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OCEAN ENVIRONMENTAL MANAGEMENT

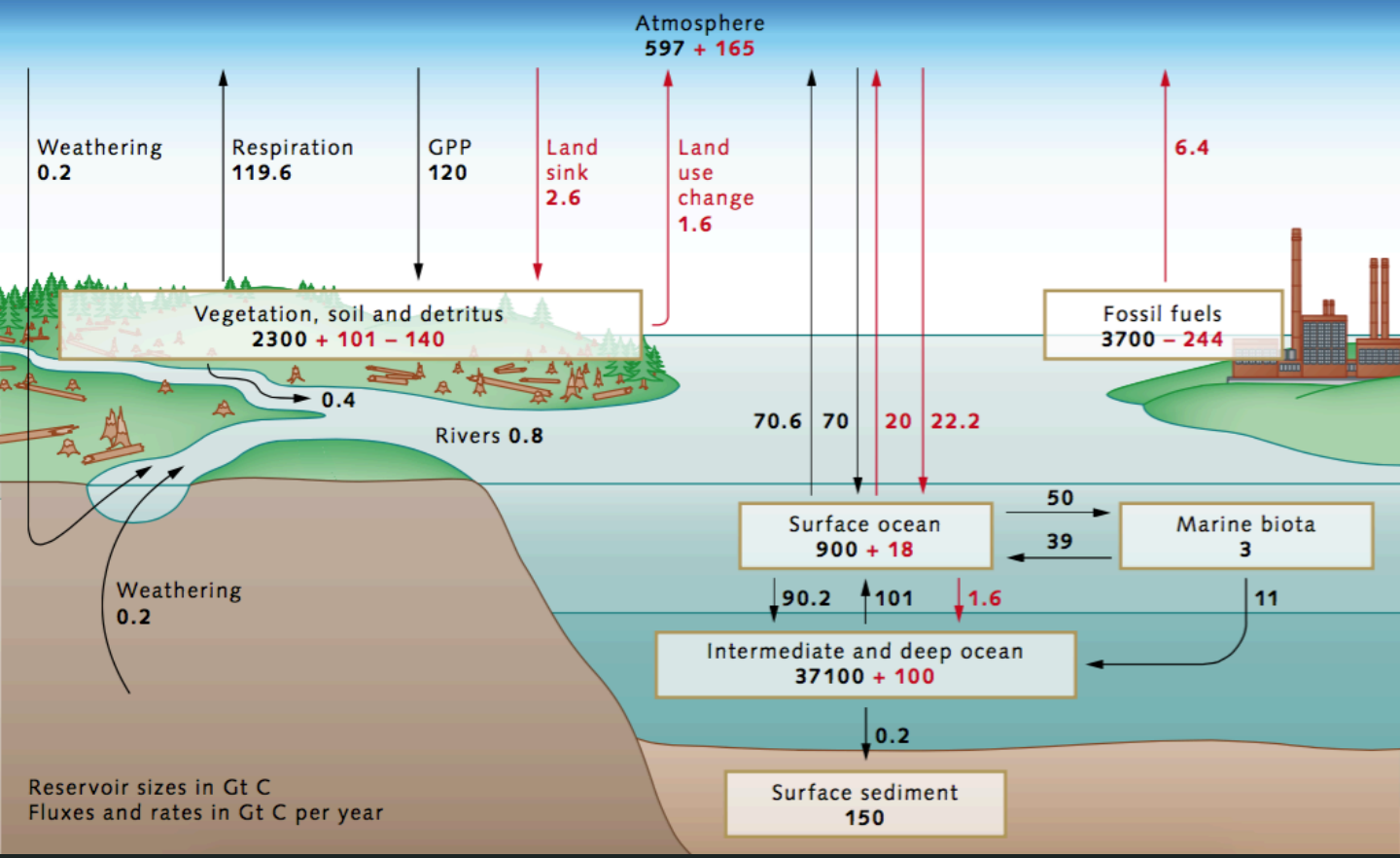
How climate change alters ocean chemistry

Major content

- The oceans – the largest CO_2 reservoir
- The consequences of ocean acidification
- Oxygen in the ocean (self-study)
- Climate change impacts on methane hydrates (self-study)

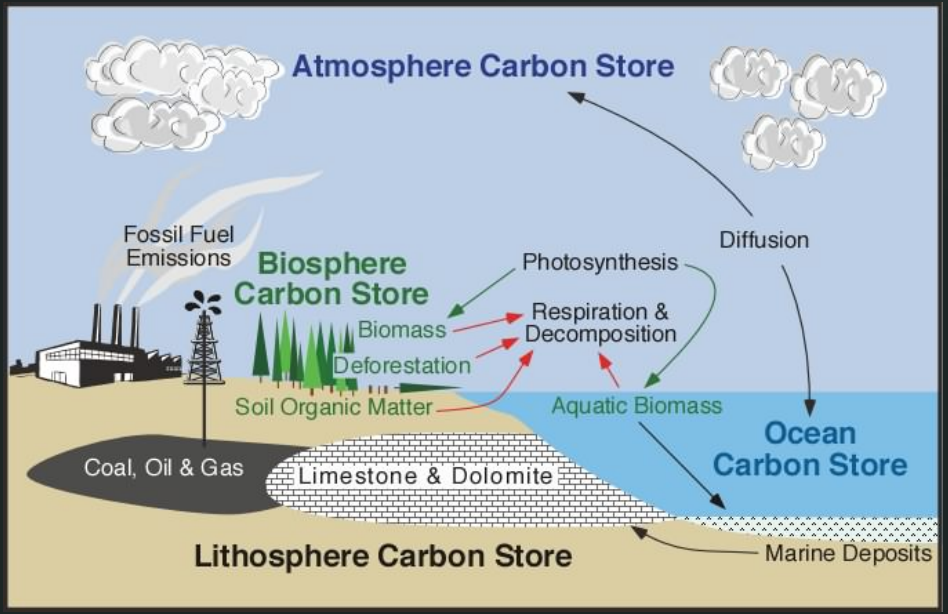
Massive emissions of carbon dioxide into the atmosphere have an impact on the chemical and biological processes in the ocean.

The warming of ocean water could lead to a destabilization of solid methane deposits on the sea floor, making the oceans more acidic.



Pre-industrial natural fluxes are shown in black, anthropogenic changes in red.

Carbon reservoirs



- Atmosphere
- Terrestrial biosphere (freshwater systems and non-living organic material, such as soil carbon)
- Oceans (dissolved inorganic carbon and living and non-living marine biota)
- Sediments (fossil fuels).

How much carbon is stored in the oceanic reservoir ?

- The ocean, with around 38,000 gigatons (Gt) of carbon (1 G = 1 billion), contains 16 times as much carbon as the terrestrial biosphere, and around 60 times as much as the pre-industrial atmosphere at only around 600 gigatons of carbon.
- The ocean is therefore the greatest of the carbon reservoirs, and essentially determines the atmospheric CO_2 content.
- The carbon, however, requires centuries to penetrate into the deep ocean, because the mixing of the oceans is a rather slow → changes in atmospheric carbon content over a time frame of centuries.

The ocean as a sink for anthropogenic CO_2

- A carbon dioxide (CO_2) sink is a carbon reservoir that is increasing in size, and is the opposite of a carbon "source".
- The main natural sinks are the oceans and plants and other organisms that use photosynthesis to remove carbon from the atmosphere by incorporating it into biomass.
- This concept of CO_2 sinks has become more widely known because of its role in the Kyoto Protocol.

The ocean as a sink for anthropogenic CO_2

- $CO_2 + H2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + CO_3^{2-} + HCO_3^-$
- The CO_2 capacity of the oceans is ten times higher than that of freshwater → absorb large quantities of CO_2 → refer to this assimilation of CO_2 as a sink.
- Oceanic reservoir and the buffering effect of deep-sea calcium carbonate sediments will assimilate around 95% of the anthropogenic CO_2 from the atmosphere.
- This takes centuries to millennia for the uptake of CO_2.

IMPORTANT NOTICE

The world ocean cannot absorb the greenhouse gas as rapidly as it is emitted into the atmosphere by humans.

Measuring exchange between the atmosphere and ocean

- Measurement of CO_2 partial-pressure differences between the ocean surface and the atmosphere:
  - Partial pressure is the amount of pressure that a particular gas such as CO_2 within a gas mixture (the atmosphere) contributes to the total pressure.
  - The gas flows from the body with the higher partial pressure into that of lower pressure.
  - Data were collected in >30 years (1970-2007).
  - The annual natural pre-industrial amount of 0.6 Gt C is flowing out of the ocean, and around 2.0 Gt C of anthropogenic carbon is entering the ocean every year, leading to the observed balance uptake of 1.4 Gt C per year.

Measuring exchange between the atmosphere and ocean

- The application of rather elaborate geochemical or statistical procedures, to calculate how much of the CO_2 in the ocean is derived from natural sources and how much is from anthropogenic sources.
  - the global hydrographic GLODAP data- set (Global Ocean Data Analysis Project), which was obtained from 1990 to 1998 through large international research projects.
  - The GLODAP data show that the world ocean has so far only absorbed around 40% of the carbon dioxide discharged by humans into the atmosphere between 1800 and 1995.

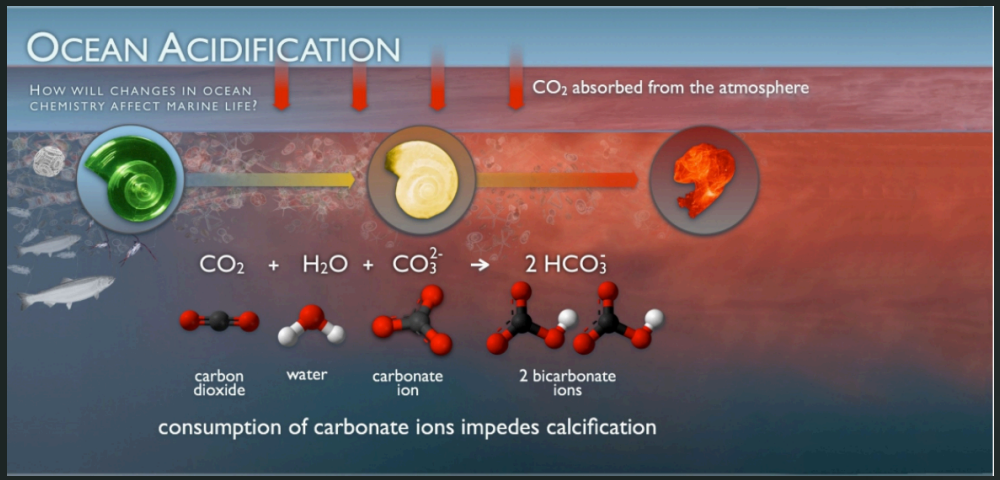
Ocean acidification

- Ocean acidification is the name given to the ongoing decrease in the pH of the Earth's oceans, caused by their uptake of anthropogenic carbon dioxide from the atmosphere.
- Between 1751 and 2004 surface ocean pH is estimated to have decreased from approximately 8.25 to 8.14.
- The pH scale is logarithmic, so this change represents approximately a 30 percent increase in acidity.

Ocean acidification

- The ocean absorbs about 30% of the CO_2 that is released in the atmosphere, and as levels of atmospheric CO_2 increase, so do the levels in the ocean.
- When CO_2 is absorbed by seawater, a series of chemical reactions occur resulting in the increased concentration of hydrogen ions.
- This increase causes the seawater to become more acidic and causes carbonate ions to be relatively less abundant.

Ocean acidification



Carbonate ions are an important building block of structures such as sea shells and coral skeletons.

Ocean acidification

- Which species is the most affected by ocean acidification? How affected?

→ 2-minute video: Ocean Acidification

https://www.youtube.com/watch?v=kxPwbhFeZSw

Solutions to ocean acidification ???

Group work

- Work individually in 5 minutes, point out several solutions to mitigate ocean acidification
- Each group has 10 minutes to communicate and select the best solution against ocean acidification.

Round-presentation

- Assign 1 speaker.
- Group's speaker has to visit each of your neighbor groups and present your findings in 3 minutes. Convince them that your solution is top choice. Take note.
- Other members: comment the visiting speaker. Take note.

You have 10 minutes to discuss again within your group to change or suppliment your idea

REPORT YOUR FINAL DECISION

SELF-STUDY:

1. Oxygen in the ocean
2. Climate change impacts on methane hydrates

THANK YOU FOR NOT SLEEPING