Tracing of the freshwater fish movement patterns and water dynamics by strontium stable isotope ratios and the elements concentrations analysis

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In coastal area of Otsuchi, Iwate prefecture, spring water is abundant and thereby the rare freshwater three-spined stickleback (Gasterosteus aculeatus), which prefer cold water environment, inhabit here. This area was damaged by the tsunami caused by the 2011 off the Pacific coast of Tohoku Earthquake. During the reconstruction and recovery works, the understanding of the habitat range and the environmental conditions of the three-spined sticklebacks contributes to the appropriate ecosystem management. Strontium stable isotope ratio ($^{87}Sr/^{86}Sr$) has been used as a powerful indicator to trace the past movement patterns of fish because of the same $^{87}Sr/^{86}Sr$ value between fish and the water of its habitat. Therefore, we used $^{87}Sr/^{86}Sr$ indicator to elucidate the three-spined stickleback movement patterns.
First, we investigated the relationship between the $^{87}Sr/^{86}Sr$ of three-spined stickleback whole otoliths (ear bone) and the water in isolated water bodies. We confirmed that both water and fish have almost same $^{87}Sr/^{86}Sr$.
Second, by analyzing the water of different rivers and tributaries in Otsuchi, we found that, just in one tributary of Kozuchi mainstream, $^{87}Sr/^{86}Sr$ and many element concentrations (e.g. Ca, Sr) were remarkably different between the upstream and downstream. Using $^{87}Sr/^{86}Sr$ and Sr concentration values of water, the downstream water was estimated to be mix of the upstream water, mainstream water and seawater (Contribution ratio; upstream: 82.6%, mainstream: 16.7%, seawater: 0.6%).
Then, using $^{87}Sr/^{86}Sr$ and elemental concentration of otoliths of fish captured in the upstream and downstream, we estimated their past movement patterns. We compared the water $^{87}Sr/^{86}Sr$ between the upstream and the downstream and the $^{87}Sr/^{86}Sr$ of otolith. As a result, it was possible to identify that stickleback lived in either upstream or downstream within single tributary; three-spined sticklebacks captured in the upstream (40 individuals in total) were not likely to move from downstream, while the fish caught at downstream (13 individuals in total) were estimated to have moved from the upstream or the mainstream. Furthermore, in the downstream, some fish otoliths showed a larger value of Sr/Ca than the others, which means that those fishes lived in high salinity environment in the past suggesting that the downstream population of three-spined stickleback was able to live in both fresh and brackish water environments.

Keywords: strontium stable isotope ratio, otolith, fish, water

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