Transport of the Cs-137 water in the North Pacific subtropical mode water at the end of March 2011 to the East China Sea and Sea of Japan

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The Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident in 2011 released radiocaesium (^{137}Cs and ^{134} Cs) into the North Pacific Ocean (NPO) primarily in late March and early April 2011. Subsequent to the incident, the ^{137}Cs activity concentrations were measured in the NPO. The ^{137}Cs activities measured enable the study the movement and circulation of the NPO ocean waters, including the mode water in NPO, by using them as a tracer. The study involves the transport of subtropical mode water (STMW) by focusing on the ^{137}Cs activity in the water which has the same density as STMW. STMW has been identified as a thermostad, characterized by its low potential vorticity, with a density of approximately 25.2 σ_Θ within or near the top of the thermocline in the northwestern North Pacific subtropical gyre. The STMW is formed in a wintertime or early springtime mixed layer (ML), the thickness of which is approximately a few hundred meters in the North Pacific subtropical gyre. Inomata et al. (2018) reported that radioactive cesium (^{137}Cs) into the North Pacific Ocean due to the Fukushima Daiichi Nuclear Power Plant accident was transported to the East China Sea (ECS) and Japan Sea (JS). The density σ_Θ at which^{137}Cs activities were detected in the ECS and JS was approximately 25.2 kg m^{-3}, which indicates that ^{137}Cs contaminated into the STMW after the accident reached to the East China Sea and Japan Sea. In this study, the advection and diffusion of 137Cs in the STMW were examined using a numerically approach with the North Pacific Region Model (ROMS). Since the formation area of the STMW covers a wide area of the North Pacific Kuroshio Current or the Kuroshio Extension, we divided the formation area into multiple rectangles and set tracers (dye01, 02 ,...) uniformly at 10 Bq m^{-3} in the depth of σ_Θ from 25.0 to 25.4 kg m^{-3} in the rectangles at 0:00 on April 1. After simulating the diffusions for tracers in the NPO, we examined the time series of the total amount of the tracers in the ECS and the JS. The number of tracer simulation ensembles is four, because the start date of the simulation for a tracer is January 1 of four consecutive years. First, we set the tracers, dye-01, dye-02, dye-03, and dye-04 0.33±0.03 PBq, 0.36±0.02 PBq, 0.04±0.01 PBq, and 0.23±0.05 PBq corresponding to the rectangles which range 28-35°N and 130-140°E, 28-35°N and 140-150°E°N, 35-42°N and 140- 150°E, and 28-42°N and 150- 160°E respectively and simulated the advection-diffusion of each tracer. The inventory of these tracers showed the following results: (1) The 80% of dye-04 were transported east of 160°E in one year after the initial simulation; (2) Approximately half of dye-01 and 02 were east of 160°E two years after the start; (3) In the ECS, the inventories of dye-01 and 02 had peaks around 1 year and 2 to 3 years after the start, respectively; (4) At the time of the peak, approximately 1.5% of the total amount, initially set, for dye-01 and 02 is present in the ECS; (5) In the JS, the inventories of dyes-01 and 02 began to increase around 1.5 years after the start and gradually increased (to about 0.2 and 0.3% of the initially set total amount in 5 years). Secondly, the area for the tracer dye-02 was divided into eastern and western segments, and tracer dye-06 and dye-07, which were set in the area, were simulated. The tracer dye-06 and 07 exhibited comparable time series of the inventories in the ECS and the JS.