Modern acidification in the northern South China Sea driven by Asian winter monsoon and CO_2

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Modern acidification by the uptake of anthropogenic CO_2 can profoundly affect the physiology of marine organisms and the structure of ocean ecosystems. Centennial-scale global and regional influences of anthropogenic CO_2 remain largely unknown due to limited instrumental pH records. Here we present coral boron isotope-inferred pH records for two periods from the South China Sea(SCS): AD 1048-1079 and AD 1838-2001, characterized by a high average value of 8.1-8.2. However, we find anomalous and unprecedented acidification during the 20th century, pacing the observed increase in atmospheric CO_2. Specifically, the pH values decreased at a rate of -0.0011 ± 0.0003 pH/a in a 110-yr interval after AD 1840. This rate of decline almost tripled to -0.0029 ± 0.0013 pH/a after AD 1950. The long-term decreasing trend of pH also corresponds to a shift to more negative $\delta^{13}C$ values. These signatures all reflect the remarkable absorption of anthropogenic CO_2 by the ocean, and induced acidification in response to the rapid rise in CO_2 since the Industrialization Period. While CO_2 governs the long-term SCS pH trend, the inter-decadal cycles of 0.1-0.2 pH varies in phase with inter-decadal changes in Asian Winter Monsoon (AWM) intensity. During weak AWM periods with reduced wind forcing in the SCS, the build-up of CO_2 due to calcification and respiration could lower pH due to poor flushing of reef waters by open seawater. In contrast, periods of relatively strong AWM with strengthened surface currents could result in higher pH values. At the same time, a weak (strong) AWM would cause the nutricline to deepen (shallow) and result in lower (higher) surface productivity and decreased (increased) pH. As the level of CO_2 keeps rising, the coupling global warming via weakening the AWM intensity could exacerbate acidification of the SCS and threaten this expansive shallow water marine ecosystem.