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# Characteristics of the Arctic and Antarctic mesozooplankton in the neritic zone during summer

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ABSTRACT: Zooplankton community composition, abundance and biomass from two polar localities – Kongsfjorden (Arctic) and Admiralty Bay (Antarctic) is compared. The community composition of zooplankton in both polar regions included similar taxonomic groups and the diversity at the species level was similar. Even though the overall species composition was different, some species were common for both ecosystems, for example *Oithona similis*, *Microcalanus pygmaeus* or *Eukrohnia hamata*. The abundance and biomass of the main zooplankton components (Copepoda) differed greatly between the two ecosystems, both being of an order of magnitude higher in Kongsfjorden than in Admiralty Bay. Kongsfjorden is situated at the border of two regions what induces high productivity with copepods playing an important role, and there is also a strong advection into the fjord. Admiralty Bay is adjacent to the homogenous Antarctic oceanic ecosystem; some advection into the bay occurs as an effect of tide and wind driven processes. Antarctic krill, which was not included in the present study, occupies most of the primary consumers niche and replaces copepods at the second trophic level.

Key words: Arctic (Kongsfjorden), Antarctic (Admiralty Bay), zooplankton, Copepoda, abundance, biomass.

## Introduction

The aim of this study was to compare mesozooplankton composition and abundance in two polar bays: Kongsfjorden (Svalbard, Arctic) and Admiralty Bay (King George Island, Antarctic).

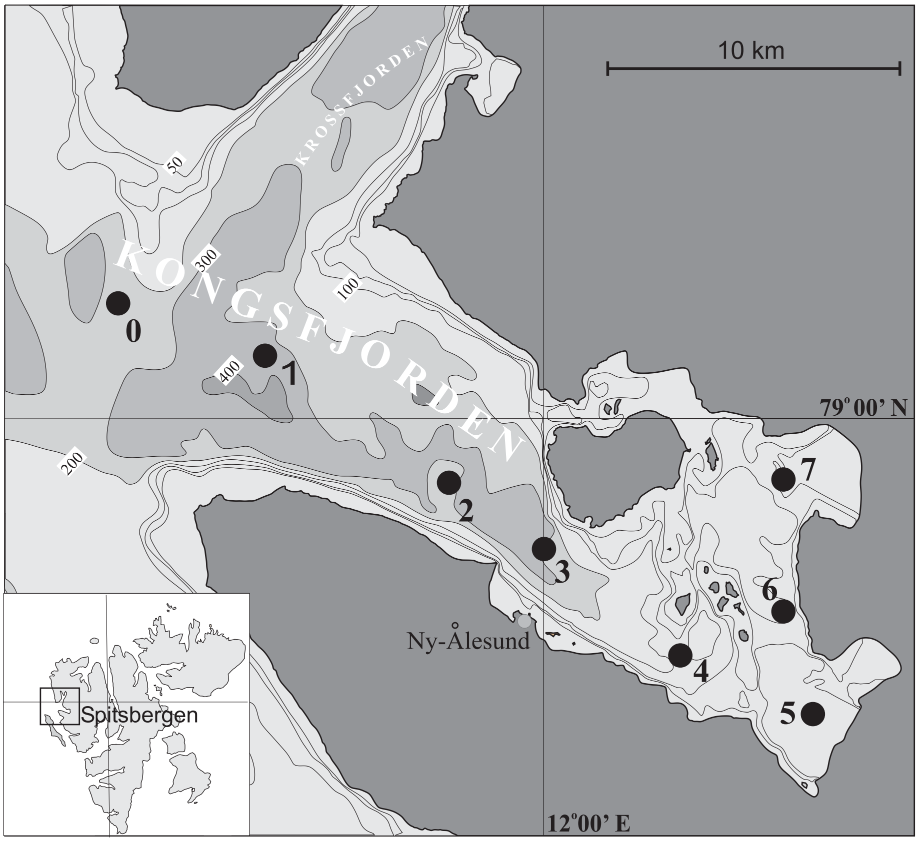


Fig. 1. Map of Kongsfjorden with the sampling stations indicated (0, 1, 2, 3, 4 – outer and middle part of the fjord; 5, 6, 7 – inner part).

Kongsfjorden (78°52 ´– 79°03´ N, 11°20´ – 12°30´ E) is a fjord of the northwest coast of Spitsbergen (Fig. 1). It is an arm of the Kongsfjorden-Krossfjorden system (418 $km^2$), an extension of Kongsfjorden shelf trench (Kongsfjordrenna). Kongsfjorden (20 km long, 231 $km^2$ area) has outer and inner basins with depths over 400 m and 90 m, respectively. These are separated by a 30 m deep ridge and there is no sill at the mouth of the fjord. A complex of driving forces governs the exchange between the Kongsfjorden-Krossfjorden system and the shelf (Svendsen *et al.* 2002). The exchange replaces intermediate and deep local fjord waters with Arctic Water and Atlantic Transformed Water originating from the Barents Sea and the Norwegian Sea, respectively. The advection of water masses into the fjord has a large impact on its hydrography and biology (Hop *et al.* 2002). In summer, the temperature in the main water body of the fjord oscillates between max 6.0°C at the surface and min –1.4°C in the deep depression near the glacier. Salinity is generally higher than 34.4 psu, except for the surface layer in the inner fjord where it can drop to 28.0 psu.

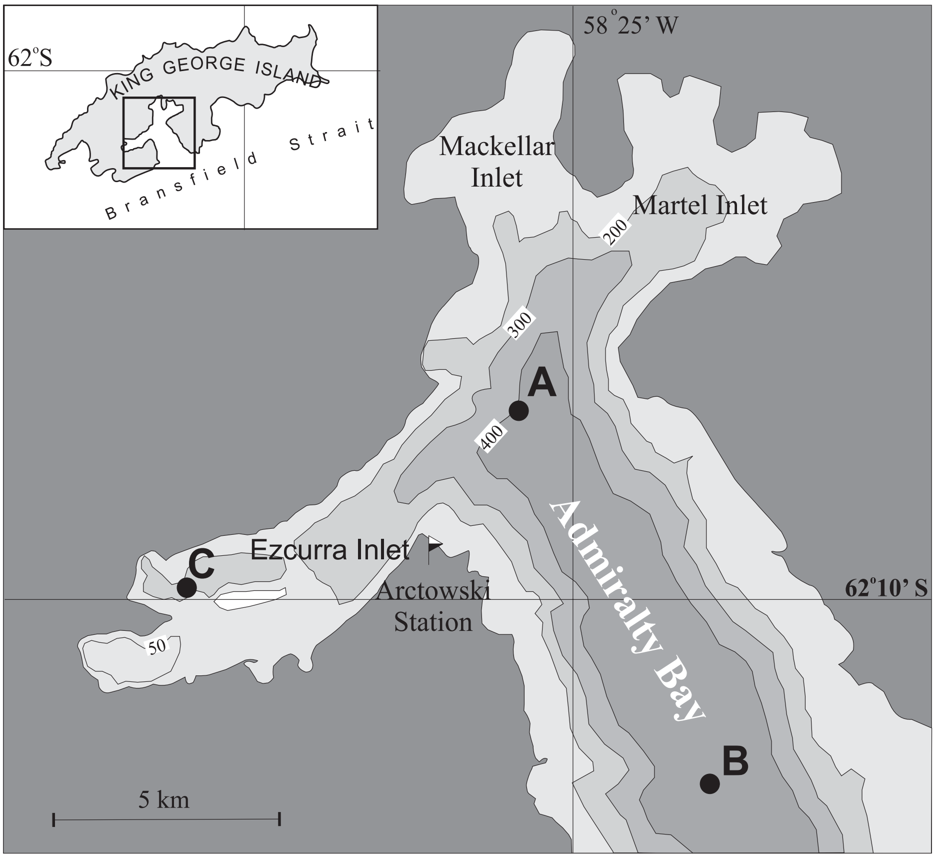


Fig. 2. The map of Admiralty Bay with the sampling stations indicated (A, B, C).

In recent years several papers on the Svalbard zooplankton have been published (*e.g.* Węsławski *et al.* 1988; Koszteyn and Kwaśniewski 1989; Kwaśniewski 1990; Węsławski *et al.* 1991; Scott *et al.* 2000; Hop *et al.* 2002; Karnovsky *et al.* 2003; Kwaśniewski *et al.* 2003; Walkusz *et al.* 2003).

It is suggested that advection and co-occurrence of Arctic and Atlantic waters result in a highly dynamic pelagic ecosystem in this area (Hop *et al.* 2002). Preliminary observations already showed a noticeable year-to-year difference in zooplankton composition and abundance there (Kwaśniewski *et al.* 2003).

Admiralty Bay is the largest bay on the King George Island and in the whole South Shetland Archipelago with an area of ca. 122 km$^2$ and a maximum depth of about 500 m (Rakusa-Suszczewski 1995). It opens to the Bransfield Strait with an outlet, which is approximately 8 km wide. The bay has a character of a fjord branching to a system of smaller inlets: the Ezcurra Inlet, the MacKellar Inlet and the Martel Inlet (Fig. 2). The water within the entire bay is well-mixed and neither a distinct halocline nor thermocline occur there. However, in the areas situated near the ice barriers, the upper 15–40 m of the water column can be distinctly modified. This layer has usually lower salinity (oscillating around 33.7 psu), lower temperature (below 1°C) and higher oxygen content (Bojanowski 1984). In the areas near glaciers, a 1 m layer of low salinity (below 20 psu) is often observed during summer due to freshwater runoff. Available literature dealing with composition of mesozooplankton of Admiralty Bay includes a number of works (Jażdżewski *et al.* 1982; Rakusa-Suszczewski 1983; Chojnacki and Węgleńska 1984; Jażdżewski *et al.* 1985; Żmijewska 1985, 1987, 1993; Kittel *et al.* 1988, 2001; Menshenina and Rakusa-Suszczewski 1992). Also several papers concerning Antarctic krill (*Euphausia superba* Dana, 1852) were published. Krill is regarded a dominant component of the Antarctic ecosystem, it serves as main food for penguins, flying birds, squids, seals and whales (*e.g.* Hempel 1985). *E. superba* dominates the pelagic Antarctic realm both in term of abundance and biomass (Kalinowski *et al.* 1985).

## Materials and methods

**Arctic**.—The zooplankton data from the Arctic are based on research carried out in Kongsfjorden in July of 1996 and 1997 (Hop *et al.* 2002) and 1999 and 2000. Zooplankton was collected in stratified vertical hauls from the bottom to the surface by a multiple plankton sampler (MPS, opening area 0.25 $m^2$, mesh size 0.180 mm). Sampling stations were established in both the outer part of the fjord (stations 0, 1, 2, 3, 4; max sampling depth 340 m) and in the inner basin (stations 5, 6, 7; max sampling depth 90 m) (Fig. 1). Samples were preserved in 4% buffered formaldehyde solution in seawater. The laboratory work was carried out in the laboratory of the Institute of Oceanology, Polish Academy of Sciences (IO PAS), Sopot. The identification of the samples was done to the lowest possible taxonomical level following procedures given by Harris *et al.* (2000). *Calanus* species were determined according to Unstad and Tande (1991) and Kwaśniewski *et al.* (2003). To calculate the biomass of the copepods, species and stage specific dry mass data provided by Karnovsky *et al.* (2003) were applied.

**Antarctic**.—Data on zooplankton from the Antarctic were obtained during the XVII Polish Antarctic Expedition of Polish Academy of Sciences to the Arctowski Station (1992–1994) (Kittel *et al.* 2001). Samples were collected during three summer months (February and December 1993 and January 1994) with a WP-2 net (opening area 0.25 $m^2$, 0.200 mm mesh size) at three stations in the hydrologically different areas of the bay. At stations A and B zooplankton was sampled in the 0–400 m layer while at the station C in 0–130 m layer (Fig. 2). The dry mass of the copepods was calculated from the wet mass presented in Kittel *et al.* (2001) by applying dry mass/wet mass ratio of 0.17 (Båmsted 1986).

## Results

**Taxonomic composition of zooplankton**.—In Kongsfjorden 63 taxa were recognized (Table 1); 46 species identified. The most diverse group in the fjord were Copepoda with 26 species present (Fig. 3), whilst among other groups the most diverse were Amphipoda and Euphausiacea with four species each. The majority of the identified taxa can be classified as holoplankton, whereas only eight taxa represented meroplankton (among them Cirripedia larvae, Echinodermata larvae, Decapoda larvae and Bryozoa larvae).

Taxonomic composition of zooplankton in Admiralty Bay was typical for Antarctic water. 65 taxa were recorded (Table 2), most identified to the species level.

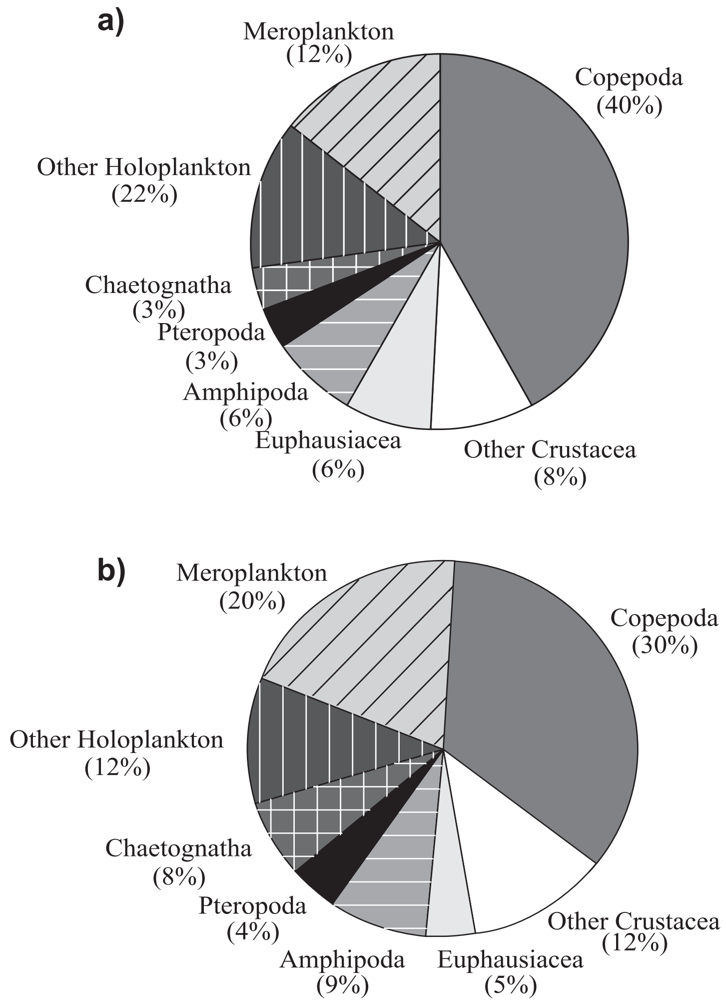


Fig. 3. Taxonomic composition of zooplankton (percentage of given taxa) in a) Kongsfjorden (for all stations and all years) and in b) Admiralty Bay (for all stations).

Table 1

List of zooplankton taxa recorded in Kongsfjorden, Arctic.

| | |
|---|---|
| Foraminifera<br>Hydrozoa (medusae):<br>*Sarsia princeps* (Haeckel, 1879)<br>*Aglantha digitale* (Müller, 1776)<br>*Halitholus* sp.<br>*Catablema* sp.<br>Hydromedusae<br>Siphonophora:<br>*Dimophyes arctica* (Chun, 1897)<br>Ctenophora:<br>*Beroe cucumis* Fabricius, 1780<br>*Mertensia ovum* (Fabricius, 1780)<br>Nematoda<br>Polychaeta – larvae<br>Ostracoda<br>Cirripedia – larvae<br>Copepoda:<br>*Acartia longiremis* (Lilljeborg, 1853)<br>*Bradydius similis* (Sars, 1902)<br>*Calanus hyperboreus* (Krøyer, 1838)<br>*C. glacialis* Jaschnov, 1955<br>*C. finmarchicus* (Gunnerus, 1756)<br>*Chiridius obtusifrons* Sars, 1902<br>*Gaidius tenuispinus* (Sars, 1900)<br>*G. brevispinus* (Sars, 1900)<br>*Heterorhabdus norvegicus* (Boeck, 1872)<br>*Mesaiokeras spitsbergensis* Schulz and Kwaśniewski, 2004<br>*Metridia longa* (Lubbock, 1854)<br>*Microcalanus pusillus* Sars, 1903<br>*M. pygmaeus* (Sars, 1900)<br>*Microsetella norvegica* (Boeck, 1865)<br>Monstrilloida<br>*Neoscolecithrix farrani* Smirnov, 1935<br>*Oithona atlantica* Farran, 1908<br>*O. similis* Claus, 1863<br>*Pareuchaeta glacialis* Hansen, 1887<br>*P. norvegica* (Boeck, 1865)<br>*Pseudocalanus acuspes* (Giesbrecht, 1881)<br>*P. minutus* (Krøyer, 1845)<br>*Rhincalanus nasutus* Giesbrecht, 1888<br>*Scaphocalanus magnus* (Scott, 1894)<br>*Scolecithricella minor* (Brady, 1883)<br>*Triconia* (*Oncaea*) *borealis* Sars, 1918<br>*Xantharus siedleckii* Schulz and Kwaśniewski, 2004<br>Harpacticoida | Isopoda<br>Cumacea<br>Tanaidacea<br>Amphipoda:<br>*Themisto abyssorum* Boeck, 1870<br>*T. libellula* (Lichtenstein, 1822)<br>*Hyperoche medusarum* (Krøyer, 1838)<br>*Hyperia galba* (Montagu, 1815)<br>Gammaridea<br>Euphausiacea:<br>*Thysanoessa inermis* (Krøyer, 1846)<br>*T. longicaudata* (Krøyer, 1846)<br>*T. raschii* (Sars, 1864)<br>*Meganyctiphanes norvegica* (Sars, 1857)<br>Decapoda – larvae<br>Pteropoda:<br>*Clione limacina* (Phipps, 1774)<br>*Limacina helicina* Phipps, 1774<br>*L. retroversa* (Fleming, 1823)<br>Bivalvia – larvae<br>Bryozoa – larvae<br>Echinodermata – larvae<br>Chaetognatha:<br>*Eukrohnia hamata* (Möbius, 1875)<br>*Sagitta elegans* Verrill, 1873<br>Appendicularia:<br>*Oikopleura vanhoeffeni* Lohmann, 1896<br>*Fritillaria borealis* Lohmann, 1896<br>Pisces – larvae |

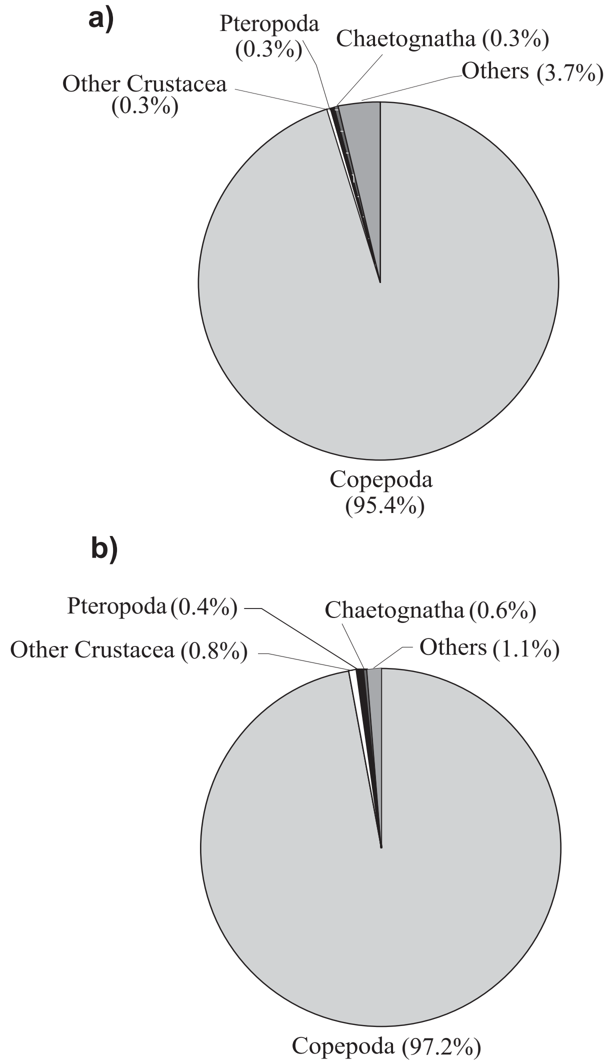


Fig. 4. Proportions of taxa in the total abundance of zooplankton in a) Kongsfjorden (mean for all stations and years) and in b) Admiralty Bay (mean for all stations).

Copepods dominated in zooplankton with 18 taxa (14 species and three genera) present (Fig. 3). Other important taxa among crustaceans were Ostracoda (6 species) and Amphipoda (6 species).

**Proportions of taxa in the total abundance of zooplankton**.—The most abundant zooplankton species in Kongsfjorden were Copepoda (Fig. 4), comprising 95.4% of all individuals counted. The next in order were pteropods and Chaetognatha, which comprised barely 0.3% each, while other taxa accounted for the remaining 4%.

Table 2

List of zooplankton taxa recorded in Admiralty Bay, Antarctic (after Kittel *et al.* 2001).

| | |
|---|---|
| Foraminifera<br>Hydromedusae<br>Siphonophora<br>Ctenophora<br>Nematoda<br>Polychaeta:<br>*Maupasia coeca* Viguier, 1886<br>*Pelagobia longicirrata* Greeff, 1879<br>*Rhynchonerella bongraini* (Gravier, 1911)<br>*Tomopteris* spp.<br>*Travisiopsis levinseni* Southern, 1910<br>*Typhloscolex muelleri* Busch, 1851<br>*Autolytus* sp.<br>Spionidae – larvae<br>Chaetosphaera f. 1<br>Chaetosphaera f. 2<br>Chaetosphaera f. 3<br>Ostracoda:<br>*Alacia belgicae* (Müller, 1906)<br>*A. hettacra* (Müller, 1906)<br>*Boroecia antipoda* (Müller, 1906)<br>*Metaconchoecia isocheira* (Müller, 1906)<br>*M. skogsbergi* (Iles, 1953)<br>*Procecorecia brachyaskos* (Müller, 1906)<br>Copepoda:<br>*Calanus propinquus* Brady, 1883<br>*Calanoides acutus* Giesbrecht, 1902<br>*Rhincalanus gigas* Brady, 1883<br>*Ctenocalanus citer* Heron *et* Bowmann, 1971<br>*Microcalanus pygmaeus* (Sars, 1900)<br>*Stephos longipes* Giesbrecht, 1902<br>*Euchaeta antarctica* (Giesbrecht, 1902)<br>*Scolecithricella glacialis* (Giesbrecht, 1902)<br>*Racovitzanus antarcticus* Giesbrecht, 1902<br>*Scaphocalanus* spp.<br>*Heterorhabdus* spp.<br>*Metridia gerlachei* Giesbrecht, 1902<br>*Lucicutia* sp.<br>*Oithona frigida* Giesbrecht, 1902<br>*O. similis* Claus, 1863<br>*Oncaea antarctica* Heron, 1977<br>*O. curvata* Giesbrecht, 1902<br>Harpacticoida | Isopoda<br>Cumacea<br>Amphipoda:<br>*Vibilia antarctica* Stebbing, 1888<br>*Cyllopus magellanicus* Dana, 1853<br>*Hyperiella dilatata* Stebbing, 1888<br>*Themisto gaudichaudii* Guerin, 1825<br>*Primno macropa* Guerin-Meneville, 1836<br>*Hippomedon kergueleni* (Miers, 1875)<br>Euphausiacea:<br>*Euphausia crystallorophias* Holt *et* Tattersall, 1906<br>*E. superba* Dana, 1850<br>*Thysanoessa macrura* G.O. Sars, 1883<br>Decapoda – larvae<br>Pteropoda:<br>*Limacina helicina* f. *antarctica* Woodward, 1850<br>*L. helicina* f. *rangi* (d'Orbigny, 1836)<br>*Spiongiobranchaea australis* d'Orbigny, 1836<br>Bivalvia – larvae<br>Echinodermata – larvae<br>Chaetognatha:<br>*Eukrohnia bathypelagica* Alvarino, 1962<br>*E. fowleri* Ritter-Zahony, 1909<br>*E. hamata* (Möbius, 1875)<br>*Sagitta gazellae* Ritter-Zahony, 1909<br>*S. marri* David, 1956<br>Appendicularia<br>Ascidiacea – larvae<br>Pisces – larvae |

In Admiralty Bay copepods were even more abundant constituting 97.2% of the total zooplankton abundance (Fig. 4). Of the remaining taxa, Chaetognatha contributed 0.6% and pteropods 0.4%.

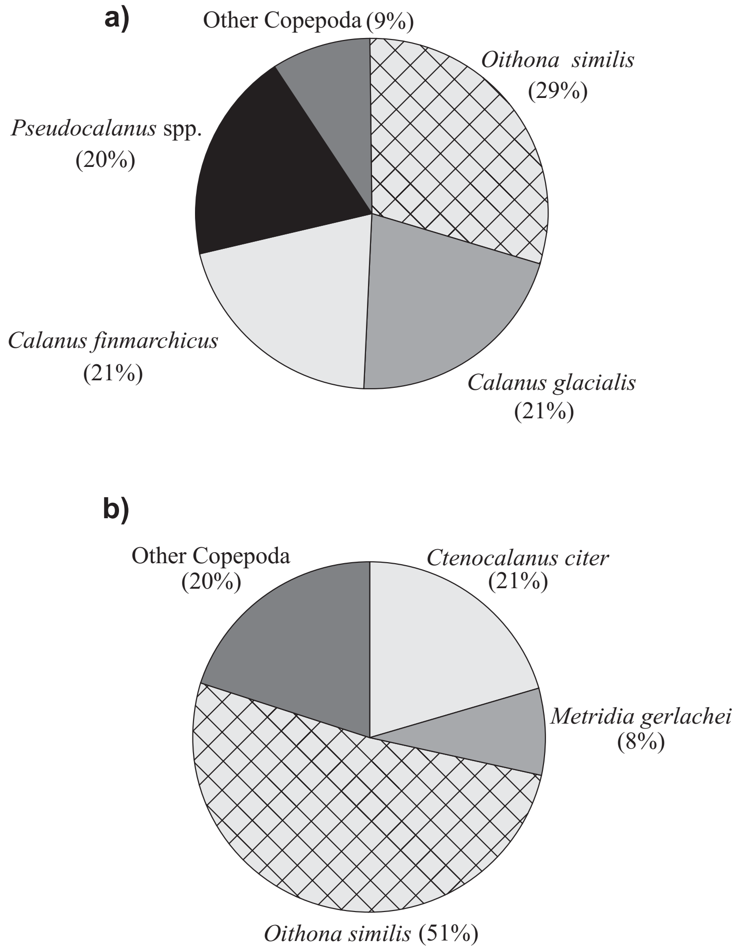


Fig. 5. Proportions of dominants in the total copepod abundance in a) Kongsfjorden (mean for all stations and all years) and in b) Admiralty Bay (mean for all stations).

**Proportions and abundance of dominant copepods**.—In Kongsfjorden among Copepoda four taxa predominated: *Oithona similis*, *Calanus finmarchicus, Calanus glacialis* and *Pseudocalanus* (including *P. minutus* and *P. acuspes*) (Fig. 5). Other copepods contributing significantly to the zooplankton community were *Microcalanus* (including *M. pygmaeus* and *M. pusillus*, 4% total), *Metridia longa* (2%) and *Calanus hyperboreus* (1%).

Of the total number of 14 species and three genera of copepods found in Admiralty Bay, the only abundant species were: *O. similis*, *Ctenocalanus citer* and *Metridia gerlachei* (Fig. 5). None of the remaining species contributed more than 1% to the total abundance.

In Kongsfjorden, the mean abundance of the most numerous copepod, *O. similis*, during the four-year study was 295 ind. $m^{-3}$ (with the maximum observed

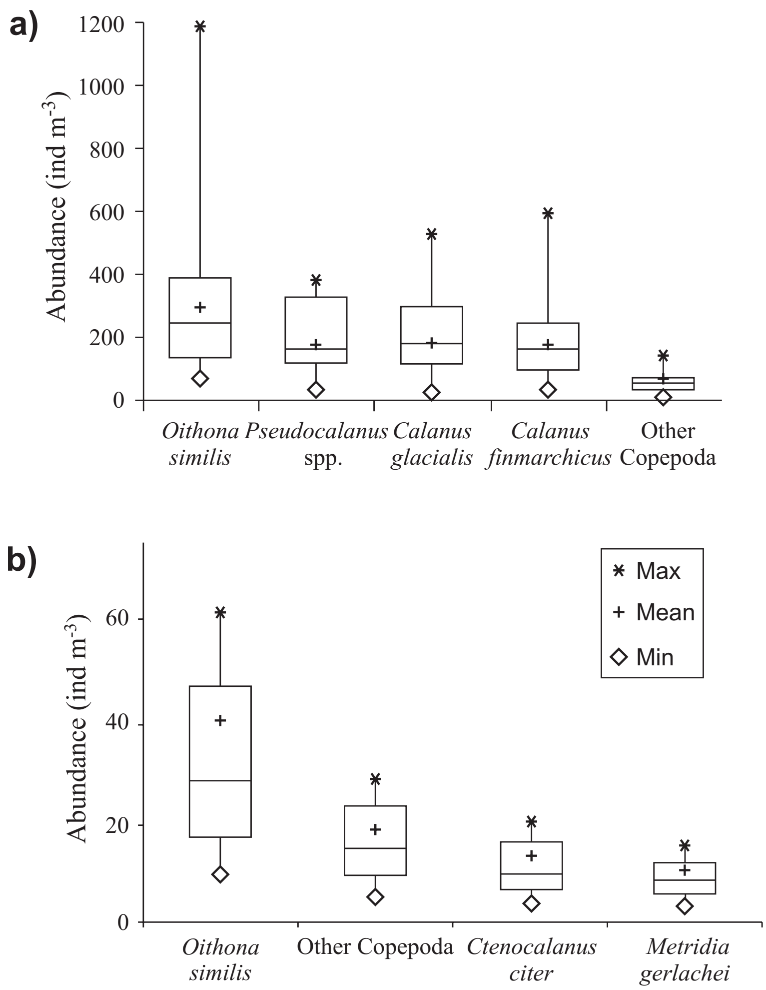


Fig. 6. Box plots of abundance of dominant copepods (ind $m^{-3}$) in a) Kongsfjorden and in b) Admirality Bay. The solid line in boxes indicates median abundance, the cross represents mean abundance, while the top and bottom edges of boxes are the 25th (Q1) and 75th (Q3) percentiles. Min = minimum value, Max = maximum value.

equalling to 1190 ind. $m^{-3}$; Fig. 6). The mean abundances of species next in order, *C. glacialis*, *C. finmarchicus* and *Pseudocalanus* spp., were similar, and equalled to approximately 180–190 ind. $m^{-3}$.

The small cyclopoid *Oithona similis* was also the most abundant copepod in Admiralty Bay (40 ind. $m^{-3}$; Fig. 6). The small calanoid *Ctenocalanus citer* had the mean density of 13 ind. $m^{-3}$. Mean abundance of *Metridia gerlachei* reported from Admiralty Bay was approximately 10 ind. $m^{-3}$.

During four years (1996, 1997, 1999 and 2000) the copepod biomass in Kongsfjorden ranged from 27 to 115 mg DM $m^{-3}$ (mean for all stations and years

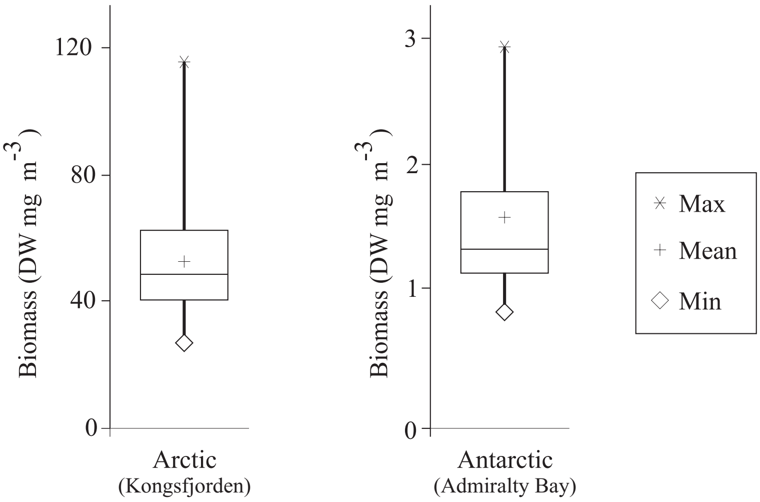


Fig. 7. Box plot of Copepoda biomass (DW; mg $m^{-3}$) in the Arctic and Antarctic. The solid line in boxes indicates median biomass, the cross represents mean biomass, while the top and bottom edges of boxes are the 25th (Q1) and 75th (Q3) percentiles. Min = minimum value, Max = maximum value.

was 55 mg DM $m^{-3}$) (Fig. 7). The copepod biomass in Admiralty Bay amounted only to 1.6 mg DM $m^{-3}$ (mean value for all stations).

## Discussion

The importance of krill in the Southern Ocean ecosystem is well documented (Hempel 1985; Kalinowski *et al.* 1985; Kittel 2000). It is likely that considering krill species (*Euphausia* in Admiralty Bay, *Thysanoessa* in Kongsfjorden) would give a different result of comparison of zooplankton biomass and abundance of the two ecosystems. However, since the sampling gears used for collecting the zooplankton in our study did not sampled krill representatively, we intentionally limited the comparison performed to the mesozooplankton size fraction.

An important feature of zooplankton in Kongsfjorden was the presence of components originating from two different marine climate zones (Hop *et al.* 2002). *Calanus finmarchicus*, *Themisto abyssorum* and *Limacina retroversa* exemplify fauna of the warm Atlantic zone, whereas *Calanus glacialis*, *Themisto libellula* and *Limacina helicina* represent the fauna of the cold Arctic zone. Representatives of different fauna are brought into the fjord as a result of advection, which is generated by several local and regional scale oceanographic processes (Svendsen *et al.* 2002) and seems important for maintaining the fjord's ecosystem (Hop *et al.* 2004).

Zooplankton found in the Admiralty Bay originated from the surrounding waters of the Bransfield Strait, the dynamic transitional zone of the Southern Ocean, which is under the influence of both Bellingshausen Sea and Weddell Sea water masses (Tokarczyk 1987). Both water masses belong to the same marine climate zone, which may be one of the reasons why their convergence does not contribute to increase of faunistic complexity of the bay. Similar to the Kongsfjorden, however, Admiralty Bay seems very much depending on the flow of cold water from the outside of the basin, which supplies the ecosystem in nutrients and organic matter (Rakusa-Suszczewski 1980, 1995) and most likely helps also maintaining the local populations of zooplankton.

The comparison of zooplankton community between the two polar regions showed similarities in respect of the presence of particular taxonomic groups as well as in the proportions of dominant taxa. The regularities discovered comply with findings of earlier studies on zooplankton from both areas. All hitherto research documents that copepods are the most abundant and diverse group in Kongsfjorden (Węsławski *et al.* 1991; Hop *et al.* 2002; Kwaśniewski *et al.* 2003; Walkusz *et al.* 2003) as well as in Admiralty Bay (Jażdżewski *et al.* 1982; Chojnacki and Węgleńska 1984; Żmijewska 1985; Kittel *et al.* 1988; Freire *et al.* 1993). Interestingly, although most of the copepod species found in each of the two regions are different, there are some, such as *Oithona similis* and *Microcalanus pygmaeus*, which are common for both ecosystems. Another species found in the two polar localities was *Eukrohnia hamata*.

Worth mentioning fact is that the most numerous copepod in both polar regions was *O. similis*. *O. similis* is a cosmopolite species regularly occurring in high abundance in areas characterized by steep gradients of environmental parameters, such as Kongsfjorden. This small cyclopoid is generally regarded as the most ubiquitous and abundant copepod in the world's oceans (Gallienne and Robins 2001).

In contrast to the similarities found in respect to composition of zooplankton community, there were drastic differences when abundance and biomass of zooplankton were compared, both being of an order of magnitude higher in Kongsfjorden than in Admiralty Bay.

In Kongsfjorden the highest abundance was found for *O. similis*. In the Marginal Ice Zone of the Barents Sea, however, this species was found in abundance equal even to 3000 ind. $m^{-3}$ (Falk-Petersen *et al.* 1999). The abundances of *Calanus finmarchicus* and *Calanus glacialis* found by us exceeded the values recorded in other study from Kongsfjorden (Scott *et al.* 2000). In the waters of the West Spitsbergen Current or in the Southern Barents Sea, though, the abundance of the warm water *C. finmarchicus* reached values of 13 400 and 1 600 ind. $m^{-3}$ respectively, in summer (Kwaśniewski unpubl. data; Helle 2000). The abundances of the cold water *C. glacialis* amounted to 150 and 70 ind. $m^{-3}$, in the Arctic shelf waters of the Northern Barents Sea and in the Arctic Ocean, respectively (Falk-Petersen *et al.* 1999; Thibault *et al.* 1999).

The low abundances of copepods in the Antarctic Admiralty Bay were unexpected, but similar densities of *O. similis* were recorded there by Jażdżewski *et al.* (1982), Chojnacki and Węgleńska (1984) and by Freire *et al.* (1993). In other areas within the Antarctic, however, the abundance of *O. similis* was higher than observed in Admiralty Bay (Metz 1995, Fransz and Gonzalez 1995, Dubischar *et al.* 2002). The same situation takes place in respect of *Metridia gerlachei*; its abundance in Admiralty Bay was much lower than that observed near Deception Island in summer by King and LaCassella (2003). Differences in zooplankton abundance between our data and data provided by Menshenina and Rakusa-Suszczewski (1992) may result from sampling in different seasons – our data concern summer, Menshenina and Rakusa-Suszczewski provide data for spring and autumn. We are of the opinion, however, that the low abundance of zooplankton in Admiralty Bay, particularly of Copepoda, depicts a true situation. The reason for it may be that the bay is located in generally biologically disadvantageous area or that copepods do not performed well there because of high competition with krill.

The average biomass of Copepoda in Kongsfjorden (55 mg DM $m^{-3}$) was much higher than that measured in the nearby east Greenland Sea (15 mg DM $m^{-3}$; Smith *et al.* 1985) and also higher than the biomass found in the Arctic Ocean (7–42 mg DM $m^{-3}$; Thibault *et al.* 1999). However, it was lower than the biomass observed in the productive waters of the Laptev Sea (up to 270 mg DM $m^{-3}$; Lischka *et al.* 2001). In the waters of the West Spitsbergen Current the biomass of Copepoda in summer of three years 1987–1989 amounted to 22–83 mg DM $m^{-3}$ (Kwaśniewski, unpubl. data). The relatively high Copepoda biomass in Kongsfjorden is most likely related to the hydrological characteristics of this fjord with strong advection of waters from the neighbouring shelf, where frontal dynamics and the presence of biologically rich West Spitsbergen Current result in increased productivity.

The average biomass of Copepoda in Admiralty Bay (1.6 mg DM $m^{-3}$) was half of that measured by Chojnacki and Węgleńska (1984) (2.8 mg DM $m^{-3}$, calculated by using factor of dry mass/wet mass = 0.17). In the nearby Bransfield Strait Copepoda biomass was, however, even lower, approx. 0.175 mg DM $m^{-3}$ (or 350 mg DM $m^{-2}$) (Hernandez-Leon *et al.* 1999). In the Indian Sector of the Southern Ocean Copepoda biomass was of similar range as in Admiralty Bay (1 mg DM $m^{-3}$, calculated from 4 g DM $m^{-2}$) (Mayzaud *et al.* 2002). The record high Copepoda biomass values from the Antarctic waters, up to 25 mg DM $m^{-3}$, were measured in the Croker Passage (Conover and Huntley 1991).

The drastic difference in abundance and biomass of Copepoda between Kongsfjorden and Admiralty Bay appears surprising when the primary production of these two localities is compared. Daily primary production in Kongsfjorden was estimated at 1.3 g C $m^{-2}$ $d^{-1}$ (Eilertsen *et al.* 1989) or within the range of 0.024–1.400 g C $m^{-2}$ $d^{-1}$(Hop *et al.* 2002). Daily primary production in Admiralty Bay was estimated at quite similar level of 0.154–1.495 g C $m^{-2}$ $d^{-1}$ by Hapter *et al.* (1983) or equalling to 0.082 g C $m^{-2}$ $d^{-1}$ by Domanov and Lipski (1990). In the view of the above we postulate that large difference in the role of Copepoda between the two polar ecosystems may be caused, most likely, by krill, which competes successfully as the first level consumer.

## Conclusions

The community composition of zooplankton in both polar regions includes similar taxonomic groups, and the species richness is also similar. The majority of zooplankton taxa in Kongsfjorden originate from different Atlantic and Arctic zones, while in Admiralty Bay the zooplankton is composed of circum-Antarctic taxa. The overall species composition is different though there are some species common for both ecosystems, for example *Oithona similis, Microcalanus pygmaeus* and *Eukrohnia hamata*. There are, however, drastic differences in the abundance and biomass of main zooplankton components (Copepoda) in the two ecosystems, both being of an order of magnitude higher in Kongsfjorden than in Admiralty Bay.

In Kongsfjorden, both, small and large Copepoda are abundant, while in Admiralty Bay mostly small species prevail. It is suggested that this is a result of large-scale ecosystem differences as well as hydrographic conditions at the two locations. Kongsfjorden is situated at the border of two regions which induce high productivity and there is also a strong advection into the fjord. Admiralty Bay is adjacent to the rather homogenous Antarctic oceanic ecosystem and the convergence of different, but more homogenous water masses, has rather limited influence on biological productivity. Another significant difference between the two polar systems is that most likely krill occupies most of the primary consumers niche in the Antarctic marine ecosystem and limits the role of Copepoda.

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## References

BÅMSTEDT U. 1986. Chemical composition and energy content. *In*: E.D.S.Corner and S.C.M. O'Hara (eds), *The biological chemistry of marine copepods*. Clarendon, Oxford; 58 pp.

BOJANOWSKI R. 1984. Hydrochemical observations at an anchored station in Ezcurra Inlet. Oceanologia 15: 21–64.

CHOJNACKI J. and WĘGLEŃSKA T. 1984. Periodicity of composition, abundance, and vertical distribution of summer zooplankton (1977/1978) in Ezcurra Inlet, Admiralty Bay (King George Island, South Shetland). Journal of Plankton Research 6: 997–1018.

CONOVER R.J. and HUNTLEY M. 1991. Copepods in ice-covered seas – distribution, adaptations to seasonally limited food, metabolism, growth patterns and life cycle strategies in polar seas. Journal of Marine Systems 2: 1–41.

DOMANOV M.M. and LIPSKI M. 1990. Annual cycle of chlorophyll a and primary production of phytoplankton in Admiralty Bay (Antarctica). Polish Archives of Hydrobiology 37: 471–478.

DUBISCHAR C.D., LOPES R.M. and BATHMANN U.V. 2002. High summer abundances of small pelagic copepods at the Antarctic Polar Front – implications for ecosystem dynamics. Deep-Sea Research II 49: 3871–3887.

EILERTSEN H.C., TAASEN J.P. and WĘSŁAWSKI J.M. 1989. Phytoplankton studies in the fjords of West Spitzbergen: physical environment and production in spring and summer. Journal of Plankton Research 11: 1245–1260.

FALK-PETERSEN S., PEDERSEN G., KWAŚNIEWSKI S., HEGSETH E.N. and HOP H. 1999. Spatial distribution and life-cycle timing of zooplankton in the marginal ice zone of the Barents Sea during the summer melt season in 1995. Journal of Plankton Research 21: 1249–1264.

FRANSZ H.G. and GONZALEZ S.R. 1995. The production of *Oithona similis* (Copepoda: Cyclopoida) in the Southern Ocean. The International Council for the Exploration of the Sea, Journal of Marine Science 52: 549–555.

FREIRE A.S., COELHO M.J.C. and BONECKER S.L.C. 1993. Short term spatial-temporal distribution patterns of zooplankton in Admiralty Bay (Antarctica). Polar Biology 13: 433–439.

GALLIENE C.P. and ROBINS D.B. 2001. Is *Oithona* the most important copepod in the world's oceans? Journal of Plankton Research 23: 1421–1432.

HAPTER R., WOŹNIAK B. and DOBROWOLSKI K. 1983. Primary production in Ezcurra Inlet during the Antarctic summer of 1977/78. Oceanologia 15: 175–183.

HARRIS R., WIEBE P., LENZ J., SKJOLDAL H.R. and HUNTLEY M. (eds) 2000. Zooplankton Methodology Manual. Academic Press. London; 648 pp.

HELLE K. 2000. Distribution of the copepodite stages of *Calanus finmarchicus* from Lofoten to the Barents Sea in July 1989. The International Council for the Exploration of the Sea, Journal of Marine Science 57: 1636–1644.

HEMPEL I. 1985. Antarctic marine food webs. *In*: W.R.Siegfried, P.R.Condy and R.M. Laws (eds), *Antarctic nutrient cycles and food webs*. Springer-Verlag, Berlin and Heidelberg: 266–270.

HERNANDEZ-LEON S., TORRES S., GOMEZ M., MONTERO I. and ALMEIDA C. 1999. Biomass and metabolism of zooplankton in the Bransfield Strait (Antarctic Peninsula) during austral spring. Polar Biology 21: 214–219.

HOP H., PEARSON T., HEGSETH E.N., KOVACS K.M., WIENCKE C., KWAŚNIEWSKI S., EIANE K., MEHLUM F., GULLIKSEN B., WŁODARSKA-KOWALCZUK M., LYDERSEN C., WĘSŁAWSKI J.M., COCHRANE S., GABRIELSEN G.W., LEAKEY R.J.G., LONNE O.J., ZAJĄCZKOWSKI M., FALK-PETERSEN S., KENDALL M., WANGBERG S.A., BISCHOF K., VORONKOV A.Y., KOVALTCHOUK N.A., WIKTOR J., POLTERMANN M., DI PRISCO G., PAPUCCI C. and GERLAND S. 2002. The marine ecosystem of Kongsfjorden, Svalbard. Polar Research 21: 167–208.

JAŻDŻEWSKI K., KITTEL W. and ŁOTOCKI K. 1982. Zooplankton studies in the southern Drake Passage and in the Bransfield Strait during the austral summer (BIOMASS-FIBEX, February–March 1981). Polish Polar Research 3: 203–242.

JAŻDŻEWSKI K., KITTEL W. and ŁOTOCKI K. 1985. Distribution and composition of plankton. *In*: S. Z. El-Sayed (eds), *Atlas of Polish oceanographic observations in Antarctic waters 1981*. BIOMASS Published by SCAR and SCOR, Scott Polar Research Institute, Cambridge: 56–64.

KALINOWSKI J., GODLEWSKA M. and KLUSEK Z. 1985. Distribution and stock of krill in the Bransfield Strait and the Drake Passage during December 1983 – January 1994, BIOMASS-SIBEX. Polish Polar Research 6: 151–158.

KARNOVSKY N., KWAŚNIEWSKI S., WĘSŁAWSKI J.M., WALKUSZ W. and BESZCZYŃSKA-MOLLER A. 2003. The foraging behaviour of little auks in a heterogeneous environment. Marine Ecology Progress Series 253: 289–303.

KING A. and LACASELLA E.L. 2003. Seasonal variations in abundance, diel vertical migration, and population structure of *Metridia gerlachei* at Port Foster, Deception Island, Antarctica. Deep-Sea Research II 50: 1753–1763.

KITTEL W., SICIŃSKI J. and ŁUCZAK C. 1988. Structure and biomass of zooplankton between King George Island and Elephant Island (BIOMASS III, October–November 1986). Polish Polar Research 9: 265–276.

KITTEL W. 2000. Polish Antarctic Bibliography: Zooplankton (1976–1999). Polish Polar Research 21: 199–208.

KITTEL W., SICIŃSKI J., ŻMIJEWSKA M.I., BIELECKA L. and BŁACHOWIAK-SAMOŁYK K. 2001. Antarctic neritic zooplankton community (Admiralty Bay, King George Island, South Shetland Islands). Polish Polar Research 22: 11–33.

KOSZTEYN J. and KWAŚNIEWSKI S. 1989. Comparison of fjord and shelf mesozooplankton communities of the southern Spitsbergen region. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer 188: 164–169.

KWAŚNIEWSKI S. 1990. A note of zooplankton of the Hornsund Fjord and its seasonal changes. Zeszyty Naukowe Wydziału Biologii, Geografii i Oceanologii Uniwersytetu Gdańskiego 12: 7–27.

KWAŚNIEWSKI S., HOP H., FALK-PETERSEN S. and PEDERSEN G. 2003. Distribution of *Calanus* species in Kongsfjorden, a glacial fjord in Svalbard. Journal of Plankton Research 25: 1–20.

LISCHKA S., KNICKMEIER K. and HAGEN W. 2001. Mesozooplankton assemblages in the shallow Arctic Laptev Sea in summer 1993 and autumn 1995. Polar Biology 24: 186–199.

MAYZAUD P., RAZOULS S., ERRHIF A., TIRELLI V. and LABAT J.P. 2002. Feeding, respiration and egg production rates of copepods during austral spring in the Indian sector of the Antarctic Ocean: role of the zooplankton community in carbon transformation. Deep-Sea Research I 49: 1027–1048.

MENSHENINA L. and RAKUSA-SUSZCZEWSKI S. 1992. Zooplankton changes during the year in Admiralty Bay (February 1990 – January 1991). Polish Archives of Hydrobiology 39: 49–58.

METZ C. 1995. Seasonal variation in the distribution and abundance of *Oithona* and *Oncaea* species (Copepoda, Crustacea) in the southeastern Weddell Sea, Antarctica. Polar Biology 15: 187–194.

RAKUSA-SUSZCZEWSKI S. 1980. Environmental conditions and the functioning of Admiralty Bay (South Shetlands Islands) as a part of the near shore Antarctic ecosystem. Polish Polar Research 1: 11–29.

RAKUSA-SUSZCZEWSKI S. 1983. The relationship between distribution of plankton biomass and plankton communities in the Drake Passage and the Bransfield Strait (BIOMASS-FIBEX, February–March 1981). *In*: T. Nemoto and T. Makuda (eds), *Proceedings of the BIOMASS Colloqium, 1982; Memoirs*. National Institute of Polar Research Special Issue 27: 77–83.

RAKUSA-SUSZCZEWSKI S. 1995. The hydrography of Admiralty Bay and its inlets, coves and lagoons (King George Island, Antarctica). Polish Polar Research 16: 61–70.

SCOTT C.L., KWAŚNIEWSKI S., FALK-PETERSEN S. and SARGENT J.R. 2000. Lipids and life strategies of *Calanus finmarchicus, Calanus glacialis* and *Calanus hyperboreus* in late autumn, Kongsfjorden, Svalbard. Polar Biology 23: 510–516.

SMITH S.L., SMITH W.O., CODISPOTI L.A., and WILSON D.L. 1985. Biological observations in the marginal ice zone of the East Greenland Sea. Journal of Marine Research 43: 693–717.

SVENDSEN H., BESZCZYŃSKA-MOLLER A., HAGEN J.O., LEFAUCONNIER B., TVERBERG V., GERLAND S., ØRBEK J.B., BISCHOF K., PAPUCCI C., ZAJĄCZKOWSKI M., AZZOLINI R., BRULAND O., WIENCKE C., WINTHER J.-G. and DALLMANN W. 2002. The physical environment of Kongsfjorden-Krossfjorden, an Arctic fjord system in Svalbard. Polar Research 21: 133–166.

THIBAULT D., HEAD E.J.H. and WHEELER P.A. 1999. Mesozooplankton in the Arctic Ocean in summer. Deep-Sea Research I 46: 1391–1415.

TOKARCZYK R. 1987. Classification of water masses in the Bransfield Strait and southern part of the Drake Passage using a method of statistical multidimensional analysis. Polish Polar Research 8: 333–366.

UNSTAD K.H. and TANDE K.S. 1991. Depth distribution of *Calanus finmarchicus* and *C. glacialis* in relation to environmental conditions in the Barents Sea. *In*: E. Sakshaug, C.C.E. Hopkins and

N.A. Øritsland (eds), *Proceedings of the Pro Mare Symposium on Polar Marine Ecology, Trondheim, 12–16 May 1990*. Polar Research 10: 409–420.

WALKUSZ W., STOREMARK K., SKAU T., GANNEFORS C. and LUNDBERG M. 2003. Zooplankton community structure; a comparison of fjords, open water and ice stations in the Svalbard area. Polish Polar Research 24: 149–165.

WĘSŁAWSKI J.M., ZAJĄCZKOWSKI M., KWAŚNIEWSKI S., JEZIERSKI J. and MOSKAL W. 1988. Seasonality in an Arctic fjord ecosystem: Hornsund, Spitsbergen. Polar Research 6: 185–189.

WĘSŁAWSKI J.M., JANKOWSKI A., KWAŚNIEWSKI S., SWERPEL S. and RYG M. 1991. Summer hydrology and zooplankton in two Svalbard fjords. Polish Polar Research 12: 445–460.

WĘSŁAWSKI J.M., KWAŚNIEWSKI S. and WIKTOR J. 1991. Winter in Svalbard fiord ecosystem. Arctic 44: 115–123.

ŻMIJEWSKA M.I. 1985. Copepoda in the southern part of Drake Passage and in Bransfield Strait during early summer 1983–1984 (BIOMASS-SIBEX, December–January). Polish Polar Research 6: 79–93.

ŻMIJEWSKA M.I. 1987. Horizontal and vertical distribution of Copepoda in the southern part of Drake Passage and in Bransfield Strait (BIOMASS-SIBEX 1983/1984). Polish Polar Research 8: 381–390.

ŻMIJEWSKA M.I. 1993. Seasonal and spatial variations in the population structure and life histories of the Antarctic copepod species *Calanoides acutus*, *Calanus propinquus*, *Metridia gerlachei* and *Euchaeta antarctica* (Calanoida) in Croker Passage (Antarctic Peninsula). Oceanologia, 35: 73–100.

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