Underway measurements of surface $pCO_2$ and total alkalinity in Kuroshio-Oyashio transition region

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We made measurements of surface partial pressure of CO$_2$ ($pCO_2$) and total alkalinity (TA) in Kuroshio-Oyashio transition region off the eastern Japan in June 2016. Surface TA was measured every 15 minutes. Spatial resolution of TA was 6 km in case of cruising at 12 knot.

Surface TA (open circle in Figure 1) showed fine spatial variation which can not be captured by the interpolation of the bottle sampling and measurement of TA (open square in Figure 1) at CTD station which located every 2 degrees in longitude. The estimation of TA by Lee et al. [2006] (gray dot in Figure 1) overestimated the measurement by up to 30 $\mu$mol/kg.

We calculated surface DIC from TA and $pCO_2$ obtained by the underway measurements. Calculated DIC was in good agreement with the measured DIC taken from nearby CTD station. Difference and standard deviation between calculated and measured value were 0.8 and 5.4 $\mu$mol/kg respectively ($N = 38$).

Underway measurement of $pCO_2$ and TA can reproduce other carbonate parameters such as DIC and pH accurately. This method is beneficial to understand carbon cycling in coastal region and Kuroshio-Oyashio transition region where spatial variation of TA is large.

The variation of TA by precipitation and evaporation can be excluded by salinity normalization. Normalized alkalinity to Salinity = 35 (NTA$_{35}$) has a large meridional gradient in the western North Pacific. NTA$_{35}$ in the subtropical region and subarctic gyre were about 2300 and 2370 $\mu$mol/kg respectively [Takatani et al. 2014]. In our observation, NTA$_{35}$ also showed large zonal varitaion and ranged 2310-2355 $\mu$mol/kg along 41°N and 2300-2325 $\mu$mol/kg along 37.5°N. These dynamic spatial variation of NTA$_{35}$ was attributable to the complicated distribution of Kuroshio and Oyashio water. $pCO_2$ was concave against NTA$_{35}$ and the smallest around NTA$_{35}$ = 2320 $\mu$mol/kg. Below this NTA$_{35}$, $pCO_2$ increased thermodynamically due to temperature rise. On the other hand, nutrients was significantly high above this NTA$_{35}$. This indicated that $pCO_2$ was high because the DIC supplied to the surface by the winter mixing had not been substantially reduced by biological production.

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