

## Carbonate System across the Antarctic Polar Front in the Drake Passage

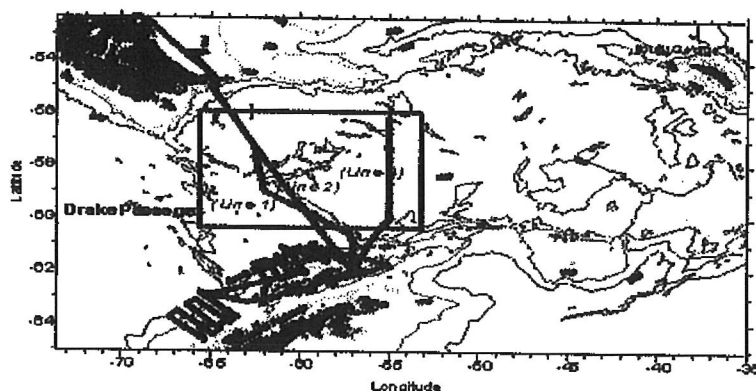
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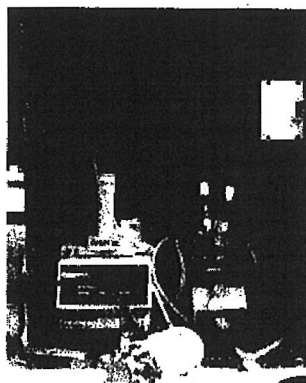
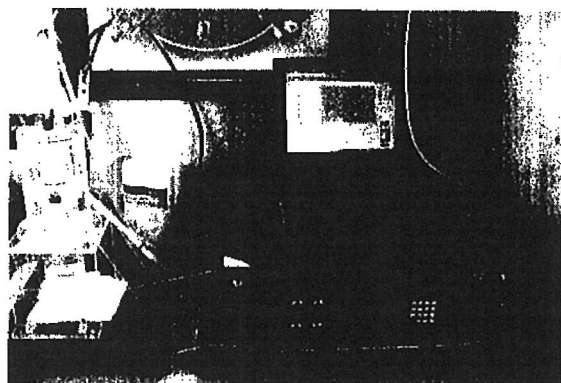
**Abstract.** CO<sub>2</sub> measurements were made across the Antarctic Polar Front in the Drake Passage during the 1998-1999 austral summer. These measurements include the partial pressure of CO<sub>2</sub> (pCO<sub>2</sub>), pH (-log [H<sup>+</sup>]), total carbonate (TCO<sub>2</sub>), and total alkalinity (TA). Surface salinity, temperature, and pCO<sub>2</sub> were automatically measured every two-minutes. Surface pH, TA, and TCO<sub>2</sub> were determined every hour. Surface temperature, salinity, and nutrients showed strong variation across the polar front. SiO<sub>2</sub> (70 mM), NO<sub>3</sub> (15 mM), and PO<sub>4</sub> (2 mM), for example, increased significantly going south traversing the front. The higher values of pCO<sub>2</sub> were observed most of the cruise survey lines. Lower values of pCO<sub>2</sub> were, however, found at the frontal zone only in early December 1998, while atmospheric pCO<sub>2</sub> showed relatively constant values (ca 360 ppmv). The lower values of pCO<sub>2</sub> at the frontal zone and positive correlation between pCO<sub>2</sub> and nutrients south of the front suggest that the Antarctic Polar Front may be sink for CO<sub>2</sub> during the cruise periods.

**The location of the cruise survey areas and cruise lines.** The Polar Frontal Zone was crossed 4 times during the study cruise period (in December 1998). The marked lines, Line-01 & 02 (begin and back) and Line-03 (up and down) are the survey lines crossing the front. Line-01 & 02 were traversed in Dec. 2nd 1998 (begin) and in Dec. 30th 1998 (back). Line-03 was surveyed between Dec. 25 and 26th 1998 (up and down).

KARP cruise tracks in Dec. 1998 and pCO<sub>2</sub> survey lines across the Polar Front



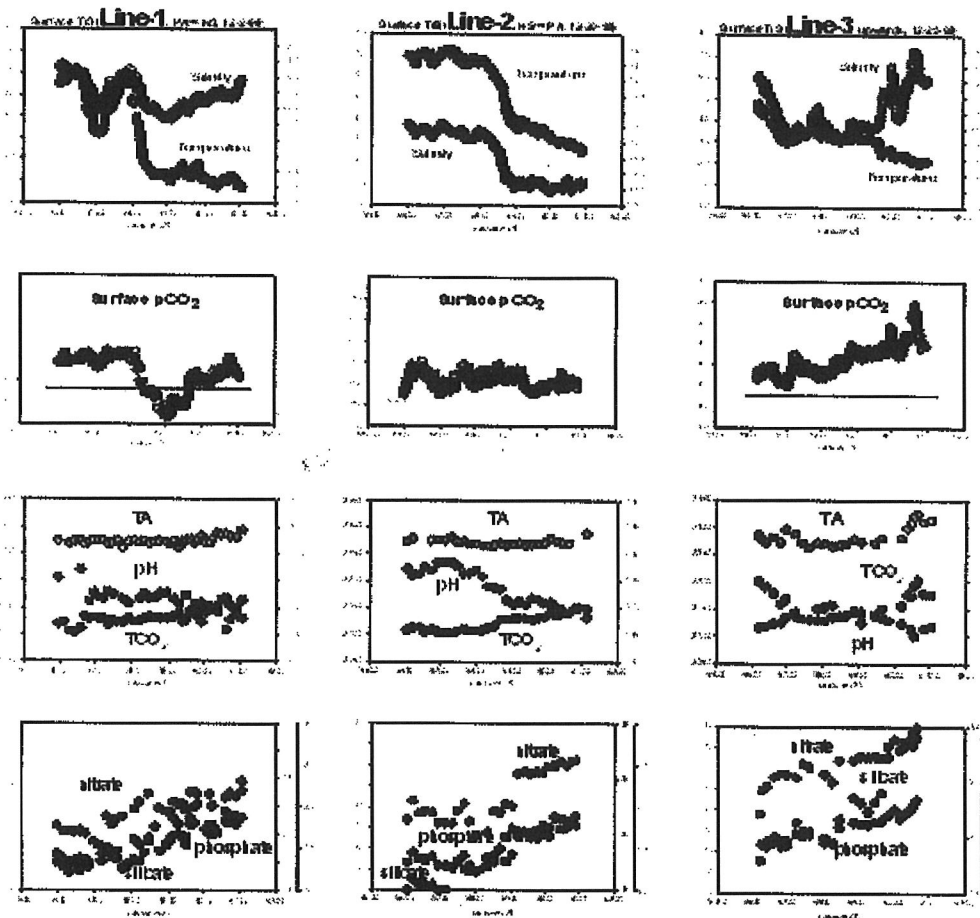
**The flowing pCO<sub>2</sub> system & TA titration system.** The partial pressure of carbon dioxide (pCO<sub>2</sub>) in the surface water and atmosphere was determined using a flowing pCO<sub>2</sub> system similar to the one designed by Wanninkhof and Thoning (1993). The TA titration system consists of a titrator (Metrohm, model 665 Dosimat) and a pH meter (Orion, model 720A), that is controlled by a personal computer (Millero et al. 1993).



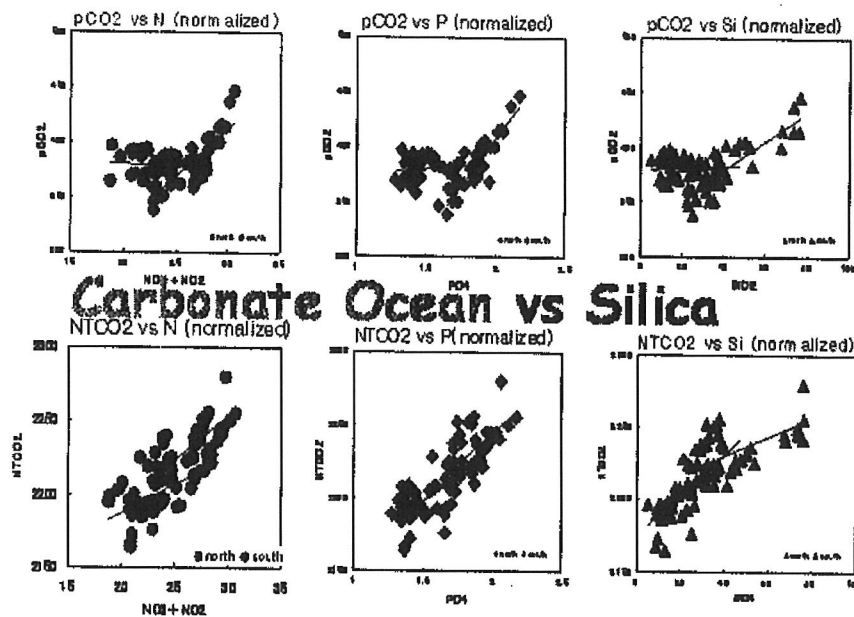
## RESULTS & DISCUSSION

*Sea surface temperature & salinity, surface pCO<sub>2</sub>, and TA, TCO<sub>2</sub>, pH, and nutrients distributions along the cruise survey lines in Dec. 1998.* Sea surface temperature and salinity fluctuated greatly when traversing the Polar Frontal Zone. The fluctuating patterns of temperature and salinity coincided with each other in the north of the front. In the south of the front, however, the temperature continued to decrease while the salinity increased. Sea surface pCO<sub>2</sub> was also fluctuated greatly when traversing the polar front. Higher sea surface pCO<sub>2</sub> was observed along the most part of the cruise survey lines except the frontal zone in Line-01 (early December), while

$pCO_2$  of the sea air unchanged and showed stable values (ca 360 ppmv). TA showed almost constant distribution along the cruise survey lines but, at the southern tip of Line-03, a little bit higher values was observed.  $TCO_2$  values were increasing along the lines to the south while pH values were decreasing to the south. Strong variations of nutrients were observed across the Polar Front. Silicate concentrations significantly increased traversing the frontal zone as well as increasing nitrate and phosphate concentrations toward the south.



*The relationships between carbonate parameters and nutrients in the surface waters of the survey lines.* a) Normalized  $pCO_2$  and Nutrients. b) Normalized total  $CO_2$  ( $TCO_2$ ) and Nutrients. Strong positive correlation between surface  $pCO_2$  and nutrients was observed only in the south of the Polar Front, while  $TCO_2$  showed positive correlations in both side of the front.



## CONCLUSIONS

Clear correlation between pCO<sub>2</sub> and nutrients in the south of the Polar Front suggests that the biological removal of CO<sub>2</sub> is more efficient in the south of the front (in the Silica Ocean) than in the north of the front (the Carbonate Ocean). Antarctic Polar Front may behave as an active CO<sub>2</sub> sink not only by the biological pump but also by downward sinking of surface seawater because the Antarctic Polar Front is the sinking site of the Antarctic Intermediate Water. Studies on particle flux and excess CO<sub>2</sub> under the Antarctic Polar Front could give a clue for the missing sink of CO<sub>2</sub>.

## REFERENCES

- Millero F. J., J. Z. Zhang, K. Lee, and D. M. Campbell (1993) Titration alkalinity of seawater, *Mar. Chem.* 44 (2-4): 153-165.
- Wanninkhof, R. and K. Thoning (1993) Measurement of fugacity of CO<sub>2</sub> in surface water using continuous and discrete sampling methods. *Mar. Chem.* 44: 189- 204.