish species, different by ecology of reproduction, is by some orders higher than that in the adjacent areas. Such sections got the name of total reproductive zones. One of such zones is in the North Atlantic in the northeastern Norwegian and southwestern Barents Seas (Serebryakov, 1988). Psammo- and lithophilous (herring, capelin, sand eel), pelagophilous (Gadidae and Pleuronectidae) and viviparous species (Sebastes marinus) spawn here.

Species composition of ichthyoplankton is representative of conditions of reproduction and early ontogeny of fish, for most of which, mainly for commercial ones, considerable fluctuations in abundance are typical. Therefore, studying of ichthyoplankton species diversity is of interest and its dynamics should be considered within "the total reproductive zones", since a populational reproduction takes place due to the spawning grounds available to the extent of these peculiar oceanic incubators.

Species diversity can be described by number of species or their percent relationship (Baranenkova, 1974). However, it is more convenient to present it as calculated indices, used in ecology to compare different communities or seasons, as well as to describe variations in ecosystems (Odum, 1986; Norvillo, 1991).

Aim of the paper is to retrace trends of variations in species diversity of ichthyoplankton community in the reproductive zone in the border area between the Norwegian and Barents Seas.

MATERIAL AND METHODS

Data from the ichthyoplankton surveys conducted in April-July in the northeastern Norwegian and southwestern Barents Seas for 1968-1990 were used in the paper (Fig.1). A peculiarity of these investigations consists in the following, i.e. the areas, term, work and methods for comprehensive observations have been similar annually (Mukhin, Dvinina, 1979). 34419 ichthyoplankton samples were analysed for species composition of eggs and larvae. When identifying fish at early ontogeny stage the determinants of T.A.Pertseva (1936), T.S.Rass (1949) and Russel (1974) were used. Abundance of eggs and larvae is given in natural logarithms. The most abundant and frequently occurring species are pooled into families. Gadidae family includes Gadus morhua (L.), Melanogrammus aeglefinus (L.), Brosme brosme (Ascanius), Trisopterus esmarkii (Nilsson), Pleuronectidae - Hippoglossoides platessoides (Fabr.), Pleuronectes platessa (L.), Microstomus kitt (Walbaum), Scorpaenidae - Sebastes marinus (L.), S.mentella (Travin), S.viviparus (Kröyer), Osmeridae - Mallotus villosus (Muller). Non-commercial species Leptoclinus maculatus (L.), Licodes polaris (Sabine), Liparis liparis (L.), Liparis koefoedi (Parr), Leptogonus decagonus (Shneider), Chirolophis ascanii (Walb.) were combined into a separate group.

The index calculated by Odum's formula (Odum, 1986) was used to estimate species diversity:

$$B = \frac{W - 1}{N},$$

where:
B - index of species diversity;
W - number of species in community;
N - total abundance of community.

The index of species importance and its status in community structure was determined by the "domination - diversity" curve (Whittaker, 1965).

The paper presents data on water temperature in 0-200 m layer on the section from the North Cape to Bear Island (No.3) per month of temperature minimum (March), as well as a size of the spawning stock of fishes from the Barents and Norwegian Seas by the data from ICES Working Group (Anon., 1992).

RESULTS AND DISCUSSION

Availability of few common or dominating species, represented by large number of specimens and most infrequent species with a small amount of specimens is a typical feature of the northern latitudes community.

The importance of species and its status in a community can be determined by the "domination - diversity" curve, suggested by Whittaker (Whittaker, 1965). It can be of 3 types (Fig.2). In case of the most abundant species two times larger than the following, and this one, in its turn, twice larger than the third one, then a straight line is produced on the plot (1). In such communities each species occupies, first of all, a free niche, without overlapping anothers. In case a space of the niches is separated into random, adjacent, however, non-overlapping sections, the curve is produced (II). These two possibilities present extreme cases, usually a majority of species in natural open systems are available under conditions of competition for resources, and a good deal of adaptations gives a possibility to divide niches without specific exclusion from habitant, therefore, distribution of species in communities has an S-shaped form curve (III) (Odum, 1986). The steeper is a curve, the less is a total diversity or stronger is a predominance of one or several species.

Eggs and larvae of 60 species (20 families) occur over the area surveyed : of them - 28 species are boreal, 20 - north-boreal, 11 - Arctic and 1 - cosmopolite (Rass, 1934; Baranenkova, 1974; Mork, Solemdal and Sundes, 1983; Norvillo, 1991; Mukhina, 1992 in press). According to our data the "domination-diversity" curve has an S-shaped form and indicates a predominance of eggs and larvae of several species in the area surveyed: Gadus morhua, Melanogrammus aeglefinus, Mallotus villosus , Sebastes sp., Hippoglossoides platessoides (Fig. 2, IV). Such structure of ichthyoplankton community agrees with a type of the northern latitudes communities.

To analyse temporal variations in community the indices for species diversity are used (Simpson, 1949; Pielow, 1966). For a long time the ecologists were agreed that the higher an index for diversity is, the more stable the system. Such systems were called "balanced" (Margalef , 1968). Recent investigations approve the opposite opinion, i.e. the ecosystems, enduring intermittent disturbance, are, as a rule, characterized by larger diversity of species and got the name of "unbalanced" (Huston, 1979).

Calculated indices for species diversity varied from 0.10 to 0.40 (Fig.3). The indices showed the variations to be in a structure of ichthyoplankton community. Periods of both the high and low species abundance were observed, i.e. the ecosystem of ichthyoplankton went from "balanced" to "unbalanced" state and vice versa. Since the index for species diversity is a value dependent on the abundance of the species themselves, some factors, limiting the abundance of fish at stages of early ontogeny, which influence a structure of community, were analysed.

Complex of biotic and abiotic factors, of which water temperature has the highest value, influence the abundance of the main commercial fish in early period of life (Saetersdal and Loeng, 1984; Ellertsen et al., 1987; Mukhina, Yaragina, 1988; Mukhina, Dvinina, 1989). In the years when water temperatures were at high and average levels in the area surveyed, the abundance of fish at stages of early ontogeny was high and was presented mainly by some commercial species related to the north-boreal type (Gadus morhua, Melanogrammus aeglefinus, Mallotus villosus, Sebastes sp., Hippoglossoides platessoides), therefore, the index for species diversity had low values (Fig.3). With cooling in 1978-1981 and 1986-1987 the abundance of eggs and larvae of predominant fish species reduced. This influenced the index of species diversity, an importance of which markedly increased due to a growing of commercial species abundance , mainly, of Arctic type, i.e. Myoxacephalus scorpius, Leptoclinus maculatus, Liparis liparis , Leptogonus decagonus , Chirolophis ascanii (Fig.3).

Besides, the cooling in 1986-1987 coincided with a period of reduction in total commercial stock of fish in the Barents and Norwegian Seas (Anon., 1992). These two factors resulted in essential reduction in abundance and variation in ichthyoplankton community structure. Since 1989 against a high level of heat content of water masses on the Norwegian and Barents Seas watershed and increase of stocks of the main commercial fish, their abundance at early stage ontogeny has increased again which led to a decrease of the index for species diversity and to stabilization of ecosystem at the level of ichthyoplankton community.

Irrational conducting of fishery in the Barents Sea and unfavourable temperature conditions for fish survival at early stages of development in 80's caused a variation in the ecosystem species structure, which was pronounced at the level of ichthyoplankton community as a reduction in abundance of eggs and larvae of the north-boreal fish species and increase in the Arctic ones. In this connection an increase of index for species diversity in ichthyoplankton community of the northern latitudes occurred to be an indicator of the system instability. Analysis for interacting factors allows to consider the variations in the ecosystem of the region mentioned to be of allogenic succession type. Index for species diversity can be a criterion of the Barents Sea ecosystem status.

Increase in abundance of eggs and larvae of the main predominant species in ichthyoplankton community, observed since late 80's, is one of the indicators for the systems stability restoration.

CONCLUSION

The investigations on species structure of fish at the level of ichthyoplankton community in the northeastern Norwegian and southwestern Barents Seas allowed to make the following conclusions:

1. "Domination - diversity" curve of ichthyoplankton community has a S-shaped form in the region mentioned, which agrees with a distribution of species of the northern latitudes community. Species structure is represented by some numerous species, mainly, of the north-boreal group, i.e. cod, haddock, capelin, redfish and long rough dab. Most less abundant non-commercial species relate to the Arctic and boreal groups.

2. Value of the index for species diversity varied from 0.10 to 0.40. Change of value of the index for species diversity is related to the variations in total abundance of eggs and larvae of the main commercial fish species. Reduction in abundance of fish at stages of early ontogeny in 1979-1981 and in 1986-1987 occurred to be a consequence of decreasing in heat content of water masses and total stock of commercial fish species.

3. Factors, influencing the species structure of ichthyoplankton community, allow to consider the variations, taking place in this region ecosystem, to be of allogenic succession type.

4. Index for species diversity of ichthyoplankton community can be a criterion of the Barents Sea ecosystem status.

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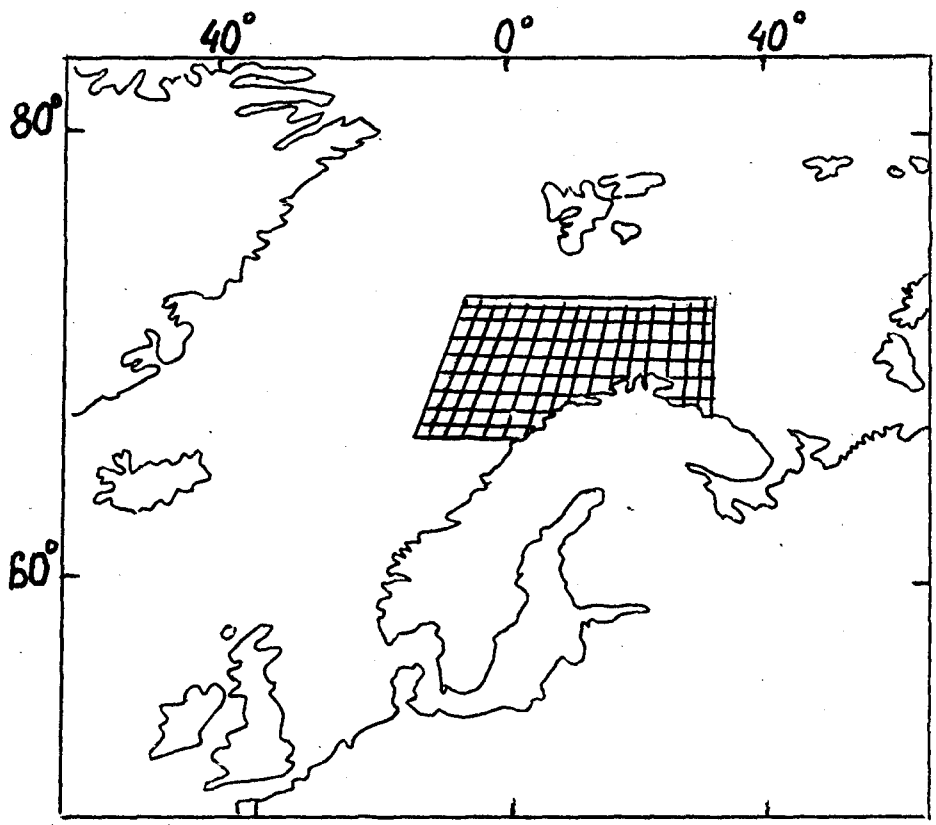

Fig.1. Area of ichthyoplankton investigations in one of reproductive zones of the North Atlantic

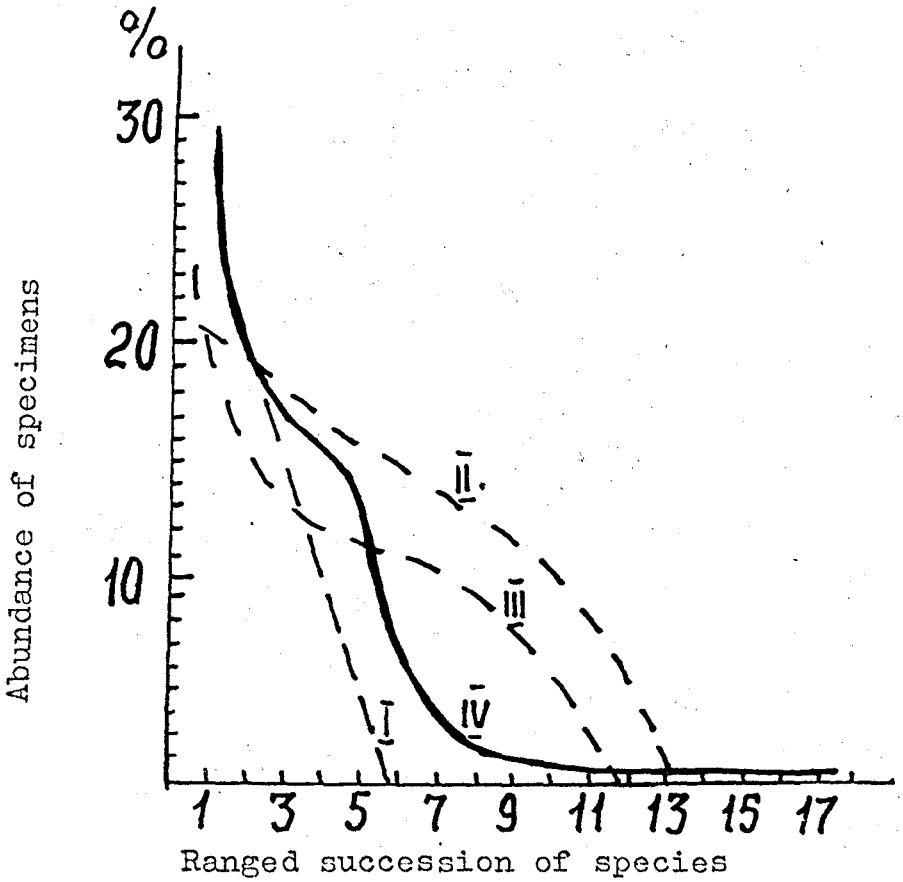

Fig.2. "Domination - diversity" curves for hypothetical selections (I-III) and for ichthyoplankton community on the border area between the Norwegian and Barents Seas (IV).

I - distribution of species with a priority of capturing the niches;

II- ecological niches are not overlapped, their values are random;

III-ecological niches are multidimensional and overlapped;

IV - species distribution typical of the communities of the northern latitudes;

1 - Gadus morhua; 2 - Melanogrammus aeglefinus; 3 - Mallotus villosus; 4 - Sebastes sp.; 5 - Hippoglosoides platessoides; 6 - Microstomus kitt; 7 - Trisopteris esmarkii; 8 - Brosme brosme; 9 - Ammodytes marinus; 10 - Clupea harengus; 11 - Pleuronectes platessa; 12 - non-commercial fish; 13 - Pollachius virens; 14 - Molva molva; 15 - Argentina silus, Argentina sphyrena; 16 - Macrurus berglax; 17 - Micromeristius poutassou.

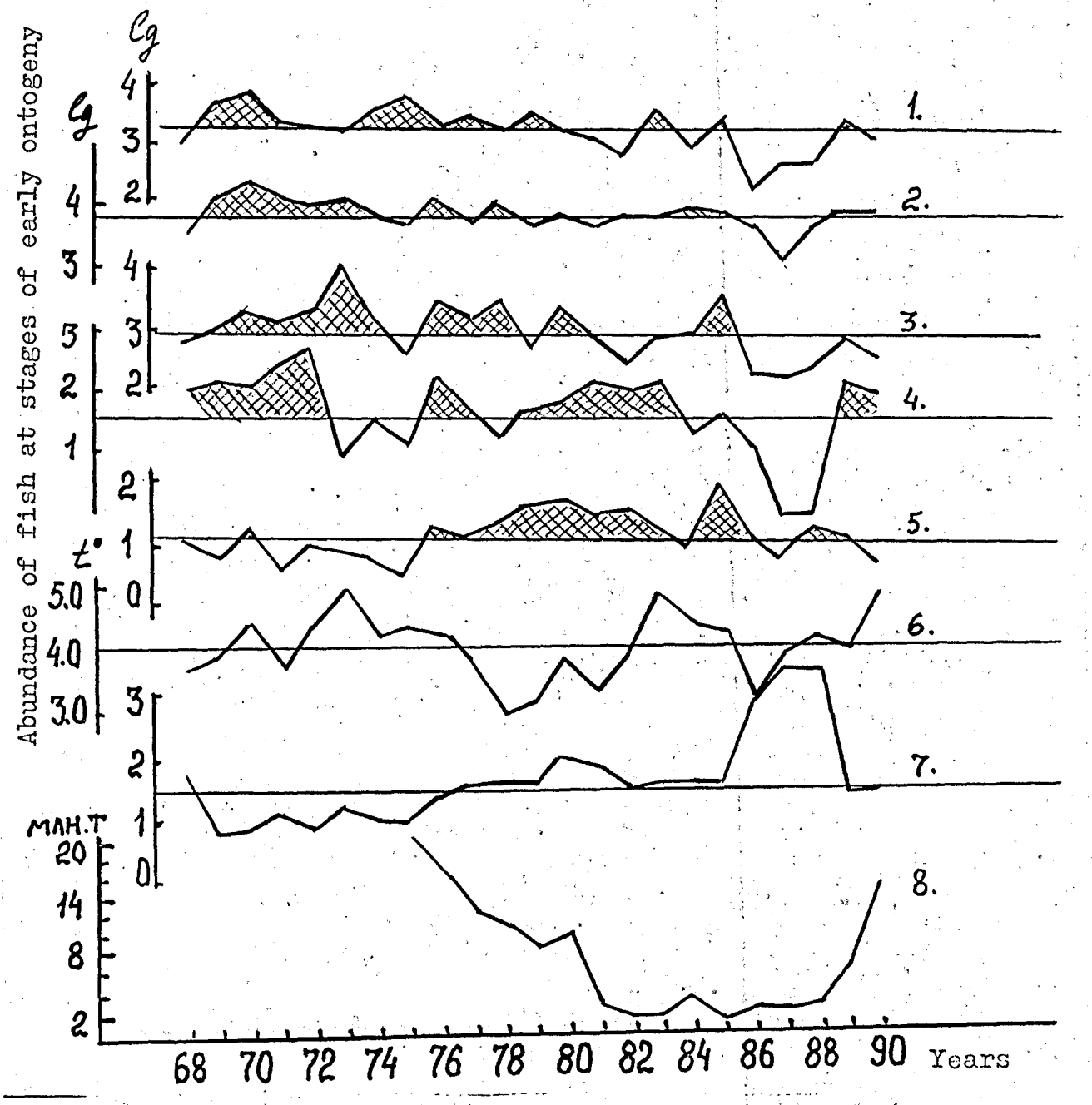

Fig.3. Relationship between the indices for abundance of fish at stages of early ontogeny, index of species diversity, water temperature and stock of commercial fishes of the Barents and Norwegian Seas.

I - Gadidae family; 2 - Scorpenidae ; 3 - Pleuronectidae; 4 - Mallotus villosus(Mul.) ; 5 - a group of non-commercial fishes; 6 - mean water temperature in 0-200 m layer in the section 3 in March; 7 - index for species diversity; 8 - stock of commercial fishes of the Barents and Norwegian Seas.