Southampton Oceanography Centre
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

GREENHOUSE OCEANS

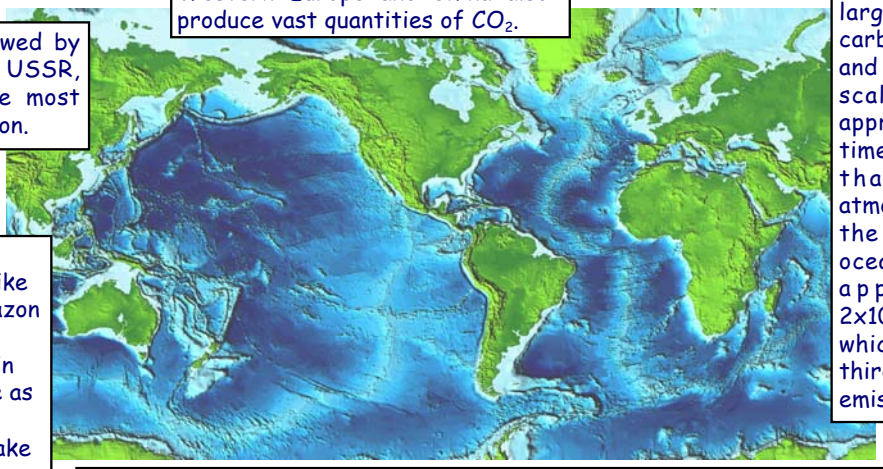
Based on a poster created by Sheila Stark, a postgraduate student at the Southampton Oceanography Centre, with the help of E. Faulkner and K. Aspinell, pupils of St Anne's School, Southampton.

WHAT HAPPENS TO CO_2 IN THE OCEANS?

Carbon dioxide enters the ocean by gas exchange between water and the overlying air. Gas molecules are continually passing in and out of the sea surface. When CO_2 is added to water most of it is rapidly converted to carbonic acid (H_2CO_3) which then forms bicarbonate (HCO^{3-}) and carbonate (CO_3^{2-}) ions. These reactions release hydrogen ions (H^+), making the water acidic. This can have a large effect on marine life as organisms are sensitive to pH but the many rapid reactions associated with CO_2 in seawater keep the acidity of the oceans at a fairly constant level.

Western Europe and China also produce vast quantities of CO_2.

The USA, followed by the former USSR, contributes the most to CO_2 production.



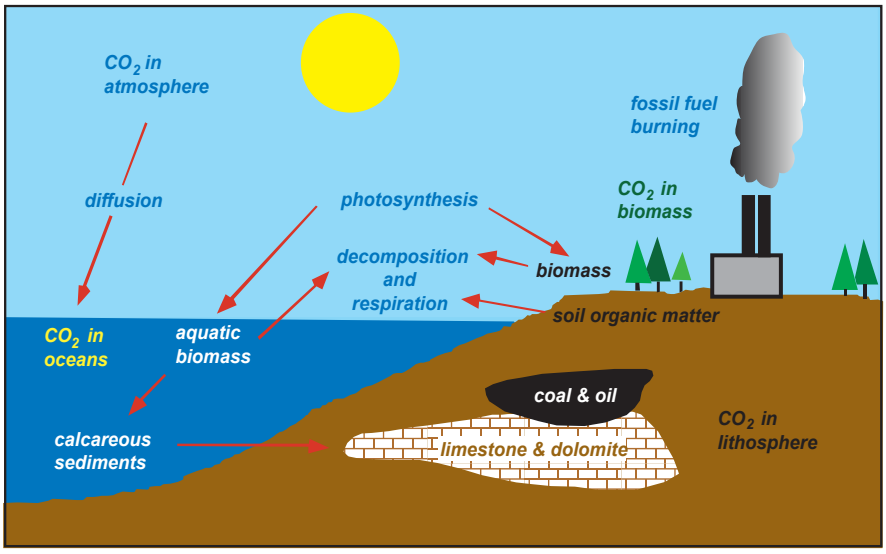
The ocean is the largest store of carbon in century and millennial time scales, holding approximately 50 times more carbon than the atmosphere. During the 1980s the oceans took up approximately $2x10^{12}$ kg of carbon, which is roughly a third of fossil fuel emissions.

Large scale deforestation like that in the Amazon increases the amount of CO_2 in the atmosphere as there is less vegetation to take up the gas in photosynthesis.

Cold water can absorb more gas than hot water. This water is dense and fills the deep ocean basins. Its high CO_2 concentration makes it acidic so it dissolves sinking calcium carbonate shells.

THE CARBON CYCLE

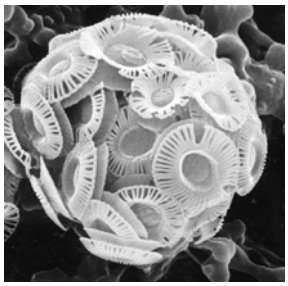
Dead phytoplankton sink to the ocean floor. Over time these accumulate and form sediments which are rich in carbon. Waste organic matter also transports carbon and nutrients from the surface to the deep ocean. In these ways the oceans can store large amounts of carbon which originated in the atmosphere as CO_2.



Fossil fuel burning and land use changes such as deforestation contribute to the accumulation of CO_2 in the atmosphere which leads to global warming.

CO_2 AND MARINE LIFE

Coral reefs are made up of calcium carbonate, which is produced by corals and other organisms. As the amount of CO_2 in surface waters increases so does its acidity making it harder for corals to form their skeletons. When corals are stressed, such as by an increase in water temperature, they may lose their algae, which are a major source of nutrients and colour. This 'bleaching' halts growth and reproduction and although reefs may recover from short bleaching episodes they are too fragile to survive prolonged attacks. Such attacks may occur as a result of global warming and increased temperatures and sea levels. This has wide implications as corals remove and recycle CO_2.



Coccolithophores are single celled marine plants that live in the upper layers of the ocean. They use carbon to build their calcium carbonate shells. They also contribute to carbon sediments on the sea floor. The reaction that forms their shells produces a CO_2 molecule from carbon and oxygen in the water. Some of the CO_2 is used as food but some of it escapes becoming part of the greenhouse gas problem. Changes in the climate of the oceans could lead to more coccoliths and hence more CO_2.

Phytoplankton are microscopic plants that live in the ocean. During photosynthesis phytoplankton remove CO_2 from seawater and release oxygen. This allows the oceans to absorb additional CO_2 from the atmosphere.

HOW DOES CO_2 AFFECT GLOBAL CLIMATE?

CO_2 allows solar radiation to pass to the earth's surface but absorbs outgoing radiation, thus warming the atmosphere. CO_2 accounts for around 50% of this effect and both CFC's and methane also contribute. There has been an increase in atmospheric CO_2 levels since the industrial revolution of the 19th century. Since the oceans are the biggest store of biologically active carbon they are thought to play a major role in controlling atmospheric CO_2 levels.

HOW DO WE KNOW THAT CLIMATE HAS VARIED IN THE PAST?

One method for studying past climatic variability is to study the gases in ice cores. Ice cores that are drilled from the Antarctic and Arctic ice sheets contain bubbles of trapped air. The composition of the air reflects the composition of the atmosphere at the time that the ice was formed. By dating the bubbles and measuring the amount of CO_2 in them it is possible to see how the amount of CO_2 in the atmosphere has varied in the past. These and other methods have shown that the climate has varied a lot in the past on both short and long time scales. This natural variability makes it very hard to determine if the current changes are greenhouse induced.