Abalone Shell Isotopes as Coastal Archives of Regional Water-Mass Variability around Japan

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Ocean currents such as the Kuroshio, Oyashio, and Tsushima Warm Current have long exerted strong influences on the climate, ecosystems, fisheries, and culture around the Japanese archipelago. Recent changes in these current systems, including shifts in the Kuroshio-Oyashio transition zone, highlight the need for high-resolution coastal archives that complement instrumental observations and capture how large-scale ocean circulation variability is expressed in nearshore environments.
Abalones (*Haliotis* spp.) are long-lived coastal mollusks distributed from subarctic to subtropical regions, inhabiting diverse oceanographic settings. Their carbonate shells accrete sequentially and preserve geochemical signatures at seasonal resolution, making them promising archives of past marine environmental variability. In this study, we evaluated the potential of abalone shells as archives of past marine environmental variability using stable isotopes (d18O, d13C) and radiocarbon (D14C). We analyzed modern specimens of *H. discus hannai* (shallow-water) from Otsuchi Bay in the Oyashio–Kuroshio transition region, *H. discus discus* (shallow-water) and *H. madaka* (deeper-water) from a Kuroshio-influenced coastal region in Tokushima Prefecture, and the intertidal species *H. varia* from Amami Oshima under persistent Kuroshio influence. By comparing different current regimes as well as habitat depth within the same regime, we examined isotopic variability in relation to both regional water-mass characteristics and species-specific habitat exposure.
Shell d18O records exhibit clear seasonal cycles, reflecting differences in species-specific growth patterns and local environmental variability. In contrast, shell D14C values show regional differences. D14C values in *H. discus hannai* shells display large fluctuations, as well as a decreasing trend from ~2011 to 2019, followed by an increasing trend from ~2019 to 2022. This recent upward trend potentially suggests an enhanced influence of the Kuroshio and Tsugaru Warm Currents in Otsuchi Bay. In contrast, *H. discus discus*, *H. madaka* and *H. varia* shells from Kuroshio-influenced regions show relatively higher and more stable D14C values, reflecting the relative stability of coastal water masses in these regions. Furthermore, *H. madaka* exhibits systematically lower and more stable D14C values than in *H. discus discus* shells despite being collected at the same time and same region, likely reflecting differences in water-mass exposure related to habitat depth.
These results suggest that abalone shell isotopes capture both regional water-mass characteristics and species-specific habitat differences. We hope this study may serve as a modest contribution toward understanding water mass mixing signals in coastal ecosystems around Japan, including the northwestern Pacific.

Keywords: Abalone, Stable Isotopes (d18O, d13C), Radiocarbon (D14C), Kuroshio Currrent, Oyashio Current

