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Early winter pack ice gas properties from the Ross Sea (Antarctica): controls from the physical and biological parameters of the sea ice cover

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This paper presents textural and gas profiles from the Ross Sea pack ice during the early winter (May and June) 1998. Measurements were performed back in the home laboratory (Université Libre de Bruxelles) on samples from ice cores collected during the 98/3 Nathaniel B. Palmer U.S. cruise in the central and western Ross Sea. The cruise was dedicated to a detailed geophysical and ecological study of sea ice along two meridional tracks (180˚ "in" and 175˚E to 175˚W "out") from the Marginal ice Zone (MIZ) to the Ross Ice Shelf front and return. Additionally, a small transect was sampled within the Terra Nova Bay polynya on the way back.

A total of 28 ice stations were visited on a near daily basis. Each of those generally consisted of a 100 to 150 meter transect to measure snow and ice thickness and temperature at a one meter resolution. In addition, three locations were chosen to collect multiple ice cores for a detailed description of the main physical and biogeochemical properties of the sea ice cover (temperature, bulk salinity, textures, total gas content, gas composition, biology including Chla and bacterial counts, POC, DOC…). In this paper, we focus on the spatial distribution of ice textures, total gas content and oxygen concentration in the ice. Ice textures are described from thin section profiles, total gas content was measured using a Toepler pump extraction system and total oxygen (dissolved + bubbles) was obtained from low temperature dry-extraction under vacuum and gas chromatography.

Ice textures show the dominance of columnar-congelation ice in the central part of

the Ross Sea (where the level sea ice is generally thicker) and of granular frazil/snow ice in the marginal Ice Zone and in the Ross and Terra Nova Bay polynyas. This is in accordance with the previous observations from Jeffries and Adolphs (1997). It is, however, somewhat in discordance with sea ice drift observations under winds and currents that should favour dynamical growth (e.g. under rafting and ridging) in these central areas during the winter. We suggest this discordance is linked to a strong bias of the sea ice stations location towards level ice areas. This is indeed confirmed by previously published hourly ship based observations and modelling exercises both indicating a higher proportion of ridging processes in the central Ross Sea.

Total gas content and oxygen concentration are discussed in the light of textural controls, growth processes and autotrophs (algae via Chla) and bacterial standing stocks. Total gas content indicates a clear control of the texture (frazil/snow ice vs. congelation) and of the freezing rate in the columnar congelation ice. Oxygen measurements show a large range of values from undersaturated to supersaturated as compared to sea water saturation values, with a strong control of the temperature profile in the ice. Stations with maximum oxygen concentrations correspond well with the stations with maximum Chla, especially where temperatures are cold (below the threshold for enhanced ice permeability). No relationship could be seen with the bacterial standing stocks. Oxygen vs. Chla shows a clear positive relationship, with a strong increase between 1 and 2 micrograms per liter Chla and supersaturation beyond. There is also a fast “levelling off” of the oxygen concentration with increasing Chla values, suggesting adaptation to hyperoxic conditions.