On the Distribution of Zooplankton in the Southeastern Barents Sea during July 2002

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Abstract - The spatial distribution and composition of the mesozooplankton community in the southeastern Barents Sea were observed at 17 stations, from 12 to 28 July 2002. Six taxa of zooplankton were found, including tintinnids, copepods, cumaceans, appendicularians, polychaetes, and barnacle larvae. Copepods were dominant, comprising 74% of the community. The copepod species *Limnocalanus grimaldii*, *Pseudocalanus acuspes*, *Calanus glacialis*, *Calanus finmarchicus*, and *Microsetella norvegica*, and the cumacean species *Diastylis rathkei* and *Campylaspis rubicunda* were identified. The overall mean abundance of the zooplankton was 72 indiv.10 m^{-3} in the study area, ranging from 4 to 197 indiv.10 m^{-3}. Zooplankton was more abundant at the oceanic than the coastal stations. The highest biomass measured was 97.4 mg 10 m^{-3}, the mean biomass was 36.9 mg 10 m^{-3}, 93% of which was copepods. *Pseudocalanus acuspes*, *C. glacialis*, and *C. finmarchicus* predominated, accounting for 61% of abundance and 86% of biomass. Spatial distributions of the zooplankton community in the study area depended on the variations in water temperature and salinity, which were influenced by freshwater runoff from the continent.

Key words : zooplankton, Arctic Ocean, Barents Sea, distribution, copepod

INTRODUCTION

The Arctic and Antarctic polar regions are the last frontier sectors on earth. The Antarctic has been surveyed intensively since the early 20th century. However, studies on the zooplankton community in the Arctic Ocean are relatively sparse, since access to the area was difficult during the period of the Cold War. The Arctic Ocean is an open system interrelated with the adjacent oceans, while the Antarctic Ocean is separated from the other oceans by the Antarctic Convergence, and has a relatively independent and closed environment. The Arctic Ocean plays an important role in temperature variations in the northern hemisphere. Although the arctic ecosystem has been a stable environment for a long time, it is increasingly exposed to air and water pollution transferred by global air and water circulation.

Generally the Arctic Ocean is confined to the deep arctic watermass but also can be extended to a larger area including the Bering, Greenland, Kara, Barents, East Siberian, Chukchi, and Beaufort Seas. The Barents Sea is bordered by the Russian northern coast and harbors the Spitsbergen Islands, near a mixing zone of the warm North Atlantic and the cold Norwegian currents. Massive amounts of fresh water flow into the Barents Sea by way of the Pechora Sea (Mat-

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tiessen and Stepanets 1999) affecting oceanic environments of the Arctic Ocean and making the Barents Sea a nutrient-rich fishery ground. Zooplankton plays an important role as food for fish in the area.

Several studies have described the community structures and population dynamics of dominant species such as the copepod *Calanus finmarchicus* in the Arctic Ocean (Scott *et al.* 2000; Tande *et al.* 2000; Madsen *et al.* 2001). Zooplankton community structures in the southern area of Novaya Zemlya Island in the Barents Sea have been described (Musaeva and Suntsov 2001; Vinogradov *et al.* 2001).

The government of South Korea recently began sponsoring research programs on the Arctic Ocean. The first Korean arctic research station was established at Ny-Ålesund, Svalbard, in April 2002. This study is the first report on the zooplankton community of the Arctic Ocean by the Korean researchers. The present study aimed to describe the structure and distribution of the zooplankton community in the southeastern Barents Sea.

MATERIALS AND METHODS

Zooplankton samples were collected from 17 stations in the southeastern Barents Sea on 12-28 July 2002 on board the RV "Ivan Petrov" (Fig. 1). The stations were divided into two regions, coastal (Stations 9, 13, 14, 15, 23, 47, 54, 61), and oceanic (the remainder). The samples were collected with a conical net (mouth diameter: 30 cm; mesh aperture: 300 μm). The net was towed vertically from 25 m depth to surface at stations deeper than 25 m, and from bottom to surface at shallower stations.

Specimens were fixed and preserved in 70% ethanol on shipboard. Zooplankton samples were sorted to major taxon by using a stereomicroscope (Olympus SZX 12®). Copepods were dissected and identified to species level. Specimens for identification were dissected in lactic acid, and dissected parts were mounted on slides in lactophenol mounting medium. Preparations were sealed with Glyceel or transparent nail varnish. Copepod species were identified using a differential interference contrast microscope (Olympus BX51®). Numbers are reported as individuals per10 m^3 (indiv.10 m^{-3}).

The volumes of zooplankton samples were measured under a stereomicroscope attached to the Image Analyzing System (UIC, Meta Morph®), and were converted to wet weight (mg10 m^{-3}; Hyde *et al.* 2003). For each

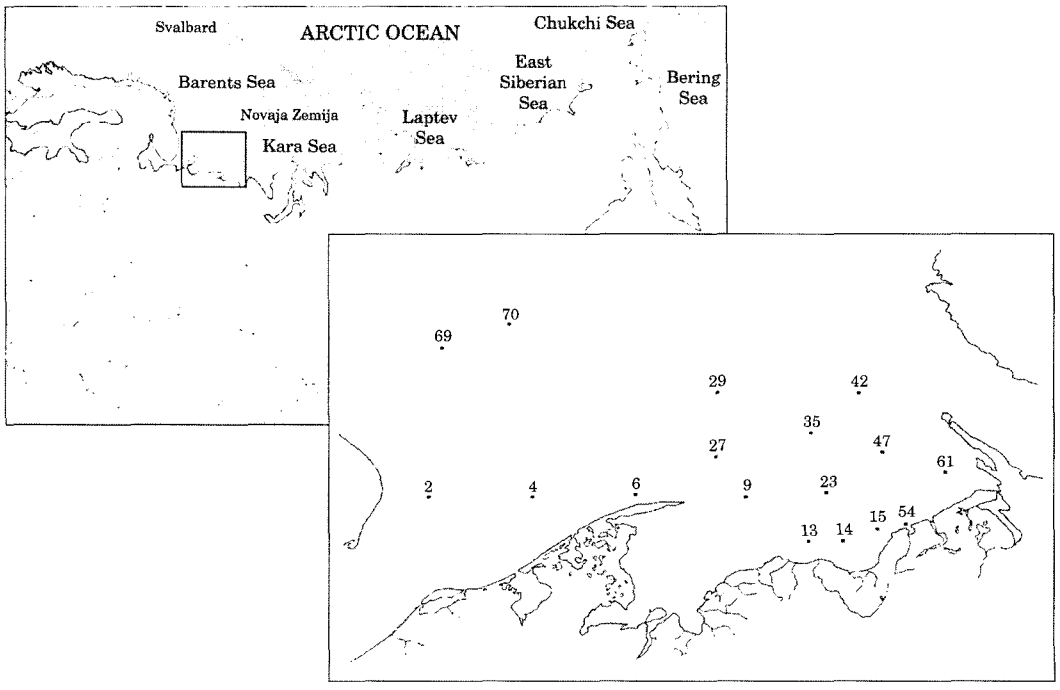

Fig. 1. Sampling stations in the Barents Sea in July 2002.

station, the following parameters were calculated: species diversity by the Shannon-Weaver function, dominance by McNaughton's dominance index, and species richness by Margalef's index.

RESULTS

During the study period, the zooplankton consisted of six major taxa and seven identified species (Table 1). Copepods, the most diverse group, included four calanoids, *Limnocalanus grimaldii, Calanus glacialis, Calanus finmarchicus*, and *Pseudocalanus acuspes*, and one harpacticoid, *Microsetella norvegica*. Unidentified copepodites and nauplii of *Calanus* sp. also occurred. Two cumacean species, *Diastylis rathkei*, and *Campylaspis rubicunda*, were identified. The normally benthic cumaceans probably occurred accidentally at the shallower stations. Other than the identified species, four major taxa: tintinnids, polychaetes, appendicularians, and barnacle nauplii were found. Copepods predominated in the study area, comprising 74% of the total zooplankton abundance (Figs. 2-3). In terms of the number of species or taxa occurring at each station, three stations, 2, 42, and 47 were most diverse with seven taxa or species respectively, while two stations, 14 and 69 had only two taxa or species. Mean abundance in the study area was 72 indiv.10 m^{-3} ranging from 4 indiv.10 m^{-3} at St. 69 to 197 indiv.10 m^{-3} at St. 13 (Fig. 2). Although copepods were dominant at nearly every station, tintinnids exceeded copepods at St.6, appendicularians at St. 23, and barnacle nauplii at St. 27. Copepods occurred exclusively at Sts. 69 and 70 (Fig. 3).

Water temperature ranged from 0.3°C to 8.4°C (Fig. 4)

Table 1. Species composition during the survey (July 12-28, 2002) in the Barents sea

Copepoda
Limnocalanus grimaldii
Pseudocalanus acuspes
Calanus glacialis
Calanus finmarchicus
Calanus sp., Copepodite
Calanus sp., Nauplius
Microsetella norvegica
Ciliata
Tintinnoinea spp.
Polychaeta
Errantia sp.
Urochordata
Fritillaridae spp.
Cirripedia
Balanidae, Nauplius
Cumacea
Diastylis rathkei
Campylaspis rubicunda

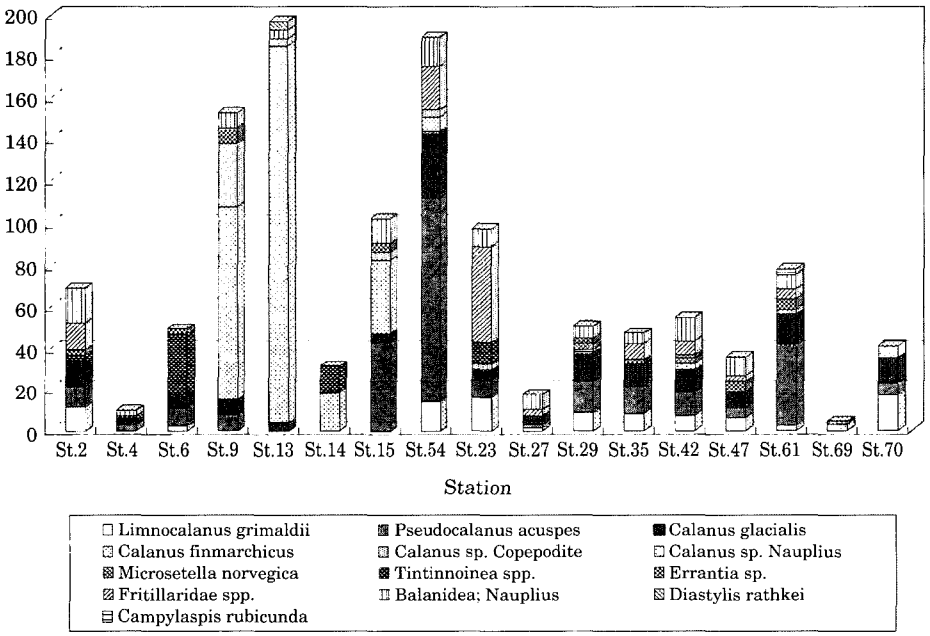

Fig. 2. Numerical abundances of the zooplankton at each station (indiv. 10 m^{-3}).

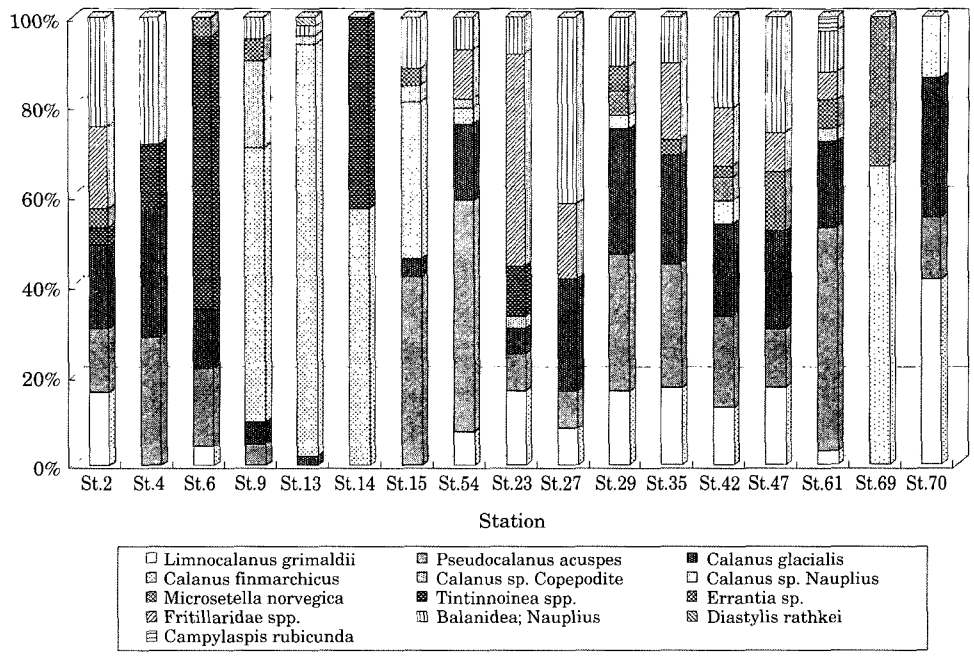

Fig. 3. Proportional compositions of the taxa occurring at each station.

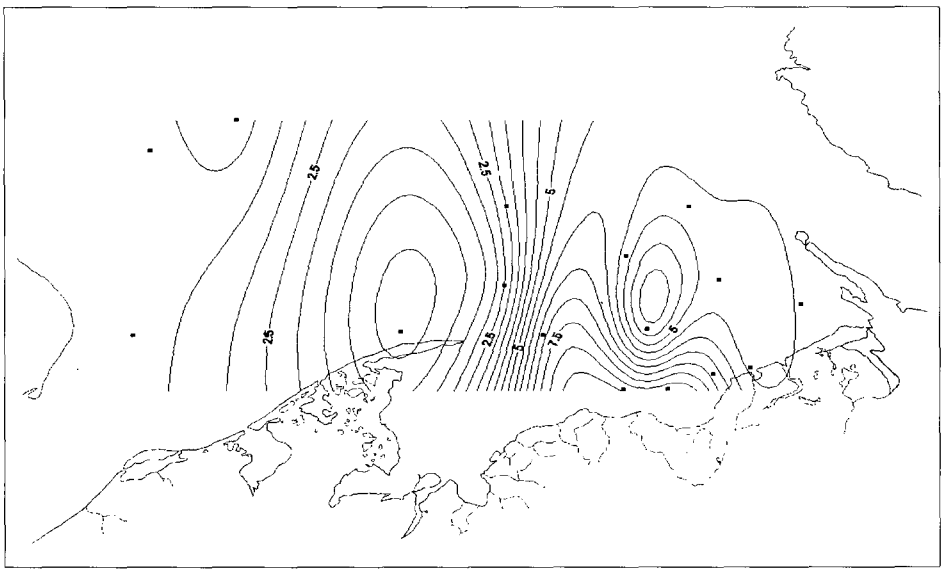

Fig. 4. Spatial distribution of temperature (unit: °C).

and salinity from 8.0 PSU to 34.1 PSU (Fig. 5) in the study area. Water temperature was higher in the coastal area than in the oceanic area or near sea ice. Salinity was above 30.0 PSU at the oceanic stations, and below 20.0 PSU at the coastal stations where fresh water flows into the Barents Sea (Fig. 5). Total zooplankton was more abundant in coastal waters, except at Sts. 14 and 54 located near estuaries and affected by freshwater runoff. Abundances showed an optimal range of temperature and salinity, and were highest at 6°C and 30.0 PSU. Copepods were more abundant in waters above 2°C and 17.0 PSU. Each copepod species showed characteristic distributions: for instance, *C. finmarchicus* dominated at the low-salinity, and high-

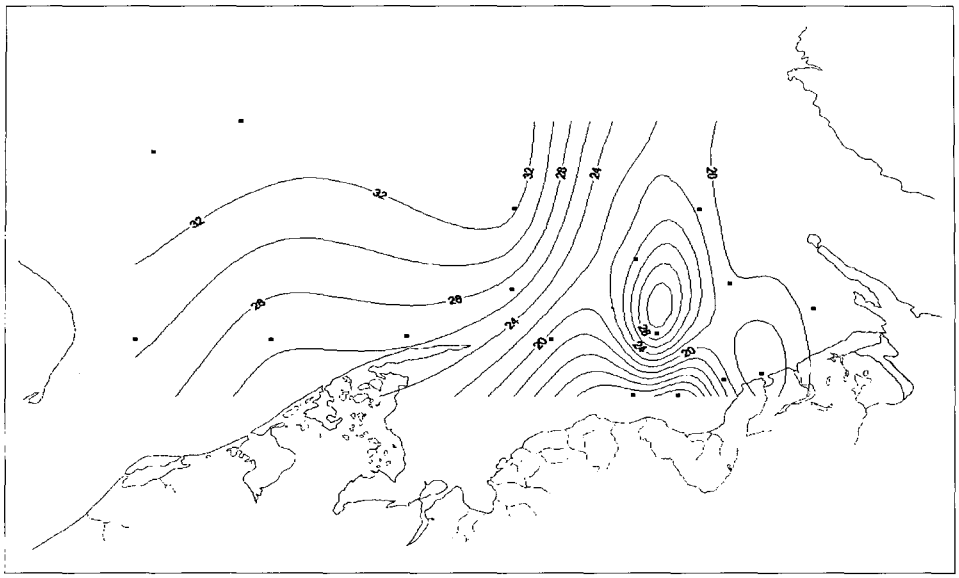

Fig. 5. Spatial distribution of salinity (unit: PSU).

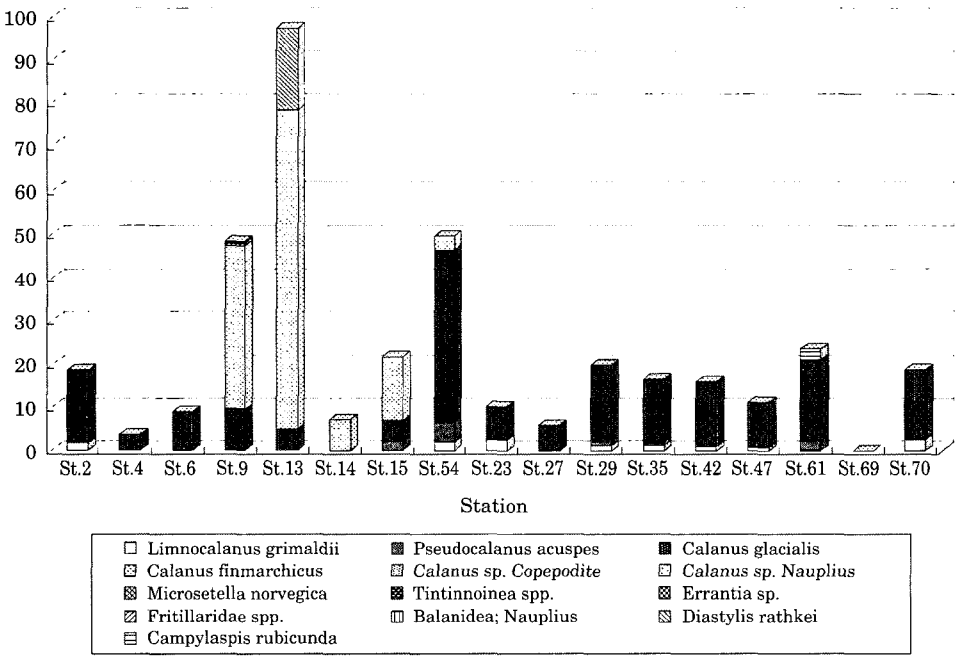

Fig. 6. Biomasses at each station (mg $10m^{-3}$).

temperature coastal stations, while *P. acuspes* dominated at the high-salinity, and low-temperature oceanic stations.

Limnocalanus grimaldii, P. acuspes, and *C. glacialis* occurred frequently, i.e., at more than ten stations. *Pseudocalanus acuspes* predominated at most stations. *Calanus glacialis* occurred at 15 stations. *Limnocalanus grimaldii* was less abundant, but occurred frequently at 11 stations, with an optimal range from 2°C to 6°C, and above 20.0 PSU. *Calanus finmarchicus* occurred at only five stations, above 6°C and below 20.0 PSU, but always in high abundances. *Calanus finmarchicus*, a common Arctic and sub arctic species, occurred mainly at the coastal stations. The three dominant species, *Pseudo-*

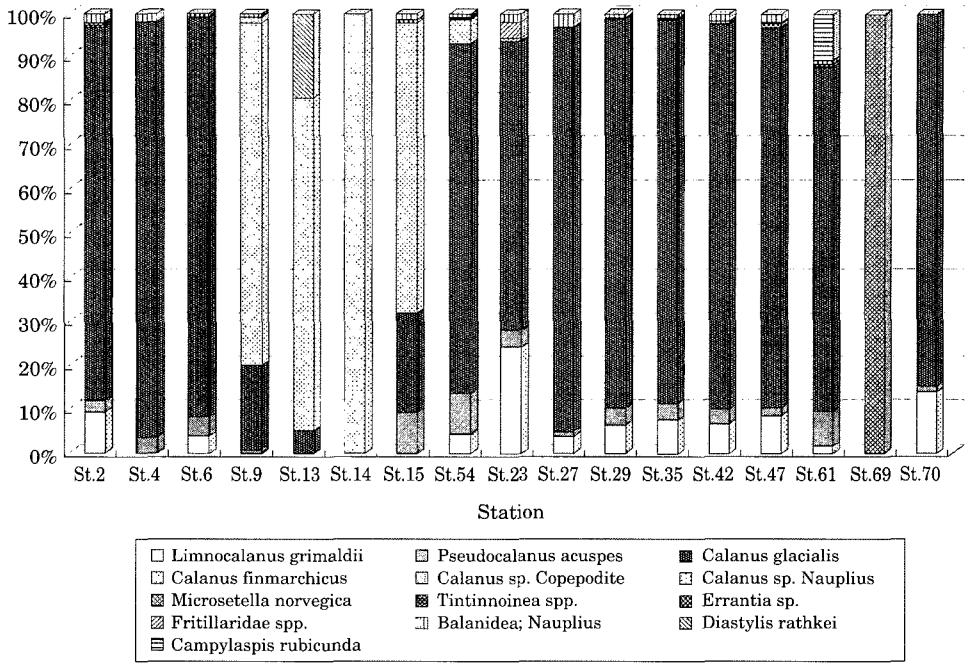

Fig. 7. Proportional compositions of the biomasses at each station.

calanus acuspes, C. glacialis, and *C. finmarchicus*, comprised 61% of abundance and 86% of biomass (Figs. 3, 7). Because *C. glacialis* and *C. finmarchicus* are relatively large-sized animals, they accounted for proportionately more biomass than abundance. Copepodites and nauplius stages of *Calanus* sp. occurred at several stations. Abundances of copepodites were higher at St. 9 than other stations. *Microsetella norvegica* was represented by only a few individuals at three oceanic area, Sts., 29, 42, and 69.

In regard to non-copepod taxa, tintinnids occurred at four stations and predominated at St. 6. Polychaetes occurred at nine stations, with a high frequency. Polychaetes occurred in warmer (above 3°C) and more saline (above 18.0 PSU) waters. Appendicularians (all belonging to the family Fritillaridae) occurred at eight stations, with a temperature range from 2°C to 6°C, and higher abundance in colder waters. Salinity range for the appendicularians was between 17.0 PSU and 32.0 PSU, and they were abundant in lower-salinity waters. Barnacle larvae were distributed widely in 13 stations and occurred in waters above 2°C and 18.0 PSU.

The mean zooplankton biomass was 22.3 mg 10 m^{-3}, and, like abundance, was higher in the coastal areas (Fig. 6). Biomass was highest at St. 13 (97.4 mg 10 m^{-3}). Mean biomass was 36.9 mg 10 m^{-3} at the coastal stations, and 12.1 mg 10 m^{-3} at the oceanic stations. Mean biomass of the copepods was 20.1 mg 10 m^{-3}, and comprised 93% of the total zooplankton biomass.

The species diversity index (SDI) was highest at St. 42 (0.827). The mean SDI was 0.583±019 for the entire study area, 0.511±0.20 for the coastal stations, and 0.633±0.17 for the oceanic stations. The dominance index (DI) was highest (0.918) at St. 13. The mean DI was 0.341±0.27 for all stations together, 0.579±0.26 for the coastal stations, and 0.174±0.09 for the oceanic stations. Generally, DI values at the coastal stations were three times higher than at the oceanic stations. The species richness index (SRI) was highest at St.42 (1.496). The mean SRI was 1.046±0.37 for all stations, 0.848±0.35 at the coastal stations, and 1.184±0.33 at the oceanic stations.

DISCUSSION

Copepods were the most diverse and abundant taxon in the study area: five species comprised 74% of the

zooplankton abundance and 93% of the biomass. The diversity of the zooplankton community was higher in the oceanic area, while abundance and biomass were higher in the coastal area as shown by the indexes of diversity, dominance, and richness. However, diversity, mean abundance of 72 indiv.10 m^{-3}, and biomass of 22.3 mg 10 m^{-3} of the total zooplankton were relatively low compared to previous observations by Vinogradov *et al.* (2001). The low zooplankton abundance and diversity in the region seem primarily to be a result of freshwater runoff from the coast, including the Pechora River. Massive amounts of freshwater runoff raise the temperature and lower the salinity, affecting local zooplankton communities. For instance, the mortality of marine copepods rises drastically with freshwater runoff into the Arctic Ocean, and salinity ranges below 24.0 PSU are lethal to marine copepods (Zajaczkowski and Legezynska 2001). Madsen *et al.* (2001) also reported that biomass of copepods decreased drastically from late July to late April the following year in Disko Bay, western Greenland.

The boreal *Calanus glacialis* and the North Atlantic *C. finmarchicus* (Madsen *et al.* 2001) dominated in the study area. These two species commonly co-occur in the mixing zone of the Arctic and North Atlantic currents (Musaeva and Suntsov 2001; Vinogradov *et al.* 2001). Because the present study was limited to the southern coastal area of the Barents Sea, the frequency of *C. finmarchicus* was higher than in previous reports. Another boreal species, *Calanus hyperboreus*, was not found, probably because of the local high water temperatures.

There were differences between the northern (oceanic) and the southern (coastal) stations in abundance and biomass of the zooplankton community. Mean abundance was twice as high at the coastal as at the oceanic stations, while biomass was three times higher at the coastal stations. High abundance and biomass are primarily caused by nutrient-rich freshwater runoff from the land, which promotes high primary production and consequently high zooplankton productivity. The higher biomass at the coastal stations is a factor of the local abundance of *Calanus finmarchicus*, a large species. Generally, copepod species have specific ranges for salinity and temperature. For instance, *C. finmarchicus* is dominant in the low-salinity, high-temperature coastal area, while *Pseudocalanus acuspes* dominates in the high-salinity, low-temperature oceanic zone. As a result, these two species can serve as indicators for physical and chemical characteristics of water mass.

In the zooplankton community of the southeastern Barents Sea, abundances and biomasses of the zooplankton decreased during summer, most likely due to the freshwater runoff from the land. The influence of freshwater runoff on the zooplankton community in the Arctic Ocean seems to be most pronounced during summer (Madsen *et al.* 2001). The present study was restricted to the southeastern Barents Sea, and conducted over a short period. In order to reveal the true fluctuations of the zooplankton community, the physical and temporal scope of future studies should be expanded. The diversity of zooplankton in the Arctic Ocean appears to be low. However, further studies will provide more information on diversity. The new data on the zooplankton will be also useful to develop useful biological indicators for environmental monitoring.

ACKNOWLEDGEMENTS

This work was supported by the Korea Polar Research Institute during the program year 2003. Authors are deeply grateful to Dr. Janet Reid for her comments and useful suggestions to improve the manuscript, especially in English.

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Manuscript Received: October 13, 2003
Revision Accepted: November 14, 2003
Responsible Editorial Member: Saywa Kim
(Yongin Univ.)