Distribution of Radioactive Cesium in Sea Sediment and Bottom Boundary Layer after the Fukushima Daiichi Nuclear Power Plant Accident

Daisuke Ambe1, Hideki Kaeriyama1, Yuya Shigenobu1, Ken Fujimoto1, Hajime Saito2, Yutaka Setou1 and Tomowo Watanabe1

1 National Research Institute of Fisheries Science, Fisheries Research Agency, Japan
2 National Research Institute of Fisheries Engineering, Fisheries Research Agency, Japan

Objective and Materials

A large amount of radioactive materials was discharged into the western North Pacific Ocean by the Fukushima Daiichi Nuclear Power Plant (FDNPP) disaster following the Great East Japan Earthquake and tsunami on 11 March 2011. One of the emerging fisheries issues is to comprehend the effects of the radioactive materials on demersal fishes. For this purpose, we conducted a basic study on radioactive cesium concentrations in sea sediment off Fukushima in February of 2012. Undisturbed sea sediment columns of 14-cm-high were collected with bottom water at 40 locations which were arrayed every 5 minutes.

Results and Discussions

Horizontal spatial pattern of $^{137}$Cs in sea sediment

- Main spatial variation scale is $10^3$ km order. However, the concentrations between the adjacent grids often have a large difference, suggesting that sub-grid scale variations are also predominant.
- The concentrations were often lower in the northern area from the FDNPP than those in the southern area.
- Higher concentrations were especially along the 100 m isobath.
- These horizontal characteristics were commonly observed in all layers.

Vertical profiles of $^{137}$Cs

- Almost concentration peaks were found in upper two layers (0-1 and 1-2 cm).
- The concentration values generally exponentially decayed with the sediment layer depth.
- Most of the sampled radioactive cesium (more than 90 %) distributed 0-10 cm layers.
- Amount of total $^{137}$Cs in this surveyed area (Fig. 2) was estimated about 0.3 % of the total discharge from the FDNPP (3.6 × 10$^{15}$ Bq).

Grain size of the sediment

- The high $^{137}$Cs concentrations did not appeared in larger grain areas which located in the northern near-shore region.
- Smaller grains were found parallel to the high $^{137}$Cs concentrations in the southern region with some spatial distance (blue ellipse in Fig. 5).

$^{137}$Cs of suspended particles in the bottom boundary layer (0-15 cm from sea-bottom)

- Correlation between the concentrations of sediment and suspended particles was not significant (Fig. 6).
- Relative high values were often detected around the 100 m isobath (Fig. 7).
- But higher values were also sometimes observed at offshore or northern areas where the concentrations were not high in the sea sediment (Fig. 7).
- The $^{137}$Cs might be frequently transported in the bottom boundary layer.
- If so, the formation of the radioactive cesium field on sea-bottom is still in transitional state at this time. Consecutive monitoring for comprehending the temporal variation is absolutely needed.

Acknowledgement

We wish to thank Captain Y. Terada and his crew members of the R/V Soyo Maru for supporting sample collection. We also thank Dr. T. Minna of Fisheries Agency for useful comments and advice. This study was financially supported by Fisheries Agency of Japan.

Fig. 1. Concentrations of $^{137}$Cs in each sliced sediment (0, 1-2, 2-4, 4-6, 6-10 and 10-14 cm)

Fig. 2. Vertical profiles of the $^{137}$Cs concentration in the all surveyed positions (black lines). Gray bold line indicates median value in each layer.

Fig. 3. Median grain size of the sea sediment in the 1-2 cm layer. Red dotted ellipse indicates the area where high $^{137}$Cs concentrations were found (Fig. 2).

Fig. 4. $^{137}$Cs concentrations in the suspended particles.

Fig. 5. Vertical profiles of the $^{137}$Cs concentration in the all surveyed positions (black lines). Gray bold line indicates median value in each layer.