# Budgeting sinks and sources of $CO_2$ in the coastal ocean: Diversity of ecosystems counts

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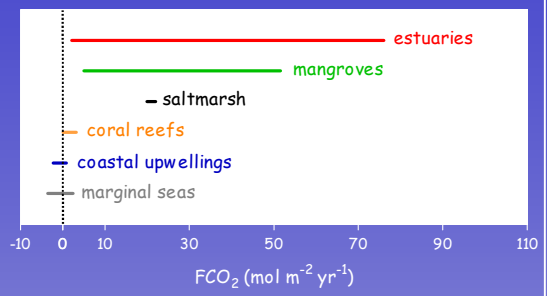
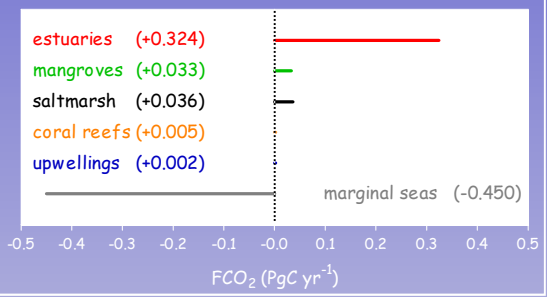
An exhaustive literature survey of air-water $CO_2$ fluxes was conducted and data in 44 coastal environments were gathered in 6 major ecosystems (marginal seas, upwelling systems, estuaries, mangrove and salt-marsh waters, and coral reefs). Near-shore ecosystems located at the land-aquatic interface (estuaries, saltmarsh waters & mangrove waters) act as intense sources of $CO_2$ to the atmosphere due to inputs of terrestrial organic carbon that fuel the net heterotrophy of the aquatic compartment. Coral reefs act as sources of $CO_2$ due intense calcification and a low net organic carbon production. Coastal upwelling systems characterized by high upwelling index (UI) values (Oman and California coasts) tend to be sources of $CO_2$ in contrast to those with low UI values (Galician coast, Vancouver Island). **Marginal seas at high (Barents Sea, Bristol Bay, Pryzd Bay, and Ross Sea) and temperate (Baltic Sea, North Sea, Gulf of Biscay, US Middle Atlantic Bight, and East China Sea) latitudes are net annual sinks of atmospheric $CO_2$ but at sub-tropical and tropical latitudes they are net annual sources of $CO_2$ to the atmosphere (US South Atlantic Bight, South China Sea, and Southwest Brazilian coast)**

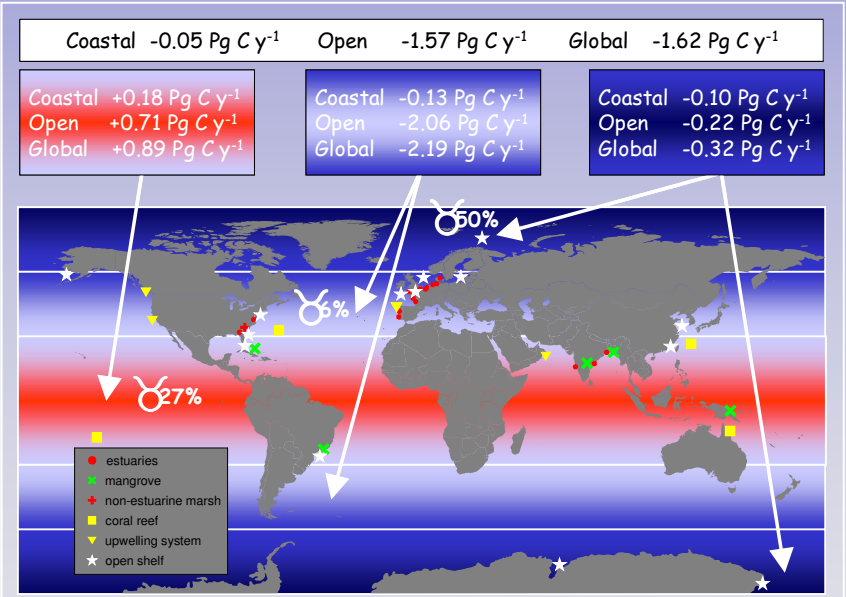
Range of air-water $CO_2$ fluxes in coastal environments




Air-water $CO_2$ fluxes were up-scaled by multiplying a reasonable flux value for a given ecosystem by its respective surface area. Marginal seas act as a significant $CO_2$ sink (-1.62 mol C $m^{-2}$ $yr^{-1}$; -0.45 Pg C $yr^{-1}$). **However, the global sink of $CO_2$ in marginal seas could be almost fully compensated by the emission of $CO_2$ (+11.09 mol C $m^{-2}$ $yr^{-1}$; +0.40 Pg C $yr^{-1}$) from the ensemble of near-shore coastal ecosystems, mostly related to the emission of $CO_2$ from estuaries (0.32 Pg C $yr^{-1}$).**

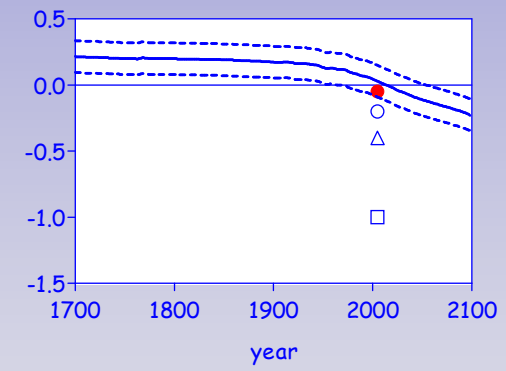
Net air-water $CO_2$ fluxes in coastal environments




An overall integration of $CO_2$ fluxes (global ocean) was carried out using the recent climatology for open oceanic waters from *Takahashi et al.* (2002). The coastal ocean would act as a net $CO_2$ sink at high and temperate latitudes and as a net $CO_2$ source at tropical latitudes. The inclusion of coastal air-water $CO_2$ fluxes would strongly increase the overall $CO_2$ sink at high latitudes (-0.22 versus -0.32 Pg C $yr^{-1}$, 50%) and temperate latitudes (-2.06 versus -2.19 Pg C $yr^{-1}$, 6%), but would significantly increase the overall $CO_2$ source at subtropical and tropical latitudes (+0.71 versus +0.89 Pg C $yr^{-1}$, 27%).

$CO_2$ fluxes (Pg C $yr^{-1}$)




Shallow-water Ocean Carbonate Model (SOCM) *Andersson & Mackenzie 2004*

● *Borges et al. 2005* △ *Thomas et al. 2004*

○ *Cai & Dai 2005* □ *Tsunogai et al. 1999*

Our up-scaled air-water $CO_2$ flux estimate taking into account the latitudinal and ecosystem diversity of the coastal ocean is in fair agreement with the one given by SOCM (*Andersson & Mackenzie* 2004). Other estimates are based on the extrapolation to worldwide continental shelves of data from the East China Sea (*Tsunogai et al.* 1999), the North Sea (*Thomas et al.* 2004) or a province based up-scaling of marginal seas (*Cai & Dai* 2005). **This clearly emphasizes the importance of the diversity of ecosystems, in particular near-shore systems, when integrating $CO_2$ fluxes at global scale in the coastal ocean.**

References :
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