MEDFLUX: ORGANIC MATTER COMPOSITION FROM TIME-SERIES AND SINKING-VELOCITY SEDIMENT TRAPS IN THE "TWILIGHT ZONE" IN THE MEDITERRANEAN

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Abstract:

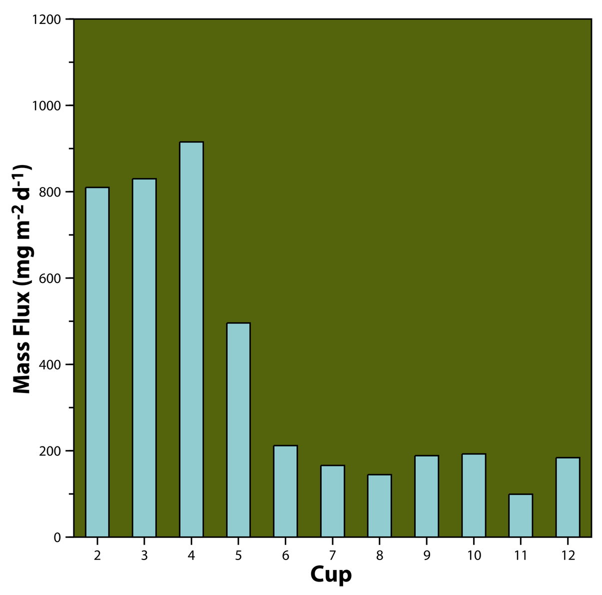
A bottom-moored sediment trap array was deployed at the French JGOFS DYFAMED site off Monaco during March - May, 2003, to evaluate the time-series flux of particulate matter (PM) and its sinking dynamics in the "Twilight Zone". One set of traps was operated in a time-series mode while a second was modified to collect PM as a function of its ambient settling velocity (poster by Peterson et al.). The settling-velocity trap collected PM over the range in settling velocities from 0.9 - 1000 m d^{-1}. The collected material has been analyzed for mass, organic carbon and total nitrogen, lipids, amino acids and pigments. Here we present results of these analyses to test hypotheses related to the association of organic carbon (OC) and mineral ballasts, the sinking dynamics of OC-mineral particles, and the protection against degradation that mineral matrices afford to associated OC.

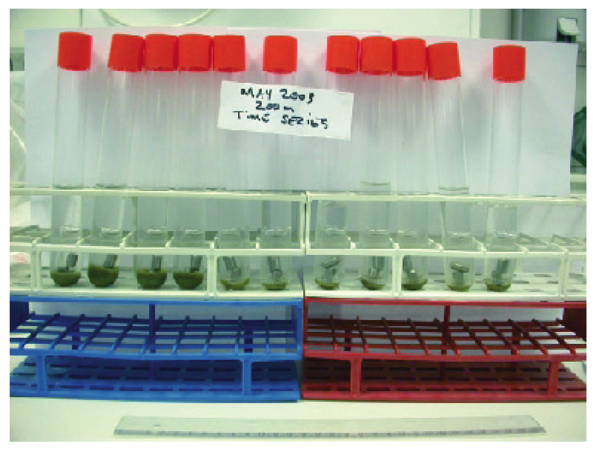
Introduction:

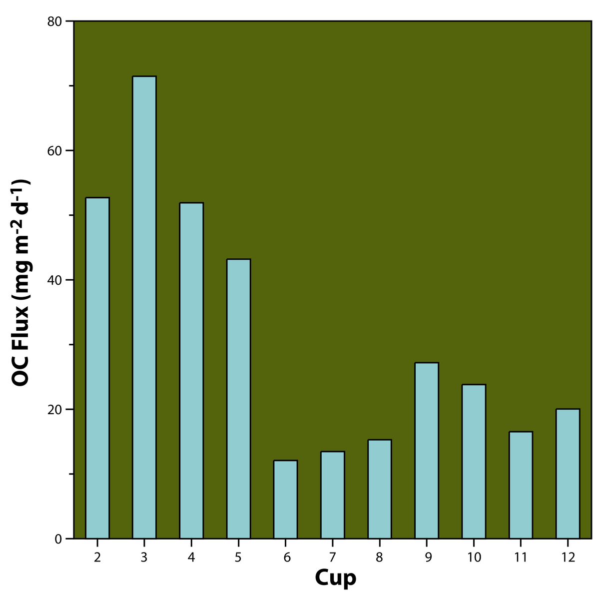
The ability to predict quantitatively the depth profile of particulate matter remineralization is critical to predicting the response of the global carbon cycle to environmental change. We hypothesize that minerals produced by organisms, or introduced into the surface ocean by winds, critically influence carbon export to the deep ocean and sediments. Minerals that typically constitute more than half of the mass of settling particles are important for making less-dense organic matter sink. Minerals may also protect organic matter from degradation, allowing it to penetrate deeper into the ocean. We are using a multi-tracer approach (elemental analyses, radioisotopes, organic geochemistry, microbiology) to evaluate relationships between mineral ballast and associated organic and radioisotope compositions. **Our hypotheses are:**

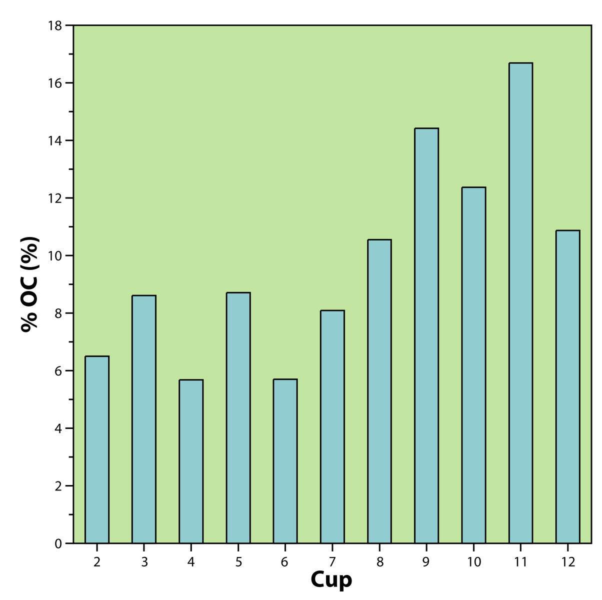
1) that ballast minerals physically protect a fraction of their associated organic carbon (OC), and the protected OC dominates over an unprotected fraction at depths >1000 m, and
2) the ratio of organic carbon to mineral ballast (OC/ballast) is key in predicting variability in export fluxes and settling velocities of organic carbon as estimated using radiotracers.

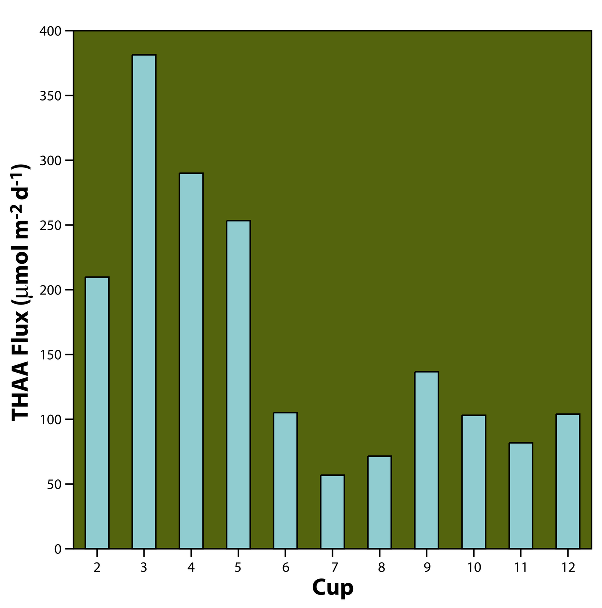
Time-series Traps

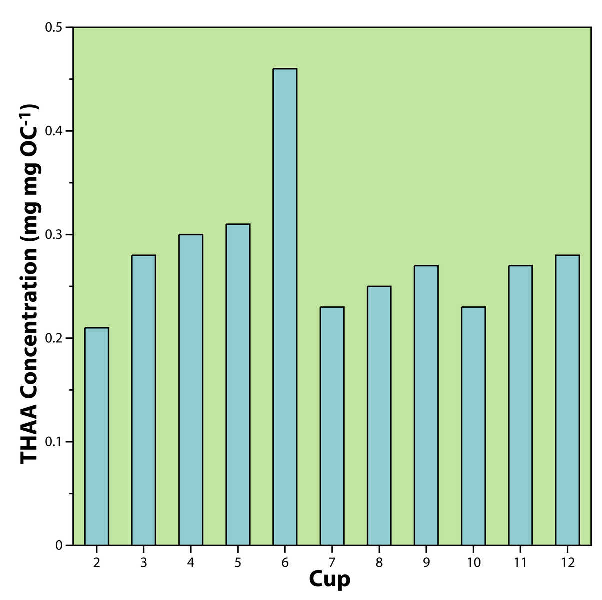


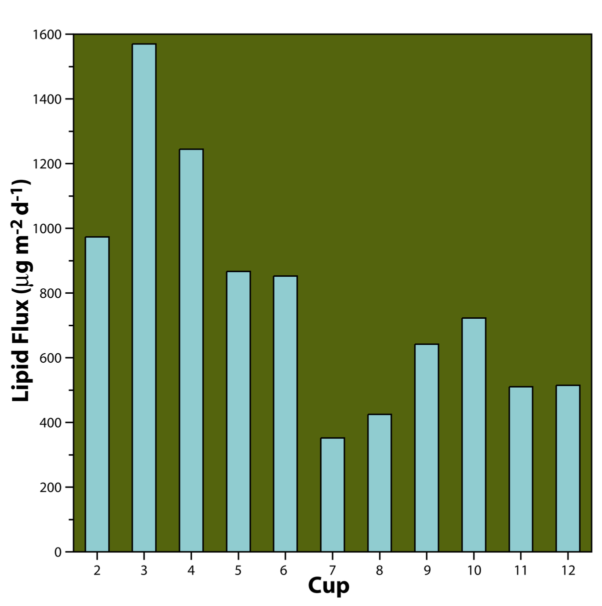


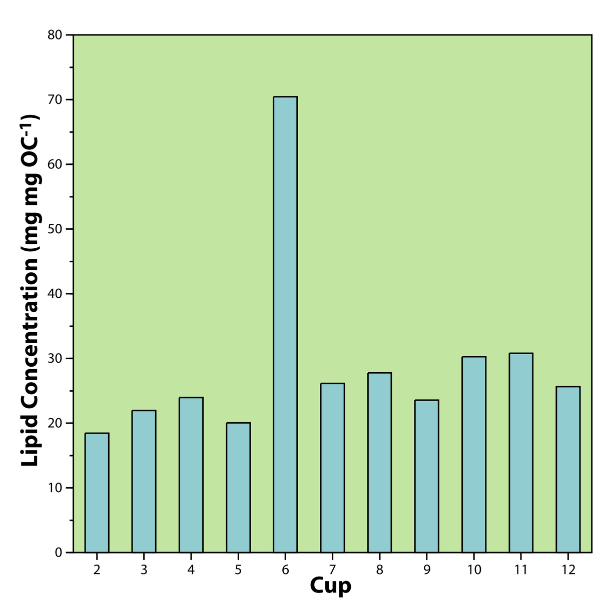


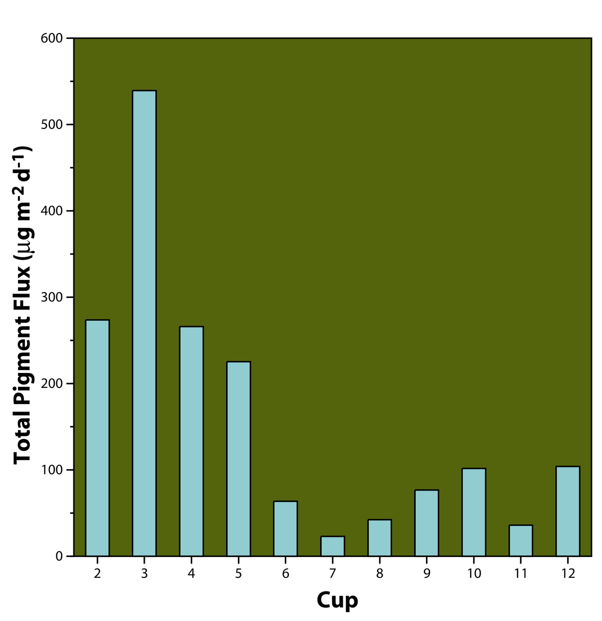


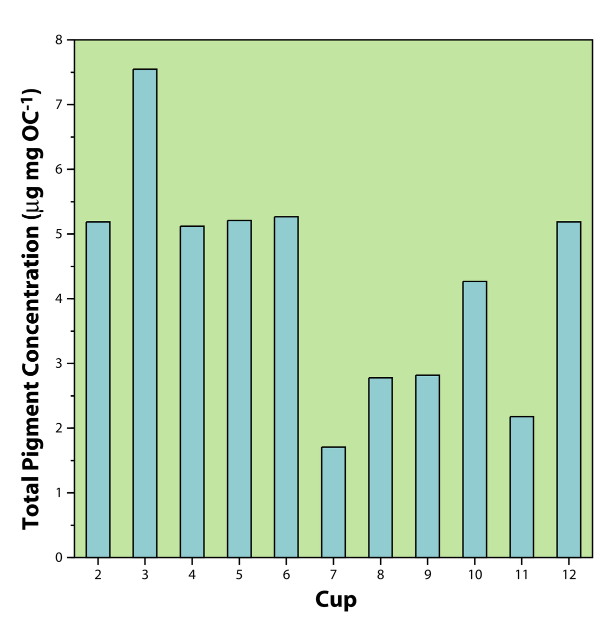












Methodology:

At the DYFAMED site (52 km off Monaco; 43°20"N, 7°40"E; 2000 m water depth), we deployed a sediment trap array between March and May, 2003. One indented-rotating sphere (IRS) valve trap were fitted with time-series carousels to determine the flux of particulate matter in the "twilight zone". A second trap was modified to collect particles as a function of their settling velocity and was set at 200 m depth. Details of trap design and functioning are given in the accompanying poster by Peterson et al. We calculate that the settling-velocity trap collected particles over a range of settling velocities between 0.9 - 1000 m d^{-1} (see figures at right). Upon recovery of both time-series and settling-velocity traps, material was split in the laboratory for a series of analyses, including OC, TN, carbonate, silicate, Al, lipids, amino acids, carbohydrates, ^{234}Th, ^{230}Th, ^{210}Pb and ^{210}Po, and microbial degradation. This poster presents initial results for organic flux and composition; other results are presented in accompanying posters (Stewart et al., ^{210}Po and ^{210}Pb; Cochran et al., OC and ^{234}Th).

Results:

Time-series Trap:

The time-series trap at 200 m depth recorded an apparent shift in mass flux from a high of ~900 mg m^{-2} d^{-1} in early March to <200 mg m^{-2} d^{-1} by early May. Organic carbon flux also decreased over the sampling period, from ~70 mg m^{-2} d^{-1} to ~20 mg m^{-2} d^{-1}, but organic carbon content (%OC) of the trap material gradually increased from ~6 - 8% to ~12 - 16% over the collection period. We expect this shift was due to elevated biogenic mineral flux during the beginning of the experiment and reduced mineral flux at the end. Fluxes for total hydrolysable amino acids, lipids, and pigments followed similar trends over the experiment. We suspect that the elevated flux early in the deployment reflects the spring diatom "bloom" in this part of the Mediterranean, with decreasing fluxes as the bloom died off. The increase in %OC may result from higher OC/ballast ratios at the end of the deployment.

Settling-velocity Trap:

The total mass flux of material collected in the settling-velocity trap was remarkably similar to that of total mass collected in the time-series trap (299 vs. 348 mg m^{-2} d^{-1}, respectively). Roughly 50% of the material collected appears to settle in the 196 - 489 m d^{-1} range. An apparent mass flux of ~110 mg m^{-2} d^{-1} in the 196 - 489 m d^{-1} "bin" was 4-5-fold higher than for other settling velocities. Organic carbon content increased from ~4% in the fastest settling particles to ~12% in the slowest settling ones, suggesting that the ratio of OC to mineral ballast may be slightly higher for the more slowly settling material. OC-normalized concentrations of THAA and lipids appear to increase in the more slowly settling particles (the high value in the <980 m/d sample is driven by a low %OC in the most rapidly settling fraction), whereas pigment concentrations trend downwards as particle settling rates decrease. Thus the more slowly settling particles are enriched in THAA and depleted in pigments relative to faster settling particles. We believe these trends and detailed organic compositions (see poster by Xue et al.) indicate that the more rapidly settling material was dominated by diatom- and zooplankton fecal pellet-derived material.

Future work:

The analyses we have completed to date only scratch the surface of the analyses still to be completed; in fact a second experiment using the time-series and settling-velocity traps was completed in May - June, 2003, and analyses of these are just beginning. In addition to chemical analyses, Madeleine Goutx and colleagues at the University of Marseilles (France) have been conducting parallel experiments on microbial degradation of organic carbon, lipids, and dissolution of silica. We believe that our investigations will continue to provide fundamental new insight into the behavior of particulate organic matter and mineral ballasts in the ocean.

Acknowledgements:

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Settling-velocity Traps