Title: Characterizing the Transport of the Atlantic Water in the Nordic Seas and Arctic Ocean by Radioactive Tracers

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Objective

(1) Characterize the advective and diffusive processes of the Atlantic Water flowing into the subarctic and Arctic Ocean using reprocessing tracers.

(2) Establish a modeling protocol to facilitate the use of the radioactive tracers as a model validation benchmark.

Description of the activity

Anthropogenic radioisotopes (e.g. ^{129}I, ^{236}U, ^{99}Tc) have been discharged to coastal waters from the European nuclear fuel reprocessing plants since the 1960s. The Atlantic Water (AW) flows northward, entraining and mixing with the contaminated coastal waters. The AW is thereby imprinted by the unique reprocessing tracer signature through its way northward into the Arctic Ocean (AO) and back southward to the deep North Atlantic. Built on previous BVF support and other efforts, the spreading of radioisotopes as marine pollutants in the marine environments are simulated with improved discharge histories and are validated against our compiled and in-house collected observations (Fig. 1). The simulated and observed reprocessing tracers also open huge potentials in climate studies. One application is on ocean connectivity. Here we propose a blue-sky research to explore the application of a novel 1D advective-diffusive model, the transit-time distribution (TTD) method, for the first time, on the observed reprocessing radioisotope pairs (^{129}I/^{236}U and ^{129}I/^{99}Tc) with improved reconstruction of input functions based on our simulation. The outcomes of the project will particularly characterize the advective and diffusive horizontal transport features of AW into the AO and back southward to the deep North Atlantic, complementing ventilation rates estimates from the gas tracers SF$_6$ and CFCs.
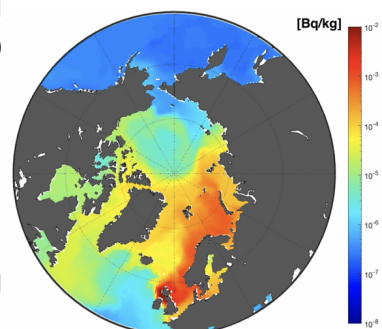

Fig. 1, Simulated Tc-99 concentration in 2000 by NorESM

Timeline: Start in April. **M1**) Prepare observational datasets and input functions by model simulations for the TTD method; **M2**) Calculate the transit times of AW by TTD constrained by different radioactive tracer pairs; **M3**) Compare the the derived TTD with directly simulated results by Eulerian (output of NKS ANTHROPIC) and Lagrangian tracer modeling (output of NFR ArMOC); **M4**) Write the report (manuscript).

Outcome: 1) Flow pathways, and the advective (mean) and diffusive (variance) features of transit times of AW in the Nordic Seas and the Arctic Ocean, and their decadal changes in the 1990s-2010s, disentangling natural regime shifts from the anthropogenic impact; **2)** A protocol for conducting simulation of reprocessing radioisotopes with improved estimates of discharges, compiled observations and program interfaces, will be established and published (after paper publication), facilitating the use of reprocessing tracers as a model validation benchmark for wild ocean modeling community.

Budget: Y. He (1 PM, 139 kNOK), E. Jeansson (1 PM, 160 kNOK), XXX (1PM, xxxkNOK), Others (in-kind). Total: xxx kNOK.