Transfer Parameters of Tritium from Seawater to Marine Organisms

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Abstract

The operation of the commercial spent nuclear fuel reprocessing plant in Rokkasho is accompanied by the discharge of a certain amount of tritium into the Pacific Ocean. Although most of the tritium discharged is diffused and spread widely throughout the ocean, some part will be transferred into marine organisms living close to shore areas. Tritium in organisms is composed of two chemical forms: one is free water tritium (FWT) and the other is organically bound tritium (OBT) fixed by the organism metabolic activity. In order to assess realistically the impact of tritium discharged into seawater to the public, it is important to understand the processes of transfer and accumulation of tritium from seawater to marine organisms, especially OBT in them. In this research, the transfer rates of tritium in seawater to OBT in several marine organisms are obtained. The OBT transfer through the food chain is also included in the scope of this study. We have used the stable isotope of hydrogen, deuterium (D), as a substitute for tritium in our experiments.

In FY 2013, we investigated the biosynthesis and metabolism of non-exchangeable organically bound deuterium (NxOBD) in olive flounder (*Paralichthys olivaceus* Temminck and Schlegel) before 1 y old. As the first experiment in FY 2014, olive flounder (1 y old) were kept in seawater containing HDO with 2.0 mmol D mol^{-1} H up to 530 d after starting the exposure, and NxOBD concentrations in their muscle and viscera were measured at the predetermined period. In the second experiment, olive flounder (2 y old) were fed on a mixture of a commercial feed and a freeze-dry powder of D-labeled rockfish (*Sebastes vulpes* Doderlein), which was prepared by keeping in seawater with HDO. The exchangeable D in the rockfish powder was removed by repeating freeze-drying after soaking the dry powder in water. The final mixture feed contained NxOBD of 1.75×10^{-3} mol D mol^{-1} H. The flounder were given the pre-weighted mixture feed once a day, and dissected at the pre-determined period. The NxOBD concentration in the muscle increased depending on the weight of labeled feed given. In the third experiment, after olive flounder were kept in seawater containing HDO with 2.0 mmol D mol^{-1} H, they were cultivated for 210 d in seawater with the background HDO to observe the excretion rate of deuterium. During the cultivation, the NxOBD concentration in their muscle was periodically analyzed.

A compartment model for metabolism of NxOBD in olive flounder was constructed by using results from those three experiments. In the model, olive flounder consisted of a muscle NxOBD compartment and a free water deuterium (FWD) compartment which was assumed to be in equilibrium with seawater. The rate constants of D transfer between each compartment were obtained by a least square fitting method using all experimental data. The observed NxOBD concentrations were fairly well described by the model calculation.

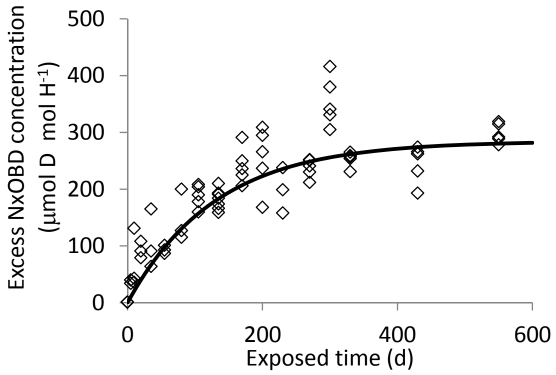

Fig. 1 Time dependent NxOBD concentration in the muscle of olive flounder (*Paralichthys olivaceus* Temminck et Schlegal) during HDO exposure. Open diamonds show measured values and the solid line shows estimated values by the metabolism model. HDO concentration was kept to 0.2 % (mol D mol H^{-1}) during the experiment. Background NxOBD concentration was subtracted.

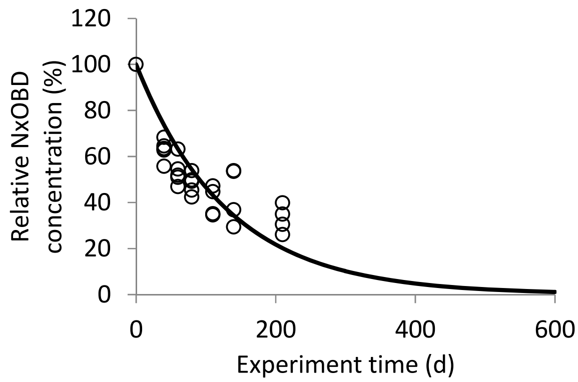

Fig. 2 Time dependent NxOBD concentration in the muscle of olive flounder kept in seawater with the background HDO after HDO exposure for 150 d. Open circles show measured values and the solid line shows estimated values by the metabolism model. Horizontal axis is time after transferring olive flounders into seawater without spiking HDO. Vertical axis is NxOBD concentration relative to that at the transfer date. Background NxOBD concentration was subtracted.

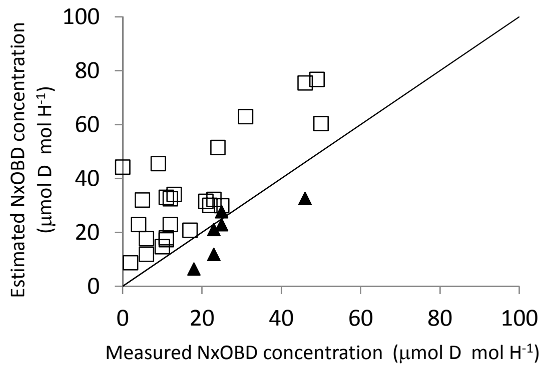

Fig. 3 Comparison between measured NxOBD concentration and that estimated by the metabolism model. Open squares and solid triangles show results of 1 y and 2 y old olive flounder, respectively. Background NxOBD concentration was subtracted.

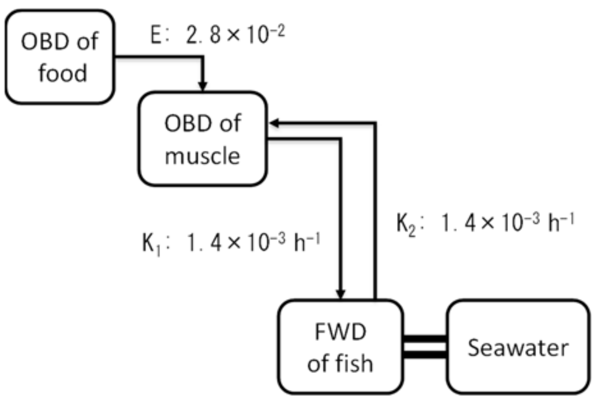

Fig. 4 Scheme of deuterium metabolism model in olive flounder.