ICES CM 2008/B:05.

Lipid compositions of calanoid copepods and an ostracod from Kongsfjorden and the Marginal Ice Zone north of Svalbard: Dietary Influences.

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Abstract

The three dominant *Calanus* species, *Calanus finmarchicus*, *C. glacialis,* and *C. hyperboreus,* were sampled at different locations along the Arctic Marginal Ice Zone (different types and ages of ice) around Svalbard and in Kongsfjorden, an Arctic fjord. High-Arctic *Scaphocalanus magnus,* a calanoid copepod, and an ostracod, *Conchoecia borealis,* were sampled only at the MIZ sites. Changes and difference in the lipid biochemistry (deposition of lipid classes and biomarkers) were used to investigate the different species under different physical regimes and potentially different food regimes. Stage V *C. hyperboreus*, for example, show greater lipid deposition at the MIZ-multiple-year old ice site compared to other sites. Stage V *C. hyperboreus* sampled at ice sites also have higher amounts of TAG and wax esters than at the fjord site. Site specific differences in the fatty acid composition were evident in the three calanoid species reflecting the variability in the phytoplankton composition. Diatom markers were more abundant at sites experiencing the bloom and flagellate markers were more abundant at sites where the seasonal bloom had passed. The dominant fatty acid biomarkers in the *C. borealis* wax esters and *S. magnus* TAG suggest an omnivorous behaviour and, potentially, particulate feeding on material originating from the larger *Calanus* copepods. The importance of the ice habitat in maintaining high quality particulate material is discussed.

Keywords: Calanus, zooplankton, Arctic sea ice, lipids

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Introduction

An Arctic field season, UNIS 1998, provided an opportunity to sample the three dominant calanoid species, *Calanus finmarchicus*, *C. glacialis* and *C. hyperboreus* at different locations along the Marginal Ice Zone (MIZ) north of Svalbard and in Kongsfjorden, thus allowing comparisons to be made between the three species under different physical regimes and potentially different food regimes. *Scaphocalanus magnus,* a calanoid copepod, and an ostracod, *Conchoecia borealis,* also known as *Boroecia borealis,* were also sampled at the MIZ sites. A preceding field season, BIODAF 1997, was carried out in its entirety in Kongsfjorden, Svalbard, during August

and September 1997 when the water column in the fjord was consistently formed of local waters overlaying a mix of Spitzbergen Shelf Water and Transformed Atlantic Water with a layer of intermediate water in between. *Calanus finmarchicus*, *C. glacialis* and *C. hyperboreus* were all present in the water column, again allowing comparisons to be made between the species from physical environments with potentially different food regimes.

The three *Calanus* species are associated with different geographical zones and their presence in the locations studied can be linked to different water masses. Thus, *Calanus hyperboreus* is primarily a deep water species found especially in the Greenland Sea and the Arctic Ocean, *C. glacialis* is primarily an Arctic shelf species and *C. finmarchicus* is primarily a North Atlantic water species (Fleminger and Hülsemann, 1977) exported to the Arctic (Hirche, 1991). *Scaphocalanus magnus* is identified as a cosmopolitan, mesopelagic-deep water species (Razouls *et al*., 2008), but it is typically a component of the high-Arctic fauna (Mumm *et al.,* 1998). *Conchoecia borealis*, as a halocyprid osctracod, is likely also mesopelagic (Vannier *et al*., 1998). .

All three *Calanus* species, classically considered herbivorous, are well known to accumulate large amounts of wax esters (see Lee *et al.,* 1971; Lee and Hirota, 1973; Sargent and Henderson, 1986). They are important contributors to both abundance and biomass in the Arctic ecosystem, and due to their innate lipid reserves are important food items.

Little is known of the biochemistry of *S. magnus* and *C.borealis*, research being focussed on the organochlorine contaminants (*S.magnus*: Hargrave *et al*., 1991) and trace metals (*C.borealis*: Ritterhoff and Zauke, 1997). Hopcroft *et al*. (2005) noted that the high abundance of *C. borealis* warrants further research into their contribution to community dynamics. And Mumm *et al*., (1993) considers the ostracod in terms of abundance and dry weight to be in the top ten most important species of mesoplankton in the Arctic and as such, can contribute a significant source of food for other zooplankton and fish (Moguilevsky and Angel, 1975). As to their diet, generically halocyprid osctracods are considered opportunistic microphagous feeders, but it is not known if they catch or feed on dead/dying prey (Vannier *et al*., 1998).

S. magnus are thought to be carnivorous (Matthews and Bakke, 1977). Harding (1974) specifically reported *S. magnus* feeding on euphasiid eyes i.e. dead material. As a genus, *Scaphocalanus* have mouthparts which have characteristics of both filter-feeding and predatory copepods (Steinberg, 1995). Their abundance varies in the Arctic relating to the distinct hydrographic regimes in the region (Mumm *et al*., 1993). They are more abundant in the meso-pelagic zone, 50-500m, in the deeper, more central regions of the Arctic (Auel and Hagen, 2002).

The present study is concerned with studying whether differences in lipids and dietary fatty acids could also be detected in the three *Calanus* species and, if so, whether the differences were genuine species differences or differences due to variations in food availability and/or composition and to elucidate the diet of likely necrophagic/detrital feeding members of the zooplankton community.

Methods

During both field seasons, zooplankton were sampled with a WP-2 of 57cm opening diameter with a 180 μm mesh size and a WP-2 of 57 cm opening diameter with a 500 μm mesh size. Nets were towed vertically from 200m depth to the surface at a rate of 45m min^{-1} (UNESCO, 1968). During BIODAF, two WP-2 hauls were taken to obtain samples every 48 hours when conditions allowed, from the 24th August to the 20th September 1997. During UNIS, one station was situated in Kongsfjorden and three stations were located at the Marginal Ice Zone north of Svalbard (Table 1). Multiple WP2 hauls were taken to sample the zooplankton.

The different water masses comprising the water column, during both studies (Table 1), were determined by CTD measurements utilising a Technical Mark EC&C Mark III CTD-sonde.

Individual copepods and ostracods were identified to species and to stage of development. Stage V individuals, i.e. the stage immediately preceding full sexual development to males or females, and females were selected. Up to 10 individuals of each of these species and two stages, if applicable, were pooled to constitute a single sample. The procedure was repeated, where possible, on 3 or more separate pooled samples and the data expressed as means ± sd.

Two-litre water samples were collected at the Ice Stations using Niskin bottles from bottom depth to surface (Table 1) at 50 m intervals. The water samples were filtered through a 125-µm circular sieve and then a 63-µm sieve to remove the larger copepods. The resultant filtrate was then passed through a 20-µm sieve and the retained particulates washed into a petri dish with the filtrate being retained. The particulate material was then examined under a binocular microscope at 40 magnification and any copepodites and large fragments of copepodites present were manually removed with forceps. The checked particulate material with the retained filtrate was finally filtered through a GF/C ultra-fine glass fibre disc, 0.26 mm thick with a 1.2 µm retention, at a filtration speed of 100 s/100 ml, which had been pre-washed with chloroform:methanol (2:1 v/v). The discs were then placed in chloroform:methanol (2:1 v/v) containing 0.01% (w/v) butylated hydroxytoluene as antioxidant in glass vials with Teflon-lined caps and stored at -20°C for no more than 2 months prior to analyses.

Total lipid was extracted from separate samples by the method of Folch *et al.* (1957) and fractionated into lipid classes by thin layer chromatography (Olsen and Henderson 1989). Wax esters and phospholipids were eluted from the plates, dried and transmethylated in methanol/toluene (2/1 v/v) containing 1% sulphuric acid for 16 h at 50°C. The reaction products were extracted into diethyl ether, dried under nitrogen and subjected to thin layer chromatography in hexane/diethyl ether/acetic acid (70/30/1 v/v/v) to separate fatty acid methyl esters and, for wax esters, free fatty alcohols. The fatty acid methyl esters and the free fatty alcohols were eluted from the plates and the fatty alcohols converted to fatty alcohol acetates by reacting with acetic anhydride in pyridine (Farquhar 1962). The % compositions of fatty acid methyl esters and fatty alcohol acetates were determined in a Fisons GC8160 gas chromatograph equipped with a chemically bonded CP Wax 52CB fused silica, wall-coated capillary column (30 m □0.32 mm i.d., Chrompack UK) with an on-column injection system and flame ionization detection. Hydrogen was used as carrier gas with an oven thermal gradient from an initial 50 to 180°C at 40°C min–1, and then to a final temperature of 235°C at 2°C min–1. Individual components were identified by comparison with known standards, with a well-characterised fish oil and by reference to published data, as described previously by Tande and Henderson (1988), and were quantified using a PC directly

linked to the detector and operating Chrom-Card Software (Thermo-Quest Italia). All solvents contained 0.01% w/v butylated hydroxytoluene as an antioxidant.

For the purpose of statistical analysis, highly conserved fatty acids, e.g. important components such as 22:6(n-3), were considered as statistically discrete units, and could be assessed with parametric analysis of variance model types, presuming that issues of normality, homogeneity, independence and fixed X are met.

Results

A. Lipid Levels.

In the UNIS 98 samples, the amount of total lipid per individual stage V *C. finmarchicus* was relatively constant regardless of water mass, with the notable exception of Ice Station 3 where the animals contained three times more lipid than those at the other three sites (Table 2). Stage V individuals of *C.glacialis* were more variable. Thus, the lowest level of lipid in *C. glacialis* individuals at Ice Station 3 was only a quarter of the highest level in Spitzbergen Shelf Water in Kongsfjorden which was nearly double that in Transformed Atlantic Water at the same site. Stage V individuals of *C.hyperboreus* were also variable with the highest level, in this case at Ice Station 3, nearly four times the lowest level, in this case in Spitzbergen Shelf Water in Kongsfjorden which in turn was one third that in Transformed Atlantic Water at the same site. With the exception of Ice Station 3, the levels of lipid were quite similar in females and stage Vs of *C. finmarchicus* and *C. glacialis*. However, lipid levels in female *C. hyperboreus* were consistently higher than in stage V of the species. The highest levels of lipid in females of both *C. glacialis* and *C. hyperboreus* occurred in Kongsfjorden in both water masses.

Wax esters accounted for circa 75-90% of the total lipid in all cases in all three *Calanus* species, triacylglycerols accounted for 5-10% of the total lipid and phospholipids accounted for the remainder.

C.borealis sampled at Ice Station 3 had 1.4 times the total lipid of ostracods sampled at Ice Station 2 (Table 2). Circa 50% of deposited lipid was triacylglycerols (TAG) with 20% being sequestered as wax esters with polar lipids accounting for the

majority of the remaining lipid. While not statistically significant, deposition of TAG in the Ice Station 3 ostracods was greater than those sampled at Ice Station 2.

S.magnus were only sampled at the Ice Station 3 (Table 2). The copepods had 0.25mg of lipid per individual which was dominated by both TAG and wax esters equally accounting for circa 40% of the total lipid.

The mass of lipid in the particulates in the water column at the three ice stations is approximately 0.2 mg/l., regardless of depth or site. The total lipid from particulates in the water column collected at Ice Station 1 and 2 consisted mostly of polar lipid with substantial amounts of wax esters (~24%), TAG (~11%) and free fatty acids/fatty alcohols (~12%) (Table 3). Ice Station 3 has a greater proportion of TAG (30%) and correspondingly less wax esters (WE) (12%), but has similar levels of FFalc/FFA to the other stations. Since the particulate fractions were stored under the same conditions as the other samples and because the other specimens contained only low levels of free fatty acids; the levels of free fatty acids/alcohols in the particulates to be real and not a storage artefact.

B. Fatty Alcohol Compositions of Wax Esters.

The percentage compositions of the fatty alcohols in the wax esters of *C. finmarchicus*, *C. glacialis* and *C. hyperboreus* are presented, respectively on Tables 4 a, b and c. Each *Calanus* spp. has a different mean ratio of 22:1 / 20:1 fatty alcohols:

Species	22:1s / 20:1s
C. finmarchicus	0.88
C. glacialis	0.80
C. hyperboreus	1.74

However, considerable variation occurred between individual values in a given species (Table 4 a, b and c), especially in *C. glacialis* (Table 4 b) where one sample taken from Transformed Atlantic Water in Kongsfjorden was clearly deviant from the rest. Multivariate Analysis of Variance (MANOVA) of 22:1(n-11), 20:1(n-9) and 16:1(n-7) fatty alcohols, assessed as discrete components, rejected the null hypothesis that the fatty

alcohol compositions of the three species were not different ($p<0.05$). Further statistical analyses were carried out to determine whether the separation between two congeners was more significant, e.g. *C.hyperboreus* from *C.finmarchicus.* This established that separation of *C.hyperboreus* from *C.finmarchicus* was most significant ($p<0.01$), separation of *C.hyperboreus* from *C.glacialis* was less significant ($p<0.05$), and separation of *C.glacialis* from *C.finmarchicus* was not achieved at $p=0.05$ but trends were observed. Separation of developmental stages, i.e. stage V from female individuals, within the same species, was not achieved with any level of significance.

The trends observed in the percentages of 20:1(n-9) and 22(n-11) fatty alcohols in the wax esters of the UNIS 98 samples were present in the BIODAF 97 samples for both stage V and female copepodids (Table 4 a, b and c). The ratios of 22:1(n-11) / 20:1(n-9) alcohols in the three species were:

Species	22:1s / 20:1s
C. finmarchicus	1.07
C. glacialis	0.69
C. hyperboreus	1.8

In *C. borealis,* the main fatty alcohols, other than *Calanus* biomarkers, are the monounsaturated 16:0 and 14:0 (Table 4d). Fatty alcohol composition of the wax esters of *C. borealis* presents a profile rich in *Calanus* derived C22:1 and 20:1. The ostracod was sampled at Ice stations 2 and 3, and further analysis of the spatially separate fatty alcohols in the WE indicates that there are distinctly different ratios (0.66, Ice Station 2; 1.42 Ice Station 3). At Ice Station 2, the C20:1/C22:1 ratio of *Calanus glacialis* females and Stage V are 0.77 and 0.52, respectively. Female and Stage V, *C. hyperboreus* sampled at Ice Station 3 display a C20:1/C22:1 ratio of 1.30 and 1.4, respectively. Thus, *Calanus*-contribution to the diet at Ice Station 2 is dominated by *C. glacialis* derived material and *C.hyperboreus* at Ice Station 3, based on the ratios described above. C24:1 is also present, albeit in low amounts.

Contrasting with the fatty alcohols in the *Calanus* copepods, in the copepod *S. magnus,* 16:0 is the dominant fatty alcohol in the wax esters (Table 4d). 18:1(n-7) is also

contributes circa 10% of the mass. *S. magnus* was only sampled at Ice Station 3, and ratio of *Calanus* fatty alcohols (20:1s/22:1s) is 1.42, which matches the ratio observed in the *C. borealis* at the same station.

C. Fatty Acid Compositions of the Wax Esters.

The fatty acids in the wax esters of the three *Calanus* species are very variable. Such variability is to be expected since the fatty acids in wax esters are known to be derived mainly from dietary fatty acids and it is highly likely that the different species sampled at different sites with different bodies of water will have different dietary inputs, thus reflecting different phytoplanktonic profiles at the different sites. We were conscious, moreover, that some dietary fatty acids can be readily metabolised by copepods, whether by chain elongation or chain shortening, e.g. 14:0 to 16:0 to 18:0 and *vice versa*, and that such metabolic conversions will inevitably complicate interpretation.

The diatom markers, 20:5(n-3) and 16:1(n-7) (Kates and Volcani, 1966) assessed as discrete components, were normally distributed. An F-Test for these fatty acids determined that their variances were not different in *C.finmarchicus*, *C.glacialis* and *C.hyperboreus,* thus allowing a Generalised Linear Model with an Analysis of Variance output to be applied. There were significant differences in both the allocations of 16:1(n-7) and 20:5(n-3) in the three species and there were differences between the UNIS sites. The flagellate markers, 22:6(n-3) and 18:4(n-3) (Sargent *et al.,* 1987; Graeve *et al*., 1994ab; Sargent *et al*, 1995), were neither normally distributed (post-transformation) nor were variances equal, therefore they could not be subject to parametric tests and statistical inferences cannot be made. But the differences observed are now pursued further by considering Tables 5 a, b and c.

The main impression from fatty acid compositional data for the wax esters of the three species (Tables 5 a, b and c) is the variation between samples. However, several trends are clear. First, fatty acids indicative of diatoms, i.e. 16:1(n-7) and 20:5(n-3), are generally present in higher concentrations than fatty acids indicative of flagellates, i.e. 18:4(n-3) and 20:5(n-3), for all three species. However, the flagellate fatty acids appear to be generally more abundant in *C. hyperboreus* than in the other two species. Second, although there are quite notable differences between stage Vs and females, e.g. in their

percentages of 16:1n-7 and 20:5(n-3), it is difficult to discern meaningful trends. In some samples 16:1n-7 is higher in stage Vs than in females while in other samples 16:1(n-7) is lower in stage Vs than in females. The same applies to 20:5(n-3). However, variations between stage Vs and females seem to be less marked in *C. hyperboreus* than in the other two species. Third, inter site variation for a given species can be marked. Thus, 16:1(n-7) and C16 PUFA are more prominent in *C. finmarchicus* females from Ice Station 1 in water of Barents Sea Origin than from Spitzbergen Shelf Water in Kongsfjorden, while the converse holds for 18:4(n-3). The same holds for female *C. glacialis* between these sites. *C. hyperboreus* from Ice Station 2, both stage Vs and females, has notably higher levels of 18:4(n-3) and 22:6(n-3) and correspondingly lower levels of 16:1(n-7) and C16 PUFA than *C. hyperboreus* from Ice Station 3. Flagellate markers are also more prominent than diatom markers in *C. hyperboreus* in Spitzbergen Shelf Water in Kongsfjorden than in *C. hyperboreus* in Transformed Atlantic Water in the fjord, and the converse holds for diatom markers. Fourth, it is generally the case that 20:1(n-9) is present in higher percentages than 22:1(n-11) in all three species including *C. hyperboreus*, i.e. the species – specificity established earlier for the ratio of 22:1(n-11) / 20:1(n-9) in the fatty alcohols of wax esters does not hold for the corresponding fatty acids. These trends notwithstanding, the impression remains from Tables 5 a, b and c of the complexity of the data and the extensive variation between samples.

In general, the trends seen in the fatty acid compositions of the wax esters in the samples from UNIS 98 were reproduced in the BIODAF 97 samples. Thus, the diatom markers 16:1(n-7), C16 PUFA and 20:5(n-3) were well represented in the three species and more so than the flagellate markers, 18:4(n-3) and 22:6(n-3) (Table 5 a, b and c). It is interesting that C16 PUFA and including 16:4(n-1) are more abundant in *C. hyperboreus* than the other two species. Differences between stage Vs and females are less marked in BIODAF 97 than in UNIS 98. The ratios observed for 22:1(n-11) / 20:1(n-9) in the fatty alcohols of the wax esters of the three species are not reflected in the corresponding fatty acids where 20:1(n-9) consistently exceeds 22:1(n-11).

Overall, the WE fatty acids of *C.borealis* match the profile of the fatty alcohols in terms of the relatively high percentage mass of the *Calanus* derived moieties (Table 5d). Dietary flagellate and diatom fatty acids are present in high amounts, especially 16:1(n-7)

and 20:5(n-3). Equally important is 18:1(n-9) which does not correspond with the WE fatty alcohol profile. Ostracods at both sites exhibit a high percentage of 18:1(n-9). At Ice Station 3, there is a higher sequestration of diatom derived fatty acids than found in ostracods at Ice Station 2. While at Ice Station 2, ostracods have slightly more percentage contribution from dinoflagellate markers (18:4(n-3) and 22:6(n-3)).

WE fatty acids in the *S.magnus* copepod are dominated by 16:1(n-7), but there are notably high levels of 18:1(n-9) (Table 5d). This is not reflected in the fatty alcohols of the wax esters. Contrastingly C16:0, very low in the WE fatty acids, but constitutes 25% of the WE fatty alcohols (Table 4d). There is a small contribution from the *Calanus* linked moieties. *S. magnus* were only sampled at Ice Station 3 preventing inter site comparison. The ice was open at Ice Station 3 and dinoflagellates and diatoms were identified. The presence of both types of phytoplankton are reflected in the fatty acid profile, but the percentage mass of diatom markers, e.g. 20:5(n-3), is greater than the dinoflagellate markers.

D. Fatty Acid composition of the TAG

Fatty acid analyses of the triacylglycerols in the three *Calanus* species are presented in Tables 6 a, b and c. Though less extensive than the analyses of fatty acids in wax esters, the triacyglycerol analyses reveal interesting findings, most notably that there can be marked differences between the fatty acids of the two lipids. Thus, *C. finmarchicus* stage Vs and females at Ice Station 1 had low levels of the flagellate markers 18:4(n-3) and 22:6(n-3) in their wax ester fatty acids (Table 5a), but quite high levels in their triacylglycerols (Table 6a). Conversely, 18:4(n-3) accounted for circa 15% of the fatty acids in the wax esters of stage V *C.hyperboreus* in Spitsbergen Shelf Water in Kongsfjorden (Table 5c) but only 3% 18:4(n-3) was registered in its triacylglycerols (Table 6c). Levels of 16:1(n-7) and 18:4(n-3) were, respectively, low and high in wax esters of stage V *C. hyperboreus* from Ice Station 2 (Table 5c), whereas 16:1(n-7) and 18:4(n-3) were, respectively, higher and lower in the triacylglycerols (Table 6c). Thus, some degree of "reciprocity" between wax esters and triacylglycerols seems to exist in that, if one lipid is rich in particular markers, the other may be deficient in that marker. A further difference between the two lipids was that, whereas 18:4(n-3) was consistently

presented in higher percentages than 22:6(n-3) in the wax esters of the samples, the converse was often the case in the triacylglycerols.

The greatest contribution to *C. borealis* TAG is 16:1(n-7) followed by 18:1(n-9) (Table 6d). There is little variability between the two stations, apart from a slightly higher contribution of diatom derived fatty acids at Ice Station 3 contrasted with slightly increased dinoflagellate fatty acids at Ice Station 2. Of note in the TAG is the small contribution of *Calanus* 20:1s and 22:1s.

TAG is indicative of recent feeding and the fatty acid profile of *S. magnus* reflects a diatom diet with highest proportions of C16 dominated by 16:1(n-7) relative to 16:0. *Calanus* derived moieties are present in the profile accounting for approximately 11% of the composition of TAG. There is, however, almost double the amount of 18:1(n-9), compared to 20:1(n-9), and similar levels of 18:1(n-7).

E. Fatty acid composition of the Total Lipid of particulate-based material.

Despite particulate samples being taken various depths there were no overt differences in the proportions of fatty acids and alcohols within the sites. Therefore results were pooled into one output for each station. At Ice Station 1, the total lipid of the particulates contained 16:0 (22.7%) as the major fatty acid, followed by 18:1*n*-9 (19.3 % of the total) (Table 7). Relatively high levels of 18:0 (9.7%) and 18:2n-6 (6%) were also present. The other PUFAs present were 22:6n-3 (3.8%) and 20:5n-3 (3%), with lesser amounts of C18 and C16 PUFA. Both 20:1n-9 and 22:1n-11 were present, albeit in small amounts. The profile and mass percentages of the fatty acids of the total lipid at Ice Station 2 is very similar. However, at Ice station 3, total lipid fatty acids are dominated by diatom fatty acids with smaller proportions of the flagellate markers, but greater percentage mass than seen at Ice Station 1 and 2. At all three stations, the contribution of the *Calanus* markers are relatively low in the total lipid, but in the WE lipid class, the 20:1 and 22:1 fatty alcohols form circa 50% of the percentage mass, with monounsaturated fatty acids 14:0, 16:0 and 18:0 providing circa 25%.

Discussion

The Arctic is a highly variable ecosystem, and the two field surveys allowed the opportunity to investigate zooplankton communities at spatially separate stations experiencing different phytoplankton production phases with different ice-habitat conditions. Kongsfjorden is an Arctic fjord – at the time of sampling during both field seasons the annual peak of phytoplankton production had passed and the fjord was relatively clear of ice. Ice station 1, on the MIZ north-east of Svalbard, was formed of a mix of young multi-year ice (MY) and first year ice (FY) – the ice had just opened and diatoms were blooming. Ice Station 2, north of Svalbard, was composed of young, thick (2.5m) MY ice with some elements of FY ice. The ice at Ice Station 2 was melting at the time of sampling, and both phytoplankton and ice algae were present in low amounts. While Ice Station 3, in the Fram Strait, was composed of old MY ice with some younger MY ice and phytoplankton and ice algae were present and blooming.

The lipid of *Calanus* spp. has been well studied (Lee *et al.,* 1971; Sargent and Henderson, 1986; Sargent and Falk-Petersen, 1988; Hagen and Schnack-Schiel, 1996). As important members of the zooplankton community in terms of abundance and as a vehicle of biosynthetically valuable and high energy fatty acids, it is useful to explore changes in their lipid composition and use these to elucidate the diet and ecology of other organisms. The three most abundant *Calanus* copepods in the Arctic store wax esters (WE) as their primary lipid depot (these results and others e.g. Lee, 1974, 1975; Sargent and Henderson, 1986; Sargent *et al.,* 1987). This is indicative of a seasonal feeding pattern, where high amounts of lipid are stored during phytoplankton production periods, followed by diapause during winter months and subsequent use of the lipid reserves to fuel metabolism and egg production (Conover and Huntley, 1991; Hirche, 1996; Hagen, 1999).

The levels of total lipid in the *Calanus* species collected during the UNIS 98 expedition are more lipid rich than those collected on the BIODAF survey, but the patterns of lipid deposition are essentially the same. Thus, stage V and female *C. finmarchicus* have similar levels of lipids, essentially the same at all sites studied, at both the fjord and the Ice Stations, with the exception of stage Vs at Ice Station 3 where the animals appear to be unusually lipid – rich. Interestingly, the yield of lipid from stage V *C.finmarchicus* at all sites, except Ice Station 3, is equivalent to that in *C. finmarchicus*

sampled in spring in the Fladen Ground in the North Sea (Kattner and Krause, 1989), whereas stage V *C.finmarchicus* at Ice Station 3 yielded three times the amount of lipid at other sites. Currents in the region of Ice Station 3, notably the Return Atlantic Current, are likely to be responsible for importing the north Atlantic *C. finmarchicus* into the Fram Strait, where evidently it thrives, reflecting the high productivity, or lack of competition for food, in regions of the MIZ. Indeed, Hirche *et al,* (1991, 1994) reported that there were low zooplankton stocks in the Northeast Water Polynya (NEW) in the Greenland Sea and a significant proportion of the primary production is advected out of the system or settles to the benthos ungrazed. Levels of lipid are also very similar in both stage V and female *C. glacialis* except the copepods in Spitzbergen Shelf Water in Kongsfjorden being the most lipid rich and, presumably, thriving most. This may reflect this Arctic shelf species being in its most favourable natural environment. In contrast, females of *C. hyperboreus* are clearly more lipid rich than stage Vs, with females in Spitzbergen Shelf Water and Transformed Atlantic Water in Kongsfjorden being most lipid – rich.

Care should be exercised in comparing the different stages and species simply in terms of their lipid levels, for various reasons. Thus, the main phytoplankton production period had passed in Kongsfjorden at the sampling time when copepods were gearing towards overwintering and were, accordingly, lipid-rich. In contrast, at Ice Station 1 and especially Ice Station 3, the ice had recently opened with a consequent abundance of phytoplankton, and copepods were taking advantage of the seasonal phytoplankton production as indicated by a wide range of copepodite stages from CI to females (data not shown). Ice Station 2 showed characteristics more directly attributable to a dominance of Transformed Atlantic Water resulting in an abundance of *C.finmarchicus* imported from the northern shelf Atlantic and a relative paucity of *C.hyperboreus* at this deep water site, and the amount of phytoplankton in the water column was low. This illustrates that the different species sampled at the different sites even within the same ecosystem are very unlikely to experience the same concentrations or species compositions of phytoplankton and their amounts of lipid are related to their feeding history.

Nor are the three species necessarily at strictly equivalent stages of development. Thus, variations in the level of lipid in stage V copepodites can partly be explained by whether early or late stage Vs were sampled for analyses, the relative abundance of these

depending on the timing of phytoplankton blooms. The same consideration applies even more so to female copepods, where the situation is further complicated by the fecundity of the species and its iteroparity. Thus, *C.hyperboreus* can live to procreate a second year (Conover and Siferd, 1993) so that females of the species are likely to vary substantially in their lipid content. In addition, Conover and Siferd (1993) observed females of various sizes in the species and proposed that the largest females moulted too late in the spring to produce eggs and consequently fattened all summer in preparation for spawning in mid-winter. Similar considerations hold for *C. glacialis* in the White Sea in that Kosobokova (1999) has shown that the copepod may also spawn in its second year. Thus, there may be two components to the lipid biology of *C. glacialis* related to the species' life history. Hirche and Kattner (1993) propose that a population of *C. glacialis* may consist of overwintering two year old females, dependant on lipid stores for egg production, and one-year-old females derived from overwintering stage Vs that depend on existing food for egg production. *C.finmarchicus* may produce several egg clutches during a single breeding season and, since lipid is extensively used in the production of eggs, the extent to which the female has developed and produced eggs will influence its amount and type of lipid. Variation in the amount of total lipid in females of *C.hyperboreus* and *C.glacialis* was greater than that observed in *C.finmarchicus* females here, so that mixed cohorts of animals at different ontogenetic stages of development could have been sampled.

These considerations aside, while variations are observed in the levels of lipid at the ice stations, the ice habitat with older, multi-year ice is linked with higher amount of lipid in the resident organisms, especially in the *C. hyperboreus* and *C. finmarchicus* stage Vs, where inferences are not clouded by whether or not reproductive use of lipid deposits has occurred.

S. magnus has comparable lipid levels to *C.finmarchicus* matching its cosmopolitan distribution, like *C.finmarchicus* this species is likely at the edge of its distribution in the Arctic. The ostracods' lipid levels were again comparable with *C.finmarchicus,* however, at the blooming, old MYI Ice Station 3 site the lipid deposition was greater. *C. borealis* stores mainly TAG and *S. magnus* has both TAG and WE equally contributing. Thus it appears that both species feed year-round (similar to TAG

rich *Calanus propinquus* -- Schnack-Schiel *et al.*, 1991), but *S. magnus* with its lipid stores equally distributed between WE and TAG appears more opportunistic in its feeding habitat, with the benefits of the more highly energy-valuable WE potentially allowing it to cope with periods of food shortage in the variable Arctic ecosystem. To illuminate their diet, it again behoves us to first look at the *Calanus* spp., this time the fatty alcohol profiles.

The discrimination of the three *Calanus* species in terms of the ratios of 22:1(n-11) / 20:1(n-9) fatty alcohols in their wax esters is statistically significant. Such discrimination was statistically significant based on MANOVA in the UNIS 98 samples, especially for *Calanus hyperboreus.* The ratios of 22:1(n-11) / 20:1(n-9) fatty alcohols for the three species were 0.88, 0.80 and 1.74 for *C. finmarchicus*, *C. glacialis* and *C. hyperboreus*, respectively. The ratios for the species from BIODAF were 1.07, 0.69 and 1.80, respectively. Clearly there is variation in the ratio for a given species but, equally clearly, the three species have different ratio trends of these fatty alcohols, i.e. the ratio is species – specific and, therefore, possibly genetically determined. Similar differences in the levels of 20:1(n-9) and 22:1(n-11) in copepod wax esters as found here have been reported in the literature (Sargent and Henderson, 1986; Kattner and Hagen, 1995; Albers *et al.,* 1996).

On a unit mass basis, a longer chain fatty alcohol (or fatty acid) has a higher energy content than a shorter chain fatty alcohol (or fatty acid), i.e. 1g of a long chain alcohol (or acid) has a higher energy content than 1g of a short chain alcohol (or acid). The most effective means of accumulating high energy lipid reserves is to form long chain fatty alcohols and fatty acids (Kattner and Hagen, 1995; Albers *et al.,* 1996). Thus the high Arctic *C.hyperboreus*, with greater synthesis and deposition of the longest fatty alcohols in its main lipid reserve is the most valuable prey item on an individual basis.

The fatty alcohols in the wax ester components of the lipid of *C.borealis* and *S. magnus* show conclusively the presence of the *Calanus* C20:1 and C22:1 biomarkers. The ratios of the fatty alcohols in their wax esters also point to a diet dominated by *C. glacialis* at Ice Station 2 and *C. hyperboreus* at Ice Station 3, in both species.

So both species obtain *Calanus* dietary material, which given that they likely feed during the winter months, as indicated by TAG reserves, is reasonable since they need to consume material other than seasonally available phytoplankton.

The profiles of fatty alcohols of the WE esters of the two species indicate different levels of dependence on *Calanus* material. *S. magnus* also has strikingly high 16:0, followed by 16:1(n-7) and 18:1(n-7) – biomarkers of diatom consumption. Whilst *C. borealis'* WE Falc profile is dominated by the *Calanus* C20:1 and C22:1 WE Falcs. There is yet, no evidence that any organisms other than *Calanus* spp. synthesise these long chain fatty acids and alcohols *de novo* (Sargent and Henderson, 1986; Sargent and Falk-Petersen, 1988). Thus *C. borealis* potentially gets the majority of its wax ester fatty alcohols from *Calanus* copepod material, while *S. magnus* is consuming more diatoms.

It is necessary to look to the fatty acids of both WE and TAG in the studied species to determine other components of their diets.

Site specific differences in the fatty acid composition, statistically significant in the Generalised Linear Model of 16:1(n-7) and 20:5(n-3), were evident in the three *Calanus* species. The highest percentages of fatty acids linked to diatoms were found at Ice Station 1 and 3, which correlates well with the observed increase in primary production at the two MIZ sites. However, flagellates appeared to be more important as a food item at Kongsfjorden and Ice Station 2, where the seasonal diatom bloom had passed allowing succession of flagellates. C16 PUFA are associated with diatoms, especially with the assemblage forming diatom *Melosira arctica* which grows under the ice in the MIZ and is characterised by high amounts of 16:4(n-1) in its polar lipid (Falk-Petersen *et al.,* 1998). Notable percentages of 16:4(n-1) were found in the wax esters of *C. finmarchicus* at the MIZ sites Ice Stations 2 and 3, whereas in the Barents Sea Water at Ice Station 1 the species had negligible levels of 16:4(n-1) in its wax esters. However, at Ice Station 1 *C. finmarchicus* had 3% 16:4(n-1) in its triacylglycerols. Hakanson (1984) proposed that triacylglycerols were an indicator of recent feeding in copepods, whereas wax esters were an indicator of feeding over a longer period exceeding a week. Thus, a snapshot is provided of *C.finmarchicus* feeding on diatoms rich in C16 PUFA at Ice Stations 1 and 3 where phytoplankton production had just started. *C. glacialis* and *C.*

hyperboreus, which are more characteristic inhabitants of the high Arctic than *C. finmarchicus*, generally had similar percentages of 16:4(n-1) in their wax ester reserves, even when present in Kongsfjorden, with the percentages of 16:4(n-1) in their triacylglycerols being more variable. This is consistent with *C.glacialis* and *C.hyperboreus* in Kongsfjorden being expatriates in the fjord from the shelf waters of the Arctic and the Greenland Sea, which are rich in *Melosira* assemblages. Differences between triacylglycerols and wax esters are also shown by *C. hyperboreus* in Kongsfjorden where the copepod had 15% and 3% 18:4(n-3), respectively, in its wax esters and triacylglycerols. Evidently the species had fed on flagellates extensively at some point before sampling, but flagellates were less important in its diet immediately prior to sampling. Thus, the fatty acid composition of copepod wax esters and TAG can be related to the conditions at the site where it is sampled. However, the extent of that relationship depends on how long the animals have been present at that site and how long they have existed at other site(s) from where they have been subsequently advected by ocean currents into the area where they are finally sampled. Considerations of fatty acid compositions of wax esters and triacylglycerols can help to illuminate the copepods' shorter and longer term dietary history at individual sites but, even so, the overall picture is one of much variation.

Despite the considerable variation in the fatty acid analytical data for neutral lipids, it is clear that the copepods sampled from both expeditions have derived much more of the fatty acids in these lipids from diatoms than flagellates. Thus, only some 9% of the fatty acid composition of wax esters consisted of flagellate markers in female *C.finmarchicus* and *C.glacialis* although 18% was observed in *C.hyperboreus* (UNIS 98). In stage V copepodites the percentage of flagellate markers in *C.finmarchicus* and *C.glacialis* ranged between 2 and 10% in the wax esters, while in stage V *C.hyperboreus* they ranged between 7-26%. Higher levels of flagellate markers in the wax ester reserve in *C.finmarchicus* have been reported in the literature (Kattner and Krause, 1987; Kattner and Hagen; 1995; Albers *et al.,* 1996) but flagellate markers in wax esters in *C.glacialis* have been notably low (Tande and Henderson, 1988; Kattner and Hagen, 1995; Albers *et al.,* 1996). One factor underlying this species difference is that *Calanus* copepods have been shown to feed selectively. Thus, Mullin (1965) states that *Calanus* prefers large

phytoplankton cells, such as spiny diatoms like *Chaetoceros* or dinoflagellates like *Ceratium.* Meyer-Harms *et al.* (1999) studied selective feeding in *C.finmarchicus* and showed that the copepod fed on diatoms during the spring bloom, but switched to feeding on dinoflagellates before and after the spring bloom. This switch was linked to a combination of factors such as algal cell size, food quality, and abundance and motility of the prey. If *C. finmarchicus* preferentially adopts the feeding-current approach described by Meyer-Harms *et al.* (1999) and prefers to consume bloom diatoms in a relatively sedentary manner, it is inevitable that diatom biomarkers will dominate its fatty acid composition. However, Sargent and Falk-Petersen (1988) reported that the haptophycean *Phaeocystis pouchetti* could be a major food item of *C.finmarchicus* in northern Norwegian fjords. Information on selective feeding in the other species is scant. Graeve *et al.* (1994b) monitoring diet-induced changes in *C.glacialis*, found evidence that the copepod may not feed extensively on dinoflagellates, but flagellate markers, both 18:4(n-3) and 22:6(n-3), were found in the present study. C.*hyperboreus* is generally considered to produce lipid - rich nauplii, primed to take advantage of the seasonal phytoplankton bloom. Higher levels of 18:4(n-3) and 22:6(n-3) fatty acids in this species may reflect its preferentially consuming organic-rich flagellates in a water column with a low abundance of phytoplankton prior to the seasonal diatom bloom. These factors apart, it remains the case that the copepods in the present study had wax esters dominated by diatom rather than flagellate biomarkers. However, this must be offset against the fact that the flagellate biomarker 22:6(n-3) dominates in the phospholipids of the copepods (Scott *et al.,* 2002a).

As stated previously, TAG is the main depot in *C. borealis.* Diatoms, as indicated by the high percentage of 16:1(n-7) in the lipid class, are important dietary items. There is some evidence, albeit not statistically speaking, that dinoflagellate fatty acids, 18:4(n-3) and 22:6(n-3), are more important at Ice Station 2 than at Ice Station 3, reflecting the observations for the *Calanus* copepods feeding patterns. *Calanus* biomarkers are notably low in the *C.borealis* TAG reserve, indicating a recent decline in feeding on *Calanus* derived material. In *C. borealis*, TAG sampled at both sites, there are high amounts of 16:0 and 18:1(n-9). The latter fatty acid is often linked with omnivorous/carnivorous diet (Falk-Petersen et al. 1987; Graeve et al. 1994a). Furthermore a high 18:1(n-9)/18:1(n-7)

ratio can indicate a carnivorous habit (e.g. Auel *et al*., 2002), albeit with consideration of other biomarkers (Dalsgaard *et al.,* 2003). This ratio is present in both the main TAG depot and the lesser WE depot. It is of interest to identify the source of the 18:1(n-9). While *de novo* desaturation in *C. borealis* of 18:0 to 18:1(n-9) is a possibility, similar high amounts are observed in the WE fatty acids but are not present in the corresponding WE falcs in *C. borealis* thus increasing the likelihood of a dietary source. In the *Calanus* copepods sampled during UNIS and BIODAF, 18:1(n-9) occurs only in low amounts, so they are likely not the source. Other copepods can have high levels (Albers *et al*., 1996; Kattner *et al*., 2003; Lee, 1974) and, while scarce, the fatty acid occurs in phytoplankton, which may supply the fatty acid when consumed.

However, halocyprid ostracods are thought to be detrital feeders (Vannier *et al.,* 1998). 18:1(n-9) is a stable energy yielding fatty acid which can be persistent in particulate material (Scott *et al*., 2002b). Faecal material can be rich in 18:1(n-9) (Mayzaud *et al*., 2007). Matching the *C. borealis* fatty acid profiles, the analyses of the total lipid (TL) of the particulates reveal Ice Station 1 and 2 to be rich in both 16:0 and 18:1(n-9). Analyses of Ice Station 3 particulates are a little different reflecting the input of relatively undegraded diatom material further down in the water column (as a result of the bloom overhead), C16:0 is a significant high proportion of the fatty acid profile but 18:1(n-9) is somewhat lower than observed at the two other stations. But as a detritus feeder, the analysed particulate material with the high percentage of 16:0 and 18:1(n-9), could be a food source for *C. borealis*. However, it appears that these particulates may not be the sole source of dietary fatty acids and alcohols in *C. borealis.* The fatty alcohols in the wax ester reserve (20% of the total lipid) of the ostracod show C20:C22 ratios which are in accordance with the ratios of *C. glacialis* at Ice Station 2 and *C. hyperboreus* at Ice Station 3, but not in accordance with the ratio of the WE fatty alcohols in the particulate material. The particulates sampled during UNIS actually consists of mixed material likely have phytoplankton cells, faecal material and body parts (whole organisms and identifiable body parts were removed prior to lipid analysis as they were thought to skew the results).

Combining the added information from the wax esters with the TAG inferences, it appears that *C. borealis* is actively taking *Calanus* material, this does not, however, tell

us the material being consumed are live organisms or relatively undecomposed body parts in the particulates. But, based on knowledge of halocyprid feeding, a picture is painted of a detritus feeder consuming well-preserved material.

S. magnus tells a different story. Interestingly, the copepod has equal amounts of TAG and WE lipid storage. *S. magnus* was sampled at Ice Station 3 and the copepod has the same WE C20:C22 fatty alcohol ratio as *C. borealis* at the station, indicating consumption of *C.hyperboreus.* But overall the profile of fatty alcohols of the wax esters differ from the sampled *Calanus* copepods' WE profiles. *S. magnus* has WE fatty alcohols of 25% 16:0 and 10% 18:1(n-7), which incidentally, are not reflected in its WE fatty acids. This implies that *S. magnus* converts the 16:0 fatty acid into the fatty alcohol, similar to *Metridia gerlachei* and *M. longa* (Hagen and Auel, 2001). The WE fatty acids have significant proportions of 18:1(n-9), which may be of detrital origin, but are more difficult to link to the TL fatty acids of the particulates as consumed 16:0 fatty acids are possibly converted into WE fatty alcohols. The ratio of 18:1(n-9) with 18:1(n-7) in the WE fatty acids indicates carnivorous feeding, but this is somewhat offset by the presence of high proportions of 16:1(n-7) and 20:5(n-3), diatom markers. Additionally, its TAG, indicative of recent feeding (Hakanson, 1984; Miller *et al*., 1998), is also dominated by 16:1(n-7), a fatty acid which can be elongated to 18:1(n-7), and possibly reduced to the alcohol in the WE. Adding credence to the observation that *S. magnus* is omnivorous its TAG 18:1(n-9)/18:1(n-7) ratio is low. As a cosmopolitan, expatriate into the Arctic system and with the ability to depot wax esters, *S. magnus* appears to be better adapted to survive in the Arctic system than *C. borealis*. But while it stores lipid, this copepod which can be as large as *C. hyperboreus* has lipid levels comparable to *C. finmarchicus* and, is not – by definition – lipid rich. In contrast, *C. borealis* may be able to subsist on detrital material, of high quality and quantity, which may be persist over longer periods than the phytoplankton production period (Scott *et al*., 2002b). Thus we have two different life strategies, of two different species, both of which consume *Calanus* derived material. These strategies allow different degrees of success in the Arctic system. *C. borealis* is the more abundant species (Mumm *et al*., 1993) and *S. magnus'* success is evidenced by local increased abundance, rather than overall high abundance. Increased abundance of *S. magnus* is observed in the Central Arctic, deep-water Amundsen and

Makarov Basins (Mumm *et al*., 1998) – where older aged ice floes are more likely, and the copepod was only sampled at the site with the older MY ice during UNIS. Most organisms sampled in the regions with the older MY ice, prior to spending reserves on reproduction, are generally more lipid rich. Thus indicating that these older MY sites, are the more productive habitats and potentially these older, 'colder' habitats retain and sustain better quality non-living material over time.

Finally, it should be noted that interpretation of fatty acid analytical data in terms of biomarkers, as has been attempted here, is not without limitations. It is obviously important to study all of the lipid classes in the whole animal, whether in specific lipid classes, as has been done here, or in total lipid analyses, as has been done in numerous other studies. A more fundamental limitation is that the level of a particular fatty acid in an animal is determined not only by its rate of input into the animal but also by its rate of catabolism by the animal which can be extensive. Thus, 18:5(n-3), which is relatively abundant in dinoflagellates and haptophyceans, is now known to be readily and rapidly oxidised by fish cells (Ghioni, *et al.,* 2001) and presumably also by zooplankton cells, accounting for its absence from trophic levels higher than phytoplankton. 18:5(n-3) was not detected in any of the zooplankton samples analysed here. In contrast, there is every reason to believe that 22:6(n-3) is relatively conserved in marine animal lipids, due not least to the complexity of its specialised catabolic pathway. Thus, it cannot be stated confidently that a higher percentage of a specific fatty acid biomarker indicates that an animal prefers or consumes more of a prey item containing that specific biomarker unless rates of turnover and biosynthetic incorporation and modification of that fatty acid are fully understood. But this has yet to be achieved with any biomarker. Thus, the conclusions here can only be approximate, though helpful, indicators of trophic interactions. They are in essence qualitative rather than quantitative indicators.

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Table 1 Position, weather and depth for the different sampling stations.

Station	Position	Water bodies	Depth (m)	Wind (m/s)
Kongsfjorden	78°58´N 11°52´E	Svalbard Shelf Water (SSW)	Surface-200	05
		Transformed Atlantic Water (TAW)	200-350	
Ice station 1	81°30´N 29°16´E	Barents Sea Origin (BSO)	Surface-160	12
		Transformed Atlantic Water (TAW)	160-270	
Ice station 2*	80°54´N 04°64´E	Transformed Atlantic Water (TAW)	Surface-350	00
Ice station 2**	80°55´N 15°04´E	Transformed Atlantic Water (TAW)	Surface-350	00
Ice station 3	80°13´N 00°15´W	Polar Water (PW) – possible influx of Return Atlantic Water	Surface-350	00

* day one ** day two

Table 2. Yield of total lipid (mg/individual) from developmental stages of *Calanus* copepods and zooplankton in Kongsfjorden (BIODAF and UNIS) with Ice Station 1, 2 and 3 (UNIS).

Data are a minimum of means of 3 pooled samples of zooplankton (10 individuals per sample)

	stage	Kongsfjorden (BIODAF)	Kongsfjorden (UNIS)		Ice Station 1		Ice Station 2	Ice Station 3
Water mass		Mix SSW and TAW	SSW	TAW	BSO	TAW	TAW	PW
C.finmarchicus	Female	0.5 ± 0.04	0.3 ± 0.06	0.2 ± 0.03	0.3 ± 0.20	0.2 ± 0.04	0.3 ± 0.09	0.40 ± 0.09
	Stage V	0.5 ± 0.03	0.2 ± 0.06	0.3 ± 0.04	0.3 ± 0.02	0.2 ± 0.03	0.3 ± 0.06	0.95 ± 0.14
C.glacialis	Female	0.48 ±0.1	1.0 ± 0.16	0.9 ± 0.63	0.7 ± 0.02	0.5 ± 0.02	0.4 ± 0.10	0.60 ± 0.12
	Stage V	0.4 ± 0.02	1.2 ± 0.05	0.7 ± 0.01	0.7 ± 0.01	0.6 ± 0.08	0.4 ± 0.04	0.31 ± 0.00
C.hyperboreus	Female	1.81 ± 0.52	3.3 ± 0.4	3.7 ± 0.2	N/A	N/A	2.1 ± 0.51	2.66 ± 1.04
	Stage V	1.24 ± 0.94	0.5 ± 0.16	1.5 ± 0.54	N/A	N/A	0.9 ± 0.07	1.89 ± 0.49
C.borealis	Indet						0.19±0.06	0.27± 0.01
S.magnus	Indet							0.25±0.08

Table 3. Lipid classes of the particulate material (UNIS data set).

	Ice Station 1	Ice Station 2	Ice Station 3
LIPID CLASSES			
Polar	45.0±6.2	47.0±21.4	40.4±5.6
DAG/pigm.	2.8±2.2	3.2±2.6	2.1±0.4
Sterols	3.7±1.5	3.6±1.7	3.7±0.5
FFAlc/FFA	12.7±3.8	12.0±4.0	11.6±3.4
TAG	11.2±2.0	11.5±2.2	29.8±8.7
Wax / Steryl Esters	24.9±7.0	23.3±7.0	12.3±2.1

Table 4a. Fatty Alcohol Compositions (Mass %) of Wax Esters in *Calanus finmarchicus* from Kongsfjorden and the MIZ North of Svalbard (BIODAF and UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	BIODAF		UNIS		UNIS		UNIS		UNIS		UNIS		UNIS
	Kongsfjjorden		**Kongsfjorden**		**Kongsfjorden**		**Ice Station 1**		**Ice Station 1**		**Ice Station 2**		**Ice Station 3**
	Mixed SSW and TAW		**SSW**		**TAW**		**BSO**		**TAW**		**TAW**		**Polar Water**
	Female	**Stage V**	**Female**	**Stage V**	**Female**	**Stage V**	**Female**	**Stage V**	**Female**	**Stage V**	**Female**	**Stage V**	**Stage V**
	n = 14	**n=14**	**n=3**	**N=3**	**n=3**	**n=3**	**n=3**	**n=3**	**n=3**	**n=3**	**n=3**	**n=2**	**n=3**
Fatty Alcohol													
"14:0"	2.1	1.9	1.7	3.5	1.8	2.8	2.6	1.7	1.7	2.4	2.4	2.8	1.3
"16:0"	8.0	8.4	7.0	9.4	7.5	9.7	10.3	6.2	7.7	9.2	8.9	6.3	5.0
"16:1n-7"	6.8	6.2	6.2	3.5	7.5	8.9	10.3	3.4	5.8	8.1	4.7	2.9	1.8
"18:0"	0.5	0.5	0.4	0.7	0.3	0.2	0.3	0.2	0.2	0.3	0.5	0.4	0.0
"18:1n-9"	1.6	2.0	1.9	1.6	1.8	1.3	1.6	2.0	1.7	1.7	1.8	0.7	1.4
"18:1n-7"	2.5	2.2	2.5	1.3	2.5	3.4	3.6	2.0	2.4	2.7	1.9	1.5	1.3
"18:2n-6"	0.5	0.8	0.7	0.7	0.6	0.4	0.4	0.9	0.5	0.7	0.5	0.3	0.6
"20:1n-9"	35.6	35.3	42.4	33.4	40.6	46.5	42.6	41.0	41.3	41.3	43.5	36.9	39.2
"20:1n-7"	2.3	0.7	1.1	0.0	1.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"22:1n-11"	36.5	39.0	35.6	43.9	33.3	23.5	24.6	38.2	34.9	30.5	34.2	46.3	48.2
"24:1 "	0.7	0.7	0.0	0.0	0.0	0.8	2.0	2.6	2.0	1.3	0.4	0.1	0.2

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 4b. Fatty Alcohol Compositions (Mass %) of Wax Esters in *Calanus glacialis* from Kongsfjorden and the MIZ North of Svalbard (BIODAF and UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	BIODAFF		UNIS		UNIS		UNIS		UNIS		UNIS		UNIS	
	Kongsfjorden		Kongsfjorden		Kongsfjorden		Ice Station 1		Ice Station 1		Ice Station 2		Ice Station 3	
	Mixed SSW and TAW		SSW		TAW		TAW		TAW		TAW		Polar Water	
	Females	Stage V	Females	Stage V	Females	Stage V	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V
	N=7	n= 8	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=1	n=2	n=3	n=1
Fatty alcohol														
"14:0"	1.5	2.1	3.1	2.7	2.2	3.9	2.6	2.4	1.8	2.5	2.2	2.3	1.8	2.2
"16:0"	7.7	9.4	10.6	9.5	5.7	9.7	10.7	8.7	6.8	8.5	8.4	8.4	8.9	8.5
"16:1n-7"	3.4	4.2	7.8	8.6	0.7	3.8	7.9	5.0	5.7	5.5	4.8	3.8	4.3	6.4
"18:0"	0.6	0.9	0.7	0.4	0.6	0.6	0.2	0.5	0.2	0.3	0.4	0.6	0.3	0.3
"18:1n-9"	1.4	2.0	1.7	1.7	0.7	1.0	1.4	1.8	2.2	1.2	1.7	1.4	1.3	1.4
"18:1n-7"	2.4	2.0	2.5	2.9	0.6	1.3	2.6	2.0	2.0	2.0	2.0	1.0	2.5	2.0
"18:2n-6"	0.2	0.6	0.7	0.0	0.0	0.5	0.4	0.5	0.8	0.5	0.6	0.6	0.8	0.6
"20:1n-9+"	45.2	41.3	41.7	44.0	31.3	35.4	43.8	46.0	34.0	43.2	44.1	43.6	50.1	44.4
"20:1n-7"	1.9	0.7	0.0	3.7	2.6	0.7	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0
"22:1n-11"	28.4	31.1	30.7	24.6	55.0	41.6	26.4	28.9	43.0	34.6	34.1	23.5	27.1	33.0
"24:1"	0.6	0.7	0.0	0.0	0.0	0.0	2.2	2.8	2.1	0.7	0.6	0.5	1.1	0.2

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 4c. Fatty Alcohol Compositions (Mass %) of Wax Esters in *Calanus hyperboreus* from Kongsfjorden and the MIZ North of Svalbard (BIODAF and UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	BIODAF Kongsfjorden Mixed SSW and TAW		UNIS Kongsfjorden SSW		UNIS Kongsfjorden TAW		UNIS Ice Station 2 TAW		UNIS Ice Station 3 Polar Water	
	n=14 mean	n=14 mean	Females n=1	Stage V n=3	Females n=3	Stage V n=3	Females n=4	Stage V n=3	Females n=4	Stage V n=3
Fatty Alcohol										
"14:0"	2.6	3.3	1.8	4.8	5.2	4.4	2.5	5.7	2.5	11.2
"16:0"	6.5	8.8	5.3	9.3	4.2	9.4	5.3	11.3	7.1	14.8
"16:1n-7"	2.0	3.5	1.2	3.1	2.2	3.6	1.4	2.3	4.6	2.8
"18:0"	0.4	0.7	0.4	0.4	0.4	0.4	0.3	0.6	0.0	0.7
"18:1n-9"	0.4	0.6	0.6	0.5	0.6	0.8	0.4	0.7	1.3	0.7
"18:1n-7"	0.9	1.1	0.7	1.1	0.4	0.4	0.8	1.4	0.5	1.5
"18:2n-6"	0.1	0.3	0.0	0.7	0.0	0.0	0.5	0.0	0.0	0.5
"20:1n-9"	27.7	28.1	28.3	24.3	28.7	28.5	32.5	31.1	32.4	26.6
"20:1n-7"	3.1	2.4	4.1	0.0	4.9	0.0	2.8	0.0	4.0	0.7
22:1n-11"	52.8	47.3	54.1	55.0	52.3	52.1	52.1	43.9	47.5	38.5
"24:1"	0.1	0.0	2.6	0.0	0.0	0.0	0.1	0.0	0.2	0.0

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 4d. Fatty Alcohol Compositions (Mass %) of Wax Esters in *C. borealis* and *S. magnus* from the MIZ North of Svalbard (UNIS data set) . The data are mean values for wax esters isolated from the samples of total lipid from pooled samples (approx. 10 copepodites or ostracods per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	SCAPHOCALANUS MAGNUS	**COCHOACAE BOREALIS**	
	Ice station 3	**Ice station 2**	**Ice station 3**
Fatty alcohol	n=3	n=3	n=3
14:0	5.3	5.9	2.9
16:0	25.3	12.2	8.7
16:1(n-7)	8.6	2.3	2.7
18:0	1.6	1.0	0.7
18:1(n-9)	2.4	1.8	1.1
18:1(n-7)	10.4	1.8	1.5
18:2(n-6)?	0.0	0.2	0.2
20:1(n-9)	12.7	38.1	29.4
22:1(n-11)	16.2	25.2	41.8
22:1(n-9)	4.4	4.7	3.8
24:1	4.5	2.5	1.5

Table 5a. Fatty Acid Composition (Mass %) of Wax Esters in *Calanus finmarchicus* from Kongsfjorden and the MIZ North of Svalbard (BIODAF/UNIS data sets). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden (B) Mix SSW and TAW		Kongsfjorden (U) SSW		Kongsfjorden (U) TAW		Ice Station 1 (U) BSO		Ice Station 1 (U) TAW		Ice Station 2 (U) TAW		Ice Station 3 (U) Polar Water	
	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V
Fatty Acid	n= 14	n= 14	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=2	n=3	n=3
"14:0"	8.8	9.4	15.3	12.8	11.9	18.4	8.6	16.5	14.1	19.2	9.4	9.5	14.4	23.3
"16:0"	6.3	7.8	10.5	6.3	8.3	13.2	5.2	9.2	8.2	9.5	7.1	5.3	8.2	10.7
"16:1n-7"	25.2	20.9	17.8	22.3	24.4	15.0	35.2	21.5	21.2	16.4	12.1	19.2	18.4	12.3
"16:2"	2.1	2.1	0.3	0.9	2.2	1.0	1.9	2.1	2.0	1.7	0.6	1.2	1.6	0.4
"16:3"	1.3	1.7	0.2	0.5	1.1	1.0	0.8	0.4	0.7	1.8	0.8	1.6	1.9	1.0
"16:4"	0.9	1.1	0.2	0.8	1.8	1.3	0.7	0.0	0.4	0.9	2.7	2.3	2.1	1.2
C16 PUFA	4.3	4.9	0.7	2.2	5.0	3.2	3.3	2.6	3.1	4.4	4.1	5.1	5.6	2.6
"18:0"	0.5	0.3	0.5	0.5	0.6	0.6	0.2	0.5	0.4	0.4	0.7	0.2	0.3	0.6
"18:1n-9"	3.2	2.1	7.6	5.8	3.0	2.8	3.8	5.8	3.1	4.2	3.7	2.7	3.7	4.1
"18:1n-7"	1.6	1.5	3.5	1.4	1.3	0.7	1.4	0.8	1.3	0.8	0.7	1.3	1.2	0.5
"18:2n-6"	1.0	0.6	1.3	1.1	0.6	1.4	0.6	1.4	0.7	1.0	0.2	0.9	0.8	1.0
"18:3n-3"	0.8	0.5	1.0	1.1	0.4	1.0	0.0	0.5	0.2	0.5	0.1	0.2	2.0	1.0
"18:4n-3"	3.7	1.8	5.7	7.3	4.5	9.0	1.7	0.5	1.8	2.3	4.2	5.5	4.6	1.6
"20:1n-9"	13.8	15.3	10.7	13.4	13.1	7.3	18.3	15.4	20.5	11.7	17.7	17.8	13.9	14.1
"20:1n-7"	1.2	2.6	1.3	0.0	0.3	0.0	1.5	0.0	0.6	0.0	0.2	0.6	0.0	0.0
"20:5n-3"	11.5	11.3	4.3	7.5	11.7	9.9	5.9	2.5	5.1	11.1	15.5	10.8	11.8	8.0
"22:1n-11"	10.9	8.6	10.7	10.0	8.3	10.7	8.6	17.3	13.8	12.5	11.0	11.6	10.9	15.4
"22:1n-9"	0.9	1.9	1.5	0.9	1.2	0.0	1.5	0.0	0.8	0.4	0.0	1.1	0.0	0.0
"22:5n-3"	0.7	0.6	0.5	0.8	0.7	0.6	0.8	0.3	0.7	0.5	9.7	0.6	0.5	0.4
"22:6n-3"	1.7	1.2	1.4	1.2	1.0	1.3	0.7	0.6	1.0	0.9	1.6	2.3	0.5	0.8

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin; B – BIODAF data set; U – UNIS data set

Table 5b. Fatty Acid Composition (Mass %) of Wax Esters in *Calanus glacialis* from Kongsfjorden and the MIZ North of Svalbard (BIODAF/UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden (B) Mix SSW and TAW		Kongsfjorden (U) SSW		Kongsfjorden (U) TAW		Ice Station 1 (U) BSO		Ice Station 1 (U) TAW		Ice Station 2 (U) TAW		Ice Station 3 (U) Polar Water	
	Females	Stage V	Females	Stage V	Females	Stage V	Female	Stage V	Female	Stage V	Female	Stage V	Female	Stage V
Fatty Acid	n = 8	n = 7	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=3	n=1	n=3	n=3	n=1
"14:0"	5.6	7.9	7.4	8.9	13.5	7.8	10.2	8.6	7.0	7.6	9.3	14.4	11.9	11.1
"16:0"	4.2	6.6	3.0	5.7	7.8	4.8	3.8	4.9	4.2	4.5	4.3	7.4	5.4	5.6
"16:1n-7"	23.2	17.8	26.4	25.1	23.6	25.0	40.0	29.9	29.5	22.1	18.6	20.0	23.8	21.4
"16:2"	1.9	1.5	1.8	1.3	2.4	1.6	1.9	1.5	1.7	1.6	1.5	1.4	0.5	1.3
"16:3"	1.3	1.0	1.7	1.2	0.7	1.5	0.1	0.8	1.5	1.5	2.0	1.3	1.0	1.3
"16:4"	0.9	0.5	2.2	2.0	1.2	1.8	0.0	1.1	1.9	2.3	3.3	2.4	2.2	2.6
C16 PUFA	4.1	3.1	5.7	4.5	4.3	4.9	1.9	3.4	5.0	5.3	6.8	5.1	3.7	5.2
"18:0"	0.3	0.5	0.3	0.1	0.3	0.3	0.3	0.2	0.5	0.3	0.0	0.0	0.1	0.2
"18:1n-9"	3.6	5.6	3.2	4.1	4.0	3.7	3.1	3.7	3.0	3.5	3.3	3.5	4.8	4.1
"18:1n-7"	1.2	0.9	1.2	1.0	1.0	0.8	1.6	1.0	1.5	0.9	1.3	1.3	0.8	0.7
"18:2n-6"	0.7	1.4	0.7	0.7	1.0	0.7	0.7	0.7	0.6	1.0	1.0	0.8	1.1	0.8
"18:3n-3"	0.4	1.0	0.5	0.3	0.5	0.5	0.1	0.1	0.2	0.4	0.6	0.6	0.7	0.5
"18:4n-3"	3.5	6.5	4.7	5.9	3.8	5.7	0.0	2.5	4.0	5.9	7.6	5.8	3.4	4.3
"20:1n-9"	20.5	16.6	17.8	16.8	13.4	17.0	23.2	21.8	17.4	17.1	18.7	13.0	18.0	17.9
"20:1n-7"	1.0	0.3	0.0	0.0	0.5	0.0	1.1	0.0	0.8	0.0	0.0	0.0	0.0	0.0
"20:5n-3"	12.9	11.7	13.4	11.1	7.4	12.1	0.5	6.5	12.2	12.3	11.4	11.2	12.3	13.2
"22:1n-11"	10.3	10.7	7.2	10.9	10.6	9.9	8.7	11.7	7.2	10.2	12.5	12.1	10.0	11.0
"22:1n-9"	1.8	0.9	1.5	0.0	0.5	0.4	1.8	1.0	1.7	1.6	0.0	0.0	0.0	0.0
"22:5n-3"	0.5	0.8	0.4	0.9	0.6	0.7	0.4	0.4	0.6	0.7	0.6	0.6	0.4	0.5
"22:6n-3"	1.5	2.4	1.2	1.4	0.9	1.5	0.5	0.8	0.8	2.6	1.7	1.7	0.9	0.9

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin; B – BIODAF data set; U – UNIS data set

Table 5c. Fatty Acid Composition (Mass %) of Wax Esters in *Calanus hyperboreus* from Kongsfjorden and the MIZ North of Svalbard (BIODAF/UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden (B) Mixed SSW and AW		Kongsfjorden (U) SSW		Kongsfjorden (U) TAW		Ice Station 2 (U) TAW		Ice Station 3 (U) Polar Water	
	Females	Stage V	Females	Stage V	Females	Stage V	Females	Stage V	Females	Stage V
Fatty Acid	**n = 14**	**n = 14**	**n=3**	**n=3**	**n=3**	**n=3**	**n=4**	**n=3**	**n=4**	**n=2**
"14:0"	3.0	3.3	3.5	3.8	4.4	5.4	3.6	2.9	3.1	0.9
"16:0"	2.6	2.3	3.1	2.6	2.7	4.2	2.7	2.0	2.3	3.2
"16:1n-7"	17.9	21.7	19.3	18.8	26.9	20.1	10.5	8.4	32.3	36.2
"16:2"	1.7	1.8	1.1	2.0	1.8	1.4	0.9	0.7	1.5	1.9
"16:3"	1.6	1.5	1.0	1.4	1.5	0.8	0.5	0.5	2.0	2.7
"16:4"	2.0	1.7	1.6	1.7	2.0	1.2	1.6	2.2	2.5	3.0
C16 PUFA	5.3	5.1	3.7	5.1	5.3	3.4	3.0	3.4	6.0	7.5
"18:0"	0.2	0.3	0.0	0.3	0.1	0.4	0.5	0.1	0.1	0.0
"18:1n-9"	2.1	2.6	3.0	3.3	2.5	3.9	3.7	3.9	2.2	1.7
"18:1n-7"	1.5	1.5	1.7	1.3	1.3	1.5	1.4	1.3	1.2	1.1
"18:2n-6"	1.0	1.4	1.3	4.0	0.7	1.9	2.1	2.9	0.5	0.6
"18:3n-3"	0.6	0.5	0.4	1.1	0.3	0.8	1.4	1.3	0.1	0.2
"18:4n-3"	4.7	6.9	6.9	15.3	4.0	6.2	11.1	16.1	3.2	3.8
"20:1n-9"	16.1	15.3	17.4	10.3	18.6	17.9	16.8	12.9	12.2	7.0
"20:1n-7"	2.9	1.8	3.7	1.0	2.4	1.1	1.2	0.2	1.9	1.1
"20:5n-3"	11.3	13.1	12.9	10.4	10.0	8.7	14.6	15.9	19.4	24.5
"22:1n-11"	12.3	15.6	11.3	9.3	11.7	14.5	11.7	10.0	7.1	5.4
"22:1n-9"	3.2	0.7	4.0	1.9	2.8	2.0	2.7	0.7	1.5	0.0
"22:5n-3"	0.9	1.1	1.2	1.4	1.2	0.7	1.5	2.4	1.2	1.3
"22:6n-3"	2.7	3.2	3.5	6.0	1.7	3.5	7.2	9.6	1.9	2.6

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin; B – BIODAF data set; U – UNIS data set

Table 5d. Fatty Acid Composition (Mass %) of Wax Esters in *C. borealis* and *S. mangnus* from the MIZ North of Svalbard (UNIS data set). The data are mean values for wax esters isolated from the samples of total lipid from pooled samples (approx. 10 copepodites or ostracods per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	SCAPHOCALANUS MAGNUS	COCHOACAE BOREALIS	
	Ice station 3	Ice station 2	Ice station 3
Fatty acid	n=3	n=3	n=3
14:0	0.4	3.86	1.33
16:0	0.5	4.02	2.67
16:1(n-7)	28.8	15.01	24.87
16:2	0.5	0.62	0.77
16:3	0.5	0.41	0.36
16:4	0.3	0.51	0.51
18:0	0.0	0.67	0.46
18:1(n-9)	26.2	12.55	9.90
18:1(n-7)	2.9	2.37	2.77
18:2(n-6)	2.0	1.44	1.38
18:3(n-3)	1.1	1.03	0.87
18:4(n-3)	3.1	5.81	4.00
20:0	0.0	0.15	0.00
20:1(n-9)	4.8	17.83	15.74
20:1(n-7)	1.1	0.51	0.72
20:5(n-3)	15.6	9.11	13.28
22:1(n-11)	3.9	11.19	9.90
22:1(n-9)	0.7	2.20	1.49
22:5(n-3)	0.6	0.67	0.67
22:6(n-3)	3.6	4.79	3.33
24:1	0.2	0.82	0.51

Table 6a. Fatty Acid Composition (Mass %) of triacylglycerols in *Calanus finmarchicus* from Kongsfjorden and the MIZ North of Svalbard (UNIS data set). The data are mean values for TAG isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden SSW	Kongsfjorden TAW	Ice Station 1 BSO		Ice Station 1 TAW		Ice Station 2 TAW	Ice Station 3 Polar Water	
	Female	Female	Female	Stage V	Female	Stage V	Stage V	Female	Stage V
	n=3	n=3	n=3	n=3	n=3	n=3	n=2	n=2	n=2
Fatty Acid									
"14:0"	11.7	11.9	11.2	11.6	8.7	14.3	0.8	5.8	14.6
"16:0"	20.3	8.0	20.1	5.8	14.3	22.1	15.7	13.1	26.2
"16:1n-7"	15.4	25.3	11.5	16.4	10.1	12.4	8.6	14.6	12.5
"16:2"	0.5	1.2	0.0	2.0	0.0	1.0	0.5	0.0	0.0
"16:3"	0.5	0.7	0.0	1.6	0.1	1.3	1.0	0.6	0.0
"16:4"	1.0	1.9	0.0	3.0	0.5	1.6	1.4	4.0	0.0
C16 PUFA	2.0	3.7	0.0	6.6	0.6	3.9	3.0	3.1	0.0
"18:0"	0.0	0.4	0.0	0.2	1.2	0.8	0.0	2.0	1.8
"18:1n-9"	7.2	2.2	6.2	5.0	3.9	3.8	8.8	2.6	0.8
"18:1n-7"	4.8	1.7	2.6	0.8	1.8	0.9	2.5	1.4	3.6
"18:2n-6"	2.6	0.6	0.0	1.5	0.7	0.0	0.7	0.6	0.4
"18:3n-3"	0.6	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
"18:4n-3"	2.8	4.8	2.8	7.2	2.5	1.5	4.2	1.7	2.7
"20:1n-9"	11.2	14.3	13.8	16.6	17.6	4.8	18.1	11.0	8.2
"20:1n-7"	1.9	0.0	0.0	0.0	1.6	0.0	15.4	0.0	0.8
"20:5n-3"	3.4	11.5	16.8	12.9	8.7	20.0	0.0	11.0	9.6
"22:1n-11"	8.4	9.6	8.9	9.4	16.3	6.8	14.8	7.6	8.2
"22:1n-9"	2.1	1.0	0.0	0.0	2.3	0.0	3.0	0.0	0.0
"22:5n-3"	0.6	0.7	0.0	0.7	1.3	1.5	0.5	11.0	1.2
"22:6n-3"	1.2	1.1	6.2	1.8	6.9	5.6	1.7	2.0	4.3
(n-6)	3.8	1.0	0.0	2.9	1.0	0.0	1.2	0.4	1.7
(n-3)	8.9	19.3	25.8	23.7	19.6	28.6	7.1	22.8	17.8

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 6b. Fatty Acid Composition (Mass %) of triacylglycerols in *Calanus glacialis* from Kongsfjorden and the MIZ North of Svalbard (UNIS data set). The data are mean values for triacylglycerols isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden TAW	Ice Station 1 BSO	Ice Station 1 TAW		Ice Station 2 TAW	Ice Station 3 Polar Water	
	Female	Female	Female	Stage V	Stage V	Female	Stage V
	n=3	n=2	n=2	n=3	n=1	n=3	n=1
Fatty Acid							
"14:0"	14.8	12.0	12.1	9.3	10.7	10.4	9.4
"16:0"	7.9	14.1	13.9	14.3	20.0	15.0	15.2
"16:1n-7"	16.7	15.9	13.9	14.0	10.6	24.0	22.1
"16:2"	4.1	0.7	0.7	0.7	1.6	0.5	0.7
"16:3"	0.3	0.6	0.8	0.8	0.4	0.7	1.0
"16:4"	1.2	0.8	0.7	1.4	0.7	0.9	1.2
C16 PUFA	5.6	2.1	2.1	2.9	2.7	2.0	2.9
"18:0"	0.5	4.5	0.9	0.6	1.1	0.6	0.6
"18:1n-9"	3.8	1.7	3.7	2.6	3.0	2.6	2.0
"18:1n-7"	0.8	0.5	1.7	1.3	1.5	1.2	1.3
"18:2n-6"	1.0	0.0	0.7	0.4	0.9	0.7	0.5
"18:3n-3"	0.9	0.0	0.0	0.0	0.6	0.5	0.0
"18:4n-3"	6.2	2.9	2.9	3.0	5.3	2.1	2.8
"20:1n-9"	11.4	10.3	11.1	15.0	10.1	8.0	11.0
"20:1n-7"	0.0	1.1	0.6	0.0	0.0	0.0	0.0
"20:5n-3"	11.7	18.4	17.3	15.9	13.5	21.0	16.6
"22:1n-11"	11.9	7.2	6.8	8.9	3.7	3.1	7.7
"22:1n-9"	0.0	1.2	1.9	3.4	0.0	0.0	0.0
"22:5n-3"	0.2	1.3	1.3	1.2	4.2	1.1	1.4
"22:6n-3"	1.8	6.3	6.6	4.7	7.9	5.3	3.8
(n-6)	1.7	0.0	1.2	0.4	1.6	1.0	0.7
(n-3)	21.8	28.9	29.1	25.9	33.8	30.3	25.3

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 6c. Fatty Acid Composition (Mass %) of triacylglycerols in *Calanus hyperboreus* from Kongsfjorden and the MIZ North of Svalbard (UNIS data set). The data are mean values for triacylglycerols isolated from the samples of total lipid from pooled samples of copepodite stages (approx. 10 copepodites per sample) standard deviations and fatty acids in trace amounts are omitted for clarity.

	Kongsfjorden SSW		Kongsfjorden TAW		Ice Station 2 TAW	Ice Station 3 Polar Water	
	Females n=1	Stage V n=3	Females n=3	Stage V n=3	Stage V n=2	Females n=3	Stage V n=1
Fatty Acid							
"14:0"	1.3	0.2	7.9	7.0	6.4	6.1	4.1
"16:0"	5.8	4.8	12.1	11.9	10.6	9.3	6.4
"16:1n-7"	17.9	20.7	23.1	12.8	14.8	25.7	26.1
"16:2"	1.9	1.4	0.5	0.2	0.0	1.0	1.5
"16:3"	4.2	1.5	0.5	0.8	1.7	1.5	2.1
"16:4"	0.0	2.7	0.3	0.3	2.7	1.6	1.5
C16 PUFA	6.1	5.6	1.4	1.3	4.4	4.1	5.0
"18:0"	5.5	0.6	0.2	0.7	0.0	0.4	0.2
"18:1n-9"	5.4	3.0	1.8	2.8	3.9	0.3	1.3
"18:1n-7"	2.9	1.9	2.8	2.5	1.5	1.6	3.4
"18:2n-6"	1.1	1.5	0.6	0.5	2.7	0.6	0.4
"18:3n-3"	0.0	0.4	0.0	0.0	0.0	0.0	0.1
"18:4n-3"	2.9	3.3	0.0	0.0	8.5	1.8	2.3
"20:1n-9"	8.8	13.6	17.3	22.9	12.5	8.4	9.2
"20:1n-7"	2.2	3.0	8.7	3.5	0.0	6.4	3.9
"20:5n-3"	5.6	13.5	0.0	0.5	16.3	18.7	22.2
"22:1n-11"	9.3	9.1	14.7	23.1	5.8	3.7	4.7
"22:1n-9"	3.3	3.7	7.4	7.6	1.6	3.7	3.0
"22:5n-3"	4.3	6.6	0.0	1.0	2.5	3.4	2.2
"22:6n-3"	2.2	3.9	1.2	1.3	10.0	2.2	2.5
(n-6)	7.6	2.8	0.8	0.5	2.7	1.9	1.4
(n-3)	15.0	28.2	1.2	2.8	40.4	26.6	29.8

SSW - Spitsbergen Shelf Water; TAW - Transformed Atlantic Water; BSO - Barents Sea Origin

Table 6d. Fatty Acid Composition (Mass %) of triacylglycerols in *C .borealis* and *S. magnus* from the MIZ North of Svalbard (UNIS data set). The data are mean values for triacylglycerols isolated from the samples of total lipid from pooled samples (approx. 10 copepodites or ostracods per sample) standard deviations and fatty alcohols in trace amounts are omitted for clarity.

	SCAPHOCALANUS MAGNUS	**COCHOACAE BOREALIS**	
	Ice station 3	**Ice station 2**	**Ice station 3**
Fatty acid	n=3	n=3	n=3
14:0	3.8	2.3	1.8
16:0	13.6	16.0	13.9
16:1(n-7)	23.0	23.5	28.0
16:2	0.3	0.3	0.3
16:3	0.3	0.2	0.3
16:4	0.3	0.3	0.2
18:0	1.1	4.2	2.9
18:1(n-9)	8.1	22.6	25.4
18:1(n-7)	9.3	3.0	4.1
18:2(n-6)	0.9	1.1	1.1
18:3(n-3)	0.5	0.7	0.6
18:4(n-3)	1.8	3.0	2.2
20:0	0.2	0.1	0.0
20:1(n-9)	5.4	5.6	5.0
20:1(n-7)	1.8	0.3	0.2
20:5(n-3)	10.4	5.3	7.2
22:1(n-11)	5.6	4.2	2.6
22:1(n-9)	2.7	0.3	0.0
22:5(n-3)	0.6	0.2	0.1
22:6(n-3)	4.2	4.4	1.5
24:1	3.8	0.4	0.1

Table 7. Fatty Acid Composition (Mass %) of Total lipid(a) and WE fatty alcohols (b) particulate material from the MIZ North of Svalbard (UNIS data set)

	Total lipids (a)				**Wax Ester Fatty alcohols (b)**		
	Ice Station 1	**Ice Station 2**	**Ice Station 3**		**Ice Station 1**	**Ice Station 2**	**Ice Station 3**
Fatty acid	**n=3**	**n=3**	**n=3**	Fatty alcohol	**n=3**	**n=3**	**n=3**
14:0	5.5	6.7	3.8	14:0	3.31	5.21	4.99
15:0	1.2	1.1	0.7	15:0	1.42	1.16	0.70
16:0	22.7	24.1	21.2	16:0	11.26	10.36	11.81
16:1(n-7)	8.8	8.7	24.9	16:1(n-7)	2.73	2.45	0.94
16:2	0.3	0.3	0.6	16:2?	0.30	0.00	0.00
16:3	0.5	0.5	0.7	16:3	0.00	0.00	0.00
16:4	0.2	0.2	0.5	16:4	0.00	0.00	0.00
18:0	9.7	14.7	9.9	18:0	8.50	5.63	7.74
18:1(n-9)	19.3	11.7	4.3	18:1(n-9)	0.62	1.51	1.56
18:1(n-7)	2.0	1.6	1.3	18:1(n-7)	0.91	1.44	0.92
18:2(n-6)	6.0	2.6	1.8	18:2(n-6)	0.00	0.00	0.00
18:3(n-3)	0.6	0.5	0.4	18:3(n-3)	0.00	0.00	0.00
18:4(n-3)	1.6	2.3	2.0	18:4(n-3)	0.00	0.00	0.00
20:0	0.8	1.2	0.9	20:0	1.59	1.03	2.37
20:1(n-9)	5.7	5.4	0.9	20:1(n-9)	21.09	18.97	10.90
20:1(n-7)	0.2	0.3	0.1	20:1(n-7)	10.10	1.73	1.75
20:4(n-6)	0.2	0.2	0.3	20:4(n-6)	0.00	0.00	0.00
20:4(n-3)	0.3	0.2	0.3	20:4(n-3)	0.00	0.00	0.00
20:5(n-3)	3.0	3.6	12.7	20:5(n-3)	0.00	0.00	0.00
22:1(n-11)	1.2	1.3	0.9	22:1(n-11)	30.58	32.35	31.96
22:1(n-9)	3.2	3.9	0.7	22:1(n-9)	0.00	0.00	6.58
22:1(n-7)	0.5	0.6	0.2	22:1(n-7)	0.00	0.00	0.00
22:5(n-3)	0.3	0.3	0.3	22:5(n-3)	0.00	0.00	0.00
22:6(n-3)	3.8	3.9	7.2	22:6(n-3)	0.00	0.00	0.00
24:1	0.2	0.3	0.2	24:1	7.32	4.93	10.1