Effects of bottom shear stress and biological activity on CO$_2$ flux between air and coastal water

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Wind speed has been regarded as a major factor controlling CO$_2$ flux between air and water. Some studies, on the other hand, indicated that water current in shallow estuaries or surface micro-layer planktonic activity induces larger CO$_2$ flux compared with that in the open ocean [O'Connor and Dobbins 1956, Upstill-Goddard et al, 2003]. However, quantitative analysis of these effects has not been made. In this study, we measured CO$_2$ flux and transfer velocity in a coral reef and in an estuary using chamber method, and compared the results with vertical turbulence energy (VTE) measured by Acoustic Doppler Velocimeter and with the rate of dissolved oxygen (DO) changes.

The relation between CO$_2$ transfer velocity and VTE was measured on a coral reef flat and in a river in Isigaki Island, the Ryukyus. Linear correlation was observed between measured transfer velocity and VTE (R=0.99 n=8). Transfer velocity and VTE measured in the coral reef was larger than those in the river. This result is attributable to the difference of sea-floor roughness, and is consistent with a previous study in which increase in CO$_2$ transfer velocity was explained from the advected shear stress in surface layer generated from the friction between water current and sea-floor [O’Connor and Dobbins 1956].

Surface-layer biological effect was examined in a eutrophic lake, Nakaumi, Shimane. Positive correlation was observed between CO$_2$ flux and rate of DO changes during daytime (R=0.97 n=5). We speculate that this is due to photosynthetic consumption of CO$_2$ in surface micro-layer, which made the CO$_2$ concentration gradients larger and therefore enhanced CO$_2$ flux. But correlation was not observed at night time (R=0.21 n=7). Further study is required for the different relationship during daytime and nighttime.

The average of transfer velocity measured in this study was 7.2 times larger than that calculated from a wind-depending formula (9.2 times for bottom shear stress, 2.9 times for biological activity). Thus coastal CO$_2$ flux is strongly affected by bottom shear stress or biological activity than wind speed and these parameters should be incorporated into an appropriate formulation calculating coastal CO$_2$ flux.

REFERENCES
