DECADAL CHANGES OF THE CO_2-SYSTEM PROPERTIES IN THE SUBTROPICAL SOUTH ATLANTIC: RESULTS FROM RE-OCCUPATION OF WHP A10 SECTION

A. Murata[1], Y. Kumamoto[1], M. Aoyama[2], K. Sasaki[1], S. Watanabe[1], and M. Fukasawa[1]

[1]*Institute of Observational Research for Global Change, JAMSTEC, 2-15, Yokosuka, Kanagawa, 237-0061, Japan; akihiko.murata@jamstec.go.jp*

[2]*Meteorological Research Institute, 1-1, Nagamine, Tsukuba, Ibaraki 305-0052, Japan*

ABSTRACT
Using high-quality data for the CO_2-system and related properties obtained 10-year apart, we estimated decadal increases of anthropogenic CO_2 along the A10 section of the World Ocean Circulation Experiment (WOCE) Hydrographic Program (WHP). Increases of anthropogenic CO_2 were found down to an isopycnal surface of $27.3\sigma_\theta$ (approx. 1000 dbar). In the sub-Antarctic Mode Water (SAMW), the increase was 6.9 ± 2.0 μmol kg^{-1} on average, while in the Antarctic Intermediate Water (AAIW), it was 4.2 ± 1.9 μmol kg^{-1}. The increase in SAMW was larger in the west than that in the east of the section. No significant increases were detected in North Atlantic Deep Water (NADW) and Antarctic Bottom Water (AABW).

INTRODUCTION
In 2003, as a part of Blue Earth Global Expedition 2003 (BEAGLE), we re-visited the WHP A10 section (30°S, 50°W – 20°E) in the South Atlantic, which was occupied previously in 1992/1993. In BEAGLE, we measured properties of the CO_2-system such as surface seawater pCO_2, dissolved inorganic carbon (C_T), total alkalinity (A_T) and pH, together with dissolved oxygen, nutrients, and CFCs.

The purpose of the present study was to estimate decadal increases of anthropogenic CO_2 in the South Atlantic, and to clarify regional differences of anthropogenic CO_2 accumulation by comparing data obtained in BEAGLE with those in WHP.

OBSERVATIONS
Shipboard observations were made from November 6 to December 9 using the R/V Mirai of JAMSTEC. Atmospheric and surface seawater pCO_2 were measured continuously by a non-dispersive infrared gas analyzer. Water column C_T and A_T were measured by coulometry and potentiometry, respectively. pH was measured by spectrophotometry.

Repeatability of C_T and A_T was estimated to be 1.0 and 2.2 μmol kg^{-1}, respectively. Both C_T and A_T were set to the values of certified reference materials (batch 60) provided by Prof. A.G. Dickson of Scripps Institution of Oceanography. Repeatability of pH was 0.0010 pH unit.

APPROACH
C_T on isopycnal surfaces
To detect increases of anthropogenic CO_2 in the ocean's interior, we corrected C_T using apparent oxygen utilization (AOU) and salinity. For the correction, remineralization of organic matters was considered, while dissolution of calcium carbonate was neglected. The corrected C_T (nC_T^{CAL}) was averaged at an interval of 20° longitude on selected isopycnal surfaces, and the averaged nC_T^{CAL} in WHP was subtracted from that in BEAGLE. The *t*-Test was applied to the calculated differences (ΔnC_T^{CAL}) to check significance of decadal increases of anthropogenic CO_2 statistically.

RESULTS

Increases of anthropogenic CO_2 on isopycnal surfaces

From distributions of the ΔnC_T^{CAL}, it was found that significant increases of anthropogenic CO_2 along the A10 section were detectable down to $27.3\sigma_\theta$ (~1000 dbar). In SAMW ($26.6 – 27.0\sigma_\theta$, 350 – 700 dbar), the average of the significant ΔnC_T^{CAL} was 7.0 ± 1.6 μmol kg^{-1}, while in AAIW ($27.1 – 27.5\sigma_\theta$, 700 – 1500 dbar), it was 3.5 ± 0.8 μmol kg^{-1}. In SAMW, the increase was larger in the west than that in the east.

Increases of anthropogenic CO_2 in abyssal waters

We attempted to detect increases of anthropogenic CO_2 in abyssal waters, i.e., NADW and AABW. In NADW (salinity maximum water), no significant increases could be detected, implying that NADW does not have a measurable anthropogenic CO_2 signal yet at the latitude. In AABW, two criteria were applied to select the water: potential temperature < 1.0 °C and σ_4 > 45.87 kg m^{-3}. From both the cases, no significant ΔnC_T^{CAL} was detected, except for 46 – 38°W by the potential temperature < 1.0 °C criterion.

CONCLUSION

From the calculated increases of anthropogenic CO_2, uptake rate of anthropogenic CO_2 was estimated to be 0.7 ± 0.4 mol m^{-2} yr^{-1}, which is close to previous estimations. This fact implies that oceanic capacity of anthropogenic CO_2 absorption did not change over the past decade.