EDDIES total 234Th methods

From Buesseler, K.O., C. Lamborg, P. Cai, R. Escoube, R. Johnson, S. Pike, P. Masque, D. McGillicuddy and E. Verdeny (2008). Particle fluxes associated with mesoscale eddies in the Sargasso Sea. Deep-Sea Research II, 55: 1426-1444.

We followed recently improved methods for the determination of total ^{234}Th on 4L samples collected on standard CTD casts (Benitez-Nelson et al. 2001; Buesseler et al. 2001). Since the cruises were relatively short, our efforts were focused on collecting and processing as many samples as possible at sea, and then returning samples immediately to WHOI for determination of ^{234}Th activities via beta counting. For the ^{234}Th flux approach, it is vitally important to have a precise and accurate determination of total ^{234}Th, particularly in areas where the disequilibrium, i.e. difference between ^{234}Th and ^{238}U, is expected to be small, such as in the Sargasso Sea. We do this by: 1) measuring ^{234}Th via low background beta counting to a counting error that is generally <2%; 2) determining the background of other possible beta emitters by recounting each sample after 5-6 months, at which point ^{234}Th has decayed; and 3) using a ^{230}Th yield monitor to correct measured ^{234}Th activities for systematic and non-systematic inefficiencies in the isolation of Th from seawater (Pike et al. 2005). While on average ^{234}Th yields with this method are high (close to 95% in this study), there is an expected distribution of yields around the mean and a small number of "flyers" with systematically low yields. This distribution is larger than our counting error, and low yields would lower apparent ^{234}Th activities and bias fluxes too high. This illustrates the necessity of using a yield monitor in order to develop a data set of the highest quality. Thorium-234 data are decay corrected to the time of sampling, and errors are propagated from the initial and final measurement of ^{234}Th, as well as the error on the ^{230}Th yield correction. This propagated

error on total ^{234}Th averages ± 3-4% for the entire data set. Uranium-238 can be estimated from salinity, and in the open ocean this relationship is thought to hold within ± <1% (Chen et al. 1986) though differences between groups and settings can be larger (>3%; Pates and Muir 2007; Rutgers Van Der Loeff et al. 2006). Unpublished data from this lab suggests that the U-salinity relationship of Chen et al. (1986) fits Bermuda waters quite well. Five to ten deep water samples (4000m) were analyzed on each cruise and these showed a ^{234}Th/^{238}U ratio of 0.992, and a standard deviation of 3.8% (n=30).

Benitez-Nelson, C. and others 2001. Testing a new small-volume technique for determining thorium-234 in seawater. Journal of Radioanalytical and Nuclear Chemistry **248(3):** 795-799.

Buesseler, K. O. and others 2001. An intercomparison of small- and large-volume techniques for thorium-234 in seawater. Marine Chemistry **74(1):** 15-28.

Chen, J. H., R. L. Edwards, and G. J. Wasserburg. 1986. ^{238}U, ^{234}U and ^{232}Th in seawater. Earth and Planetary Science Letters **80:** 241-251.

Pates, J. M., and G. K. P. Muir. 2007. U-salinity relationships in the Mediterranean: Implications for 234Th:238U particle flux studies. Marine Chemistry **106:** 530-545.

Pike, S., K. O. Buesseler, J. A. Andrews, and N. Savoye. 2005. Quantification of ^{234}Th recovery in small volume sea water samples by inductively coupled plasma mass spectrometry. Journal of Radioanalytical and Nuclear Chemistry **263:** 355-360.

Rutgers Van Der Loeff, M. and others 2006. A review of present techniques and methodological advances in analyzing 234Th in aquatic systems. . Marine Chemistry **100:** 190-212.