

Biological specimens reveal centurial tropho-dynamics of predatory fishes

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Although lakes and ponds bring various ecosystem services to humans, they are one of the most vulnerable ecosystems to human activities such as overexploitation, pollution, and development. For evaluating the past human-induced impacts and making complete plans for appropriate conservation and fishery, it is important to clarify the long-term dynamics of food-web structures in the lake. In this study, we focused on the fish specimens collected in the Lake Biwa (Shiga Pref.) over 100 years and aimed to clarify the long-term dynamics of trophic positions (TPs) using the values of stable nitrogen isotopic composition of individual amino acids ($\delta^{15}\text{N}_{\text{AA}}$). We used the specimens of typical fish-eating fish in the Lake Biwa, *Opsariichthys uncirostris uncirostris* (Japanese name: “Hasu”). We measured the values of $\delta^{15}\text{N}_{\text{AA}}$ of *O. uncirostris uncirostris* collected from the 1910s onwards and evaluated the relative contributions of aquatic and terrestrial food sources to the fishes by the two-source mixing model. As the proxy of aquatic food sources in the past Lake Biwa, we used the specimens of swimming goby, *Gymnogobius isaza* (Japanese name: “Isaza”). Whereas The TPs of *O. uncirostris uncirostris* remained on almost the same level from the 1910s to the 1960s (TP: 3.0–4.0), they increased in the 1970s (approximately 4.0), and then decreased from the 1980s to the 2010s (TP: 3.0–3.5). We also obtained the same trend of the TPs by the analysis using the values of bulk-tissue $\delta^{15}\text{N}$. Our results suggest that $\delta^{15}\text{N}_{\text{AA}}$ is the useful tool to reveal the long-term dynamics of food-web structures. It seems that the long-term dynamics of the TPs of *O. uncirostris uncirostris* is closely associated with the environmental changes in the lake Biwa, e.g., the eutrophication in the 1960s and subsequent remediation of water quality, inter-specific competition with the alien fishes exclusively increased in the 1980s, and the conservation and restoration of the coastal areas in recent years. In the future, analyses of $\delta^{15}\text{N}_{\text{AA}}$ for the biological specimens stored in various institutes allow us to reconstruct past food-web structures and apply them to effective ecosystem managements.

Keywords: stable nitrogen isotopic composition of individual amino acids, food-web analysis, ecosystem management