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Food interrelations between the  
Barents Sea capelin and polar cod

by

L.D. Panasenko and M.S. Soboleva

Abstract

Dynamics of food interrelations between capelin and polar cod is analysed on the basis of changes in the degree and index of food similarity of both species.

Local, seasonal and annual changes in the magnitude of competition in the southern Barents Sea are considered. The paper is aimed at revealing the regularities which make possible a joint existence of the most abundant Barents Sea pelagic fishes. After comparing spectra of capelin and polar cod feeding some common food organisms were found. The index of food similarity throughout the southern Barents Sea was 56.0 (according to K.P. Yanulov, 1963). In the areas of joint feeding the magnitude of competition is higher than in the whole Barents Sea and it has its peculiarities in each separate area. In central areas the greatest similarity in food of capelin and polar cod is observed in spring in relation to euphausiids (index of food similarity - 47.7); in north-eastern areas the aggravation of

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\* PINRO, Murmansk, USSR

food interrelations may result from joint feeding on copepods in summer (index of food similarity - 43.5).

Capelin and polar cod are feeding mainly in summer, the mean index of stomach fullness ranges from 1.7 to 2.3. Their foraging areas in this period coincide. The highest coincidence of feeding areas and aggravation of the competition should be expected in the north-eastern and central Barents Sea in warm years. A high index of stomach fullness of capelin and polar cod in the areas of joint feeding is indicative of fish being well supplied with food, which proves that there is no keen competition between these species.

#### Résumé

L'analyse de la dynamique des rapports alimentaires du capelan et du saïda est effectuée en fonction des variations du degré et de l'indice de l'analogie alimentaire de ces poissons.

La publication traite le problème des variations locales, saisonnières et annuelles du volume de concurrence dans la partie sud de la mer de Barents. Le but essentiel de ces recherches consiste à relever des facteurs qui influent sur l'existence en commun des poissons pélagiques les plus nombreux de la mer de Barents. La comparaison du spectre alimentaire du capelan et du saïda a démenti la présence de mêmes objets de nutrition servant à l'engraissement de ces deux poissons.

Dans la partie sud de la mer l'indice total de l'analogie alimentaire était de 56,0 (Ianoulov, 1963). Dans les régions de l'engraissement commun le volume de la concurrence alimentaire est supérieur à celui de la mer de Barents en général; il a ses particularités pour chaque région. Dans les régions centrales, en printemps, l'analogie alimentaire du capelan et du saïda est due surtout aux Euphausidae (l'indice d'analogie alimentaire - 47,5);

tandis que dans les régions nord-est, en été, la concurrence alimentaire est due aux copépodes (l'indice d'analogie alimentaire - 43,5).

L'engraissement du capelan et du saïda ayant lieu essentiellement en été, le taux moyen de la réplétion varie de 1,7 à 2,3. C'est une période de la convergence des régions de leur engraissement. La convergence maximum de ces régions ainsi que l'accentuation de la concurrence alimentaire sont caractéristiques pour les régions nord-est et centrales de la mer de Barents au cours des années douces. Un taux élevé de réplétion du capelan et du saïda dans les régions d'engraissement commun témoigne de la présence suffisante de la nourriture ce qui signifie l'absence de la concurrence entre ces espèces.

#### Introduction

Interspecific relations between fishes are an important factor determining their food supply, that is why they attract attention of many scientists in the world. The paper by A.A.Shorygin (Shorygin, 1952) is the most interesting one in this respect: for the first time methods of quantitative study of food interrelations between fishes were worked out, the North Caspian Sea fishes being taken as an example. Weight data on the food composition and annual rations were used as a basis for quantitative characteristic of food interrelations. Food interrelations between main commercial fishes of the Barents Sea - cod and haddock - are considered in the paper by N.S.Petrova-Grinkevich (Petrova-Grinkevich, 1944).

Food interrelations between the most abundant pelagic fishes of the Barents Sea - capelin and polar cod - are characterized in the present paper. The paper considers the magnitude of competition between these species when they have a common nutritive base. The dynamics of food interrelations was analysed on the basis of changes in the degree and index of food similarity of fish. The paper considers also seasonal

and local changes in the magnitude of competition; an attempt is undertaken to determine the conditions ensuring a joint existence of these species.

#### Material and methods.

Qualitative and quantitative samples of capelin and polar cod feeding taken in the areas of joint feeding in the central, eastern and north-eastern Barents Sea in 1974-1978 served as a basic material for the present paper. The volume of data examined is given in Table 1.

The data were analysed in laboratory according to the quantitative-weight method (Borutsky, Zheltenkova and others, 1974). Following indices of fish feeding are used in the paper: mean index of stomach fullness, general and particular indices of stomach fullness (used as an index of the amount of food in the stomach). The frequency of occurrence of food components was calculated (in % of the number of stomachs with food) and the value of these components in per cent of the index (of weight).

The dynamics of food interrelations between capelin and polar cod was analysed on the basis of changes in the degree and index of food similarity of fish calculated according to Yanulov (Yanulov, 1960) and Shorygin (Shorygin, 1952) method.

#### Results

##### 1. Degree of similarity of capelin and polar cod food.

A number of common food objects was determined on the basis of data on changes in capelin and polar cod feeding for 1974-1978 (Table 2). The most important objects both in capelin and polar cod feeding are copepods (by frequency of occurrence) and euphausiids (by

weight).

The analysis of data obtained shows that following copepodite species are the most frequent in capelin and polar cod stomachs: *Calanus finmarchicus*, *Calanus hyperboreus*, *Pareuchaeta norvegica*, *Petridia longa*. The role of these species in fish feeding is not the same within the year, they become more important in the north-eastern Barents Sea in summer autumn (Fig.1). The frequency of copepods occurrence in fish stomachs in this period reaches 80-100% or 33-63% by weight. Fish feed on grown copepods of the spring generation.

Euphausiids - *Thysanoessa inermis*, *Thysanoessa raschii* - are less important in capelin and polar cod feeding as far as their frequency of occurrence is concerned. They are found in capelin and polar cod stomachs all the year round but fish feed on them mostly in winter in the central Barents Sea where they make up 33-33% by weight.

Besides, capelin and polar cod feed on Gammaridea and Hyperiidea which become more important in the north-eastern Barents Sea in autumn.

By frequency of occurrence fish make up 23% of polar cod food. Mostly polar cod of elder age groups feed on them and mainly in autumn beginning with August. The role of fish in capelin feeding is not very important, this food is found in their stomachs only in winter.

The magnitude of competition calculated by the frequency of occurrence according to Yanulov method was 56.0 in the southern and north-eastern Barents Sea. The magnitude of competition (index of food similarity) is not a constant value and depends on just how accurately food organisms have been indentified. The index of food similarity calculated according to Shorygin method (1952) using the data from processing by quantitative-weight method is lower and equals to 44.4.

It should be noted that the magnitude of competition varies depending on season, area, fish migration and abundance of food organisms.

2. Indices of food similarity of capelin and polar cod in different areas of the Barents Sea and their seasonal changes.

Capelin and polar cod have a similar annual rhythm of feeding. The minimum index of fullness is registered in November/January. Then the index is steadily growing till July/August, the time when the feeding reaches its peak. All biological characteristics of fish are as a rule at their maximum annual level. The index of stomach fullness of capelin and polar cod depends on the nutritive base of areas of their distribution which in turn depends on the heat content of the Barents Sea waters.

1974-1978 differ as far as their hydrology is concerned. By heat content of water masses 1974 belongs to moderate years, 1975-1976 to warm and 1977, 1978 - to cold.

In warm years the bulk of capelin migrate in spring/summer across central areas rich in food to the north-east where fish feed intensively in summer and autumn. In cold years the migration routes are shifted to the west and north-west. Polar cod migrate also to the north-eastern areas, along the Novaya Zemlya, where they feed intensively during summer/autumn. In cold years the area of their feeding is shifted a little to the west.

Thus, in the period of maximum feeding, namely in July and August, capelin and polar cod are feeding in the same areas. The greatest coincidence of feeding areas and the keenest competition between capelin and polar cod should be expected therefore in warm years.

The main foraging areas of capelin and polar cod are as follows:

north-eastern - the northern part of the Novaya Zemlya Shoal, Sykhov Nos, Admiralteistvo Peninsula area, Novaya Zemlya Bank; central - the Central Deep, slopes of the Goose Bank; south-eastern - the Kolguev and Pechorsky areas. Fig. 2 shows the spectra of capelin and polar cod feeding in central and north-eastern areas. It is seen that the greatest coincidence of food of these two species in central areas is registered in relation to euphausiids and in north-eastern areas - to copepods. The index of food similarity calculated according to Shorygin method is higher for euphausiids than for copepods (47.7 and 43.5 respectively). In the areas of joint feeding the magnitude of food competition is higher than in the whole southern Barents Sea (Table 3).

Table 3. Magnitude of competition in different fishing areas of the Barents Sea.

Areas	Southern		Central		North-eastern		Joint feeding	
	1	2	1	2	1	2	1	2
Magnitude of competition	56.0	44.4	49.6	47.7	-	43.5	63.5	-

1 - magnitude of competition calculated according to Yanulov method (1963).

2 - magnitude of competition according to Shorygin method (1952).

As it is seen from Table 4 the increase of index of food similarity was registered in April/May when capelin and polar cod start to feed jointly on euphausiids in the central Barents Sea where these Crustacea are the most abundant. A tendency towards increase of the

magnitude of competition is in force within the whole summer period till August. In August when polar cod start to feed on fish (young capelin, polar cod, sand eel and other fishes) the magnitude of competition decreases. In October a joint feeding on euphausiids again makes the competition between capelin and polar cod very keen.

Thus, the competition between capelin and polar cod in the Barents Sea may result from their joint feeding on two main food objects: euphausiids and copepods. In areas of joint feeding the degree and index of food similarity calculated according to Yanulov method are the highest (45.2 to 64.7) in April/May when capelin and polar cod feed on euphausiids and in summer (the degree of food similarity 103.8) when copepods make up the bulk of their food.

Notwithstanding that the magnitude of competition in the areas of joint feeding aggravates in summer, the index of fullness of capelin and polar cod is very high (mean indices of fullness are 1.7 and 2.5 respectively). This proves that the two species are well supplied with food in these areas, which in turn indicates that there is no tension between capelin and polar cod during feeding.

#### Conclusions.

Copepods and euphausiids play the most important role in the feeding of the Barents Sea capelin and polar cod. Fish feed on euphausiids in the central Barents Sea in spring, and on copepods - in north-eastern areas in summer.

The index of food similarity of capelin and polar cod throughout the southern and north-eastern Barents Sea was 56.0 (according to K.F. Yanulov) and 44.4 (according to A.A. Shirygin). In the areas of joint feeding the index of food similarity increases in summer to 63.5 (according to K.F. Yanulov).

A high index of stomach fullness of capelin and polar cod in the



gress of joint feeding is indicative of fish being well supplied with food which shows that there is no tension between these two species.

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Table 1. The volume of data on the feeding of the Barents Sea capelin and polar cod.

Area	Year	Capelin		Polar cod	
		Field analysis	Quantitative weight analysis	Field analysis	Quantitative weight analysis
North-eastern	1974	1309	-	2423	-
	1975	1524	-	1485	140
	1976	2995	122	999	198
	1977	611	25	820	26
	1978	229	205	-	50
Central	1974	1410	-	2317	-
	1975	1501	-	1122	77
	1976	1496	-	1096	187
	1977	1578	79	1212	50
	1978	727	452	-	279
Eastern	1974	-	-	2148	-
	1975	13	-	1022	24
	1976	-	-	1077	524
	1977	228	-	687	-
	1978	25	25	-	25
Total		13646	903	14970	1579

Table 2. The role of common food organisms in the feeding of the Barents Sea capelin and polar cod.

Food organisms	Capelin		Polar cod	
	frequency of occurrence, %	by weight, %	frequency of occurrence, %	by weight, %
Copepoda	61,0	33,7	41,5	14,2
Lysidacea	-	0,01	-	0,2
Hyperidea	11,5	1,9	14,5	15,4
Gammaridea	-	0,06	-	4,3
Luphausiacea	34,5	54,7	16,5	25,8
Macrura	0,09	-	2,5	-
Another Crustacea	-	0,02	-	0,6
Chaetognatha	1,4	1,7	0,26	0,5
Otenophora	3,3	-	1,0	-
Polychaeta	0,02	-	0,29	-
Fishes	1,5	1,9	11,5	33,0

Table 4. Seasonal changes in the degree and index of food similarity of capelin and polar cod according to Yanulov in the areas of joint feeding in 1974-1978.

Months	Degree of food similarity	Index of food similarity
January	20,3	18,8
April	45,2	40,4
May	64,7	44,5
June	64,4	76,5
July	103,8	80,6
August	29,0	20,9
September	25,3	20,8
October	47,0	47,1

Headings for Figures

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Fig. 1. Seasonal changes in the frequency of occurrence of main food organisms in stomachs of the Barents Sea capelin and polar cod.

1 - Copepods. 2 - Euphausiids. 3 - Hyperiidea. 4 - Fish.

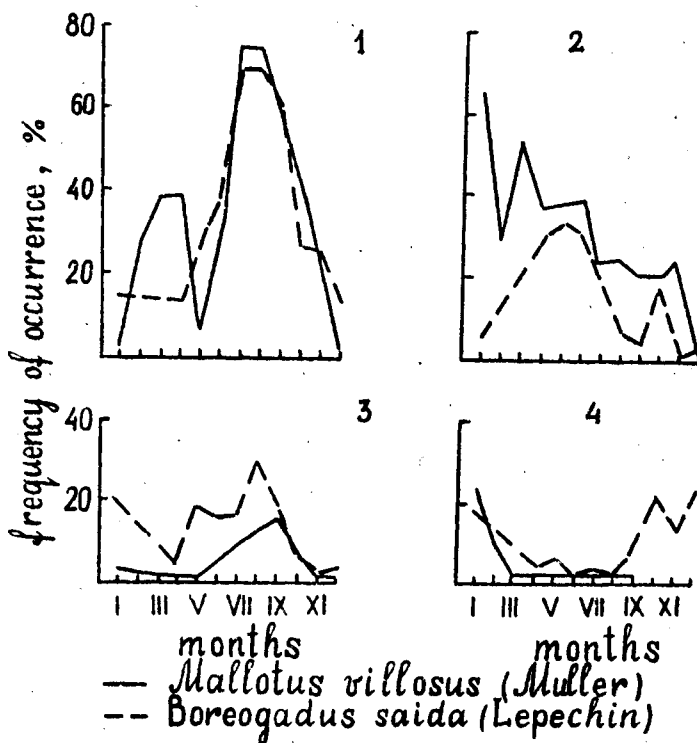


Fig. 2. Spectra of capelin and polar cod feeding in different areas of the Barents Sea

A. Central. B. North-eastern.

1 - Copepods. 2 - Hyperiidea. 3 - Gammaridea. 4 - Mysidacea. 5 - Euphausiids. 6 - Fish. 7 - Chaetognatha. 8 - Digested Crustacea.

The figures show the magnitude of competition in different parts of the Barents Sea.

