FAABulous: Future Arctic Algal Blooms – and their role in the context of climate change

Research project 2015-2020, funded by the NRC

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Forskningsrådet

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The aim of the FAABulous project is to understand how Arctic marine algal blooms in sea ice and water will change as a response to climate warming.

Background

Environmental conditions in the Arctic are currently changing at an unprecedented rate. Most prominently, temperature rise leads to a decrease in sea ice cover and thickness, resulting in a fundamental increase inthe amount of light in the water. This has far-reaching implications for Arctic marine ecosystems. Algae living in sea ice and water are key in the coupling of environmental changes to ecosystem structure and function. Through photosynthesis the algae utilize sunlight to build up the entire biomass that the ecosystem is based upon. The algae serve as food source for small crustaceans that then are fed upon by fish, seabirds and others. They also remove CO_2 from the atmosphere.

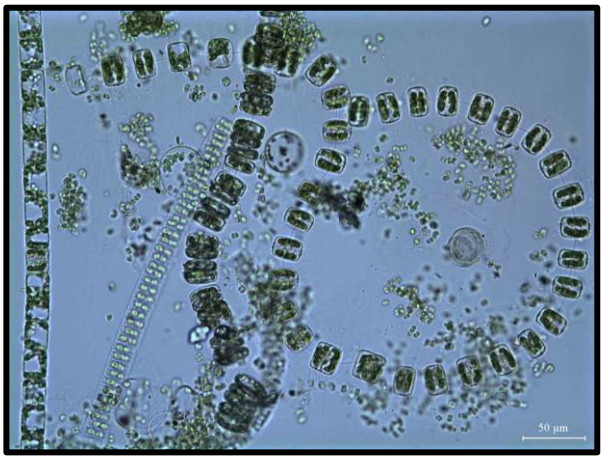


Fig. 1: Chains of algal cells under the microscope. These organisms constitute the basis of the Arctic marine food web.(From a spring bloom in Kongsfjorden, 2003)

Because the algae are so dependent on light and nutrients, their seasonal development is controlled by the changes in temperature and light conditions throughout a year (see Fig. 2) – and it changes immediately in response to alterations of these factors.

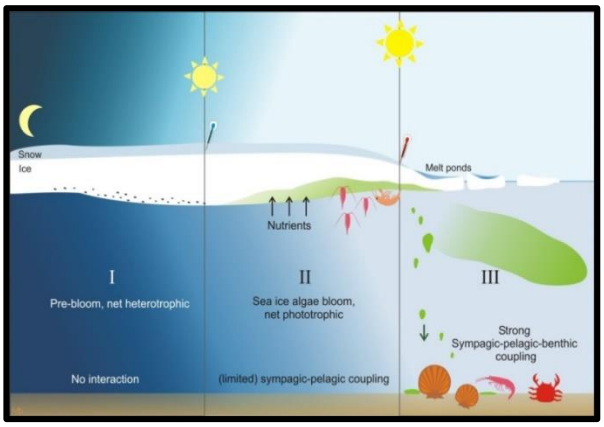


Fig. 2: Seasonal development of algae blooms in sea ice and water during the transition from winter (I) to early summer (III) (Leu et al. 2015)

Research questions

- How will the timing, duration and quantity of these algal blooms develop under the changes in sea ice conditions we observe?
- How will the increased CO_2 concentration in the atmosphere and ocean affect their physiology?
- How will the species composition of Arctic algal blooms change if more temperate species are transported to the Arctic, and can they survive there because of increased temperatures?

Research approach

To address such complex questions, we combine three different approaches:

Field observations

We have chosen two very different fjord systems on the west coast of Svalbard: **Kongsfjorden** that has been almost completely ice-free during the past decade, as a consequence of strong inflow of warm Atlantic water year-round, and **Van Mijenfjorden** where an island at the fjord mouth prevents the warm water to enter the fjord, resulting in lower water temperatures, and, usually, a relative extensive coverage with sea ice.

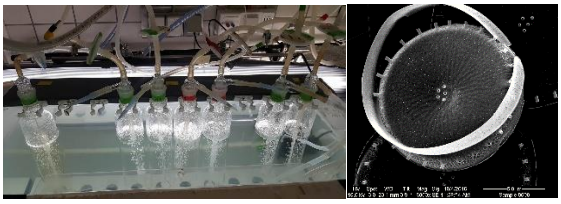
Fig. 3: Kongsfjorden (upper) and Van Mijenfjorden (lower) in western Spitsbergen

By combining continuous measurements from ocean and sea ice observatories with regular sampling campaigns, we obtain detailed data about the seasonal changes of the environmental conditions and the algal development in these systems.

Unfortunately, however, the ongoing warming has been so dramatic since the project started in 2015 that we have severe difficulties to carry out the sampling program as planned. Due to exceptionally high winter temperatures in the Arctic, the sea ice formation in Van Mijenfjorden reduced so strongly that we had to postpone our main campaign by one year.

Laboratory experiments

To test in a controlled setting how either algal communities or single key species will respond to future environmental conditions, we perform different experiments in the laboratory, simulating light stress, high CO_2 levels or other aspects of future Arctic scenarios. Then we measure the responses of the algae and try to understand why some species are better prepared to withstand the coming changes than others.



Example of experimental setup in the laboratory (left) and an algal cell (diatom) seen under the electronmicroscope (right)

Modeling

In order to understand how changes in sea currents, wind and temperature conditions affect the two fjord systems, one group of researchers in our project is developing a high-resolution 3D-model of the western Spitsbergen coast. To make sure that the model is capable of reproducing real scenarios, we compare it with historical data that we and our partners have collected from these fjords. Afterwards, we can test different scenarios and use the model to see how they will impact ice formation and bloom timing in the fjords.

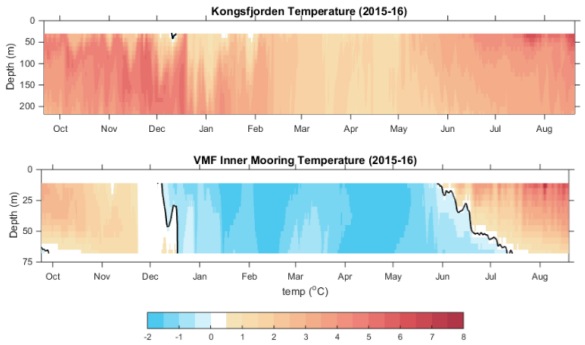


Fig. 4: Continuous temperature profiles measured in Kongsfjorden (upper panel) and Van Mijenfjorden (lower panel) 2015-2016. Water in Kongsfjorden was warmer than 0°C year round!

What do we hope to learn?

This project will improve our understanding of how changes in the environment alter algal blooms in the Arctic. This will help us to:

- Improve models that predict future productivity in Arctic seas
- Predict potential consequences for the marine food web in the Arctic
- Increase our understanding about feedback mechanisms of algae onto their environment, in particular sea ice. This aspect has been more or less neglected in global models so far.

All this will contribute to create a knowledge base for a sustainable management of human activities in the Arctic.

Why is this such a 'hot topic' right now?

Researchers working in the Arctic, and in particular in the Svalbard region, have been witnessing temperature increases and changes of sea ice conditions during the past 10-20 years that exceed model predictions and expectations from most experts. In fact, the fjords in this region at 78-80°N now change so fast that it is challenging to carry out research projects as planned.

Not much sea ice to study here anymore …

Project facts and collaborators

FAABulous was funded by the Research Council of Norway under the OKOSYSTEM program and received 16.3 million NOK. It is led by Akvaplan-niva, and runs from 2015 to 2019. Collaboration partners are UNIS, UiT The Arctic University of Norway, Nord University, NIVA, Alfred-Wegener-Institute (AWI), Max-Planck-Institute for Meteorology, Scottish Association of Marine Sciences (SAMS), and Institute of Oceanology, Polish Academy of Science (IOPAS).

For more information, see also: http://mare-incognitum.no/index.php/faabulous

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