Impacts of ocean acidification and iron enrichment on phytoplankton assemblages in the Southern Ocean

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Rising atmospheric CO_2 concentration is leading to greater CO_2 uptake by the oceans, resulting in a concomitant decrease in seawater pH (i.e. ocean acidification; Caldeira and Wickett, 2003). Although CO_2 is the primary substrate for algal photosynthesis, it is largely unknown whether or not ocean acidification can promote photosynthetic carbon fixation by marine phytoplankton in situ. In addition, climate change might increase iron supply to surface water from dust deposition in some oceanic regimes (Woodward *et al*., 2005). To clarify the physiological responses of marine phytoplankton to CO_2 and iron enrichments in the Southern Ocean, in-situ bottle incubation experiments were carried out aboard the TR/V *Umitaka-Maru* in Austral summer of 2011/2012. Seawater samples were collected from 15 m depth at the Station C02, C07, D07, and D13 (Figure) with an acid-clean teflon pump system. Prior to incubation, $FeCl_3$ solutions were added into acid-clean incubation bottles in order to reduce iron limitation. Since the Southern Ocean is known to be one of the High-Nutrient, Low-Chlorophyll (HNLC) regions, non-iron-added bottles were also prepared to assess the effects of iron availability on the growth and photo-physiology of the phytoplankton. The incubation experiments were conducted for 3 or 4 days in a laboratory incubator. The HPLC pigment-based estimates of algal community composition using CHEMTAX revealed that haptophytes were predominant at Station C02, and diatoms were predominant at the other stations in the initial phytoplankton assemblages. At the Stations C02 and D13, a biomarker of haptophytes (19'-hexanoyloxyfucoxanthin) decreased in response to rise in CO_2 level at the end of incubation. At the Stations C07 and D07, on the other hand, a biomarker of diatoms (Fucoxanthin) decreased in the high CO_2 treatments relative to ambient CO_2 treatments. In all stations, remarkable increases in the maximum photosynthetic rate (P^{B}_{max}) were observed in response to the iron additions, while CO_2 effect on P^{B}_{max} was not clear. Our results suggest that progression of ocean acidification and iron enrichment possibly regulate the community composition and/or photosynthetic physiology of phytoplankton assemblages in the Southern Ocean, and those can feed back to the biogeochemical carbon cycle and climate change.

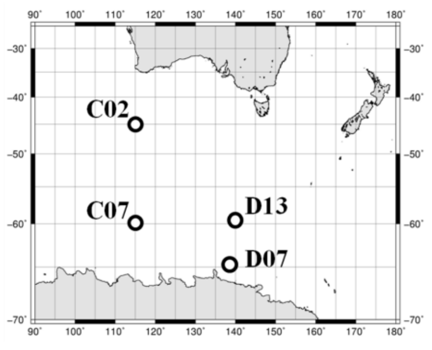

Figure. Sampling sites of seawater for our incubation experiments.

Table. Effects of CO_2 and iron enrichment on phytoplankton pigment concentration and maximum photosynthetic rate (P^{B}_{max}) in our experiments (*t*-test, $p < 0.05$).

Station	Dominant Group	Effects of CO_2 enrichment				Effects of Fe enrichment			
		Chl*a*	Fucox	19'-Hex	P^{B}_{max}	Chl*a*	Fucox	19'-Hex	P^{B}_{max}
C02	Hapto	NS	NS	−	+	+	+	+	+
D13	Diatom/ Hapto	NS	NS	−	−	+	+	+	+
C07	Diatom	−	−	NS	+	+	+	+	+
D07	Diatom	NS	−	NS	NS	NS	−	NS	+

+: positive; −: negative; NS: not significant
Hapto: haptophytes; Chl*a*: chlorophyll *a*; Fucox: fucoxanthin; 19'-Hex: 19'-hexanoyloxyfucoxanthin

References

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Woodward, S., Roberts, D. L., and Betts, R. A.: A stimulateion of the effect of climate change-induced desertification on mineral dust aerosol, Geophys. Res. Lett., 32, L18810, 2005.

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