Transfer of Radiostrontium and Radioiodine to Marine Organisms

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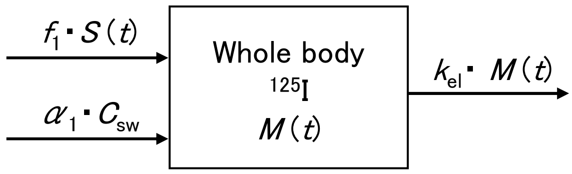
Abstract

A commercial large-scale nuclear fuel reprocessing plant in Rokkasho, Aomori Prefecture, Japan is now under final safety assessment by the Nuclear Regulation Authority. Radionuclides including radiostrontium and radioiodine are discharged by the normal operation of the plant. In order to assess the realistic impact of those radionuclides, it is important to understand the processes of their accumulation from seawater to marine organisms. In this research, we investigated the transfer of Sr and I from seawater and feed to olive flounder (*Paralichthys olivaceus*), a commercially important fish found in the coastal waters of Aomori Prefecture.

From FYs 2018 to 2019, ^{86}Sr-labelled olive flounder were kept in natural seawater, and the concentrations of ^{86}Sr in their muscle and vertebra were measured to clarify the long-term elimination rate of Sr. A four-compartment model was developed by using the data obtained from the exposure experiment of the olive flounder to ^{86}Sr-enriched seawater, feeding experiments using ^{86}Sr-labelled shrimp (*Litopenaeus vannamei*) and ^{87}Sr-labelled Japanese medaka (*Oryzias latipes*), and the elimination as described above. In our compartment model, Sr entering a transfer compartment is transferred to two muscle compartments with different turnover rates and one vertebra compartment. The model estimates of the concentrations of ^{86}Sr and ^{87}Sr in muscle and vertebra were in good agreement with the experimental observations.

In FY 2019, we developed a short-term metabolism model of ^{125}I in olive flounder using retention data after exposure experiments in water containing ^{125}I. Olive flounder aged >200 d after hatching were kept for 1 – 7 d in water containing ^{125}I. Most of the olive flounder were collected at the end of this exposure and dissected, followed by the measurement of radioactivity in their tissues. However, additionally, certain fish in the group exposure for 7 d were transferred to ^{125}I-free water for 1 – 7 d, before collection, dissection and radioactivity measurement. A single-compartment model was developed by using whole body retention data of ^{125}I excluding the gastrointestinal (GI) tract by a feeding experiment in FY 2018 and the exposure experiments in FY 2019. The GI absorption ratio (f_1=0.5), uptake rate of seawater for ^{125}I absorption (α_1= 2.7 g h^{-1}) and elimination rate constant from the whole body (k_{el}=0.014 h^{-1} corresponding to biological half-time of 2.1 d) were obtained using the least squares method. The model adequately simulated the short-term behavior of ^{125}I and indicated the rapid metabolism of radioiodine in olive flounder.



f_1 : GI absorption ratio
$S(t)$: Feeding rate (Bq h^{-1})
α_1 : Uptake rate of seawater for ^{125}I absorption
C_{sw} : ^{125}I in seawater (Bq g^{-1})
$M(t)$: Whole body ^{125}I (Bq)
k_{el} : Elimination rate constant from the whole body (h^{-1})

Fig. 1 Scheme of single compartment model of ^{125}I in olive flounder.

Table 1 Estimated values of GI absorption ratio (f_1), uptake rate of seawater for ^{125}I absorption (α_1) and elimination rate constant from the whole body (k_{el}) by the single compartment model.

Unknown parameter	Estimated value
f_1	0.5
α_1 (g h^{-1})	2.7
k_{el} (h^{-1})	0.014

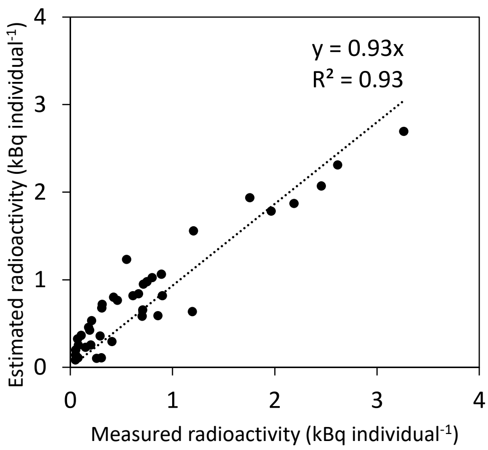


Fig. 2 Comparison of estimated radioactivity using a single compartment model withmeasurements in olive flounder in ^{125}I feeding experiment.

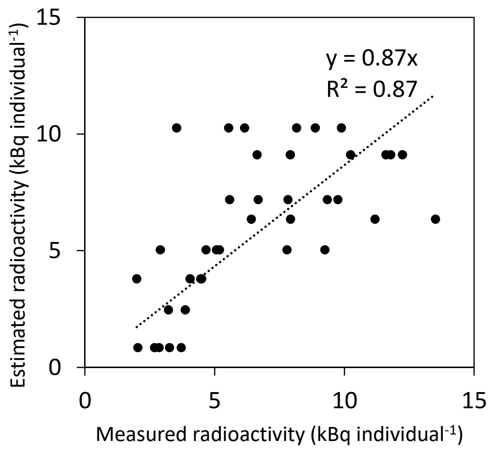


Fig. 3 Comparison of estimated radioactivity using a single compartment model with measurements in olive flounder in ^{125}I exposure experiments.