World Oceans becoming Acidic - Consequences of Ocean Acidification

[CO_2 (atmospheric) $\Leftrightarrow CO_2$ (aqueous) + $H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO^-_3 \Leftrightarrow HCO^-_3 \Leftrightarrow H^+ + CO_3^{-2}$]

The ocean absorbs approximately (~30%) of the CO_2 added to the atmosphere from human activities (fossil fuel burning, cement manufacture and deforestation) each year, therefore greatly reducing the impact of greenhouse gas on climate. Without this ocean sink, the CO_2 concentrations would have been much higher than the observed 380 parts per billion by volume (ppmv). However, the absorption of CO_2 has acidified the surface layers of the ocean causing an overall decrease of 0.1 pH units since the pre-industrial period, which is equivalent to a 30% increase in hydrogen ion concentration or acidity. The surface ocean pH is projected to decrease by 0.3-0.4 pH units by 2100 relative to pre-industrial conditions if atmospheric CO_2 concentrations reach 800 (ppmv) (Figure 1) (this is equivalent 150% increase in acidity (H^+) and 50% decrease in CO_3^{2-})).

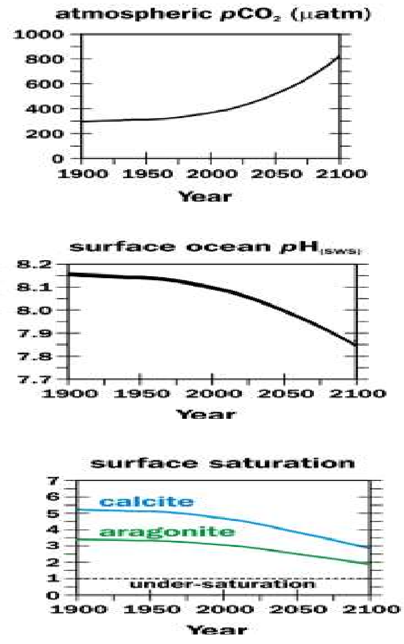

Figure 1: Projected global ocean CO_2, pH and calcite and aragonite saturation[1].
Note[2]: **pCO_2** = carbon dioxide partial pressure; **pH** (is a measure of ocean acidity and hydrogen ion H^+ concentration; pH= -log10[H^+]; **saturation**= thermodynamic condition of seawater that describes the degree of supersaturation or under saturation with respect to the particular phase of the $CaCO_3$; **calcite**: a mineral form of calcium carbonate found in many marine plankton and invertebrates that is less soluble than aragonite; **aragonite**: a relatively soluble mineral form of calcium carbonate found in corals, pteropods, molluscs.

When anthropogenic carbon dioxide is absorbed by seawater, chemical reactions occur that (a) increase the concentrations of carbonic acid (H_2CO_3), bicarbonate (HCO^-_3) and hydrogen ion (H^+) and (b) reduce/decrease seawater pH (pH=-log[H^+]), concentration of carbonate ion ($CO^2{}_3{}^-$), and the saturation state of the biominerals aragonite and calcite in a process commonly referred to as **Ocean acidification** (see Figure 1). *[Note: the increase in H^+ ions reduces seawater pH].*

Figure 3: Pteropod or sea butterflies. Pteropod or sea butterflies also known as Thecosomata or flapping snails, are a taxonomic suborder of small pelagic swimming sea snails. They have a calcified shell and are about the size of a lentil, they are eaten by various marine species, including a wide variety of fishes that are, in turn, consumed by penguins and polar bears. They are also consumed by sea birds, whales, and commercially important fish.Increased levels of atmospheric CO_2 or ocean acidification could threaten the survival of shell-forming thecostomes. Aragonitic thecostomes have been predicted to become regionally extinct as soon as 2050[6].

The drop of pH will have negative consequences on oceanic calcifying organisms such as cocolithophores and foraminifera, echinoderms, crustaceans and molluscs. The shells and skeletons of many marine organisms are made of calcium carbonate ($CaCO_3$). $CaCO_3$ exists in marine systems in two commonly occurring forms: calcite (e.g. cocolithophores or calcifying planktonic algae (see Figure 2) and foraminifera or calcifying protozoans), aragonite (e.g corals, pteropods (see Figure 3) of which aragonite form of calcium carbonate are more soluble than calcite. Therefore, calcifying organisms that produce calcite form of $CaCO_3$ (e.g. cocolithophores or calcifying planktonic algae (see Figure 2) and foraminifera or calcifying protozoans) are less vulnerable to changes in ocean acidity than those that construct aragonite structures (corals and pteropods (see Figure 3) or planktonic marine mollusc))

The tendency for a structure to dissolve is strongly influenced by the saturation (Ω) of each particular mineral and as oceans turn more acidic, the saturation state of aragonite progressively decreased (see Figure 1) thus could effect areas where coral reefs can develop[3] *[note: reef-building corals are very sensitive to ocean acidification].* In addition, marine organisms (reef building corals, molluscs, echinoderms, copepods and krill) may suffer from reproductive and physiological effects of ocean acidification, in particular reduced pH may cause decreased fertlisation, disruption of larval shells and skeletons development and reduced hatching success and therefore may cause negative effects on marine food web and seafood production. Likewise, the loss of calcifers organisms may cause a loss of many thousand marine species including commercial fish since many marine species use coral reef as a habitat, for example, one fourth of worlds marine fish species use the coral habitat at least part of their lifetime. Therefore ocean acidification could not only impacts on the commercial fisheries and shellfish production but could also threaten protein supply and food security for millions of the worlds poorest people *[note: molluscs, crustaceans support valuable commercial & recreational fisheries and coral reef ecosystems support a variety of subsistence, recreational and commercial fisheries worldwide, in addition calcifers also provide pearls, shells and coral pieces for jewellery. 82 developing nations including many island nations depend heavily on calcifying species to support subsistence or artisanal fisheries that provide both income and protein. Many of these small island nations have limited agricultural alternatives[8]].* Coral reefs generate billions of dollars through tourism[5]. Only reducing the emissions CO_2 in the atmosphere can reduce the impacts of ocean acidification.

Figure 2[7]: Diatoms, a type of phytoplankton. Many phytoplanktons are microscopic algae that form the base of the marine food we. They build calcium carbonate shells to protect themselves from microscopic predators called ciliate protozoa. A disruption of the ability of phytoplankton to build their shells could have ripple effects throughout the marine food web. (Credit: iStockphoto/Nancy Nehring)

References

1.Turley, C., Eby, M., Ridgwell, A.J., et al. 2010. The societal challenge of ocean acidification. Marine Pollution Bulletin 60: 787-792. 2. Doney, S.C., Fabry, V.J., Feely, R.A., and Kleypas. 2009. Ocean acidifications: The other CO_2 problems. Annual Review of Marine Science 1: 169-192. 3. Pajero, C, Calvo, E. and Hoegh-Guldberg, O. 2010. Paleo-perspectives on ocean acidification. Review. Trends in Ecology and Evolution. 25332-344.(6): 332-344. 4. Royal Society of the UK. 2005. Ocean acidification due to increasing atmospheric car bondioxide. 5.http://oceanacidification.wordpress.com/2007/07/02/2nd-symposium-on-the-ocean-in-a-high-co2-world-monaco-6-8-october-2008/. 6. http://en.wikipedia.org/wiki/Sea_butterfly. 7. http://www.sciencedaily.com/releases/2008/12/081217190334.htm. 8. Cooley, S., Kite-Powell, H.L. and Doney, S.C. 2009. Ocean acidifications potential to alter global marine ecosystems services. Oceanography. 22(4): 172-181.

The article is based on various sources and was compiled by Golam Kibria, Ph.D in July 2010 for http://www.sydneybashi-bangla.com (17) for community benefits. Views expressed in this article are those of the author and are not to be taken to be the views of any others including third parties. The information in this article may be assistance to you but the author donot guarantee that it is without flaw of any kind and therefore disclose any liability for any error, loss or other consequences which may arise from relying on any information in this article.