

Carbon dioxide accumulation at the subarctic-subtropical frontal zone of 165E meridian

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The concentration of carbon dioxide (CO₂) in the oceans is increasing due to the increase of CO₂ concentration in the air. The formation of mode water is considered important in transporting CO₂ from surface into the ocean interior. At subtropical area of 137E meridian, increasing trend of total dissolved inorganic carbon (TCO₂) has been seen in the subtropical mode water as well as surface seawater.

In this study, we focus our interest on North Pacific Central Mode Water, which is characterized by 9–12 deg. C, 34.1–34.4 psu, and 26.2 sigma-theta. North Pacific Central Mode Water is formed in the Transition Domain between subarctic front and Kuroshio bifurcation (36–43N, 130–180E). The observation line of this study (28N–50N along 165E meridian) includes this area. We tried to determine the TCO₂ increase in the North Pacific Central Mode Water basically by comparing the property-property plot of TCO₂ vs. potential alkalinity in 1992 (WOCE P13) and that in 2005.

In order to determine the temporal changes in concentrations of chemical parameters by observation, we have to compare these parameters in a water masses whose origin would be common. The water masses in the ocean interior are considered to move along isopycnal surfaces. However, potential density is insufficient to distinguish water masses, because temperature and salinity at the time that the water masses were at ocean surface could be different even though the potential density was same. Therefore, in addition to temperature and salinity, we examined to use potential total alkalinity as a third axis to compare chemical parameters. Potential alkalinity is defined by total alkalinity plus nitrate concentration. Potential alkalinity is conservative against nitrate formation / consumption caused by biological activity.

For our objective described above, desired accuracy for total alkalinity is +/- 2 micro mol/kg. We developed an apparatus to measure total alkalinity based on spectrophotometry of indicator dye bromocresol green. The concentration of HCl solution for the titration was calibrated with a suite of sodium carbonate standard solutions.

We made observation of TA, TCO₂, nutrients and dissolved oxygen during the cruise RF0506 of R/V Ryofu-maru in June 2005. Samples were collected along the 165E meridian from 28N to 50N, which encompassed both the subtropical gyre and western subarctic gyre.

Potential alkalinity normalized at salinity 35 (Pot-NTA) in surface seawater was about 2300 micro mol/kg at subtropical gyre and about 2380 micro mol/kg at subarctic gyre. Pot-NTA in this study was about 10 micro mol/kg lower than those of WOCE P13 at potential density 27.5 kg/m³. This difference might be a systematical error of measurements.

In this study, we focused on change in TCO₂ below the winter mixed layer, and analyzed the data for the layer whose potential temperature was lower than sea surface temperature in winter, or the layer below the intercooled water. TCO₂ (normalized at salinity 35, NTCO₂) gave linear plots against Pot-NTA in the Pot-NTA range from 2300 micro mol/kg to 2400 micro mol/kg. This result indicates TCO₂ and TA would be explained by mixing of two water components.

Comparing linear fit of NTCO₂ vs. Pot-NTA between RF0506 and WOCE P13, NTCO₂ increased 13.4, 19.9, 26.5 micro mol/kg at Pot-NTA 2300, 2340, 2380 micro mol/kg, respectively. This difference was reduced to 11.6, 13.7, 15.8 micro mol/kg, if our Pot-NTA data was corrected for the systematical error. Comparing quadratic fit of NTCO₂ vs. potential density, NTCO₂ increased 19.9 micro mol/kg at sigma-theta 25.5 kg/m³, 5.4 micro mol/kg at sigma-theta 26.1 kg/m³ (minimum), and 29.7 micro mol/kg at sigma-theta 26.8 kg/m³.

We will discuss the factors for the increase in TCO₂ in the ocean interior, considering change in concentration of nutrients and dissolved oxygen.