Project information

Keywords
Carbon flux, Pelagic processes, Protists, Biological carbon pump, Sea ice cover, Svalbard

Project title
Carbon flux dynamics in ice-free versus ice-covered Svalbard fjords-Exploring the effects of sea ice variability on the downward flux of biogenic particles

Year
2018

Project leader
Janne E. Søreide

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Kongsfjorden mooring: 78o57.76'N 11o47.93'E; Rijpfjorden mooring: 80o17.223'N 22o15.455'E

Participants

Janne E. Søreide (University Centre in Svalbard)
Gérald Darnis (Université Laval)
Jørgen Berge (UiT The Arctic University of Norway and University Centre in Svalbard)
Philipp Assmy (Norwegian Polar Institute)
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Finlo Cottier (Scottish Association of Marine Sciences and UiT The Arctic University of Norway)

Flagship
Fjord and Coast

Funding Source

380 kNOK Fjord and Coast Flagship

Summary of Results

We compared the sinking flux of biogenic matter in 2 Svalbard fjords (Kongsfjorden and Rjipfjorden) with contrasting environmental conditions especially with ice cover, analysing the sediment trap samples deployed in the Svalbard moored observatory program. The annual cycle 2016-2017 was cold and had a long-lasting ice cover in Rijpfjorden, which made an informative contrast with 2015-2016, a warm year with little ice-cover (sea ice formed first in April). The following 3 hypotheses were tested and we summarize our main findings below:

Hypothesis 1: *Sea ice influences sinking flux through a control on pelagic and sympagic primary production.*

The hypothesis was confirmed. There were observed a higher proportion of pennate diatoms (incl. the

ice-obligate *Nitzschia frigida*) in the vertical flux in the seasonal ice covered Rijpfjorden versus the warmer, ice free Kongsfjorden (Figure 1).

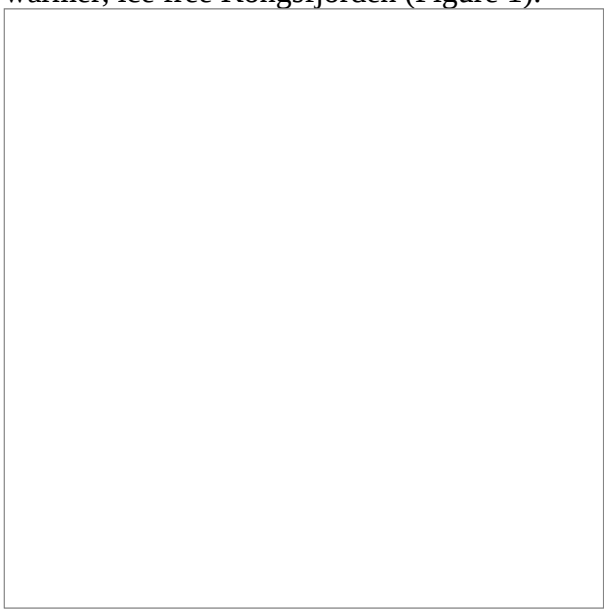

Figure 1. Sinking flux at 100 m depth of protists in Kongsfjorden and Rijpfjorden throughout the annual cycles 2012-2013, 2013-2014 and 2015-2016.

Hypothesis 2: *Sea-ice cover duration affects timing, magnitude and nature of sinking flux.*
The hypothesis was confirmed. In the warmer year 2015-2016 the timing of the spring bloom in the two fjords were rather small (2 weeks), while in the colder more ice-rich year 2016-2017 the spring bloom in Rijpfjorden was delayed by .

Rijpfjorden the spring bloom followed the sea-ice breakup, leading to a respective delay by 2.5 months compared to Kongsfjorden (Figure 2).

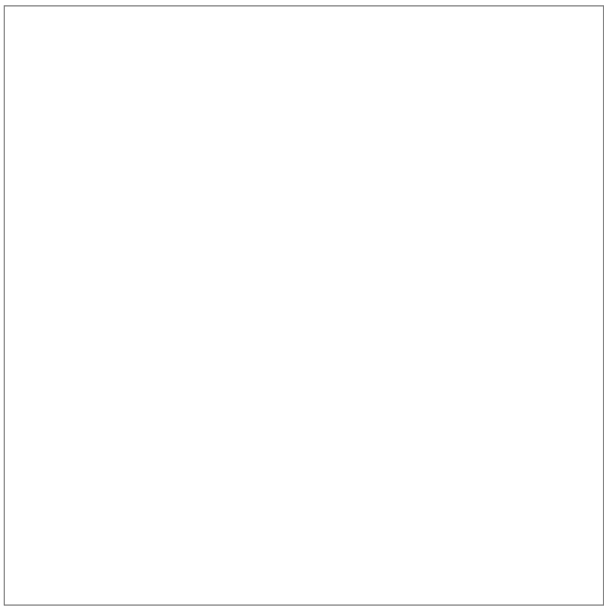

Figure 2. Time series of normalized fluorescence and PAR measurements at respective mooring sites.

Total particle matter (TPM) and particle organic matter (POC) flux was overall higher in Kongsfjorden than in Rijpfjorden (Table 3). Total annual TPM flux remained similar high for both years in Kongsfjorden whereas in Rijpfjorden TPM flux was 3 and 6 times lower, respectively for consecutive years. Surprisingly, the summer flux was very low in both fjords, both years and we are currenly investigating the possibility of hydrograpgical features like upwelling explaining this somewhat unexpected low flux values. This will be done by looking into the ADCP data and vertical velocity and are currently under analyses.

Hypothesis 3: *Variability in the intrusion of Atlantic Water dictates nature and magnitude of sinking flux* by *modulating the community composition of primary producers and consumers.*

This hypothesis was also confirmed. The spring 2016, Kongsfjorden experienced a strong diatom bloom, while in in spring 2017 the spring bloom mainly comprised of *Phaeocystis pouchetii.* Similarly high chlorophyll a biomass and productivity was found both years (Clara Hoppe pers. communication), but the magnitude of the vertical flux differed between the years with less in 2017 versus 2016 (Table 3).

Master and PhD-students involved in the project

Steffen Swoboda (defended his thesis in June 2018)

For the Management

[Norwegian] Den biologiske karbon-pumpen er svært viktig og i dette prosjektet studerer vi mengden og sammensetningen av organisk materiale i overflate-laget som synker ut og ned til dypet. Vi undersøker to ulike fjorder på Svalbard : den varme, isfrie Kongsfjorden og den kalde vinterisdekte Rijpfjorden hvor det siden tidlig 2000-tallet har vært plassert havobservatorier utstyrt med fysiske og biologiske instrumenter, samt sedimentfeller på 100 m dyp. Vi ser tydelige sesongvariasjoner i karboneksporten i årene 2015-2017 med en stor eksport topp koblet til våroppblomstringen. I Kongsfjorden ser vi at det er vesentlig høyere eksport når kiselalger dominerer sammenlignet med når *Phaeocystis pouchetii* dominerer. I den mer arktiske Rijpfjorden ser vi i tillegg en relativt stor andel pennate kiselalger som er kjent for å vokse i sjøis. Rijpfjorden har derimot mye lavere karboneksport sammenlignet med den varmere Kongsfjorden med unntak av når *Phaeocystis* dominerer.I begge fjorder ble det funnet ekstremt lav karboneksport om sommeren noe som er svært overraskende og trenger mer inngående studier. Sammenligning av disse to fjordene gir verdifull kunnskap om evt. effekter av global oppvarming og sjøisreduksjon når det gjelder produktivitet og karboneksport til havbunnen hvor vi har våre viktigste høstbare ressurser (reker) i Svalbards fjorder.

[English] The project multi-year dataset on the export of organic matter from the surface layer of the two Svalbard fjords, Kongsfjorden and Rijpfjorden, highlight the large interannual variability in the magnitude of the sinking export of phytoplankton and ice algae cells in these ecosystems. This variability is bound to influence biological productivity of benthic communities at the seafloor that rely on algal primary production in the ocean surface layer. In the more Atlantic-influenced and ice-free Kongsfjorden, some of this interannual change in particle export can be linked with the occurrence of blooms of *Phaeocystis pouchetii*, a species known to produce chemicals detrimental to other phytoplankton species and plankton. The research results revealed also a recurrent extremely low export of particulate organic matter in summer in the two fjords, a counterintuitive phenomenon that needs to be thoroughly

documented. This work advocates for the continuation of such particle export time series to monitor Svalbard fjord ecosystems responses to the effects of sea-ice decline and other manifestations of climate change.

Published Results/Planned Publications

Darnis, G., Hobbs, L., Geoffroy, M., Grenvald, J.C., Renaud, P.E., Berge, J., Cottier, F., Kristiansen, S., Daase, M., E. Søreide, J., Wold, A., Morata, N., Gabrielsen, T., 2017. From polar night to midnight sun: Diel vertical migration, metabolism and biogeochemical role of zooplankton in a high Arctic fjord (Kongsfjorden, Svalbard). Limnol. Oceanogr. 62, 1586-1605.

Darnis, G., Geoffroy, M., Daase, J., Renaud, P.E., Søreide, J., Cottier, F., M., Berge (in preparation). Downward export of biogenic matter during the transition from polar night to spring in a high-Arctic Svalbard fjord-the key role of zooplankton processes. For Biogeosciences.

Darnis, G., Lalande, C., Swoboda, S., Søreide, J., Cottier, F., Assmy, P., Berge, J., (in preparation). Effects of sea ice on the biogenic carbon export in high-Arctic Svalbard fjords. For Glob. Biogeochem Cycles.

Communicated Results

Since last reporting:

Darnis, G., Lalande, C., Søreide, J., Berge, J., Assmy, P., Swoboda, S., Halsband, C., Cottier, F., 2017. Export fluxes of biogenic particles in the sea ice-free Kongsfjorden and the seasonally ice-covered Rijpfjorden (Svalbard), Arctic Change 2017, Quebec City, 11-15 December.

Darnis, G., Lalande, C., Swoboda, S., Søreide, J., Cottier, F., Assmy, P., Berge, J., 2018. Effects of sea ice on the biogenic carbon export in high-Arctic Svalbard fjords, POLAR 2018, Davos, Switzerland, 15-26 June 2018.

Darnis, G., Lalande, C., Søreide, J., Berge, J., Assmy, P., Swoboda, S., Halsband, C., Cottier, F., 2018. Export fluxes in Svalbard fjords: an insight into the influence of sea ice on the sinking flux of biogenic matter Arctic Frontiers 2018, Tromsø, Norway, 21-26 January 2018.

Upcoming presentations:

Darnis G., T. Dezutter, J. Søreide, C. Lalande, P. Assmy, F. Cottier, L. Fortier and J. Berge. (2018). The influence of sea ice on the protist sinking export in high Arctic systems. ArcticNet annual meeting, 10-14 Dec, Ottawa (oral presentation)

Presentation of new paper at the ASLO 2019 Aquatic Sciences Meeting, for which the authors of the first contribution of our flagship project published in L&O were invited to present further research advances in an ASLO spotlight session. So, the title submitted for this session is:
Darnis G., M. Geoffroy, M. Daase, J. Søreide, S. Swoboda, F. Cottier, P. E. Renaud, J. Berge. (2019). The key role of zooplankton processes in the export of biogenic matter during the transition from polar night to spring in a high-Arctic marine system. ASLO 2019 Aquatic Sciences Meeting-PLANETWATER Challenges and Successes, 23 Feb-2Mar, San Juan (oral presentation).

Master thesis:
Swoboda S (2018) The annual cycle of particle flux in sea ice influenced and ice free Arctic fjords. Master thesis, The University Centre in Svalbard and the University of Gothenburg, 35 pp

Interdisciplinary Cooperation

The project includes marine biologists specialised in phyto- and zooplankton biology, a physical oceanographer and a specialist in marine sinking particle flux.

Budget in accordance to results

Yes

Could results from the project be subject for any commercial utilization

No

Conclusions

The project is in its final year and the plan is to submit the two manuscripts we are currently working on in early spring 2019. The project has been successful and the third year made it possible for us to analyse an additional year of the long-term sediment trap samples which have been very valuable since it captured new aspects, important for predicting future changes in vertical flux as the climate warms and changes in the primary production regime occur. We are very enthusiastic about the data analyses so far in the two manuscripts we are currently working on. Our last year published results in this project (Darnis et al. 2017) have

been of large interest in the international science community and this paper has been one of the most downloaded paper this year in the highly ranked journal Limnology and Oceanography.