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. In FY 2013, we investigated the biosynthesis and metabolism of non-exchangeable OBD (NxOBD) in olive flounder (*Paralichthys olivaceus* Temminck and Schlegel). In addition, the deuterium transfer model in a system consisting of seawater, a seaweed species (*Ulva. pertusa*) and an abalone species (*Haliotis discus hannai* Ino) was constructed based on experimental data, which were obtained through FY 2012.

The stable isotope of hydrogen, deuterium (D), was used as a substitute for tritium in the following two experiments. In the first experiment, olive flounders (1 y old) were kept in seawater containing HDO with 2.0 mmol D mol^{-1} H up to 200 d, and NxOBD concentrations in their muscle and viscera were measured at the predetermined period after starting the exposure. The concentration factor from HDO in seawater to OBD in muscle was obtained as 0.22 after 200 d exposure. In the second experiment, fry of olive flounder (20-28 weeks old) were fed on a mixture feed of freeze-dry powder of polychaete (*Perinereis aibuhitensis* Grube) kept in seawater with HDO and a commercial feed. The exchangeable D in the polychaete powder was removed by repeating freeze-drying after soaking the dry powder in water. The final mixture feed contained NxOBD of 1.11×10^{-3} mol D mol^{-1} H. The flounders were given the pre-weighted mixture feed once a day, and dissected at the pre-determined period. The NxOBD concentrations in the muscle and viscera were increased depending on the weight of labeled feed given.

The deuterium transfer model of the seaweed, which was used as feed to the abalone, had a single NxOBD compartment with assumption of equivalent D between FWD in the seaweed and seawater. The deuterium transfer model of the abalone consisted of hepatopancreas and muscle NxOBD compartments those were constructed by using our metabolism data of D. In the deuterium transfer model of the abalone, NxOBD in feed was directly transferred into both NxOBD compartments, while a part of NxOBD in feed was promptly decomposed to FWD. The FWD in abalone was assumed to be in equilibrium with seawater. Parameters in the models were obtained by a least square fitting method using experimental data. The two models were connected to simulate tritium transfer in the seawater-seaweed-abalone system. Test simulations successfully described the dynamic transfer of tritium in this system.

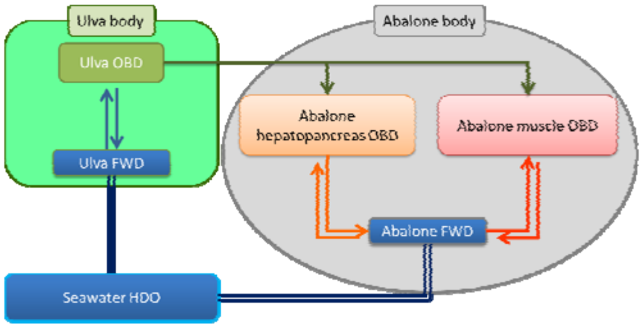

Fig. 1 Outline of deuterium transfer model in the seawater-seaweed-abalone system. FWD in seaweed (ulva) and abalone were assumed to be in equilibrium with seawater.

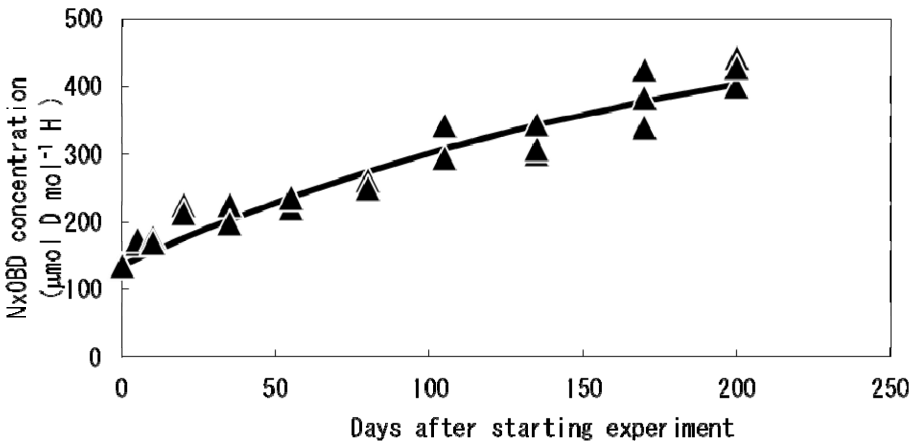

Fig. 2 Accumulation of NxOBD in muscle of olive flounder (*Paralichthys olivaceus* Temminck and Schlegel) kept in seawater containing HDO with 2.0 mmol D mol^{-1} H.

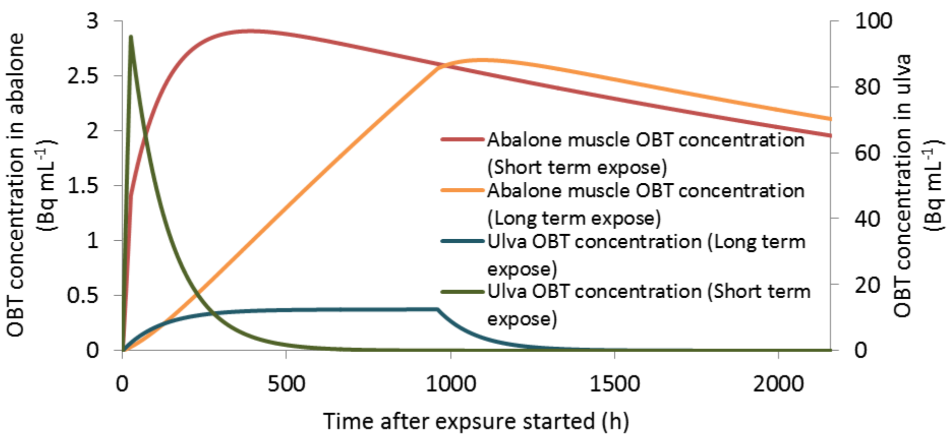

Fig. 3 Estimated OBT concentration in seaweed (*Ulva. pertusa*) and abalone (*Haliotis discus hannai* Ino). Tritium concentration in seawater was set to 1 kBq mL^{-1} for 24 h (short term expose) or 2.5 Bq mL^{-1} for 40 d (long term expose).