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Ocean Carbon Sink Core Measurements Protocols

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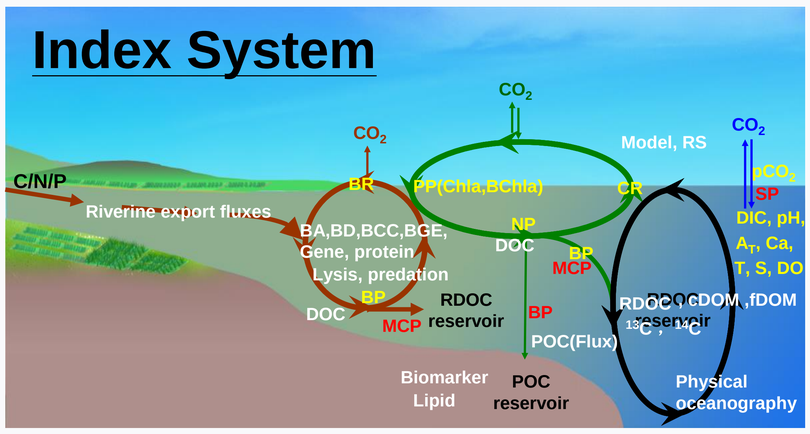
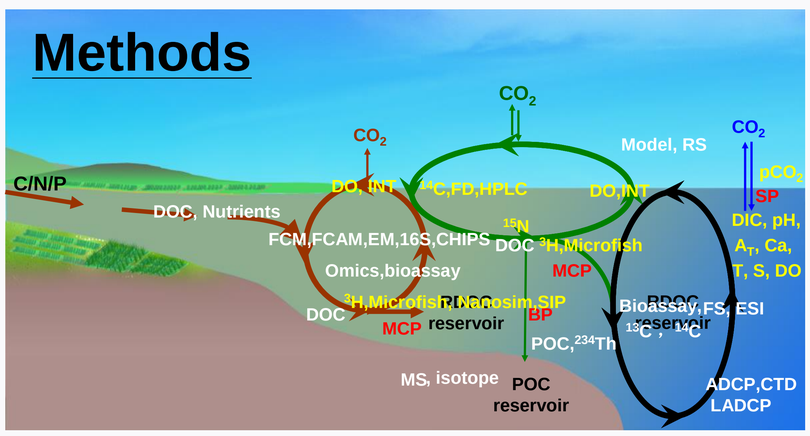
The ocean is the largest carbon pool on the planet, playing a critical role in global carbon cycling and climate change as a buffer of atmospheric CO_2. The contemporary ocean has taken up 48% of the anthropogenic CO_2 since industrialization. However marine carbon sink was ignored in the Kyoto Protocols two decades ago, partially due to lack of measurable indices. The recently published "Blue Carbon" report by the United Nations and IPCC 2013 report, have both emphasized the role of the ocean in climate change. Thus the needs for marine carbon sink protocols are emerging. Here we propose a framework of core measurements of carbon sink in a variety of marine ecosystems (estuary, wetland, saltmarsh, continental shelf, open sea and oceanic gyre) with diverse biota (phytoplankton, bacteria, viruses, zooplankton, seagrass, mangroves and fisheries) for peers to work on, toward the development of a standard protocol of multiple disciplines with comparable parameters of inorganic carbon (e.g., CO_2, HCO_3^-,CO_3^{2-}), organic carbon (e.g., POC, DOC, Semi-LDOC, RDOC, CDOM), ecological processes (primary production, export production, respiration etc) and even physical oceanographic parameters (e.g., salinity, alkalinity, current, water mass, material flux) and models (box model, numerical model). Particularly, techniques for measuring new parameters such as those involved in the microbial carbon pump (e.g., bacterial growth efficiency, RDOC bioassay, gene-chips-assay) should be dedicatedly worked out with special attention. The marine carbon sink protocol are not only necessary for scientific research but also for carbon trade and ecological compensation policy.

Challenges

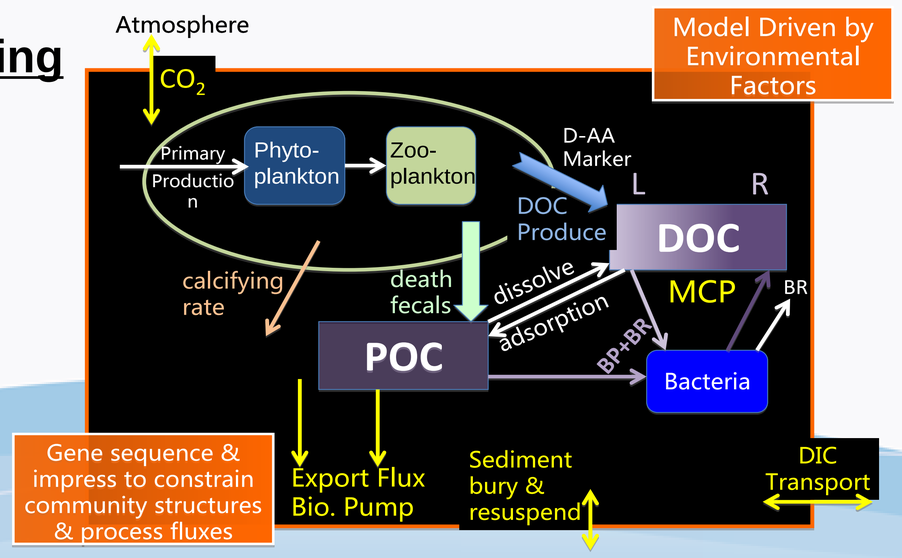
- **Can we calculate the ocean carbon sink and the contribution of MCP?**
- **If can we form the protocols (TCCCA: Transparency, Consistency, Comparability, Completeness, Accuracy) for determination of ocean carbon sink?**

Ocean Carbon Sink and Protocols

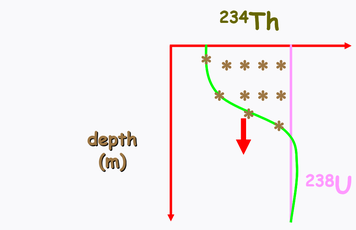




Modelling

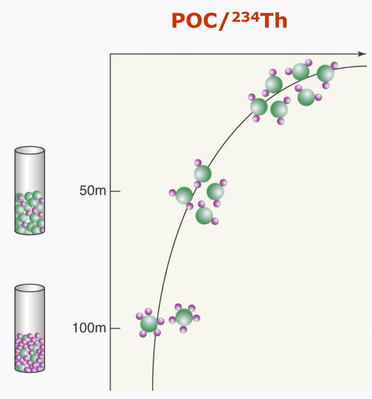


□ e.g. 1: ^{234}Th-based POC export rates technique



At Steady State:
(^{238}U - ^{234}Th) λ *Z = ^{234}Th Export (dpm m^{-2} d^{-1})

Measure C/^{234}Th on sinking particles
→ **Carbon Export**



- **Empirical approach**
- **Must use site and depth appropriate ratio**

From Buesseler (2004)

➢ In the past decade, a MnO_2- impregnated cartridge technique has been widely to extract ^{234}Th from seawater.
➢ One of the inherent assumptions associated with this technique is that all Th species in the dissolved phase are subject to extraction by the MnO_2.
➢ An inter-calibration between the cartridge technique and a small-volume co-precipitation technique was carried out to test this assumption. It was demonstrated that the collection efficiency for ^{234}Th could be substantially overestimated by the MnO_2 cartridge technique.
➢ This may be the result of organic complexation of a significant portion of ^{234}Th in seawater, causing this fraction of Th to pass through the MnO_2 cartridges. The overestimate in collection efficiency may explain the deep-water ^{234}Th deficit observed in some oceanographic settings (e.g. the Gulf of Mexico, the Middle Atlantic Bight and the Gulf of Maine).
➢ Sensitivity tests show that using the cartridge technique can yield ^{234}Th-based particulate organic carbon export rates that are overestimated by factors of up to 10. Furthermore, the frequent observed disagreements between Th fluxes recorded by shallow sediment traps and estimated using the cartridge method may be ascribed, at least partially, to this methodological issue.
➢ A newly developed small MnO_2 coprecipitation technique was carried out [Buesseler et al., 2001; Pike et al., 2005; Cai et al., 2006].

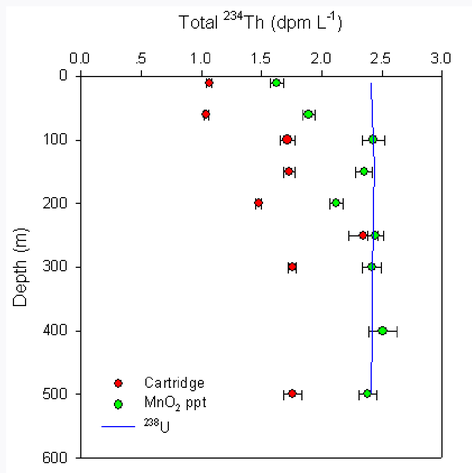


Figure 1. Depth profiles of total ^{234}Th activities based on the MnO_2 cartridge technique and on the MnO_2 co-precipitation technique. The solid line represents depth distribution of ^{238}U. (Cai et al., 2006)

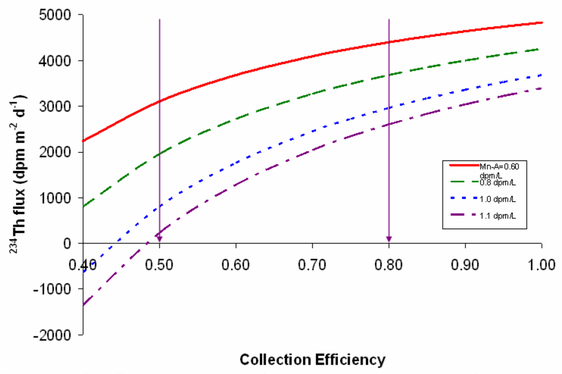


Figure 2. Sensitivity of the collection efficiency (for MnO_2 cartridges) in the calculation of ^{234}Th flux at 100 m. Calculations refer to theoretical ^{234}Th activities of 0.6, 0.8, 1.0, and 1.1 dpm L^{-1} (Cai et al., 2006)

➢For the depth profile based on the MnO_2 ppt technique, ^{234}Th activities are lower than equilibrium in the upper 100 m, indicating that significant particulate export is occurring. Below, a secular equilibrium is reached between ^{234}Th and ^{238}U except at 200 m. In contrast, the depth profile based on the MnO_2 cartridge technique shows ^{234}Th deficit relative to ^{238}U throughout the 0-500 m water column. Similar structure has been observed in the Gulf of Mexico and in the Middle Atlantic Bight [e.g., Baskaran et al., 1996; Hung et al., 2004; Santschi et al., 1999], and was ascribed to benthic nepheloid layer exchange processes over the continental slope.

➢Sensitivity tests show that using the cartridge technique can yield ^{234}Th-based particulate organic carbon export rates that are overestimated by factors of up to 10. This may explain well the discrepancy between ^{234}Th fluxes expected from the ^{234}Th deficit in the water column and from the sediment trap deployed in the Middle Atlantic Bight, where the water column deficit below 200 m amount to 8300-13,000 dpm m^{-2}d^{-1}, while in the sediment trap at 800 m, on average, only 1000-3000 dpm m^{-2}d^{-1} were collected [Santschi et al., 1999]. Similarly, it is possible that the under-collection of ^{234}Th by shallow sediment traps as observed in some studies [e.g., Gustafsson et al., 2004; Hung et al., 2004] can be ascribed, at least partially, to this collection efficiency issue

References

Buesseler, K. O., C. Benitez-Nelson, M. Rutgers van der Loeff, J. Andrews, L. Ball, G. Crossin, and M. A. Charette (2001), An intercomparison of small- and large-volume techniques for thorium-234 in seawater, Mar. Chem., 74, 15–28.
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Cai, P., M. Dai, D. Lv, and W. Chen (2006), How accurate are ^{234}Th measurements in seawater based on the MnO_2- impregnated cartridge technique?, Geochem. Geophys. Geosyst., 7, Q03020.

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