Contrasting Controls of Spring Air-sea CO_2 Flux between the Northern and Southern Yellow Sea and a First-order Estimation of Anthropogenic CO_2 Accumulation Rate

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Due to the complexity of both physics and biogeochemistry of the coastal ocean, there remain many unknowns on the roles of shallow oceans in the global carbon cycle. In this study, we examined the carbonate system and air-sea CO_2 fluxes based on three spring cruises conducted in March, April and May in the Yellow Sea, a large shallow shelf sea system. We observed that there existed substantial spatial and temporal variations even in a single season. In the northern part of the Yellow Sea, sea surface pCO_2 was basically controlled by thermodynamics in both March and April, while water mixing and biological production dominated air-sea CO_2 fluxes in the southern Yellow Sea. The southern Yellow Sea proper shifted from a source for atmospheric CO_2 in March through equilibrium in April into a moderate sink in May. The seasonally integrated CO_2 sinking flux in the southern Yellow Sea in spring was estimated as 0.9 ± 2.9 mmol m^{-2} day^{-1}, which was significantly lower than the recent CO_2 sinking flux estimation in the adjacent northwestern East China Sea. Total alkalinity (TAlk) ranged 2240-2340 μmol kg^{-1} in the northern Yellow Sea, and 2260-2320 μmol kg^{-1} in the southern Yellow Sea off the Yangtze River plume area. Dissolved inorganic carbon (DIC) ranged 2060-2090 μmol kg^{-1} in the northern Yellow Sea, and 1970-2090 μmol kg^{-1} in the southern Yellow Sea. Both TAlk and DIC in the northern Yellow Sea followed simple mixing lines. In the southern Yellow Sea, biological drawdown of ~80 μmol kg^{-1} of DIC and ~190 μatm of pCO_2 was observed in April. The chemical buffering capacity of CO_2 in the northern Yellow Sea was weaker than in the southern Yellow Sea. Based on the recent atmospheric CO_2 increasing rate, we conducted a first-order estimation of the anthropogenic CO_2 accumulation rates, which were approximately 0.73 and 0.82 μmol kg^{-1} yr^{-1} in the northern and southern Yellow Sea respectively, or 0.15×10^6 t C yr^{-1} for the whole Yellow Sea. This anthropogenic CO_2 accumulation rate should be taken into consideration when assessing a specific shallow sea as a source or sink of CO_2. The cumulative effect of such an accumulation on the regional biogeochemistry and ecosystem could be substantial.