OCEAN ACIDIFICATION –
ALTERATION TO THE CHEMISTRY OF THE MARINE CARBONATE SYSTEM

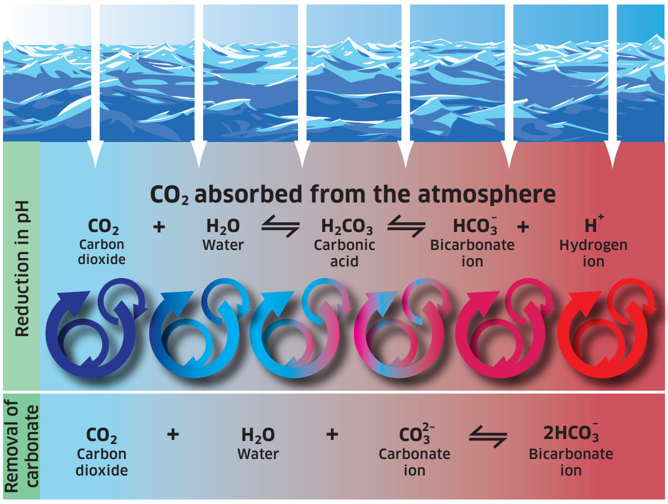

FIGURE 1
THE CARBONATE SYSTEM OF SEAWATER AND THE POTENTIAL IMPACT AS A RESULT OF ABSORPTION OF ATMOSPHERIC CO_2.

Ocean acidification – What is it?

Acidity is measured using a scale known as the pH scale. As an example, soya milk which is neutral (neither acid nor alkaline) has a pH of 7, egg whites are slightly alkaline have a pH of 7.9 and an acid such as vinegar has a pH of approximately 3.

Ocean acidification is a change in the chemical balance of the sea – in this case a decrease in the pH of the earth's oceans - primarily as a result of uptake of carbon dioxide (CO_2) in the air arising from human activities (see Figure 1).

It has been reported that a third of the CO_2 produced over the past 200 years from human activities (such as fossil fuel burning) has been absorbed by the oceans, resulting in a decrease in the pH from 8.2 to 8.1. By 2100 the pH is predicted to decrease by a total of 0.4 units to 7.8.

Although the uptake of CO_2 from the atmosphere is generally the same over large areas of the oceans, some marine regions will be more rapidly affected. The susceptibility of seawater chemistry to change is, for example, dependent on the chemical composition and temperature of the water. The colder the water temperature the higher its potential to absorb atmospheric CO_2, meaning that the high latitude shelf regions are likely to show effects earlier than the tropics.

Why is ocean acidification of concern?

Changing the acidity of sea water may have an impact on many living organisms in the sea, as well as processes that effect such things as the creation of new sediment. Processes including the formation of hard external skeletons by some plankton species, carbon and nutrient uptake by the sea, and primary production may be affected. Planktonic organisms are most active near the ocean surface (the upper 200 m), and this layer is likely to be the most affected by ocean acidification. Any impact on plankton may affect other parts of the food chain. Cold-water corals found in deep waters may also be particularly sensitive to changes in pH. These coral colonies serve as shelter, feeding and breeding habitats for fish.

What can be measured?

The chemistry of the seawater carbonate system is complex. An imbalance as a result of absorption of CO_2, by oceans, has the potential of making them more acidic and reducing carbonate ion availability (see Figure 1). There are four parameters of the carbon dioxide system in solution that can be measured directly; total alkalinity (TA, a measure of the ability of a solution to neutralise an acid), pH , carbon dioxide fugacity (fCO_2) and dissolved inorganic carbon (DIC).

marine scotland

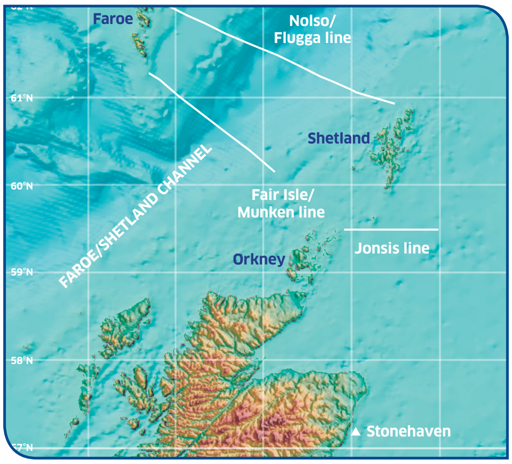

FIGURE 2
MARINE SCOTLAND SCIENCE SAMPLING SITES WHERE SEAWATER WILL BE COLLECTED AS PART OF A BASELINE STUDY TO INVESTIGATE THE SEASONAL AND INTER-ANNUAL VARIABILITY OF CARBONATE CHEMISTRY OF SCOTTISH OFFSHORE AND COASTAL WATERS.

DIC in the marine environment consists of ~90% bicarbonate ions (HCO_3^-), ~9% carbonate ions (CO_3^{2-}) and ~1% remaining as dissolved carbon dioxide (CO_2) and carbonic acid (H_2CO_3).

At least two of these parameters must be measured and from these the remaining two can be calculated using a programme called CO_2SYS.

What is Marine Scotland Science doing?

Between November 2008 and March 2011 weekly samples were collected from a site off Stonehaven, North-East Scotland, for TA and DIC analysis as part of the DEFRA pH and UKOA projects[1]. The aim of which was to understand temporal variation of the carbonate chemistry.

Since 2012, a baseline study to investigate the seasonal and inter-annual variability of the carbonate chemistry of Scottish offshore and coastal waters has been undertaken (see Figure 2).

The Stonehaven Story (so far!)

TA and DIC were measured directly from duplicate samples in surface (1 m) and bottom waters (45 m). The data revealed considerable variability on a weekly time scale at the Stonehaven monitoring site. On a seasonal scale it showed a relationship with the phytoplankton growing season as DIC is lowest and TA highest when phytoplankton numbers were elevated (Figure 3).

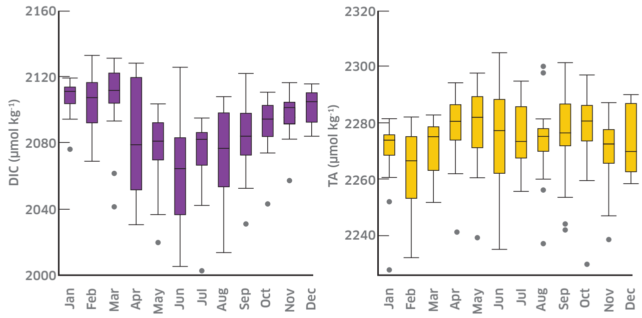

FIGURE 3
SEASONAL DISSOLVED INORGANIC CARBON (DIC) AND TOTAL ALKALINITY (TA) AND THE STONEHAVEN COASTAL MONITORING SITE.

The calulated pH and calcite (carbonate ion) saturation state decreased at the Stonehaven site during 2012-2013 (Figure 4). This is consistent with other observations around UK waters over the same period[2]. At Stonehaven, this event coincided with unusually high salinity water in the autumn of 2012, followed by very low temperatures in spring 2013

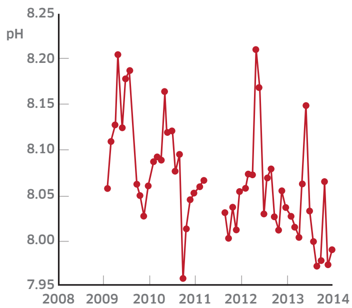

FIGURE 4
DERIVED pH (TOTAL SCALE) AT THE STONEHAVEN MONITORING SITE DURING THE PERIOD 2009-2014

The monitoring at Stonehaven is ongoing but highlights the requirement for a robust dataset to distinguish changes as a consequence of man-made inputs from that of the natural seasonal and inter-annual variability.

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[1] All samples have been analysed By National Oceanography Centre (NOC) Southampton, samples collected between 2008 and 2011 were for the Department of Environment, Food and Rural Affairs (DEFRA) pH and UK Ocean Acidification Projects

[2] Ostle C., Williamson, P., Artioli, Y., Bakker, D.C.E., et al (2016). Carbon dioxide and ocean acidification observations in UK waters: Synthesis report with a focus on 2010- 2015. doi:10.13140/RG.2.1.4819.4164.