The Dangers of Ocean Acidification Outline

by Scott C. Doney - Scientific American 3/2006

1956 – Scripps scientists Revelle & Suess look into CO2

* Geochemists
* Wished to understand climate effects of CO2
* Hired researcher to help: Charles Keeling
* Set up equipment in remote locations
* South Pole
* Mauna Loa – almost uninterrupted data since 1958
* Hawaiian location showed ups and downs w/ growing season
* The concentration of CO2 year after year rose.
* Conclusion: CO2 was not disappearing but building up
* Revelle calculated that some CO2 would go into the ocean
* This would change ocean chemistry

Today scientists look at many data sets to verify the Revelle/Keeling data

* Ice core data measures CO2 in trapped air bubbles
* Results – CO2 levels constant for 1000’s of years until industrial revolution
* Since 1800’s – CO2 is 30% more abundant
* Expected to double or triple by 2100.

Source of most of CO2

* Fossil fuels (mainly coal, oil, natural gas)
* Fossil fuels do not contain C 14 isotope
* Fossil fuels have signature of two stable isotopes C 12 & C 13
* Therefore there is no debate on where excess CO2 comes from

Absorption of CO2

* 40% of CO2 stays in atmosphere
* 30% of CO2 is taken up by plants/algae
* 30% of CO2 is absorbed by the ocean

Doney study compares CO2 levels from 1986 to levels from 2005

* Upper 100 meters of ocean in South Atlantic had higher CO2 levels in 05
* Sea is taking in more of the excess CO2
* Other studies in other oceans show same trend

What is going on?

* Carbon dioxide combines with water to form carbonic acid (H2CO3)
* Carbonic acid releases hydrogen ions H+ (among other things)
* An increase in H+ ions makes the water more acidic.
* Neutral pH = 7 pure water = pH of 7
* Pristine seawater has a pH of 8 – 8.3 (Ocean is normally slightly alkaline)
* Absorption of CO2 today has lowered ocean pH levels about 0.1 on pH scale
* Predictions: by 2100, ocean chemistry will have pH lowered by 0.3.

What do we make of this?

* Lowering pH makes it harder to build a shell
* Marine organisms depend on carbonate ions to build calcium carbonate shells
* All of the extra H+ ions combine w/ carbonate ions to form bicarbonate ions.
* Result = reduction of available carbonate ions for shell building
* Message – lowering of pH makes it more difficult for some organisms to grow
* What life forms?
* Phytoplankton (coccolithophorids)
* Foraminifera
* Pteropods
* Coral
* Coralline algae
* Some shells might start dissolving in the changed ocean
* Calcium carbonate comes in 2 mineral forms
* Calcite
* Aragonite
* Some shells combine calcite & magnesium
* Aragonite & magnesium shells – more soluble than normal calcite
* This fact makes corals, pteropods & coralline algae susceptible to OA
* Solubility of calcium carbonate dependent on
* Carbonate ion concentration
* Temperature
* Pressure
* Most susceptible organisms live in deep, cold water – “under saturated”
* Shallow, warm waters “supersaturated” (in calcite & aragonite)
* Higher CO2 in atmosphere – shifts the saturation closer to surface
* 50 – 200 M closer to surface
* as compared to levels in 1800s
* upper, shell friendly area is becoming thinner
* Higher levels of CO2 slows growth even in supersaturated water
* High latitude, cold and deep marine ecosystems most vulnerable
* Polar aragonite might disappear by 2100 as might pteropods
* Pteropods - form of zooplankton spending life entire life cycle as plankton
* Pterodods – key link in southern ocean food chain
* Coral Reefs – OA is just one of many environmental stresses

What next?

* Study effects on single species
* Study effects of higher CO2 levels on entire ecosystems
* Look at case studies – Galapagos naturally has high CO2 levels
* Look at geologic record (55 mya) – huge marine extinction event