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Ocean acidification: past, present and future.

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With rising atmospheric pCO_2, ocean acidification is an increasing threat to carbonate-secreting biota. As the diffusion of CO_2 from the atmosphere into the oceans is relatively slow, it is the surface water plankton and the shallow water benthos that are most at risk. In some quite restricted environments, naturally sourced CO_2 and NH_4 are bubbling to the sediment surface, creating reduced pH environments. Near the Italian island of Ischia (Dias *et al*., 2010), locally derived CO_2 is emerging into sea grass meadows, and reducing pH from 8.17 to 7.5 and this is causing a progressive loss of calcareous taxa and reducing the foraminiferal assemblage to only agglutinated taxa, with a distinct reduction in species richness. In the Gulf of California (Petit *et al*., 2013) the pH in surface sediments is being reduced from normal values to 7.5 and while the assemblage of living benthic foraminifera seems to be little affected, once dead the tests of calcareous taxa begin to be dissolved (as witnessed by enlarged pores and holes in the carbonate test material). In the plankton, especially the pteropods and heteropods, there is increasing evidence of shell dissolution and fragility with reducing pH and – in the Late Pleistocene of the Caribbean Sea – one can see a reduction in shell quality during interglacial conditions and concentrations of well-preserved shells in the glacial intervals. These records demonstrate that ocean acidification is not a new process and that variations in pH and shell mineralisation extend through the fossil record. In areas such as SW England, maerl (rhodophyte algae) accumulations are potentially at risk and may be overtaken by increases in sea grass meadows.

Evidence of short-duration, surface-water acidification events are known from the earliest Jurassic (Hettangian) and the earliest Paleocene (following the K/Pg boundary; see Hart *et al*., 2019) based on the interpretation of calcareous nannofossil distributions and benthic foraminifera.

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