Dissolved Carbon in the Oceans: How much can be stored, and for how long?

Cascade Climate

The ocean is the world's largest natural carbon sink, having absorbed ~500 of the 1,300 gigatons of CO_2 emitted by humans over the last 200 years. In total, it holds over **37,000 gigatons of carbon—roughly 45 times more carbon than is currently in the atmosphere**.[1]

Most of this carbon is stored as dissolved inorganic carbon (DIC) in the form of dissolved carbonate and bicarbonate ions. Dissolved carbonate and bicarbonate ions remain **stable for upwards of 10,000 years**.[2]

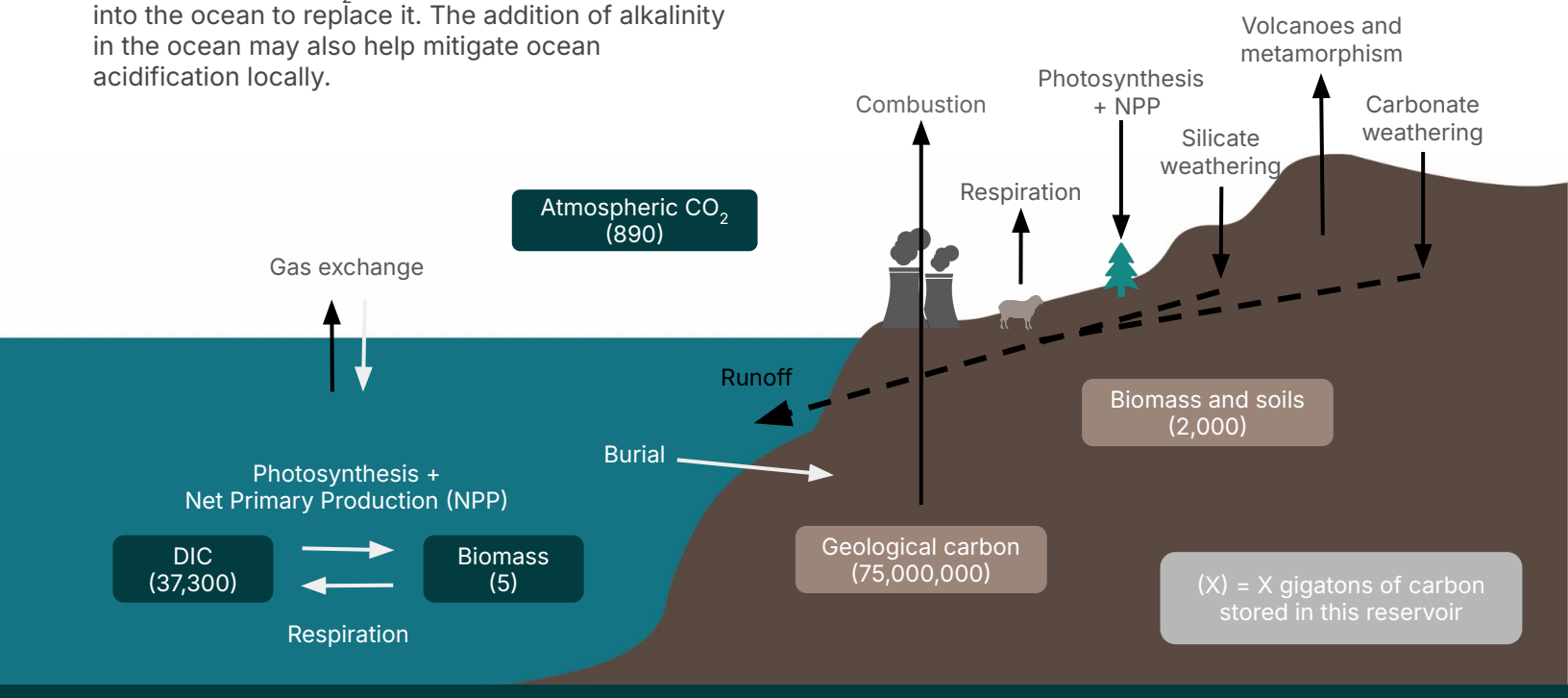
Most of this CO_2 enters the ocean via equilibration with the atmosphere.[3] The increase in oceanic CO_2 uptake in the last 200 years has had significant negative effects on marine ecosystems, biodiversity, and coastal communities, primarily in the form of ocean acidification.

However, the addition of **alkalinity** to the ocean allows the ocean to **store more atmospheric CO_2 – without increasing ocean acidification**. The addition of alkalinity can can convert dissolved inorganic CO_2 in the surface ocean into bicarbonate and carbonate ions. The surface ocean is in contact with the atmosphere, and they are constantly equilibrating with respect to each other, following Henry's Law.[3] Thus, decreasing the amount of CO_2 in seawater means that more CO_2 moves from the atmosphere into the ocean to replace it. The addition of alkalinity in the ocean may also help mitigate ocean acidification locally.

Several carbon dioxide removal (CDR) pathways deploy alkalinity addition, including **enhanced rock weathering (ERW), ocean alkalinity enhancement (OAE), and river alkalinity enhancement (RAE)**. These approaches take advantage of the 10,000+ year durability of bicarbonate and carbonate ions in the ocean, and the ocean's near limitless capacity for storage.

There is a significant amount of anthropogenic CO_2 that could be stored via adding alkalinity to the ocean. **The issue is not capacity**, but rather a question of **how to accelerate oceanic uptake and storage** in a safe and cost-effective way.

On very long timescales (>1 million years), the atmosphere, biosphere, and ocean can be considered one single carbon reservoir whose inventory is regulated through weathering and volcanic activity.[4]



1. Sabine, C. L., and T. Tanhua (2010) An. Rev. Mar. Sci., 2, 175–198, 2. Renforth, P. and Henderson, G. Rev. Geophys., 55, 636–674
3. IPCC: *Carbon Dioxide Capture and Storage.* 4. DeVries, T. 2022. *Annu. Rev. Environ. Resour.* 47:317-41