

## Project information

### Project title

The role of Sea Ice processes on CO<sub>2</sub> exchange and Calcium Carbonate saturation levels - SICCA

### Year

2012/2013

### Project leader

Agneta Fransson, NPI

### Participants

#### Project leaders:

- Agneta Fransson (NPI) and Melissa Chierici (IMR)

#### Participants:

- Mats Granskog (NPI), Daiki Nomura (NPI)
- Evgeniy Yakushev (NIVA)

### Flagship

Ocean acidification, Theme: Understanding the physical and chemical mechanisms controlling ocean acidification in Arctic waters - past, present and future

### Funding Source

Fram Centre (Ministry of the Environment and Ministry of Fisheries and Coastal Affairs), in kind

### Summary of Results

- First study of sea-ice and water carbonate system along a gradient from glacier front to the sea-ice edge in a Svalbard fjord (TempICE). The influence of oceanic water and glacier ice melt was investigated. Preliminary results show that glacier meltwater contribute to excess total alkalinity in both sea ice and surface water, resulting in a higher calcium carbonate CaCO<sub>3</sub> (higher pH and lower pCO<sub>2</sub> relative to outer part of fjord) closest to the glacier front. This means that glacier meltwater has the potential to limit OA and has an effect on sea-air CO<sub>2</sub> fluxes.
- First CaCO<sub>3</sub> crystals (ikaite) found in sea ice north of Svalbard in 2011 - may have implications for CO<sub>2</sub> flux and ocean acidification during ice melt due to excess alkalinity left in the ice at CaCO<sub>3</sub> formation
- Publication Nomura et al, submitted for peer-review 2012, on ikaite crystals in Arctic sea ice (Annals of Glaciology, in press, Nov 2012)
- First study of the carbon system in sea ice, aiming at estimating the export of inorganic carbon and total alkalinity in sea ice from the Arctic Ocean through the Fram Strait and north of Svalbard 2012. Preliminary results show that the sea ice was depleted in carbonates relative to salinity, implying that largest part of inorganic carbon is released in the Arctic Ocean before exiting Fram Strait.
- First direct CO<sub>2</sub> fluxes from sea ice were measured north of Svalbard, in May 2011 (Nomura et al., in preparation)

### Published Results/Planned Publications

#### **Peer-review papers:**

##### *Published results:*

Nomura et al., 2012, Ikaite crystals in Arctic first-year sea ice, Annals of Glaciology, in press.

#### **Planned publications/in preparation:**

Fransson et al., Export of sea-ice inorganic carbon from Arctic Ocean: implication for ocean acidification.

Fransson et al., Impact of glacier meltwater on the carbonate system in ice and water and on ocean acidification in a Svalbard fjord.

Fransson et al., Seasonal impact of sea-ice processes on calcium carbonate saturation in the East Greenland Current.

Nomura et al., CO<sub>2</sub> fluxes from first-year Arctic sea ice.

#### **Conference abstracts 2012:**

Fransson, A., M. Chierici, L.A. Miller, G. Carnat, E. Shadwick, H. Thomas, T.N. Papkyriakou., Effect of sea ice and brine rejection on the CaCO<sub>3</sub> saturation state in the Amundsen Gulf, Arctic Ocean, presented in session: "Biogeochemical consequences of ocean acidification and feedbacks to the Earth system", posted two days and presented 24th and 25th September between 17:30 to 19:30.

Nomura, D., Granskog, M., Assmy, P., Nehrke, G., Hu, Y., Fischer, M. and Dieckmann, G. Characterization of ikaite (CaCO<sub>3</sub>\*6H<sub>2</sub>O) crystals in first-year Arctic sea ice north of Svalbard: Crystal size and melted-ice total alkalinity, International Symposium on Seasonal Snow and Ice, 28 May - 1 June 2012, Lahti, Finland. (poster)

Nomura, D. M.A. Granskog, D. Simizu, Y. Kodama, G. Hashida, P. Assmy, M. Fukuchi, and N. Koc. Antarctic and Arctic flooded sea ice acts as a sink for atmospheric CO<sub>2</sub> during spring and summer. SOLAS Open Science Conference, 7-10 May 2012, Cle Elum, Washington State, USA (poster)

Communicated Results

### **Conferences/workshops 2012**

- IPY2012-Montreal “From knowledge to action”, 22-27 April 2012, Montreal, Canada
- The Third International symposium on the Ocean in a high CO<sub>2</sub> world, 24-27th September, Monterey, USA
- International Conference on seasonal ice and snow, 28 may – 1 June 2012, Lahti, Finland
- SOLAS Open Science Conference, 7-10 May, 2012, USA.
- OA Flagship meetings
- SICCA: Status report and presentation (Fransson et al.) at two OA Flagship meetings in April and September 2012.

### *Public presentations*

- Vaardal-Lunde,J., Chierici, M., and A. Fransson: “Lance in Fram Strait 2012”movie for public use to enhance awareness of the procedure in the field to sample and investigate for several scientific issues such as: ocean acidification, sea-ice physics and chemistry, and methodology.
- Chronicle in Fram Forum magazine ” Ocean acidification in high-latitude oceans – Does the Arctic turn acid? – Towards understanding ocean acidification in the Arctic ” submit in 2012

Interdisciplinary Cooperation

The project has had great benefit of the large collaboration between the natural science disciplines. In particular, inter-disciplinary cooperation between chemical and physical oceanographers offers a wide range of knowledge and contribution to the project, especially regarding the water column studies in the fjord. Only positive aspects. On the ICE expedition, we also collaborated with biologists regarding primary production in the ice and nutrient availability. For all studies of the sea ice, we have collaboration with biologists regarding nutrients availability and consumption in the sea ice, brine, snow, and underlying water. Only positive aspects.

### ***Disciplines involved in the project***

- Physical oceanography (water column studies such as stratification, water mass)
- Chemical oceanography (carbonate system and OA state in water column)
- Glaciology (Biogeochemistry in sea-ice, ice-water interactions and glacier melt water influence). Formation of CaCO<sub>3</sub> crystals in sea-ice
- Atmospheric science: CO<sub>2</sub> flux at the (air-ice/snow interface)

For the Svalbard fjord study, the planned sea-ice biology component regarding bacteria and phytoplankton was cut out due to difficult sea-ice conditions during a warm 2012. Infrastructure and logistical difficulties. Hope to include the biological part in 2013 if funding accepted.

Budget in accordance to results

The funding was used to support two major field activities which could not have been performed without the funding. It also supported sampling and analysis of several chemical parameters which are used as tracers for water mass composition. Field work, travel costs for personal and instrumentation, field equipment (partly), purchase of CO<sub>2</sub> sensor (SICCA+OAstate, 2012), certified reference material, chemicals, sampling bottles.

The Fram Center funding supported and boosted activity within the ICE centre by facilitating the incorporation of sea-ice chemistry during the ICE expedition in July 2012.

Could results from the project be subject for any commercial utilization

No

Conclusions

### ***Future research:***

- a) Include biological parameters for sea-ice system studies. Planned for the Lance DRIFT-ICE expedition 2013/2014.

b) Add chemical and biological sensors to moorings for use under the sea ice to investigate diurnal and seasonal variability in sea-ice dynamics and biogeochemical drivers of carbon flux. Need to optimize flux chambers of other greenhouse gases than CO<sub>2</sub>, such as CH<sub>4</sub> and di-Nitrogen Oxide (N<sub>2</sub>O).