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. However, information on the transfer of tritium from seawater to marine organisms is quite limited. In this research, the transfer rates of tritium in seawater to OBT in several marine organisms are obtained for the realistic dose estimation of tritium discharged from the reprocessing plant. The OBT transfer through the food chain is also included in the scope of this study. In FY 2012, we investigated the biosynthesis and metabolism of non-exchangeable OBD (Nx-OBD) in Ezo abalone (*Haliotis discus hannai* Ino).

The stable isotope of hydrogen, deuterium (D), was used as a substitute for tritium in the following three experiments. In the first experiment, Ezo abalones were kept in seawater containing HDO with 2000 μmol D mol^{-1} H up to 160 d, and biosynthesis rate of Nx-OBD in their muscle and hepatopancreas was measured. In the second experiment, after Ezo abalones were kept in seawater containing HDO with 2000 μmol D mol^{-1} H for 100 d, they were cultivated for 100 d in seawater in which the HDO concentration was the background level. During the cultivation, the Nx-OBD concentration in their muscle and hepatopancreas were periodically analyzed. In the third experiment, Ezo abalones were fed on seaweed (*Ulva. pertusa*) containing Nx-OBD with 580±86 (SD) μmol D mol^{-1} H for 26 to 28 d. The consumed weight of the seaweed by each Ezo abalone was measured at every feeding, and the Nx-OBD concentrations in the muscle and hepatopancreas were analyzed.

A compartment model for metabolism of Nx-OBD in Ezo abalone was constructed by using results from these three experiments. In the model, Ezo abalone consisted of hepatopancreas and muscle Nx-OBD compartments connected to each other. A part of the OBD in food was assimilated into the hepatopancreas OBD compartment, and the remaining part was promptly decomposed to FWD. Although a FWD compartment in Ezo abalone was installed in the model, the HDO in the compartment 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 experimental data. The observed Nx-OBD concentrations were well described by the model calculation.

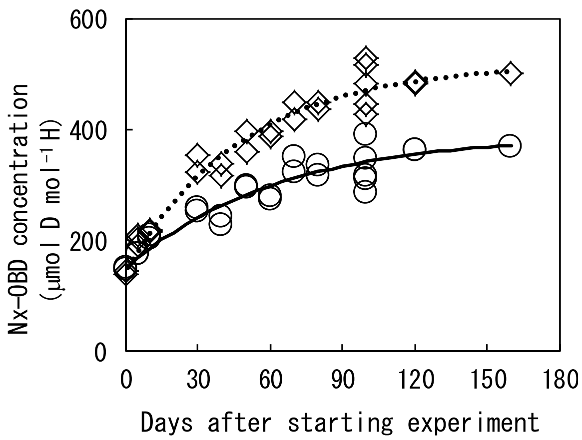

Fig. 1 Accumulation of Nx-OBD in Ezo abalone grown in seawater containing HDO with 2000 μmol D mol^{-1} H .
(◇: hepatopancreas, ○: muscle, Line: model estimation)

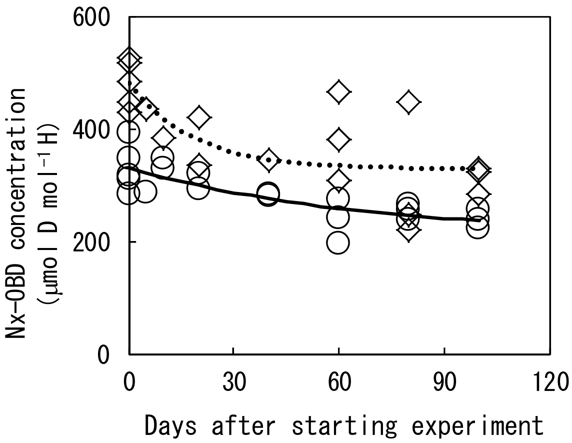

Fig. 2 Decrease in concentration of Nx-OBD in Ezo abalone grown in seawater, in which concentration of HDO was background level.
(◇: hepatopancreas, ○: muscle, Line: model estimation)

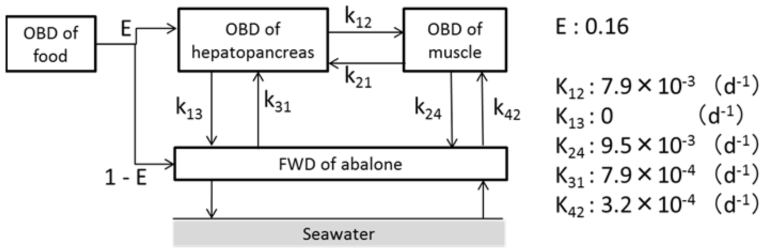

Fig. 3 Scheme of a compartment model for transfer and accumulation of deuterium in Ezo abalone.

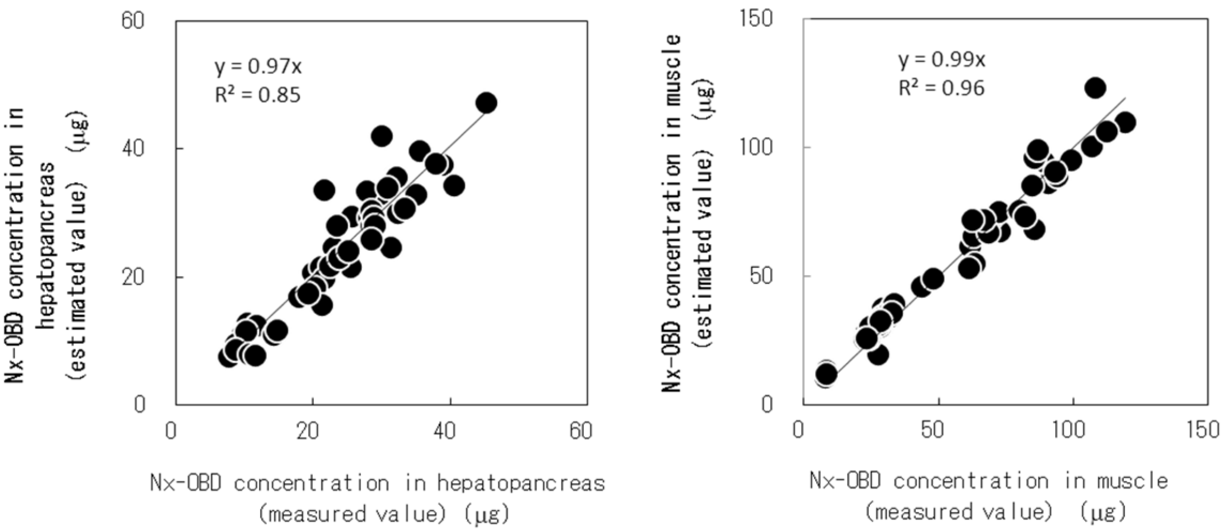

Fig. 4 Comparison between values measured and estimated using a model shown in Fig. 3, for Nx-OBD in muscle (right panel) and hepatopancreas (left panel).