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Tracing environmental history of macroalgae by the use of radiocarbon and stable isotope ratio analyses

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In the bays located along the Sanriku coastal area (northeast Japan), where the Kuroshio and Oyashio mix in a complex manner, environmental conditions (e.g. water temperature, irradiation and nutrients) may largely change depending on which current predominantly enters into the bays. Changes in environmental conditions, in turn, may exert a large influence on growth of and interactions between organisms residing there. However, knowledge is limited regarding relationships between shifts in hydrographic conditions and physiological responses of organisms to environmental variability. The purpose of this presentation is to report our attempt to trace environmental history of individual macroalgae (wakame, *Undaria pinnatifida*), a widespread benthic primary producer and an important aquaculture product in the Sanriku area, by a combined use of radiocarbon and stable isotope ratio analyses. The key concept was to use distinct ^{14}C abundance between the two water currents, i.e., ^{14}C abundance of dissolved inorganic carbon in the Oyashio water is lower than that in Kuroshio water due to upwelling of old deep water. We assumed that ^{14}C abundance profile of pinnate blades of macroalgae (blades near the top are older than those near the bottom) reflects a temporal change in dissolved inorganic carbon ^{14}C (hence, shift in water current) via photosynthetic fixation. We also analyzed carbon and nitrogen stable isotope ratios (δ^{13}C and δ^{15}N) of the blades to gain insights into changes in physiological state of the macroalgae during their growth.

We collected sporophytes of *U. pinnatifida* cultured between October 2012 and March 2013 at two stations (one located near the bay center and the other located near the river mouth) in Otsuchi Bay. One individual (length, ca. 190 cm) was collected at each station. For each individual, a tip of each pinnate blade was cut, treated with HCl, reduced to graphite, and served for determination of radiocarbon composition ($\triangle^{14}$C) profile using an accelerator mass spectrometer. δ^{13}C and δ^{15}N of the corresponding samples were also measured using a stable isotope ratio mass spectrometer.

$\triangle^{14}$C of pinnate blades of the saprophyte collected near the bay center varied between 0 and 40 permil. $\triangle^{14}$C values were high for the blades located at the upper and lower parts of the macroalgae, whereas they were low for the blades situated at the middle part. These results indicate that the sporophyte experienced the intrusion of the Oyashio water during the period of the development of the middle blade. Similar to the pattern in $\triangle^{14}$C, δ^{13}C and δ^{15}N values were also lowest at the middle part, although the position of the minimum was skewed toward bottom relative to the position of the $\triangle^{14}$C minimum. There was a significant positive correlation between δ^{13}C and δ^{15}N, suggesting that the variation in stable isotope ratios reflected macroalgal physiological responses and associated shifts in isotope fractionation. Collectively, these results were interpreted as an indication that the physiological state of the saprophyte was altered with a time lag after the intrusion of the Oyashio water into the bay. In contrast, $\triangle^{14}$C profile of pinnate blade was complex for a saprophyte collected near the river mouth. For this individual, there was no clear pattern in distribution of δ^{13}C and δ^{15}N among blades. Complex variations in isotopic compositions for this individual might be ascribed to the influence of inflow river water.

Keywords: macroalgae, Sanriku coast, water current, radiocarbon, stable isotope