

To the interface and beyond: Results and legacy of SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces

by Lisa A. Miller

This is a story that began with the Fram Expedition of 1893–96. Well, perhaps it's not necessary to go back that far. Instead, let's start in 2009, when a group of people interested in sea ice convened a session at the Open Science Conference of the Surface Ocean–Lower Atmosphere Study (SOLAS) in Barcelona, Spain. At that time, the new field of sea-ice biogeochemistry was exploding. Scientists working at both poles had discovered that sea ice contained extremely high concentrations of dimethyl sulfide (DMS), that inexplicably large quantities of CO₂ were moving in and out of the ice, and that changing sea-ice structure, as well as distributions, was impacting polar primary productivity. It had become clear that sea ice plays a much larger role in the biogeochemical cycles of climatically important compounds than had previously been thought. However, at the same time, we were painfully aware that the global community did not have the capacity to effectively study biogeochemical processes occurring within the ice. Thus in Barcelona, the idea was hatched to form an international working group focussed on sea-ice biogeochemistry, and with additional support from the European Union, through a COST Action 735 workshop held in Amsterdam in April of 2011, a successful working group proposal was prepared for the Scientific Committee for Oceanographic Research (SCOR).

The original SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces ([BEPSII](#)) included 10 full members, myself as a PICES-supported associate, and 26 other associate members. Over the subsequent four years, the mailing list expanded to include nearly 100 interested scientists. The Working Group was organized around three task groups focussed on what we felt were the most critical problems facing the community:

1. **Methodologies and intercomparisons** This task group published a treatise on the methods used to study sea-ice biogeochemistry, including best practices and recommendations for future method development (Miller *et al.*, 2015). We also designed intercalibration experiments and facilitated their opportunistic implementation during field expeditions.
2. **Data** The primary goals were to compile existing data sets and develop standardized protocols for recording and archiving sea-ice biogeochemical data. Data compilations were completed for chlorophyll (Meiners *et al.*, 2012) and iron (Lannuzel *et al.*, 2016), and efforts are still underway for inorganic carbon, nutrients, and particulate organic carbon. We also developed standardized data sheets for documenting [sea-ice biogeochemical parameters](#).
3. **Modelling** In a concerted effort to facilitate the productive exchange of information and ideas between observationalists and modellers (Steiner *et al.*, 2016), this task group has published a series of articles documenting what is and is not known about biogeochemical processes occurring in sea ice and their relevance on regional and global scales (Vancoppenolle *et al.*, 2012; Bowman, 2016; Grimm *et al.*, 2016; Moreau *et al.*, 2016).

Many of these reviews, as well as a number of papers on the results of specific experiments, expeditions, and model implementations are being published in a [BEPSII special issue](#) of the journal *Elementa: Science of the Anthropocene*.



Characterizing the sea ice off Cape Evans, Southern Ocean, November 2012. Photo credit: F. Fripiat.

As SCOR Working Group 140 was winding down, it became clear that the group was not ready to disband. Quite to the contrary, we found that once we had figured out how to resolve our methodological inconsistencies, document our data properly, and actually talk to each other, we were ready to tackle some real scientific questions together. Therefore, with encouragement from both SOLAS and the Climate and Cryosphere program (CliC), BEPSII has evolved into a larger, long-lived consortium that will continue working together to understand the role of sea-ice biogeochemistry in the global system, including building capacity in the scientific community and developing new approaches. The first meeting of this expanded BEPSII consortium coincided with the final meeting of SCOR Working Group 140 in Paris during March 2016. In addition to our SOLAS and CliC sponsorship, BEPSII is now also supported by the

Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC). In addition, SCOR has approved a new working group dedicated specifically to intercalibration experiments for sea-ice biogeochemical methods (Measuring Essential Climate Variables in Sea Ice, ECV-ice).

Going forward, the goals of the expanded BEPSII consortium are to:

- Develop dedicated, consistent methodologies for sea-ice biogeochemical research;
- Establish effective sea-ice biogeochemical data archiving approaches and databases;
- Foster ecological process studies to determine their impact on biogeochemical cycles;
- Foster technological developments towards large-scale, autonomous, and high-frequency sampling of sea-ice biogeochemical parameters;
- Improve the representation and evaluation of sea-ice biogeochemistry in regional and Earth System numerical models;
- Synthesize and integrate observational and modeling efforts; and
- Continually revise and renew scientific foci, teams, and objectives.

These goals are organized among four task groups:

1. *Methodologies and data collation* (leads: Klaus Meiners, Klaus.Meiners@aad.gov.au and Lisa Miller, lisa.miller@dfo-mpo.gc.ca);
2. *Modelling and observational process studies* (leads: Hauke Flores, Hauke.Flores@awi.de, and Nadja Steiner, nadja.steiner@canada.ca);
3. *Syntheses and outlook* (leads: Delphine Lannuzel, Delphine.Lannuzel@utas.edu.au, and Martin Vancoppenolle, martin.vancoppenolle@locean-ipsl.upmc.fr); and
4. *Outreach* (leads: Bruno Delille, Bruno.Delille@ulg.ac.be and Letizia Tedesco, Letizia.Tedesco@ymparisto.fi).

Anyone interested in participating in BEPSII is encouraged to contact the relevant task group leaders or the BEPSII Chairs, Jacqueline Stefels (j.stefels@rug.nl) and Nadja Steiner (nadja.steiner@canada.ca).

The next BEPSII meeting will be held in La Jolla, California, on April 3–5, 2017. For up-to-date information, see the [BEPSII website](#) or follow us on Twitter (@BEPSII_seaice).



Participants of the final SCOR Working Group 140 meeting in Paris, March 16-18, 2015. Co-Chairs: Jacqueline Stefels and Nadja Steiner (front row, third and fourth from left); PICES associate, Lisa Miller, middle row, wearing red jacket.

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In summary, the abundance integrated over five years (Fig. 6) states that the JTMD (hence, invasive species) has not washed ashore homogeneously on western U.S. and Canadian beaches. Indeed, JTMD has been found from northern California to Alaska. It is, suggested however, that a large amount of JTMD may have been washed ashore in a relatively narrow area (<1000 km) around Vancouver Island, which might act as a “gate” for invasive species carried by JTMD.

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Thomas Murphy (ThomasMurphy@live.com) is a research technician at Oregon State University's Hatfield Marine Science Center and is a graduate of the University of Miami. He has been involved in maintenance of monitoring equipment as well as collection and cataloging of tsunami debris items for the Oregon Coast.

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Dr. Lisa Miller is a climate geochemist with Fisheries and Oceans Canada and a member of the PICES Section on Carbon and Climate. She studies air-sea exchange of carbon dioxide and other climatically-active substances, including the roles of sea ice and the sea-surface microlayer. She was on the scientific steering committee of the Surface Ocean-Lower Atmosphere Study from 2011 to 2016 and is currently on the BEPSII Steering Committee.