THORIUM-234 WATER COLUMN PROFILES AND DOWNWARD CARBON FLUX ACROSS A FRONTAL ZONE IN THE LIGURIAN SEA

J.C. Miquel [1], B. Gasser [1], A. M. Rodriguez y Baena [1], E. Verdeny [2], P. Masqué [2], J. K. Cochran [3], S. W. Fowler [3] *

[1] Marine Environment Laboratories, International Atomic Energy Agency, Monaco

[2] Institut de Ciencia i Tecnologia Ambientals, Universitat Autonoma de Barcelona, Bellaterra, Spain

[3] Marine Sciences Research Center, Stony Brook University, NY USA - s.fowler@free.fr

Abstract

Thorium-234 has been intensively used in the past decade as a proxy for carbon export assessment but, ^{234}Th-based POC fluxes do not always agree with those directly measured using sediment traps. The present work reports on ^{234}Th vertical distribution at several stations across a frontal structure in the Ligurian Sea and suggests that hydrodynamic factors could be responsible for the observed discrepancy between radioisotope- and trap-derived particle flux estimates.

Keywords : Particle Flux, Radionuclides, Ligurian Sea, Carbon.

Over the past 4 years, the multidisciplinary MedFlux program has been studying the spatial and temporal variability of carbon fluxes associated with ballast minerals across the "Twilight Zone", a still poorly characterized region extending over a depth range from 100 to 1000 m. Experiments have taken place at the French JGOFS DYFAMED site (NW Mediterranean) where multitracer measurements have been carried out in order to better understand interactions between particle composition, settling velocities, and downward transport of particulate material [see http://www.msrc.sunysb.edu/MedFlux/]. Carbon export from upper waters has been assessed using moored sediment traps [1] and natural radionuclides (^{234}Th:^{238}U; ^{210}Po:^{210} Pb) disequilibria in the water column [2]. Direct measurement of flux and radionuclide-based estimations have agreed in most cases but in late spring-early summer 2003 the two approaches showed some disagreement, which could be associated with an uncommon intrusion of a distinct coastal water mass at the DYFAMED site. In order to evaluate this possible effect, we sampled the water column in May 2006 at four stations between the coast and the central zone of the Ligurian Sea where the DYFAMED station is located (43° 25 N; 7° 52 E).

The main hydrological feature of the Ligurian Sea is a cyclonic eddy which is formed along the northern shore by the Northern Current, a geostrophic current flowing westward generally between 15 - 35 km from the shoreline [3]. This current separates a zone in the centre of the basin from a coastal, peripheral zone. The frontal zone associated with the current is marked by the presence of a density gradient in the sub-surface layer. It is also associated with a secondary circulation system which enhances biological production through a nutrient enrichment of the surface waters [4]. In the present study, the frontal zone was located using the ship's thermosalinograph recordings across a transect from the coastal to the central zone. The recording showed rather complex structures including a relatively warm water mass (and associated low density) at around 14 km from the coast and a fairly weak density gradient starting at about 33 km. We selected the most pronounced section of the gradient at 35 km as being the frontal site. The sites at 46 km and 17 km were retained to represent the central and the peripheral zone, respectively.

The downward flux of mass and carbon have been previously assessed in the frontal zone, as well as in open waters closer to the shore and in the central part of the Ligurian Sea [5]. Reported values indicate that vertical fluxes at 200 m depth are 4 to 6 times higher in the more productive frontal zone as compared to both adjacent zones. Mean values were 832 mg $m^{-2}d^{-1}$ and 48 mg POC $m^{-2}d^{-1}$ for mass and carbon flux at the frontal zone, respectively, compared to 119-151 mg $m^{-2}d^{-1}$ and 10-13 mg POC $m^{-2}d^{-1}$ measured north and south of the front.

Thorium samples were collected using a CTD-Rosette at the following stations: peripheral, frontal, central and DYFAMED located at 17, 35, 46 and 52 km from the shore, respectively. At each station, samples were collected at 11 or 12 depths in the 0-300 m water column and ^{234}Th was measured in 2 or 4 litres of seawater according to the single (IAEA-Monaco) or double (UAB-Barcelona) spike procedures described by Rodriguez y Baena *et al.* [6]. Uranium-238 activity concentration was derived from salinity after Chen *et al.* [7].

^{234}Th/^{238}U ratios in the upper 60 meters were significantly <1 at all stations. Below that depth, ^{234}Th was in *quasi* equilibrium with ^{238}U at the frontal and central stations, whereas it was in deficit with respect to its parent nuclide throughout the 0-300 m water column at the peripheral station. Only at the frontal station were ^{234}Th activities in excess with respect to ^{238}U activities at several depths between 60 and 300m.

Preliminary results suggest that (1) the intrusion into the central part of the Ligurian Sea of isolated water bodies originating from north of the Northern (Ligurian) Current may modify the ^{234}Th signature in the water column and, thus, any carbon export estimation derived from the ^{234}Th:^{238}U disequilibrium, and (2) in the frontal zone, ^{234}Th-derived calculations do not indicate higher carbon export than in adjacent regions, as previously measured by sediment traps. However, a higher spatial resolution study is needed in order to confirm the latter observation.

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