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Long-term fluctuations of abundance indices of the Barents Sea euphausiids (Crustacea: Euphausiacea) according to the data from the autumn-winter survey

by

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Abstract

The paper generalises the long-term data (1953-1978) of the stock assessment of euphausiids in the southern Barents Sea. The analysis of the material made it possible to start investigating the main regularities of the euphausiid abundance dynamics, the influence of certain species on formation of total abundance, fluctuation of euphausiid abundance during the period of investigations.

As a result the existence of fluctuations of total abundance of euphausiids with the 10-12-year periodicity was noted. The periods of rise were at the beginning of decades. The arcto-boreal species were of great importance for the formation of the stock: the level of abundance depended on T. raschii; periodic fluctuations were determined by T. inermis.

Fluctuations of species structure of community at the expense of growth of cold water T. raschii abundance were observed during the period of observations. Steady increase of total abundance occurred against periodic fluctuations, the most productive parts moved to the south-east of the sea and a powerful and stable nutritive base of fish had been formed by the seventies.

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Résumé

Il s'agit des résultats généralisés des recherches de plusieurs années (1953-1978) sur l'abondance des Euphausidae dans la partie sud de la mer de Barents.

A la base des données obtenues on a relevé:

les lois principales de la dynamique de l'abondance des Euphausidae,

le rôle des espèces particulières dans la composition de l'abondance totale,

les variations de l'abondance des Euphausidae au cours des recherches.

Il a été démontré que les variations de l'abondance totale des Euphausidae ont lieu tous les 10 à 12 ans. Les débuts des décennies étaient les périodes de pointe. Le rôle essentiel dans la composition de l'abondance revenait aux espèces arcto-boréales; le niveau de l'abondance était fonction de T.raschii; les variations périodiques étaient définies grâce à T.inermis.

La période étudiée était caractérisée par le changement de la structure spécifique de la communauté dû à l'abondance accrue de T. raschii provenant des eaux froides.

Les variations périodiques de l'abondance s'accompagnaient de l'augmentation incessante des ressources totales; les zones les plus productives se sont déplacées vers la partie sud-est de la mer ce qui a contribué à la formation, dans cette région, de la base alimentaire stable des poissons.

Introduction

The importance of euphausiids in the biotic chain of the Barents Sea is so great that their influence on the productivity of the following links including fish is beyond doubt. The volume of knowledge of this relationship determines rational exploitation of fish supply of the reservoir. Long-term observations on biology and abundance of euphausiids carried out by PINRO in 1953-1978 make it possible to start estimating the production level of the stablest regularities of their dynamics against interspecific relations and to explain the causes of specific formation of the nutritive base of the Barents Sea fish.

Material and methods

The generalised results of annual winter surveys performed since 1953 until now in the southern Barents Sea were the material for the paper. Concentrations of euphausiids were fished off by the net (gauze No.140 with the 50 cm diameter of the admission opening), attached to the middle of the headline of a commercial trawl moving at an average speed of 3 knots per hour.

In all 4489 samples were taken. Characteristics of fishing gears, the degree of coverage with sampling of different sea areas, substantiating the season of sampling and methods of processing of samples were described in details in the report at the preceding ICES session (Drobysheva, 1979).

Investigations into the Barents Sea euphausiids were started with the aim of providing Gadidae with food during the period of summer feeding of euphausiids. Assuming that migrating fish shoals have greater possibility to find and utilize food in a vast sea area, at first we did not take into account single local concentrations of euphausiids, which were not typical of the whole

surveyed area. The index of state of the nutritive base of fish was calculated as the arithmetic mean of the sum of catches excluding several anomalously rich ones - 2-3 samples of 100 annually. The criterion of rightness of such index was its conformity with actual intensity of young fish feeding (Ponomarenko, 1961, 1973). The above-mentioned indices undoubtedly reflect certain fluctuations of euphausiid abundance and this information is presented in the paper (Drobysheva, Soboleva, 1973).

The accumulation of long-term data and an attempt to use trophic links of fish in forecasting necessitated to explain the conditions of formation of the Barents Sea euphausiid stock. More accurate data on abundance dynamics of Crustacea dwelling in the surveyed area were needed. The method of removal of anomalous samples employed earlier was unacceptable for this purpose. That is why the arithmetic mean of all the catches of trawl-attached nets per trawling hour is accepted at present for the index of euphausiid abundance which gives an idea of a number of euphausiids in 1000 m^3 of water at a speed of trawling of 2.5-3.5 knots. These data were the material for the paper.

Results of investigations

During the period of 25 years of our investigations (1953-1978) the euphausiid abundance in the southern Barents Sea was on the whole at the level of 100-300 (Table 1, Fig.1) , in some years the index fell to 60-80 and rose to 500-900. Usually peaks of abundance fluctuations did not exceed 2-3 fold limits , and only in winter 1975/76 the abundance of euphausiids was 10 times as high as an average level and amounted to 2216 (unfortunately, there was a mistake in Table 1 of the similar paper in 1979:

the value of 216 was given instead of 2216). This fact testifies to great production capacities of euphausiids and probabilities of a sudden increase of abundance.

The mean number of euphausiids during the whole period of investigations was 315, but we consider it more reasonable not to take into account the anomalous 1975 while analysing the dynamics and accept the mean annual level equal to 228.

Short periods of the increase of euphausiid abundance were during the first 2-3 years of every decade, and long periods of decrease included 7-8 years in the middle and at the end of the decade. Thus, after a great increase of abundance in 1953 (it was almost 3 times as high as an average level), the long poor period came. It was concluded with the increase of 1962 (twice as high as the average) after which an amount of euphausiids again became below the norm. In 1969 the amount of euphausiid increased and was keeping to the high level during four years, it being 4 times as high as the average norm in 1972. After a short period of decline (1973 and 1974) there came a unique rise in 1975, when the amount of euphausiids was 10 times as high as the mean long-term value, after which it again dropped to the norm. Comparing long-term data we see that the amount of euphausiids in the seventies was greater than in the previous decades, and peaks became more clearly defined and sudden.

Consequently, the increase of total abundance occurred against regular increases of abundance with 10-11 - year duration.

As far as the stock of the Barents Sea euphausiids includes four species different in their zoogeographical nature and origin, their functions in the formation of the stock differ.

During the period of our investigations the arcto-boreal neritic species Thysanoessa inermis and Thysanoessa raschii (45 and 48% of the total amount, respectively) were the most important in the local community, and the boreal neritic Meganictiphanes norwegica and arcto-boreal oceanic Thysanoessa longicaudata constituted the insignificant part of the total amount - 3 and 4%. The significance of the species was unaffected during our investigations, but the share of each of them has underwent changes - the gradual decline of the share of warm water M.norwegica from 17% in the fifties to 1% in the sixties - seventies and, correspondingly, the growth of the share of cold water T.raschii from 14 to 48% (Fig.2, Table 2) occurred. In the seventies this species made up more than a half of the total amount of euphausiids having attained maximum advantage in 1973. The share of cold water species grew in all the areas and they became the universally dominating species.

The long-term fluctuations of T.inermis abundance had the 10-13 year periodicity with a growing amplitude: the amount of euphausiids increased sharply at the beginning of every decade and declined in intermediate years. The mean index of abundance for the period of investigations was equal to 119. The amount of euphausiids became 3-5 times as high as the average norm during the periods of rise, and halved during the periods of falls.The amplitude of abundance fluctuations did not exceed ten-fold values. These fluctuations occurred at the expense of young specimens assessed at the age of 0+. The amount of young euphausiids was varying from 4 to 277, while the amount of older specimens at the age of 1+ was varying from 4 to 91.

The dynamics of T.raschii abundance was quite different. The

periodic fluctuations of this species abundance coincided with those of T.inermis, but the amplitude of fluctuations was smaller and the periods were not so clearly defined. These fluctuations occurred against gradually growing amount of T.raschii. Both minimal and maximal levels of abundance had grown by the end of the period of our investigations. As a result, this value did not exceed 14 in the fifites, 38 in the sixties, 370 in the seventies, with a mean annual index of abundance of 154. Fluctuations of T.raschii abundance were determined equally by both age groups.

The amount of M.norwegica and T.longicaudata was 20 and 10 times as low as that of the above-mentioned species. The average amount for the whole period of investigations was equal to 6.3 and 12.0, respectively. The catches of M.norwegica during the period of the fifties - seventies were gradually declining: 14.0 - in 1953-61; 1.3 - in 1964-73. The amount of T.longicaudata was the greatest in the fifties and seventies, and the lowest - in the sixties.

As a result, the arcto-boreal T.inermis and T.raschii were the species determining the level of euphausiid abundance in the southern Barents Sea. Regular fluctuations with the 10-12-year periodicity were characteristic of their abundance. At the same time the growth of cold water T.raschii abundance was observed in these years and this fact conditioned the increase of total abunadnce of euphausiids and determined the possibility of unique increase of 1975.

Discussion

The analysis of fluctuations of euphausiid abundance in the southern Barents Sea for more than half a century showed that

the amplitude of summary abundance fluctuations of all species usually does not exceed 2-3-fold values of the norm (the mean long-term amount). The biomass is 11.4 g with the norm of 228 specimens and the mean weight of the Barents Sea euphausiids equal to 50 mg.

It may be supposed that weight indices of the community of the Barents Sea euphausiids are determined during the winter survey, because in this period populations of certain species are recruited with grown young fish born in the given year, and predation of mass fish species - cod and capelin - is minimal. The trawl-attached nets employed by us fish on euphausiids better than other gears, but still have a low catchability coefficient. That is why the value given here reflects just the portion of actual biomass by which we still can judge of the level of possible production of euphausiids.

It is quite evident that the bulk of euphausiid stock was formed at the expense of the arcto-boreal T.inermis and T.raschii species. Their abundance was characterised by simultaneous periodic increases against the main tendency. Gradual cooling of the Barents Sea waters occurred in the fifties-seventies, and growth of cold water T.raschii abundance was observed at the same time.

The lack of significant fluctuations of euphausiid abundance proves the existing opinion on definite stability of the Arctic community, on availability of compensatory adaptation to environment in arctic species (Zelikman, 1977). In this case the stability of euphausiid abundance is achieved to a great extent by common dwelling of species of different zoogeographical nature interchanging each other under sharp changes of environ -

ment. It is determined by the fact that the southern Barents Sea is a buffer zone between different water masses - warm Atlantic and cold Arctic. Sharp gradients of environment typical of such areas of the world ocean are redoubled here by complicated geomorphological and hydrodynamic characteristics (Matishev, et al., 1978; Tantsura, 1952). Because of this the area of dwelling of the bulk of some species is disconnected: ice-neritic T.raschii are dominating in shallow waters of the eastern part of the sea, more stenothermic T. inermis - in the central and coastal areas of the sea, boreal M.norvegica and oceanic T.longicaudata prevail in the open waters of the south-east. Naturally, the most mixed zoogeographical composition of euphausiid groupings is usually registered in the central and coastal areas of the sea, and this conditions the most stable amount. Ecologically different species prevail in the south-west and south-east of the sea determining great lability of abundance.

In the period of our observations gradual increase of T.raschii abundance, and, vice versa, disappearance of M.norvegica occurred under conditions of general cooling of the Barents Sea waters (Mukhin, 1975; Bochkov, 1978). The potentialities of the arcto-boreal T.raschii proved so high that they conditioned an extra-ordinary rich stock of the Barents Sea euphausiids in the seventies. This resulted in a sharp increase of food supply in the eastern areas.

Conclusions

1. The mean index of euphausiid abundance in the southern Barents Sea for the period of 1953-1978 is equal to 228. Changes of summary abundance were subject to regular fluctuations with

the 10-12-year periodicity and amplitude from 100 to 1000 specimens. The increase of the index to 2216 occurred in 1975.

2. The arcto-boreal neritic species T.inermis and T.raschii, the mean indices of abundance of which were equal to 119.0 and 154.0 (the indices of boreal neritic M.norvegica and boreal oceanic T.longicaudata did not exceed 6.3 and 12.0), were the most important for the formation of the stock of the Barents Sea euphausiids. In the period of our investigations gradual increase of the amount of T.raschii and sharp decrease of the share of M.norvegica occurred. Since the middle of the sixties the cold water species became prevailent, and the warm water one practically disappeared.

3. The abundance dynamics of certain species for the last 25 years was as follows: the amount of T.inermis varied regularly with the 10-12-year periodicity; the amount of T.raschii was growing steadily having become 27 times as high as the initial abundance by the end of the period of investigations; the amount of M.norvegica, on the contrary, decreased, Fluctuations of T.raschii abundance on the one hand, and M.norvegica, on the other hand, are antiphase and clearly connected with the change of the thermal level of waters. Owing to this the steadiest stock of euphausiids was kept in the coastal and central areas, where T.inermis were of great importance, and the greatest changes in composition and, consequently, in abundance, occurred in the western and eastern areas.

Table 1

Yearly fluctuations of a number of euphausiids in the southern Barents Sea (average number in 1000 m^3).

Year (XI-II)	T.inermis	T.raschii	T.longicaudata	M.norvegica	Average
1952/53	122	3	1,0	45,5	168
1953/54	282	11	3,0	2,0	615
1954/55	83	7	24,0	9,7	113
1955/56	72	6	7,0	14,5	195
1956/57	34	18	0,1	13,9	115
1957/58	29	38	7,0	17,3	76
1958/59	-	-	-	-	63
1959/60	70	45	0,6	0,6	183
1960/61	57	6	10,0	1,2	83
1961/62	116	10	6,0	21,8	146
1962/63	551	145	2,0	0	499
1963/64	-	-	-	-	-
1964/65	45	69	3,0	2,2	128
1965/66	22	22	0,5	2,0	87
1966/67	44	16	3,0	1,6	179
1967/68	53	15	2,0	1,3	111
1968/69	60	16	4,0	0,1	112
1969/70	43	96	10,0	3,2	322
1970/71	48	32	11,0	0,4	334
1971/72	20	49	15,0	0,2	248
1972/73	156	1091	13,0	0,2	952
1973/74	73	164	15,0	0,1	241
1974/75	133	144	11,0	1,2	149
1975/76	570	1230	10,0	0,4	2216
1976/77	69	158	18,0	0,1	231
1977/78	179	213	8,0	0	400
1978/79	32	95	8,0	0	135

Table 2

Correlation of mass species of euphausiids in the southern Barents Sea (in %)

Year /XI-II/	T.inermis	T.raschii	M.norwegica	T.longi-caudata
I952/53	7I	2	26	I
54	95	3	I	I
55	67	6	8	I9
56	72	6	I5	7
57	52	27	2I	0
58	32	42	I9	7
59	-	-	-	-
I959/60	58	37	I	4
6I	77	8	2	I3
62	75	7	I4	4
63	79	2I	0	I
I963/64	-	-	-	-
65	37	58	2	3
66	47	48	4	I
67	68	25	3	4
68	75	2I	I	3
69	75	20	0	5
70	28	63	2	7
7I	52	35	I	I2
72	24	58	0	I8
73	I3	86	0	I
74	29	65	0	6
75	46	50	0	4
76	30	64	0	6
77	28	65	0	7
I977/78	45	53	0	2
79	23	70	0	7
Average annual	45	48	3	4

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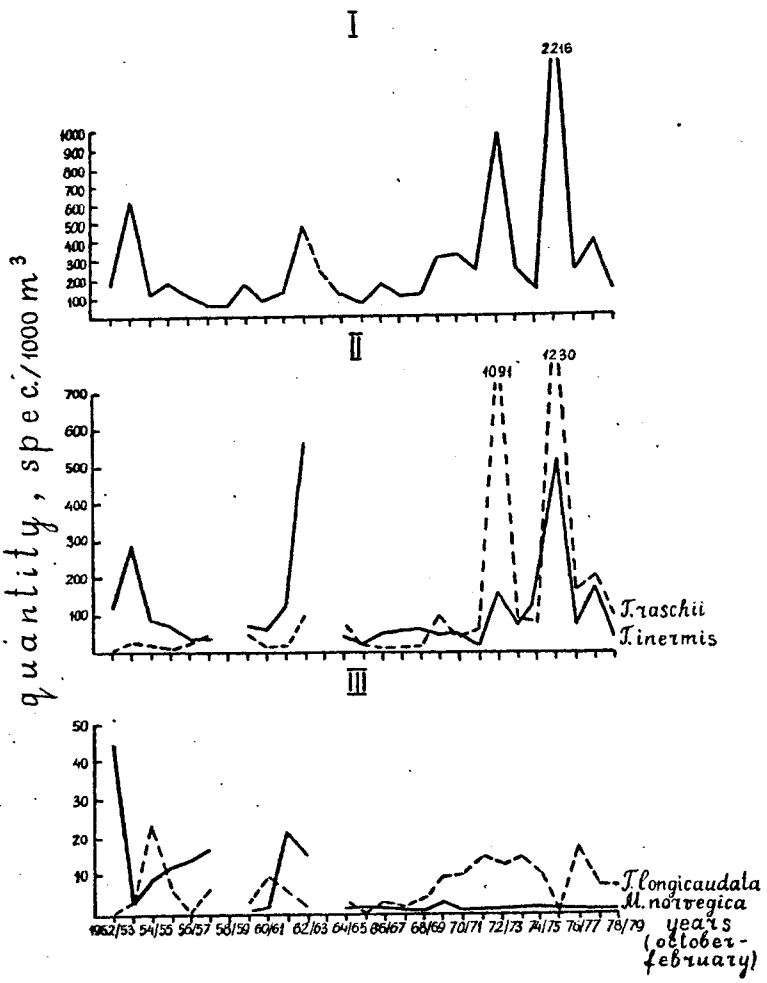
Headings for Figures

to the paper by S.S.Drobysheva

"Long-term fluctuations of abundance indices of the Barents Sea euphausiids (Crustacea: Euphausiacea) according to the data from the autumn-winter survey"

Fig.1. The long-term dynamics of indices of euphausiid summary abundance in the southern Barents Sea (1), of local T.inermis and T.raschii abundance (II) and transported M.norvegica and T.longicaudata (III).



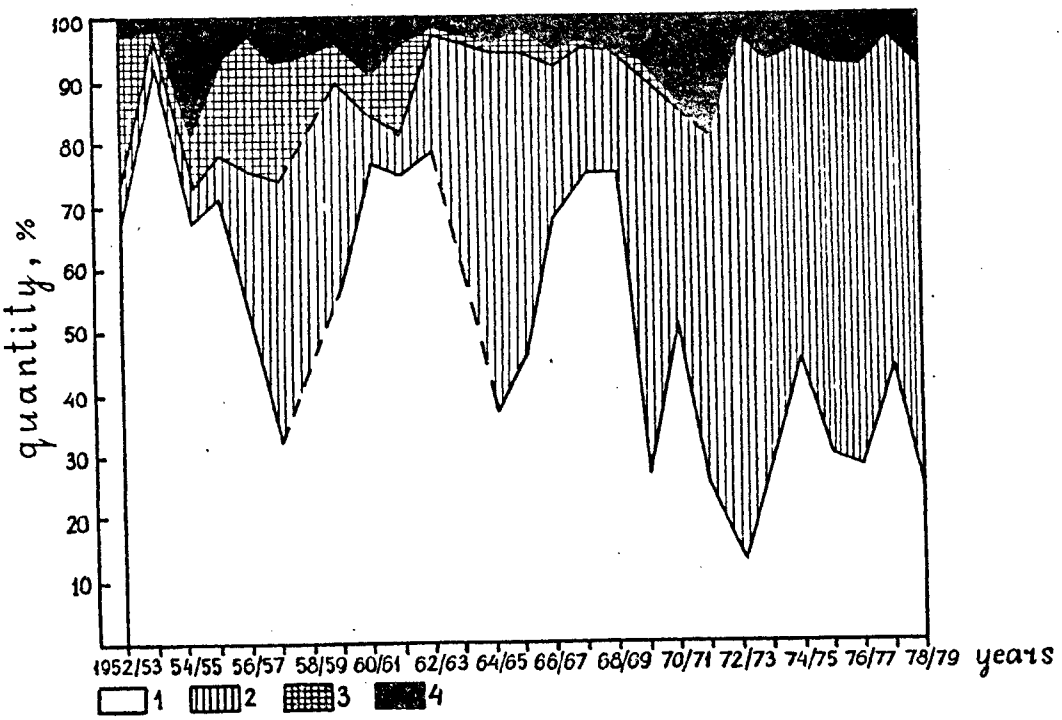


Fig.2. Species correlation of euphausiids in the southern Barents Sea.

Legend:

1-T.inermis

2-T.raschii

3-M.norvegica

4-T.longicaudata