3.3 Ocean Acidification and Carbon Dioxide Concentrations

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Atmospheric carbon dioxide (CO_2) caused by human activities is absorbed by seawater and leads to ocean acidification. It is estimated that levels of ocean acidity have increased by 30% over the last 200 years and projections by the IPCC are that it could increase by a further 120% by 2100, if emissions of CO_2 continue unabated. Although the ecological implications of ocean acidification are still unclear, there is mounting concern as to the potential effects of such rapid acidification on many marine species and in particular on calcifying species such as corals, shellfish and crustaceans. This has the potential for large knock-on effects on the whole ocean ecosystem and related socio-economic activities, including fishing and aquaculture.

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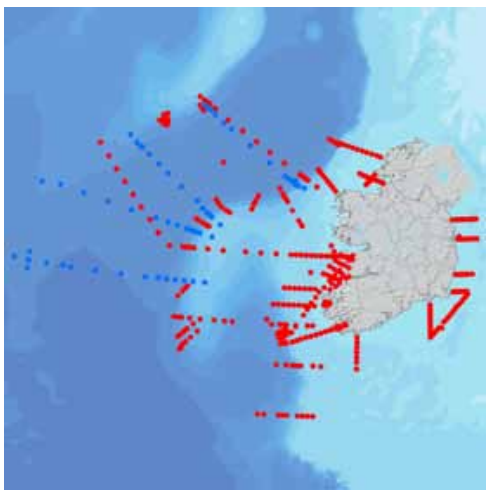


Map 3.3. Location of cruise tracks where observations of variables relating to the carbonate system have been carried out.

Measurements

Currently, there is no systematic ocean acidification monitoring programme in Irish waters. Between 2008 and 2010 as part of a joint project between the Marine Institute and the National University of Ireland Galway a series of measurements of carbonate and associated biochemical parameters were taken in coastal, shelf and deep waters (red), to establish the baseline state and variability of the carbonate system. These include dissolved inorganic carbon (DIC), total alkalinity (TA) and the partial pressure of carbon dioxide in the water (pCO_2).[14] pCO_2 measurements were also made in

14 Seawater pH can be calculated accurately from these parameters. Direct measurements of pH in seawater are insufficiently accurate for monitoring ocean acidification

coastal waters near the Mace Head Observatory, Co. Galway and on research surveys. Carbonate data measured across the Rockall Trough in some of the recent surveys were compared to data measured in the early 1990s by the World Ocean Circulation Experiment (WOCE) (blue).

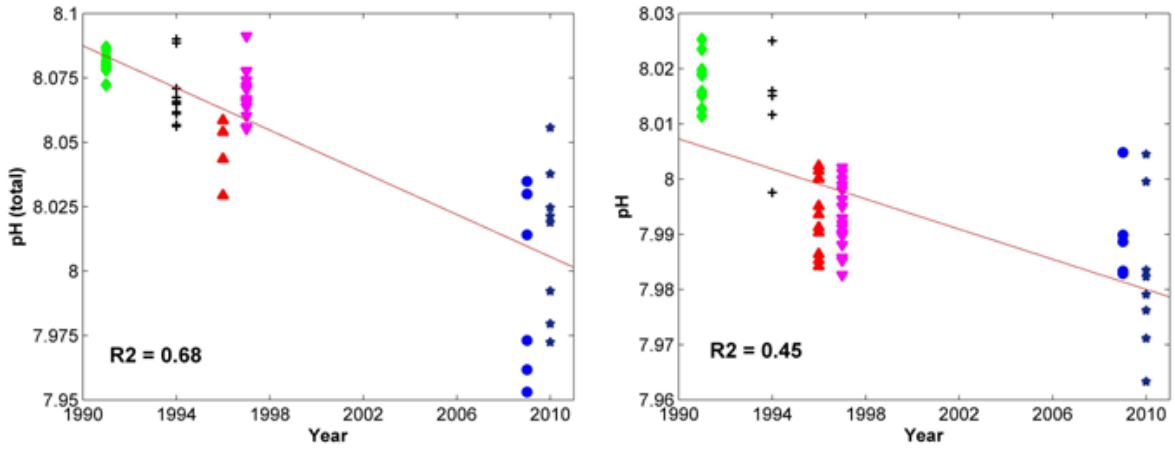
'Ocean acidity has increased significantly in sub-surface and deep offshore waters around Ireland between 1991 and 2010.'

Time-series and Trends

From measurements of DIC and TA, along with temperature, salinity and nutrients, calculations of acidity (pH) were made. In Fig. 3.6, the derived pH values are shown along the transects of the WOCE surveys (1990s) and the more recent 2008–2010 surveys in subsurface waters (a) and at depth (b) in the Rockall Trough. The different colours represent different transects. In sub-surface waters, after correcting the change in DIC for biological activity, there was a decrease of 0.043 pH units, representing an increase in acidity, between 1991 and 2010. This is in line with the IPCC's observed decline of 0.02 pH units per decade. In deeper waters (1500–2000 m) there was a decrease of 0.035 pH units, indicating an increase in acidity also at depth.

Figure 3.7 illustrates the seasonal variability in pCO_2, for a 12-month period from November 2008 to November 2009, as measured at a buoy near Mace Head. These are overlaid on the atmospheric CO_2 concentrations (green). Concentrations were generally lower in winter and higher in summer. A series of spikes recorded in summer 2009 may be associated with a large influx of freshwater into the bay area at these times. Concentrations of CO_2 measured during the open-ocean surveys generally displayed lower values over all seasons.

'Integrated monitoring of the carbonate system is vital but due to funding and resource restrictions there are no plans for continued observations at present.'



(a) (b)

Figure 3.6. Derived pH values from World Ocean Circulation Experiment (WOCE) (1990s) and more recent surveys in sub-surface waters (a) and at depth in the Rockall Trough (b).

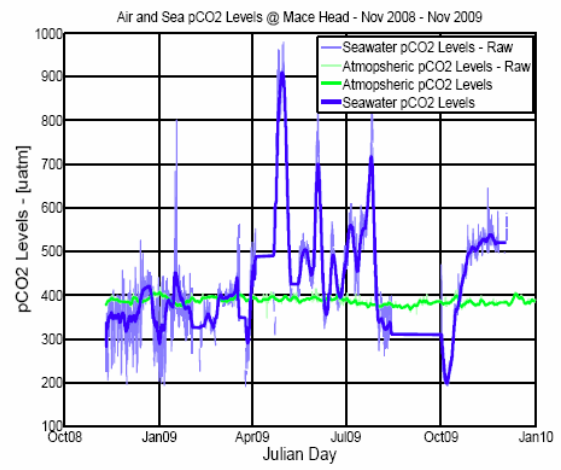


Figure 3.7. Variability in water CO_2 concentration (pCO_2), November 2008–November 2009, as measured at a buoy near Mace Head (blue). Atmospheric CO_2 concentration is also shown (green).

Maintaining the Observations

The results of this short-term project emphasise the importance of continued, integrated monitoring of the carbonate system alongside other oceanographic parameters in Irish coastal and deep waters, including vulnerable habitats such as cold water coral reefs on the Irish shelf slopes. This could be achieved cost effectively by including these parameters in current ship-based monitoring campaigns. Furthermore, the Mace Head atmospheric research station offers great potential for combined high-frequency monitoring of atmospheric-ocean processes. However, because of funding and resource restrictions, there are currently no plans for continued carbon observations.

Further Information and Data Sources

McGrath, T., Kivimae, C., Tanhua, T., Cave, R. and McGovern, E. (2012) Inorganic carbon and pH levels in the Rockall Trough 1991–2010, *Deep Sea Research-Part 1*.

Ní Longphuirt, S., Stengel, D., O'Dowd C. and McGovern, E. (2010) *Ocean Acidification: An Emerging Threat to our Marine Environment*. Marine Foresight Series No. 6, Marine Institute, Galway, p. 98.

O'Dowd, C., Cave, R., McGovern, E., Ward, B., Kivimae, C., McGrath, T., Stengel, D. and Westbrook, G. (2011) *Impacts of Increased Atmospheric CO_2 on Ocean Chemistry and Ecosystems*. Marine Institute, Galway.

Carbon data from cruises are archived by the Marine Institute and may be accessed on request: http://www.marine.ie/home/publicationsdata/

Carbon data are archived at the National University of Ireland Galway: http://www.nuigalway.ie/c-caps/