Effect of marine oligotrophy on the biogeochemistry of radionuclides

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Oligotrophic or low productivity waters comprise more than 50% of the world's oceans. Moreover, their extent and degree of oligotrophy has increased in one region over the past 50 years. Oligotrophic waters are characterised by greater a) thermal stratification of the water column, b) temporal stability in phytoplankton and zooplankton abundances, and c) prominence of picoplankton. With regard to the presence of nuclides in these waters our studies have focussed on i) ^{210}Po bioaccumulation in marine organisms, relevant to its pre-eminence in human radiological dose from the consumption of seafoods, and ii) the use of naturally occurring nuclides, such as ^{234}Th, as tracers of biogeochemical processes in the euphotic zone. A study of ^{210}Po concentrations in zooplankton collected from the low productivity waters of French Polynesia during 1990-1992 has demonstrated their enhanced uptake of ^{210}Po when zooplankton biomass is low. ^{210}Po in zooplankton increases exponentially to previously unreported levels up to 3200 Bq.kg^{-1} dry weight, as their biomass decline to levels as low as 0.14 mg dry weight/cubic metre. A validated mathematical model, incorporating the established role of zooplankton in the removal of ^{210}Po from the water column, captures the shape of this empirical relationship and also explains this biomass-related mechanism that increases ^{210}Po concentrations in zooplankton. In a further study the model structure was reviewed to determine a set of biogeochemical behaviours of ^{210}Po, proposed to be critical to its environmental enhancement under oligotrophy: this set was then used to identify 25 other elements with comparable behaviours to ^{210}Po. Field investigation in the Timor Sea showed that four of these a *priori* identified elements *viz.* Cd, Co, Pb and Mn, as well as Cr and Ni, showed elevated water concentrations with reduced particle removal rates in the euphotic zone, results that are consistent with those previously obtained for ^{210}Po and the proposed explanatory model. These findings point to the enhanced susceptibility to contamination with particle-reactive elements of oligotrophic marine systems, whose degree and geographic extent may be enhanced by projected increases in sea surface temperatures from global warming. Alternative interpretations of the inverse relationship between biomass and environmental concentrations of particle-reactive elements in the euphotic zone will also be discussed.