Quantifying pH dynamics in a changing ocean

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The ocean provides an important ecosystem service to mankind by absorbing 25-30% of the anthropogenic carbon dioxide and > 90% of global warming. This service comes at the expense of changes in ocean chemistry. Here we present explicit equations for calculating the sensitivity of protons to changes in ocean chemistry. These expressions can include as many acid-base systems as desirable and are fully consistent with existing equations that only include the carbonate and borate acid base systems. Moreover, a similar generic approach can be applied to the Revelle factor. Such expressions are instructive to advance our understanding of pH dynamics in a changing world or the impact of biogeochemical processes on pH.

Using these expressions and observed changes in DIC, TA, temperature and salinity, we were able to reproduce seasonal pH evolution at three time-series stations: ALOHA (Pacific), DYFAMED (Mediterranean) and Iceland Sea (Atlantic). Moreover, we identified contrasting patterns for each of three study sites. At the subtropical Station ALOHA, temperature variability dominates the trend in pH year-round. pH at DYFAMED is dominated by the DIC signal between November and May and by the temperature-driven pH changes in the remainder of the year. In the Iceland Sea, where TA also shows significant seasonal variability, DIC variability dominates the trend in pH for most of the year, with the exception of early summer and early winter, when temperature and TA are the respective dominant drivers.

Using these analytical expression and CO_2 and temperature projections for the year 2100 we show that ocean pH will be 3.5 to 4 times more sensitive to changes in ocean chemistry, but ocean pH becomes less sensitive to temperature and salinity.