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Status of food zooplankton in the feeding period of capelin from the central latitudinal zone of the Barents Sea in cold and warm years

E. L. Orlova, V. D. Boitsov, M. Yu. Antsiferov, V. N. Nesterova, and N. G. Ushakov

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The impact of environmental conditions on the period of development and formation of plankton biomass in August during the cold and warmer-than-usual years is discussed. Predation is shown to dominate over abiotic effects in influencing the distribution of copepods during the years of high capelin abundance.

Keywords: Barents Sea, *Calanus*, copepod, biomass, plankton, temperature.

E. L. Orlova, V. D. Boitsov, V. N. Nesterova, and N. G. Ushakov: Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich Street, 183763 Murmansk, Russia [tel: +7 815 247 3424; fax: +47 789 10518; e-mail: inter@pinro.murmansk.ru]. Correspondence to E. L. Orlova.

Introduction

Feeding conditions of the Barents Sea capelin change due to the effects of sea temperature, food supply, their own abundance, their migration pattern, and competition for food. This study was aimed at estimating capelin food supply considering the abundance of their population and zooplankton status in the feeding areas.

Material and methods

Data for 1987, 1989, and 1992 were obtained during PINRO's research cruises undertaken in the central Barents Sea (Figure 1). Plankton were collected with a Juday net (37 cm diameter of opening, gauze No. 38) in the layers 0–50, 50–100 m, and from 100 m to the bottom. In total, 425 samples were processed. The plankton biomass was weighed and expressed in weight per m^3; the biomass of some species was calculated by their amount in 1 m^3 and standard weights.

Results and discussion

The analysis of hydrographic conditions in the covered years showed their essential differences. In August of the cold year of 1987, water masses with negative temperature (61% of the total volume of waters) predominated. The 0–50 m layer contained freshened Arctic waters, with the Barents Sea salt waters below them.

In August 1989, the Atlantic waters were characterized by greater heat supply, but lowered salinity. In the northeast of the latitudinal zone, the Arctic waters prevailed. In the zone of their contact with Atlantic waters, the horizontal Gradients of density were raised, indicating intensification of the currents. In the west of the area surveyed, the hydrographic conditions developed as in the warm years, and in the east, as in the moderate cold ones.

1992 was the warmest among the years analysed. The waters in the upper 50 m layer were characterized by high temperature and salinity, and the dynamics of warm and cold currents was, probably, weakened.

In those years, in the 0–50 m layer, the predominance of *C. finmarchicus* in the plankton community structure was widespread (Table 1). The relative number of cold water species increased with depth and copepod vertical distribution was different. *C. finmarchicus* descent in August was mainly caused by maturation, while the majority of cold water species (primarily old copepodites) occurred there continuously. *M. longa* formed dense concentrations at all the development stages, often making up 60–90% of the total abundance.

In the years reviewed, plankton biomass varied significantly in the different parts of the central zone (Figure 2). Their raised values (500 and more) were

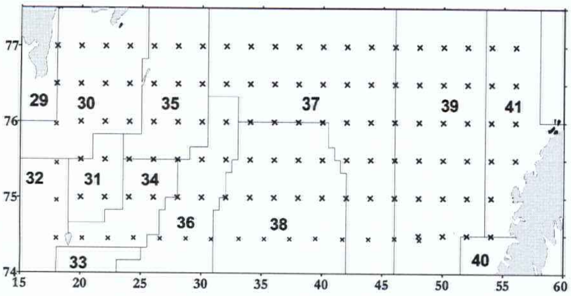

Figure 1. Fishing areas and position of stations in the latitudinal area surveyed in the central Barents Sea. *Oceanographic and plankton stations: 29 – the West Spitsbergen; 30 – the South Cape Deep; 31 – the Spitsbergen Bank; 32 – the Western slope of Bear Island Bank; 33 – the Southern slope of Bear Island Bank; 34 – the Eastern slope of Bear Island Bank; 35 – the Hopen Island area; 36 – the Western Deep; 37 – the Persey Elevation; 38 – the Central Elevation; 39 – the Novaya Zemlya Sallows; 40 – the Sukhoy Nos area; 41 – the Admiralteistvo Islands area.

Table 1. Relative abundance *Calanus finmarchicus* and *Calanus glacialis* in the 0–50 m layer in fishing areas of the central Barents Sea in 1987, 1989, and 1992 (in %).

Copepod species	Areas								
	30	31	34	35	36	37	38	39	41
	1987								
C. finmarchicus	98	70	99	98	–	96	91	93	74
C. glacialis	2	30	1	2	–	3	2	3	22
	1989								
C. finmarchicus	74	47	77	64	62	76	84	79	82
C. glacialis	24	52	16	27	37	18	11	13	15
	1992								
C. finmarchicus	–	–	–	94	87	58	68	68	64
C. glacialis	–	–	–	0	11	7	0	2	16

Fishing areas in accordance with numeration and their location are given Figure 1.

registered at separate stations in August. Mean values in the 0–50 m layer (on conversion to a station) were essentially different, amounting to 156 mg m^{-3} (1987), 269 mg m^{-3} (1989), and 177 mg m^{-3} (1992).

Forming biomass, to a great extent, depended on specific and age composition of copepods, the rates of their growth and maturation. In cold 1987, in the majority of central and eastern areas, where the mean temperature in the 0–50 m layer did not exceed 1°C, 80–90% of plankton (not counting small species) were represented by nauplii and small copepodites (I–II stages). Only in some areas was the prevalence noticed of *C. finmarchicus* copepodites at Stages III and IV–VI (Nos. 31, 34, 38) and *C. glacialis* (No. 31), which also remained in the 50–100 m layer.

In 1989, despite continuing spawning of copepods in the north and northeast (Nos. 37, 39, 41), accompanied by the high abundance of nauplii and young copepodites (to 600–2000 ind./m^3 or 70–90%), together with them, in all the areas, the essential numbers of old copepodites, primarily *C. finmarchicus* and *C. glacialis*, occurred. Their largest number (250–600 ind. m^{-3}) was registered in some western areas (Nos. 30, 34, 35). In the 50–100 m layer it was somewhat lower.

In August of the warm year of 1992, in the central and eastern latitudinal zone, nauplii and young copepodites, as well as old copepodites of *C. finmarchicus* and *C. glacialis*, were less abundant (with maximal values of 300–400 ind. m^{-3}), excluding the eastern areas, where the aggregations of the latter reached 400–500 ind. m^{-3}. They were also predominant in the 50–100 m layer. In the west, the surveys for plankton were stopped because of low concentrations of plankton. We have considered plankton distribution in the warm years more minutely in another article (Orlova *et al.*, 2000a).

As a result, the contribution of every species to the total biomass was dissimilar (Table 2). In most cases, in 1987 and 1989, the raised *C. finmarchicus* biomass was recorded to 100-m depths in the areas affected by the Atlantic waters. In warm 1992, their biomass also increased in the area of the Admiralteistvo Peninsula (Table 2), located in the zone of cold current effect. In some areas, the high biomass due to the presence of *C. finmarchicus* was also observed in the near-bottom layers (to 50–90 mg m^{-3} in 1987, 40–45 mg m^{-3} in 1989, 20 mg m^{-3} in 1992).

In a number of cases, high biomass of *C. glacialis* was also recorded in the same areas (mainly in the 50–100 m layer), but its values were maximum (90–130 mg m^{-3}) in the areas where the Arctic Water masses predominated (Table 2), as well as in the near-bottom layers.

C. hyperboreus played a smaller part in forming biomass. In 1987, in the western parts, their values were under 5 mg m^{-3}, in the central and western ones, 20–30 mg m^{-3} in all the layers. In 1989, the biomass of that species was the same, but distributed more evenly all over the area. Although more abundant, the biomass of *Metridia* was not high, because of the great number of younger copepodites. In the lower layers, the maximal values did not exceed 20–30 mg m^{-3}.

As early as August, alongside the old copepodites (main food supply of adult fish), a high abundance of *Calanoida* nauplii remained in the plankton. On the one hand, they are the main food component of capelin juveniles and other fishes, and on the other hand they characterize food potential in separate areas. We (Orlova *et al.*, 2002b) noticed the high correlation between the abundance of nauplii in

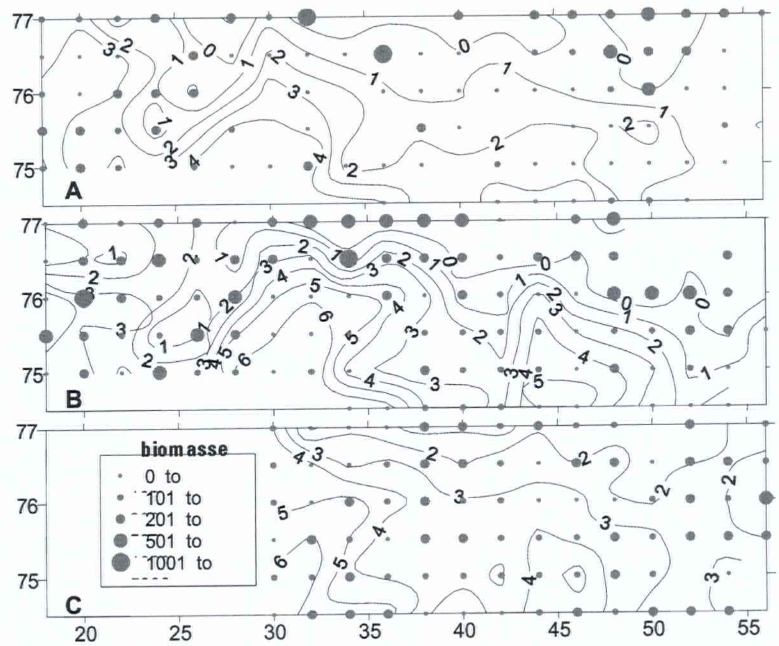

Figure 2. Distribution of plankton biomass (mg m^{-3}) and mean water temperature (°C) in the 0–50 m layer in August in 1987 (A), 1989 (B), and 1992 (C).

Table 2. Mean biomass of *Calanus finmarchicus* and *Calanus glacialis* in the 0–50 m and 50–100 m layers in fishing areas of the central Barents Sea in 1987, 1989, and 1992 (mg m^{-3}).

Copepod species	Depth, (m)	Areas								
		30	31	34	35	36	37	38	39	41
					1987					
C. finmarchicus	0–50	36	36	64	31	–	17	36	15	11
C. glacialis	50–100	50	–	68	1	–	9	41	22	11
C. finmarchicus	0–50	10	89	8	16	–	11	9	20	20
C. glacialis	50–100	49	–	27	1	–	16	15	28	2
					1989					
C. finmarchicus	0–50	84	5	180	90	16	36	24	61	8
C. glacialis	50–100	43	–	25	40	–	24	24	20	–
C. finmarchicus	0–50	54	16	80	132	29	55	21	33	12
C. glacialis	50–100	80	–	19	74	–	25	49	37	–
					1992					
C. finmarchicus	0–50	–	–	–	16	10	22	14	88	108
C. glacialis	50–100	–	–	–	–	23	15	2	21	35
C. finmarchicus	0–50	–	–	–	0	5	19	0	20	186
C. glacialis	50–100	–	–	–	–	0	18	0	15	48

Fishing areas in accordance with numeration and their location are given Figure 1.

July, capelin consumption, and index of fullness in August ($r = 0.86 - 0.92$).

The abundant, widely distributed eurythermal species *Pseudocalanus elongatus* also certainly played a role as a food supply for small capelin. Its abundance was close to and even greater than that of *C. finmarchicus*, especially in 1992. Owing to that species, the biomass reached great values at certain times (10–50 mg m^{-3} in 1987 and 20–100 mg m^{-3} in 1992).

Quite a close relationship between zooplankton biomass in the 0–50 m layer and some oceanographic factors was revealed for 1987 and 1989. Raised biomass occurred most often in waters with decreased temperature and salinity (correlation coefficient $r = -0.60 - 0.65$). In these parts of the latitudinal zone, the density gradient was more within the limits of the pycnocline and its upper border was located closer to the surface than in warmer and saltier waters. For 1992, the relationship between zooplankton biomass and environmental parameters was absent. In this year, capelin predation obviously had a great influence on the distribution of food organisms.

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