

Importance of the fish predation on the composition and structure of copepods communities in the Franz Josef Land area (the northeastern Barents Sea)

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Summary

The Franz Josef Land area is a region of a great scientific interest in the northern Barents Sea where rapid and significant changes in the mesoplankton community (especially in copepods) have been recently observed. Both Arctic (*Calanus glacialis*, *C. hyperboreus*, *Pseudocalanus minutus* and other species) and boreal (*C. finnmarchicus*) species occur in the area and some of them are important prey species for abundant pelagic fishes (capelin and polar cod). The feeding preferences of pelagic fish for different copepods are determined by their species, size and developmental stages. Capelin prefers to feed on large mature females of *C. glacialis*, whereas small individuals of *P. minutus* are virtually absent in the fish diet. Changes in the species composition, the predominance of various species, the total abundance and biomass of copepods as well as impacts of the fish predation on the copepods community in the Franz Josef Land area in 2008-2011 are discussed in this paper.

Introduction

Significant variations in the composition of copepod communities and their importance for the diet of abundant pelagic fish – capelin and polar cod – were caused by variations in the climatic conditions which have been observed in the latest 10 years in the northeastern Barents Sea. Oceanographic conditions in the Franz Josef Land area during the period under study were characterized by a northern shift of the ice edge in July- September (no ice virtually occurred south of 80° N) and higher water temperatures in the upper layer in the years when ice melted rapidly. However, some deviations from generally increased temperatures were observed at different depths in the northern sea and that resulted in occurrence of waters with negative temperatures in the upper (2009) and intermediate water layers (2010, 2011). Differences in the above mentioned parameters had impacts on the species composition, growth rates and abundance of copepods.

During the period under study zooplankton was mainly represented by copepods, the most abundant of them were Calanoida presented by Arctic species *C. glacialis*, *P. minutus*, *C. hyperboreus* and *Metridia longa* and the North Atlantic species *C. finnmarchicus*. Their abundance and species ratio in the Franz Josef Land area were variable in different years. The stage composition of copepods also varied, and, since the reproduction and development of copepods, as well as consumption of them by fish in northern areas virtually coincided, the impacts of predation can be assessed by carrying out simultaneous analysis of copepods of certain species and groups in fish stomachs and the copepods population. Such analysis was carried out and that allowed to obtain data on feeding preferences of capelin and polar cod, as well as the impacts they have on the composition of populations and numbers of abundant copepod species in the Franz Josef Land area in 2008-2011.

Materials and Methods

Data collected in the Franz Josef Land area during the ecosystem surveys in August-September 2008-2011 was used to characterize communities of copepods (the total number of

samples was 52). 27 stomachs of capelin and 190 stomachs of polar cod were collected during the same surveys. Stomachs were examined using standard quantitative and weight methods. Weight percentage (%m) of food items and their portion of the total number of preys in fish stomachs were calculated to assess importance of different food organisms. The feeding intensity was estimated by the stomach fullness index (SFI, ‰).

Results and Discussion

C. glacialis, *P. minutus* and *C. finmarchicus* were predominant species in the Franz Josef Land area in 2008. The density of concentrations of *C. glacialis* in northern stations significantly varied at different depths (315-6735 ind./m³), and averaged 3375 ind./m³. The concentrations of *P. minutus* were dense as well, however, variations in its abundance were less prominent. Abundance of *C. finmarchicus* varied from 65-1560 (on average 485) ind./m³ in the northern stations, to 4000-6000 ind./m³ in southern once. The most intensive feeding of mature capelin of 13-19 cm was observed in areas between 79-80° N (SFI was 600-800 ‰) where *C. glacialis* was the key prey in the diet of capelin (37-86 %n and 23-77 %m) and polar cod of 11-19 cm (34-97 %m and 25-95 %n). In addition to that, capelin fed predominately on females of *C. glacialis* and polar cod fed on individuals of copepodite stage CV of this species. Juveniles of copepodite stages CI-III (2000-2300 ind./m³) predominated in the population of *C. glacialis* in that period. However, in areas north of 82° N the species composition of *Calanus* changed. *C. finmarchicus* was virtually extinct from the plankton, but the abundance of juvenile *C. glacialis* remained high.

In 2009 abundance of all copepod species was low and Arctic species were widely distributed.. The occurrence of waters with negative temperatures in the upper layer in areas north of 79° N probably caused their retarded reproduction and development, as confirmed by abundant nauplii of Calanoida occurred in August. As a result, the consumption of *C. glacialis* at older stages by capelin and polar cod in 2009 was low. Capelin fed predominately on euphausiids (Orlova et al., 2013) and polar cod mainly fed on hyperiids (Orlova, Prokopchuk, 2013). Juveniles prevailed in the population of *C. finmarchicus* and *C. glacialis* in the northeastern Barents Sea and the transition to older stages had hardly begun.

The oceanographic conditions of 2010 also contributed to the formation of sparse concentrations of zooplankton. The low warming of water in the northeastern areas could probably cause delay in development of zooplankton, and water temperatures in the upper layer in areas north of 79° N were negative. The year of 2010 was particularly characterized by the intensive inflow of Atlantic waters in spring that resulted in the wider distribution of *C. finmarchicus* across the sea. *P. minutus* was the most abundant species. Zooplankton was at the late stage of reproduction due to the late collection of samples in that year (from 1 to 20 September). It was evident as the rare occurrence of nauplii in the Franz Josef Land area. However, males and females of *C. glacialis*, as well as large eggs of this species, regularly occurred in northern areas with low water temperatures. Apparently, the low abundance of zooplankton indicated its high consumption by capelin feeding in those areas. In areas north of 80° N *C. finmarchicus* and *C. glacialis* comprised 38-64 % by weight. Feeding preferences for adult individuals, especially females of this species, were revealed and portion of *C. finmarchicus* in the diet of capelin was 35-42 %, and *C. glacialis* was 59-65 %. However, their importance for the diet of polar cod was low since it predominately fed on hyperiids and occasionally on copepods (*C. glacialis* of CV and females). In northern areas of the Franz Josef Land individuals of *C. finmarchicus* at different developmental stages only occasionally were found in low numbers. . On the contrary, juveniles (CI-III) of *C. glacialis* were numerous there. . Similar observations were made for the area 79-81° N. The rapid retreat of the ice edge to the north during the melting season in 2011 is assumed to have an important significance for the distribution of zooplankton in the northeastern Barents Sea. The abundance of zooplankton was

low and its distribution was restricted. In addition to that, the intensity of plankton consumption by capelin had also declined by 2011 with a gradual reduction in its abundance and biomass from 2009 to 2011, though abundance of *C. glacialis* remained high against the increased stock of capelin.

Thus, in the years, when the abundance of capelin was low (2006) or had hardly begun to increase (2007), the consumption of wintering individuals of *C. glacialis* of CV-VI stages was not so high and a large number of them occurred in the population. All these findings allow to conclude that in the presence of increased abundance of capelin and a high number of copepods in its diet, particularly older stages and females of *C. glacialis*, the consumption of the latter by capelin (to a lesser extent by polar cod) is one of the primary factors of regulation the population of *C. glacialis*.