SCAR Fellowship Report 2007-2008

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Institution visited
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Title:
The role of iron as a micro-nutrient to the Antarctic sea ice zone algal community

Objectives:
This project aims at assessing the importance of the trace element iron (Fe) as a micro-nutrient to seasonal sea ice algal communities in the Australian sector of Antarctica.

Methodology
All samples were collected by SCAR fellow Delphine Lannuzel and PhD Pier van der Merwe (UTAS) during an interdisciplinary Antarctic fieldwork expedition on board the *RSV Aurora Australis* in Sept/Oct 2007. The visited stations include both land-fast and pack ice (64-65ºS/116-128ºE) in the winter-spring seasonal transition period. Field collection was achieved under trace metal clean condition using coring equipment fabricated from electropolished stainless steel. Melted ice, snow, brine and seawater were then filtered onboard through 0.2 µm pore size polycarbonate filters to obtain the particulate and dissolved metal fractions, together with an unfiltered aliquot. Dissolved Fe (dFe) and total dissolvable Fe (TDFe) were measured in the home laboratory using flow injection – chemiluminesence (FI-CL) adapted to high gradients of salinity and Fe concentrations.
Sea ice temperature was measured in situ. Ancillary biogeochemical parameters such as Chlorophyll *a* (Chl*a*), major nutrients, dissolved organic carbon (DOC), particulate organic carbon (POC), salinity and ice textures were also measured in collaboration with University of Bangor for all sampled stations.

Preliminary results
Ice textures
Sea ice thickness at our selected sampling sites ranged from 0.35m (station 8) to 1.0m (station 13) thickness. Thin section observations reveal a typical (land-) fast ice structure at station 5. The rest of the collected cores exhibit typical pack ice structure, with granular ice (ie. snow ice and/or frazil ice), underlain by columnar ice. Stations 6, 13 and 14 display a more complex sequence of ice growth processes, probably involving rafting (Figure 1a).

Temperature, salinity and Chla profiles
The temperature profiles scan a whole range of situations that fully characterize the winter-spring transition observed during SIPEX, from the very cold ice with a strong temperature gradient at station 5, to the relatively warm ice of station 11 (Figure 1b). The salinity profiles all exhibit the typical c-shape described in most circumstances in Antarctic first-year ice (Figure 1b).
The increased permeability in the ice cover has drastic consequences for the biological activity, as reflected by the increase in Chl*a* concentrations within the ice cover as spring progresses (Figure 1c) (e.g. Chla concentration ranges are 0.002 - 3.71 µg Chl*a*.l^{-1} at station 5 and 0.62 - 8.39 µg Chla.l^{-1} at station 11).

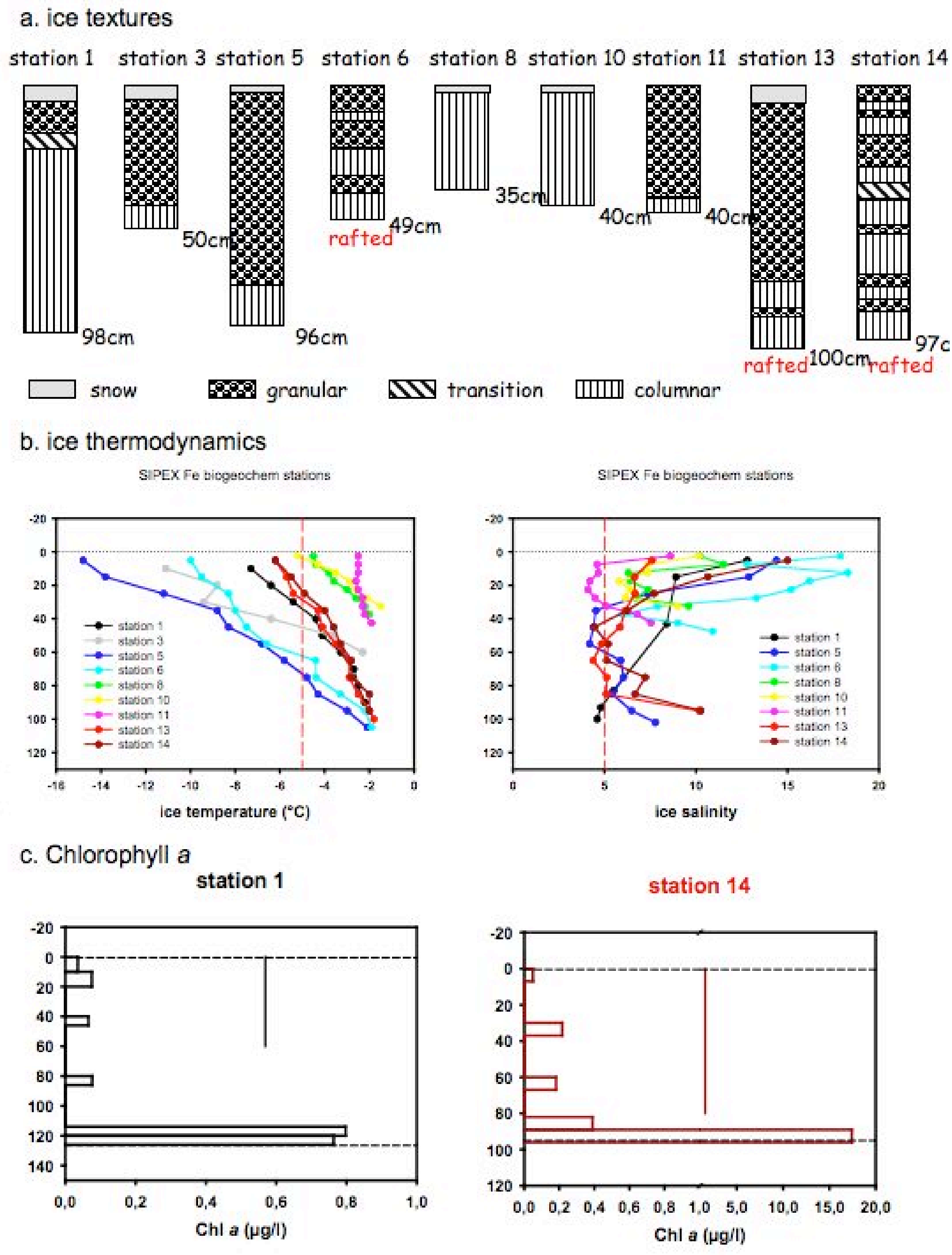

Figure 1. Stations visited during the SIPEX expedition a. ice textures b. Temperature and salinity (the dotted red line indicates the reference –5°C temperature value, above which ice is thought to become permeable profiles) and c. Chlorophyll a

Nutrients (macro-nutrients and iron)

All results for silicates, nitrates, phosphorous and dissolved iron concentrations are presented in van der Merwe et al. (submitted). Briefly, Dissolved Fe (dFe) averaged 2.38 nM across all ice cores (range 0.23 to 14.4 nM) and averaged 0.52 nM in the basal ice of high Chl*a* sites. We also observe a drawdown of dFe as a combination of sea ice melting and biological uptake.

Spatial versus temporal distribution of iron in Antarctic sea ice

When extending the 2007 SIPEX data set to data collected in 2003 and 2005 (Lannuzel et al., 2007; 2008), no clear differences in dFe concentrations were observed between pack ice sampled in East Antarctica and the Weddell Sea, and there were no clear trends in the distribution of dFe and biogenic material between land-fast and pack ice. Contrastingly, we observed a remarkable drawdown of dFe during the spring-summer for all studies. In addition, we observed large inter-annual variations in dFe and organic matter distributions in sea ice collected in the East Antarctic sector between expeditions in late austral winter-spring of 2003 and 2007 (Lannuzel et al., in prep). Variabilities in the water column productivity (e.g., organic matter speciation and concentration), and in the magnitude of the "new" iron supply (e.g., upwelling, lateral advection, delivery from shelf sediments) when sea ice formed could explain the inter-annual differences measured in sea ice (Lannuzel et al., in prep).

Future work

SCAR fellow Delphine Lannuzel was granted a 3-year APD fellowship starting in January 2009 at the Centre for Marine Science (UTAS, Australia).

Polycarbonate (PC) filters (Nuclepore 0.2 µm pore size) retaining particulate metals will be digested in a mixture of strong, ultrapure acids (750 µl 12N HCl, 250 µl 40% HF, 250 µl 14N HNO_3) on a hotplate at 125°C for 12 h. The procedure will be applied to estuarine and river sediment reference materials to verify the recovery of the digestion treatment. The concentrations of particulate metals (e.g. Fe, Mn, Ba, Co, Al, Cu and Zn) will be determined by high resolution ICP-MS at the Central Science Laboratory at UTAS in February-March 2009.

Allocation of SCAR funds

Personnel

US$ 6000 were used to cover living expense for a three months period (January – March 2008) for Dr Delphine Lannuzel. Subsistence allowance for Dr Lannuzel was fundamental to the implementation of this project.

Travel - airfares

Funding from the SCAR (US$ 2500) for one economy class return airfare (Brussels to Hobart) was used to relocate the candidate to Australia.

Publications :

Lannuzel D., Schoemann V., Pasquer, B., van der Merwe, P. Bowie A.R., 2009. Spatial versus temporal forcing: what controls the distribution of dissolved iron in the seasonal ice zone, Geophysical Research Letters, in prep.

van der Merwe, P., Lannuzel, D., Mancuso Nichols, C.A., Meiners, K., Heil, P., Norman, L., Thomas, D., Bowie, A.R., 2009. Biogeochemical observations during the winter-spring transition in East Antarctic sea ice: implications of exopolysaccharides. Marine Chemistry, submitted.