南極海の酸性化が植物プランクトンに及ぼす影響

服部寛[1]、三島翼[1]、遠藤寿[2]、本川正三[3]、飯田高大[4]、橋田元[4]、鈴木光次[2]、西岡純[2]、田口哲[3]、佐々木洋[5]
[1] 東海大学、2 北海道大学、3 創価大学、4 極地研究所、5 石巻専修大学

Effects of Southern Ocean acidification on phytoplankton

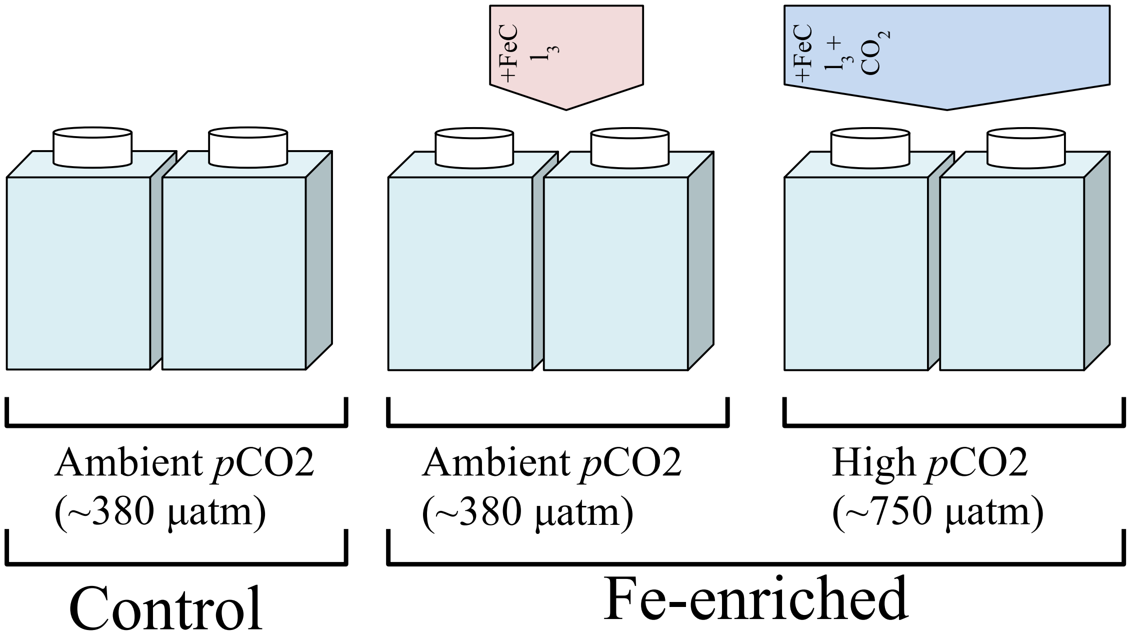
Hiroshi Hattori[1], Tsubasa Mishima[1], Hisashi Endo[2], Shozo Motokawa[3], Takahiro Iida[4], Gen Hashida[4], Koji Suzuki[2], Jun Nishioka[2], Satoru Taguchi[3] and Hiroshi Sasak[5]
1:Tokai University, 2:Hokkaido University, 3:Soka University, 4:NIPR, 5: Senshu University of Ishinomaki

Southern Ocean is one of high biological productive areas in the whole ocean because large amount of primary production is successively occurred in the seasonal sea-ice zone. Predicted acidification in the seawater would affect on the marine food web particularly on the phytoplankton such as diatoms and haptophytes. In the present study, samplings were carried out along 110 ^{o}E and 140^{o}E in the Indian Sector of the Southern Ocean to represent the diatoms biomass and to estimate the acidification effects on the phytoplankton communities during the T/V Umitaka-maru cruise in Austral summer of 2011/2012. This study is made as a part of the 53th Japanese Antarctic Research Expedition (JARE-53). Ocean acidification experiment was carried out 4 times during the cruise. Phytoplankton collected by a clean pump method at 45^{o}S (Stn C02) and 60^{o}S (Stn C07) of 110^{o}E and 50^{o}S (Stn D13) and 64^{o}S(Stn D07) of 140^{o}E were replaced in around 750 µatm of pCO$_2$ water to compare the non-acidified natural condition (Fig. 1). Each experiment was done for three days.

About cell density of diatoms, Stn C02 is not presented in this report because density of this station is low (0.04x10^3 cellsL^{-1}). The Initial densities of *Fragilariopsis kerguelensis* and *Thalassiosira oestrupii* and the other diatoms at Stn C07 were reaching to 3.94x10^3 cellsL^{-1} (39%), 2.22x10^3 cellsL^{-1} (22%) and 3.66x10^3 cellsL^{-1} (39%), respectively. At Stn D07, the Initial densities of *F. kerguelensis* and *Chaetoceros* sp. and the other diatoms were 0.18x10^3 cellsL^{-1} (18%), 0.48x10^3 cellsL^{-1} (44%) and 0.44x10^3 cellsL^{-1} (40%), respectively. At Stn D13, the Initial densities of *F. kerguelensis* and *T. oestrupii* and the other diatoms were 1.64x10^3 cellsL^{-1} (71%), 0.34x10^3 cellsL^{-1} (15%) and 0.34x10^3 cellsL^{-1} (15%), respectively. After the three days experiments (Table 1), in comparing to the Control, cell densities of major diatoms in the Fe enriched condition (+Fe) were increased 436% for *F. kerguelensis* and 695% for *T. oestrupii* at Stn C07 and 296% for *F. kerguelensis* and 438% for *Chaetoceros* sp. at Stn D07 as well as 330% for *F. kerguelensis* and 226% for *T. oestrupii* at Stn D13. On the other hand, cell density of diatoms in the Fe enriched with high CO$_2$ water (+Fe+CO$_2$) in comparing to the Fe enriched (+Fe), *F. kerguelensis* and *T. oestrupii* decreased to 5% and 67%, respectively at Stn C07. In case of Stn D07, only *F. kerguelensis* increased to 125% whereas *Chaetoceros* sp. reduced to 81%. *F. kerguelensis* and *T. oestrupii* were declined to 63% and 43% at Stn D13.

Standing stocks of haptophytes (Initial), *Phaeocystis antarctica* and coccolithopholids mainly composed of *Emiliania huxleyi* Type B/C, were abundant in the northern stations of C02 (45^{o}S) representing 62.7 x10^3 cellsL^{-1} (93.6%) and 3.4 x10^3 cellsL^{-1} (6.4%), respectively. The initial densities of *P. antarctica* and *E. huxleyi* (other coccolithopholid species did not appear) at south-eastern station of D13 (59^{o}S) were reaching around 110.2 x10^3 cellsL^{-1} (81.2%) and 25.5 x10^3 cellsL^{-1} (18.8%), respectively. At Stn. C02, after closing the incubation experiments, control densities of *P. antarctica* decreased to 90% of the initial whereas 676% increase in *E. huxleyi* and 5,577% rise in *Calcidicus leptoporus* (Table 1, lower). In this station, density rises were conspicuous at the Fe enriched incubation showing 154%, 1,170%, and 5,889% increase in *P. antarctica, E. huxleyi* and *C. leptoporus* to those of the initial concentrations, respectively. Under the Fe enriched condition, once these three species were put in the high CO2 condition, relative densities to the initial were lowre or similar levels of the initials. Higher declines were obtained between Fe-enriched with or without high CO$_2$ on *P. Antarctica, E. huxleyi* and *C. leptopolus* dropping to 51%, 0.1% and 71% of the Fe enriched concentration, respectively. At Stn. D13, densities of *P. antarctica* and *E. huxleyi* in the control increased 167% and 109% of the initial, respectively. In the Fe enriched bottle, *P. antarctica* highly multiplied to 388% and *E. huxleyi* grew 256% of the initial. On the other hand, concentrations of *P. antarctica* and *E. huxleyi* at the Fe enriched with high CO$_2$ bottle were not increase as much as 115% and 65% to the initial, respectively. Compering the haptophyte densities in the Fe enriched with/without high CO$_2$, *P. antarctica* and *E. huxleyi* decrease to 1/2.0 and 1/1473 at Stn. C02 as well as 1/3.4 and 1/3.9 at Stn. D13. This reveals that haptophytes particularly *E. huxleyi* are highly affected by the ocean acidification for their growth other than *C. leptoporus*, which showed positive effect on it density representing 1.4 times higher density in the high CO$_2$ bottle at Stn. C02. Effects of the acidification on haptophytes may surly represent on the thinner cells than on the thicker cells. Concentrations of *P. antarctica* and *E. huxleyi* were almost same in the initial and the Fe enriched with high CO_2 bottles, as mentioned before. This also means that acidified water may disturb and/or sabotage their production.

These results reveal that many diatom and haptophyte species were affected by the ocean acidification under the Fe enrich conditions. However, negative biological effects of acidified water was less obvious in the diatom (43%) species comparing to the small haptophytes (50%) such as coccolithopholids (Table 1).



Figur 1. Incubation diagram of ocean acidification experiment

Table 1. Relative changes in cell densities to the Initial (%, A, B, C, D), estimated CO_2 effects and relative daily loss rete (%)

	Initial	controle	+Fe	+Fe+CO2	CO_2 effect (%)	Relative daily loss rate in the present cell density (%)
	A	B	C	D	D/C	((D−C)−(B−A))/A/Day
Fragilariopsis kerguelensis-D13	1.00	1.15	3.33	2.09	62.81	−0.42
Fragilariopsis kerguelensis-C07	1.00	1.21	4.36	0.20	4.65	−0.70
Fragilariopsis kerguelensis-D07	1.00	1.33	2.96	3.71	125.14	0.10
Thalassiosira oestrupii-D13	1.00	0.76	2.26	0.98	43.42	−0.42
Thalassiosira oestrupii-C07	1.00	2.49	6.95	4.67	67.17	−1.03
Chaetoceros sp-C07	1.00	1.13	7.50	5.00	66.67	11.61
Chaetoceros sp-D07	1.00	2.54	4.38	3.54	80.95	−0.60
Diatom total					43.05	
Phaeocystis antarctica-C02	1.00	0.90	1.54	0.78	50.81	−0.23
Phaeocystis antarctica-D13	1.00	1.67	3.88	1.15	29.69	−1.02
Phaeocystis antarctica-C07	1.00	1.09	1.83	1.21	66.03	−0.20
Phaeocystis antarctica-D07	1.00	1.03	2.20	1.44	65.51	−0.20
Emiliania huxleyi-C02	1.00	6.76	11.70	0.01	0.07	−6.12
Emiliania huxleyi-D13	1.00	1.09	2.56	0.65	25.50	−0.60
Emiliania huxleyi-C07	1.00	16.80	179.95	128.30	71.30	−18.48
Calcidiscus leptoporus-C02	1.00	55.77	58.89	42.10	71.48	−25.11
Haptophyte total					50.4	