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North Atlantic Ocean acidification from time series measurements

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The world oceans have sequestered about 48% of the carbon dioxide that has been released by fossil fuel burning and sement production since early industrialization to 1994 and the anthropogenic carbon inventory is particularly high in the North Atlantic Ocean (Sabine et al. 2004). The anthropogenic carbon dioxide causes shifts in chemical equilibria of the sea water carbonate system which lead to increased hydrogen ion concentration, [H+] (acitity), and decreased carbonate concentration, [CO32-], which increases the solubility of calcium carbonate thus making less feasible the formation of marine biogenic calcium carbonate. A study by Orr et al. (Orr et al. 2005) using ocean carbon cycle models indicated that changes in the calcium carbonate saturation state in high latitude oceans will lead to undersaturation and impacts on ecosystems by the end of the century. However, the rate of change was uncertain due to lack of observation data. The sea water carbonate chemistry has been observed regularly since 1983 at two North Atlantic stations. One is in the northern Irminger Sea with relatively warm and saline Modified North Atlantic Water derived from the North Atlantic Current. The other is in the Iceland Sea where cold Arctic Intermediate Water usually predominates but the Polar Water influence in the surface layers is variable (Stefánsson 1962; Hansen and Østerhus 2000).

The observations, 1983-2008, provide evidence on present rates of change in pH and calcium carbonate saturation and how they relate to water masses and depth. We evaluate the long term changes from winter observations, when biological activity is at seasonal minimum. These reveal that the local rates of pH surface water change are -0.0014 yr-1 for the Irminger Sea and -0.0024 yr-1 for the Iceland Sea, compared with -0.0017 yr-1 observed in the BATS and ESTOC time series from the sub-tropical N-Atlantic (Bates 2007; Santana-Casiano et al. 2007). The rates of change in calcium carbonate saturation decrease with depth in the Iceland Sea but the aragonite saturation horizon, which is at about 1800 m depth, is rising 2 m yr-1 . Considering the hypsographic characteristics of the Iceland Sea, this transition brings each year 400 km2 of the sea floor to a state of aragonite undersaturation.

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