MEDFLUX: Relationships among ballast, particulate organic carbon and ^{234}Th activities and fluxes in the upper water column

J. K. Cochran[1], J. C. Miquel[2], S. W. Fowler[2], B. Gasser[2], J. E. Szlosek[1], A. Rodriguez-y Baena[2], D. J. Hirschberg[1], G. M. Stewart[1] and P. Masqué[3]

1. Marine Sciences Research Center, Stony Brook, NY USA 2. Marine Environment Laboratory (MEL), IAEA, Monaco 3. ICTA, Universitat Autonoma de Barcelona, Bellaterra, Spain

INTRODUCTION

Sinking fluxes of particulate organic carbon (POC) in the oceanic water column are frequently measured using the disequilibrium between the natural radionuclide ^{234}Th and its parent ^{238}U. Such estimates require measurement of both the extent of disequilibrium and the POC/^{234}Th ratio on the sinking particles. The latter is commonly estimated through measurement of the POC/^{234}Th ratio in a large (e.g. >50 or >70 μm) filterable fraction or in sediment trap material. The relationship between the POC/Th in the filterable and sinking particles remains uncertain, however. As part of the MedFlux program, we used *in situ* pumps to measure the patterns of Th/U disequilibrium in the water column at the French JGOFS time-series DYFAMED site in the northwestern Mediterranean. In addition, IRS swimmer-exclusion sediment traps were deployed at 200 m to collect both a regular time series of particle flux and a composite sample with individual cups programmed to collect particles separated according to settling velocity. A large sample of particles sinking through 200 m was collected by means of a newly-designed "net trap" deployed for 3 days, and subsequently separated into settling velocity fractions using an elutriator (see poster by Peterson et al., this session, for further information on sampling design*).

METHODS

- Samples were collected by *in situ* pumps that passed water through a 70 μm Teflon (MSRC) or Nitex (MEL) prefilter and a 1 μm Microquartz (MSRC) or GFF (MEL) filter, followed by two manganese oxide-impregnated wound fiber (Hytrex) filter cartridges that extracted "dissolved" Th from solution. ^{234}Th was measured in the particulate fractions using non-destructive beta counting and in the dissolved fraction by non-destructive gamma spectrometry of the cartridge ash.
- Aliquots from the sediment traps were filtered onto 0.4 μm pre-weighed Nuclepore filters and ^{234}Th was determined by non-destructive beta counting.
- The net trap sample was passed through an elutriator consisting of several stages characterized by different flow velocities of water passing through the system (see Peterson et al., this session*). The particles were separated into several fractions according to settling velocity and were subsequently processed like the sediment trap samples.

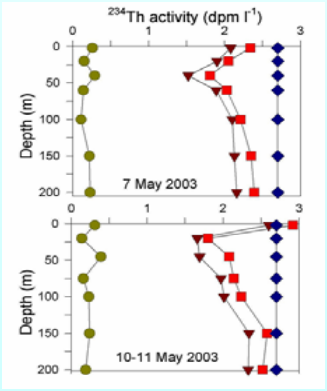

Figure 1

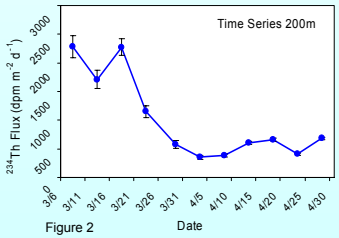

Figure 2

Several water column profiles of particulate and dissolved ^{234}Th were collected over a one-week period in May 2003 (Fig. 1). The data show a pronounced minimum in total ^{234}Th (particulate + dissolved) centered on the depth of the chlorophyll maximum. Fluxes of ^{234}Th at 200 m (calculated applying a steady state model to the ^{234}Th deficit) were ~3000 dpm m^{-2} d^{-1} on May 7 and ~2000 dpm m^{-2} d^{-1} on May 10-11. These fluxes were in the range of those observed in a time-series sediment trap deployed at 200 m during the previous 60 days, although they more closely corresponded to trap fluxes measured early in the period (Fig. 2).

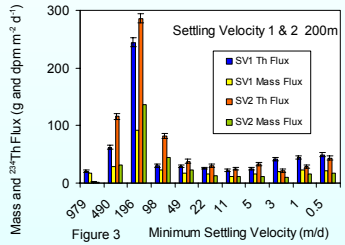

Figure 3

Particles separated by settling velocity using both the sediment trap and net trap/elutriator methods showed similar results. More than 50% of the ^{234}Th flux in the integrated sediment trap sample separated into settling velocity classes was carried in particles sinking faster than 196 m d^{-1} (Fig. 3).

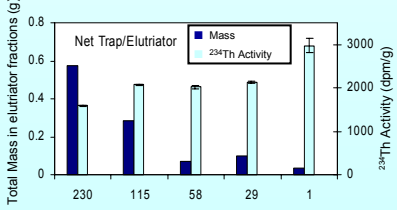

Figure 4

In the net trap sample collected May 6-8, more than 80% of the ^{234}Th collected was present on particles sinking at rates >100 m d^{-1}. The specific activity of ^{234}Th in the elutriated samples showed an inverse relationship with mass in the fraction (Fig. 4). This likely reflects the fact that the slowly sinking particles had high surface area/volume ratios and thus adsorbed more Th. The pattern is distinctly different from that of ^{210}Po (see Stewart et al. poster, this session*).

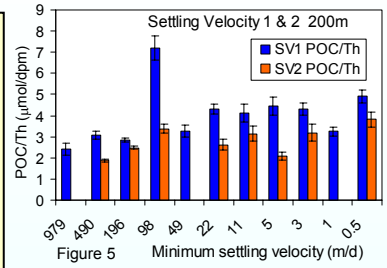

Figure 5

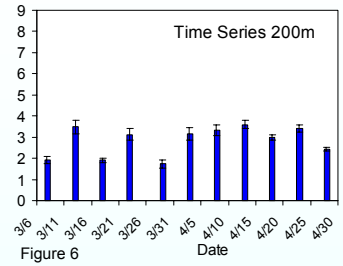

Figure 6

Table 1 POC/^{234}Th ratio comparisons of *in situ* pump and sediment trap material

	in situ pumps		Settling Velocity 200m		Time Series 200m	
	>70μm	1-70μm	SV1 weighted average	SV2 weighted average	TS range	TS average
POC/^{234}Th (μmol/dpm)	3.2 ± 0.4	2.4 ± 0.2	4.5 ± 0.3	2.4 ± 0.1	1.9 - 3.6	3.2 ± 0.4

POC/^{234}Th ratios vary from ~2 – 7 μmol C/dpm in the 200 m trap samples separated according to settling velocity (Fig. 5). Cups 3 and 4 in both traps contained over 50% of the Th flux and these fractions had POC/Th values of 2.9 in SV1 and 2.3 in SV2. POC/Th ratios in the time series sediment trap ranged from 1.9 – 3.6 μmol/dpm over the two months of deployment (Fig. 6). In comparison, the POC/Th ratios measured on filterable particles collected by *in situ* pumps at 200 m were 3.2 ± 0.4 in the >70 μm fraction and 2.4 ± 0.2 in the 1 – 70 μm fraction (Table 1).

POC Export

POC fluxes may be calculated from the water column ^{234}Th deficit multiplied by the POC/ ^{234}Th ratio on sinking particles. We use 200 m, the depth of the shallowest trap to calculate export. The Th deficits obtained from the water column ^{234}Th profiles (Fig. 1), when multiplied by the POC/Th ratio on the >70 μm filterable fraction, yield POC fluxes of 9.4 (May 7) and 6.7 (May 10) mmol/m^2 d^{-1}. In comparison, the trap POC fluxes at 200 m range from 1.7 – 6 mmol C/m^2 d^{-1}, and are higher early in the trap deployment. (see Table 2) Shortly before the trap deployment ended, and the water column ^{234}Th profiles were taken, the trap POC flux at 200 m was 1.7 mmol C/m^2 d^{-1}. A similar offset is evident in a comparison of ^{234}Th fluxes measured by trap and water column Th deficit: the fluxes estimated from the Th deficit in May agree with fluxes measured in the sediment trap early in its deployment. The cause of the offset in POC fluxes is not the choice of POC/Th ratios: the >70 μm filterable fraction yielded virtually the same value as collected in the 200 m trap. Instead it is likely that the steady state interpretation of the ^{234}Th profiles, at a time of declining POC flux, introduces uncertainty into the ^{234}Th flux (and consequently, the POC flux) estimated from Th water column profiles. ^{234}Th profiles collected in March and July may help to better interpret the Th profiles from May.

Table 2 Comparison of *in situ* pump and sediment trap POC Flux (mmol C/m^2 d^{-1}) from 200m

May 7 *in situ* pump	May 10-11 *in situ* pump	Time Series sediment trap
9.4	6.7	1.7 - 6

CONCLUSIONS

- Particles separated according to settling velocity at 200 m at the DYFAMED site show that >80% of the ^{234}Th flux is accounted for by particles sinking faster than 100 m d^{-1}.
- POC/^{234}Th ratios measured in sediment traps and *in situ* pumps agree well. In the settling velocity sediment traps, POC/Th ratios in the cups accounting for >50% of the Th flux are 2.3 – 2.9 μmol/dpm, while values in the >70 μm filterable fraction (at 200 m) are 3.2 ± 0.4 μmol/dpm, comparable to the average ratio of particles caught in the time series trap.
- ^{234}Th and POC fluxes estimated from water column Th and POC profiles agree with values recorded in sediment traps ~50 days prior to the water column sampling. This offset points to the necessity of evaluating non-steady state effects on Th profiles to better estimate POC fluxes from ^{234}Th data.

*FOR FURTHER INFORMATION ABOUT METHODS

Posters : Peterson et al., Stewart et al.,Liu et al., Wakeham et al., Xue et al.
Talk: Lee et al. Thursday 1:45 in room 316B
The poster is available on the MedFlux website (http://www.msrc.sunysb.edu/MedFlux/)

This research was supported by the NSF Chemical Oceanography Program