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Possible southward transport of the directly-discharged Fukushima-derived radiocesium across the Kuroshio Extension

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The massive Tohoku earthquake and consequent giant tsunami of March 11, 2011 resulted in the global release of radiocesium (Cs-134 and Cs-137) in the environment from the Fukushima Dai-ichi nuclear power plants (FNPPs). In the North Pacific Ocean, a large portion of the Fukushima-derived radiocesium has been settled both through atmospheric deposition and direct discharge. The direct discharge of radionuclide-contaminated waters brought a serious contamination of radiocesium (about ten million times higher than the background level) in coastal seawaters near the FNPPs just after the accident. Some observations in open oceans clarified that radiocesium activity in surface water of the North Pacific became more than ten times higher than that before the accident due to the atmospheric deposition. About two years after the accident, the radiocesium activity in seawaters decreased remarkably while that in sediment samples on coastal seafloors is still high. Therefore it is necessary to address risks to marine ecosystem and public health for a long time. Meanwhile evaluations of the total amount and behavior of the Fukushima-derived radiocesium in the vast North Pacific Ocean are essential for an estimation of the total amount of the released radiocesium and a prediction of spreading process of the radiocesium in the future, respectively. We present here the Fukushima-derived radiocesium in seawaters at stations in the northwestern North Pacific Ocean hundreds km away from FNPPs in January and February 2012. Surface and deeper samples (0 - 800 m) were collected into 20-L cubitainers using a bucket and a conductivity-temperature-depth rosette with water samplers. The samples were filtrated and acidified by nitric acid on board. Radiocesium in the seawater sample was concentrated onto ammonium molybdophosphate (AMP). Radiocesium, cesium-134 (half-life 2.07 years) and -137 (half-life 30.04 years), in the AMP/Cs compound was measured using a gamma-spectrometry with well-type Ge detectors. Cesium-134 was observed in surface waters from all the stations between 20^{o}N and 42^{o}N about one year after the disaster (0.2 - 18 Bq/m^3). This suggests that the Fukushima-derived radiocesium has been settled at all the stations because cesium-134 activity in the North Pacific before the accident was below detection limit. The cesium-134 activity in surface waters of the subarctic (north of 39^{o}N approx.) and subtropical (south of 35^{o}N approx.) areas were less than 4 and 1 Bq/m^3, respectively. Relative high activities of cesium-134 (8 - 18 Bq/m^3) were found in the transition area between the subarctic and subtropical areas, which is due to an eastward transport of the direct-discharged radiocesium from FNPPs along the North Pacific Current. Cesium-134 activities in the winter mixed layer from surface to 150 or 200m depth approx. were constant and these below the mixed layer were not detected. At a station located just south of the Kuroshio Extension, which is boundary between the transition and subtropical areas, the activity in the mixed layer was less than 1 Bq/m^3 while there was a cesium-134 maximum (5 - 9 Bq/m^3) just below the mixed layer (200m and 300m depths). Water density (sigma-theta) of the maximum ranged from 25.2 to 25.4, which corresponds to densities of surface waters in the transition area in winter. Thus the subsurface cesium-134 maximum at the station in the subtropical area probably originated from the direct-discharged radiocesium in the transition area. Furthermore in deeper layers (400m and 600m depths) at the station low activities of cesium-134 were detected significantly. These results suggest a southward transport of the directly-discharged radiocesium from the transition to the subtropical areas along isopycnal layers across the Kuroshio Extension during the one year after the accident. In our presentation results from other stations, including results of cesium-137, will be discussed.

Keywords: Fukushima Dai-ichi nuclear power plants, radiocesium, North Pacific