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Transfer of radionuclides from high polluted bottom sediments to marine organisms through benthic food chain in post Fukushima period

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A catastrophic earthquake and tsunami occurred on March 11, 2011 and severely damaged the Fukushima Daiichi Nuclear Power Plant (FDNPP) that resulted in an uncontrolled release of radioactivity into air and ocean. Around 80% of the radioactivity released due to the FDNPP accident in March-April 2011 was either directly discharged into the ocean or deposited onto the ocean surface from the atmosphere. A large amount of long-lived radionuclides (mainly Cs-137) were released into the environment. The concentration of radionuclides in the ocean reached a maximum in mid-April of 2011, and then gradually decreased. From 2011 the concentration of Cs-137 in water essentially fell except the area around the FDNPP where leaks of contaminated water are continued. However, in the bottom sediment high concentrations of Cs-137 were found in the first months after the accident and slowly decreased with time. Therefore, it should be expected that a time delay is found of sediment-bound radionuclides in marine organisms.

For the modeling of radionuclide transfer from highly polluted bottom sediments to marine organisms the dynamical food chain model BURN-POSEIDON (Heling et al, 2002; Maderich et al., 2014) was extended. In this model marine organisms are grouped into a limited number of classes based on their trophic level and type of species. These include: phytoplankton, zooplankton, fishes (two types: piscivorous and non-piscivorous), crustaceans, and molluscs for pelagic food chain and bottom sediment invertebrates, demersal fishes and bottom predators for benthic food chain and whole water column predators feeding by pelagial and benthic fishes. Bottom invertebrates consume organic parts of bottom sediments with adsorbed radionuclides which then migrate through the food chain. All organisms take radionuclides directly from water as well as via food. In fishes where radioactivity is not homogeneously distributed over all tissues of the organism, it is assumed that radionuclide accumulates in a specific tissue called target tissue. This tissue (bone, flesh, stomach, and organs) controls the overall elimination rate of the nuclide in the organism. The model prediction for the coastal area around the FDNPP agree well with observations. In addition the effects from the Chernobyl accident on the Baltic Sea are modelled and these results also are in good agreement with available data. These results demonstrate the importance of the benthic food chain in long-term transfer of radionuclides from high polluted bottom sediments to the marine organisms. The developed model can be applied for different regions of the World Ocean.