Marine applications of nuclear fuel reprocessing tracers in the global ocean

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Since their introduction into the environment from atmospheric nuclear weapons tests in the 1950s, artificial radionuclides have proven to be useful global tracers of water circulation and deep ocean ventilation. Skilful applications of radionuclide tracers are favoured by strong, rapidly time varying sources and accurate knowledge of their input functions, conditions that are satisfied by discharges from the Sellafield, UK and La Hague, France nuclear fuel reprocessing plants and the 2011 Fukushima, Japan nuclear reactor accident. Discharges of ^{129}I and ^{137}Cs from European reprocessing plants are transported through the Nordic Seas and Arctic Ocean and are then injected into Denmark Strait Overflow Water south of Greenland which flows equatorward and supplies the deep waters of the North Atlantic. During the past 35 y, time series measurements along this northern arm of the global overturning circulation have revealed that radioactive tracers from the North Sea take about 10 years to reach the North Pole, an additional 5 years to return to the Nordic and Labrador Seas and a further 8 years to reach deep ocean locations off Bermuda.

Recent measuirements of ^{129}I in the Arctic and North Atlantic Oceans have been used in conjunction with new models based on transit time distributions (TTDs) to provide more precise estimates of transit times and mixing rates for flow along deep ocean circulation pathways. Results from the 2015 GEOTRACES studies in the Canada Basin reveal that Atlantic Water flow through the western arctic basins has a strong advective component while downstream flow in the Nordic and Labrador Seas and Deep Western Boundary Current on Line W off Cape Cod reflects significant modification of the same water masses through mixing. ^{129}I is particularly well suited for studying global ocean circulation, because unlike gas ventilation tracers that undergo ocean atmosphere exchange in surface waters, ^{129}I levels undergo little modification other than by mixing once ^{129}I is discharged into the ocean.