Sea ice

We are on the cusp of a paradigm shift from “nothing happens in frozen environments” to “even winter sea ice is a dynamic microbial ecosystem capable of affecting the rate of Arctic climate change.”

As climate continues to warm and winter sea ice is thinner and warmer, with more new sea ice forming in winter, various microbial activities are expected to accelerate. Sea ice is known to be home to unique ecosystems of cold-adapted microbes (and their viruses), which can be expected to change in response to global warming. Sea ice microbial processes greatly affect elemental cycling and regulate primary production in polar environments.

During ice cover, the propagation of light to the underside of the sea ice is strongly impeded due to backscattering and attenuation, primarily in the snow cover, but also within the sea-ice matrix. In addition, sea ice affects wind-induced upwelling of nutrient-rich water to the photic zone.

Recently, we have shown that processes in sea ice are much more complex than previously anticipated. Freezing and melting processes create a highly heterogeneous distribution of gases within the ice matrix. Sea ice consists of inclusions of frozen freshwater, brine, and solid salts. When sea ice freezes, the gases dissolved in the water are either released into the brine or trapped in bubbles. Hence, super-saturated oxic conditions prevail in the brine as the sea ice consolidates. During winter, the brine concentration decreases due to gravity drainage. When sea ice melts, under-saturated and anoxic water is added to the brine. Bacterial O_2 consumption in the brine system during this period ensures development of anoxic microsites; we were able for the first time to detect and quantify rates of the anaerobic bacterial processes of denitrification and anaerobic ammonia oxidation (anammox) rates in meltwater of sea ice.

The role of ice-covered oceans in the CO_2 balance has been largely ignored because sea ice is assumed to impede gaseous exchange with the atmosphere. However, sea ice itself is permeable when warm enough and can support gas exchanges. In addition, we have recently shown that physical and chemical processes in the sea ice itself may act as an important control on pCO_2 levels of the sea surface in Arctic Seas.

The focus is to examine the role of sea ice on physical, chemical and biological conditions in Arctic marine systems. This approach will

- Provide detailed information of the magnitude and regulation of bacterial and algal activity in sea ice
- The influence of algal activity and chemical processes on pH in sea ice and surface waters
- Determine the composition and distribution of gases and nutrients in sea ice
- Quantify and understand chemical transformations in sea ice
- Understand permeability of sea ice to gases, salts and nutrients
- Understand the seasonal variation in fluxes of gases above and below sea ice
- Understand the effect of sea ice growth and melt on atmospheric CO_2 uptake
- Enable us to integrate this information to global processes and models.

Researchers affiliated with Sea Ice Research:

Søren Rysgaard   Lorenz Meire   Dan Carlson   Arctic Science Partnership

Photos: Søren Rysgaard