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A comparison between short-term sediment traps with filtered sea water and without during two contrasting periods with respect to Chl a and phytoplankton composition

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Table of content

1. Abstract

Kaldfjorden is an ice-free fjord located in northern Norway (69.75°N 18.67°E). This study investigated (1) the difference between two methods of determining the vertical export with sediment traps; sediment traps deployed with filtered seawater and sediment traps deployed with unfiltered seawater. In addition, the study also looked at (2) how the concentration of chlorophyll a changed over the two periods and (3) a comparison between the distribution of phytoplankton in February and April in the fjord was made. The concentration of chlorophyll a increased considerably between February and April, correlating with the change in physical conditions of the fjord and the growth in phytoplankton community. This also affected the distribution of taxa where diatoms, and particularly pennate diatoms, were the most abundant in February, while centric, chain forming diatoms and Phaeocystis were the most abundant taxa in April. These findings correlated to the studies that have taken place in other fjords in northern Norway, such as Balsfjorden. A difference could also be seen between the two methods to deploy traps, where the concentrations of chlorophyll a was higher in the majority of samples in the sediment trap cylinders without filtered seawater than in the cylinders with filtered seawater. This might be explained by the barrier that is created from the increased salinity in the sediment traps with filtered seawater and the biomass already in the seawater that filled the traps when they were deployed. These results can be used to compare future studies that use different treatments of the sediment traps.

2. Acknowledgment

A special thanks to Ingrid Wiedmann for supervising this thesis and all the encouragement along the way.

Thank you Rolf Gradinger for taking the time to increase my knowledge in identifying phytoplankton.

I also want to thank Emily-Zoe Walker for the help when sampling but especially for letting me look at her results as well to be able to get a better impression of the effect of the traps.

A big thank you to Angelika Renner for helping me during both sampling occasions.

And thank you Tierney Carter for proof-reading, and for the never ending moral support.

3. Introduction

Norway has a large number of fjords along its coast from 58° to 71° N and they are a characteristic trait that many associate with the country. The fjords have been created by glacial erosion and are defined by their submarine sill(s), their steep sides and most often by the long and narrow shape (Inall and Gillibrand, 2010). Apart from Norway, fjords are found in both hemispheres in mid to high latitudes and are therefore classified depending on what climate regime the fjord is located in (Howe *et al.*, 2010); polar, subpolar and temperate fjords. The polar fjords are most often permanently covered with sea ice and are connected to a glacier. Subpolar fjords often have a cover of sea ice in winter but are ice-free in summer and do not always have a connection to a glacier. Most temperate fjords do not have the cover of sea ice during any period of the year and are not connected to a glacier. This thesis focusses on Kaldfjorden, located in northern Norway (69.75°N 18.67°E). It is ice-free year-round and not connected to a glacier and is therefore classified as a temperate fjord. The fjord is located on the outside of the island Kvaløya and is thus influenced by the coastal water of the Norwegian Sea. The Norwegian Sea has two major currents that affect Kaldfjorden: the Norwegian Coastal Current (NCC) and the Norwegian Atlantic Current (NAC). The NCC originates from the eastern Skagerrak and consist of a mixture of Baltic Sea water, North Sea water and fresh water runoff from the Norwegian coast (Sætre, 2007).

Phytoplankton, together with macroalgae, are marine primary producers and they play a vital role in all marine ecosystem, because they also form the first step of the marine food web in a fjord. Phytoplankton can conduct photosynthesis, meaning it can transform carbon dioxide and inorganic nutrients into carbohydrates, fat and protein that other animals in the marine ecosystem need to survive and thrive. This process, transforming carbon dioxide to oxygen, also make the phytoplankton into an important of the global carbon cycle, because they reduce CO_2 and generate approximately half of the oxygen in the atmosphere. (NOAA, 2014). The biomass that is produced when the phytoplankton grow and reproduce becomes a food source for zooplankton, that are the primary consumers of the marine ecosystem, and in turn, they become a food source for larger animals such as fish and bivalves. This food chain makes life in the oceans possible and it is all based on primary producer's ability to transform inorganic matters into organic biomass (Townsend, 2012).

Phytoplankton are classified as planktons which means that they drift freely in the water column and follow the water movement as most of them are either poor swimmers or cannot

swim at all. Most of the species that belong to the phytoplankton are unicellular and thousands of species can be found in the world's oceans (Townsend, 2012). Even though phytoplankton plays an important role in taking up the carbon dioxide from the atmosphere and transferring it into organic biomass, not all phytoplankton is consumed by higher trophic levels. Some phytoplankton will also sink to the bottom of the sea floor as ungrazed biomass. Here, it is a major food source for the benthic organisms, but parts of this biomass will also be sequestrated. In this way, it contributes to the "the biological carbon pump" (Turner, 2015).

The growing period for the phytoplankton in northern Norway takes place between the end of March and October/November (Eilertsen and Frantzen, 2007). The growing season can only take place during the time of year when the sun rises above the horizon and gives enough light for the organisms to be able to grow. The annual biomass peak, the phytoplankton spring bloom, occurs in mid to late April and a smaller autumn bloom can sometimes be observed in the end of August or during September (Eilertsen & Frantzen, 2007). The definition of a bloom is when a species of phytoplankton multiplies quickly in a short period of time because of a high reproduction rate (Diersing, 2009) and the biomass increase rapidly without being significantly affected by grazers. Phytoplankton are dependent on a high quantity of light to be able to reach these levels of biomass and are therefore dependent on the increased irradiance during spring (Townsend, 2012).

There is different hypothesis on how the phytoplankton spring bloom starts. One of the well-known hypothesis is the one by Sverdrup (1953) that is called the Critical Depth Hypothesis. The hypothesis says that a new thermocline will be created when the water column becomes more stratified during spring which will keep the phytoplankton in the upper part of the water column, the upper mixed layer. The bloom, according to Sverdrup (1953), can only occur when the upper mixed layer is shallower than the critical depth. The definition of the critical depth is when the integrated photosynthesis is equal to the integrated respiration of the phytoplankton in the water column. The bloom will then occur if the integrated photosynthesis is greater than the integrated respiration, meaning that phytoplankton can produce more energy than they need for respiration. The Critical Turbulence Hypothesis (Huisman et al. 1999), is an alternative hypothesis for the onset of the spring bloom and it says that the blooms are determined by the balance of photosynthesis and turbulence. The spring bloom can only be initiated when the convective overturn decreases in the end of winter. This has also been found to be the case in Northern Norway (Eilertsen, 1993). A third hypothesis on the onset of the

spring bloom is the Disturbance-Recovery Hypothesis which says that the increase and decreases in the phytoplankton biomass is mainly caused by grazers, viral attacks and dilution (Behrenfeld, 2010).

The environmental conditions, and therefore also the abundance of plankton, changes with the seasons and this in turn causes a variation of the quantity of downward particulate organic carbon (POC) throughout different seasons. The major downward flux takes place during and after the spring bloom, when the abundance of zooplankton in the water column is low (Wassmann et al, 1991). There has not been a lot of research done in Kaldfjorden and a study investigating the phytoplankton community is so far lacking. The species found in this study will therefore be compared with the species found in the neighbouring fjords, primarily Baldsfjorden that is located southeast of Tromsø and is the best studied fjord in the surrounding area. Baldsfjorden is also connected to the Norwegian sea, but has shallower sills (8 m, 9 m and 30 m) than Kaldfjorden and it is thus less exposed to coastal water. The most abundant phytoplankton classes during the spring bloom in Balsfjord are the prymnesiophyte *Phaeocystis pouchetii* and diatoms, both centric and pennate (Eilertsen & Degerlund, 2010). These taxa are thus also expected to be found in Kaldfjorden.

The downwards biomass flux can be studied by using short-term sediment traps that collect particles such as organic matter and dead organisms that sink from the upper water column to the sea floor. They are therefore seen as a good tool for researchers to use to get a better understanding of pelagic-benthic coupling in e.g., fjords (Wassmann et al., 1991).

This study will compare sediment traps that are deployed into the water without any water inside as done by Reigstad et al. (2008), with a method where some traps are filled with filtered sea water with a salinity increased to 40 PSU before deployment as described by Juul-Petersen et al. (2006). The increased salinity in the traps containing filtered seawater gives the water a higher density than the surrounding water and ensures that the filtered seawater stays in the sediment trap cylinder.

The aim of this study is therefore to (1) see if there is any difference in the quantity of collected chlorophyll a in the sediment traps depending on if they contain filtered seawater or unfiltered seawater. In addition, (2) I investigate the species composition of the samples taken in February and April, within the two different types of sediment traps and (3) compare the

quantity of chlorophyll a collected in the different traps in February and April with the suspended chlorophyll a in Kaldfjorden, to estimate how much of the chlorophyll was actually sinking out.

4. Method

4.1. Sampling

The samples for this study was collected by using a sediment trap in Kaldfjorden in Northern Norway. Samples were taken on two occasions; the first on the 16th of February 2018 and the latter was taken the 5th of April 2018 at station KaF (69.746 N, 18.683 E).

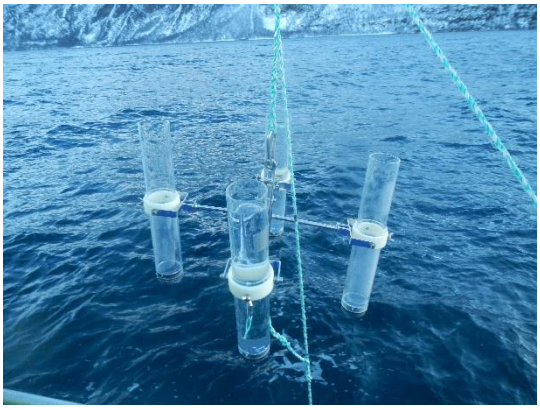

Figure 1. The sediment traps before deployment into the fjord. Photo: Angelika Renner

The first step of the process was to filter 15 litres of seawater for two of the sediment trap cylinders that were deployed at 20, 30 and 50 m. The water was collected from the seawater intake at UiT The Arctic University of Norway (UiT), which takes in water from the nearby Tromsø Sound (8 m depth). These 15 litres were vacuum filtered through a Whatman GF/F filter (pore size 0.7 µm). The salinity of the filtered water was increased after the filtration to 40 g/kg compared to 35 g/kg measured in the fjord by adding salt. The water was stored in carboys in the fridge for 24 hours before being using in the deployed sediment traps. The water was poured into two trap cylinders per depth just before they were deployed into the fjord (Figure 1), while the other two cylinders per depth were prepared by Emily-Zoe Walker and contained no filtered sea water. Four sediment traps, two with filtered seawater and two without, were deployed at station KaF at 20, 30 and 50 m. The sediment trap array was left in the fjord for approximately 24 hours before it was recovered and the water from the cylinders from different depths (with and without pre-added filtered sea water) was transferred into distinct carboys. These carboys were stored cool and in darkness in an insulating container, so

that the phytoplankton would not be able to photosynthesise. The carboys were brought back to the laboratory at UiT for filtration approximately four hours after being collected from the fjord. A subsamples of 100 mL was collected from each sampling depth before the water was filtrated to use for identifying the species of phytoplankton and analyse their quantity (see detailed description in section 4.3).

4.2. Chlorophyll a measurement

The water collected in the sediment traps with filtered seawater was vacuum filtered approximately four hours after they were collected in the fjord. From each sampling depth, three subsamples of 400 mL were filtered on a Whatman GF/F filter with a pore size of 0.7 µm. The filters from the sediment traps with filtered seawater from February were then put into 5 mL of methanol and stored in the fridge (+4°C) for 24 hours for chlorophyll a extraction. The remaining filters from February and April were stored in the freezer for approximately four weeks before they were put into 5 mL of methanol and stored in the fridge for 24 hours to extract the chlorophyll a. The chlorophyll a level was measured the next day with the help of a Turner Design AU-10 fluorometer, where the samples were measured first with only methanol (Rb) and then with methanol and a drop of hydrogen chloride (HCl, 10 %, Ra). The quantity of chlorophyll a present was calculated from the raw values given by the fluorometer using the equation (1).

Chl a (mg/m3) = Fd*tau*(Rb-Ra)*volume methanol/volume filtrated (1)

With Fd = 2.6 (calibration factor)

tau = 1.509 (calibration factor)

Rb = raw value from fluorometer before adding one drop of HCl

Ra = raw value from fluorometer after adding one drop of HCl

The water collected from the sediment traps on the 16th of February that did not contain any filtered seawater, was filtered at the same time by Emily-Zoe Walker using the same process.

4.3. Phytoplankton samples

The phytoplankton counting samples (100 mL) were collected by two different sampling methods: (1) the sediment trap with filtered seawater (20 m, 30 m and 50 m) and (2) the sediment trap without filtered sea water (20 m, 30 m and 50 m). Lugol (0.5 mL) was added to the samples before they were put into the fridge (+4 °C) until analysed within six weeks. Half of the sample, 50 mL, was left for 24 hours to settle according to the "Utermöhl method" before the sample

was counted in an inverted microscope at magnification 200 x and 400 x. The different taxa that could be found in the samples was mainly identified by using *Marine Mikroalger i farger* (Throndsen and Eikrem, 2001) and by consulting Rolf Gardinger, professor in the Department of Arctic and Marine Biology, UiT. Phytoplankton that were larger than 5 µm were included in the counting with a special focus on prymnesiophyte, diatoms, dinoflagellates, foraminifera, tintinnids and ciliates. The area counted in each sample was either the whole chamber, half the chamber or two transects depending on the abundance of phytoplankton (at least 200 cells counted).

5. Results

5.1. Chlorophyll a measurements

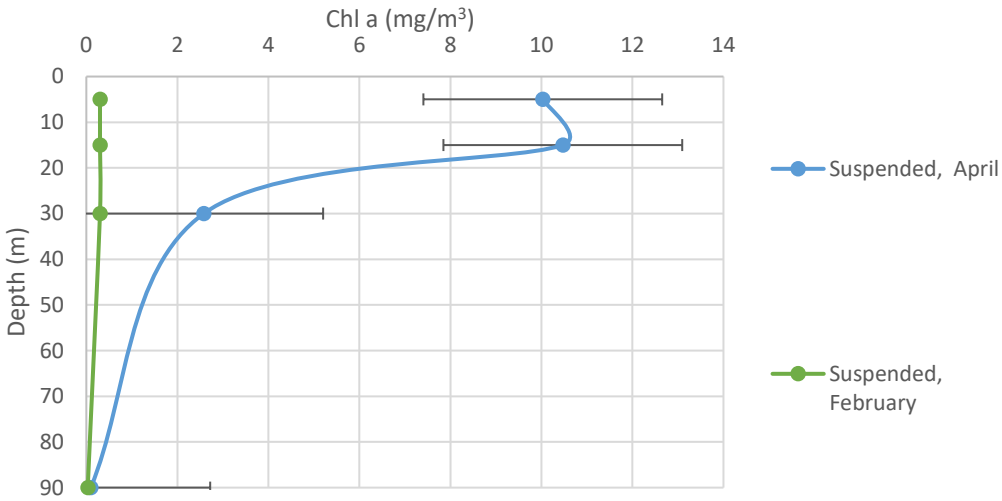

Figure 2a. The suspended Chl a concentration during the sampling dates in February and April 2018 at KaF. Error bars show the standard deviation.

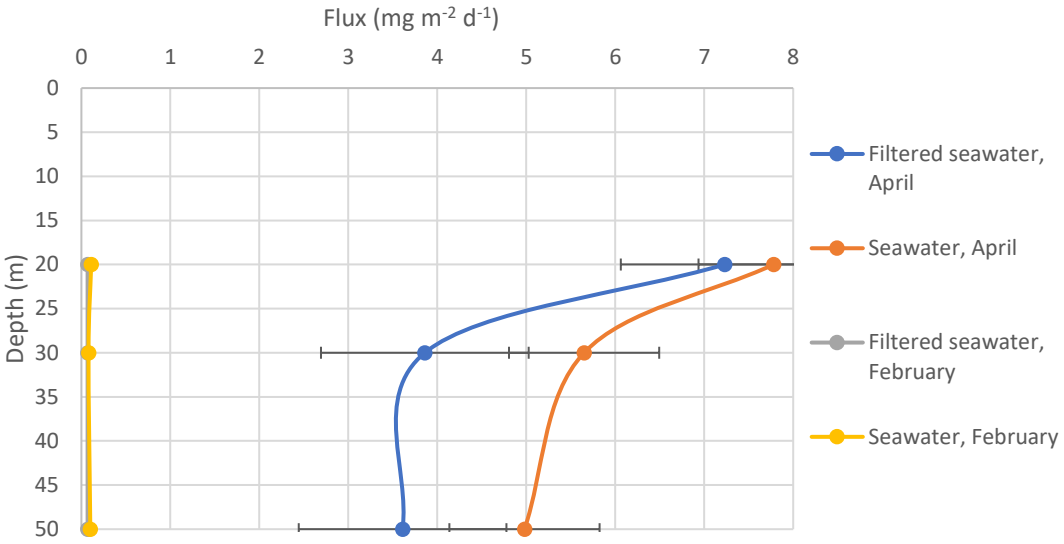

Figure 2b. The measured chlorophyll a downward flux from the two sediment traps deployed for 24 hours in February and April. Note: "Seawater" refers to the sediment trap cylinders that were deployed empty and then just filled themselves with seawater. "Filtered seawater" refers to the sediment cylinders that were pre-filled with filtered seawater. Error bars show standard deviation.

The sediment traps from February without filtered seawater had a higher average of chlorophyll a flux compared to the traps containing filtered seawater during the deployment from the same month (Figure 2b). The shallowest traps, 20 m, had a difference of 0.04 mg m^{-2} d^{-1}, the traps on 30 m a difference of 0.01 mg m^{-2} d^{-1} and the traps at the deepest, 50 m, a difference of 0.03 mg m^{-2} d^{-1}. The sediment traps with filtered seawater from April also had a lower mean quantity of chlorophyll a flux compared to the traps deployed without filtered seawater (Figure 2b). The largest difference could be seen at 30 m where the difference between the two traps were 1.79 mg m^{-2} d^{-1}.

The highest chlorophyll a flux was in general found in the traps deployed at 20 m whereas the lowest were found at 50 m.

A considerable different chlorophyll a flux was found in the traps deployed in February and April. A considerable increase in chlorophyll a are shown in figure 2b where the largest difference was found in the traps with seawater at 20 m, where the difference between February and April were 7.67 mg m^{-2} d^{-1}. The least significant increase can be found in the trap at 50 m with filtered seawater that increased by 3.54 mg m^{-2} d^{-1}.

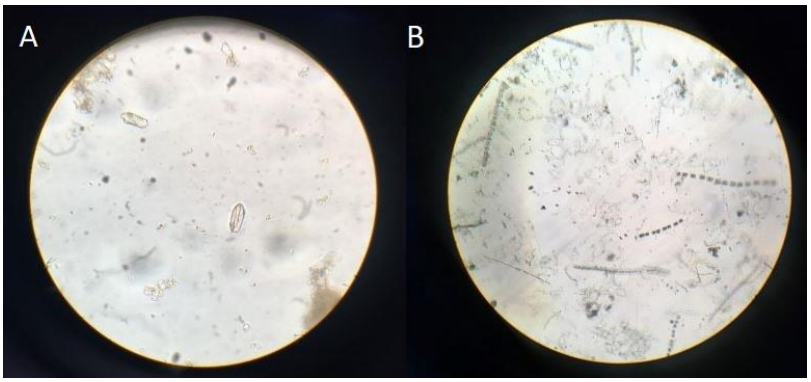

Figure 3. Comparison between sample taken at 20 m in February (A) and April (B) seen at a magnification of 200x.

A comparison of the abundance of cells at 30 m in February and April can be seen in Figure 3 where the sample from February has a much lower abundance.

The suspended water samples and the sediment traps followed the same pattern between February and April. The concentrations in the suspended water samples were low and homogenous throughout the water column and the sediment traps showed a low and homogenous flux at all three depths. The suspended water samples from April showed a considerably higher concentration than in February with a decreasing concentration with increasing depth. This was the same pattern as with the sediment traps where the flux decrease with increased depth

5.2. Phytoplankton samples

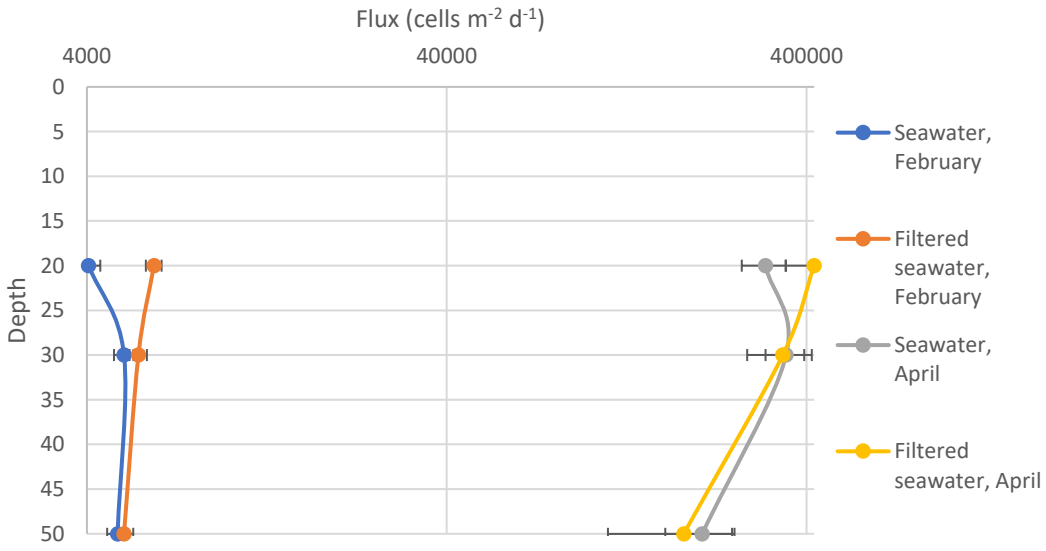

Figure 4. The vertical flux of cells in the sediment traps over 24 hours. Error bars show standard deviation.

There is a considerable difference between phytoplankton cell flux in the traps in February

and April, comparable to the difference in the chlorophyll a flux (section 5.1). The lowest cell flux was found in the traps at 20 m filled with seawater in February (4043 cells m^{-2} d^{-1}) and thereafter the same trap at 30 m (5072 cells m^{-2} d^{-1}), see figure 4. The traps in April had the highest cell flux where the largest quantity was found in the traps with filtered seawater at 20 m (419 827 cells m^{-2} d^{-1}) compared to the trap with seawater at 20 m (307 475 cells m^{-2} d^{-1}).

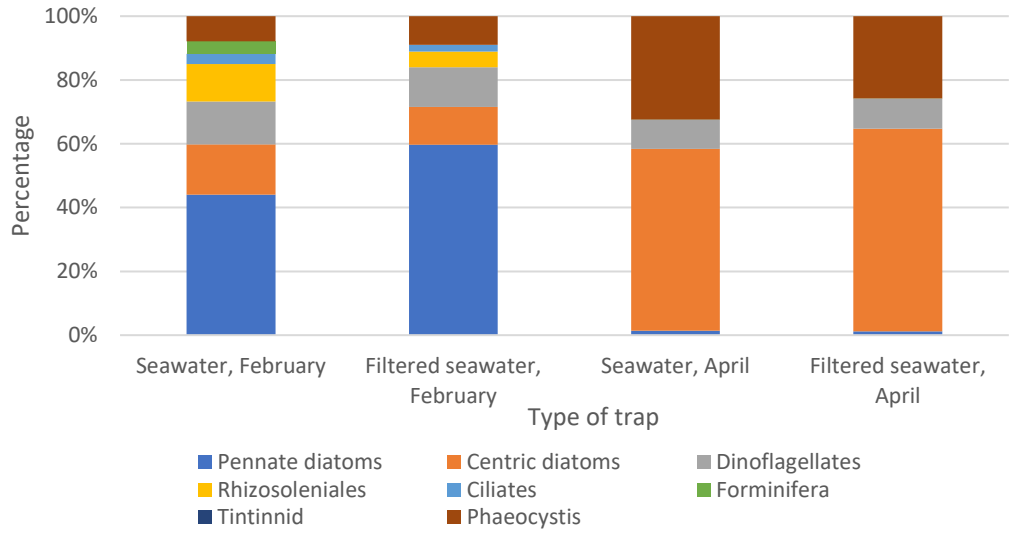

Figure 5. The relative distribution of phytoplankton taxa collected in the sediment traps deployed in February and April. Note: "Seawater" refers to the sediment trap cylinders that were deployed empty and then just filled themselves with seawater. "Filtered seawater" refers to the sediment cylinders that were pre-filled with filtered seawater.

The relative distribution of the different taxa of phytoplankton was different depending on when the samples were taken (figure 5). Sediment trap cylinders deployed in February and April contained approximately the same quantity of taxa but the samples from February had a more even distribution between the taxa's compared to April. The samples taken in April that were dominated by two species (see figure 5). The most abundant order in the February samples, that were approximately 50 % of the identified cells, were pennate diatoms. Centric diatoms and dinoflagellates could also be found in a larger abundance. The April samples on the other hand were almost completely dominated by two taxa, centric diatoms and Phaeocystis. The dinoflagellates and pennate diatoms were still present but did not dominate the relative abundance as they did in the samples collected in February.

6. Discussion

The main aim of this study was to investigate the difference between two different methods how sediment traps are deployed (containing filtered sea water and containing seawater). The results showed that the traps with seawater was the ones collecting the highest chlorophyll a concentrations in the majority of the samples and the relative phytoplankton composition varied to a minor extend.

The concentration of chlorophyll a showed a major difference between February and April. The difference of the almost two months between the sampling occasions have shown how quickly the community of phytoplankton change in northern Norway. Walker (2018) shows that the water column in Kaldfjorden was completely mixed in February and this can be seen in the chlorophyll a measurements where the concentrations are homogenous (see figure 2a) throughout all depths. Kaldfjorden experienced approximately seven hours of daylight during February while this increases to 14 hours of sunlight in April. The short days during February affect the phytoplankton community as they cannot produce enough energy for survival, growth and reproduction. This, along with other physical factors, affect the stratification of the water column and a weaker stratification was seen in April (A. Renner, personal communication, 24 May). The suspended chlorophyll a concentration correlated well with the results from the sediment traps (see figure 2a & b), because the chlorophyll flux was rather similar in all sediment traps during February, but this changed in April. Then, the traps at 20 m had the highest concentrations and then a decreasing concentration the deeper the traps were deployed. This shows that the increases in sunlight increase the reproduction and growing rate as the phytoplankton can start to photosynthesis to a higher level than during winter time.

The present study showed chlorophyll a concentrations in the suspended water in February was 0.03 mg/m^3 which is comparable to Wiedmann et al. (2015) where the winter concentrations were approximately 0.6 mg/m^3 in Adventfjorden, Svalbard. The concentrations during spring in Kaldfjorden increased to around 10 mg/m^3 and this is bolstered by other studies from the region where for example Degerlund and Eilertsen (2010) showed that the mean value of a spring bloom in these areas in northern Norway normally is 3–10 µg L^{-}. The levels of chlorophyll a in April (see figure 2a) therefore show the bloom has reached its peak when these samples were collected. The concentrations during spring bloom can also be compared to the study made by Archer et al. (2000) that found concentrations of 5.4 to 6.3 mg/m^3 in the three fjords investigated. It can also be seen in the change of quantity of phytoplankton counted and composition of species in the samples taken in February and April. The quantity

in April increases with at least three times the numbers in February, which shows the major change in growing and reproduction rate during the almost two months between the two sampling occasions. The phytoplankton species composition also changed during this period. The most common order in February was the pennate diatoms while this changed in April where chains of centric diatoms followed by colonies of Phaeocystis were the most common (see figure 5). Degerlund and Eilertsen (2010) also showed that one of the most frequently found taxa before the spring bloom were diatoms and in particular pennate diatoms. This result also matches the findings of Kubiszyn (2017) that showed a high abundance of pennate diatoms in the winter community in Adventfjorden, Svalbard. Degerlund and Eilertsen (2009) investigated the most common orders in northern Norway in their study, and they correspond to the most common taxa found in this study, Phaeocystis and Diatoms. The diatoms, that dominated the sediment trap samples in this study in April and also dominated the samples of Degerlund and Eilertsen (2010), were Chaetoceros followed by Skeletonema. This composition can also be found in other studies such as Eilertsen (1981) and Kubiszyn (2017) that both shows that Phaeocystis and Diatoms are the most abundant taxa's during the spring bloom. Based on the good agreement of the species composition in the above presented studies based on suspended samples and the dominance of these species in sediment traps, it must be assumed that the most dominant diatoms in the water column are also the species that contribute most to the vertical flux.

The cell flux follows the same pattern as the chlorophyll a flux with as strong increase from the first to the second sampling. Some deviation can be seen at the different depths (see figure 4) that does not correspond with the chlorophyll a measurements. It should in these cases be taken into account that this method of counting the abundance of phytoplankton is good for seeing the abundance of taxa but the chlorophyll a content of phytoplankton cells can vary (Kruskopf and Flynn, 2005) and thus deviation between both flux measurements need to be taken into account.

Comparing the results of the chlorophyll a flux to other fjords in northern Norway shows similar concentrations in Kaldfjorden. Noji et al. (1993) found that the chlorophyll a flux at 30 m in December in Ramfjorden was approximately 0.15 mg m^{-2} d^{-1}. This is slightly higher than found in Kaldfjorden during February, 0.08 mg m^{-2} d^{-1} (see figure 2b) in the sediment traps without filtered seawater and 0.07 mg m^{-2} d^{-1} (see figure 2b) in the ones with filtered seawater. Reigstad et al. (2000) found that the concentrations in Balsfjorden was approximately 3 mg m^{-2} d^{-1} at 40 m, which are a bit lower than the ones found in Kaldfjorden at 30 m (5.65 mg

m^{-2} d^{-1} for the sediment traps without filtered seawater and 3.86 mg m^{-2} d^{-1} in the ones with filtered seawater). Thus, in general there was a good agreement of the chlorophyll a fluxes in Kaldfjorden with those reported in literature.

The difference between the two types of traps, filtered and unfiltered, can be seen in both February and April (Figure 2b). The traps deployed without the filtered seawater had a higher chlorophyll a flux compared to the traps with filtered seawater, during February, but the chlorophyll a flux was also low and thus the difference was not considerable. Potentially, the storage time of the filters could however have had an effect on the results in February as the filters from the sediment traps with filtered seawater was analysed instantly while the filters from the sediment trap with seawater was stored in the freezer for approximately three weeks. A study by Wasmund et al. (2006) shows that the immediate extraction gives the most reliable result and that filters stored for a longer period can lose some of its content. The difference between the two traps could therefore have been more considerable if they have been analysed with the same method. This however does not affect the comparison between the traps in April as all the samples from the sediment traps and the suspended water samples were stored in the freezer for about four weeks.

The traps in April also showed a larger chlorophyll a flux in the sediment traps without filtered seawater (see fig. 2). The difference between the traps was considerable at this sampling as higher fluxes was collected. It is so far unclear, what caused this effect, but there some possible explanations. The higher chlorophyll a concentration in these traps might be because of the density difference of the water inside and outside the traps. The higher density inside the traps may create a barrier at the top of the trap that prevents a lot of the smaller grazers such as microzooplankton to enter the trap and feed on the plankton, but it might also create a layer of phytoplankton on the top of the trap that do not sink through this barrier before the grazers consume them or they get carried away by currents or waves. Alternatively, the filtration of the seawater can also have contributed to the lower results. The seawater in the sediment traps with filtered seawater was cleared from all of the cells and other organisms larger than the filter size while the traps that filled up with seawater as they were deployed in the fjord were filled with the content of the fjord and most likely a number of phytoplankton. It should here be taken into consideration that the sampling was only done at two occasions. A follow-up study where more traps were deployed at multiple occasions could confirm or change the result of this study. These results could be useful when comparing different studies as different researches uses different methods where some fill their traps with filtered seawater and some

do not (Reigstad et al. 2008, Wiedmann et al. 2015 vs. Juul Pedersen 2006). It would therefore be a good idea to know the difference between the two methods and how much the different methods affect the results.

The difference between the sediment traps and the suspended water samples shows that leaving the traps in the fjord for 24 hours collect a significantly larger quantity of POC than collection water samples the same day. The difference between these traps shows how much POC that descend in the fjord every day at this particular location. It should however be taken into consideration that the suspended water samples and the sediment traps were deployed at different depths. But the difference can be seen at 30 m where both the suspended chlorophyll a concentration and the chlorophyll a flux was measured. The chlorophyll a concentration in the Niskin was only 1.77 Chl a mg/m^3 at this depth while the filtered seawater trap collected 12.73 mg/m^3 and the trap without filtered sea water collected 9.3 mg/m^3. That means that these differences have happened during the 24 hours that the traps where deployed. This is expected since the phytoplankton community is in the middle of the spring bloom and a lot of the organisms will sink downwards in the water column if they do not get eaten by grazers or other animals.

7. Conclusion

The difference in season can be seen clearly in Kaldfjorden when looking at the results in this study, both in the change of chlorophyll a concentrations, the chlorophyll a flux and in the distribution of taxa in the exported phytoplankton community. The samples taken in February showed low, homogenous concentrations of chlorophyll a and chlorophyll a flux which can be explained by a mixed water column while a spring bloom could be seen in the samples taken in April when the water column was more stratified. This study also showed that the most common taxa in the vertical flux in February was pennate diatoms while this changed to centric diatom chains and Phaeocystis during the spring bloom in April. The sediment traps without the filtered seawater showed the higher levels of chlorophyll a in both February and April which can be explained by the increased salinity in the sediment traps with filtered seawater. In addition, the sediment traps without filtered seawater was filled with seawater as they were deployed in the fjord that contained phytoplankton.

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9. Appendix

Supplementary Table 1: Example of table with sampling data for the sediment traps. The date the samples were taken, type of sample, depth of the traps, the values before adding HCl (Rb), the values after adding HCl (Ra), the concentration of Chl a, the mean concentration of Chl a, deployment time, Flux during the deployment time and the mean flux.

Date	Sample	Depth (m)	Rb	Ra	Rb-Ra	Chl a (mg/m^3)	Mean Chl a (mg/m^3)	Deployment (d^-1)	Flux (mg m^-2 d^-1)	Mean flux (mg m^-2 d^-1)
2018-05-05	Filtered seawater	20	289	119	170	16.67		1.0625	6.94	
2018-05-05	Filtered seawater	20	294	119	175	17.16		1.0625	7.14	
2018-05-05	Filtered seawater	20	318	132	186	18.24	17.36	1.0625	7.59	7.23
2018-05-05	Filtered seawater	30	351	161	190	9.32		1.0625	3.88	
2018-05-05	Filtered seawater	30	343	157	186	9.12		1.0625	3.80	
2018-05-05	Filtered seawater	30	357	165	192	9.42	9.29	1.0625	3.92	3.86
2018-05-05	Filtered seawater	50	346	162	184	9.02		1.0625	3.76	
2018-05-05	Filtered seawater	50	319	154	165	8.09		1.0625	3.37	
2018-05-05	Filtered seawater	50	314	159	182	8.93	8.68	1.0625	3.72	3.61