The Carbon Cycle in the Ocean

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About the Carbon Cycle:

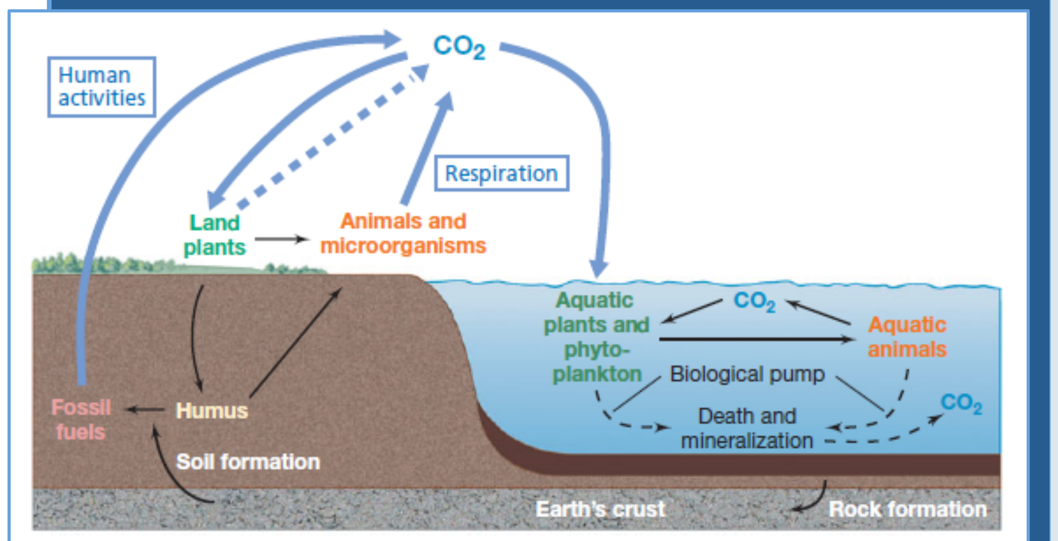

Fig.1: General Carbon Cycle. The carbon cycles through all of the Earth's compartments. In the hydrosphere, the Biological pump plays the most important role and is in charge of photosynthesis and respiration. While, in other compartments Human activities, land plants and animals play a more important role. *Extracted from Brock: Biology of microorganisms (13th edition)* **[20]**

The biggest carbon reservoir is found in the lithosphere. However, the decomposition rate is so low that is not significant for human beings. This is why, the most important compartment for us is the atmosphere since the carbon transfer is incredibly fast. Today, it is no secret that the anthropogenic release of CO_2 has surpassed biological contribution to the atmosphere, which is alarming.

Organic compounds are generated in earth by organisms that fixate CO_2 through photosynthesis. In terrestrial environments, the organisms in charge are plants. While in the hydrosphere, microorganisms are the ones who play the main role.

On the other hand, carbon also cycles chemically. More concretely, in the hydrosphere we can find the Carbonate system which acts like a buffer and controlls pH, which is essential for biological and chemical reactions.

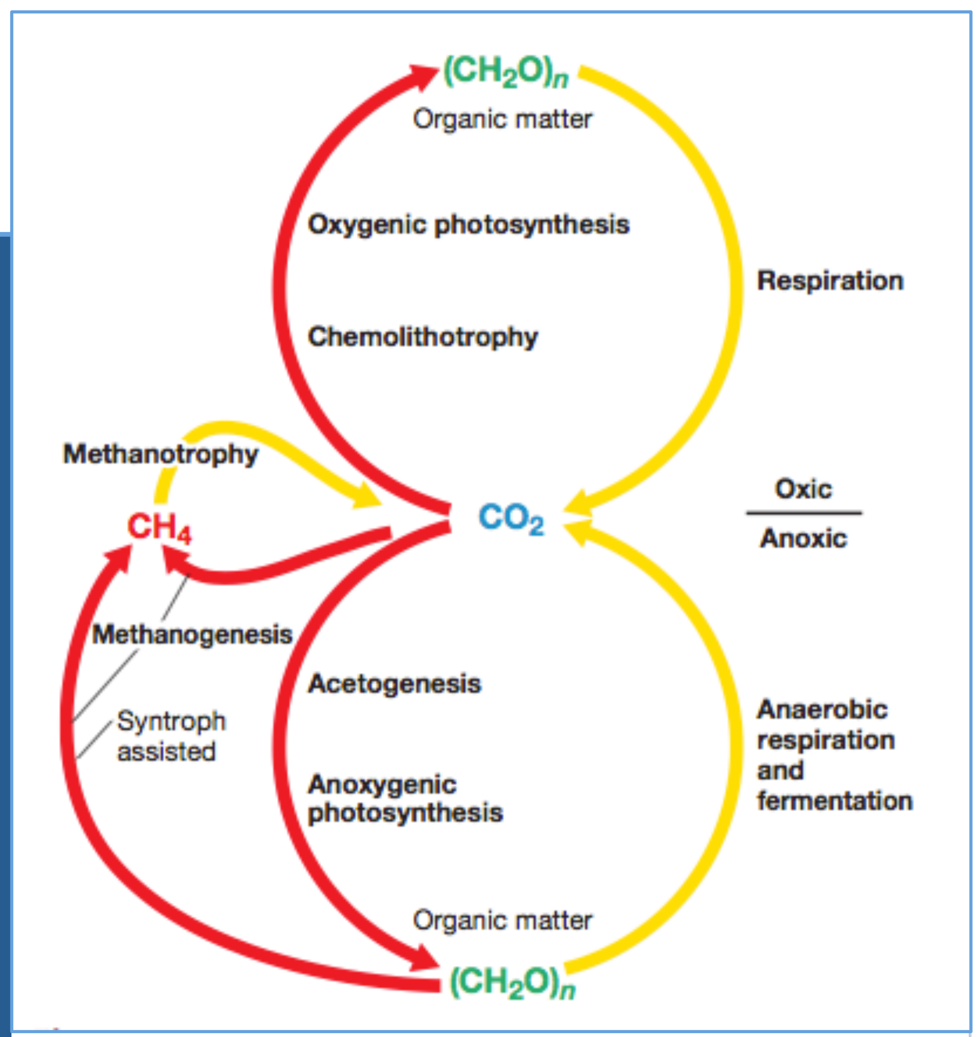

Fig.2: Redox Carbon Cycle. This diagram shows the autotrophic and heterotrophic process. The yellow arrows indicate an oxidation is taking place and the red arrows indicate that a reduction is taking place. *Extracted from Brock: Biology of microorganisms (13th edition)* **[20]**

The Carbon Cycle in the Ocean:

The Carbon Cycle in the Ocean has been divided into three main stages: 1)carbon fixation by photosynthetic organisms 2)sinking of the carbon particles 3)Mineralization of these carbon particles.

Forms of the Carbon in the Ocean Carbon Cycle	
DOC	Dissolved Organic Carbon. It is the largest reservoir, particles are less than 0.45μm.
RDOC	Refractory DOC. It involves the DOC that escapes mineralization. Acts as a carbon sink.
POC	Particulate Organic Carbon. The carbon that sediments into the deep ocean, it is bigger than 0.45μm

Biotical processes in the Ocean Carbon Cycle	
Biological pump	CO_2 is fixed by the primary producers and transported to the deep ocean as POC or DOC.
Microbial loop	Trophic pathway where bacteria and other microorganisms incorporate the DOC produced by the photosynthetic organisms.
Microbial Carbon pump	Biochemical pathway for the generation of RDOC and carbon sequestration.

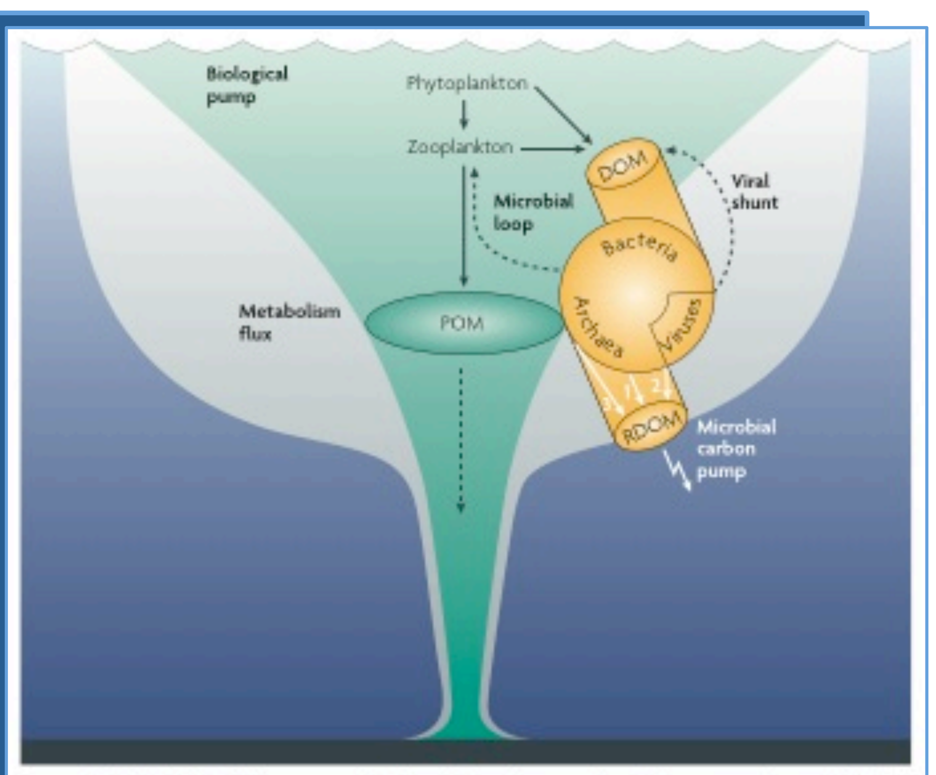

Fig.3: Biotic Ocean Carbon cycle. Diagram showing the relationship between Biological pump, microbial loop, microbial carbon pump and the different carbon forms. *Extracted from Jiao N. et al. (2010)* **[15]**

Microorganisms Involved:

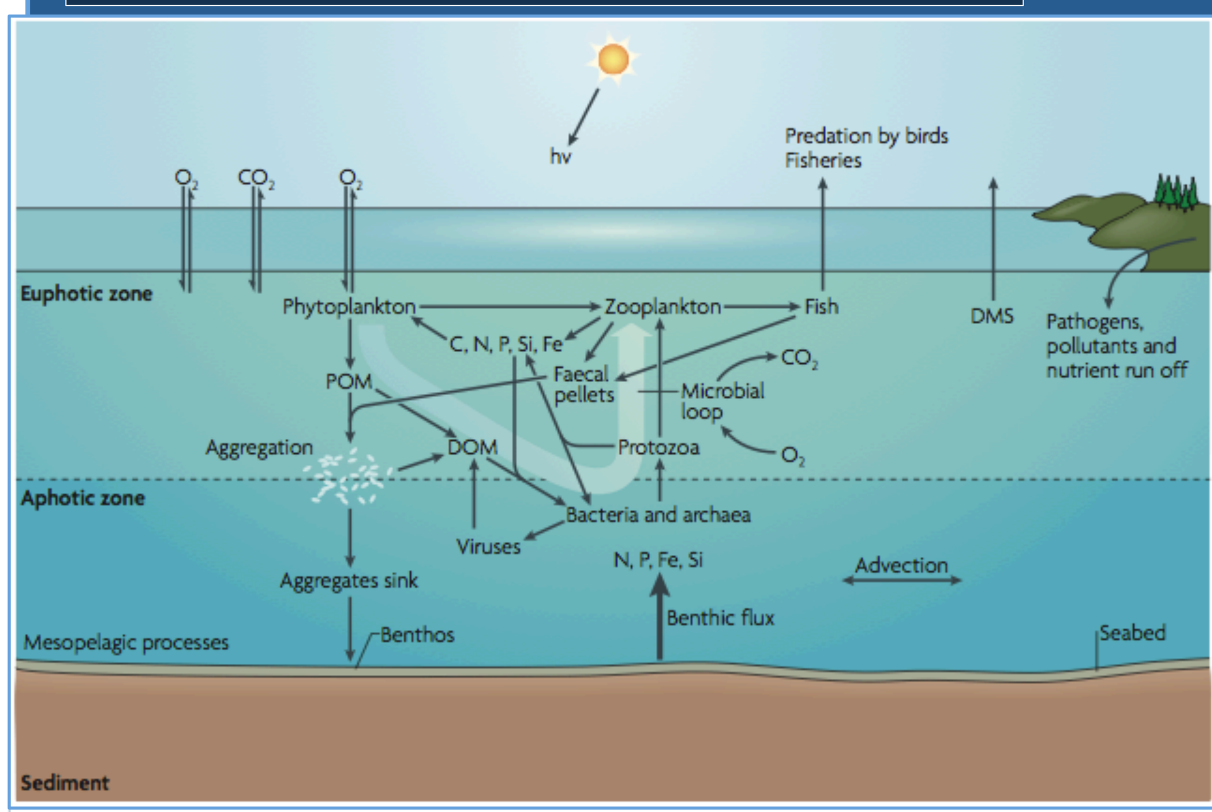

Fig. 4: Structure of organisms in the Oceanic Carbon cycle. Almost all DOM is initially taken by Bacteria and Archaea.. *Extracted from Azam F and Malfatti F (2007)* **[4]**

Plankton	Microscopic organisms that are floating in the Ocean, still they show chemiotaxis towards organic matter. The two main types are: phytoplankton and zooplankton. They have the most important role in the Biological pump.
Bacteria	The DOC-POC bacterial pathway is what dominates the carbon flux in the deeper ocean layers. They couple the microbial loop to the biological pump by hydrolyzing phytoplankton.
Archaea	Lately, it has been discovered that they are as important as bacteria in terms of abundance and role in the Ocean Carbon cycle.
Virus	The biggest unknown until recently. They perform "viral shunt" that is the release of DOC and POC to the ocean through the lysis of different microorganisms, mainly Bacteria and Archaea. It is thought to be closely related with RDOM formation. Besides, they have an important role in the microbial carbon pump.
Protozoa/other predators	They keep the balance of microorganisms and therefore of the carbon cycle in the Ocean through grazing.

Results of the unbalancing of the Oceanic Carbon cycle:

Atmospheric warming	This results on a change in the temperatures, chemistry and oceanic currents. Therefore, the different organisms will find themselves not suitable for the niches they occupy and they will have to change and adapt.
Ocean Acidification	Alteration on chemical balances and a reduction of the pH of the Ocean. This not only has a colossal effect on the carbonate system, but also results in problems of calcification for aquatic organisms.
Deoxygenation	Decrease of oxygen solubility because of a temperature increase, intensification of oxygen demand and decrease of ventilation.

Conclusions:

Today, the research in this field is increasing because of the rising fear for the atmospheric warming and what this would lead to.

Nevertheless, there are no active movements that can make a difference and prevent what it seems now unavoidable.

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