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LONG-TERM DYNAMICS OF CAPELIN FEEDING IN THE BARENTS SEA AND DECISIVE FACTORS

by

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Abstract

Long-term data on capelin feeding are used to study the dependence of capelin feeding on stock size and structure, distribution pattern and food supply in the cold (1976-1982) and warm (2001-2004) periods. Special attention is paid to size- and age-related features of capelin feeding associated with food abundance and availability, duration of feeding and food competition. It is shown that capelin prefer larger food objects which do not always dominate in plankton. It is concluded that capelin feed most efficiently (reaching up to 12-18% fatness) on the abundant, especially in warm years, food resources of the northern Barents Sea, including Arctic species of larger copepods (*Calanus glacialis, Calanus hyperboreus*) which are characterised by a high content of lipids.

Keywords: *Calanus glacialis*, *Calanus hyperboreus*, capelin, distribution, food supply, stock.

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Introduction

In the 1960s-1990s, a great deal of data on regularities of migrations, feeding behaviour and conditions of the Barents Sea capelin were accumulated (Prokhorov, 1965; Luka, 1977; Panasenko, 1978, 1989; Ozhigin, Ushakov, 1985; Nesterova et al., 1987; Skøldal et al., 1992). Further, they were added by the information about peculiarities of capelin food supply forming with regard for fish abundance and age structure, under different water temperature, and a great attention was paid to the efficiency of fish feeding determined by fish fatness dynamics (Gjøsaeter *et al*., 2002; Orlova *et al*., 2002, 2004, 2005 a, b). According to the analysis of long-term data, after feeding had been completed the capelin fatness fluctuated from 6 to 21 %. It was found that the minimal fatness providing the transition to sexual maturation was 8.5-9.3% for males and 5.6-6.2 % for females (Oganesyan, Dvinin, 1988). Obviously, insufficient fat accumulation may lead to slowing down of capelin gonad rate and have a negative impact on fish reproduction.

This paper is aimed at studying long-term and seasonal dynamics of capelin feeding and fat accumulation in different climatic periods and under the different state of population which condition the differences in fish food supply in the main area of feeding – the central latitudinal Barents Sea.

Material and methods

To characterize capelin feeding the data on quality and quantity analysis for 1977-1982, 1983-1985, 1987, 1992, 2002-2004 (more than 20 thousand stomachs) were used. The significance of food objects in the fish food was expressed in % of food bolus weight; feeding intensity was estimated in the indices of stomach fullness, in prodecimiles (‰). Capelin feeding was studied within the fish feeding ground, in the Barents Sea fishing areas adopted in PINRO (Fig.1).

When estimating capelin food supply the data on zooplankton obtained during the integrated surveys for the Barents Sea by PINRO (1982-1992, 2002-2004) (in all, about 600 samples) were used. The Juday net with 37 cm inlet diameter, with 180 μm mesh size of net, collected plankton samples in different layers. The samples were processed using standard methods (Anon., 2004); the biomass was expressed in mg/m^3 of raw weight. PINRO's reference materials about euphausiid concentrations in the mentioned years (ind./1 000 m^3) obtained when sampling pre-bottom concentrations of macroplankton by a net attached to the trawl were also used.

To estimate the efficiency of capelin feeding the data on fish fatness obtained by biochemical analysis method (Lazarevsky, 1955) were applied.

The data on capelin abundance were taken from the materials (Anon., 2004), capelin distribution was analyzed by the data of fishing statistics and trawl-acoustic surveys.

Results

In warm 1950s-1960s, capelin fed in the northern Barents Sea where euphausiids (48 % by weight) as well as copepods and hyperiids prevailed in this fish diet. After the completion of feeding capelin fatness reached 19-21 % (Prokhorov, 1965). In the late 1960s, when the abundance of Atlanto-Scandian herring, capelin food competitor, abruptly reduced, that one of the latter increased. The commercial fishery of capelin stock was commenced and, in the mid-1970s, the catches reached 1.5-3 x 10^6 t. In the population of capelin fish from elder age groups occurred, but their portion fluctuated (Fig. 2).

In the cold period (1976-1982), capelin distribution was wide, with the boundaries in the north and off the Novaya Zemlya Land, along 78º-80ºN (Røttingen, Dommasnes, 1985). In some years, the feeding area of capelin reduced and its boundaries were more south - and westward that, according to some authors (Loeng, Nakken, Raknes, 1983; Ozhigin, Luka, 1985), was connected with plankton development.

It was shown (Luka, 1977) that, at the beginning of summer, when mesoplankton reproduction only started, euphausiids played an important role in capelin feeding. Prevailing were the local species from *Thysanoessa* genus: *T. inermis*, which was abundant in shelf Atlantic waters, with the center of distribution in the west, and ice-neritic *T. raschii*, with that one in the east (Drobysheva, 1967). In the 1970s, unusually wide distribution of *T. raschii* to the northwest with forming concentrations in the periphery of the North Cape Current northern branch (Drobysheva, 1994) where its aggregations coincided with those ones of *T. inermis* was observed. Anomalous

1978 and 1979 were characterized by the greatest abundance and widest distribution of the euphausiid joint aggregations (Fig.3); cold 1977 was close to them.

Anomalous cold years (1978-1979). In 1978, capelin feeding started in the first days of June, during feeding migrations in the Atlantic waters, and fish aggregations overlapped those ones of euphausiids. Capelin began to feed, mainly, on euphausiids in the late August, practically simultaneously in the northwestern and central areas (Fig.4). The stomach fullness was maximal in the Persey Elevation, in September (the indices of stomach fullness – 320-1120 ‰) with a high role of euphausiids for all fish (1-4+ years). Their food was mainly composed by the warmwater species *T. inermis*, *T. longicaudata*, *Calanus finmarchicus*, *Themisto abyssorum*. The period of euphausiid consumption by capelin was long-lasting, in total, they made up 48 and 37 % in August and September, 33 % in October. The data of 1979, to a great extent, corroborated the scheme of capelin feeding in 1978. The main difference was more scattered distribution of *T. inermis* and *T. raschii* that resulted in limited area of capelin feeding on euphausiids (chiefly, in the Hopen Island area). To the north of 77˚N, capelin did not feed on euphausiids and started consuming copepods (Fig.2).

Cold years (1977, 1981). In 1977, the main differences in capelin feeding were connected with the prevalence of young fish (1-2 + years) in population that stipulated their feeding on, mainly, copepods. The capelin was characterized by wide distribution and, fed in the west, central and east areas. The total portion of copepods was high – 59 %, euphausiids made up 36 %. In 1981, the capelin feeding area was small, with concentration of fish aged 2-3+ in the northwestern and central sea. The food was mixed, but copepods predominated. Their significance for immature and mature fish was high (50-60 %), the rest portion was represented by euphausiids (16-27 %) and hyperiids (15-1 %).

Normal years (1980, 1982). In 1980, despite the reduction in the euphausiid abundance, in August, they played a considerable part in feeding of fish from every age group (alongside with copepods and hyperiids) from the South Cape Deep to the Persey Elevation, and, in September, - also to the north of 78˚N. In the early September, in the north of West Spitsbergen, in the number of cases, capelin only fed on euphausiids. On the whole, that year was characterized by unusually high consumption: 55-95 % in July, 60-75 % in August, 60-85 % in September. At that, chiefly, euphausiids were consumed by mature fish. Immature capelin, mainly, fed on copepods (to 52 % in August and 76 % in September). Due to intensive feeding, capelin reached high fatness already in mid-September: 10.6-12.5 % in the Hopen Island area and 12.5-13.7 % in the South Cape Deep.

In 1982, when PINRO first conducted the survey for plankton, in the latitude of 76˚44’N (arctic water masses), in the Hopen Island area and the South Cape Deep, the high concentrations of large arctic species *C. hyperboreus* and *C. glacialis* were observed. And though mean biomass of copepods in the upper layer was small (200-230 mg/m^3) their variations during a day (from 20-40 to 890-960 mg/m^3) indicated on high food supply in the areas mentioned.

Due to high abundance of copepod arctic species capelin started feeding on mainly them in the area to the north of 76˚N already in the middle of August, they also predominated in the fish food in the majority of areas in September (Fig. 4). In the Persey Elevation, small capelin moderately only fed on three *Calanus* species – *C. finmarchicus*, *C. hyperboreus* and *C. glacialis* at Stages IV-V as well as deep-water copepod *Pareuchaeta norvegica*. With the consumption of copepods capelin also fed on hyperiids. Due to irregular character of capelin feeding in 1982, the period of reaching high fatness (over 10 %) was prolonged in different areas: I-II decades of September (the Hopen Island area), the middle of September (the Persey Elevation), the end of September (the South Cape Deep).

On the whole, the seasonal dynamics of capelin feeding in the cold period of 1977-1982 is presented in Table 1.

Under warming having begun in the Barents Sea (the 1980s-1990s) the situation abruptly changed. The intensive fishery of capelin continued and the fish stock state became collapsible instead of stable (1985-1987); further it also significantly varied under the influence of fishery and predators (Fig. 2). The fluctuations of capelin stock, in turn, were the reason of rises and drops in euphausiid abundance, besides, with the deficiency of capelin, the consumption of them by adult cod as well as by cod juveniles rose. As a result, the total press on euphausiids considerably increased, and copepods became leading food objects in capelin feeding. The press on them was very high that the inverse relationship of capelin stock and mesoplankton biomass in 1982-2004 showed (Fig. 5). The Norwegian scientists also mentioned the similar regularity for the Barents Sea (Gjøsaeter *et al.*, 2002).

Food supply and feeding conditions for capelin in this period depending on sea temperature regime were studied in the number of papers (Nesterova, Panasenko, Pashkova, 1987; Orlova, Oganin, Tereshchenko, 2000; Orlova, Boitsov, Ushakov, 2004; Orlova *et al*., 2002 a, b; Orlova *et al*., 2005). With dynamic state of capelin stock and increase in the biotic factor role the forming of food supply was determined by abundance and growth rate of abundant species *C. finmarchicus* and *C. glacialis*. Under plenty of them in anomalous warm years (1983 and 1992) and wide distribution of capelin large concentrations, the conditions for that fish feeding were the most favourable in the west, during copepod reproduction (July) and maturation (August). However the quick rates of zooplankton growth and its intensive consumption resulted in periodic lack of food. That especially revealed it in 1992, when capelin migrated to the east where that fish concentrations were overlapped with the polar cod ones. The food competition arisen between them was the reason of feeding conditions having been deteriorated and low capelin fatness. The index was only 5.7 % in September, 6.6 % in October and 7.3 % in November that was much lower than in 1983 (10 %).

In normal 1984-1985, the features of cold period still existed. In 1984, slow growth rates of plankton gave the picture, which was close to 1982, and in the number of northwestern areas high concentrations of euphausiids remained. With almost 50% reduction of capelin abundance and the prevalence of young fish in population their distribution was western. Thus, the food supply of capelin was rich. Feeding started early and was characterized by intensive consumption of euphausiids but already in July-August, at 76-77˚N, fish from all age groups mainly fed on copepods gradually migrating to the north to 78-80˚N. In September-October, the average fatness of capelin was high – 9.6-10 %. In 1985, plankton slower growth and intensive maturation in August caused the special conditions of capelin feeding. Unlike previous years, the peak of capelin feeding was in September, when most of plankton already had been occurring at the bottom. Feeding on copepods at elder stages capelin had no vertical migrations. In the fish diet the portion of *C. glacialis* was the greatest (65 % by weight). Due to poor feeding in August, in September 1985, capelin fatness was low (5.7 %) and only in October that index increased to 8.2 %.

In anomalous cold 1987, the situation with capelin feeding was determined, on the one hand, by relatively high density of euphausiid concentrations in the northwest and, on the other hand, by the late completion of copepod reproduction that, on the whole, corresponded to characteristics of the cold period. Nevertheless, owing to the prevalence of young fish in population and low abundance of capelin that fish feeding migration was late and feeding area – small. Capelin mainly fed in September, primarily (moderately), in the west and having migrated to the areas of the Hopen Island, the Central Elevation and the Central Deep the fish consumed euphausiids and

copepods more intensively. There, moderate feeding lasted till the early October, as well as in the Persey Elevation to which small aggregations of capelin migrated. We had no data for 1987 but it may be assumed that the late beginning and early completion of feeding, the prevalence of young individuals in population, the limited feeding area could lead to low fatness of fish.

Warm years at the beginning of new century (2002-2004). Despite a rise of capelin abundance in 1999-2002, at the end of that period, a progressing reduction as well as the decrease in the relative number of fish aged 2-3+ years happened (Fig. 2). Capelin distribution was the widest in 2002 when large fish had occurred in the population yet (Fig. 6).

In anomalous warm 2004, the main features of forming fish food supply were the increased bringing of warm-water euphausiid species and poor consumption of them by capelin. As a result, the abundance of copepods exceeded mean long-term value in two, three times. This year, when carrying out the survey in the northern areas for the first time dense aggregations of euphausiids (primarily, *T. inermis*) were also found.

In the late August – early September, in feeding areas of capelin, the community of mesoplankton was characterized by the completion of Calanoida reproduction. In 2002, in the areas which had become free of ice recently and along the ice edge (77-79˚N) *C. finmarchicus* predominated. In the north of the Persey Elevation and the Novaya Zemlya Bank, that species aggregations were composed by copepodites at Stages I-III (185-330 ind./m^3), in the southern stations, they were represented by copepods at Stages IV-V (160-250 ind./m^3). Higher concentrations of *Calanus* – to 460 ind./m^3 of *C. finmarchicus* and 90 ind./m^3 of *C. glacialis* and *C. hyperboreus* – were observed in the Franz Joseph Land (FJL) area. In 2003, plankton was sampled in the southern areas (73-75˚N), in the late September. This explains the prevalence of *C. finmarchicus* most of which had already become mature by that time here, to a great extent. The most significant differences in plankton distribution were noticed in 2004. Alongside with the areas with maximal high density of *C. finmarchicus* aggregations (300-900 ind./m^3) those ones with large concentrations of *C. glacialis* (the Persey Elevation, FJL and the Novaya Zemlya Bank), where the density of that species concentrations reached 300-700 ind./m^3 (on the Novaya Zemlya Bank – to 2 400 ind./m^3).

Spatial differentiation of zooplankton growth conditioned the differences in the character of biomass forming. In 2002, their values varied at the level of 50-200 mg/m^3 reaching 300-750 mg/m^3 in the north. In 2003, in the sampling areas, the biomass was lower: 100-300 mg/m^3. In 2004, as in the previous years, the arctic species *C. glacialis* made a great contribution to biomass forming. In the most farthest north areas of FJL (79-81˚N) only owing to that species the biomass reached 200 mg/m^3, being even higher in the north of the Novaya Zemlya Bank – 450 mg/m^3 - that significantly exceeded such due to *C. finmarchicus*.

Capelin distribution was the most connected with copepod development in 2002 when the fish mainly fed in the northern areas (78-80˚N) in September. Intensive consumption of copepods by both small and large fish was observed in the Persey Elevation (Fig. 7). It is important to note that *C. glacialis* elder individuals chosen by capelin did not predominate in plankton (Fig. 8).

In 2003, the areas of the collection of data on plankton and feeding of capelin were mainly overlapped in the southern areas where fish feeding was very poor (stomach fullness index 11.2 ‰). Under the stable feeding in further north areas its character was traditional for different age fish: small capelin primarily consumed copepods which were replaced by euphausiids or added by hyperiids and the other food such as chaetognaths and polar cod larvae in larger fish diet (Fig. 7). As in 2002, large food items prevailed in capelin feeding (Table 2).

In 2004, in the basic feeding grounds of capelin, copepods were practically excluded in the diet where euphausiids and hyperiids chiefly prevailed, in the number of areas the role of chaetognaths significantly increased. As compared to 2002, feeding intensity of capelin (especially in young fish) was much lower (Fig. 7) that indicated on the lack of food.

The relationship of capelin fatness with the fish size, character of feeding and distribution has been revealed. In 2002, in the farthest north areas of the Persey Elevation and Novaya Zemlya Bank, large capelin reached the greatest fatness (Table 3). In 2004, on the Novaya Zemlya Bank, capelin fatness of large fish was relatively high, in the majority of other cases – lower than that one in 2003. Especially low fatness (3.2-3.9 %) was typical for small (9-11 cm) fish in the Persey Elevation in the late September due to their poor feeding on copepods which were their main food.

Great local differences in feeding and fatness of capelin in 2004, probably, were connected with two factors – the southern distribution of fish main concentrations and food competition with polar cod. This is indicated by stable feeding of polar cod in the northern part of the Persey Elevation (77-78˚N) where also capelin fed. At that, small polar cod consumed, primarily, copepods. Differing from small capelin having very low indices of stomach fullness (58-73 ‰) polar cod had that one of 280-440 ‰. As it is shown, more abundant polar cod intensively fed on their basic food – copepods, and capelin was almost without them that resulted in poor feeding and low fatness.

Discussion

The analysis of capelin feeding pattern during seven years showed that in this cold period, with the north distribution fish was provided well with main food – euphausiids and copepods. They started feeding already in June-July, but mainly in August. In September, the area of capelin feeding on euphausiids widened to the north to 76-77˚N where they were consumed alongside with copepods; feeding on euphausiids capelin reached 78˚N and even migrated higher (1979, 1980). In some normal and cold years (1977, 1980, 1982), there were the conditions for earlier (at the beginning-middle of August) completion of capelin feeding on euphausiids and increase in feeding on copepods that influenced different age fish feeding efficiency.

In the 1970s, capelin was characterized by high level of fatness – 6-10 % already in July and 16-18 % in September. With such fatness capelin mass maturation takes place (Oganesyan, Dvinin, 1988). In the mentioned cold years, moderate and strong year-classes prevailed in capelin population (Anon., 1991).

In the transitional climatic period (1980s-1990s), the pattern of capelin feeding was influenced by many factors of which the biotic one connected with increased consumption of meso- and macroplankton by the consumers at different trophic levels (capelin, polar cod, juvenile cods, adult cod) was the most important. The influence of the factor was aggravated by dynamic stock status of the species mentioned and their age structure having an impact on fish distribution and accessibility of food resources.

In the warm period (2002-2004), the food supply of plankton eaters was stabilized due to wide distribution of warm water euphausiid and copepod species in the Barents Sea as well as the bringing of cold water ones. Mostly, the possibility of using food resources in the north areas was realized by capelin in 2002, under the availability of elder fish in the population; capelin fatness was comparable with that one in the 1970s. That factor, migration northward, where in the zone of floating ice, owing to copepod reproduction, food supply remains to be rich, favours long-lasting feeding and accumulation of a great amount of fat by capelin. The latter is

connected with feeding on large arctic species of copepods, which are characterized by high content of lipids, in their turn (Conover, Corner, 1968; Smith, 1988). In 2004, main concentrations of capelin were distributed more southward that led to insufficient consumption rich food supply in the north areas.

On the other hand, plenty of zooplankton favoured wide distribution of polar cod the abundance of which increased. In the warm years, in the northwest, feeding areas of capelin and polar cod were overlapped that resulted in increased food competition (copepods) accompanied by reduction in capelin fatness in the number of cases (1992, 2004).

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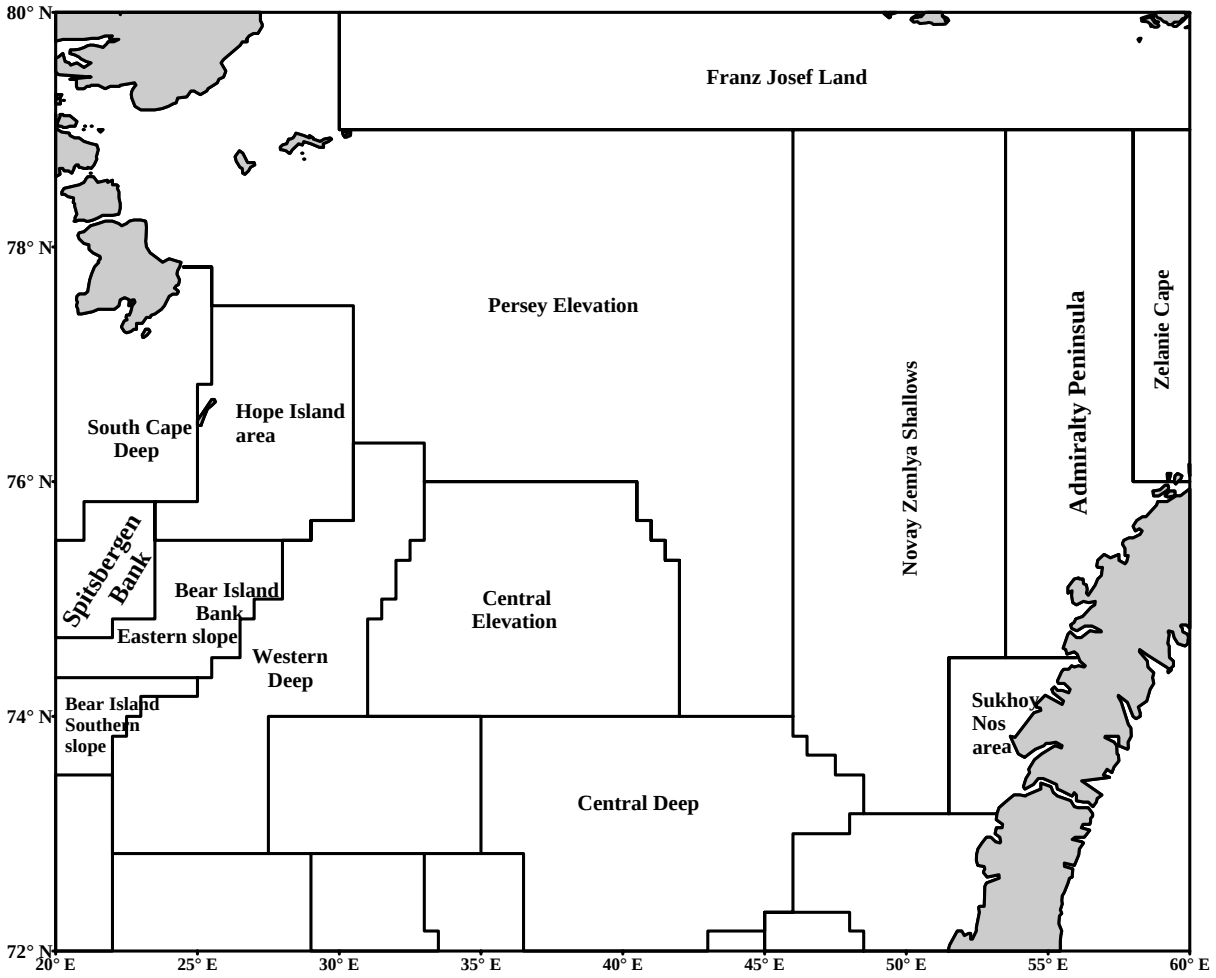


Fig.1 Chart of the Barents Sea fishing area.

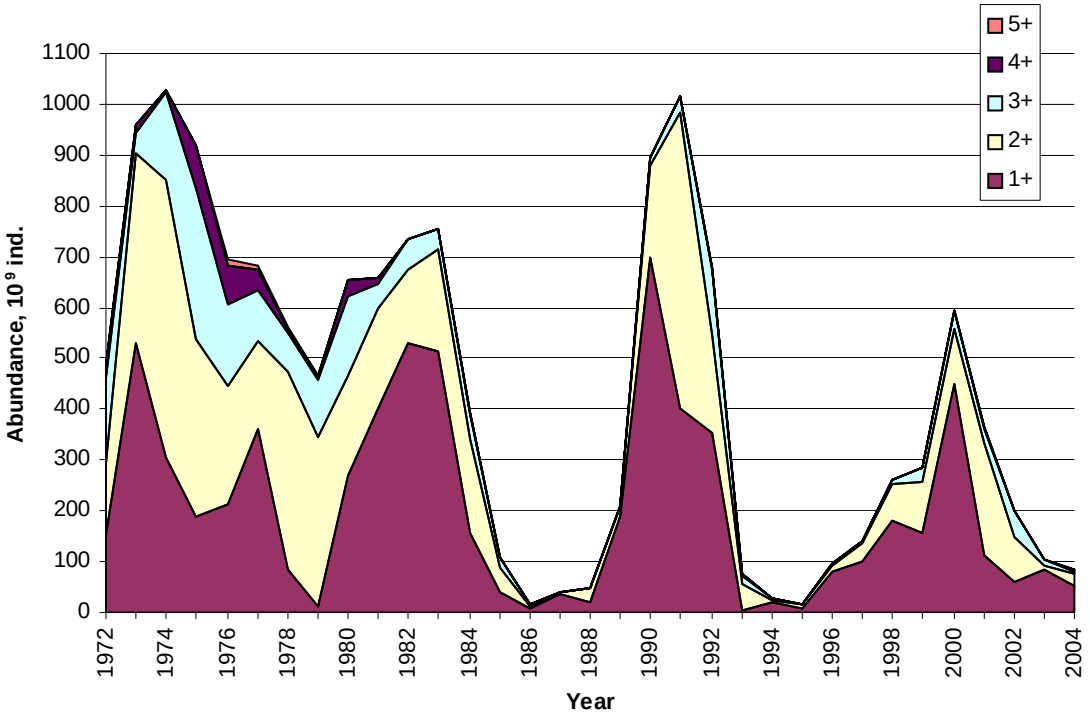


Fig.2 Dynamics of capelin abundance in the Barents Sea according to the TAS data.

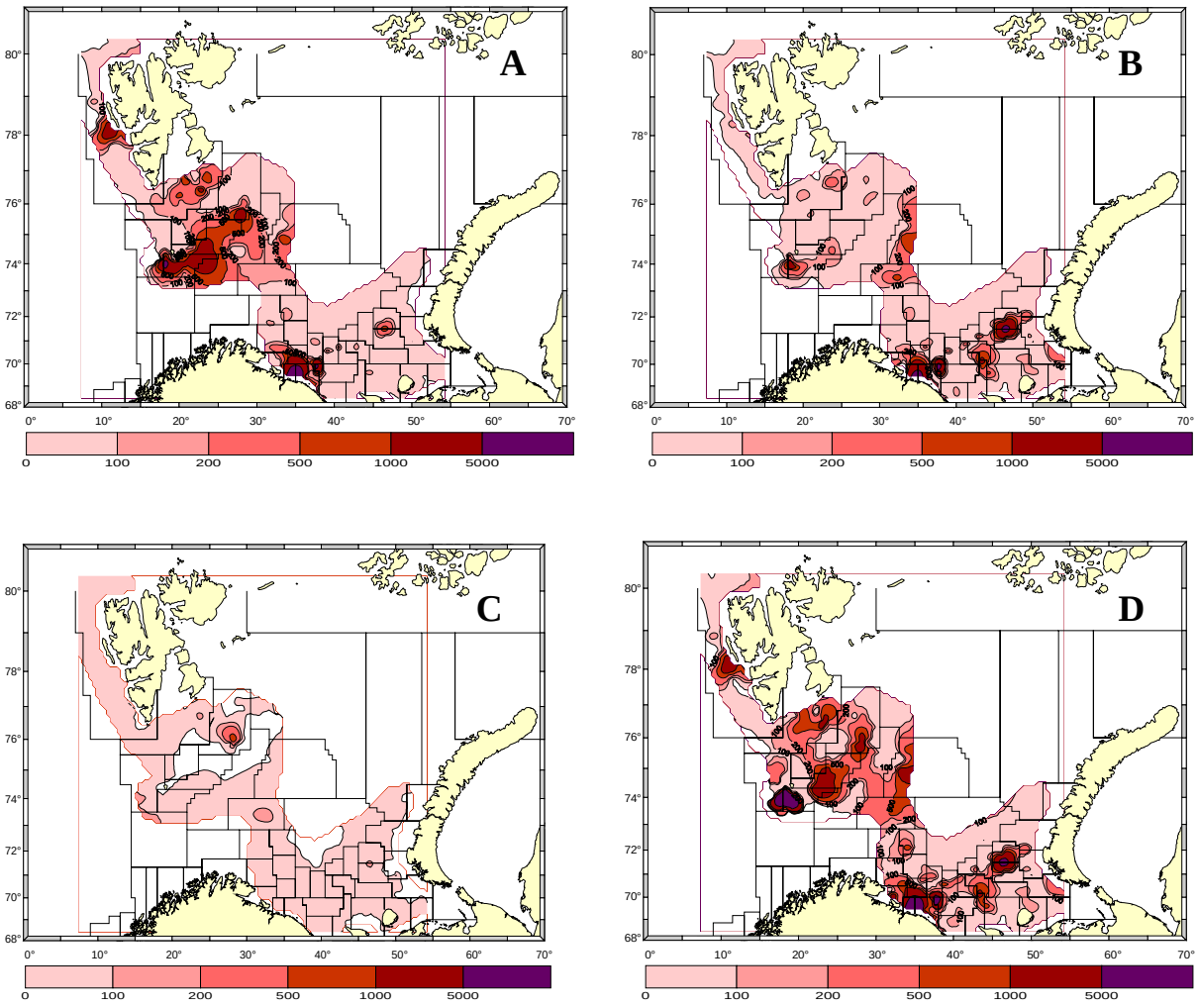


Fig. 3 Density of pre-bottom concentrations of euphausiids in autumn-winter 1977/1978, ind./1 000 m^3 (A – *Thysanoessa inermis*, B – *T. raschii*, C – *T. longicaudata*, D – combined aggregations of euphausiids).

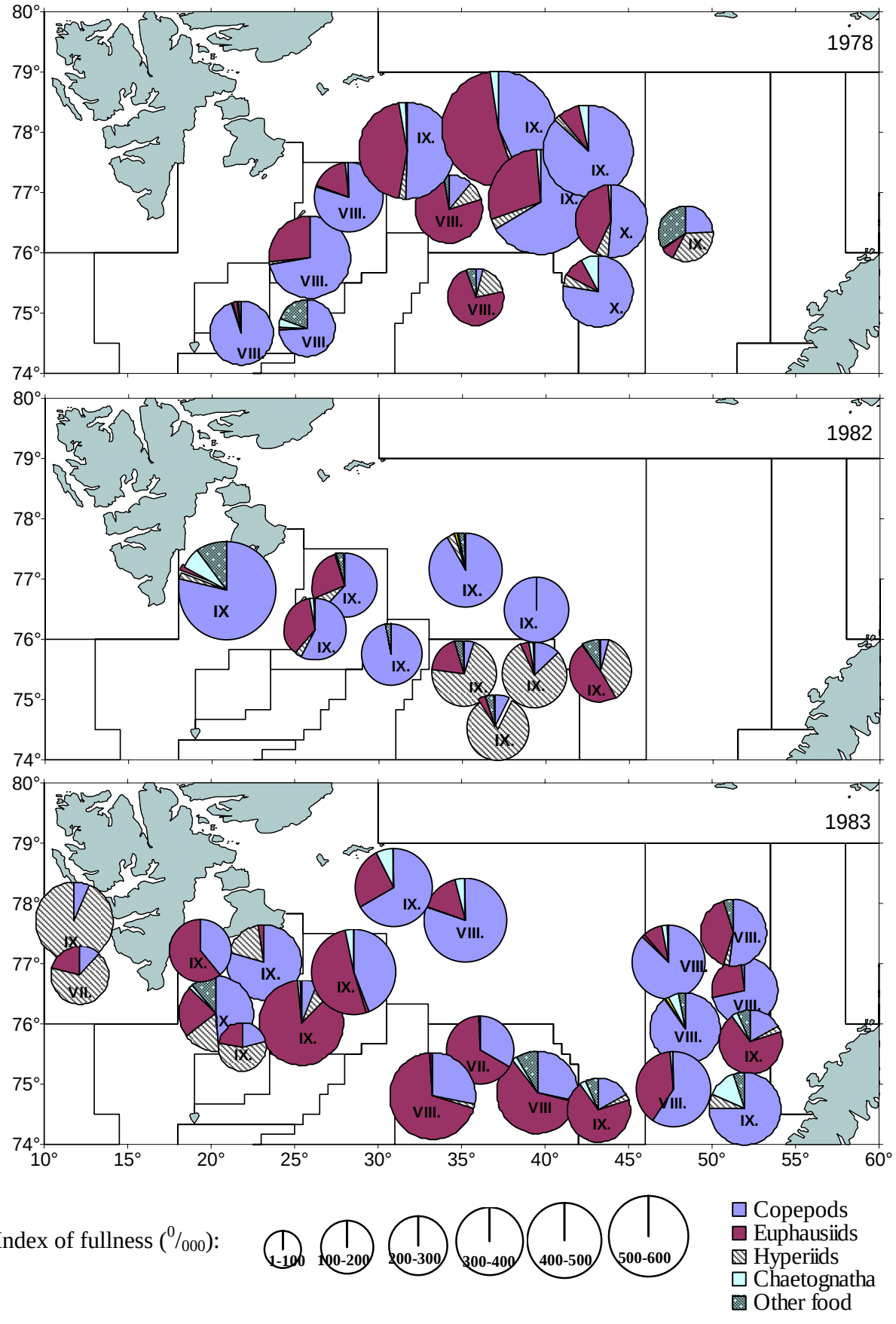


Fig. 4 Food composition (% by weight) and consumption intensity (‰) by capelin in July-September 1978, 1982, 1983.

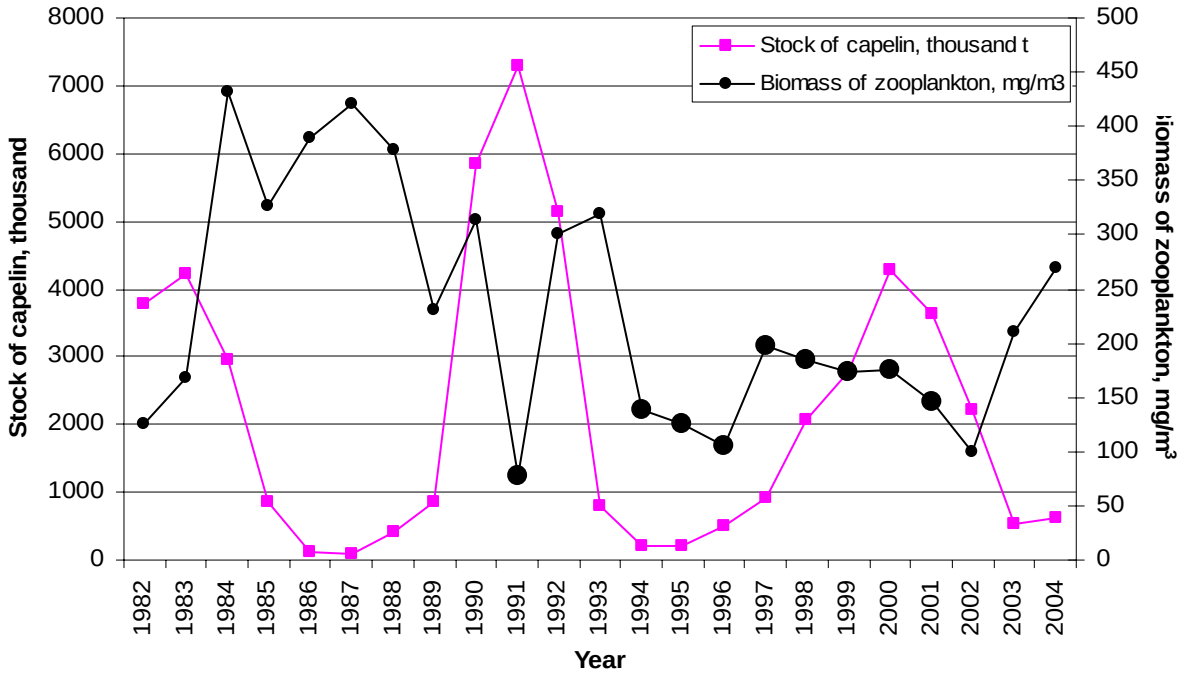
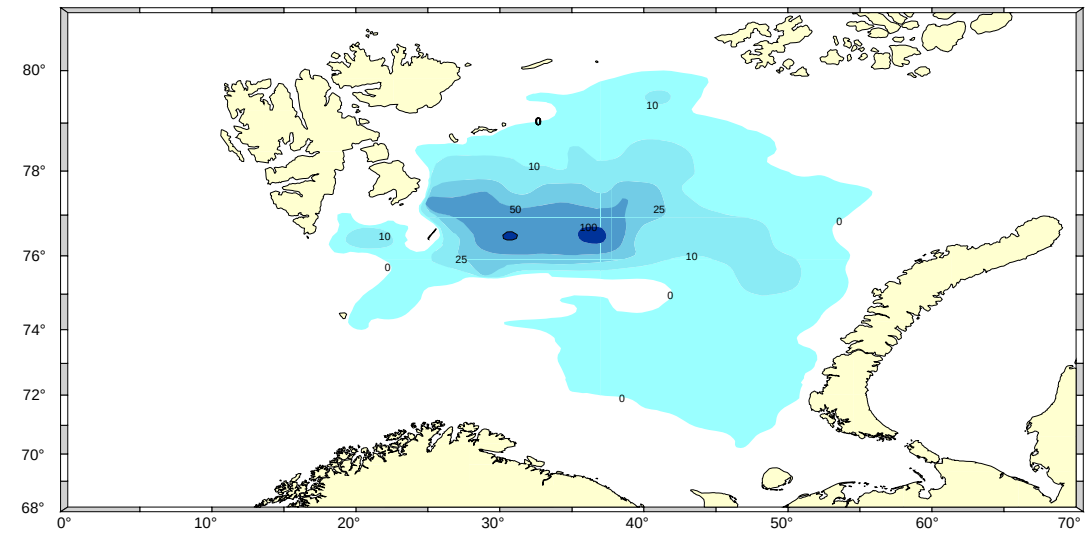
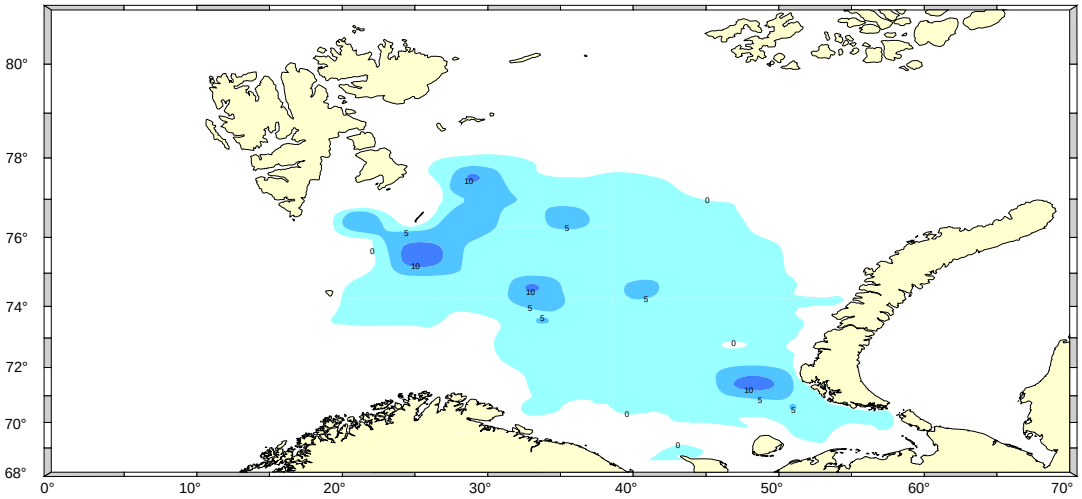


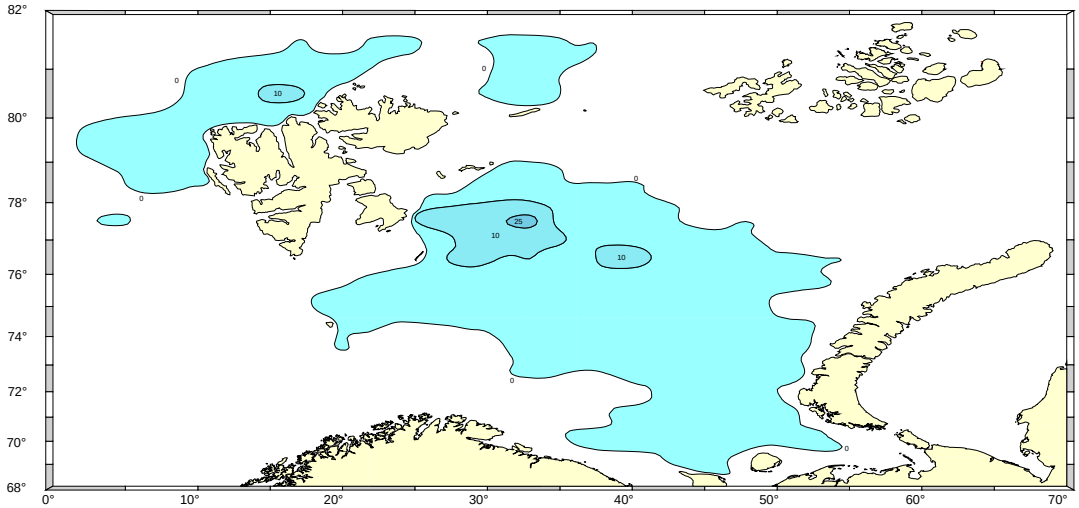
Fig. 5 Year-to-year dynamics of capelin stock and zooplankton biomass in the central latitudinal zone of the Barents Sea in 1982-2004.



2002



2003



2004

Fig. 6 Distribution of capelin in September-October in the Barents Sea in 2002-2004, t/sq.mile.

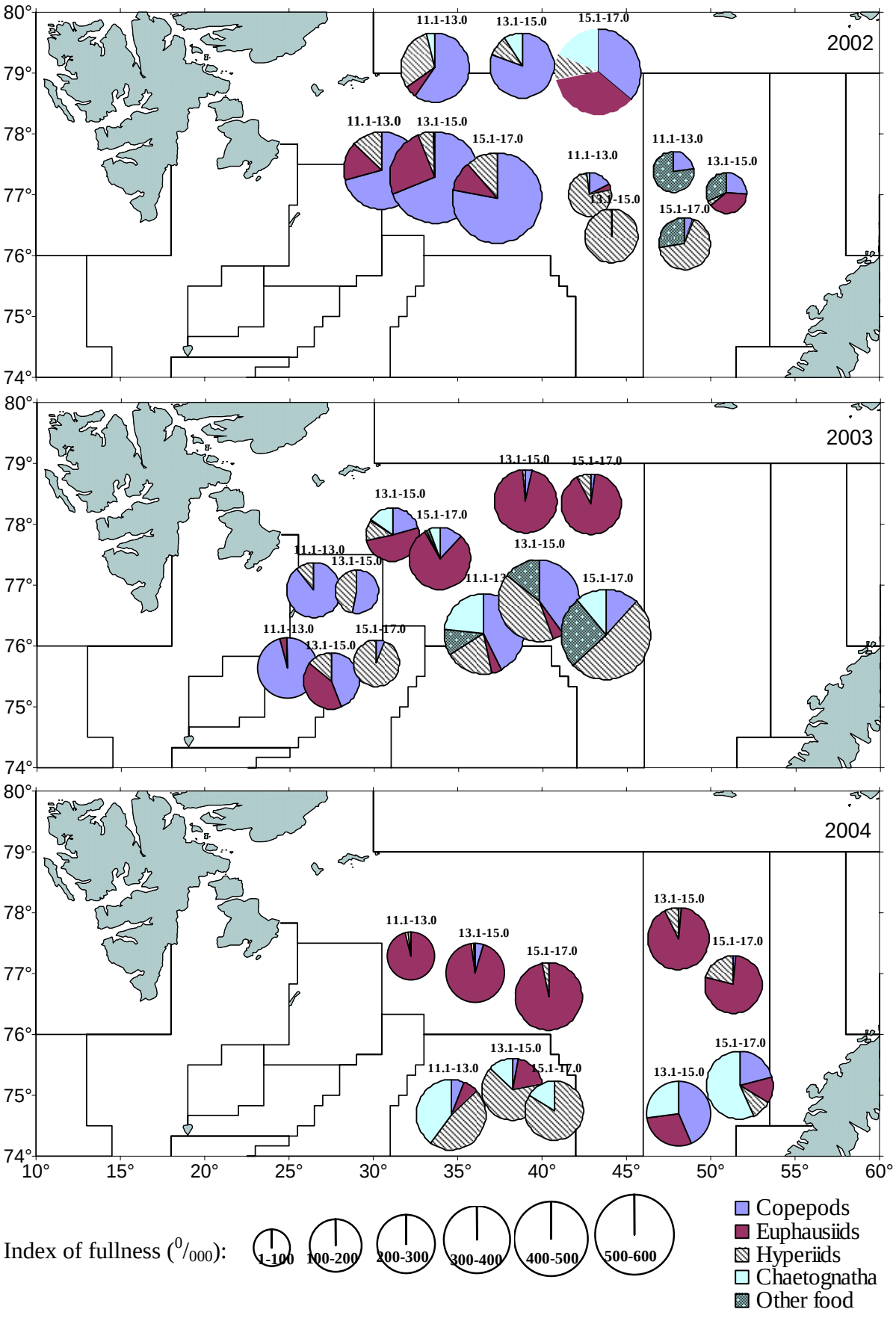


Fig. 7 Food composition (% by weight) and consumption intensity (‰) by capelin from different size groups (cm) in August-September 2002-2004.

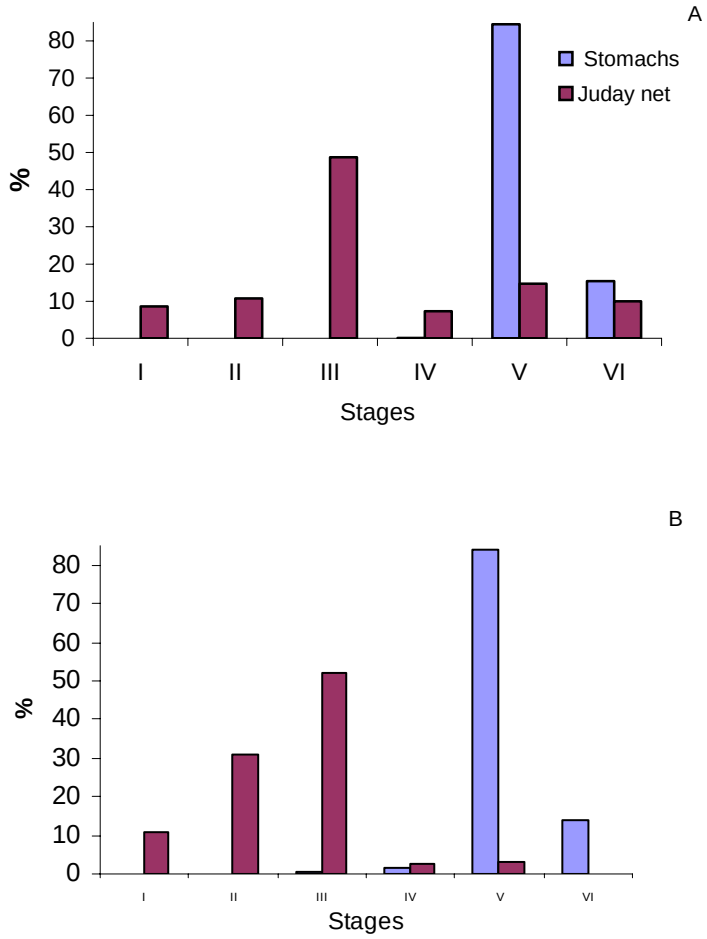


Fig. 8 Stage composition of *C. glacialis* in capelin stomachs and Juday net catches in the Franz Josef Land area (A) and the Persey Elevation (B) in September 2002.

Table 1. Feeding of capelin in summer-autumn period 1976-1982 (by Panasenko, L. D. data).

Month	Number of fish, ind.	Average mass, g	Total index of fullness	Feeding components (% by weight)		
				Copepods	Euphausiids	Hyperiids
July	129	16,2	235,0	5,3	90,9	0,3
August	1485	13,3	207,1	42,7	36,1	13,9
September	555	15,4	279,7	65,0	23,8	6,0
October	150	17,5	134,9	39,4	54,1	3,8

Table 2. Dominant feeding objects of capelin of different size groups (the Persey Elevation, 2003).

Size group, cm	Morning	Day	Evening	Night
9,1-11,0	-	-	-	-
11,1-13,0	-	*Metridia longa* (V♀) (2,7-4,5 mm) *Calanus finmarchicus* (IV-V) (2,4-4,0 mm)	*Calanus finmarchicus* (IV) (2,5 mm) *Metridia longa* (V♀) (2,7-4,5 mm) *Calanus glacialis* (V) (4,1-4,7 mm)	*Metridia longa* (V♀) (2,7-4,5 mm) *Calanus glacialis* (V) (4,1-4,7 mm)
13,1-15,0	*Calanus glacialis* (V♀) (4,1-5,2 mm)	*Metridia longa* (V♀) (2,7-4,5 mm) *Calanus glacialis* (V♀) (4,1-5,2 mm) *Calanus finmarchicus* (V♀) (3,0-4,9 mm) *Thysanoessa inermis* *Themisto* sp.	*Thysanoessa inermis* (21-23 mm) *Calanus glacialis* (V♀) (4,1-5,2 mm) *Calanus finmarchicus* (V♀) (3,0-4,9 mm) *Metridia longa* (V) (2,7-3,2 mm) *Themisto libellula* (6-21 mm)	*Metridia longa* (V♀♂) (2,7-4,5 mm) *Calanus finmarchicus* (V♀) (3,0-4,9 mm)
15,1-17,0	*Calanus glacialis* (V♀) (4,1-5,2 mm) *Calanus hyperboreus* (V♀) (6,3 – 8,5 mm) *Thysanoessa inermis* (18-22 mm)	*Calanus finmarchicus* (V) (3,0-4,0 mm) *Calanus glacialis* (V♀) (4,1-5,2 mm) *Calanus hyperboreus* (V♀) (6,3-8,5 mm) *Metridia longa* (V♀) (2,7-4,5 mm) *Thysanoessa inermis* (17-23 mm) *Themisto libellula* *Themisto abyssorum*	*Thysanoessa inermis* (15-30 mm) *Calanus glacialis* (V) (4,1-4,7 mm) *Metridia longa* (V) (2,7-3,2 mm) *Calanus finmarchicus* (IV-♀) (2,4-4,9 mm) *Themisto libellula*	*Metridia longa* (V♀) (2,7-4,5 mm) *Calanus glacialis* (V) (4,1-4,7 mm) *Thysanoessa inermis* (18-22 mm) *Calanus hyperboreus* (V♀) (6,3-8,5 mm) *Themisto libellula* (9-15 mm) *Pareuchaeta norvegica*
17,1-19,0	*Calanus glacialis* (V♀) (4,1-5,2 mm) *Thysanoessa inermis* *Themisto libellula*	*Thysanoessa inermis*	*Thysanoessa inermis* (18-30 mm)	*Thysanoessa inermis* (18-22 mm) *Themisto libellula* (9-15 mm)

Table 3. Fat content in muscular tissue (%) of capelin from different size groups in September 2002-2004.

Area of catch	Date of catch	Number of fish, ind.	Size group, cm	Fatness, % (mean value)
		2002		
Persey Elevation				
78°50´N 43°01´E	09.09.02	25	14,0-17,5	13,6
78°30´N 44°52´E	10.09.02	25	12,0-16,0	10,7
76°15´ N 45°15´E	16.09.02	25	14,5-18,1	8,7
Novaya Zemlya Bank				
77°25´ N 47°15´E	14.09.02	25	13,1-18,2	10,8
76°55´ N 49°45´E	15.09.02	25	14,0-17,6	8,1
		2003		
Persey Elevation				
76°18´N 37°01´E	18.09.03	25	9,9-13,7	5,2
76°48´N 43°34´E	21.09.03	25	12,0-16,5	7,6
77°55´N 30°35´E	23.09.03	25	14,5-17,0	6,6
76°40´N 32°48´E	27.09.03	25	13,0-15,7	8,1
		2004		
Central Elevation				
74°16´N 41°35´E	30.08.04	25	11,1-17,0	3,8
Novaya Zemlya Bank				
75°05´ N 47°12´E	04.09.04	25	13,1-17,0	5,0
75°05´ N 47°12´E	04.09.04	25	15,1-16,6	7,8
Persey Elevation				
78°43´N 31°00´E	19.09.04	25	9,1-17,0	5,8
77°45´N 31°00´E	20.09.04	25	9,1-17,0	5,7